Final
Camp Allen Landfill RI Report
Norfolk Naval Base
Norfolk, Virginia
Volume I
Text

Baker

Baker Environmental, Inc

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WESTON

MANAGERS DESIGNERS/CONSULTANTS

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03.13-07/01/94-00592

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Text

Prepared For:

Department of the Navy
Atlantic Division
Naval Facilities
Engineering Command
Norfolk, Virginia

Under the

LANTDIV CLEAN Program

Comprehensive Long-Term
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FINAL

REMEDIAL INVESTIGATION REPORT

CAMP ALLEN LANDFILL
NAVAL BASE, NORFOLK, VIRGINIA

CONTRACT TASK ORDER 0084

JULY 14, 1994

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared By:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

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SECTION 1
INTRODUCTION

1.0 INTRODUCTION

The objectives of the Remedial Investigation (RI) were to determine the extent and degree of potential contamination associated with Areas A and B of the Camp Allen Landfill Site. The objectives were accomplished through investigation of subsurface soils, surface soils, sediment, surface water, groundwater, and air. Additionally, a quantitative Risk Assessment (RA) evaluating current and potential future risks associated with the site was completed and is submitted as a separate document. The information gathered and evaluated in the Remedial Investigation and the Risk Assessment formed the basis for conducting the Feasibility Study (FS).

1.1 Installation Restoration Program (IRP)

In 1975, the Department of Defense (DoD) began a program to assess past hazardous and toxic materials storage and disposal activities on military facilities. The goal of this program, the DoD's Installation Restoration Program (IRP), is to address uncontrolled hazardous waste sites by mitigating hazards to health and welfare.

The realization that hazardous waste disposal practices may have adverse effects on human health and the environment was addressed by Congress in 1976, with the passage of the Resource Conservation and Recovery Act (RCRA). RCRA was legislated to manage the present and future disposal of hazardous wastes. In 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was passed to investigate and remediate areas resulting from past, formerly accepted, hazardous waste management practices. "Superfund" is the phrase often used when CERCLA activities are conducted by the U.S. Environmental Protection Agency (USEPA) or state agencies.

In 1981, the DoD's IRP was reissued, with additional responsibilities and authorities specified in CERCLA delegated to the Secretary of Defense. In order to address the 1986 Superfund Amendments and Reauthorization Act (SARA), the Navy restructured the IRP to match the terminology and structure of the USEPA program. The current IRP is consistent with applicable state and federal environmental laws.

The IRP process generally consists of the following steps:

- Preliminary Assessment/Site Investigation (PA/SI) - Initial study to identify potential threat to human health or the environment. Equivalent to Initial Assessment Study/Confirmation Study (IAS/CS) completed at Naval Base Norfolk prior to restructuring the IRP process in 1986.

- Initial Assessment Study/Confirmation Study (IAS/CS) - Initial phase including record searches and personal interviews to collect and evaluate all evidence supporting the possible existence of a contamination problem at several sites within the Naval Complex. Based on conclusions of the IAS, a confirmation study may be performed.

- Remedial Investigation/Feasibility Study (RI/FS) - Complete study to define nature and extent of contamination, risk assessment for human health and environmental concerns, and evaluation of proposed remedial alternatives.

- Record of Decision (ROD) - Decision document which summarizes RI/FS results and outlines remedial action(s) for a site. Includes public comment period.

- Remedial Design/Remedial Action (RD/RA) - Engineering design and implementation of the remedial action.

The Camp Allen Landfill Site was identified during the IRP process as requiring investigation and evaluation of potentially hazardous materials. The following sections describe the history of the Camp Allen Landfill Site and summarize the results of previous investigations.

1.2 Base/Site History (including Areas A and B)

1.2.1 Naval Base Norfolk History

On June 28, 1917, 474 acres of land were acquired by Presidential Proclamation to establish the Sewells Point Naval Complex (SPNC) to support the war effort. In addition to the land, this acquisition included many buildings constructed as part of a 1907 Exposition celebrating the 300th anniversary of the Jamestown settlement. These buildings have been maintained and serve as officers quarters and also house the Hampton Roads Naval Museum. The 19 remaining buildings were placed on the Virginia Landmarks Register and later on the National Register of Historic Places.

Construction of facilities began on July 4, 1917. On October 12, 1917, the naval facilities were officially commissioned as the Hampton Roads Naval Operating Base (NOB). In order to fulfill the NOB mission, bulkheads were built from 1917 to 1918 in the waters along the coast to extend available land. After dredge and fill operations, the total land under Navy control was increased from 474 to 792 acres. An additional 143 acres were acquired in 1918 and officially commissioned for the Naval Air Station (NAS).

Several major commands originated during this period. Seven sea planes and a number of lighter-than-air (LTA) planes were based in hangars in this area and conducted wartime patrols along the Atlantic Coast. This activity later evolved into the current NAS Norfolk. Additionally, the Naval Supply Station was officially commissioned in 1919, later to become the Naval Supply Center.

The post-World War I period was one of decreased naval operations and of economic depression. Few physical changes to the facility occurred between 1920 and 1935. From 1936 to 1940, improvements to the piers and expansion of supplies and materials handling facilities were completed. During this time, the area of the Naval Base expanded to over 2,100 acres because of the involvement of the United States in World War II. Between 1940 and 1945, the major projects completed included seven piers, numerous runways and hangars, a hospital, a power plant, a tank farm, and several barracks/housing facilities.

After World War II, naval operations again declined; many ships were decommissioned and crews were discharged. Administrative reorganization of the Navy according to peacetime needs resulted in the establishment of Naval Base Norfolk. Naval Base Norfolk comprised several major components of the NOB and other Hampton Roads facilities.

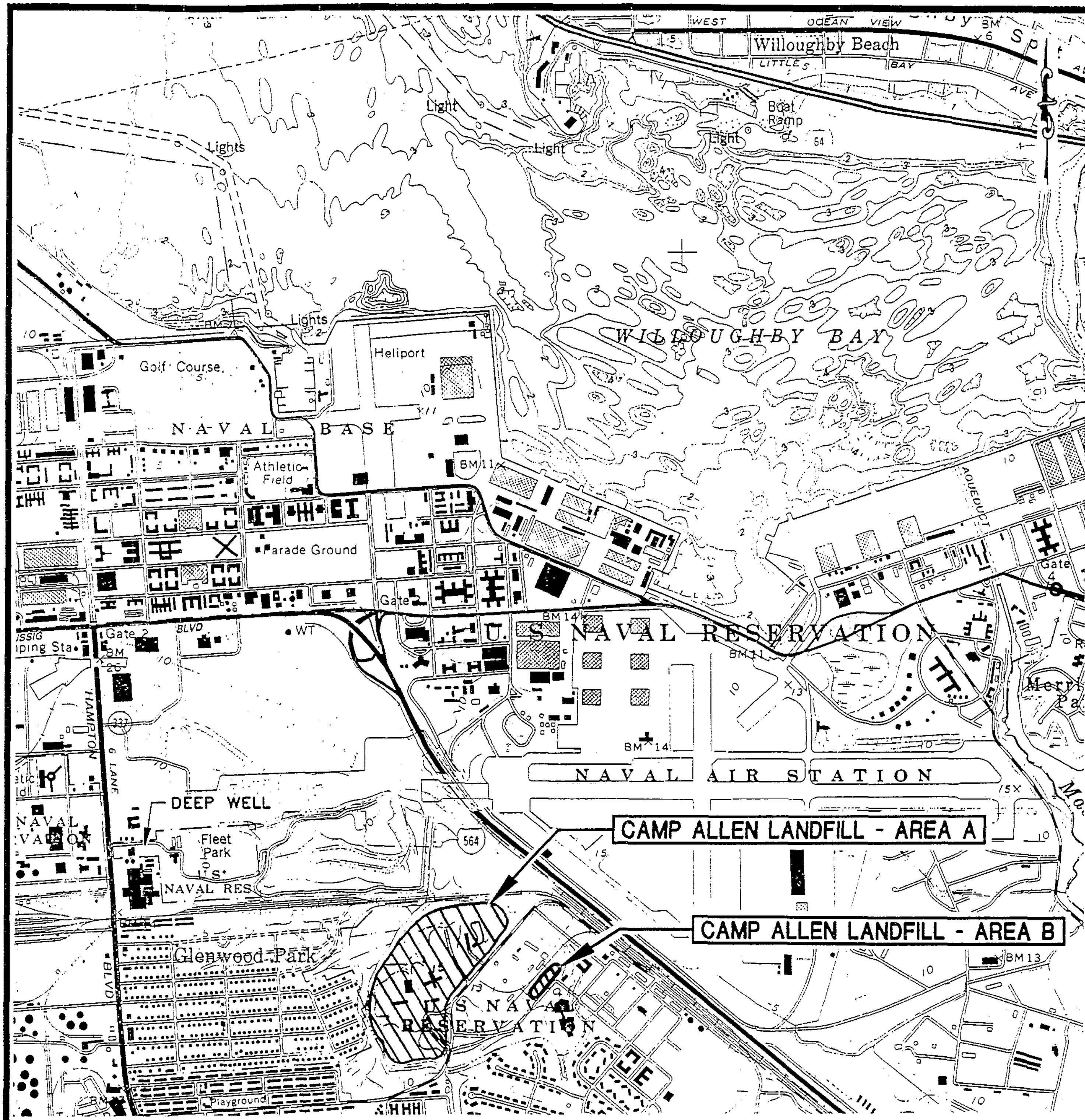
The evolution of naval hardware has necessitated many changes since 1960. Facilities to provide support and maintenance for the primary tools of naval operation including aircraft carriers, guided-missile cruisers, and helicopters were the main projects. Rehabilitation of hangars, taxiways, runways, and air traffic control facilities, as well as waterfront construction of several piers, also increased the capability to fulfill the Commander, Naval Base (COMNAVBASE) mission. The mission of COMNAVBASE is to provide fleet support and readiness for the Atlantic Fleet. The mission is four-fold: to command assigned naval shore activities; to coordinate support to afloat units, their air arm, and other naval activities on the naval base complex; to act as regional area coordinator; and to act as senior officer present afloat for administration in the Hampton Roads area.

During its history, Naval Base Norfolk has expanded to become the world's largest naval installation, with 105 ships homeported in Norfolk. The base currently has 15 piers handling 3,100 ship movements annually. COMNAVBASE supports 20 tenant commands located on the Atlantic Fleet compound. Figure 1-1 presents the Naval Base Norfolk Location Map.

1.2.2 Camp Allen Site History

The Camp Allen site is located approximately one mile east of Hampton Boulevard and one mile south of Willoughby Bay (see Figure 1-1). Prior to 1940, this area was primarily occupied by surface water features related to Bousch Creek, which flows north into Willoughby Bay. Development of residential, commercial, and military related structures was limited to adjacent topographically high areas during this time period. In the late 1930s, the Camp Allen area was reportedly used as a soils borrow area for Naval Base Norfolk related developments.

The history of Camp Allen is one of expansion. Originating as numerous acres of undeveloped, low-lying areas adjacent to Bousch Creek (as evidenced in a pre-1940 topographical photograph), the Camp Allen area evolved into a residential and military community. An aerial photo taken in September of 1944 portrays a highly developed area around the outskirts of Camp Allen, consisting of on-base and off-base military housing, the residential community of Glenwood Park, and assorted military operations (U.S. Army Unit "D" Camp Allen, constructed in 1942 and transferred to the USMC in 1952). The region now known as Area A appears to be a combination landfill and soils borrowing area. Aerial photography after 1944, but prior to 1970, demonstrates the gradual expansion of the Camp Allen area to include the present day Salvage Yard and changes to the adjacent USMC facilities (currently known as the Camp Allen Development Area [CADA]). An aerial photo taken in January of 1970 depicts a highly developed residential area including the Camp Allen Elementary School and Capehart (off-base military housing); the operating boundaries of the landfill at Area A appear to have pulled inward, resulting in a smaller working area. As evidenced by a 1985 aerial photograph, Area A landfill operations have ceased, a grass cap covers the landfill, and portions of the landfill now contain the Navy Brig Facility and a heliport. Area B appears to be contiguous with Area A, and the newly constructed CADA. The information obtained from



SOURCE: U.S.G.S. TOPOGRAPHIC MAP
NORFOLK NORTH QUADRANGLE
1965 (PHOTOREVISED 1986)

2000 0 1000 2000 4000
1 inch = 2000 ft.

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FIGURE 1-1
LOCATION MAP
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

064-102

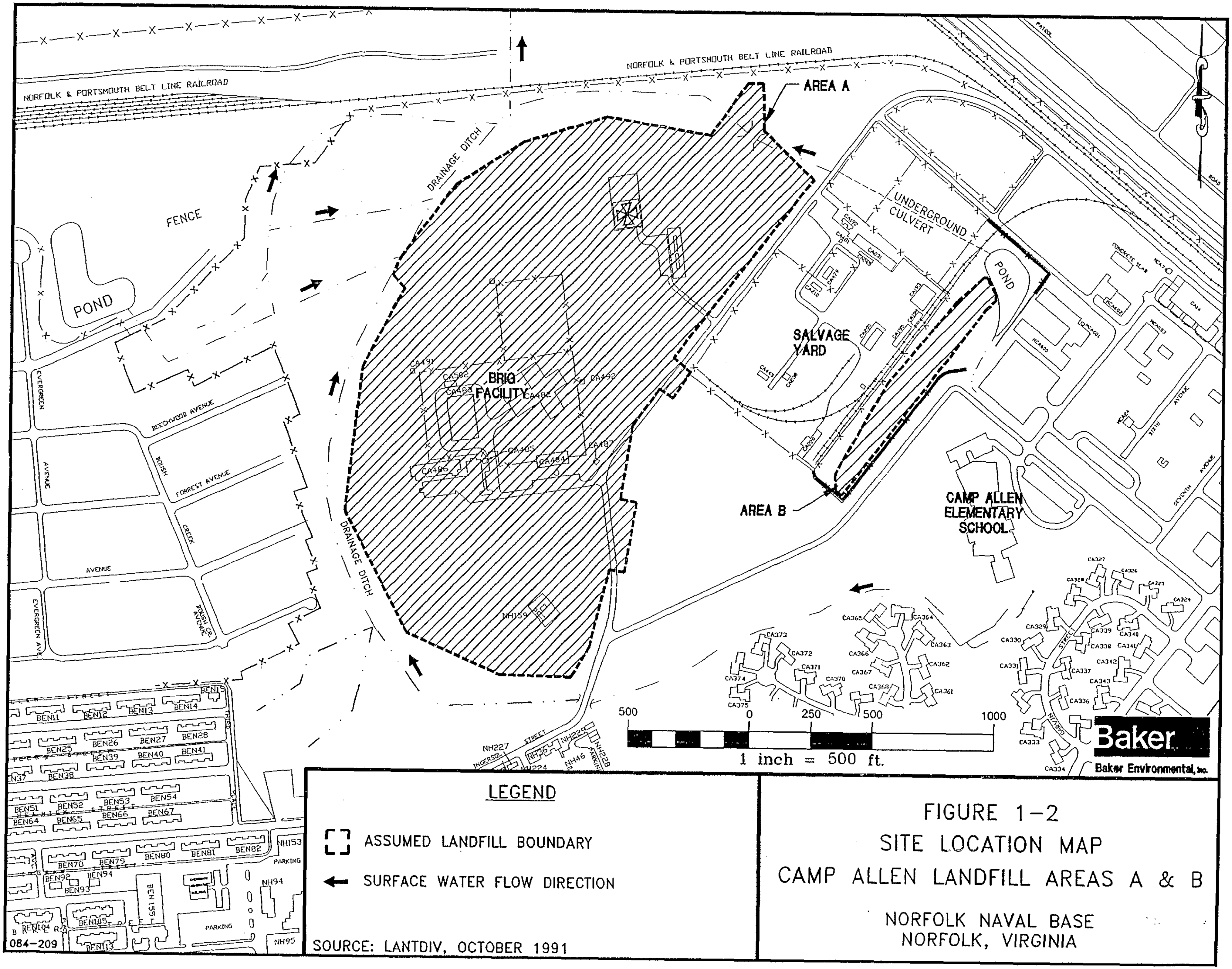
the aerial photos appears to have substantiated the history of the site. See Appendix A for a copy of these historical photos. Specific detail regarding historic disposal operations is discussed below.

During Naval Base Norfolk's long history, a variety of wastes were generated and disposed on base, including municipal, solid, and hazardous wastes. The base followed the conventional (accepted) disposal practice of landfilling wastes. During the early 1940s, landfilling operations commenced in the Camp Allen area (Camp Allen Landfill). Disposal activities continued until approximately 1974. In general, the Camp Allen Landfill is divided into two areas (Area A and Area B). Figure 1-2 presents the Camp Allen Landfill Site Location Map.

Area A of the Camp Allen Landfill is a 45-acre site that was used for the disposal of wastes from the early 1940s until 1974. During this time, significant quantities of municipal, solid, and hazardous wastes were disposed including the following: general refuse, demolition debris, sludges from metal plating processes, parts cleaning and paint stripping wastes, over-age chemicals, various chlorinated organic solvents, acids, caustics, paints and paint thinners, pesticides, and asbestos. It is estimated, from approximated waste generation rates, that about 40,000 pounds of metals plating sludge, 60,000 pounds of parts cleaning sludge, and 400,000 pounds of paint stripping residue were disposed at Area A. Additionally, ash from the incineration of solid wastes, as well as fly and bottom ash from the power plant, were landfilled.

In the mid-1940s, an incinerator was constructed in the southern portion of Area A of the Camp Allen Landfill (just south of the current location of the brig) to burn combustible wastes. This incinerator operated until the mid-1960s. Materials too bulky for the incinerator were burned in Area A of the Camp Allen Landfill. Incinerator ash was disposed in the landfill.

At present, most of Area A is capped and revegetated to minimize surface erosion. Area A incorporates the Navy Brig facility and a heliport built over a portion of the landfill during the mid-1970s. The area is surrounded by drainage ditches, which convey surface water runoff to Willoughby Bay. These drainage ditches are remnants of Bousch Creek, the main channel of which was completely filled and replaced by a network of ditches and channels during the development of Norfolk Naval Base. Additionally, a residential area (Glenwood Park) is located to the west of the site.



LEGEND

ASSUMED LANDFILL BOUNDARY

SURFACE WATER FLOW DIRECTION

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 1-2
SITE LOCATION MAP
CAMP ALLEN LANDFILL AREAS A & B

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

The eastern portion of the Camp Allen Landfill (Area B) received wastes from a 1971 salvage yard fire. The Camp Allen Salvage Yard, which is still in operation, is located between Camp Allen Landfill Areas A and B. The salvage yard fire occurred in the northern portion of the yard. The salvage yard housed lubricating oil, organic solvents, paints, paint thinners, acids, caustics, and pesticides. The residue and debris resulting from this fire were buried in the eastern portion of the landfill. The Salvage Yard (IAS Site 22) is currently undergoing a separate environmental study (PA/SI). Information on this study was not available at the time of this report.

1.3 Previous Investigations

Previous investigations of hazardous waste sites at the Naval Base, Norfolk, Virginia (including the Camp Allen Landfill) have been conducted under an Initial Assessment Study, Site Suitability Assessment Study, Confirmation Study, and an Interim RI Report of the Installation Restoration Program. The following sections summarize previous investigations and their results. Detailed information is incorporated into and discussed in Section 6.0, Nature and Extent of Constituent Migration.

1.3.1 Installation Assessment Study (February 1983)

In April 1982, an IAS was conducted at the Sewell's Point Naval Complex, Naval Base Norfolk, Norfolk, Virginia. The Final IAS (dated February 1983) identified 18 sites of concern with regard to potential contamination. The Camp Allen Landfill (Site 1) Areas A and B were included as potential areas of concern (refer to Figure 1-2). Based on IAS findings, investigations continued at the Camp Allen Landfill.

Under Navy contract, Malcolm Pirnie, Inc. conducted two separate but related investigations at the Camp Allen Landfill Area between 1983 and 1987. The investigations included a Site Suitability Assessment for a proposed Brig facility expansion at the site (begun in 1983 and completed in 1984) and a Confirmation Study (begun in 1983 and completed in 1987).

1.3.2 Site Suitability Assessment (June 1984)

A Site Suitability Assessment (SSA) for a proposed Brig facility expansion at the site was begun in 1983 and completed in 1984. The field investigation included a magnetometer survey, soil borings, and installation of 11 shallow groundwater monitoring wells and nine gas monitoring stations. Chemical constituents were analyzed from 11 groundwater samples for the Priority Pollutant List (PPL), and groundwater elevations and flow direction were determined. Gas sampling was conducted for combustible gas, oxygen, hydrogen sulfide, methane, and volatile organics from the PPL. Figure 1-3 presents Gas Monitoring Well and Groundwater Monitoring Well Locations at Area A.

SSA results indicated the following:

- The magnetometer survey findings indicated significant quantities of metallic objects beneath the ground surface throughout Area A. Identification of types of metal was not possible.

- Shallow groundwater flow was in a westerly direction towards the drainage ditch.

- Gas monitoring identified methane concentrations significantly less than 220 ppm in all but one location. An existing sewerline was possibly the cause of the one high reading.

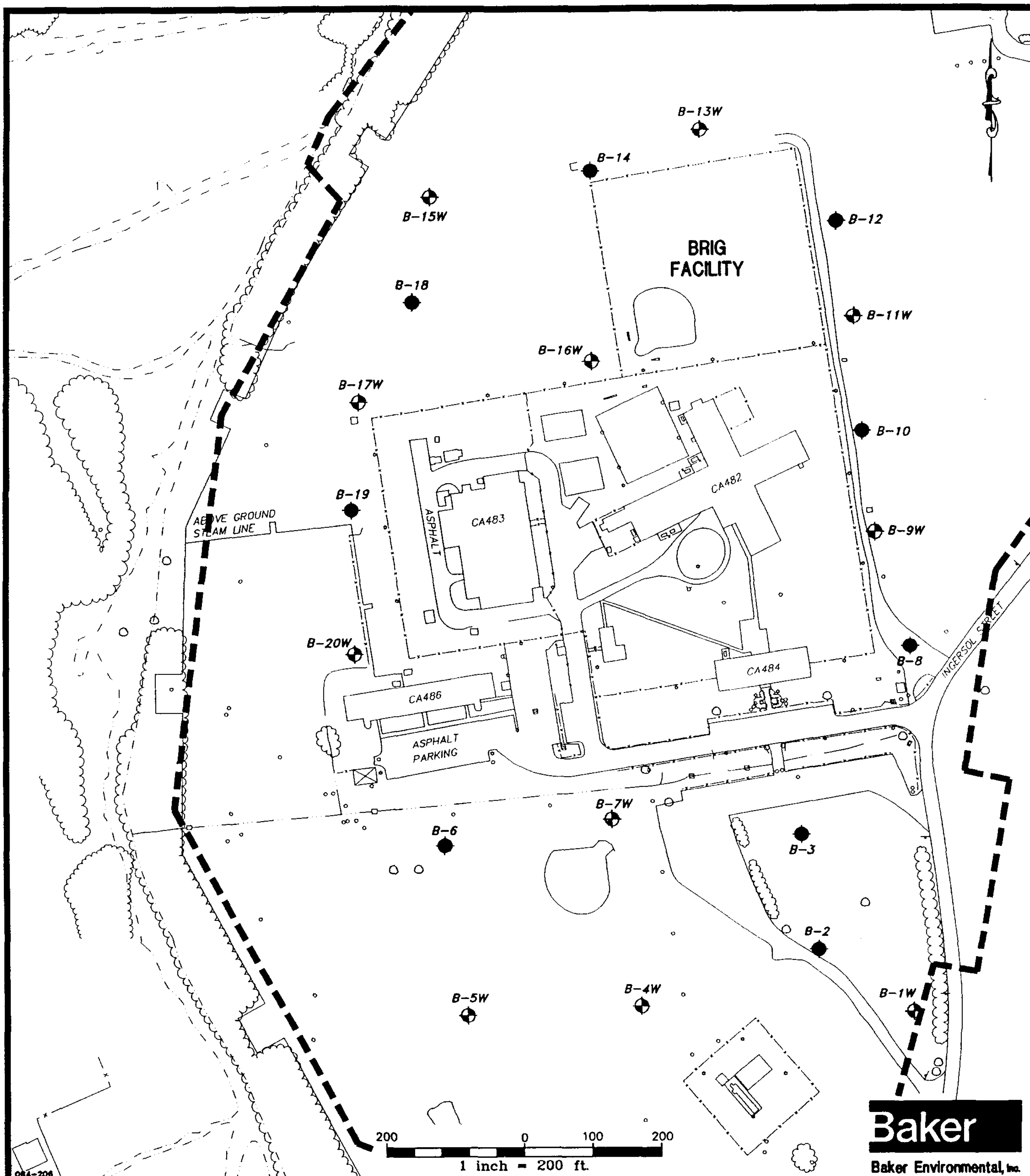
- Groundwater sample analyses identified one location (B-20W) as having organic pollutants in concentrations that exceeded USEPA water quality criteria.

- Analysis of inorganic constituents in the 11 groundwater samples identified eight metals from several wells that exceeded USEPA water quality criteria. Average concentrations of copper, mercury, selenium, and zinc exceeded these criteria in Area A.

SSA recommendations included implementation of proposed brig expansion activities only with numerous safeguards and contingencies. Also, follow up Confirmation Study activities were suggested.

1.3.3 Confirmation Study (April 1987)

Six shallow (approximately 25-feet deep) and one deep (approximately 90 feet deep) groundwater monitoring wells were installed as part of the Confirmation Study. Three wells (GW-1, GW-2, GW-3) were installed in the northern portion at Area A and three wells (GW-4, GW-5, GW-6) were installed in the east/northeastern portion at Area B in 1983. The deep well



LEGEND

B-2 GAS MONITORING STATION

B-1W SHALLOW MONITORING WELL LOCATION

LIMITS OF AREA A LANDFILL

SSA CONDUCTED BY MALCOLM PIRNIE, INC.
MAP SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 1-3
SITE SUITABILITY ASSESSMENT FOR PROPOSED BRIG EXPANSION MONITORING WELL AND GAS MONITORING STATION LOCATIONS

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

(GW-7) was located approximately one mile northwest of Camp Allen and was installed to determine if contaminant migration was being affected by two private deep wells that provide manufacturing process water. Additionally, four surface water samples were collected from the drainage ditches surrounding Area A. Figure 1-4 presents Confirmation Study monitoring well and surface water locations.

Groundwater and surface water were sampled in four separate sampling events conducted during the Confirmation Study (December 1983, August 1984, April 1986, and June 1986). Round 1 was conducted in December 1983 and included groundwater sampling from the seven wells installed during the Confirmation Study, one existing deep, non-potable well located at the Camp Elmore (15th Marine Regiment) Marine Barracks, and four surface water samples. All samples were analyzed for Priority Pollutant List constituents and groundwater samples were also analyzed for xylene. Additionally, the 11 monitoring wells installed as part of the SSA were reportedly sampled at that time.

Round 2 was conducted in August 1984 and included groundwater sampling from the eight shallow wells sampled during Round 1, SSA well B-20W, and collection of four surface water samples. All samples were analyzed for Priority Pollutant List constituents, and dioxin screening. Xylene was not included in this sampling event. As a result of the sampling and analysis of the 11 SSA wells in December of 1983, only well B-20W was found to contain several organic constituents of concern. Consequently, the remaining 10 SSA wells were not sampled again during the Confirmation Study.

Round 3 was conducted in April 1986 and included groundwater sampling from the nine wells sampled during Round 2 as well as from four surface water locations. All samples included Priority Pollutant List volatile organics, semivolatile organics, and inorganics. PCBs were not included during this sampling event. In addition to the above listed constituents, xylene again was analyzed, as were methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and ethylene dibromide (EDB) per direction from the Navy Engineer-in-Charge (EIC). These three solvents, which are similar to xylene, had been widely used at the Naval facility and were considered important constituents.

Round 4 was conducted in June 1986 and covered nine groundwater and four surface water sampling locations. Analyses included MEK, MIBK, and EDB only.

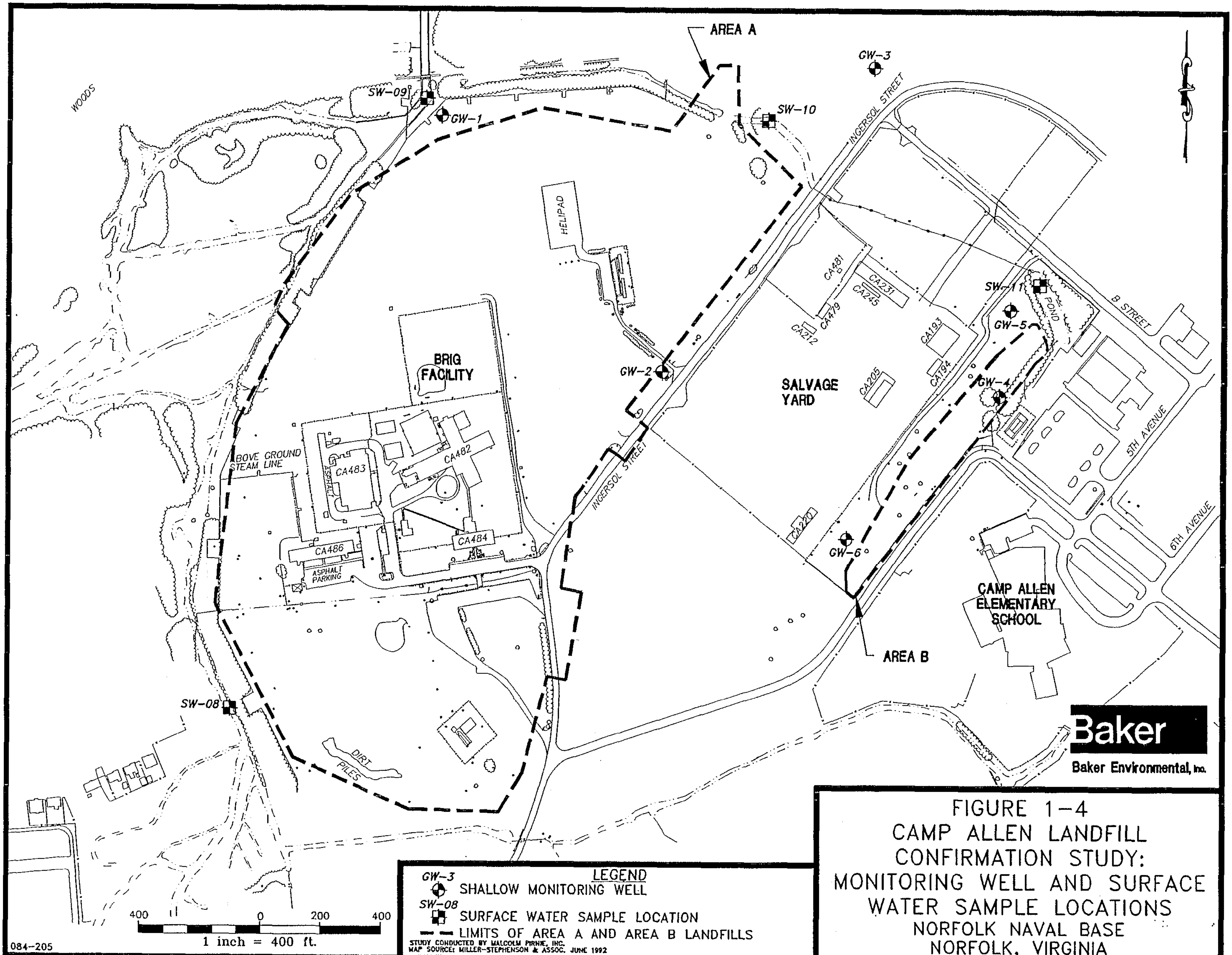


FIGURE 1-4
CAMP ALLEN LANDFILL
CONFIRMATION STUDY:
MONITORING WELL AND SURFACE
WATER SAMPLE LOCATIONS
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

Confirmation Study results indicated the following:

- Analyses of organic compounds in groundwater samples from two locations (B-20W and GW-4) identified significant concentrations of several volatile organics. In general, detected concentrations were found to have decreased with time.

- Surface water sample results indicated that leaching of organic compounds had occurred directly east of Area B into the drainage ditch and pond surface waters.

- Analysis of inorganic compounds in groundwater and surface water indicated elevated concentrations (for total metals) of cadmium, chromium, lead, and zinc.

- Special analysis indicated elevated concentrations of MEK and MIBK at wells B-20W and GW-4.

1.3.4 Interim Remedial Investigation Report (Malcolm Pirnie - March 1988)

An Interim RI Report for IAS Sites 1 to 5 was prepared by Malcolm Pirnie in 1988. In summary, the report for Site 1 (Camp Allen Landfill Areas A and B) identified the following: (1) localized contamination in the vicinity of two wells (B-20W at Area A and GW-4 at Area B) with significant concentrations of organics which have decreased with time; (2) organic constituents identified in GW-4 migrating to the drainage area located adjacent to the well; and, (3) cadmium, chromium, lead, and zinc concentrations in groundwater and surface water slightly exceeding water quality criteria (Malcolm Pirnie, 1988). This interim report only summarized Confirmation Study Results. Additional field activities were not performed.

1.3.5 Interim Remedial Investigation (CH_2M Hill)

In the fall and winter of 1990-1991, CH_2M Hill continued the original Interim Remedial Investigation activities at the Camp Allen Landfill.

A soil gas survey (68 Petrex sample locations) was performed in the vicinity of Area B. Nine shallow and six deep monitoring wells at Area A and eight shallow and three deep monitoring wells at Area B were installed. A total of nine well nests resulted from the additional well installations. In-situ conductivity tests were conducted in ten wells at Area A and eight wells at Area B. Additionally, a week long tidal study was performed in order to determine estimated influence on the groundwater regime.

Groundwater was subsequently sampled from 26 new and 10 existing monitoring wells, exclusive of the SSA wells, with the exception of B-20W. Samples were analyzed for volatile organics, semivolatile organics, and metals (total and dissolved). A second round of samples was collected from the nine deep wells and analyzed for volatile organics. In addition, 55 residential wells in Glenwood Park, which are installed in the shallow aquifer (<50 feet) and are primarily used for lawn watering, were sampled for volatile organic compounds.

Surface water and sediment samples were collected and analyzed from adjacent drainage ditches at Area A and the pond at Area B. Surface water samples were analyzed for volatile organics, semivolatile organics, and metals (total and dissolved). Sediments were also analyzed for these parameters with the exception of dissolved metals.

Investigation sampling points for Area A are shown on Figure 1-5. Area B sample locations are shown on Figure 1-6. In general, investigation results were as follows:

Area A

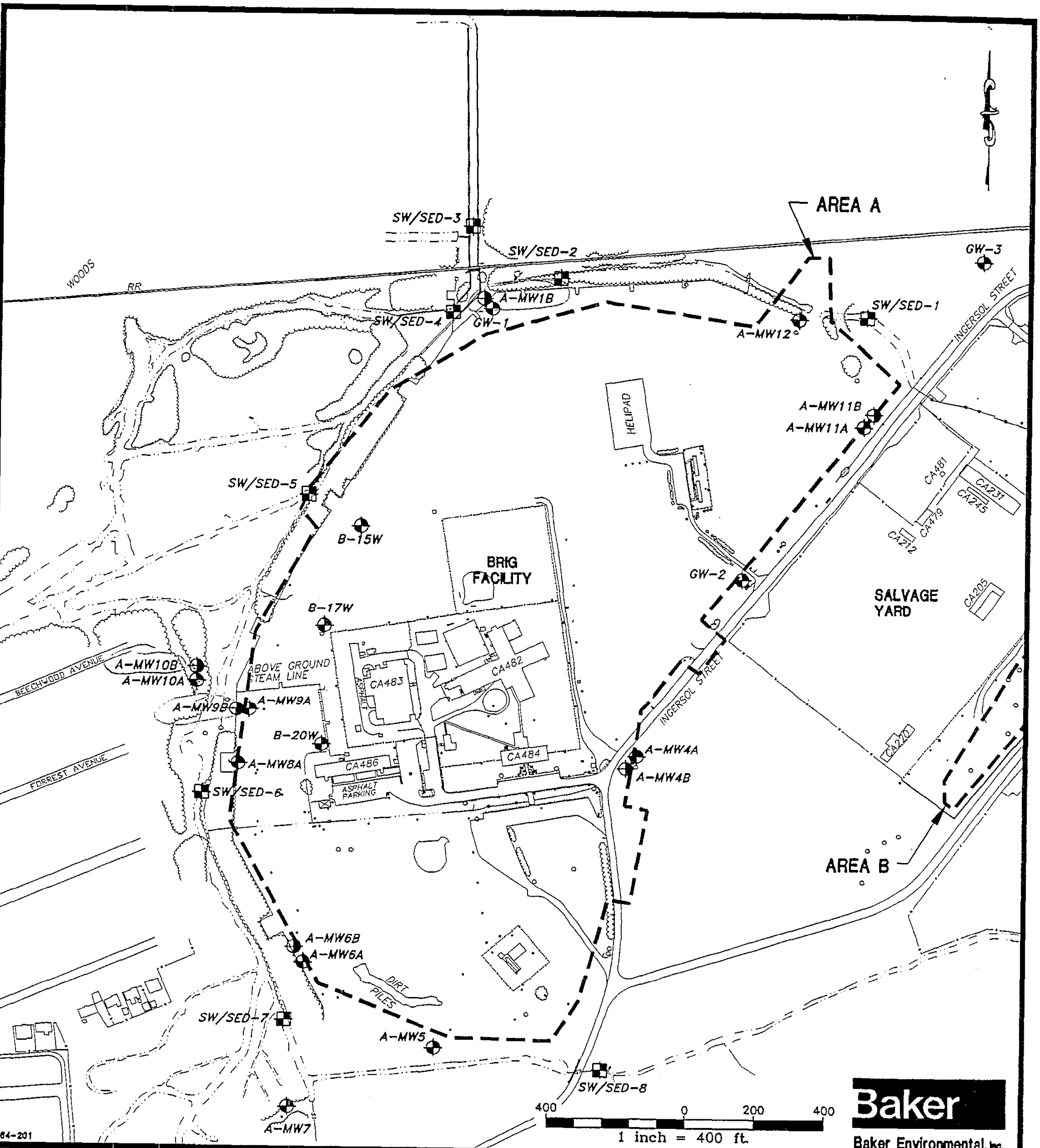
- Elevated volatile organics were detected in monitoring well B-20W. Volatile organics were also detected in two other shallow monitoring wells, GW-1 and A-MW11A.

- Volatile organics were detected in three of the deep monitoring wells (A-MW1B, A-MW9B, and A-MW10B). All of these wells are downgradient of the landfill.

- Several metals were detected above "background" levels in sediment samples (SED-2, SED-3, SED-4, and SED-5).

- The confining clay unit, which separates the water table and Yorktown aquifers, appears to be absent in various locations. This probably allows for the downward migration of contaminants from the landfill.

- Shallow groundwater appears to flow radially away from the landfill at an estimated rate of 1 to 50 feet/year.



LEGEND

A-MW6A SHALLOW MONITORING WELL

A-MW6B DEEP MONITORING WELL

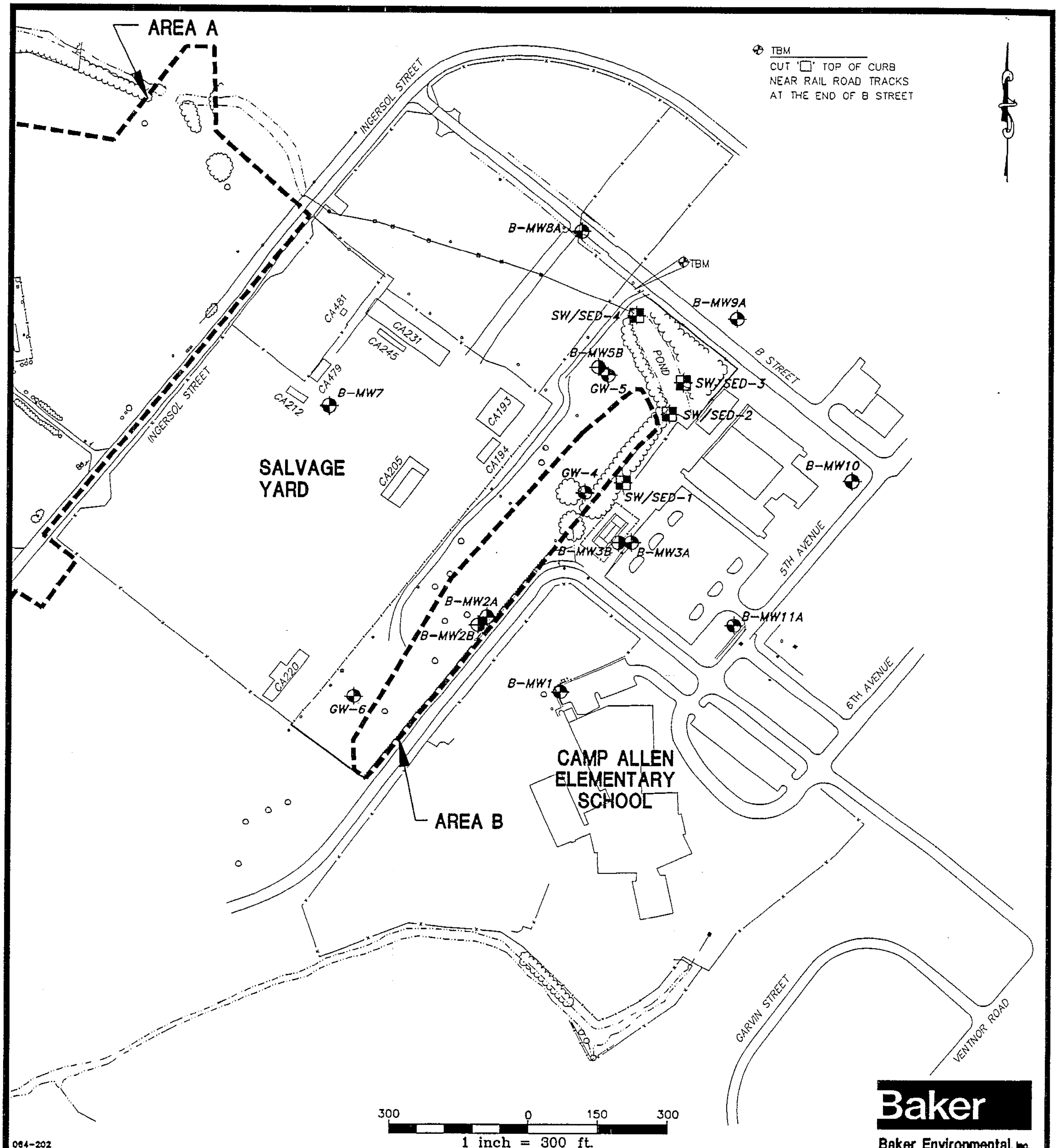
SW/SED-1 SURFACE WATER/SEDIMENT SAMPLE LOCATION

LIMITS OF AREA A LANDFILL

STUDY CONDUCTED BY CH2M HILL, INC.
MAP SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 1-5
CAMP ALLEN LANDFILL
INTERIM REMEDIAL INVESTIGATION:
AREA A SAMPLING POINTS

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

A-MW6A SHALLOW MONITORING WELL

A-MW6B DEEP MONITORING WELL

SW/SED-1 SURFACE WATER/SEDIMENT SAMPLE LOCATION

LIMITS OF AREA A AND B LANDFILLS

STUDY CONDUCTED BY CN2M HILL, INC.
MAP SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 1-6
CAMP ALLEN LANDFILL
INTERIM REMEDIAL INVESTIGATION:
AREA B SAMPLING POINTS

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

- Deep groundwater flow appears to be to the west-northwest at an estimated rate of 10 to 20 feet/year.

- Contamination related to Area A was not apparent in the residential well samples.

Area B

- Elevated volatile organics were present in shallow monitoring wells directly downgradient (southeast) of Area B.

- Volatile organics were detected in all three deep monitoring wells.

- Volatile organics were detected in surface water and sediment sample collected from the drainage ditch and pond areas.

- The confining clay unit below Area B also appears to be absent in places, allowing for downward migration of contaminants.

- Groundwater flow rates are similar to those in Area A.

1.3.6 Summary of Previous Investigations

Previous investigation results preliminarily identified areas of significant contamination, as well as important geologic/hydrogeologic considerations within Areas A and B of the Camp Allen Landfill. The composite information generated in these studies over the past 10 years has been incorporated into this study's interpretations of nature and extent of contamination, as appropriate. In general, findings indicate that primary site conditions are as follows:

- The primary source areas are located directly west of the Brig Facility (Area A) and near monitoring well GW-4 (Area B). The nature of both sources appears to be primarily volatile organic in nature.

- The water table aquifer was found to contain elevated volatile organic concentrations in and downgradient from the primary source areas.

- The water table aquifer appears to both discharge into drainage ditches surrounding the Camp Allen Landfill Site and recharge the Yorktown Aquifer via an erosional breach in the confining clay layer separating the aquifer regimes.

- Concentrations of volatile organics were also detected in the Yorktown Aquifer at monitoring points situated downgradient of the primary source areas.

- Surface water and sediment samples reveal elevated metal concentrations at the northern end of Area A and elevated volatile organic concentrations at Area B.

- Residential wells do not appear to be impacted by landfill-related contamination because the drainage ditches surrounding the landfill appear to intercept shallow groundwater discharge.

Previous investigation results identified primary site conditions; however, issues related to contaminant nature and extent and complex subsurface conditions lacked definition. Accordingly, a final remedial investigation was performed by Baker Environmental, Inc., during 1992 and 1993. This document represents the culmination of site investigative activities at the Camp Allen Landfill.

As has been noted, previous investigations were performed by various firms; however, site monitoring point coding was not standardized. This is especially apparent with site monitoring wells. In order to clearly identify previous well labeling, Table 1-1 presents the Camp Allen Landfill monitoring wells (for groundwater collection) by landfill area, aquifer being monitored, and firm which supervised construction of each well.

In order to simplify sampling efforts performed under the final remedial investigation, Baker followed previous coding when constructing additional well nests, so that presentation of additional data would be as clear and consistent as possible.

TABLE 1-1

PREVIOUS INVESTIGATION MONITORING WELLS
CAMP ALLEN LANDFILL

	Area A	Area B
Deep(1)	A-MW1B A-MW4B A-MW6B A-MW9B A-MW10B A-MW11B	B-MW2B B-MW3B B-MW5B
Shallow(2)	GW-1 GW-2 GW-3 B-1W B-15W B-17W B-20W	GW-4 GW-5 GW-6
Shallow(1)	A-MW4A A-MW5 A-MW6A A-MW7 A-MW8 A-MW9A A-MW11A A-MW12	B-MW1 B-MW2A B-MW3A B-MW7 B-MW8 B-MW9 B-MW10 B-MW11

(1) CH2M Hill wells.
(2) Malcolm Pirnie wells.

1.4 Remedial Investigation Report Organization

Following is a brief summary of the organization and content of this report:

SECTION 2
ENVIRONMENTAL SETTING

2.0 ENVIRONMENTAL SETTING

2.1 Physical Geography

Norfolk lies within the outer coastal plain of the Atlantic Plain Physiographic Province. Typically, the outer coastal plain has low elevations and gently sloping relief. Few locations have elevations greater than 25 feet above mean sea level (msl).

Historically, depositional topography has dominated the greater Norfolk area. This scheme typifies depositional morphology "of ancient barrier and lagoonal environments (Siudyla, et al., 1981)" and has produced the Princess Anne terrace among others. This terrace extends across the Camp Allen Landfill Site. The Princess Anne was developed from marine sediments whose major constituents include sands, silts, and clays with considerable amounts of shell material and gravel. Soil material originated from numerous transgression and regression episodes during the Late Tertiary and Quaternary time periods. Based on a literature search and historical review of areal photographs, the Camp Allen Landfill Site and surrounding area can be characterized as a former tidal flat associated with the Bousch Creek drainage channel.

The Camp Allen Landfill Site is located in mixed urban or built-up land with surrounding wetlands. Military facilities are located both atop and directly adjacent to the landfill area. These facilities include the following:

- Naval Brig (atop Area A)
- Heliport (atop Area A)
- Camp Allen Salvage Yard (between Areas A and B)
- USMC, Camp Elmore (east/southeast of Area B)

Residential communities are adjacent to the general Camp Allen area. A civilian community (Glenwood Park), is located west of Area A. Capehart military housing is located southeast of the landfill. Additionally, Camp Allen Elementary School is located southeast of Area B.

Several types of wetland areas are located nearby. Wetland areas are discussed in detail in Section 2.8.

2.2 Climate

The Norfolk climate is classified as oceanic (Siudyla et al., 1981), typically with mild winters and long warm summers with high humidity. Temperatures average 78.6°F in July and 41.2°F in January. Maximum temperatures rarely exceed 100°F and low temperatures rarely drop below 20°F. Mean temperatures range from a maximum of 68°F to a minimum of 50.5°F.

Precipitation is well distributed throughout the year. Average precipitation is about 44 inches per year. Heaviest precipitation occurs during the month of July and August. An occasional tropical storm brings heavy rainfall. Winter precipitation occurs as rain; however, light snowfalls during December and January, produced by mid-latitude cyclones, are not uncommon.

Wind direction is predominantly from the southwest. Typical wind velocities do not exceed 12 knots in the Norfolk area. The highest wind velocities usually occur as land breezes and very rarely exceed 20 knots (ESE, 1991).

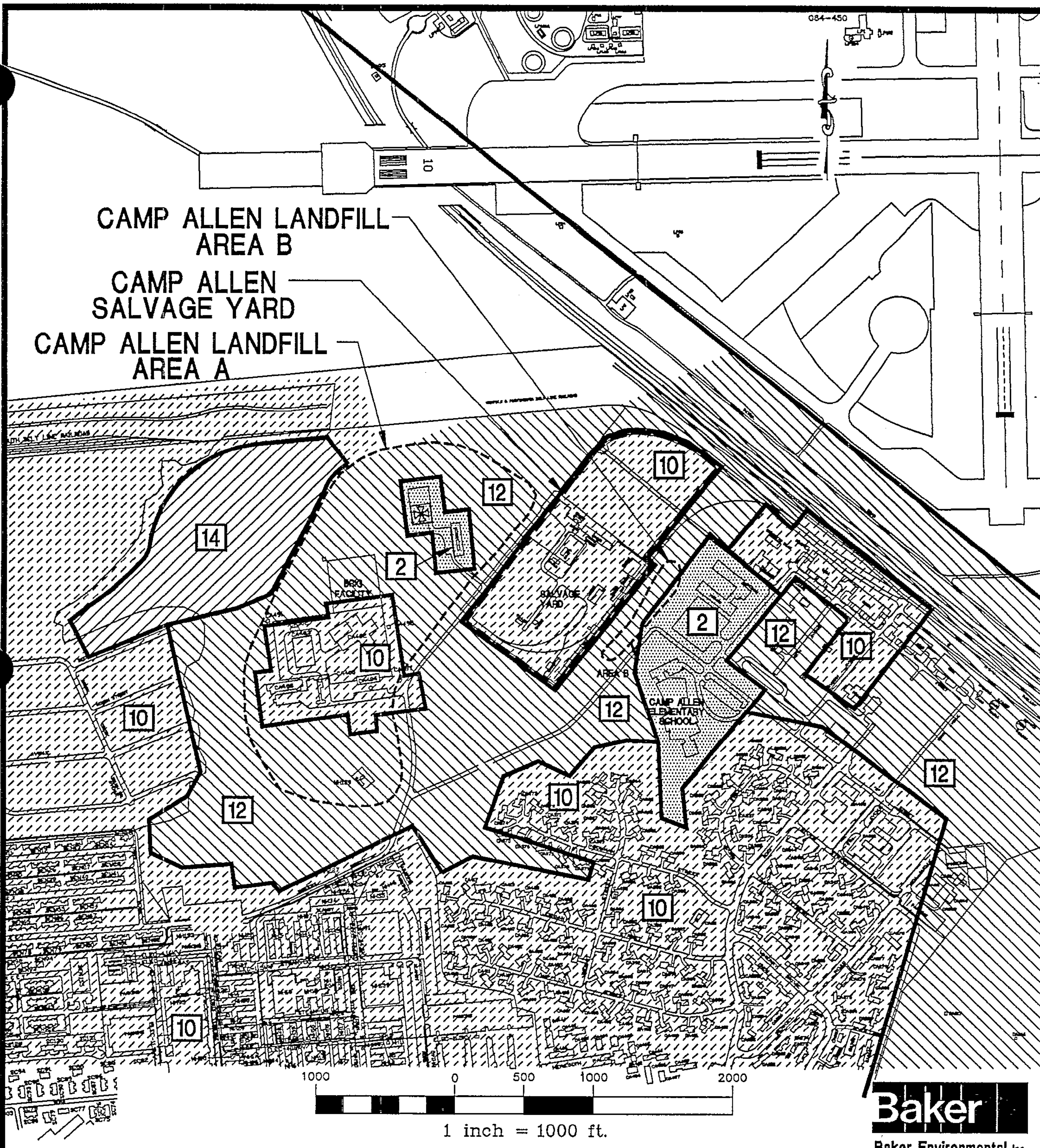
2.3 Soils

Four soil types have been delineated on or bordering the Camp Allen Landfill Site. Scientific classification of these soils are Urban Land; Urban Land-Udorthents ; Udorthents, Loamy, and Udorthents, Clayey. Site soils are shown on Figure 2-1.

Urban Land soils (soil unit No. 2) are altered, reworked, or removed soil material in "areas where more than 70 percent of the land surface is covered by asphalt, concrete, buildings, or other impervious materials" (USDA, 1983).

Urban Land-Udorthents soils (soil unit No. 10) "have been graded, cut, filled, or otherwise disturbed by construction and earthmoving activities" (USDA, 1983). This soil complex has an urban setting and occupies gentle slopes and areas of moderately well and poorly drained Udorthents soils.

Udorthents, Loamy soils (soil unit No. 12) are "soil material in areas where the soil has been altered during excavation or covered by earthly fill material" (USDA, 1983). This soil complex has an urban setting near transportation arteries, manmade waterways and mining activities. Generally, Udorthents are well-to-moderately-well-drained loamy and sandy material.



LEGEND

2		URBAN LAND
10		URBAN LAND – UDORTHENTS
12		UDORTHENTS – LOAMY
14		UDORTHENTS – CLAYEY

FIGURE 2-1
SITE SOILS MAP
CAMP ALLEN SALVAGE YARD

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

Udorthents, Clayey soils (soil unit No. 14) consist "mostly of clayey fill material that has been placed on soils of various drainage classes on low-lying terraces, flood plains, and tidal marshes" (USDA, 1983). This soil complex has a slow-to-very-slow permeability allowing water to pond easily on its surface. This results in little threat of erosional episodes taking place. Due to the perpetual wetness and slow permeability of Udorthents, Clayey soils, their use for civil construction is limited.

Although the Columbia Group underlies the native soils discussed above at the Camp Allen Landfill Site, the uppermost deposits of the landfill are representative of fill material used to create the landfill, rather than Columbia Group lithology. Fill material at Areas A and B includes incineration ash, fly and bottom ash from the Navy power plant, over-age chemicals, spent chlorinated organic solvents, acids, caustics, paints, paint thinners, pesticides, asbestos, scrap metal, construction and demolition debris, lubricating oils, burned materials, and drummed or otherwise contained wastes.

2.4 Surface Drainage

Four major surface drainage systems surround the greater Norfolk area including the James and Elizabeth Rivers and Willoughby and Chesapeake Bays, all of which are tidal in nature in this area. Surface drainage from the Camp Allen Site eventually is conveyed to Willoughby Bay.

Surface water at Area A is primarily accommodated by two drainage ditches that follow the perimeter of Area A and merge at the northwestern corner of the site. These drainage ditches are remnants of Bousch Creek, the main channel which was filled and replaced by a network of ditches and channels during the development of the Norfolk Naval Base. Surface water is eventually conveyed to Willoughby Bay via this network. Due to the proximity of this network to Willoughby Bay and the low relief of the land surface, the remnant tributaries of Bousch Creek are tidal throughout the base.

The first ditch (bordering the southern and western portions of Area A) begins at a storm sewer outfall located behind the Camp Allen Elementary School and flows northward from the southern end of Area A. Several tributaries enter this ditch along the western side of the site. Three storm sewers, draining the Ben Morrell Naval Housing Complex and CINCLANFLEET, converge into the main ditch in the southeastern portion of Area A. Three other drainage areas located north of the community of Glenwood Park discharge to the main ditch in the northwestern portion of the site. These ditches drain a wetlands area situated northwest of the site.

The second (smaller) ditch enters Area A from a culvert located at the northeast corner of the site. Water flows westward from the pond at Area B, through a culvert under the northern portion of the Camp Allen Salvage Yard (located between Areas A and B), and along the northernmost boundary of Area A where it intercepts the larger ditch at the northwest corner of the site. From that point, surface water flows northward towards Willoughby Bay through a series of concrete drainage channels and underground culverts. Surface water from the Camp Allen Salvage Yard is directed via storm sewers to the drainage ditches north of Area A.

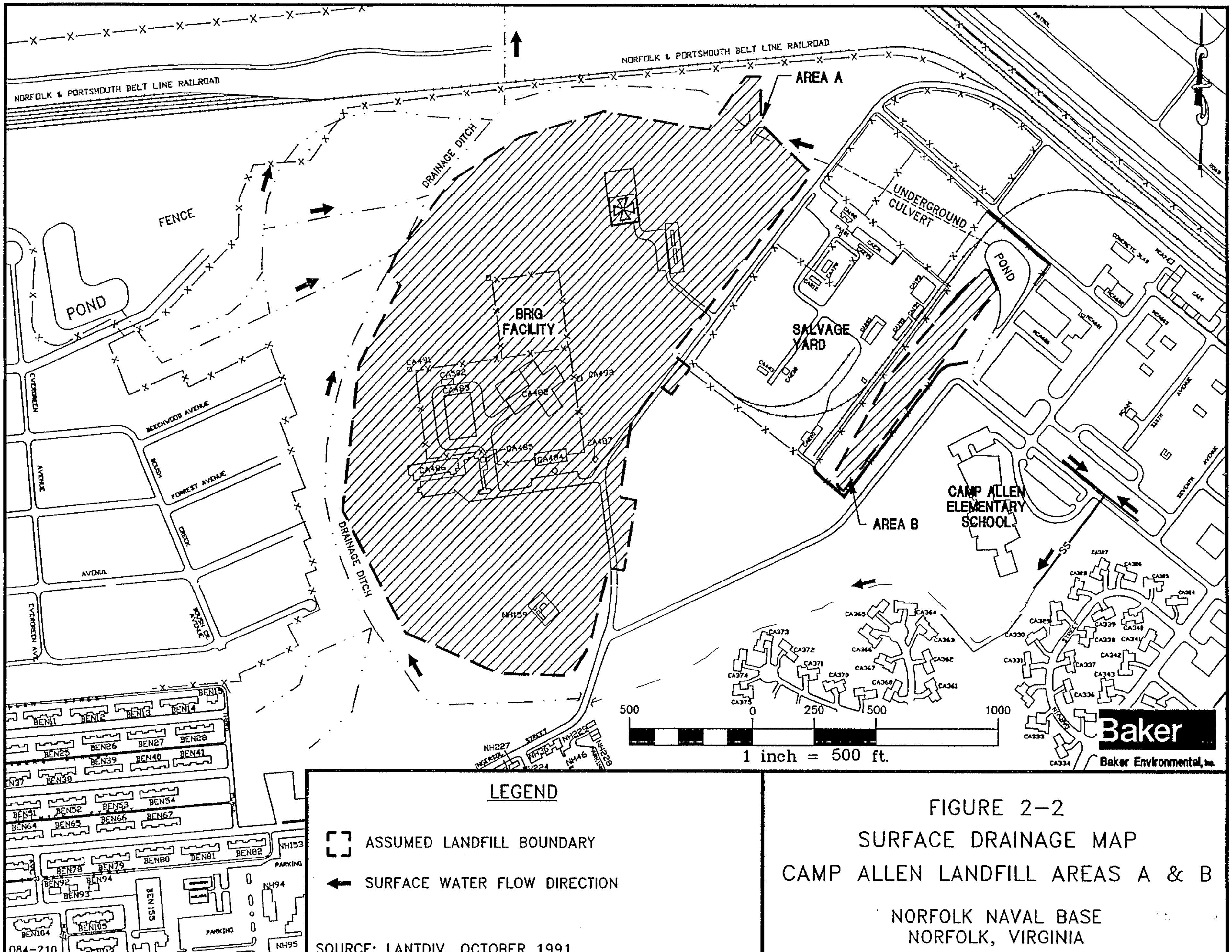
Surface drainage at the Camp Allen Landfill Site is relatively poor in places. This is especially true at Area B. After a period of heavy rainfall standing water can cover the entire site. In general, this can be attributed to the flatness of the area and silty/clayey nature of site surficial soils, which tend to retard infiltration. Patterns of surface drainage can be observed on Figure 2-2.

2.5 Geology

2.5.1 Regional Geology

The Camp Allen Landfill is located in the outer Atlantic Coastal Plain Physiographic Province, characterized by low elevations and gently sloping relief. Several thousand feet of unconsolidated sediments gently dipping to the east are found in the Tidewater area. The six geologic units located in the area are: Patuxent Formation, "Transitional beds," Mattaponi Formation, Calvert Formation, Yorktown Formation, and the Columbia Group (ESE, 1991). Table 2-1 briefly describes the stratigraphic and hydrogeologic units.

The uppermost geologic unit and youngest formation is the Columbia Group; its average thickness ranges from 20 to 50 feet. The unconsolidated sediments are characterized by light-colored clay, sand, and silt. Monitoring wells installed at Camp Allen and in the vicinity confirm the sand depth to an average of 23 to 25 feet and dark clays, silts, and sands from 25 to 30 feet below ground surface. These later elements extend to the top of the Yorktown Formation. Surficial soils are primarily silts and clays that quickly grade into the sands and silts of the Columbia Group.



LEGEND

ASSUMED LANDFILL BOUNDARY

SURFACE WATER FLOW DIRECTION

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 2-2

SURFACE DRAINAGE MAP

CAMP ALLEN LANDFILL AREAS A & B

NORFOLK NAVAL BASE

NORFOLK, VIRGINIA

TABLE 2-1
STRATIGRAPHIC AND HYDROGEOLOGIC UNITS - SOUTHEASTERN VIRGINIA

<table>
<tr><th>SYSTEM</th><th colspan="2">SERIES</th><th colspan="2">STRATIGRAPHIC UNITS</th><th>HYDROGEOLOGIC UNITS</th><th>LITHOLOGY</th><th>DESCRIPTION OF HYDROGEOLOGIC UNITS</th></tr>
<tr><td>Quaternary</td><td colspan="2">Recent
Pleistocene</td><td colspan="2">Recent
Columbia Group</td><td>Water Table
or
Quaternary Aquifer</td><td>Unconsolidated sand, silt, clay, and some gravel.</td><td>Sand units yield quantities adequate for domestic and small industrial demands, used extensively for lawn watering. Unconfined aquifer.</td></tr>
<tr><td rowspan="4">Tertiary</td><td rowspan="2">Miocene</td><td>Upper</td><td rowspan="2">Chesapeake Group</td><td>Yorktown</td><td>Yorktown
Aquifer</td><td>Fossiliferous sands, gravel, marls, and coquinas.</td><td>Sand and shell beds are main water-bearing units. Adequate for moderate public and industrial supplies. Artesian.</td></tr>
<tr><td>Middle</td><td>Calvert</td><td>Confining
Units</td><td>Dark colored silt and clay predominant, minor light-colored sand lenses; often referred to as “blue clay.”</td><td>Acts as the lower confining bed for the Yorktown Aquifer System.</td></tr>
<tr><td rowspan="2">Eocene</td><td rowspan="2"></td><td colspan="2">Nanjendy</td><td>Not Found in
Study Area</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">Mattaponi
(Upper)</td><td rowspan="2">Eocene-Upper
Cretaceous
Aquifer</td><td rowspan="2">Glauconitic sand and interbedded clay and silt; often referred to as “green sand” or “black sand.”</td><td rowspan="2">Infrequently used as a water supply. Yields adequate for moderate supplies. Brackish in most of area. Artesian.</td></tr>
<tr><td rowspan="3">Cretaceous</td><td rowspan="3">Paleocene</td><td>Upper</td></tr>
<tr><td rowspan="2">Lower</td><td rowspan="2">Lower Cretaceous</td><td>Transitional
Beds</td><td rowspan="2">Lower
Cretaceous</td><td rowspan="2">Interbedded gravel, sand, silt, and clay.</td><td rowspan="2">Yields are adequate for large industrial use. Brackish in most of area. Artesian.</td></tr>
<tr><td>Patuxent</td></tr>
</table>

Source: Siudyla, et al., 1981.

The Yorktown Formation underlies the Columbia Group and is Miocene in age. The unit is characterized by coarse sand, gravel, and abundant shell fragments. Regionally, the formation ranges in thickness from 300 to 400 feet. During the Remedial Investigation (Baker, 1992), the Yorktown Formation was encountered between 37 to 63 feet below grade.

The Calvert Formation also is Miocene in age and underlies the Yorktown Formation with an average thickness of 200 feet. It is characterized by fine-grained, light-colored sands, dark blue to black sandy clays, and diatomaceous layers.

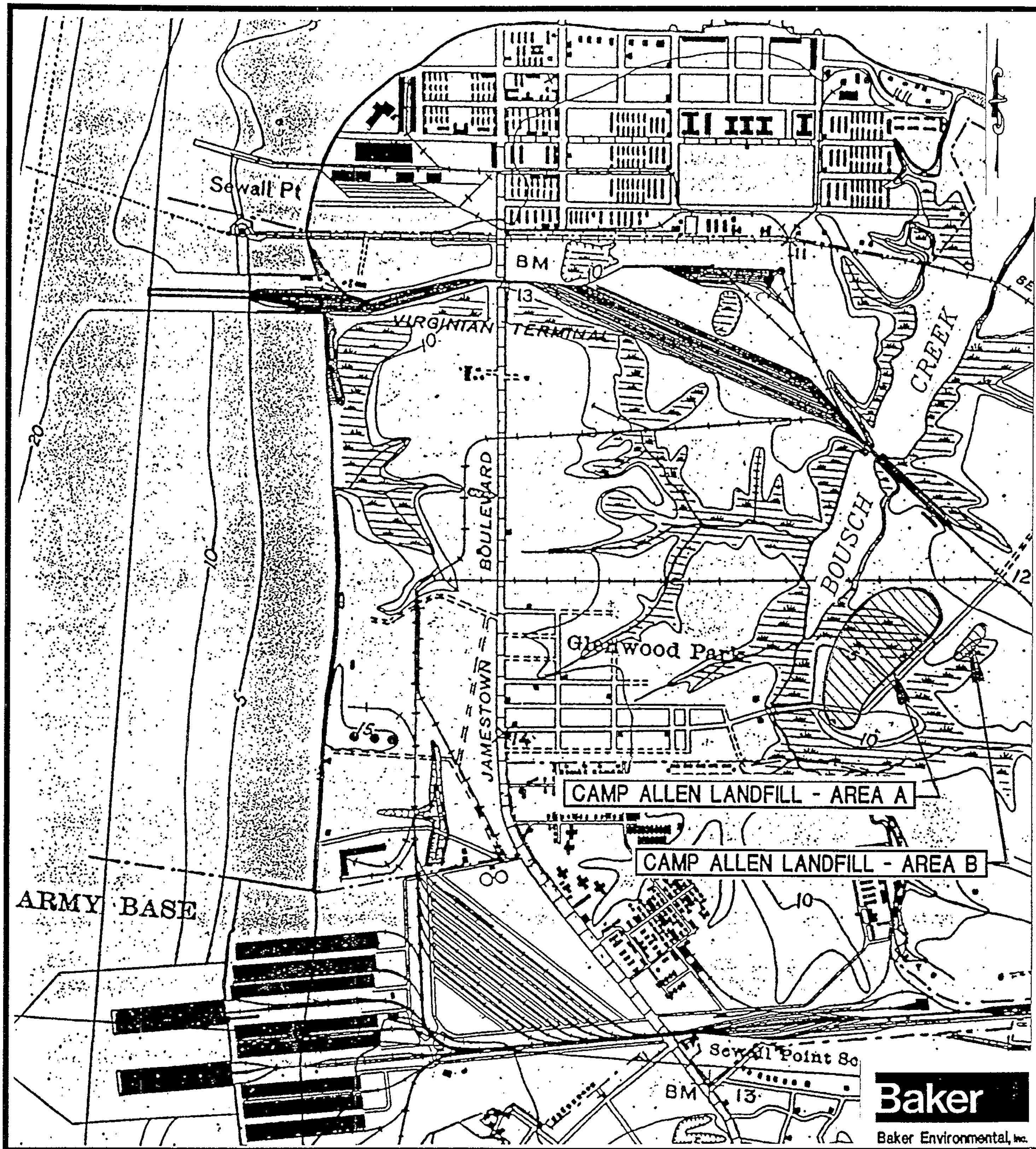
The Mattaponi Formation consists of glauconitic sand, glauconitic clay, and shell fragments; its estimated thickness is 65 feet. This upper Cretaceous formation overlies the "Transitional beds" and Patuxent Formation.

The "Transitional beds" and the Patuxent Formation are lower Cretaceous in age and are the oldest unconsolidated units found in the Tidewater area. Both units are characterized by interbedded gravels, sand, silt, and clay; it is sometimes difficult to distinguish the silt and clay.

2.5.2 General Site Geology

Site geology, in general, consists of four to five separate strata, including the following: (1) fill/landfill materials [ranging from 0 to 18 feet below ground surface (bgs)]; (2) silts, clays, and sands ranging from 0 to 27 feet bgs or deeper; (3) a confining clay layer (when present) ranging from 25 feet to approximately 40 feet bgs; and/or, (4) a silt/sand/shell hash unit (Yorktown Aquifer) ranging from about 40 to 130 feet bgs where it abruptly contacts the St. Mary's "blue bed" of the Calvert Formation.

As noted above, the confining clay unit is locally absent in portions of the Camp Allen area. Breaching of the confining clay unit possibly was caused by scouring, a result of erosional forces associated with Bousch Creek. This could also be the result of the variable, depositional, shallow marine environment (transgressing/regressing seas) or a combination of both. As noted earlier, Bousch Creek has been replaced by a network of drainage ditches and culverts during the development of the base. The original riverine area of Bousch Creek is shown on Figure 2-3. Areas where major Bousch Creek channels were present are potentially areas where the clay unit is breached or poorly represented.



NOTE: APPROXIMATE LOCATIONS OF CAMP ALLEN LANDFILL AREAS A AND B
-MAP PRE-1940

FIGURE 2-3
HISTORIC LOCATION OF BOUSCH CREEK
AT CAMP ALLEN LANDFILL SITE

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

084-211

Extensive areas of fill were developed along the Elizabeth and Lafayette Rivers between 1887 and 1973 (Naval Base Expansion Operations). It can also be assumed that similar fill activities took place along Bousch Creek on a smaller scale. Fill material utilized to claim land along Bousch Creek likely came from dredging operations. It should be noted that the fill areas in the vicinity of the Camp Allen Site depicted on Figure 2-4 coincide with areas where the clay unit is breached or poorly represented.

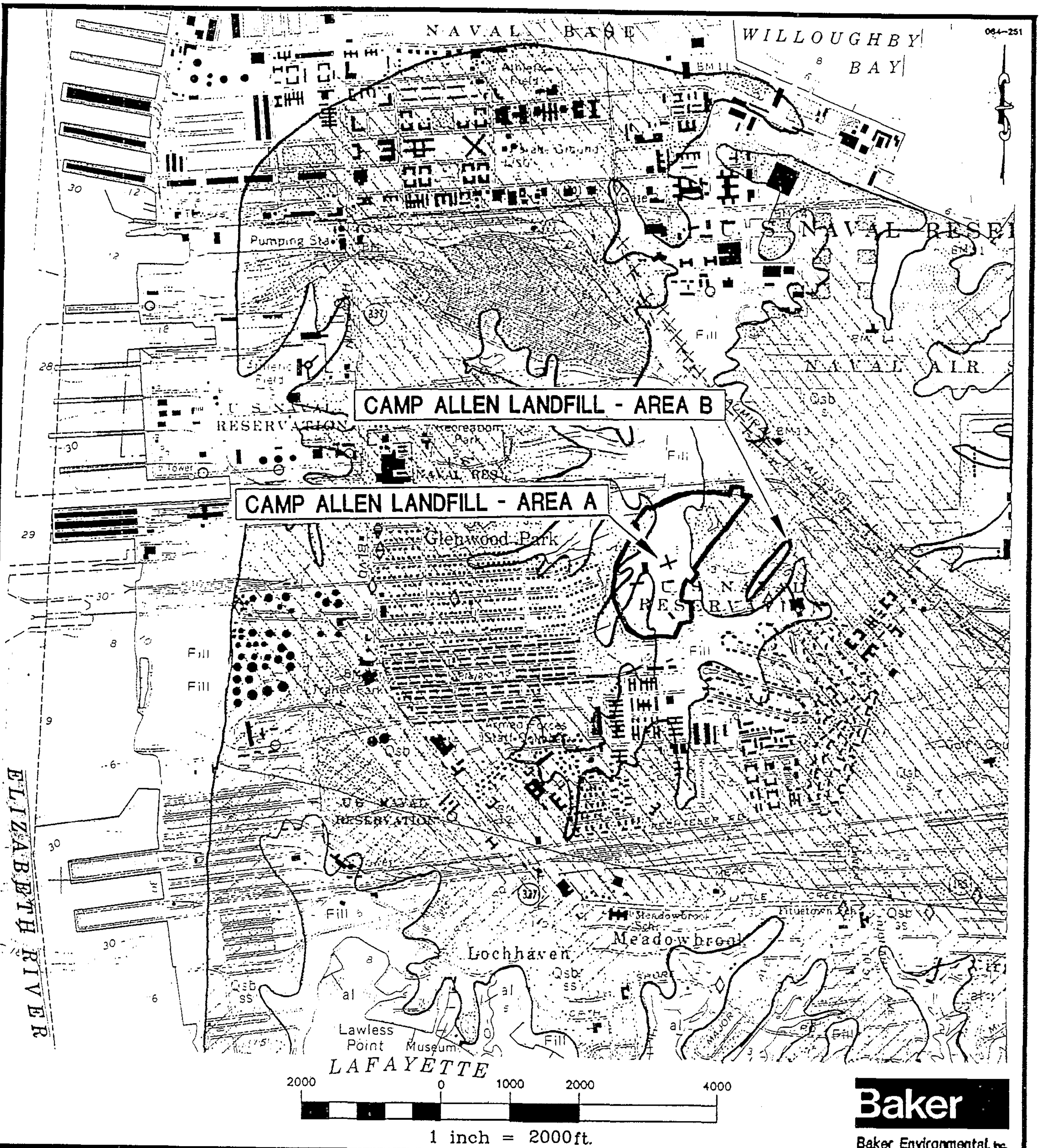
Figure 2-5 presents a generalized geologic cross-section of subsurface lithologic conditions in the vicinity of Camp Allen. Section 4.0 (Physical Results) discusses site geology in more detail.

2.6 Hydrogeology

2.6.1 Regional Hydrogeology

The hydrogeologic framework of the Norfolk area includes four principal aquifers, one unconfined and three confined. These aquifers and their geologic equivalents are as follows: (1) the water table aquifer (primarily the Columbia Group); (2) the Yorktown Aquifer (upper part of the Yorktown Formation); (3) the Eocene-Upper Cretaceous Aquifer (lower part of the Calvert and the Mattaponi Formation); and (4) the Lower Cretaceous Aquifer (the Potomac Group). Confining beds 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 Chesapeake Bay. The Lower Cretaceous Aquifer exhibits the most confinement (Siudyla, et al., 1981).

The Columbia Aquifer (water table aquifer) consists of beds and lenses of sand and some gravel, shell beds, silt, sandy clay, and clay. The sand and shell beds and sand and shell lenses (i.e., the major water-bearing strata) are very heterogeneous and discontinuous because of the complex marine estuarine environments in which they were deposited. Sand units yield groundwater quantities adequate for domestic and small industrial demands. Individual well yields range from 5 to 50 gallons per minute (gpm) and specific capacities range from about 1 to 2 gpm/ft (Siudyla, et al., 1981). Groundwater in portions of the water table aquifer near coastal regions may be saline (Hamilton and Larson, 1988).



LEGEND

☐ - FILL MATERIAL

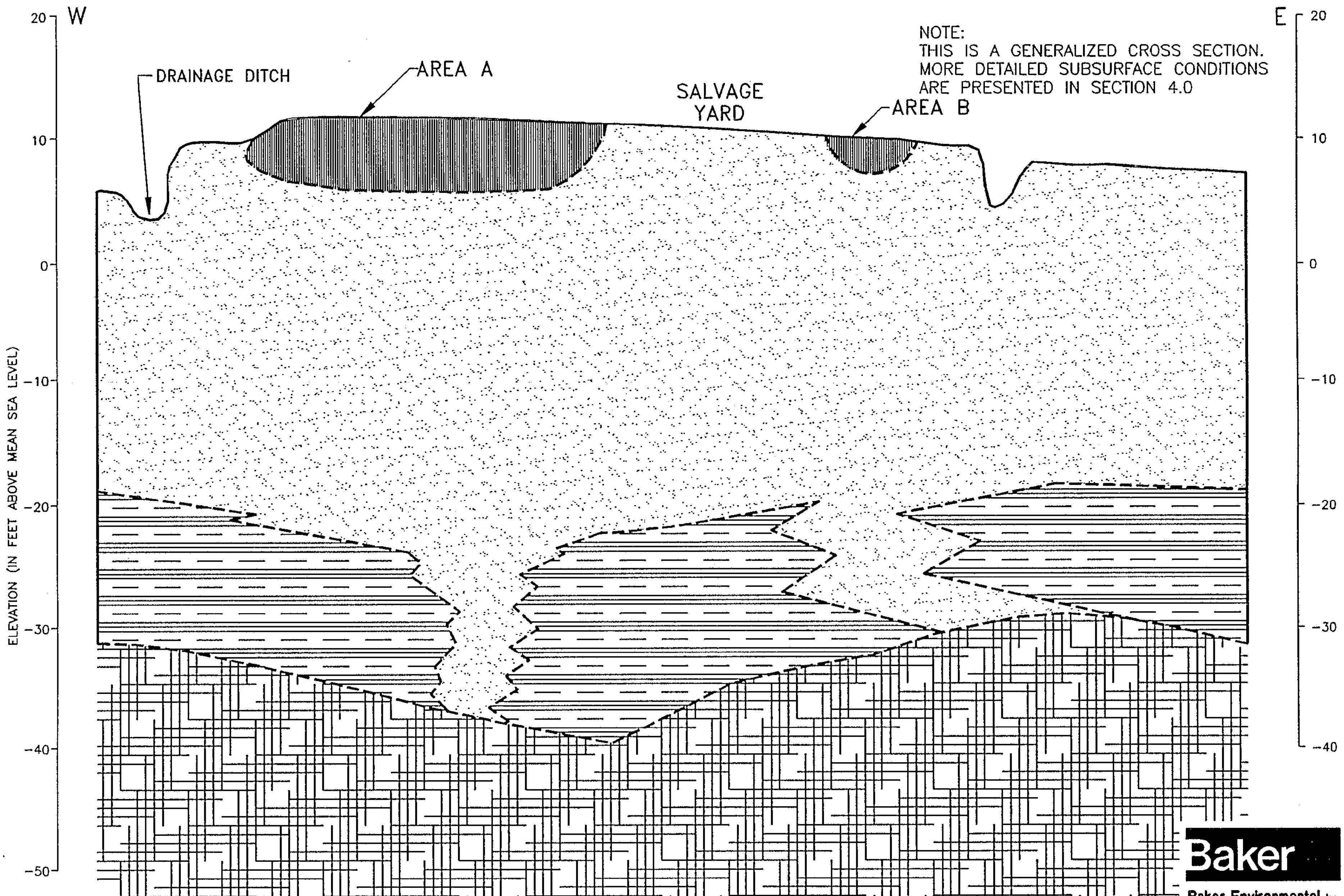
☐ - UNCONSOLIDATED MATERIAL

NOTE: THIS FIGURE DEPICTS A GENERAL RELATIONSHIP BETWEEN FILL MATERIAL AND UNCONSOLIDATED SEDIMENTS OF THE COASTAL PLAIN.

SOURCE: U.S.G.S., 1965
NORFOLK NORTH QUADANGLE

FIGURE 2-4
GEOLOGY OF THE NORFOLK NORTH QUADRANGLE (FILL AREA)
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



Baker
Baker Environmental, Inc.

300 0 150 300
1 inch = 300 ft.
HORIZONTAL SCALE

VERTICAL EXAGGERATION ±20x

084-212

LEGEND

- FILL
- SILTY AND CLAYEY SANDS (COLUMBIA GROUP)
- CLAY WITH LITTLE SILT, SAND (YORKTOWN CONFINING UNIT: BREACHED AT PLACES)
- SILTY SANDS WITH SHELLS (YORKTOWN FORMATION)

FIGURE 2-5
GENERALIZED GEOLOGIC CROSS-SECTION
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

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. The water-bearing zones are composed of beds of fine to coarse sand, gravel, and shells generally 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. This clay unit is occasionally breached in localized areas. 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 about 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).

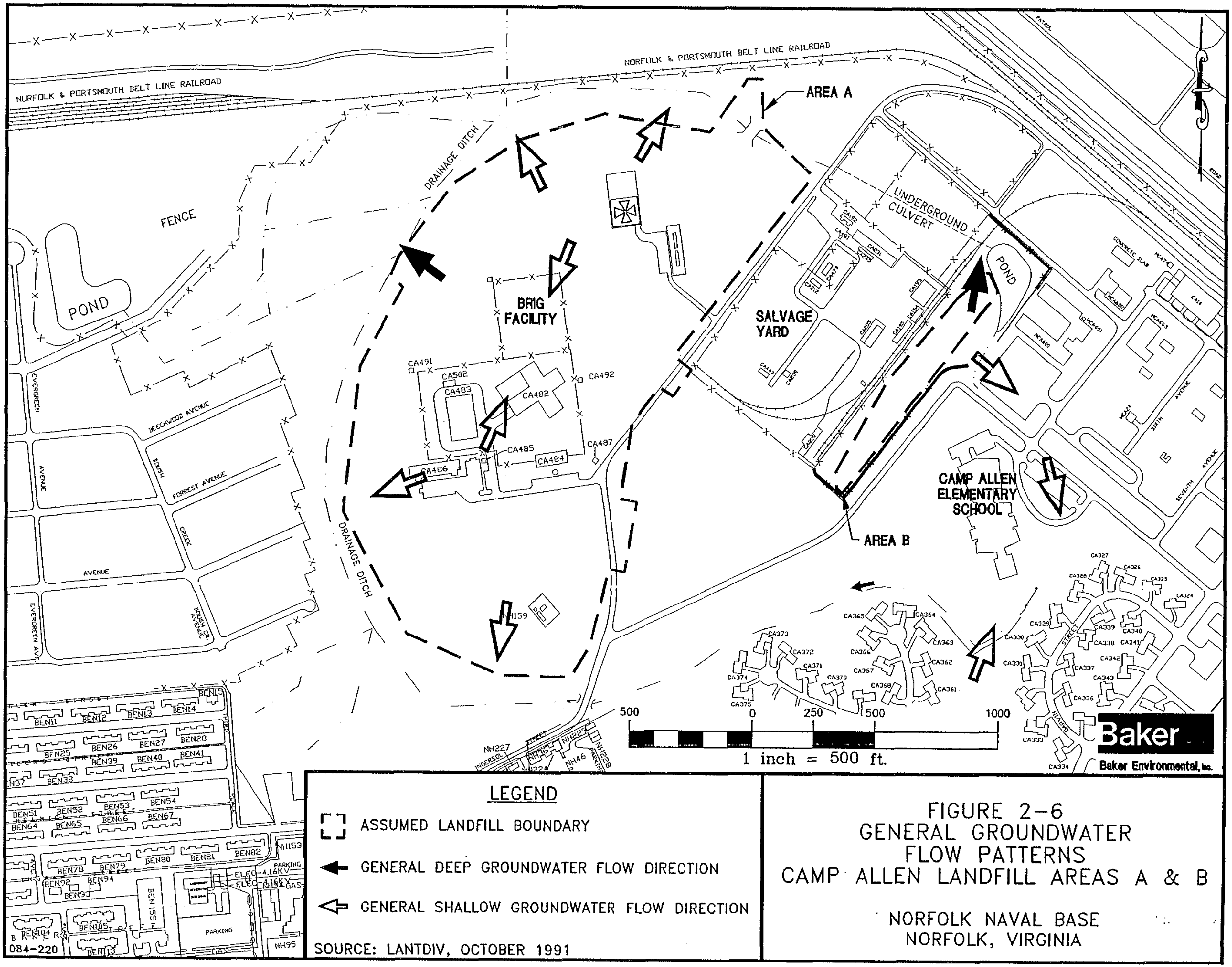
The Eocene-Upper Cretaceous Aquifer is found at a minimum depth of about 500 feet in the western section of the Norfolk area to depths of approximately 1,000 feet in the eastern section. The aquifer generally consists of one or two fine- to medium-grained glauconitic sand beds, 10 to 30 feet thick, interbedded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

The Lower Cretaceous Aquifer is composed of interbedded gravel, sand, silt, and clay. Generally, 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 permeable 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 rocks 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).

2.6.2 General Site Hydrogeology

The water table aquifer and the Yorktown Aquifer are the primary aquifer systems of concern at the Camp Allen Landfill Site. Figure 2-6 presents generalized groundwater flow directions at Areas A and B.

The water table aquifer, consisting of primarily silts and fine sands, tends to follow site topography, flowing radially from Area A and eastward from Area B. Prior to filling activities in Areas A and B, the water table aquifer was characterized by a riverine environment



LEGEND

ASSUMED LANDFILL BOUNDARY

GENERAL DEEP GROUNDWATER FLOW DIRECTION

GENERAL SHALLOW GROUNDWATER FLOW DIRECTION

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 2-6
GENERAL GROUNDWATER FLOW PATTERNS
CAMP ALLEN LANDFILL AREAS A & B

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

dominated by Bousch Creek (see Figure 2-3). Although the local groundwater flow patterns at the Camp Allen Site were altered due to filling activities and the resulting groundwater mounding within the fill areas, flow in the water table aquifer still discharges to Bousch Creek. Shallow groundwater in this area is typically encountered about four to six feet below ground surface.

Groundwater in the Yorktown Aquifer consisting of silt, sand and shell material, flows primarily northwest from Area A and more northward from Area B. This is a semi-confined aquifer system with a noncontinuous (intermittently breached) upper confining layer. The Yorktown Aquifer is approximately 90 to 100 feet thick in the vicinity of the site. Groundwater flow patterns in the Yorktown Aquifer were not affected by filling activities in Areas A and B.

2.7 Ambient Air/Water Quality

2.7.1 Air Quality

2.7.1.1 General Overview

Ambient air quality is dependent on background conditions, which include potential off-site (unrelated) sources. Prevailing winds (from the North, Northeast) are expected to have a major impact with regard to interferences, as the Camp Allen Landfill is located adjacent to the Naval Air Station and an Interstate Highway along the northern boundary. Therefore, to supplement results obtained from ambient air samples, samples collected at the Camp Allen Landfill, a preliminary search was performed utilizing a national ambient volatile organic data base. Regional information was obtained, as site-specific data on air quality with regard to volatile organic compounds was nonexistent. The implementation of the data base and its correlation with air quality are discussed below.

2.7.1.2 National Ambient Volatile Organic Data Base

The national ambient volatile organic data base was prepared by an independent contractor for the U.S. Environmental Protection Agency (USEPA), since the implementation of new federal regulations for volatile organic compounds (VOCs) in air has increased the monitoring process in many states. The data base was prepared by collecting, evaluating, and consolidating reports of ambient concentrations of VOCs throughout the United States from

1970 through 1980 (Shah and Heyerdahl, 1988). The data base has been updated periodically to include ambient and indoor VOC concentrations in urban, rural, remote, source-dominated, and indoor environments. Currently the data base includes a total of 320 volatile organic compounds with 261 obtained from outdoor air and 66 measured indoors. The data extracted were primarily limited to the warmer months and daylight hours. The outdoor data are characterized as urban, rural, suburban, remote, or near source.

The data base was utilized to perform a preliminary comparison of air quality in urban, nonurban, source-dominated, and indoor environments for cities in the state of Virginia. Specific compounds were selected and the necessary information extracted from the data base, which provided at a minimum, the average concentration, number of times the compound was below the detection limit or equal to zero, sampling and analysis methods, and the city and state where the data were recorded.

The data base provides a useful starting point for chemical concentration distribution, trend analyses, location of "hot spots," and census data for volatile organic compounds in ambient air conditions for the Virginia area. It should be noted that, for any one chemical, too little information may have been available to make accurate health assessments or trend analyses; i.e., there was no information available from the database for an indoor air quality comparison in Virginia. For more information regarding the data base report for the Virginia area see Appendix B.

2.7.2 Surface Water Quality

Water quality in the estuarine area surrounding the Norfolk Naval Base reflects the stressed environmental conditions caused by significant sewage and industrial discharges, non-point sources, and shipping related activities. Elevated levels of phosphorous, nitrogen, metals, and oil and grease have been recorded and are linked to similar readings exhibited by corresponding sediment samples (IAS, February 1983). Willoughby Bay has historically been closed to shellfishing due to metals pollution.

Surface water quality in the Camp Allen area (remnant Bousch Creek drainage channels) is directly related to stormwater runoff from residential, commercial, and military areas, as well as effects from the Camp Allen Landfill. Miscellaneous litter, unauthorized dumping, and other non-point sources from the adjacent developed areas impact surface water quality in the vicinity.

Networks of storm sewers convey surface runoff from nearby areas into the drainage ditches situated in and around the Camp Allen Site. The Bousch Creek drainage systems eventually drain into Willoughby Bay.

2.7.3 Groundwater Quality

Groundwater quality of the water table and Yorktown Aquifer systems varies from place to place. Table 2-2 contains a comparison of major chemical parameter concentration ranges between the water table and Yorktown Aquifer systems.

The water table aquifer is affected by the quality of the surface water where hydraulic connection occurs. The quality of water in this aquifer is quite variable depending on land use and potential tidal impacts. Regionally, the surficial aquifer exhibits low amounts of dissolved solids ranging from 200 to 300 milligrams per liter (mg/L). Chlorides are generally low (state criteria for chlorides is 250 mg/L), but can be high adjacent to tidal waters. Hardness ranges from hard (121 to 180 mg/L) to moderately hard (61 to 120 mg/L).

The most common water quality problems for the water table aquifer are low pH and high iron content. In the Norfolk area, high concentrations of iron (greater than the Virginia State Health Department Standard of 0.3 mg/L) and manganese (greater than 0.05 mg/L) and low pH (less than 6) are documented in the surficial aquifer (Siudyla, et al., 1981). As a result of these characteristics, the water table aquifer is generally not suitable for domestic use, but can be used for lawn watering and other similar uses as long as the quality limitations are recognized.

The Yorktown Aquifer is generally suited for potable and most other uses. However, in test wells in the Norfolk area, hardness ranged from less than 1 to 1430 mg/L and iron content ranged from less than 0.1 to 48 mg/L.

In lower portions of the Yorktown and in areas adjacent to tidal waters, the aquifer can be brackish with chloride ranging from 6 to 2000 mg/L and total dissolved solids (TDS) ranging from 77 to 4110 mg/L (Siudyla, et al., 1981).

TABLE 2-2

SUMMARY OF QUALITY ANALYSES FOR FOUR CITIES AREA*

Aquifer	Depth (feet)	Alkalinity	Total Dissolved Solids	Hardness	Chloride	Nitrate Nitrite	Fluoride	Sodium	Calcium	Iron	pH**
Water table											
Minimum	10	3	63	16	5	0.05-	0.1-	4	3	0.1-	6.6
Maximum	43	295	1178	347	1178	16.50	0.7	172	140	18.6	8.5
Mean	23	88	344	113	48	2.20	0.1	39	33	3.0	7.4
Yorktown											
Minimum	40	14	77	1-	6	0.01-	0.1-	4	1-	0.1-	6.2
Maximum	200	780	4110	1430	2000	6.50	3.6	1000	340	48.0	12.4
Mean	82	208	584	200	171	0.12	0.2	107	57	2.5	8.7

* All quality values are given in milligrams/liter units except for pH values, which are unitless. Any value with a dash after the number, such as 0.1-, indicates that the value is the detectable limit for the laboratory test. Source: Virginia State Water Control Board - TRO

** pH data was obtained from well development logs (Appendix I of RI Report) from wells installed by Baker Environmental, Inc. at the Camp Allen Landfill Site in 1992.

2.8 Natural Resources and Ecological Features

2.8.1 Local Ecology

The Sewell's Point Area, Navy Complex (Norfolk Naval Base) is located in Norfolk, Virginia at the mouth of the Elizabeth River on Hampton Roads and the Chesapeake Bay. The total land area is approximately 4,465 acres or 7 square miles. The Norfolk Naval Base is bounded on the north by Willoughby Bay; on the east by Interstate 64; on the south by International Boulevard; and on the west by Hampton Roads (USDA, 1983). Sewell's Point Area Navy Complex is within the Tidewater Region of the Atlantic coastal plain; the mean elevation on the Naval base is 11 feet above sea level (Audet, 1988).

Historically, the area now occupied by the Naval base was covered with stands of hardwoods including white oak (Quercus alba), willow oak (Quercus phellos), southern red oak (Quercus falcata), and sweetgum (Liquidamber styraciflua). Vast areas of tidal marsh were also present. As the base was developed these areas were altered. All existing streams and creeks are disturbed or severely changed. Bousch and Thelball Creeks were completely filled; Mason Creek was partially filled; and tidal influences are now regulated by a gate along the aqueduct flowing into Willoughby Bay (Audet, 1988).

Generally, eight habitat types are present on the Naval base. These habitat types were identified by USDI, Fish and Wildlife personnel based upon aerial photographs (1982), topographic maps (U.S. Geological Survey, 1973), and LANTNAVFACENGCOM maps from 1979 and 1980. Ground truthing of habitats was conducted during eight site visits made in 1987. Acreage estimates were developed from planimetry readings taken from the 1982 aerial photographs (Audet, 1988). The habitat types and their acreage estimates are as follows:

- Hardwood Forest - 1-5 acres in small stands
- Pine Woods - generally loblolly Pine (Pinus taeda) - 157 acres
- Young Mixed Deciduous/Coniferous Woods - 143 acres
- Improved Fields (regularly mowed) - 504 acres
- Semi-improved Fields (irregularly mowed) - 21 acres
- Unimproved Fields (not maintained) - 187 acres

- Wetlands - 161 acres
- Urban Areas - 3,292 acres

A number of different species of birds, mammals, reptiles, and amphibians are found in these habitats, particularly in the wooded areas, semi-improved and unimproved fields, and wetlands. Details on wildlife expected to be present and verified by field investigations are provided in Section 3.6.

2.8.2 Sensitive Environments

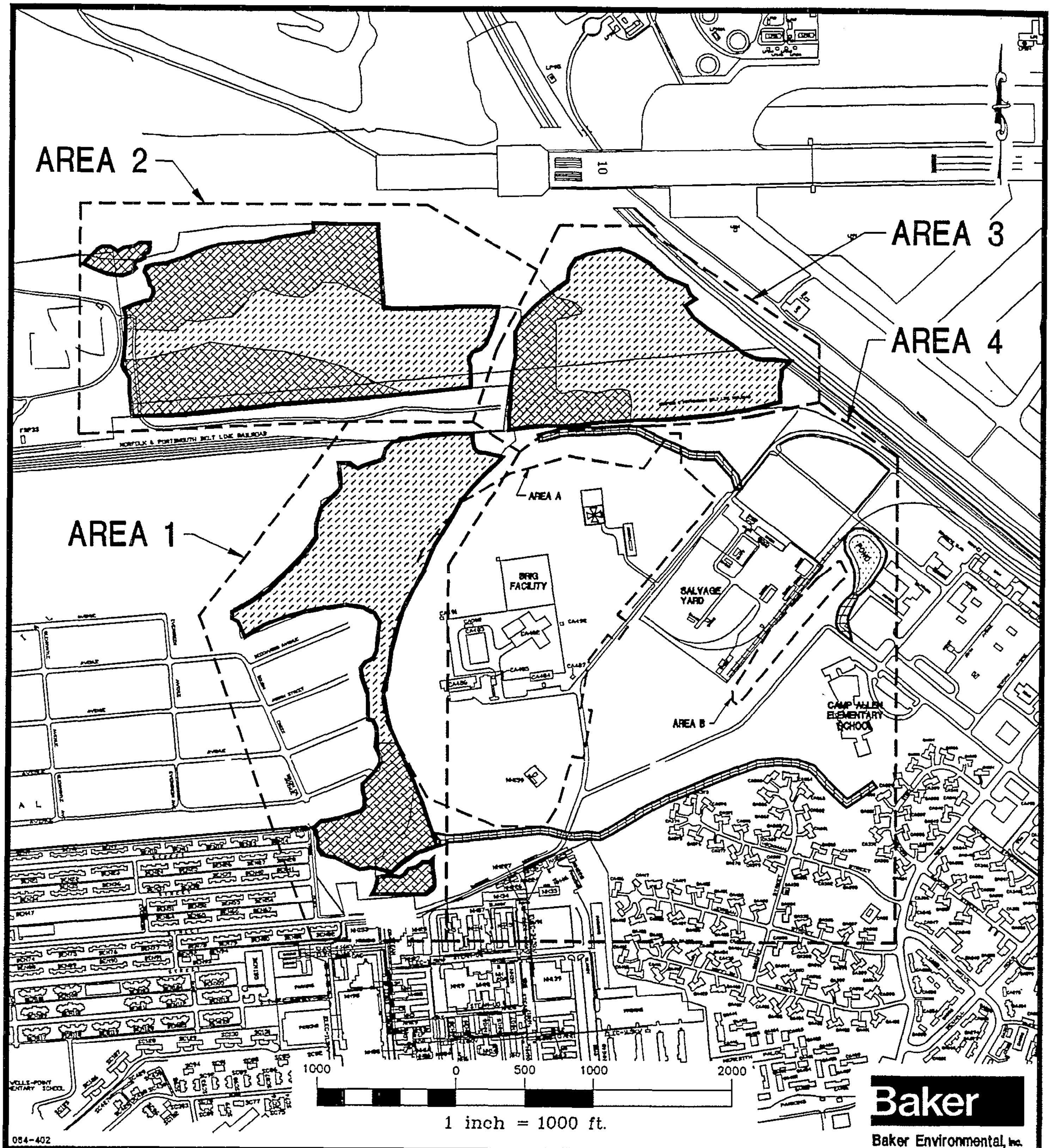
2.8.2.1 Site-Specific Wetlands

A wetland can be defined as "... land that is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water... Wetlands must have one or more of the following attributes: (1) at least periodically supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year" (Mitsch and Gosselink, 1986).

Wetlands are a very important natural resource because of their well documented abilities in flood and soil erosion control. Wetlands provide suitable habitat and cover for a variety of wildlife including birds, reptiles, mammals, fish, and plants. The wetlands identified at the Camp Allen Site area are described as mostly a Palustrine system with a subsystem classification of Palustrine Scrub Shrub (PSS), Palustrine Emergent Wetland (PEM), and a Riverine Intermittent system with a Riverine stream bed subsystem (R4SB). Wetland areas are detailed in the following section.

Figure 2-7 depicts the most recently identified wetland areas near the Camp Allen Site (USDI, 1991). Each of these wetland areas has been assigned numbers 1 through 4 for identification purposes. To date, the information gathered for this report shows that numeric qualifiers have not yet been assigned to the wetland system classification.

Wetland Area Number 1 is located on the western side of Area A and follows a north/south trend. It is densely vegetated with wetland grasses, shrubs, mixed trees, and some vining



LEGEND

PALUSTRINE EMERGENT WETLAND (PEM)

PALUSTRINE SCRUB SHRUB (PSS)

RIVERINE STREAM BED SUBSYSTEM (R4SB)

PALUSTRINE UNCONSOLIDATED BOTTOM (PUB)

SOURCE: USFWS/NATIONAL RESOURCE MANAGEMENT STAFF, ATLANTIC DIVISION, NAVAL FACILITIES ENGINEERING COMMAND

FIGURE 2-7
WETLAND LOCATION MAP
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

plants, and is primarily a Palustrine emergent, persistent, semi-permanent wetland system. The ditches in this area are subject to daily tidal influences.

Wetland Area Number 2 is located on the northwestern side of Area A and trends east/west. It is densely vegetated with large areas of mixed woodland trees, some shrubs, vining plants, and few wetland grasses. This area is divided into two U.S. Fish and Wildlife Service (USFWS) wetland classification systems. The first system is defined as a Palustrine wetland system emergent persistent seasonal. The second system is defined as a Palustrine scrub shrub wetland system.

Wetland Area Number 3 is located on the northeastern side of Area A and follows an east/west trend. It is densely vegetated with large areas of mixed woodland trees, some shrubs, vining plants, and some wetland grasses and is divided into two USFWS wetland classification systems. The first system is defined as a Palustrine scrub shrub wetland system and the second system is defined as a Palustrine wetland system with an (PEM) subsystem.

Wetland Area Number 4 includes drainage ditches in two locations. The first location is north of both Areas A and B, following an east to west direction. The second location is south of both Areas A and B, following an southeast to northwest direction. The area to the north is densely vegetated with large areas of wetland grasses and shrubs, some vining plants, and few mixed woodland trees. The area to the south is moderately vegetated with some wetland grasses, few shrubs, and few mixed woodland trees. Area Number 4 has one USFWS wetland classification system. The system is defined as a Riverine Intermittent wetland system with a stream bed (R4SB) subsystem that comprises all of this wetland area. This riverine system is also tidally influenced.

In one section of Area 4 a portion of the drainage ditch east of the salvage yard had been widened in the past to form a "pond". Although there is flow through this ponded area, and it is technically a drainageway, it provides a pond-like habitat. This area has been identified as a Palustrine, unconsolidated bottom wetland (PUB).

2.8.2.2 Threatened and Endangered Species

According to updated Hazard Ranking System (HRS) information several federally designated threatened (T) or endangered (E) species have been identified in the area near the Naval base (i.e., cities in the Norfolk area) (Baker, 1991). These species include the following:

1. Bald Eagle (E) (*Haliaeetus leucocephalus*)
   (Suffolk, Virginia Beach, and York);

2. Red-Cockaded Woodpecker (E) (*Picoides borealis*)
   (Suffolk, Virginia Beach, and York);

3. Piping Plover (T) (*Charadrius melodus*)
   (York and Virginia Beach);

4. Northeastern Beach Tiger Beetle (T) (*Cincindela dorsalis dorsalis*)
   (York and Virginia Beach);

5. Dismal Swamp Southeastern Shrew (T) (*Sorex longirostris fisheri*)
   (Suffolk and Chesapeake Bay);

6. Eastern Cougar (E) (*Felsi concolor couguar*)
   (Suffolk) (note: siting is unconfirmed, may be extinct);

7. Peregrine Falcon (*Falco peregrinus anatum* (E) and *Falco peregrinus tundrius* (T))
   (Virginia Beach).

In addition, the Fish and Wildlife Management Plan prepared for the Norfolk Naval Base identifies several other "federally endangered" species or classes of species: marine mammals, sea turtles, and the shortnose sturgeon. State "species of concern" identified in this plan include the yellow-crowned night heron (*Nycticorax violacea*) and "colonial waterbirds." Colonial waterbirds of concern include the least tern (*Sterna albifrons*), common tern (*Sterna hirundo*), and black skimmer (*Rynchops niger*). According to the plan, the yellow-crowned night heron and all three species of colonial waterbirds have been sighted on the Naval base (Audet, 1991). A list of endangered species is included in Appendix C.

Most of these federal and state endangered and threatened species are not expected to be present on or near the Camp Allen Landfill because of the specific habitats they require. For example, the red-cockaded woodpecker requires large stands of loblolly pine and the terns and skimmers frequent seashores. However, the peregrine falcon has been sighted near Camp Allen by U.S. Fish and Wildlife Service representatives who believe that it may have been attracted to the area by populations of pigeons and starlings at the salvage yard.

2.8.2.3 Other Sensitive Environments

Sensitive environments were addressed in the updated HRS report (Baker, 1991) as follows:

- No national parks have been identified within a four-mile radius of the site.
- No designated federal wilderness areas were identified within a four-mile radius of the site.
- No state designated natural area has been identified within a four-mile radius of the site.
- No Critical Habitats as defined in 50 CFR 424.02 were identified within a four-mile radius of the site.

However, a critical crab habitat is located offshore in Chesapeake Bay (Rooney-Char, no date). This habitat "is extremely important for reproduction, nursery, and commercial harvest of blue crabs" and is particularly sensitive in summer when larval crabs are present.

SECTION 3
RI FIELD ACTIVITIES

3.0 REMEDIAL INVESTIGATION FIELD ACTIVITIES

Remedial Investigation activities were performed following LANTDIV/Activity-approved Project Plans. The Camp Allen RI/FS Project required the following working documents:

- Work Plan (WP)
- Sampling and Analysis Plan (SAP)
- Quality Assurance Project Plan (QAPP)
- Health and Safety Plan (HASP)
- Round 3 Project Plan Addendum
- Air Sampling Program Project Plan Addendum (WP/SAP/QAPP/HASP inclusive)
- Camp Allen RI/FS, Additional Wetland/Ecological Evaluations, Scope of Work and Attachments

General activities and standard operating procedures followed guidelines and protocol set forth in the required Project Plans. Final Project Plans were submitted to LANTDIV in April 1992, and Final Round 3 Project Plan Addenda were submitted in December 1992. Additional ecological and wetland evaluations were performed in accordance with the scope of work submitted in June of 1993. Field activities were performed from late-April 1992 through June, 1993. In order to clearly present project information, field activities are discussed by Area (Area A and Area B) of the Camp Allen Landfill. This section discusses general field activities and depicts appropriate investigative points on graphical figures. Section 4.0 contains detailed information relating to physical results of the investigation and Section 5.0 contains detailed sample summaries and analytical results.

3.1 Overview of Area A Activities

Field activities, conducted at Area A as three separate events (designated as Rounds 1, 2, and 3), included:

- Geophysical Survey (Round 1)
- Monitoring Well Installation (Rounds 1, 2, and 3)
- Surface Soil Sampling (Round 3)
- Surface Water and Sediment Sampling (Rounds 2 and 3)
- Source Characterization (Rounds 2 and 3)
- Geologic Borings (Round 2)

- Residential Well Sampling (Round 2)
- Groundwater Sampling (Rounds 1, 2, and 3)
- Slug Tests (Round 2)
- Aquifer Pumping Test (Round 2)
- Land Surveying (Rounds 2 and 3)

Round 1 field activities at Area A consisted of a geophysical survey (surface and downhole) and the installation and sampling of deep monitoring wells west of the site to determine the extent of contamination in the Yorktown Aquifer. Round 1 activities were conducted in late April and early May 1992. Please note that per the scope of work, no subsurface soil samples were collected for sample analysis during monitoring well installation except those samples obtained for source characterization.

Round 2 field activities included residential well sampling, surface water and sediment sampling in the drainage areas which encompass Area A, source characterization borings west of the Brig facility, geologic borings to help define the extent of the aquitard clay layer beneath the site, and the installation of a shallow stainless steel monitoring well within the previously identified source area. Round 2 activities were conducted during May and June 1992.

Round 3 field activities performed at Area A included additional sediment sampling, surface soil sampling, additional source characterization, drilling and installation of additional groundwater monitoring wells with associated groundwater sampling, and land surveying. Round 3 was conducted in December, 1992.

3.1.1 Geophysical Survey (Area A)

At the onset of the investigation for this site, a geophysical survey was conducted to assist in defining subsurface lithology and a breech in the confining clay layer thought to be present below the landfill. Additionally, data were used to modify locations of subsequent soil borings and monitoring wells. Various techniques were utilized including electromagnetism, resistivity, and gamma logging. Survey activities included:

- <u>Electromagnetometer Survey</u> - Continuity of the confining clay layer and extent of waste/fill boundaries were investigated by electromagnetic (EM) terrain conductivity profiling and resistivity constant spacing profiling. Both shallow and deep penetrating profiling was conducted via three transects each of EM 31 and EM 34 data runs.

- Resistivity Sounding - Vertical electrical resistivity soundings (five sectors) were used to determine the presence or absence of the clay layer. Resistivity data from these locations were modeled to determine the subsurface strata and the thickness of the clay layer.

- Downhole Gamma Logging - Originally six wells were to be used in the gamma logging study, but one well's (B-1W) PVC casing diameter was too narrow and could not accommodate the slimline downhole equipment. Natural-gamma logging in five deep wells was utilized to identify lithology and for stratigraphic correlation across the site.

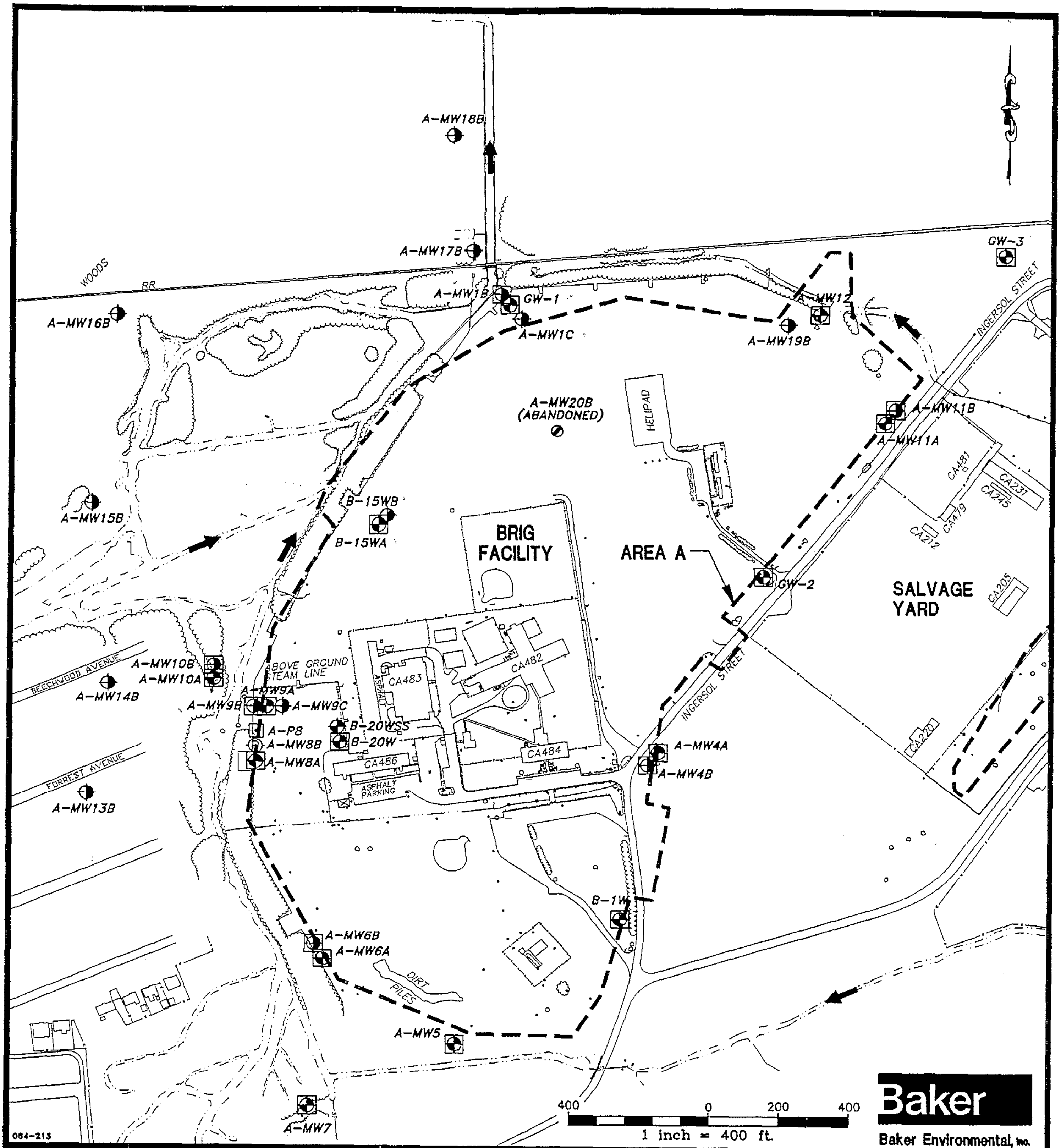
Geophysical survey results are detailed in Section 4.0.

3.1.2 Monitoring Well Installation (Area A)

In order to complement the existing network of monitoring well points at Area A, a series of monitoring wells were constructed within and adjacent to the site. Eight deep monitoring wells were installed to monitor the upper portion of the Yorktown Aquifer. Two deep monitoring wells were installed to monitor the lower portion of the Yorktown Aquifer. A 4-inch pumping well and a 2-inch piezometer were installed to perform an aquifer test on the Yorktown Aquifer. Also, a shallow stainless steel well was installed to evaluate a volatile organic source area. Existing and newly installed well points are presented in Figure 3-1. Please note that only newly installed wells and wells that were used as groundwater monitoring points are depicted on this figure. Several wells were not used for environmental sampling because of their age and/or construction. However, these wells were used for water elevation and lithologic correlation. Well construction activities are discussed below, and detailed results of the drilling operations and physical site characteristics are presented in Section 4.0 (Physical Results).

Rounds 1 and 2 Monitoring Well Installation

Subsequent to the geophysical survey, a series of Type III monitoring wells were installed to help determine the extent of groundwater contamination in the Yorktown Aquifer near



LEGEND

- EXISTING DEEP MONITORING WELL (A-MW6B)
- NEWLY INSTALLED DEEP MONITORING WELL (A-MW1C)
- EXISTING SHALLOW MONITORING WELL (A-MW7)
- NEWLY INSTALLED SHALLOW MONITORING WELL (STAINLESS STEEL) (B-20WSS)
- PIEZOMETER LOCATION (A-P8)
- PUMPING WELL LOCATION (A-MW8B)
- ABANDONED BORING (A-MW20B)
- LIMITS OF LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-1
MONITORING WELL LOCATIONS
AREA A
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

Area A. Type III monitoring wells are wells which are double cased so as to "case-off" between the upper and lower aquifer systems, thereby reducing the possibility of vertical migration of contamination. Rounds 1 and 2 well construction activities are discussed below.

Lower Yorktown Aquifer Wells

Three deep wells, A-MW9C, B-15WB, and A-MW1C, were installed as nested with existing monitoring wells A-MW9A, A-MW9B, B-15W, GW-01, and A-MW1B, respectively. The newly installed monitoring wells were constructed as Type III wells and were set with bottoms of screens at 130.6 feet, 124 feet, and 114 feet, respectively. They were installed to characterize groundwater quality closer to the base of the Yorktown Formation. Drilling extended to a maximum depth of 137 feet in A-MW1C in order to define the bottom elevation of the Yorktown Aquifer.

These three deep wells were installed prior to any other Round 1 drilling at Camp Allen. During Round 1, field verification groundwater sampling and analysis were performed to facilitate proper siting and construction of remaining proposed wells. Two of the wells (A-MW1C and A-MW9C) were sampled for volatile organics (non-CLP/NEESA: EPA Method 624) on a 24-hour turnaround basis. If contaminants existed at levels below 65 feet, the total depth of the five remaining, 65-foot deep wells to be drilled downgradient from the landfill would be evaluated and modified, if necessary. However, results indicated that the remaining wells would be effective at the originally-determined, bottom screen depth of 65 feet. Field verification sampling continued during Round 1. Groundwater from remaining newly-installed deep monitoring points was sampled for volatile organics using EPA Method 601.

Upper Yorktown Aquifer Wells

Six approximately 65-foot deep, Type III monitoring wells were also installed at Area A to complement the existing upper Yorktown monitoring well network.

Well A-MW8B is installed on site near location A-MW8. This deep well was set as a 4-inch, Type III well to facilitate conducting a Yorktown Aquifer (pumping) test. Five wells were installed downgradient of the landfill (west of Area A). Monitoring wells A-MW13B and A-MW14B are located on Forrest and Beechwood Avenues, respectively, in the residential community of Glenwood Park. Well A-MW15B is located west of the large wetland area and just east of the Breezy Point Apartment Complex. Well A-MW16B was installed south of the Norfolk/Portsmouth railroad line where the rails split. Well A-MW17B was placed between the railroad line and the eastward flowing drainage ditch and just west of the concrete conduit that drains to the north.

Piezometer

A 65-foot deep, 2-inch diameter, screened piezometer (A-P8) was installed along the western edge of Area A adjacent to the newly installed 4-inch pumping well (A-MW8B). The piezometer was to be used during the aquifer test to measure water levels. The piezometer also was utilized during Round 3 groundwater sampling as described in Section 3.1.8.

Stainless Steel Monitoring Well

During Round 2, one shallow, Type II, stainless-steel monitoring well (B-20WSS) was installed to the base of the water table aquifer (25 feet below ground surface), to accurately characterize the nature of contamination near the source Area (B-20W). Drilling was performed in protective equipment during this activity, as previous analytical results indicated high concentrations of volatile organic compounds present in the subsurface.

<u>Round 3 Monitoring Well Installation</u>

Three Type III monitoring wells were originally to be installed during Round 3 activities at Area A to better define the extent of contamination in the Yorktown Aquifer. Well A-MW18B, located northwest of the most northern well (A-MW17B), was installed to a depth of 76 feet below ground surface. This well was advanced to a lower depth because of the apparent northeastern thickening of the confining clay unit toward Willoughby Bay. The Yorktown Aquifer in this location is present at 63 feet below ground surface, as opposed to the 37 to 47-foot, below grade range encountered in the other deep well borings on site. This is discussed in further detail in Section 4.0 (Physical Results). Well A-MW19B, located in the northeastern section of the Area A landfill, was drilled to a final depth of 65 feet. This well was installed to provide additional information regarding water quality beneath the Area A landfill.

Boring A-MW20B was drilled between the northern Brig ballfield and the helipad, but was not completed as a well. During drilling, waste materials were encountered in the boring and the photoionization detector (PID) measured elevated levels of volatile organics in the split spoon samples. Additionally, as a competent clay layer was not present to "case-off" the surficial aquifer from the lower aquifer, the well was abandoned and pressure grouted to the surface to eliminate the possible downward migration of contaminants into the Yorktown Aquifer. Two subsurface soil samples were collected and analyzed for TCL parameters to characterize the potential source area (see Section 3.1.5).

Well construction and development procedures used during field operations are contained in the Final Project Plans (Baker, 1992).

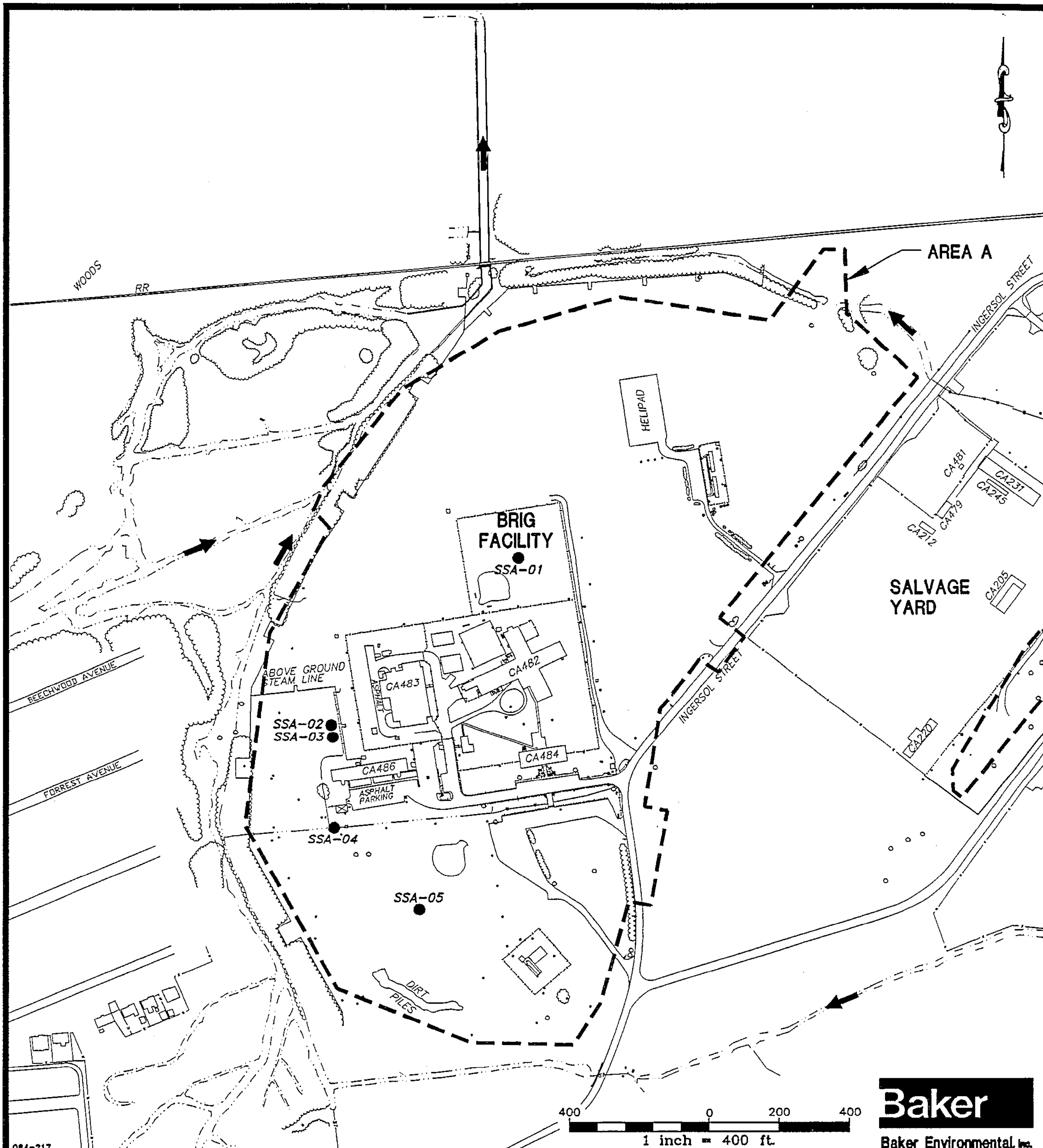
3.1.3 Surface Soil Sampling (Area A)

Five shallow (0 to 0.5 foot depth) surface soil samples (SSA-01 through SSA-05) were collected in areas used by Brig personnel and inmates and in locations suspected to be atop concentrated source areas (two samples from ballfields, one sample from a picnic area, and two samples from the lawn area near B20W). Samples were analyzed for TCL and TAL parameters. Soil sample locations are shown on Figure 3-2.

3.1.4 Surface Water/Sediment Sampling Program (Area A)

Surface water and sediment were sampled from the drainage channels in the vicinity of Area A; sampling locations are presented in Figure 3-3. Surface water samples (SWA) were collected prior to sediment samples (SDA) from eight locations (SWA/SDA-01 through SWA/SDA-08) that approximated previous investigation surface water/sediment sample points and from three other locations as well (SWA-11, SWA-12, and SWA-17). Additional sediment samples were collected subsequent to surface water sampling from a depth of 0 to 0.5 feet at 13 locations (SDA-09 - SDA-20, and SDA-24). Additionally, one sediment sample was collected from a depth of approximately 0.5 to 1.0 feet at five of the locations (SDA-10[D], SDA-12[D], SDA-14[D], SDA-16[D], and SDA-18[D]).

Surface water and sediment sampling was conducted from downstream to upstream locations to reduce the amount of turbidity in the surface water sample. Additionally, sample collection occurred at times of low tide to reduce the disturbance of potential contaminants within the sample.



LEGEND

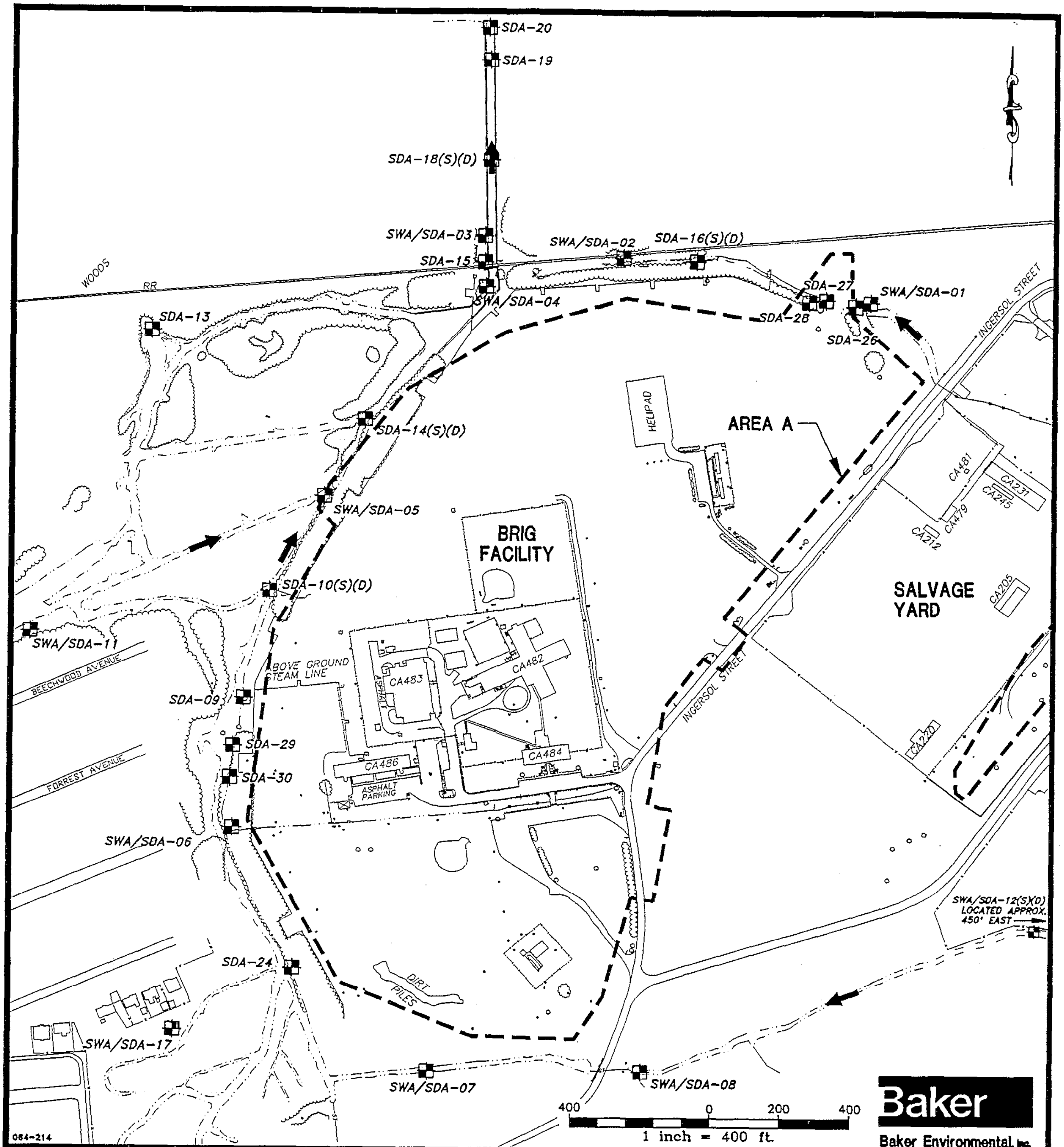
SSA-01 SURFACE SOIL SAMPLE

LIMIT OF AREA A LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-2
SURFACE SOIL SAMPLE LOCATIONS
AREA A
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

SWA/SDA-08 — SURFACE WATER/SEDIMENT SAMPLE LOCATION

SDA-16(S)(D) — SHALLOW SEDIMENT SAMPLE LOCATION (0 TO 0.5 FEET); DEEP SEDIMENT SAMPLE LOCATION (0.5 TO 1.0 FEET)

— — LIMITS OF AREA A LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-3
SURFACE WATER/SEDIMENT SAMPLE LOCATIONS
AREA A
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

A total of 11 surface water and 26 sediment samples were collected during Round 2. Surface water samples were analyzed for TCL and TAL (total and dissolved) parameters. Sediment samples were analyzed for selected metals based on the results of previous site investigations.

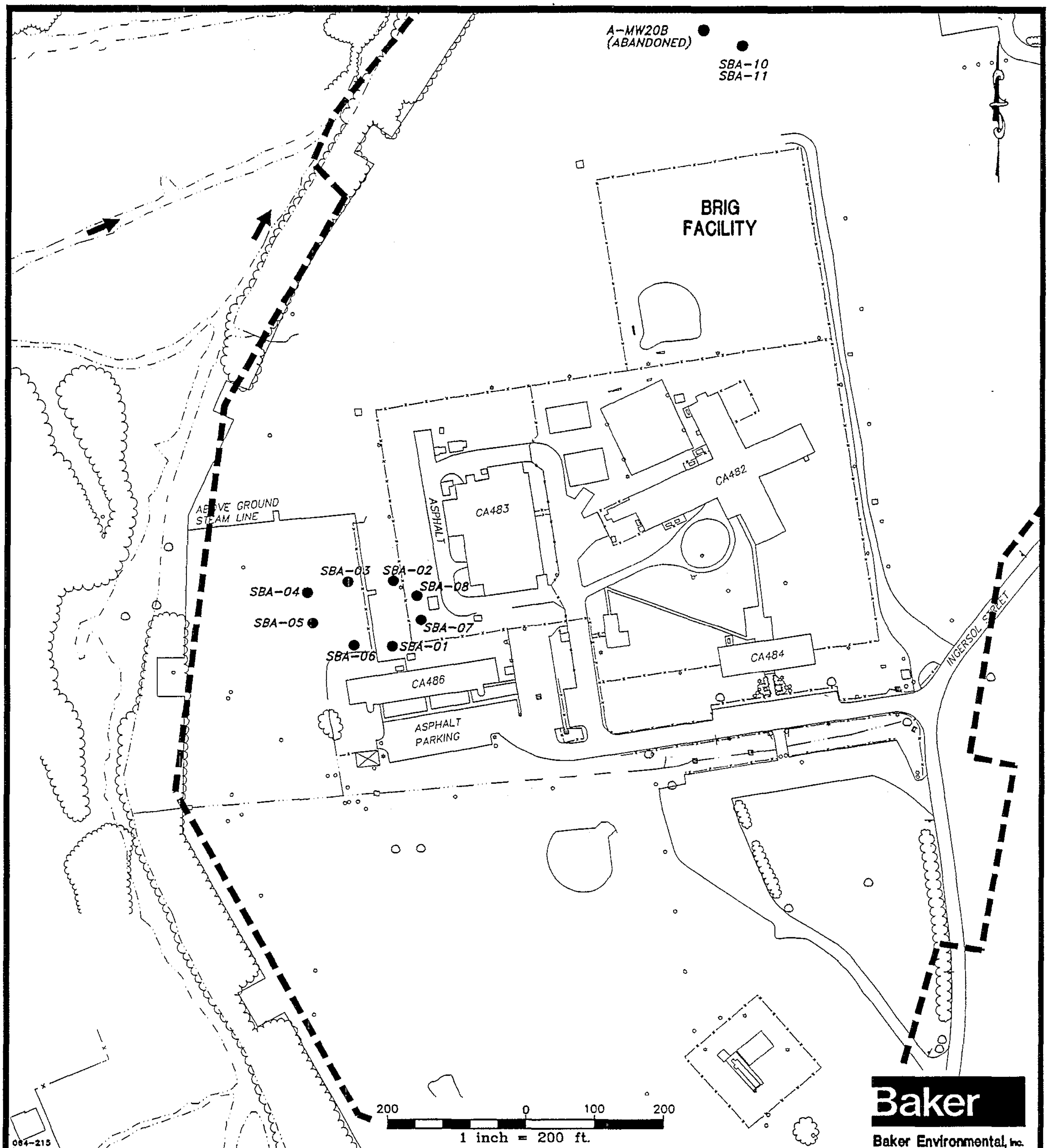
During Round 3, five additional sediment samples (SDA-26 through SDA-30) were collected from 0 to 0.5 feet from the drainage ditches encompassing Area A. These additional sampling points were located in areas where previous (Round 2) surface water samples were found to contain various TCL parameters. As Round 2 sediments were analyzed for selected metals only, Round 3 samples were analyzed for TCL parameters to better define site conditions.

A total of 11 surface water and 31 sediment samples were collected at Area A during the entire field program. Surface water and sediment sample numbering and corresponding analyte parameters are detailed in Section 5.0 (Analytical Results). Surface water and sediment sampling procedures are detailed in the Final Project Plans (Baker, 1992).

3.1.5 Source Characterization (Area A)

Eight soil borings (SBA-01 through SBA-08) were drilled to beneath apparent fill material to depths ranging from 14 to 18 feet near B-20W. In order to evaluate the extent and nature of the contamination source, subsurface soil samples from the borings were screened with an HNu photoionization detector to measure volatile organic vapors. One subsurface soil sample from each boring was submitted for analysis of TCL parameters, as per the scope of work. These samples (SBA-01 through SBA-08) were obtained from just above the water table or from samples exhibiting strong evidence of contamination.

During Round 3, as originally stated in the Project Plan Addendum, monitoring well A-MW20B was to be installed to provide additional information regarding the source of contamination in the Yorktown Aquifer. Due to wastes encountered during drilling, indications of volatile organics (visual and measured), and the apparent lack of a competent confining layer at this location, A-MW20B was abandoned via pressure grouting to the ground surface. Because of the need to identify possible contaminants in the vicinity, the boring for A-MW20B was converted to a "Source Characterization Boring." Two split spoon soil samples (SBA-10 and SBA-11) exhibiting signs of contamination were collected and submitted for analysis of TCL parameters. In all, 10 source characterization subsurface soil samples were analyzed for TCL parameters. Source characterization boring locations are presented on Figure 3-4. Results of source characterization activities are presented in Sections 4.0 and 5.0.



LEGEND

SBA-03 ● SOIL BORING LOCATION

STREAM FLOW DIRECTION

LIMITS OF AREA A LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-4
SOURCE CHARACTERIZATION BORING LOCATIONS
AREA A
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

3.1.6 Geological Investigation Borings (Area A)

Eleven subsurface borings (TBA-01 through TBA-11) were advanced in and around the landfill at Area A to better define the distribution of the confining clay layer beneath the water table aquifer. Due to the potentially hazardous nature of landfill materials, all borings were advanced using Level B personal protective equipment.

The confining clay layer was assumed to begin at a depth of approximately 25 to 30 feet. The borings were advanced to depths ranging from 29 to 37 feet. If the clay layer was encountered, drilling advanced no further than two feet into the clay. If the clay layer was not present, drilling advanced to just above the top of the Yorktown Formation, about 35 to 37 feet below ground surface. Borings were abandoned via pressure grouting.

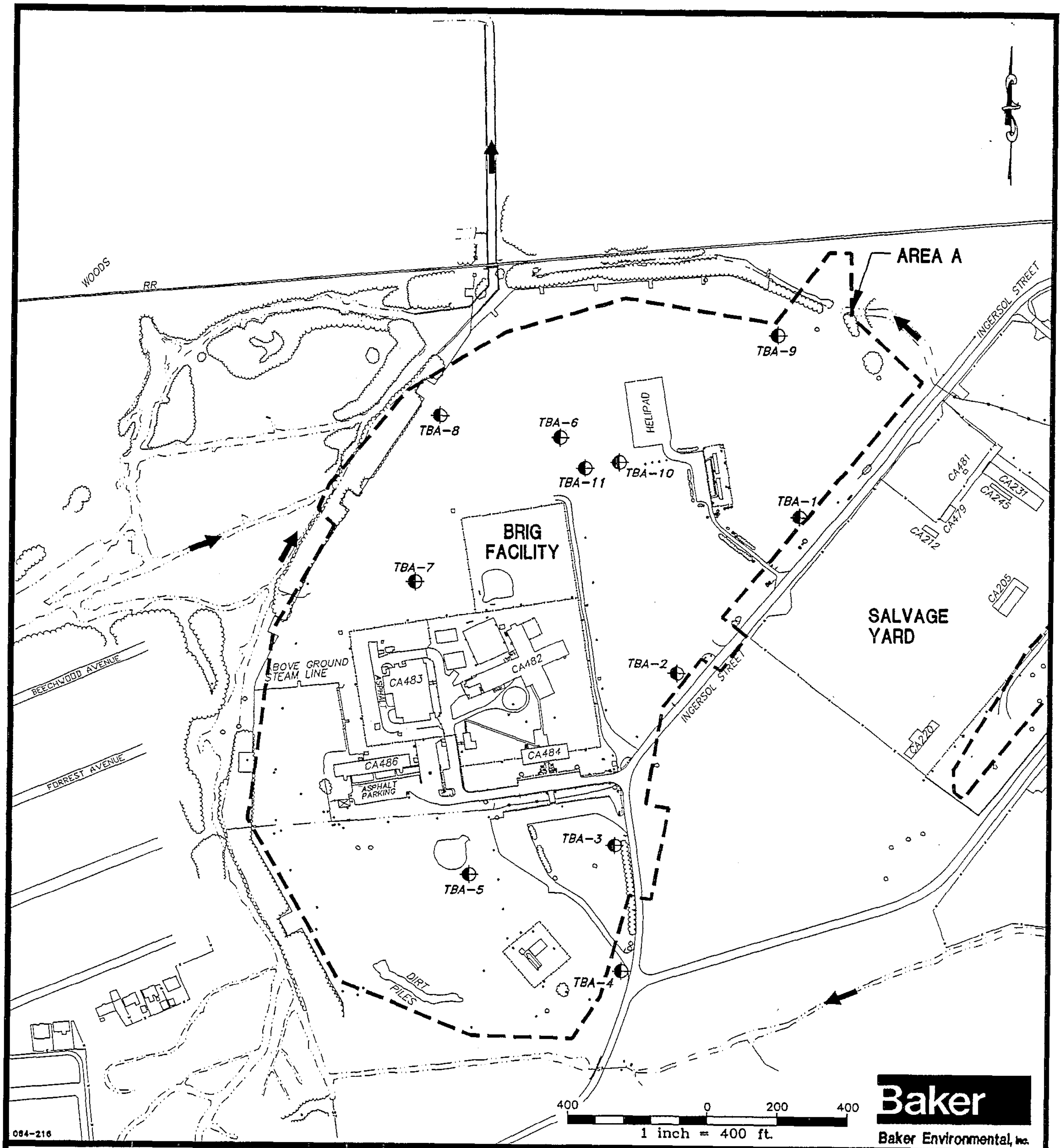
One sample of clay was collected from four of the 11 borings (GB-01 through GB-04) and submitted to the laboratory for physical parameter testing including:

- Grain size by sieve and hydrometer
- Atterberg limits
- Bulk specific density
- Moisture content

Geologic boring locations are presented on Figure 3-5. Physical testing results are presented in Section 4.0.

3.1.7 Residential Well Sampling (Area A)

A residential well sampling program was conducted in Glenwood Park (immediately west of Area A) and included 57 wells in all (RW-01 through RW-57). One well (RW-58) could not be sampled due to an obstruction within the well. Figure 3-6 presents previously sampled wells and Round 2 residential well locations. In addition to previous residential well sampling (55 wells) performed by CH_2M Hill in 1991 in Glenwood Park (west of Area A), Baker sampled two Glenwood Park residential wells for TCL parameters during Round 2 activities. Residential well RW-56, located at 400 Glendale Avenue, and RW-57, located at 314 Rogers Avenue, were sampled. A third residential well (RW-58), located at 135 Glendale Avenue, could not be sampled due to a broken well pump.



LEGEND

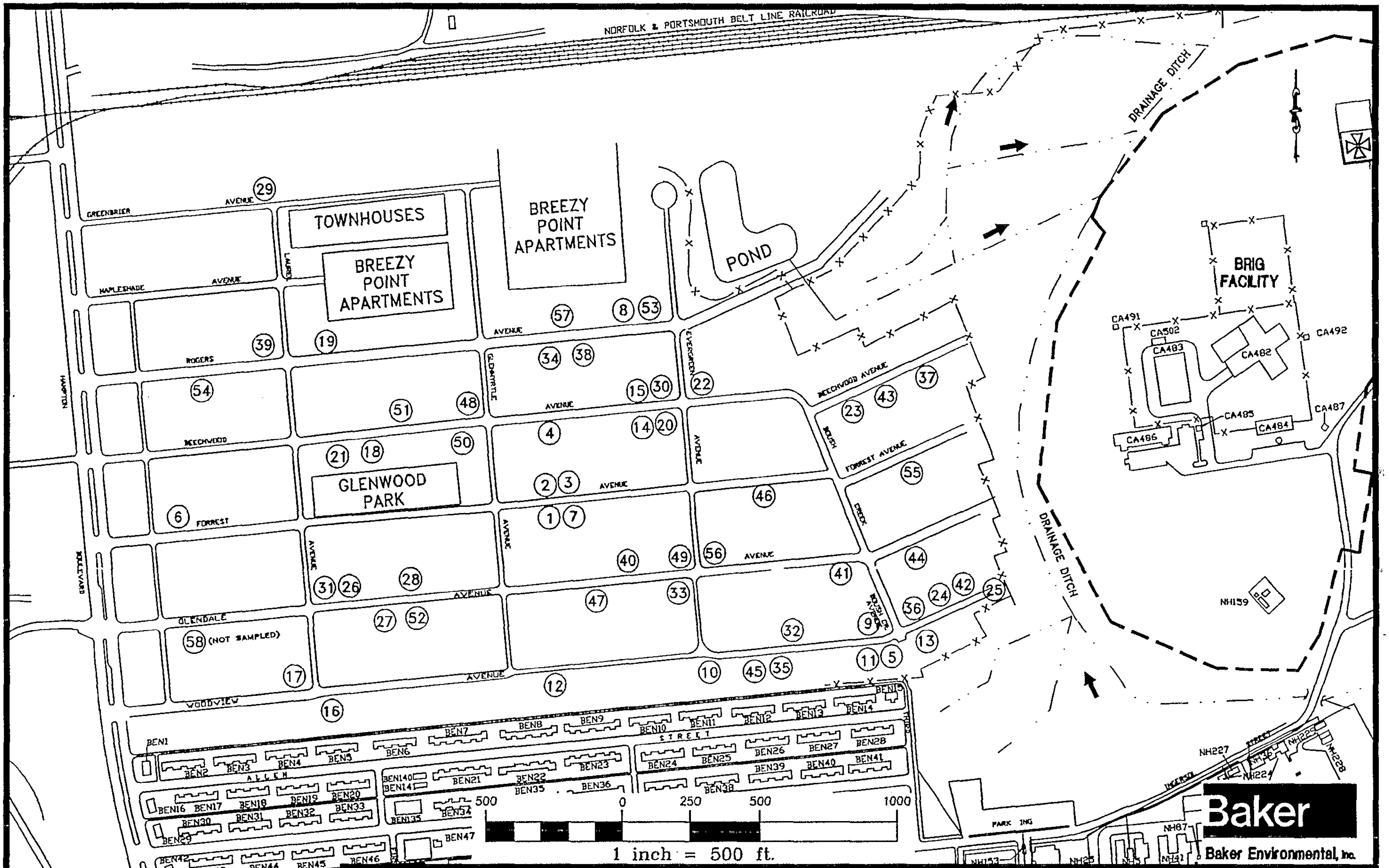
TBA-7 GEOLOGICAL INVESTIGATION BORING LOCATION

STREAM FLOW DIRECTION

LIMITS OF AREA A LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-5
GEOLOGICAL INVESTIGATION
BORING LOCATIONS
AREA A
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

① RESIDENTIAL WELL

← STREAM FLOW DIRECTION

— — LIMITS OF AREA A LANDFILL

NOTE: WELL OWNERS ARE IDENTIFIED IN SECTION 5.0

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 3-6
RESIDENTIAL WELL SAMPLING LOCATIONS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

084-207

Based on previous information, all of the residential wells were reportedly constructed within the water table aquifer. Details regarding the well inventory are contained in Section 4.0 and analytical results are presented in Section 5.0.

3.1.8 Groundwater Sampling (Area A)

Groundwater sampling at Area A was conducted as three separate events (Rounds 1, 2, and 3). Round 1 consisted of field verification groundwater sampling (non-CLP/NEESA analyses), and Rounds 2 and 3 were primarily for environmental groundwater sample analysis via CLP methods.

Round 1 Groundwater Sampling

The two deep monitoring wells (A-MW1C and A-MW9C), constructed to monitor the lower Yorktown Aquifer, were sampled and analyzed via EPA Method 624. A local, non-NEESA laboratory (Environmental Testing Systems, Inc.[ETS]) provided 24-hour turnaround of analytical results to facilitate proper construction of the remaining 65-foot deep wells installed during Round 1 (A-MW8B, A-MW13B, A-MW14B, A-MW15B, B-15WB, A-MW16B, and A-MW17B). Subsequent to development of the newly installed 65-foot deep wells, groundwater was collected and analyzed for VOCs using EPA Method 601. Field verification groundwater sampling and analysis enabled the field team to make decisions regarding proper well placement. Round 1 groundwater sample numbering and analytical results are detailed in Section 5.7.

Round 2 Groundwater Sampling

Groundwater samples collected from 17 shallow wells and 15 deep wells were submitted for analyses of TCL and TAL (total and dissolved) compounds. Sampling occurred in June, 1992 after all wells were installed and developed. Monitoring well construction, development, and purging, as well as groundwater sampling procedures, are detailed in the approved project plans and in Section 4.0 (Physical Results).

In general, prior to the collection of groundwater samples, all monitoring wells were purged of a minimum of three well casing volumes. Field measurements of pH, specific conductance, and temperature were taken until measurements stabilized to within plus or minus 10 percent or until a maximum of five well volumes was purged from the well.

Round 3 Groundwater Sampling

The two deep wells installed at Area A during Round 3 were sampled for TCL and TAL (total and dissolved) parameters as were the wells installed during Round 2. In addition, all wells sampled during Rounds 1 and 2 were resampled and analyzed for TCL VOCs only. Because the integrity of well A-MW8B was compromised during the aquifer test, groundwater was collected for chemical analysis from the adjacent piezometer (A-P8) during Round 3.

In summary, Round 1 groundwater sampling included the analysis of nine groundwater samples for VOCs by a non-CLP/NEESA laboratory. Round 2 consisted of groundwater sampling and analysis of TCL and TAL (total and dissolved) parameters for 32 wells. Round 3 consisted of the sampling of all deep monitoring wells and the newly installed shallow well for TCL VOAs only. All samples collected during Rounds 2 and 3 were submitted for TCL and TAL analyses at a CLP/NEESA certified laboratory. Comprehensive groundwater sample summaries correlating well numbers, sample numbers, and analytical parameters during each round of groundwater sampling are presented in Section 5.0 (Analytical Results).

3.1.9 Aquifer Testing

The characteristics of the shallow and deep aquifer systems at Camp Allen were tested using two methods: slug testing using the In-Situ Hermit Datalogger/transducer system on all newly installed wells and a deep aquifer test (25-hour) using a submersible pump system in the 4-inch well installed for this purpose (A-MW8B). Specific details and results of the aquifer testing are discussed in Section 4.0 (Physical Results).

3.1.10 Land Survey (Area A)

Previously existing monitoring wells, as well as the eleven newly installed deep wells, one shallow stainless steel well, and new piezometer were surveyed for vertical and horizontal control using the Virginia coordinate system. Other investigation points surveyed for control included surface water and sediment sampling locations, soil sample locations, source characterization boring locations, and geologic boring locations. Additionally, special site features such as building corners, drainage ditches/structures, and roadways were also surveyed for control. A local, licensed surveyor (Miller-Stephenson) performed site surveying activities in July and December of 1992.

3.2 Overview of Area B Activities

Field activities at Area B were conducted as three separate events (Rounds 1, 2, and 3). Field activities conducted at the Area B Landfill included:

- Geophysical Survey (Round 1)
- Geoprobe (In-situ Groundwater) Sampling (Round 1)
- Monitoring Well Installation (Rounds 1, 2, and 3)
- Surface Soil Sampling (Rounds 2 and 3)
- Surface Water/Sediment (Round 2)
- Source Characterization (Round 2)
- Groundwater Sampling (Rounds 1, 2, and 3)
- Slug Tests (Round 2)
- Land Surveying (Rounds 2 and 3)

Round 1 field activities included a geophysical survey, a geoprobe investigation, and installation of deep groundwater monitoring wells with associated groundwater sampling. Round 1 activities were performed in late-April and early-May 1992.

Round 2 activities, performed from May to July 1992, included a surface water/sediment sampling program, collection of surface soil samples, source characterization borings, shallow monitoring well construction, groundwater sampling, aquifer (slug) tests, and a land survey.

Round 3 activities at Area B consisted of additional surface soil sampling, drilling and installation of additional monitoring wells, and a final site land survey. Round 3 activities were performed in December of 1992.

3.2.1 Geophysical Survey (Area B)

Prior to implementing investigation activities at Area B, a geophysical survey was conducted at Area B. Investigation activities included:

- Electromagnetometer Survey - Continuity of the confining clay layer and extent of waste/fill boundaries were investigated by electromagnetic (EM) terrain conductivity profiling. Both shallow and deep penetrating profiling were conducted.

- Ground Penetrating Radar - GPR was used to identify concentrated areas of buried metallic wastes. GPR readings covered Area B on a grid pattern. Preliminary GPR results were used to refine proposed boring locations for the source characterization study.

Specific details and results of the geophysical survey for Area B are detailed in Section 4.0 (Physical Results).

3.2.2 Geoprobe Investigation (Area B)

Prior to shallow monitoring well installation southeast (downgradient) of Area B, a geoprobe investigation was performed in two phases. The initial phase was performed in April 1992, and investigated areas of potential shallow groundwater contamination adjacent to Area B. The second phase was performed in June 1992, and investigated the extent of shallow groundwater contamination identified during the initial phase.

Geoprobe investigation was performed by driving a stainless steel vacuum probe to a depth below the groundwater table. Groundwater samples were screened in the field using a portable Gas Chromatograph (GC) and verbal analytical results provided within approximately 20 minutes. Geoprobe samples were analyzed in the field for selected VOCs including 1,2-dichloroethene (total), trichloroethylene, and benzene.

After sampling, the Geoprobe apparatus was removed and the borehole backfilled with granular bentonite to seal the 1-inch diameter borehole. Geoprobe equipment was decontaminated between sample locations, and equipment blanks and duplicate samples were analyzed throughout the investigation. The geoprobe results were utilized to supplement the rationale for placement of the shallow monitoring wells. Detailed results of the geoprobe investigation are presented in Section 5.0.

3.2.3 Monitoring Well Installation (Area B)

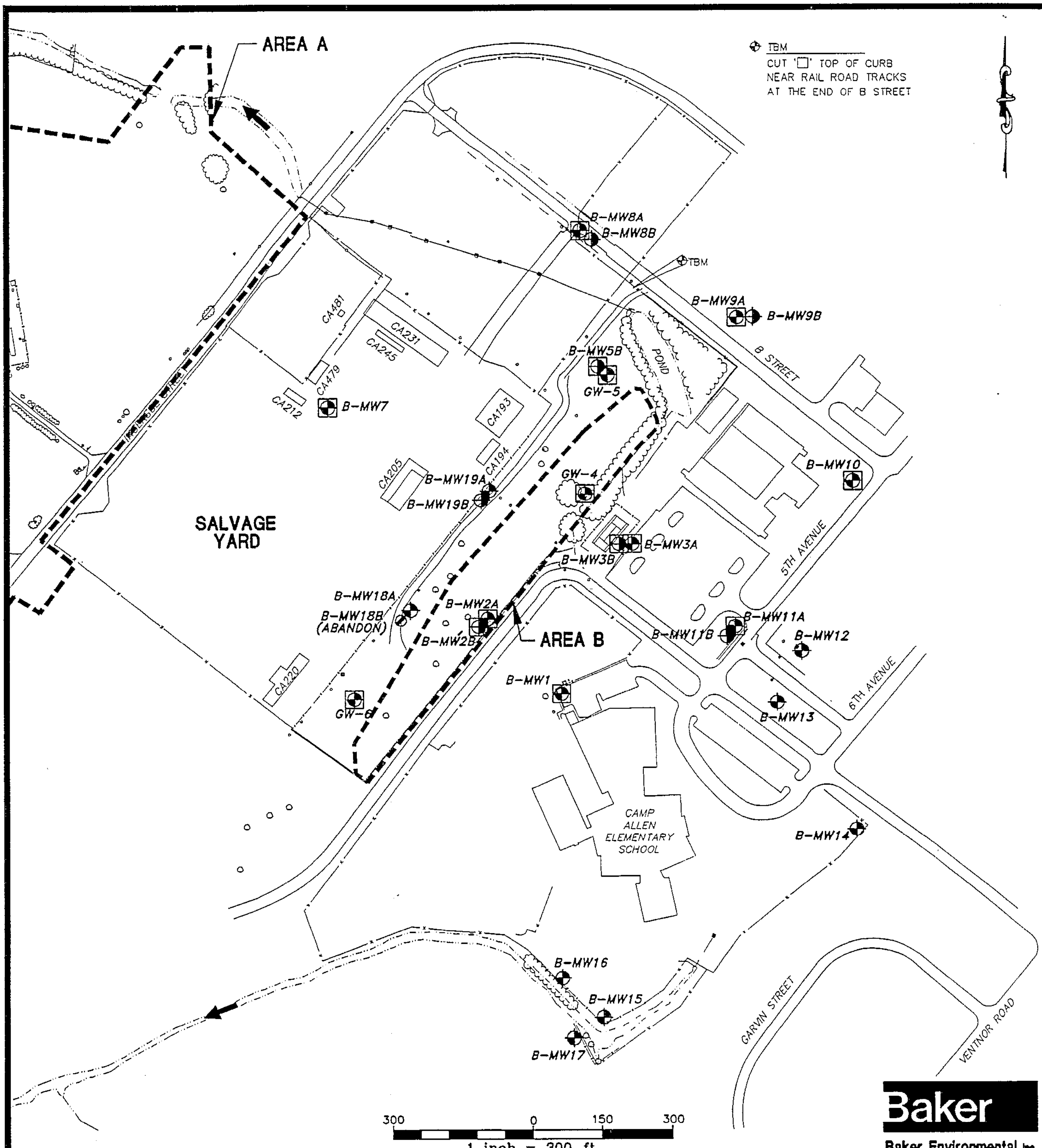
To complement the existing network of monitoring well points at Area B, a series of monitoring wells were constructed within and adjacent to the site. Four deep monitoring wells were installed to monitor the upper portion of the Yorktown Aquifer. Also, eight shallow monitoring wells were installed in the water table aquifer. Existing and newly installed Area B wells are presented in Figure 3-7. Well construction activities are discussed below, and details of the drilling operations are presented in Section 4.0 (Physical Results).

Rounds 1 and 3 Deep Monitoring Well Installation

During Round 1, three 65-foot, Type III, deep monitoring wells (B-MW8B, B-MW9B, and B-MW11B) were installed near existing shallow well locations B-MW8A, B-MW9A, and B-MW11A as nested monitoring points. The wells were nested with the existing shallow wells to characterize water quality in the upper portion of the Yorktown Aquifer.

To evaluate potential contamination in the water table and Yorktown aquifer systems originating from the Camp Allen Salvage Yard, proposed Round 3 well construction was to include the installation of two well nests northwest of Area B, adjacent to the Salvage Yard. These well nests were to include two, Type III, deep wells (B-MW18B and B-MW19B). Monitoring well B-MW19B, installed just south of the storm sewer line crossing Area B, was set at a final depth of 67 feet below grade to characterize groundwater quality in the upper portion of the Yorktown Aquifer.

Proposed monitoring well B-MW18B, located south of the water line crossing the site, was advanced to a depth of 65 feet. However, when a near-surface void developed during drilling (approximately 4 feet by 5 feet and about 4 feet deep), the proposed well point was abandoned because significant shifting of near surface soil/fill materials caused construction and safety concerns. The borehole and the surficial expression of the void were grouted to prevent further enlargement.



LEGEND

A-MW6B EXISTING DEEP MONITORING WELL

A-MW1C NEWLY INSTALLED DEEP MONITORING WELL

A-MW7 EXISTING SHALLOW MONITORING WELL

B-20WSS NEWLY INSTALLED SHALLOW MONITORING WELL

A-MW20B ABANDONED BORING

STREAM FLOW DIRECTION

LIMITS OF AREA A AND AREA B LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-7
MONITORING WELL LOCATIONS
AREA B
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

Rounds 2 and 3 Shallow Monitoring Well Construction

During Round 2, a series of six shallow monitoring wells were installed to determine the extent of groundwater contamination in the water table aquifer. Locations were initially determined during site visit activities and were revised based on the results of the geoprobe groundwater sampling program.

Six shallow monitoring wells (B-MW12, B-MW13, B-MW14, B-MW15, B-MW16, and B-MW17) were installed to depths ranging from 14 to 16 feet below ground surface and have been located as follows:

- B-MW12 - Located in the parking area across 5th Avenue from the Camp Elmore (15th Marine Regiment) Barracks. The flush-mounted well, installed to 14 feet below grade, was placed in this location to characterize the suspected edge of the contaminant plume.

- B-MW13 - Located in the grassy traffic island along C Street near 5th Avenue, the flush-mounted well, installed to 14 feet, was placed in this location to characterize the suspected edge of the contaminant plume in this location.

- B-MW14 - Located on the Camp Allen Elementary School property at the northeast corner fence. The flush-mounted well was installed to 16 feet below ground surface and placed to verify contaminant plume extent in this vicinity.

- B-MW15 - Located at the corner of the Camp Allen Elementary School property where the drainage ditch bends around the ballfield/playground area. The flush-mounted well was installed to 16 feet in this location to characterize shallow groundwater quality.

- B-MW16 - Located adjacent to the southern ballfield. The flush-mounted well was installed to 16 feet in this location to determine the extent of the contaminant plume established during the geoprobe investigation.

- B-MW17 - Located between wells B-MW-15 and B-MW16 on the southern bank of the drainage ditch. This flush-mounted well was installed to 14 feet in this location to confirm the extent of the contaminant plume.

Two shallow monitoring wells were installed during Round 3 Activities. Well B-MW18A was advanced to 15 feet and completed north of the water line crossing the southern end of the site and adjacent to abandoned B-MW18B. Well B-MW19A also was advanced to a depth of 15 feet and was completed north of the storm sewer line crossing the northern end of the site in association with deep well B-MW19B.

Both wells were screened to intercept the water table so that water quality at the soil/water interface of the surficial aquifer could be characterized. Drilling was conducted in Level B protective equipment due to the potentially hazardous nature of the landfilled materials.

3.2.4 Surface Soil Sampling (Area B)

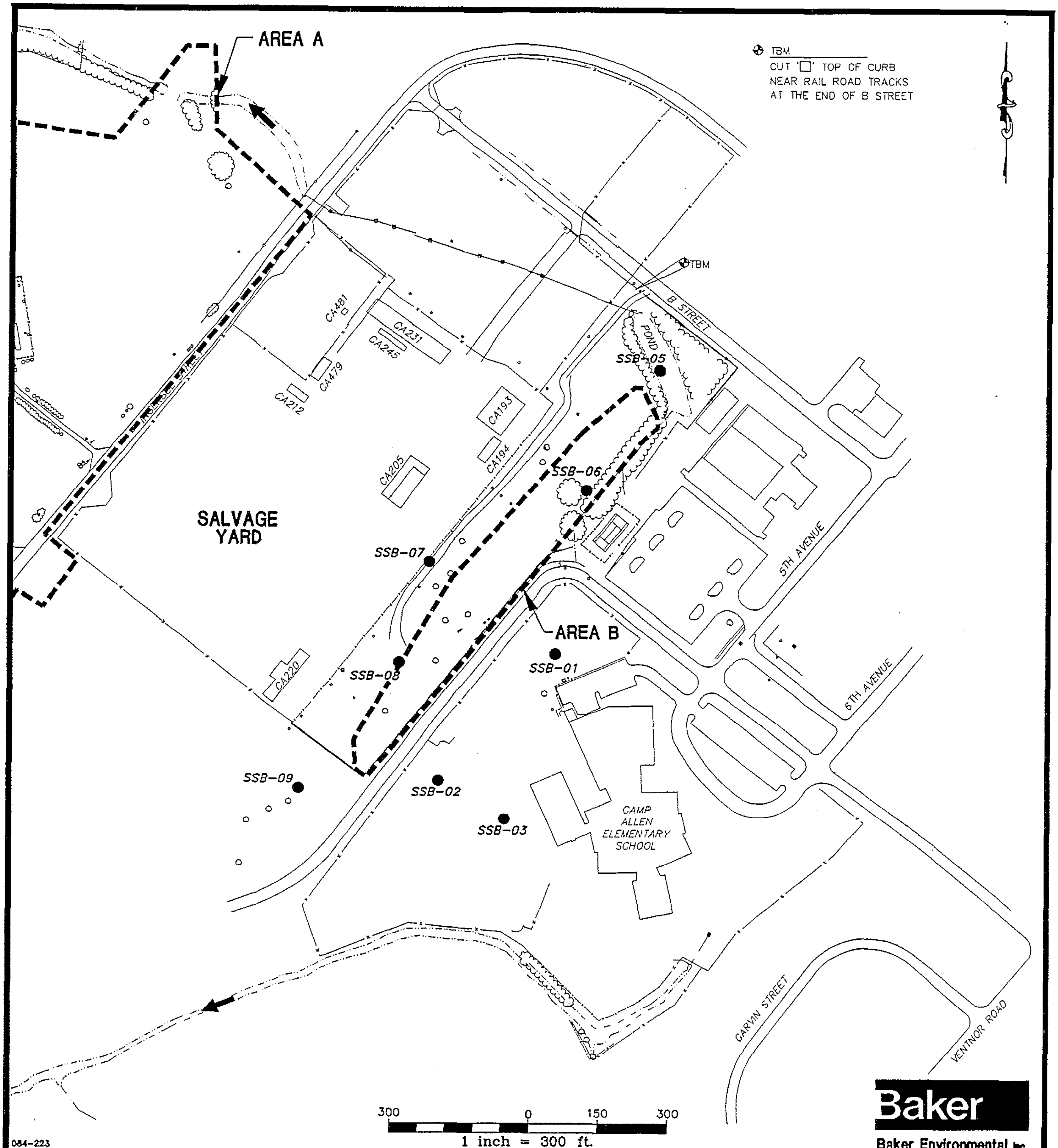
During Round 2, surface soil samples were collected as discrete grab samples from a depth of 0 to 1.0 feet below ground surface in the vicinity of the schoolyard adjacent to Area B. A total of three samples (SSB-01 through SSB-03) were submitted to the laboratory for analysis of TAL metals only. Round 2 soil sampling at the schoolyard was performed in order to address a request to characterize metal concentrations in surface soils. This request was reportedly made at a Norfolk Naval Base Technical Review Committee meeting in 1991.

During Round 3, five shallow (0 to 0.5 feet) surface soil samples (SSB-05 through SSB-09) were collected as discrete grab samples in the vicinity of Area B. Soil samples were analyzed for TCL and TAL parameters. Sample locations were based on preliminary geophysical and analytical results.

Soil sample locations for Area B are presented on Figure 3-8. Analytical results are presented in Section 5.0.

3.2.5 Surface Water/Sediment Sampling (Area B)

During Round 2, surface water samples were obtained from five locations (SWA-01 through SWA-05) in the vicinity of previous investigation sample locations and were analyzed for TCL and TAL parameters. A total of eight sediment samples were submitted for analysis of TCL and TAL parameters. Shallow sediment samples were collected as discrete grab samples from six locations at a depth of 0 to 0.5 feet (SDB-01S through SDB-06S). Additionally, two deep



LEGEND

SSB-05 SURFACE SOIL SAMPLE LOCATION

STREAM FLOW DIRECTION

LIMITS OF AREA A AND AREA B LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-8
SURFACE SOIL SAMPLE LOCATIONS
AREA B
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

sediment samples (SDB-04D and SDB-05D) were collected as discrete grab samples from a depth of 0.5 to 1.0 feet .

Surface water and sediment sample locations are presented in Figure 3-9. Please note that surface water/sediment samples (SWA/SDA-08 and SWA/SDA-12[S][D]) were originally to be collected in Area A; however, due to field modifications these samples were collected in Area B in order to characterize conditions in the drainage ditch behind the Camp Allen Elementary School. Sample details and analytical results are presented in Section 5.0.

3.2.6 Source Characterization Borings (Area B)

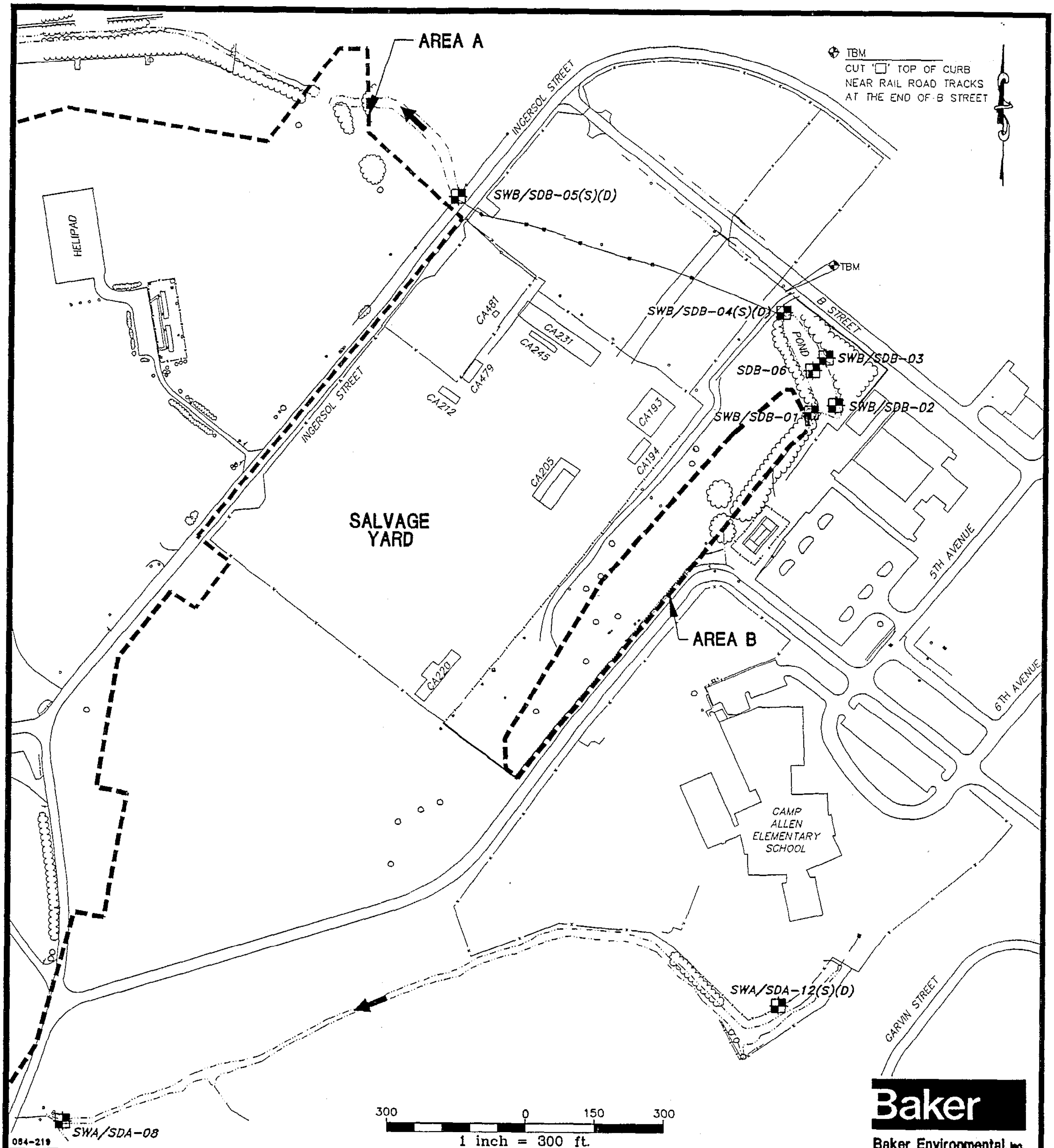
Ten borings (SBB-01 through SBB-10) were advanced to depths ranging from 8 to 10 feet to characterize sources of contamination at Area B. Soil samples were screened for volatile organic vapors using an HNu photoionization detector (PID) and visually described in the field logbook. Based on a "worst case" or "biased" sampling scheme, one subsurface soil sample from each borehole was submitted to the laboratory for chemical analysis. Chemical analyses included TCL and TAL parameters.

Boring locations were based on preliminary results of the geophysical survey. Due to the potentially hazardous nature of the landfilled materials, drilling was performed in Level B personal protective equipment. Borings were grouted to ground surface subsequent to drilling activities. Source characterization boring locations are provided in Figure 3-10.

3.2.7 Groundwater Sampling (Area B)

Round 1 Groundwater Sampling

After well development, the three, newly installed, 65-foot deep wells (B-MW8B, B-MW9B, and B-MW11B) were sampled during Round 1. Field verification groundwater sampling was conducted, as the deep wells were constructed to evaluate potential modification in location or depth of remaining deep wells. Wells were developed and sampled not less than 24 hours after installation. Samples were analyzed for VOCs using EPA Method 601.



LEGEND

SWA/SDA-08 — SURFACE WATER/SEDIMENT SAMPLE LOCATION

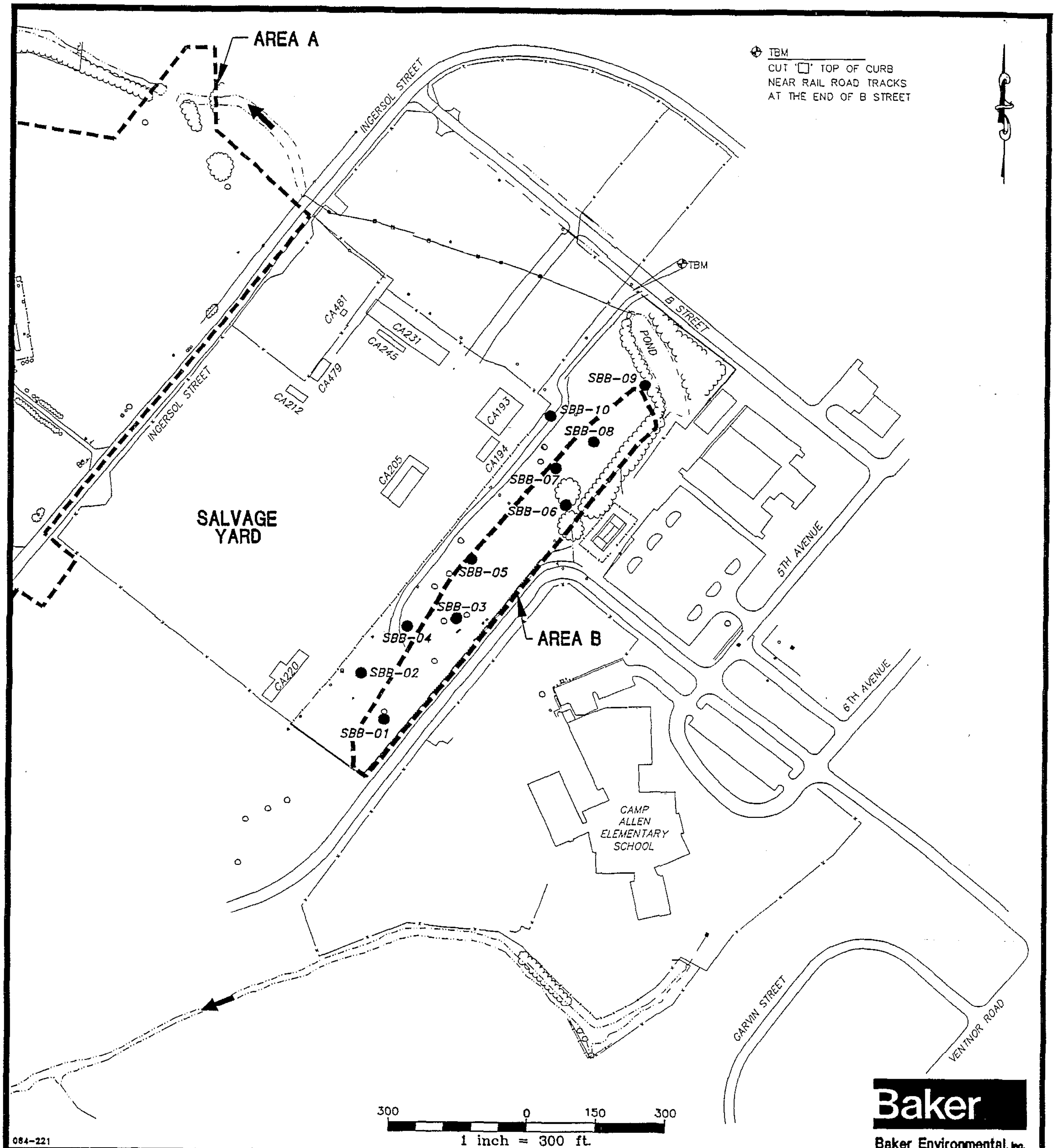
SWB/SDB-04(S)(D) — SHALLOW SEDIMENT SAMPLE LOCATION (0 TO 0.5 FEET); DEEP SEDIMENT SAMPLE LOCATION (0.5 TO 1.0 FEET)

STREAM FLOW DIRECTION

LIMITS OF AREA A AND AREA B LANDFILLS

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-9
SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
AREA B
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



Baker

Baker Environmental, Inc.

LEGEND

SSA-01 ● SOURCE CHARACTERIZATION BORING LOCATION

← STREAM FLOW DIRECTION

– – – LIMITS OF AREA A AND AREA B LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-10
SOURCE CHARACTERIZATION BORING LOCATIONS
AREA B
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

Round 2 Groundwater Sampling

Seventeen (17) shallow and six deep groundwater monitoring wells were sampled and analyzed for TCL and TAL (total and dissolved) compounds. Sampling occurred in June 1992 after all wells were installed and developed.

Round 3 Groundwater Sampling

Groundwater samples collected from the three, newly installed, Round 3 wells were analyzed for both TCL and TAL (total and dissolved) parameters. In addition, the three deep monitoring wells (B-MW8B, 9B, and 11B) installed during Round 2, the three existing deep wells (B-MW2B, 3B, and 5B) installed during the Interim RI, and the six, newly-installed (Round 2), shallow monitoring wells were sampled for TCL volatile organic compounds only. Monitoring well GW-4 was also resampled for TCL VOCs, in order to verify previous (Round 2) results.

In summary, Round 1 groundwater sampling included the analysis of three groundwater samples for VOCs by a non-CLP/NEESA laboratory. Round 2 consisted of groundwater sampling and analysis of TCL and TAL (total and dissolved) parameters for 23 wells. Round 3 consisted of the sampling of groundwater from all seven deep monitoring wells, newly-installed shallow wells, and GW-4 for TCL VOCs. Additionally, wells constructed during Round 3 were sampled for TCL and TAL (total and dissolved) parameters.

Monitoring well construction, development, and purging, as well as groundwater sampling procedures, are detailed in the approved project plans and in Section 4.0 (Physical Results). Comprehensive groundwater sample summaries correlating well numbers, sample numbers, and analytical parameters for each round of groundwater sampling are presented in Section 5.0 (Analytical Results).

3.2.8 Aquifer Testing

The characteristics of the shallow (water table) and deep aquifer systems near Area B were tested using the In-Situ Hermit Datalogger/transducer system on all newly-installed wells. Aquifer testing detail is presented in Section 4.0 (Physical Results).

3.2.9 Land Survey

Fourteen existing monitoring wells and twelve newly-installed monitoring wells were surveyed for vertical control and horizontal control. Additionally, 10 test boring locations, five surface water and sediment locations, and eight surface soil locations were surveyed. Also, appropriate surface features were surveyed for site plan control. Surveying was performed in July and December 1992.

3.3 Air Sampling Program

3.3.1 General Overview

From January 12 through 14, 1993, air sampling was performed at and around the Camp Allen Landfill (CAL) to provide analytical support in the assessment of potential health risks from certain volatile organic compounds. These compounds (as identified in previous studies) have the potential to become airborne and escape the confines of the landfill. The primary study area focused on the Brig Facility because of the proximity of potential receptors. Potential receptors have been identified based on evaluation of data collected during the review of historical information and the preliminary findings from the Remedial Investigation. In addition to the sampling scheme designed specifically for the Brig Facility (10 indoor area locations and one outdoor point source), five locations were chosen in the Camp Allen Elementary School as a precautionary measure, given data obtained from the Remedial Investigation. Five ambient sampling locations were also positioned (two upwind and three downwind) to monitor the ambient conditions during the study.

The state of Virginia does not have applicable regulations governing the volatile organic compounds related to this study; therefore, comparisons to the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), and the National Ambient Volatile Organic Compounds Database (discussed in Section 2.7.1) will serve as guidance. Based on previous investigations, volatile organic compounds are the primary constituents of concern at the Camp Allen Landfill Site. However, an investigation into applicable air regulations for the state of Virginia or the city of Norfolk revealed only the National Ambient Air Quality Criteria, which do not include many of the analytical parameters under the scope of this study.

An OSHA Time-Weighted Average (TWA) PEL is the average, airborne exposure concentration that employees must not exceed during any eight-hour work shift of a 40-hour workweek. The ACGIH Time-Weighted Average (TWA) TLV is also considered an average concentration for a normal eight-hour workday and a 40-hour workweek, that nearly all workers may be repeatedly exposed to day after day, without an adverse effect. For the purposes of this report, an adjusted TWA-PEL and TWA-TLV for a twelve-hour versus an eight-hour workday, has been provided to more appropriately reflect the workday for potential receptors at the Brig Facility. For consistency purposes, these adjusted TWAs will also be used for the Camp Allen Elementary School (CAES). Table 3-1 provides a listing of the eight and twelve-hour TWA-PELs and TWA-TLVs, respectively, for each constituent of concern. For comparison purposes, an Action Level (half of the twelve-hour TWA) has been used to demonstrate the level at which some type of "action" would be taken to lessen or eliminate an individual's exposure. This action includes administrative controls, engineering measures, or as a last or interim resort, the use of personal protective equipment. Please note that the standards have been converted to parts per billion by volume (ppbv), so that they may be readily compared to the detected concentrations.

3.3.2 EPA Compendium Method TO-14

Samples collected during the investigation followed the procedures specified in the United States Environmental Protection Agency's (USEPA) Compendium Method TO-14, which is applicable for the determination of a wide variety of volatile organic compounds. This method was specifically established for the collection of whole air samples in SUMMA electropolished, stainless steel canisters.

The SUMMA canister was used in the passive sampling mode, which requires that the canister is initially evacuated (subatmospheric pressure) and attached to a mass flow controller to regulate the flow over a specified period of time.

Samples were collected over an eight-hour period on three consecutive days. The same mass flow controller was used at each station, to avoid cross-contamination. Each day a trip blank was collected for quality control measures. The samples were shipped to the laboratory, then analyzed by gas chromatography/mass spectrometry (GC/MS) SCAN, which has provided detection limits ranging primarily from 0.2 to 0.8 ppbv. However, in a few instances (due to the dilution of the sample) the detection limits ranged from 10 to 240 ppbv. A list of the target analytes and detection limits is included as Table 3-2.

TABLE 3-1

SUMMARY OF REGULATORY AIR QUALITY STANDARDS FOR THE CAMP ALLEN LANDFILL

Chemical Name	Actual Values		Adjusted Values		Action Levels	
	OSHA-PEL	ACGIH-TLV	OSHA-PEL	ACGIH-TLV	PEL	TLV
Dichlorodifluoromethane	$1x10^6$	$1x10^6$	666,667	666,667	333,334	333,334
Chloromethane	50,000	50,000	33,333	33,333	16,667	16,667
Bromomethane	5,000	5,000	3,333	3,333	1,667	1,667
Freon 113	$1x10^6$	$1x10^6$	666,667	666,667	333,334	333,334
Methylene Chloride	25,000	50,000	16,667	33,333	8,334	16,667
Chloroform	2,000	10,000	1,333	6,667	667	3,334
1,1,1-Trichloroethane	350,000	350,000	233,333	233,333	116,667	116,667
Benzene	1,000	10,000	667	6,667	334	3,334
Toluene	100,000	50,000	66,667	33,333	33,334	16,667
Tetrachloroethene	25,000	50,000	16,667	33,333	8,334	16,667
Ethylbenzene	100,000	100,000	66,667	66,667	33,334	33,334
m-/p-Xylene	100,000	100,000	66,667	66,667	33,334	33,334
o-Xylene	100,000	100,000	66,667	66,667	33,334	33,334
Styrene	50,000	50,000	33,333	33,333	16,667	16,667
1,4-Dichlorobenzene	75,000	75,000	50,000	50,000	25,000	25,000
Benzyl Chloride	1,000	1,000	667	667	334	334
Freon 114	$1x10^6$	$1x10^6$	666,667	666,667	333,334	333,334
Trichlorofluoromethane	$1x10^6$	$1x10^6$	666,667	666,667	333,334	333,334
1,3,5-Trimethylbenzene	25,000	25,000	16,667	16,667	8,334	8,334
1,2,4-Trimethylbenzene	25,000	25,000	16,667	16,667	8,334	8,334
1,2,4-Trichlorobenzene	1,000	5,000	667	3,333	334	1,667
Hexachlorobutadiene	20	20	13	13	7	7

Note: All values reported in parts per billion. "Action levels" (1/2 of the adjusted PEL or TLV).

TABLE 3-2

TARGET ANALYTES AND DETECTION LIMITS

Compound	Approximate Detection Limit (ppbv)	Compound	Approximate Detection Limit (ppbv)
Dichlorodifluoromethane	0.2	1,1,2-Trichloroethane	0.2
Chloromethane	0.2	Tetrachloroethene	0.2
Vinyl chloride	0.2	1,2-Dibromomethane	0.2
Bromomethane	0.2	Chlorobenzene	0.2
Chloroethane	0.2	Ethylbenzene	0.2
1,1-Dichloroethene	0.2	m- and/or p-Xylene	0.2
Freon 113*	0.2	o-Xylene	0.2
Methylene Chloride	0.2	Styrene	0.2
1,1-Dichloroethane	0.2	1,1,2,2-Tetrachloroethane	0.2
c-1,2-Dichloroethene	0.2	1,3-Dichlorobenzene	0.1
Chloroform	0.2	1,4-Dichlorobenzene	0.1
1,1,1-Trichloroethane	0.2	Benzyl Chloride	0.2
Carbon tetrachloride	0.2	1,2-Dichlorobenenze	0.1
Benzene	0.2	Freon 114**	0.2
1,2-Dichloroethane	0.2	Trichlorofluoromethane	0.2
Trichloroethene	0.2	1,3,5-Trimethylbenzene	0.2
1,2-Dichloropropane	0.2	1,2,4-Trimethylbenzene	0.2
c-1,3-Dichloropropene	0.2	1,2,4-Trichlorobenzene	0.1
Toluene	0.2	Hexachlorobutadiene	0.1
t-1,3-Dichloropropene	0.2		

ppbv = parts per billion by volume
* Freon 113 = 1,1,2-Trichloro-1,2,2-trifluoroethane
** Freon 114 = 1,2-Dichloro-1,1,2,2-Tetrafluoroethane

3.3.3 Air Sampling Locations

Sampling conducted at the Brig consisted of 10 indoor area stations (within four Brig buildings) and one outdoor point-source station connected in-line to a gas monitoring station (B-8).

Indoor sampling stations were chosen based on the following information (refer to Table 3-3 and Figures 3-11, 3-12 and 3-13 for rationale and station locations, respectively):

- The amount of personnel activity taking place within each building, the estimated duration, and acute versus chronic exposure conditions.

- The proximity of the buildings to various "hot spots" determined from soil/groundwater analyses and gas monitoring stations, as volatile emissions from control points are likely to be higher than emissions from the site surface.

- The flow of groundwater and potential migration of contaminants both horizontally and vertically, as contaminated soils represent a source of potential air emissions via the transfer of contaminants in the atmosphere.

- The network of various utilities (i.e., sanitary/storm sewers, steam lines, electric lines, and water lines), because of potential air pathway emissions resulting from the utility design. In addition to utility intakes, the construction of the building foundations and wall sections were preliminarily evaluated for potential air pathways for volatile emissions.

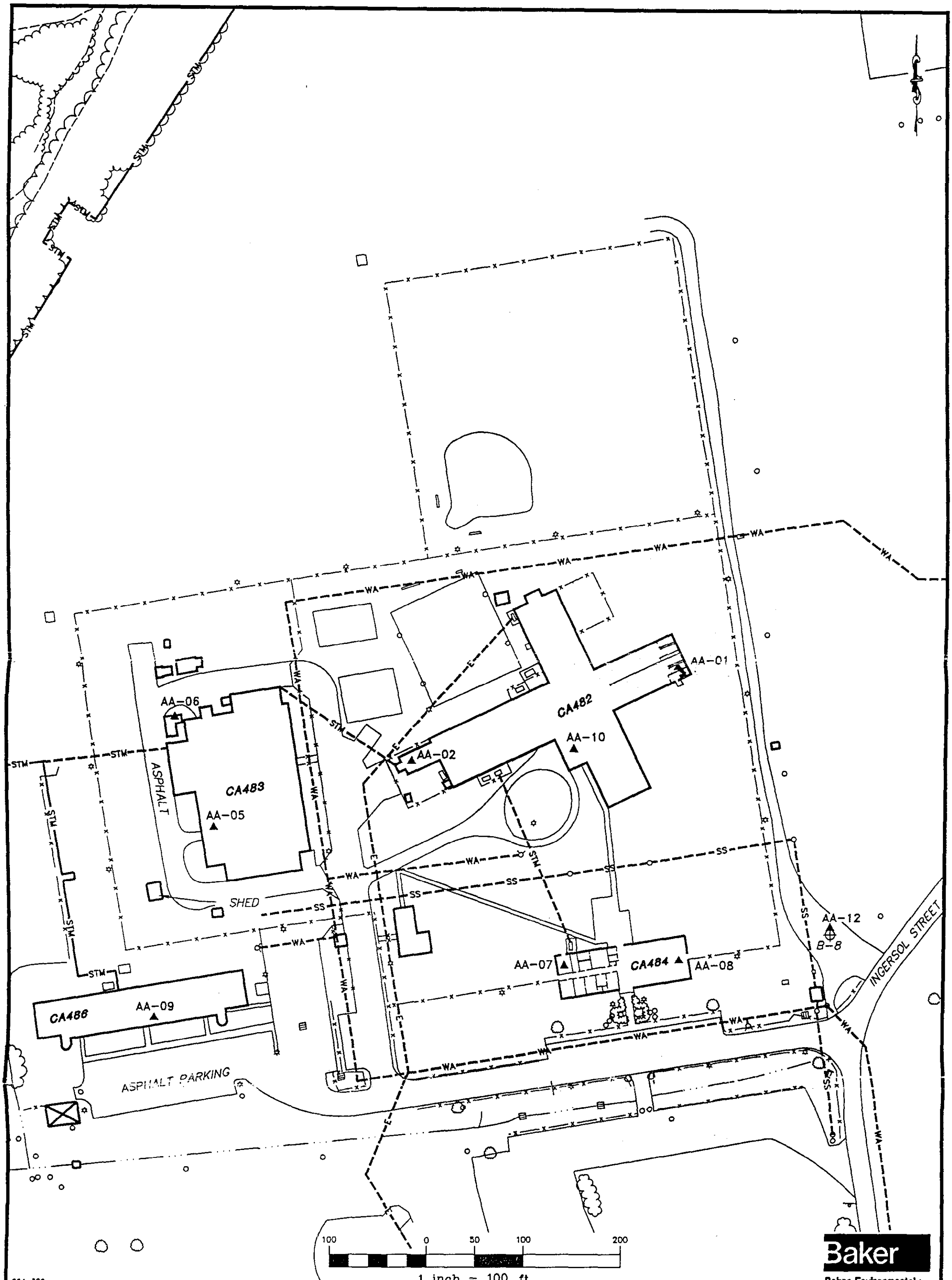
The outdoor point source location was chosen based on monitoring results from previous studies that identified gas monitoring station B-8 as detecting contaminants of concern.

It is important to note that some of the predetermined air sampling stations within the Brig were changed after a walk-through performed on January 11, 1993. The rationale for relocating the predetermined stations was based on the level of personnel activity taking place, the potential air pathway for volatile emissions and the proximity of the sampling station to suspected contaminant migration.

TABLE 3-3

AIR SAMPLING LOCATIONS: BRIG FACILITY (AREA A)

Building Number	Floor	Level	Sample Designation	Comments (Rationale)
CA 482	First	Breathing Zone	AA-01	Lavatory area near dormitory 2A. Utility network and potential air emission pathway.
CA 482	First	Ground	AA-02	Near utility network (steam) in kitchen. Potential air emission pathway and chronic exposure conditions.
CA 482	Second	Ground	AA-03	Lavatory area in dormitory 2B next to pipe chaise. Utility network and potential air emission pathway.
CA 482	Third	Breathing Zone	AA-04	C-Deck near cleaning gear room. Utility network and potential air emission pathway.
CA 483	First	Breathing Zone	AA-05	Laundry area - west wall. Proximity of building to determined "Hot Spot," potential air emission pathway, and chronic exposure conditions.
CA 483	First	Ground	AA-06	Boiler room. Proximity of building to determined "Hot Spot," steam line network, potential air emission pathway, and chronic exposure conditions.
CA 484	First	Ground	AA-07	Boiler room over grate. Proximity of building to determined "Hot Spot," potential air emission pathway, and chronic exposure conditions.
CA 484	First	Breathing Zone	AA-08	Eastern corridor of building, proximity of building to determined "Hot Spot," potential air emission pathway, and chronic exposure conditions.
CA 486	First	Breathing Zone	AA-09	Quarterdeck, high activity area. Proximity of building to "Hot Spot," potential air emission pathway, and chronic exposure conditions.
CA 482	First	Breathing Zone	AA-10	Control room (quarter deck), high activity area. Potential air emission pathway.
CA 486	Second	Breathing Zone	AA-11	Dormitories, high activity area. Potential air emission pathway and chronic exposure conditions.
B-8	NA	Ground	AA-12	Gas monitoring station. Potential emission source.



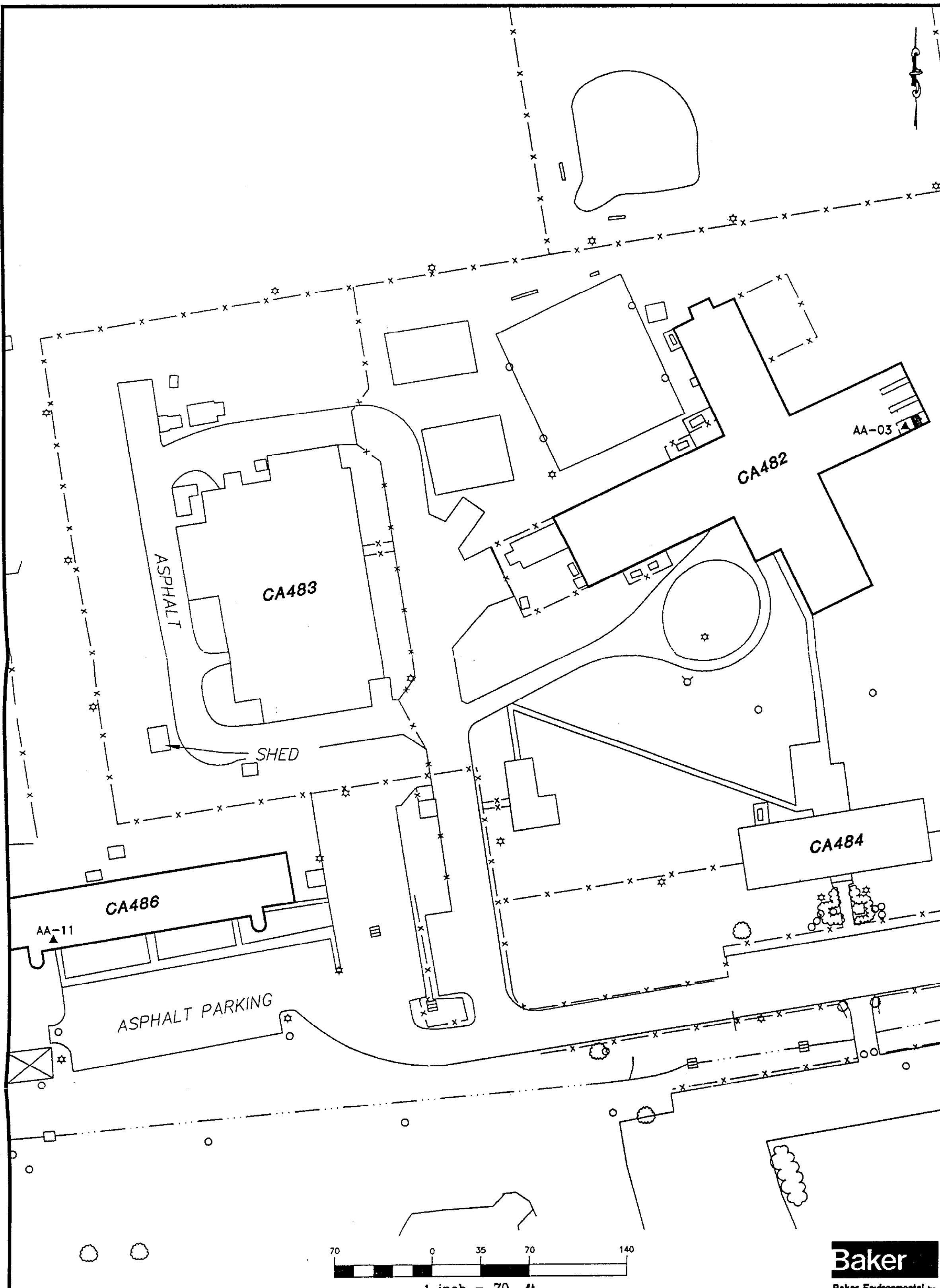
LEGEND

AA-01 ▲	LOCATION OF SUMMA CANISTER
B-8	GAS WELL
——SS——	APPROXIMATE LOCATION OF SANITARY SEWER
——S——	APPROXIMATE LOCATION OF STORM SEWER
——STM——	APPROXIMATE LOCATION OF STEAM LINE
——E——	APPROXIMATE LOCATION OF ELECTRIC LINE
——WA——	APPROXIMATE LOCATION OF WATER LINE
————	FIRST FLOOR BUILDING OUTLINE

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-11
AIR SAMPLING LOCATIONS (FIRST FLOOR)
AND UTILITY DETAIL
CAMP ALLEN BRIG FACILITY (AREA A)

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

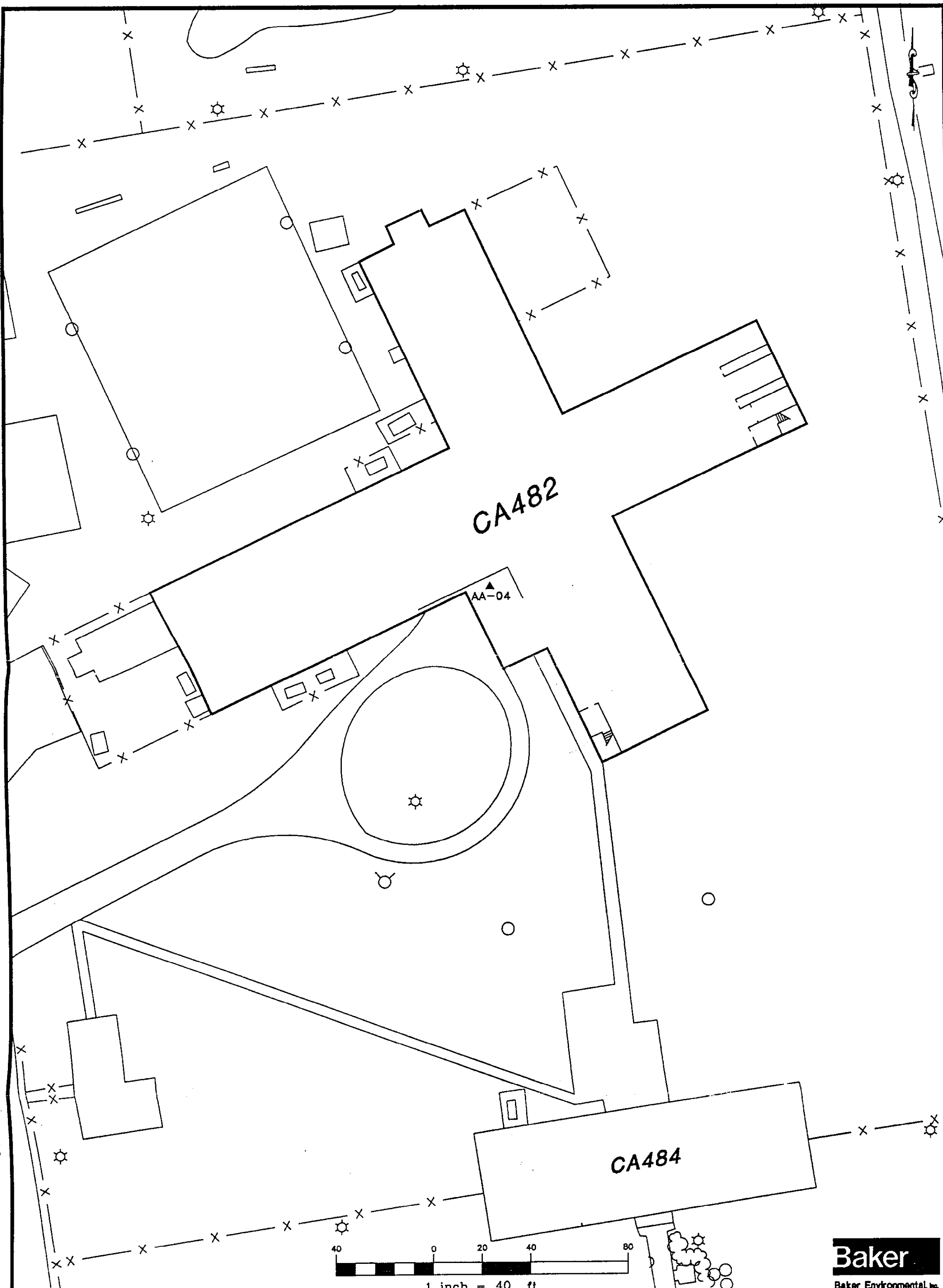
AA-03 ▲ LOCATION OF SUMMA CANISTER

—— SECOND FLOOR BUILDING OUTLINE

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-12
AIR SAMPLING LOCATIONS (SECOND FLOOR)
CAMP ALLEN BRIG FACILITY (AREA A)

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

AA-04 ▲ LOCATION OF SUMMA CANISTER

—— THIRD FLOOR BUILDING OUTLINE

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-13
AIR SAMPLING LOCATIONS (THIRD FLOOR)
CAMP ALLEN BRIG FACILITY (AREA A)

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

Based on previous investigation results, volatile organic contaminants in the shallow groundwater appear to be migrating in a southerly direction along both the underground utility conduit for the storm sewer system (located adjacent to the eastern portion of the school) and an underground water pipeline that trends southeast from the Salvage Yard area. Therefore, as a precautionary measure, sampling stations were placed within the CAES.

Sampling conducted at the CAES consisted of five stations located within Sections A, B, D, and the Annex. Based on the suspected migration of contaminants and the factors listed below, no air sampling station was established in Section C.

Sampling stations were selected based on the following factors (refer to Table 3-4 and Figure 3-14 for rationale and station locations, respectively):

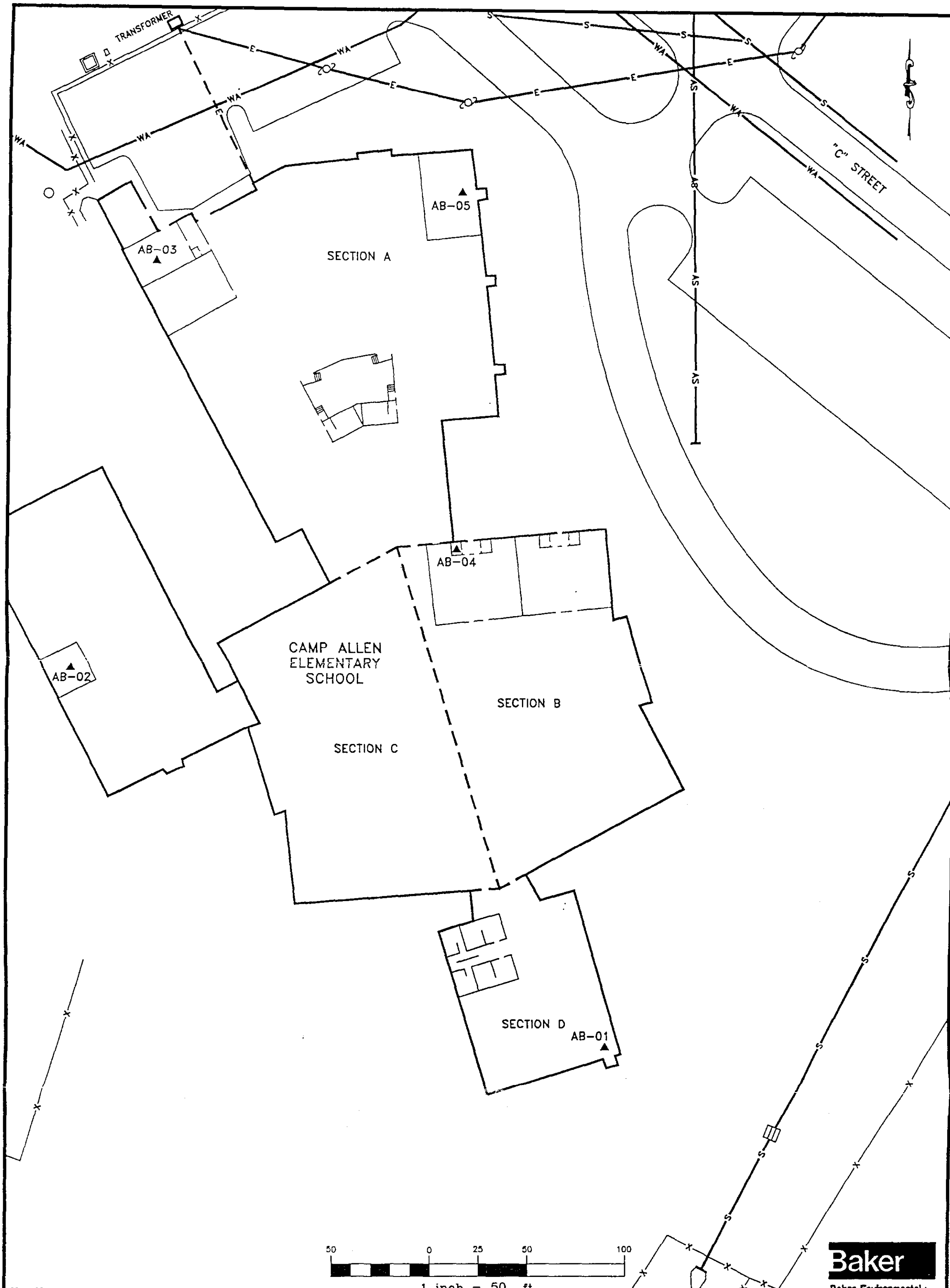
- Detection of volatile organics in the shallow groundwater
- Shallow groundwater flow direction
- Underground conduits present in the surrounding area
- Underground utility hook up areas at the CAES

It is important to note that two of the predetermined air sampling stations within the CAES were changed after a walk-through performed on January 11, 1993. The rationale for relocating the predetermined stations was based on the level of personnel activity taking place, the potential air pathway for volatile emissions and the proximity of the sampling station to suspected contaminant migration.

Wind direction and speed are the primary factors governing transport of air contaminants (gases/vapors). Therefore, wind rose data (prepared for the Federal Aviation Administration for wind direction versus wind speed for all weather conditions in the Norfolk Virginia Airport area) were consulted to supplement the rationale for the outdoor ambient air sampling and placement of the SUMMA canisters.

Additional information was utilized to support the rationale for sample station placement and is outlined below.

- All ceiling and visibility conditions were assessed. Wind direction versus wind speed tables depicting daytime distributions for six ceiling visibility classes were also reviewed based on the time and duration of the proposed air sampling program.



LEGEND

AB-01 ▲	LOCATION OF SUMMA CANISTER
——S——	APPROXIMATE LOCATION OF ACTIVE STORM SEWER
——AS——	APPROXIMATE LOCATION OF ABANDONED STORM SEWER
——E——	APPROXIMATE LOCATION OF ELECTRIC LINE (ABOVE/BELOW)
——WA——	APPROXIMATE LOCATION OF WATER LINE
————	FIRST FLOOR BUILDING OUTLINE

SOURCE: LANTDIV, OCT. 1991

FIGURE 3-14
AIR SAMPLING LOCATIONS AND UTILITY DETAIL
CAMP ALLEN ELEMENTARY SCHOOL (AREA B)

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

TABLE 3-4

AIR SAMPLING LOCATIONS: CAMP ALLEN ELEMENTARY SCHOOL (AREA B)

Building Number	Section	Level	Sample Designation	Comments (Rationale)
CAES	Section D	Breathing Zone	AB-01	Southeast corner of gymnasium. Groundwater flow and proximity of building to potential air emission pathway.
CAES	Annex	Breathing Zone	AB-02	Classroom #32. Potential air emission pathway. Heating/cooling unit draws air from outside, separate from ventilation Sections A through D.
CAES	Section A	Ground	AB-03	Maintenance area. Utility network, air emission pathway, and potential exposure conditions.
CAES	Section B	Breathing Zone	AB-04	Classrooms 1 and 2. Groundwater flow, air emission pathway, and potential exposure conditions.
CAES	Section A	Breathing Zone	AB-05	Classrooms K5 and K6. Utility network and air emission pathway.

- Air releases can potentially occur from volatilization of contaminated soils from covered landfills (with and without internal gas generation). Temperature, atmospheric pressure, and ground cover influence the rate of air releases. With increasing temperatures, decreasing pressures, and permeable ground cover, the rate of volatilization of compounds tends to increase.

- Ambient air quality is also dependent on background conditions, which include potential off-site (unrelated) sources. As the Camp Allen Site is close to the Naval Air Station and a major highway (both located to the North), ambient air sampling locations must also address potential upwind/downwind variations possibly caused by off-site sources. Therefore, ambient air sampling locations were repositioned and increased (from 3 to 5 stations) based on site concerns and present wind directions. Figure 3-15 presents ambient air sampling locations, and Table 3-5 provides a summary and rationale for ambient air sampling locations.

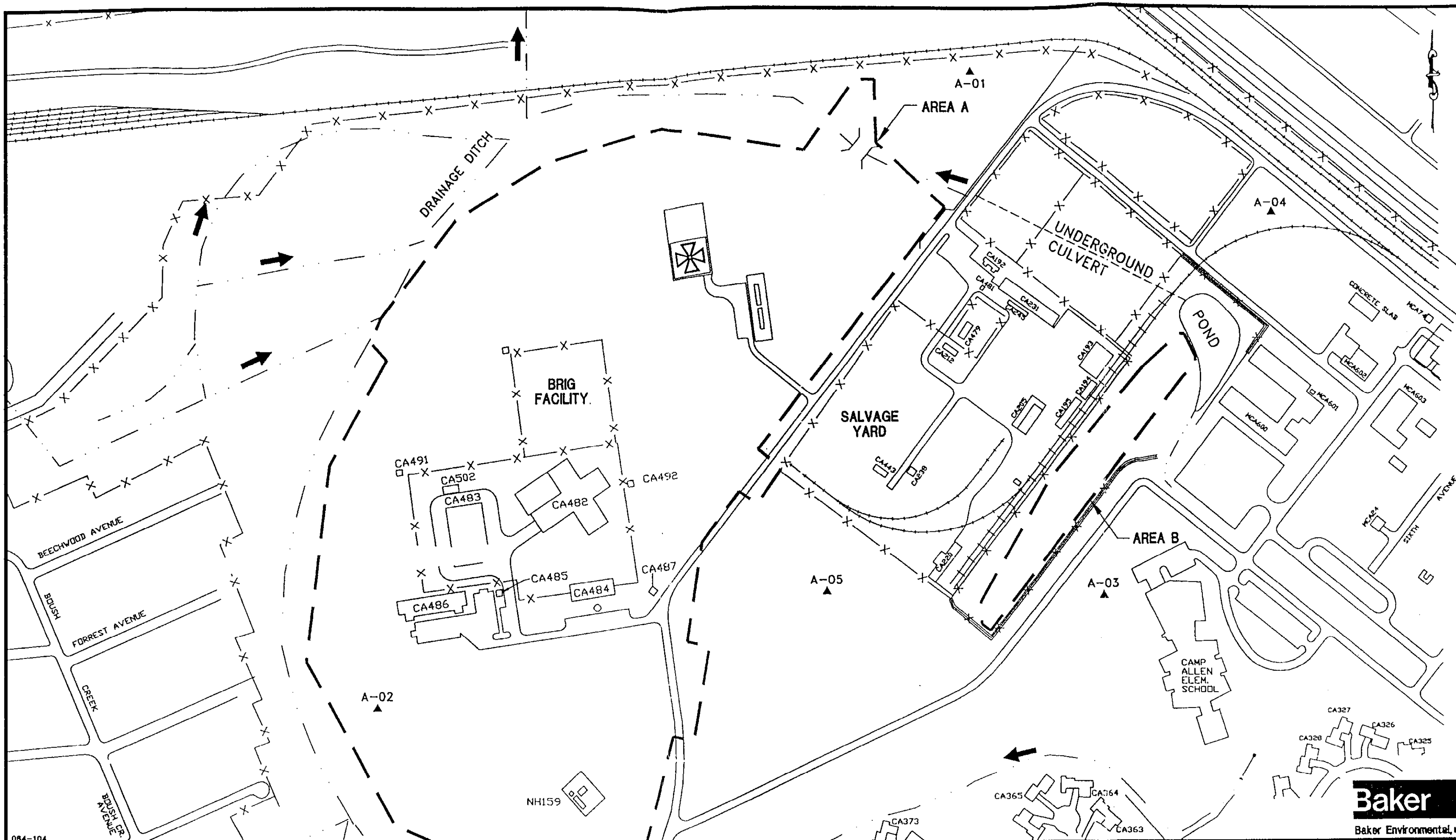
It should be noted that during Rounds A(1) and C(3) wind directions were primarily from the north, northeast. Round B(2) wind directions originated from the south, southwest.

3.4 Quality Assurance/Quality Control

The primary objectives of the Quality Assurance (QA) evaluations are to: (1) assess the adequacy of the procedures used in the field, (2) evaluate the accuracy and precision of the laboratory analyses, (3) determine completeness of the information gathered, and (4) ensure the quality, integrity, and representativeness of the samples. The data for the environmental and associated Quality Control (QC) samples collected during sampling efforts at the Camp Allen Landfill Site have been reviewed by an independent subcontractor (AWD Technologies).

Samples collected during the field program were shipped for laboratory analysis to Wadsworth/ALERT Laboratories (soil/sediment and water) located in Canton, Ohio and IT Corporation (air) located in Cincinnati, Ohio. Wadsworth/ALERT Laboratories and IT Corporation are members of the USEPA Contract Laboratory Program (CLP) and are also certified/approved by the Naval Energy and Environmental Support Activity (NEESA).

Sample analysis performed by Wadsworth/ALERT included Target Compound List (TCL) volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs),



LEGEND

A-01 LOCATION OF SUMMA CANISTER

STREAM FLOW DIRECTION

LIMITS OF AREA A AND AREA B LANDFILL

SOURCE: LANTDIV, OCT. 1991

300 0 150 300 600

1 inch = 300 ft.

FIGURE 3-15
AMBIENT AIR SAMPLING LOCATIONS
CAMP ALLEN LANDFILL
(AREAS A AND B)

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

TABLE 3-5

AMBIENT AIR SAMPLING LOCATIONS: CAMP ALLEN LANDFILL (AREAS A & B)

Ambient Air Location	Level	Sample Designation	Comments (Rationale)*
Northeast of CA Heliport	Breathing Zone	A-01	Upwind of predicted wind direction. Background sample point.
Southwest of CA 486	Breathing Zone	A-02	Based on wind direction, wind rose, historical information, and analytical results. Downwind of predicted wind direction for Area A.
South of CAES	Breathing Zone	A-03	Based on wind direction, wind rose, historical information, and analytical results. Lateral (west) of predicted wind direction and downwind of Area B.
North of Area B	Breathing Zone	A-04	Upwind of predicted wind direction. Background sample point.
South of Salvage Yard	Breathing Zone	A-05	Based on wind direction, wind rose, historical information, and analytical results. Lateral (west) of predicted wind direction and downwind of Areas A and B.

*NOTE: During the second round of sampling (Round B), the wind shifted from the prevailing north-northeast direction to a south-southwest direction, switching upwind and downwind locations.

Pesticides/PCBs, and total and dissolved Target Analyte List (TAL) metals. In addition, wet chemistry and engineering parameters were also analyzed. Sample analysis performed by IT Corporation included VOCs via USEPA Compendium Method TO-14. To date, NEESA has not certified a laboratory for the analysis of air samples; therefore, the selection of the laboratory subcontractor was based on the laboratory's qualifications, personnel experience in the analysis of air samples, the availability of the laboratory equipment, and the cost effectiveness of the analysis as determined by a competitive bidding process. In addition, a review of the laboratory's Quality Assurance Plan was performed prior to the analyses. NEESA was notified of the laboratory for the project and provided approval.

Field analysis and analysis of non-NEESA parameters were also performed in order to verify field conditions during investigation activities and to gather information related to risk assessment and feasibility study evaluation activities. The QA/QC performed on non-NEESA parameters was performed according to the utilization of the data.

3.4.1 Overview of QA/QC

Tables 3-6 and 3-7 present information regarding analytical methods, a summary of containers, and holding times for water and soil/sediment samples, respectively. The air samples have not been included in the summary tables because the preservation requirements and holding times are not applicable. The SAP and the QAPP for the Camp Allen Landfill Final Work Plan (Baker, April 1992) and the Final Project Plan Addenda (Baker, December 1992) describe the QC samples that were collected to assess the accuracy, precision, and representativeness of the sampling and analytical operations. The following is a list of the QC samples collected during the field investigation:

- One trip blank per shipping container for every batch of volatile organic compounds analyzed.

- Two field blanks (ambient condition blanks) per sampling event. One field blank was prepared using potable water (used for steam-cleaning of drilling equipment etc.) collected from a fire hydrant located on base. A second sample was collected from laboratory grade deionized water (used for decontamination of sampling equipment).

- One equipment blank for every sampling event per day.

TABLE 3-6

SUMMARY OF CONTAINERS, PRESERVATION AND HOLDING TIMES FOR WATER SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time (1)	Analytical Method	Bottle Volume
TCL Volatile Organic Analysis (VOA)	glass, teflon lined cap	Cool to 4°C 1:1 HCl pH <2	10 days	CLP	2 x 40 ml
Volatile Organic Compounds (2) (EPA 601/602)	glass, teflon lined cap	Cool to 4°C 1:1 HCl pH <2	10 days	CLP	2 x 40 ml
TCL Semivolatile Organic Analysis (SVOA)	glass, teflon lined cap	Cool to 4°C	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
TCL PCB/Pesticides	glass, teflon lined cap	Cool to 4°C	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
TAL Metals	plastic/glass	HNO_3 to pH <2	180 days except Mercury is 26 days	CLP	1 x 1 liter
Chloride	plastic/glass	None required	28 days	EPA 325.3	1 x 1 liter
Sulfate	plastic/glass	Cool to 4°C	28 days	EPA 375.4	1 x 1 liter
Alkalinity	plastic/glass	Cool to 4°C	14 days	EPA 310.1	1 x 1 liter
TOC	glass	Cool to 4°C HCl or H_2SO_4 pH <2	28 days	EPA 415.1	2 x 40 ml
BOD	polyethylene bottle	Cool to 4°C	48 hours	EPA 405.1	1 x 1 liter
COD	polyethylene bottle	Cool to 4°C H_2SO_4 pH <2	28 days	EPA 410.4	1 x 250 ml
TSS	polyethylene bottle	Cool to 4°C	7 days	EPA 160.2	1 x 250 ml

(1) Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991.
(2) For Round 3 groundwater samples only.

TAL - Target Analyte List
TCL - Target Compound List
TOC - Total Organic Content
BOD - Biological Oxygen Demand
COD - Chemical Oxygen Demand
TSS - Total Suspended Solids

TABLE 3-7

SUMMARY OF CONTAINERS, PRESERVATION AND HOLDING TIMES FOR SOIL/SEDIMENT SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time (1)	Analytical Method	Bottle Volume
TCL Volatile Organic Analysis (VOA)	glass, teflon lined cap	Cool to 4°C	10 days	CLP	1 x 4 oz
TCL Semivolatile Organic Analysis (SVOA)	glass, teflon lined cap	Cool to 4°C	Extraction within 10 days Analyze 40 days	CLP	1 x 8 oz
TCL PCB/Pesticides	glass, teflon lined cap	Cool to 4°C	Extraction within 10 days Analyze 40 days	CLP	1 x 8 oz
TAL Metals	plastic/glass	Cool to 4°C	Mercury is 26 days 180 days	CLP	1 x 8 oz
TOC	1-4 oz. wide-mouth glass jar	Cool to 4°C	28 days	EPA 415.1	1 x 4 oz

(1) Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in the CLP statement of work of February, 1991.

TAL - Target Analyte List
TCL - Target Compound List
TOC - Total Organic Content

- One field replicate/duplicate for every ten samples collected.

During the actual field investigation QC samples were collected in quantities greater than or equal to those specified in the Work Plan. Sample data were evaluated by the subcontracted data validator, AWD Technologies, against data completeness, applicable method holding time requirements, calibration blanks and matrix spike/matrix spike duplicate (MS/MSD) analyses at a minimum.

3.4.2 Trip Blanks

Trip blanks were prepared at the laboratory before the beginning of sampling activities by pouring carbon-treated, deionized water into 40 milliliter (ml) glass sample bottles. Sample containers were filled to yield a representative blank for each type of volatile organic compound analysis, resulting in a volatile organic trip blank for the sampling event. The sample bottles were randomly selected from the supply of prepared sample bottles. The trip blanks were prepared at Wadsworth/ALERT Laboratories and sent to the Camp Allen Landfill Site along with unopened sample containers. Trip blanks were then sent back to the laboratory for analysis with the environmental samples collected during the field investigation.

3.4.3 Field Blanks

Two field blanks (ambient condition blanks) were prepared at the commencement of the sampling activities. The field blanks were prepared by pouring potable water directly into one set of sample bottles and deionized water directly into an additional set of sample bottles. These sample bottles were randomly selected from the supply of prepared sample bottles submitted by Wadsworth/ALERT Laboratory. A sample container was selected, filled, and preserved in a manner that was appropriate for each of the analyses being performed. The field blank was then processed and analyzed in the same manner as the environmental samples.

3.4.4 Equipment Blanks/Rinsates

Equipment blanks were prepared for manual sampling equipment utilized to collect environmental samples; rinsates were not prepared for secondary sampling equipment (i.e., drill rig sampling equipment). Rinsates were collected once each sampling day by pouring deionized water over/through a clean split spoon, hand auger, stainless steel spoon, or teflon bailer and dispensing the water into prepared sample bottles. Rinsate samples were analyzed for parameters associated with each sampling event.

3.4.5 Field Replicates

Field replicates were collected in quantities equal to or greater than ten percent of the total number of solid environmental samples collected during sampling activities. These samples were collected at the same time and using the same techniques as the planned environmental samples. Replicate locations were either preselected before the daily sampling activities were initiated or were based upon abnormal instrument readings and/or unforeseen field conditions (i.e., strong odor or visible discoloration). The identification of each replicate was coded with an individual sample number to prevent external laboratory bias.

Replicate soil/sediment samples were collected with a 2-inch split spoon, hand auger, or stainless steel spoon and homogenized in a stainless steel container (with the exception of the portion to be analyzed for volatile organics). The sample portion to be analyzed for volatile organic compounds was collected first and was not homogenized to minimize compound volatilization. After the collection of the volatile organic sample, the remaining samples were collected in order of volatilization concern (SVOC, Pesticide/PCB, metals, and wet chemistry parameters).

3.4.6 Field Duplicates

Duplicate surface water and groundwater samples were collected using a stainless steel container and teflon bailer, respectively. For the purpose of the project, water samples were designated as duplicates even though several containers or bailers were required to fill the sample containers at some locations. The volatile fraction was collected first to minimize compound volatilization. The first container and bailer volumes were used to fill the vials used for volatile organic compound analyses of the environmental samples. Subsequent volumes were used to fill the duplicate VOC or SVOC, pesticide/PCB, TAL metals, and wet chemistry parameters, respectively.

3.4.7 Matrix Spike/Matrix Spike Duplicate

Matrix spike/matrix spike duplicate (MS/MSD) samples were collected at a number equal to or greater than ten percent of the total number of environmental samples collected during sampling activities. The volume required varied by media and by analysis. Spike analysis was performed to demonstrate the accuracy of an analysis. The spike was initiated prior to sample preparation and analyzed by adding a known amount of analyte(s) to a sample. The spike was carried through the entire analytical procedure.

3.4.8 Data Validation Summary

The quality of data is determined by its accuracy and precision against prescribed requirements or specifications. To make these determinations, data quality evaluations were performed by the validation firm of AWD Technologies, Pittsburgh, Pennsylvania. Data were evaluated by AWD Technologies in accordance with the criteria established by the USEPA federal guidelines ("Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses-Draft" [USEPA, 1991a] and Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses" [USEPA, 1988]). Data quality was evaluated based on, but not limited to the following parameters:

- Data completeness
- Holding times
- GC/MS tuning (for VOC, SVOC analyses only)
- Calibrations
- Blanks
- Surrogate recoveries
- Laboratory Control Samples
- Matrix spike/matrix spike duplicate
- Internal standard performance (SVOC analysis only)
- Compound identification
- Compound quantitation

Based upon the results of this evaluation, some analytical results have been "qualified". Qualified data are data that have been evaluated for accuracy and precision and, depending on the qualifier, need an associated explanatory note to clarify the analytical results.

3.5 Overview of Feasibility Study Sampling

Feasibility study (FS) samples were gathered to obtain data that will be used in FS and risk assessment reporting activities. These data will be used in the FS to help evaluate applicable interim or long term remedial technologies that may be required at the site. The risk assessment portion of this report will be able to utilize some of this data as a determining factor for species distribution in the Camp Allen area and other risk-related calculations/assumptions. Also, one round of four surface water samples was obtained for the determination of water hardness. The following sections will describe the feasibility samples and the surface water hardness samples taken by area and by analytical round.

3.5.1 Feasibility Samples Area A, Round 2

During Round 2, feasibility samples were collected in Area A from surface water and groundwater to evaluate indicator quality criteria. In addition to the CLP related parameters, all surface water and groundwater samples collected were analyzed for the following parameters: chloride (Method USEPA 325.2), sulfate (Method USEPA 375.2), and alkalinity, total (Method USEPA 310.1). A total of 12 surface water and 36 groundwater samples collected at Area A during Round 2 were analyzed for these parameters (including duplicates).

3.5.2 Feasibility Samples Area B, Round 2

During Round 2, groundwater samples only were collected from Area B to correlate conditions across the entire site. In addition to the CLP related parameters, all groundwater samples collected were analyzed for the following: chloride, sulfate, and alkalinity, total. A total of 26 groundwater samples collected at Area B during Round 2 were analyzed for these parameters (including duplicates).

3.5.3 Feasibility Samples Area A, Round 3

During Round 3, feasibility samples were collected from Area A for the following media: sediment, surface soil, surface water, and groundwater. All samples were analyzed for total organic carbon (TOC, Method USEPA 415.1); the surface water and the groundwater were analyzed for total suspended solids (TSS, Method USEPA 160.2), biochemical oxygen demand (BOD, Method 405.1), and chemical oxygen demand (COD, Method 410.4). Five sediment samples, five soil samples, one surface water sample, and two groundwater samples were collected for feasibility analyses at Area A during Round 3 to complement Round 2 feasibility samples.

3.5.4 Feasibility Samples Area B, Round 3

During Round 3, feasibility samples were collected from Area B for the following media: surface soil, surface water, and groundwater. All samples were analyzed for TOC and only the surface water and the groundwater were analyzed for TSS, BOD, and COD. Five soil samples, one surface water sample, and two groundwater samples were collected for feasibility parameter analysis at Area B during Round 3. Round 3 sample locations for Areas A and B are shown on Figure 3-16.

3.5.5 Surface Water Hardness Samples, Areas A and B, Round 3

Four surface water samples were collected to determine hardness concentration. These concentrations are expressed as calcium carbonate in milligrams per liter (mg/L). Surface water sample locations are provided in Figure 3-17. A HACH hardness kit, Model HA-DT, was utilized for obtaining these hardness concentrations. All samples were filtered to remove suspended solids, then a hardness buffer solution along with a red coloring agent were added to each sample. Hardness was determined by titrating in a digitally-controlled amount of 0.8 molar solution of ethylene-diamine-tetra-acetic acid and tetrasodium salt. Sample hardness concentrations were determined by a color change from red to blue.

Results for the feasibility study samples are presented in Section 5.5. Additionally, feasibility study parameter concentrations are used to complement risk assessment and feasibility study evaluations.

3.6 Ecological Field Investigation

An ecological field investigation was performed at the Camp Allen Landfill Areas A and B to provide aquatic and terrestrial data for use in an ecological risk assessment. The ecological risk assessment will be used in conjunction with the human health risk assessment to determine the appropriate remedial action at this site for the overall protection of public health and the environment.

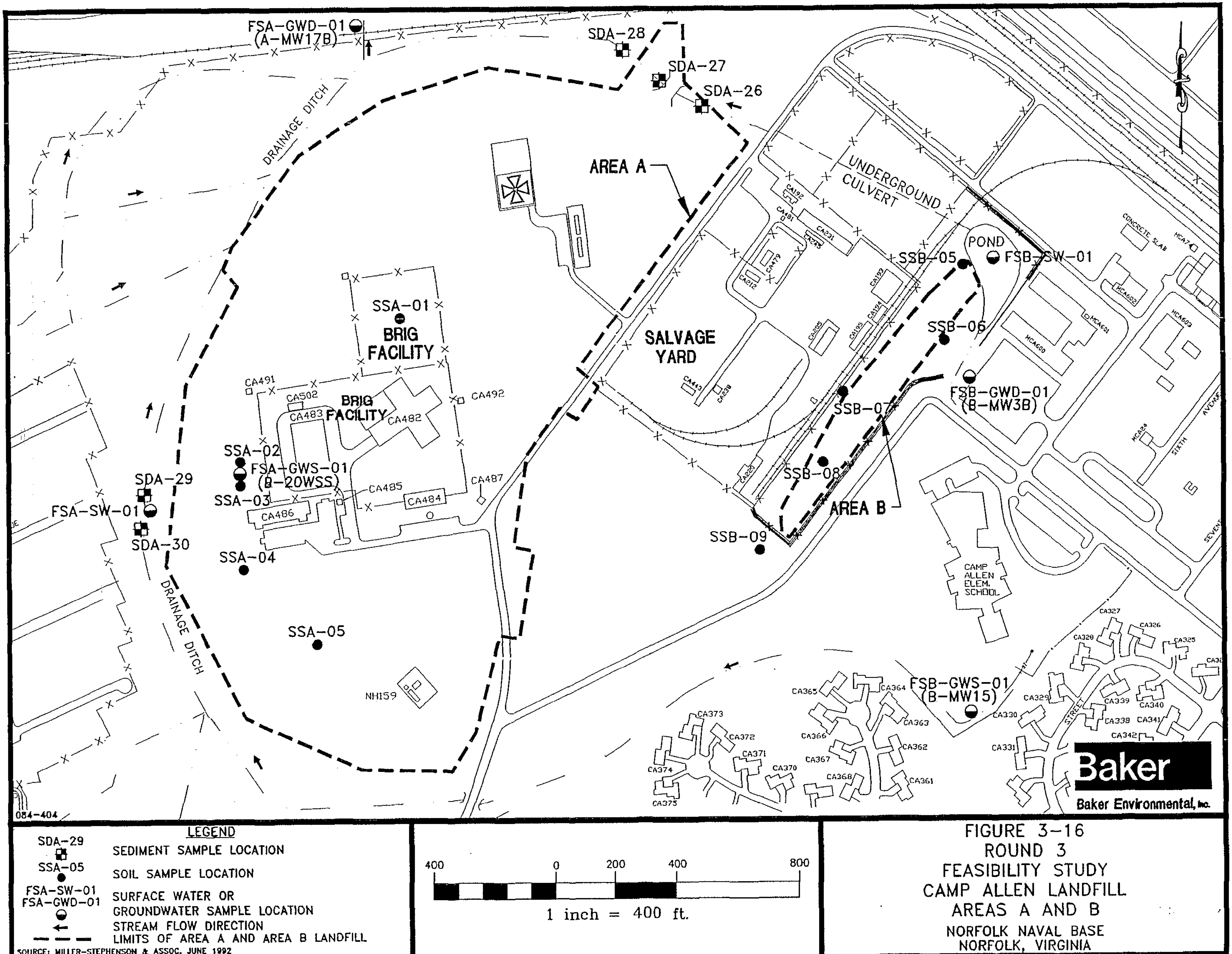
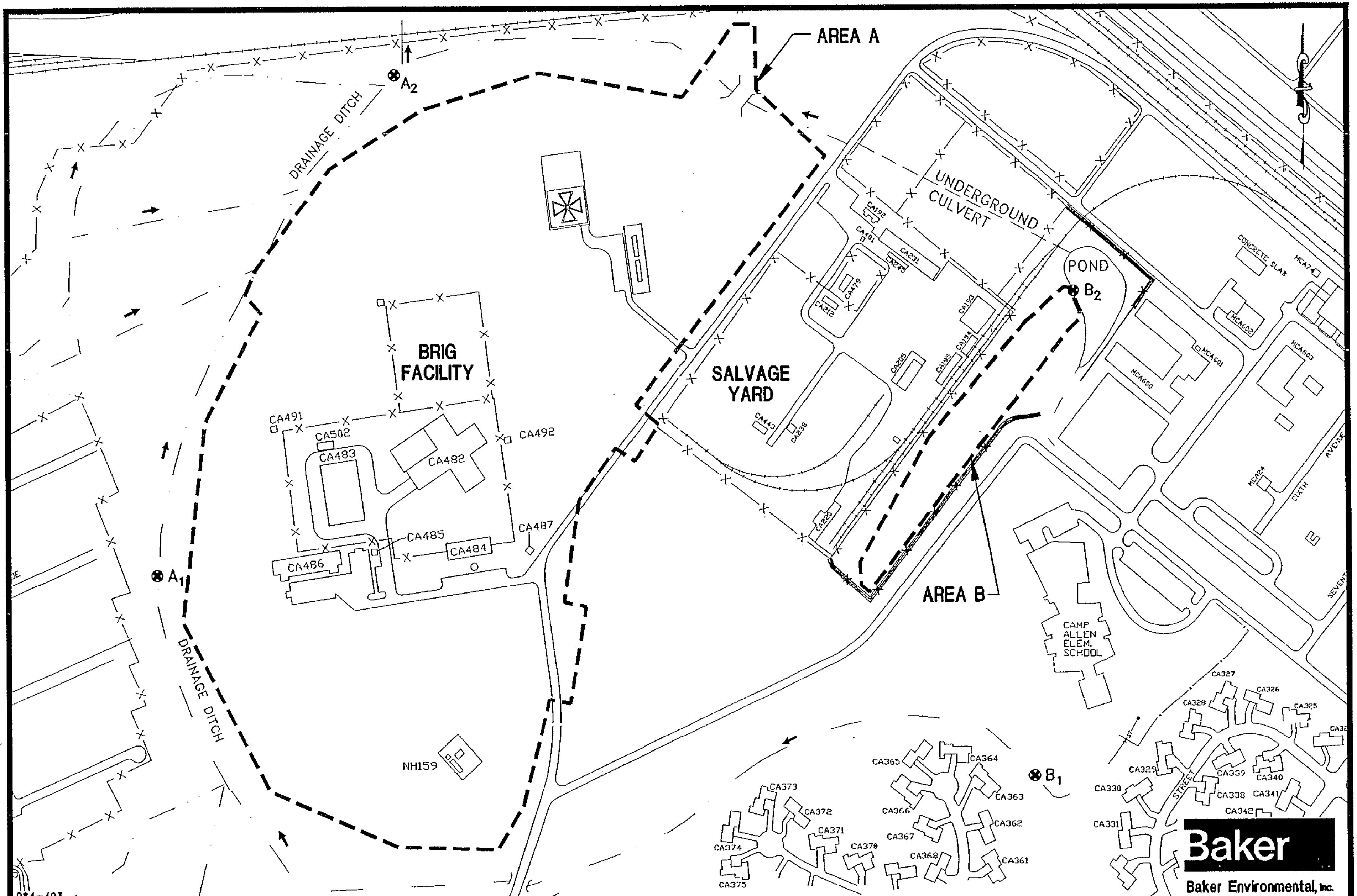


FIGURE 3-16
ROUND 3
FEASIBILITY STUDY
CAMP ALLEN LANDFILL
AREAS A AND B
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

A_1 SAMPLE LOCATION

STREAM FLOW DIRECTION

LIMITS OF AREA A AND AREA B LANDFILL

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

400 0 200 400 800

1 inch = 400 ft.

FIGURE 3-17
SURFACE WATER HARDNESS
SAMPLE LOCATIONS
CAMP ALLEN LANDFILL
AREAS A AND B
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

The ecological field investigation included collection of benthic macroinvertebrates for population analysis, collection of sediment samples for grain size analysis, vegetation surveys, and observations of terrestrial fauna. This section of the RI includes the field related ecological activities that occurred at Camp Allen during June of 1993. Section 4.5 of the RI provides the results of the field activities including the biotic and abiotic characteristics of the aquatic environments studied, grain size analysis, benthic macroinvertebrate collections, and qualitative terrestrial assessment.

3.6.1 Aquatic Sampling Methodology

The following section describes the biological sampling methodology used at Camp Allen including the sampling locations selected and the sampling procedures utilized.

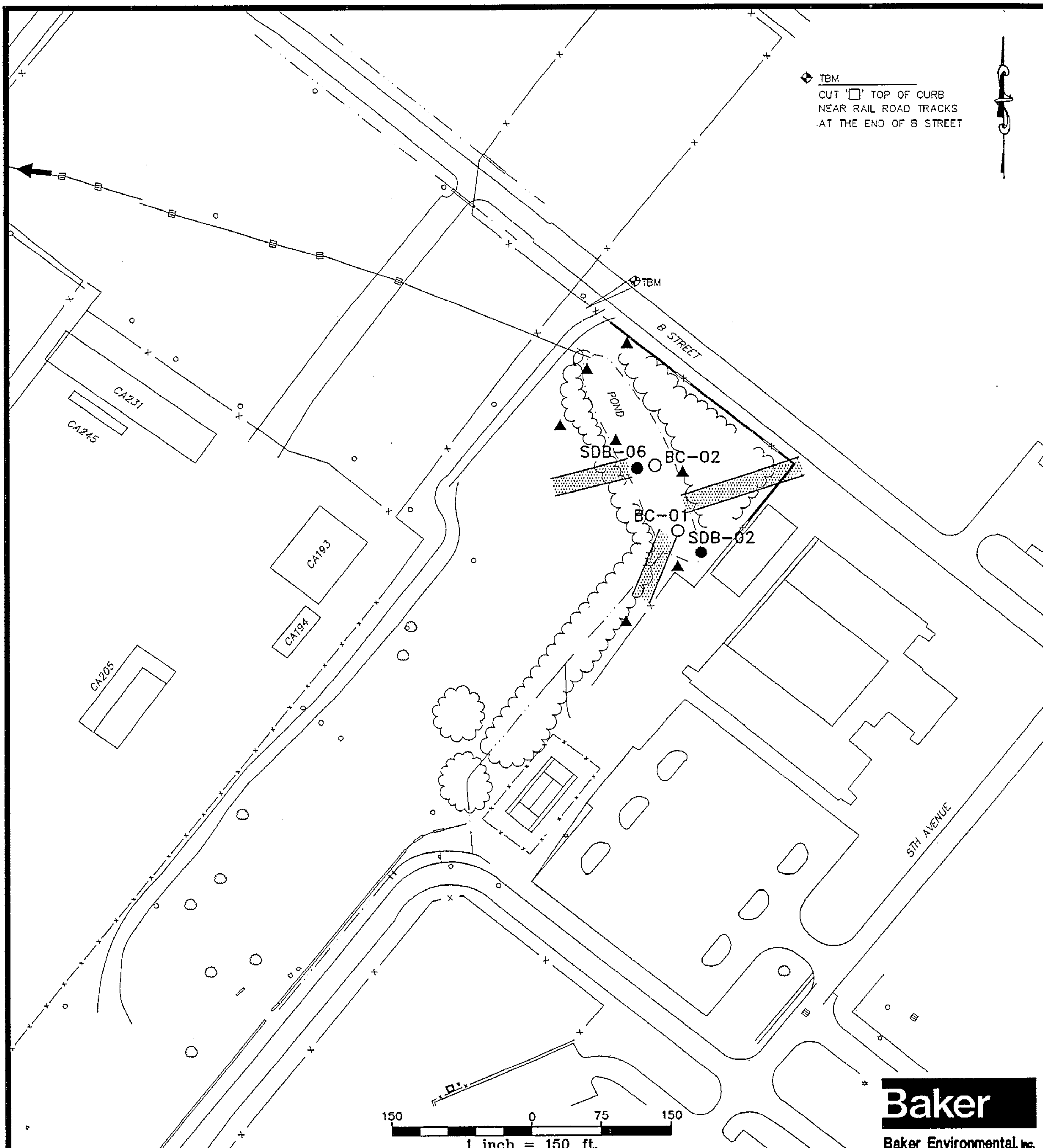
3.6.1.1 Station Locations

Benthic macroinvertebrates were collected at five stations at Camp Allen (see Figures 3-18 to 3-21). Stations BC01 and BC02 were located in the Area B pond, Station BC03 was located in a drainage ditch downstream of the pond (Area A), Station BC04 was located in the drainage ditch on the western side of the landfill (Area A), and Station BC05 was located in a drainage ditch, upstream of Station BC04 (Area A).

The biological stations were situated near locations where surface water and/or sediment samples were collected for chemical analysis during previous investigations. Selection of biological sampling locations was made based upon the number of contaminants of concern detected at each location and the levels at which they were detected. Three sampling points (BC02, BC03, and BC04) were selected to provide benthic macroinvertebrate information in relatively contaminated areas. Two sampling points (BC01 and BC05) were selected because contaminants were less evident; these two points were to provide a contrast to the more contaminated locations.

At each biological station, samples were collected, looking downstream, at the mid-right, mid-left, and the middle of each location. The samples were numbered BC##L (for mid-left), BC##M (for middle), and BC##R (for mid-right).

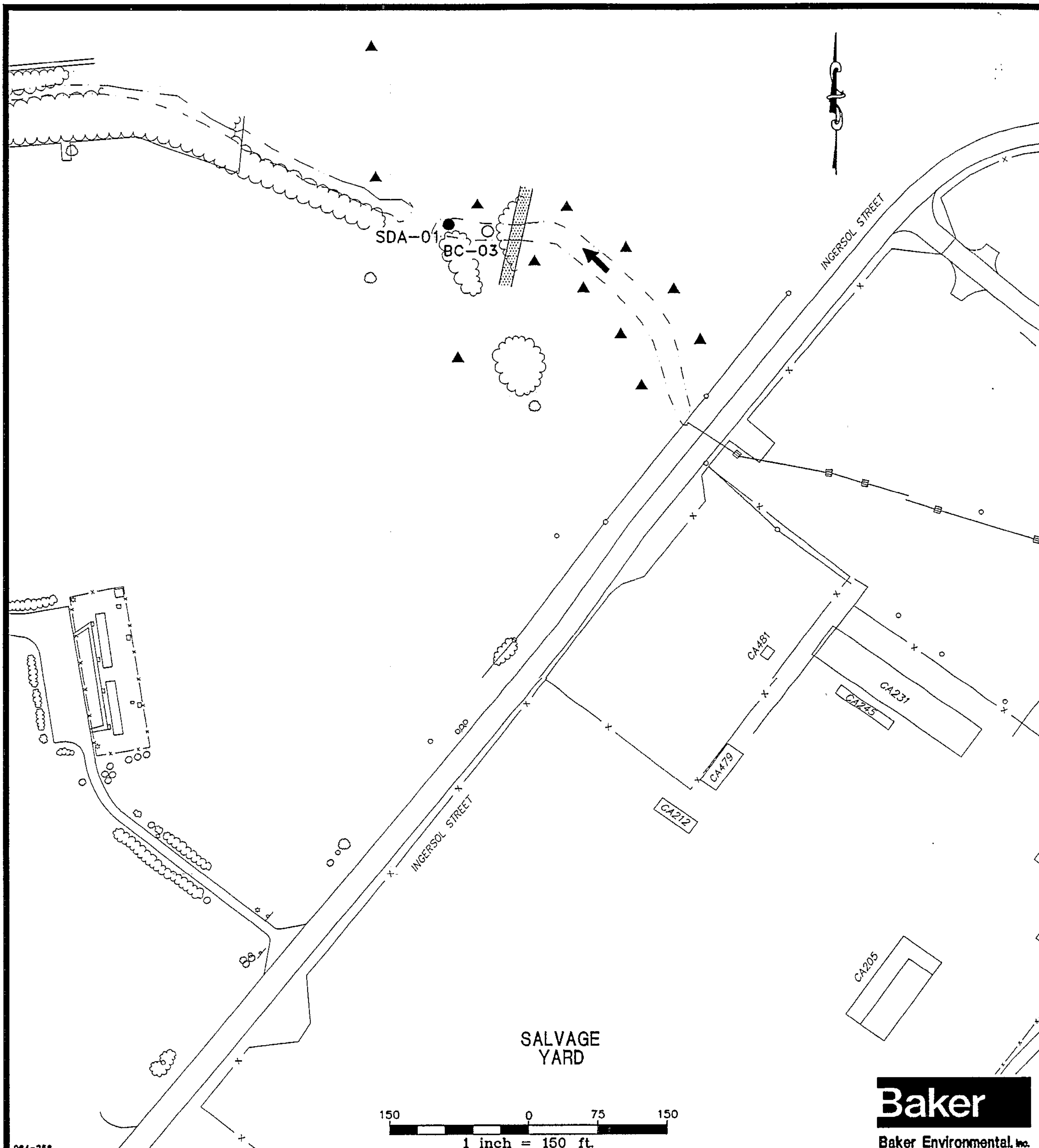
Station BC01 was sampled upstream of Station BC02, located slightly downstream of a seep from the landfill, in an area of high chemical contamination. Station BC03 was located to



LEGEND

- ▲ WILDLIFE OBSERVATION POINT
- ← STREAM FLOW DIRECTION
- SDB-02 ● SEDIMENT SAMPLE LOCATION
- BC-01 ○ BENTHIC MACROINVERTEBRATE SAMPLE LOCATION
- VEGETATION STUDY
- x —— x FENCE

FIGURE 3-18
ECOLOGICAL FIELD
INVESTIGATION LOCATIONS
AREA B POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

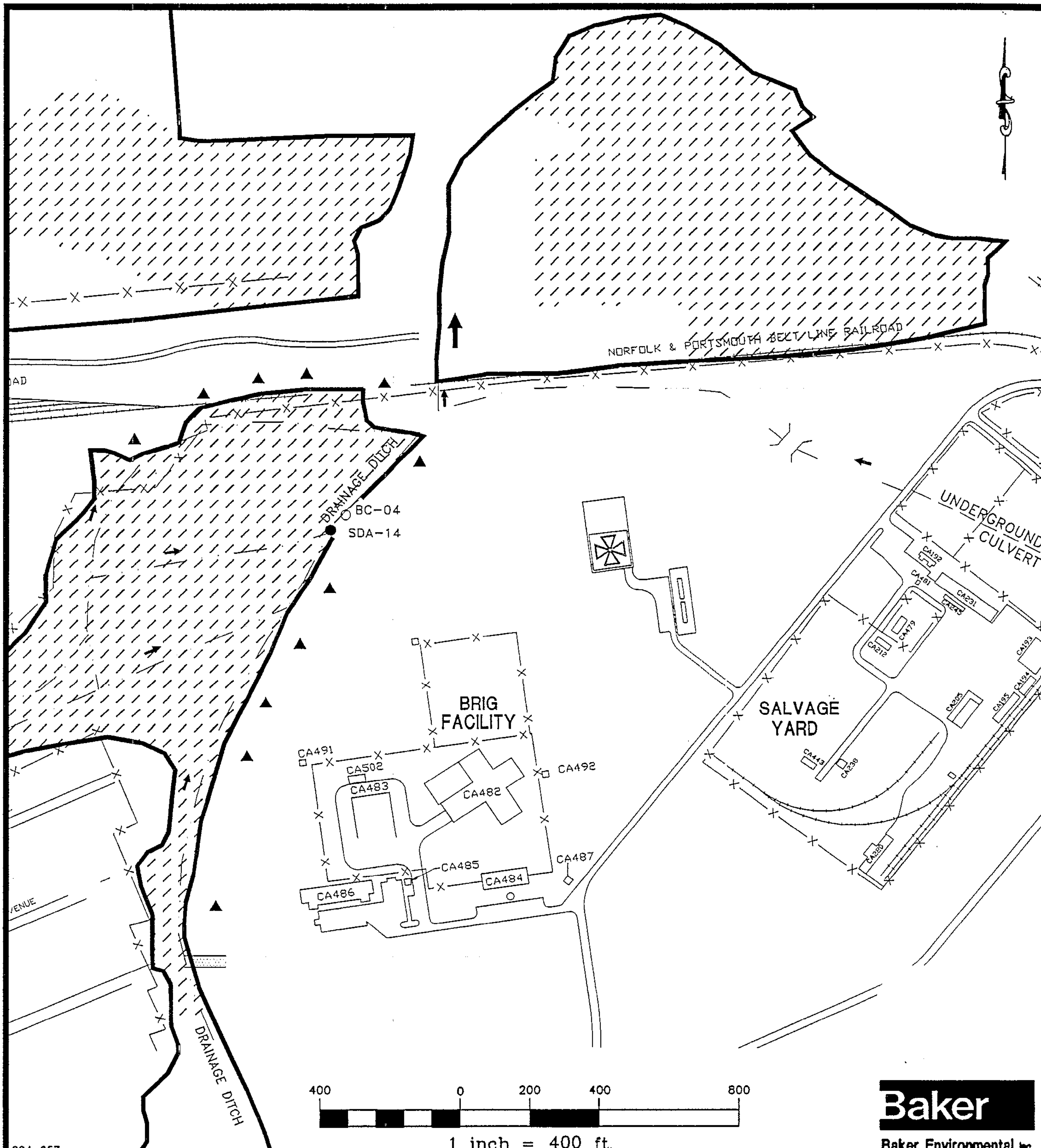


LEGEND

▲	WILDLIFE OBSERVATION POINTS
SDA-01 ●	SEDIMENT SAMPLE LOCATION
BC-03 ○	BENTHIC MACROINVERTEBRATE SAMPLING LOCATION
←	STREAM FLOW DIRECTION
	VEGETATION STUDY
x—x	FENCE

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-19
ECOLOGICAL FIELD
INVESTIGATION LOCATIONS
AREA A DRAINAGE WAY
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

SDA-14 SEDIMENT SAMPLE LOCATION

BC-04 BENTHIC MACROINVERTEBRATE SAMPLING LOCATION

WILDLIFE OBSERVATION POINTS

VEGETATION STUDY

STREAM FLOW DIRECTION

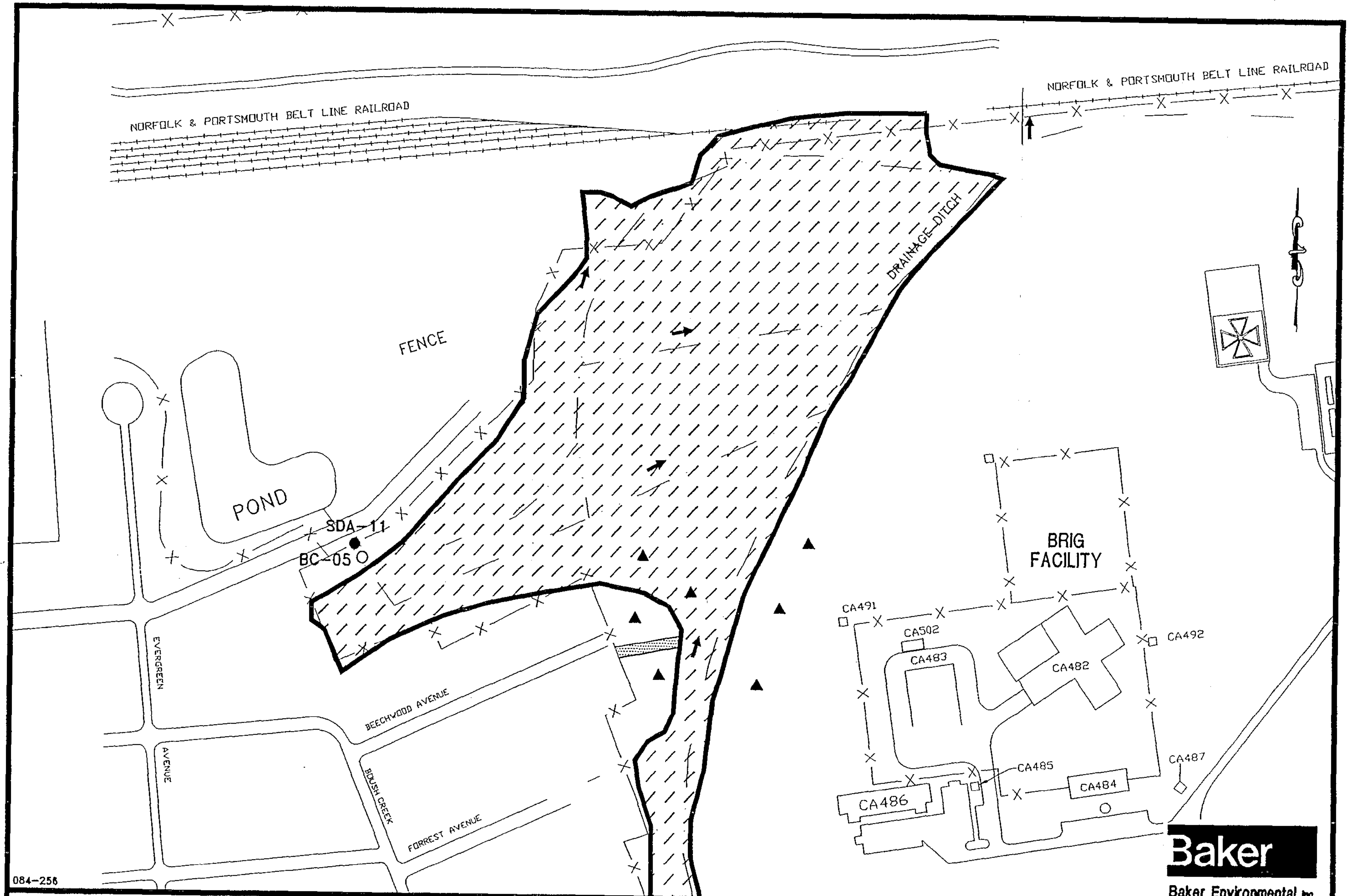
WETLANDS

FENCE

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 3-20
ECOLOGICAL FIELD
INVESTIGATION LOCATIONS
AREA A DRAINAGE WAY

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

SDA-11 ●	SEDIMENT SAMPLE LOCATION
BC-05 ○	BENTHIC MACROINVERTEBRATE SAMPLING LOCATION
←	STREAM FLOW DIRECTION
X—X	FENCE
(hatched box)	WETLANDS
(stippled bar)	VEGETATION STUDY
▲	WILDLIFE OBSERVATION POINTS

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

300 0 150 300 600

1 inch = 300 ft.

FIGURE 3-21
ECOLOGICAL FIELD
INVESTIGATION LOCATIONS
CAMP ALLEN LANDFILL
AREA A DRAINAGE WAY
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

assess the downstream impacts from the landfill. Station BC04 was located to assess the impacts of the landfill near the marsh area. Finally, samples at Station BC05 were collected to serve as background data for samples from Station BC04.

3.6.1.2 Sampling Procedures

Water quality measurements consisting of temperature, pH, specific conductance, salinity, and dissolved oxygen were conducted at each of the stations prior to sample collection. All the instruments were calibrated in accordance with the manufacturers' operating procedures prior to use.

At each station, the following information describing the site and sampling events were recorded on field log sheets:

- Date, time, weather, names of sampling personnel, sampling procedures, and sampling equipment used
- Sketch of sampling location including boundaries of the water body
- Average width, depth, and velocity of the water body
- Substrate type (i.e., silty, sandy, rocky, etc.) and visual description of water (i.e., clear, cloudy, muddy, etc.)
- Abiotic characteristics of the reach such as pools, riffles, runs, channel shape, and shade/sun exposure
- Biotic characteristics of the reach including aquatic and riparian vegetation

Benthic macroinvertebrates were collected at each station using a 5.5 inch sediment core instrument with a 3.9 inch diameter (sampling area of 0.0077 m^2). The sediment core was open at one end and had a 0.500 mm mesh screen covering the other end.

The open end of the corer was driven into the sediment, until the sediment reached the mesh screen. The open end of the corer was covered, and the corer was removed from the sediment. The sediments were transferred to a 0.5 mm sieve that was agitated (by hand) in the water to remove any small particles. The remaining contents in the sieve were transferred into 16-ounce plastic sample jars. The jars were half filled with sediments, and buffered formalin solution (10 percent by weight) was added to the remainder of the jar to fix the benthic macroinvertebrates contained in the sediments. A 100 percent cotton paper label, marked in pencil with the sample number, was placed inside the jar. The outside of the jar was labeled with the sample number using a black permanent marker to identify the sample containers.

After the benthic sampling was completed, the sample jars were transported to the Baker Ecological Laboratory for sample processing. Sample processing included washing each sample through a 0.5 mm sieve, transferring the washed sample back into the jar, and adding 90 percent ethanol to the washed sample in the jar. Rose bengal was added to each jar to stain the benthic macroinvertebrates a pink-red color to aid in sorting. The rose bengal stained the tissue cells of the organisms and helped to distinguish them from plant and other materials in the sediments.

The benthic macroinvertebrates were stained for at least 24 hours prior to sorting under a dissecting microscope. The macroinvertebrates were removed from the sediments using a pair of forceps and placed into glass vials containing 90 percent ethanol and a 100 percent cotton paper label marked in pencil with the sample number. The vials were sealed with cotton and placed into a jar containing 90 percent ethanol. The date, sorting time, approximate number of benthic macroinvertebrates collected, and the name of the person who sorted the sample were recorded on a sample processing log sheet.

The same sorting procedures outlined above were repeated on a subset of samples as a QA/QC measure, with any additional species identified being placed into their respective vials. A senior environmental scientist was employed to perform this QA/QC measure.

The vials containing the benthic macroinvertebrates were sent to RMC Environmental Services for taxonomic identification down to the family level.

3.6.1.3 Grain Size Analysis

Sediment samples were collected at each benthic coring location and were analyzed for grain size. Sixteen-ounce plastic sample jars were filled with sediments collected at the middle replicate of each of the five locations (BC01, BC02, BC03, BC04, and BC05) and were conveyed, unpreserved, to the laboratory. SPL Environmental Laboratory analyzed the samples via ASTM Method D422. Results of this analysis are included in Section 4.5.3 of this report.

3.6.2 Terrestrial Field Investigation

Terrestrial flora and fauna on Camp Allen Landfill Areas A and B were evaluated qualitatively via a field study. The field study focused on species composition, species diversity, and general health of the environment (i.e., evidence of vegetative stress). It included a vegetative survey at each sampling location and field observations of birds, mammals, reptiles, and amphibians.

3.6.2.1 Sampling Locations

Sampling/observation locations for the terrestrial field study were chosen to correspond to the sampling locations selected for the benthic macroinvertebrate coring. For the vegetation survey each location was further subdivided by habitat/community and representative locations selected following a general area survey. Because birds, mammals, reptiles, and amphibians are mobile and range over larger areas, a series of observation points, connected by observation lines, were determined.

The sampling/observation locations included the following:

- Area B Pond (BC01 and BC02) - For the terrestrial survey the pond; the woodland, shrubby woods edge, and grassy edge around the pond; and the field between the pond and the salvage yard were included in the survey area. Some mammal and bird observations were also made from the field trailer (see Figure 3-18).

- Area A Drainageway (BC03) - For the terrestrial survey this area included both banks of the drainage ditch and the ditch itself. Bird and mammal observations were also made in the fields along the drainageway (Figure 3-19).

- Area A Drainageway (BC04) - This drainageway bordered a large spartina/phragmites marsh. For the terrestrial survey this area included the field edge and the shrubby edge along the drainage ditch as well as the marsh. Observations in the marsh, taken from the railroad bed were conducted for the bird, mammal, and reptile surveys only. No vegetative surveys were conducted in the marsh itself (see Figure 3-20).

- Area A Marsh (BC05) - Because the area around the sediment collection point was severely disturbed, a nearby area along the same ditch was chosen for the terrestrial survey. This area encompassed the marsh edge, an open area, woods edge, and woodland between the Brig and Glenwood Park, off Beechwood Avenue. Bird observations were also made from the Brig side across the marsh (see Figure 3-21).

The wetland areas discussed in Section 2.0 of this report were not included in the terrestrial field survey because they had been previously studied. Observations of fauna were made in the wetland areas where possible.

3.6.2.2 Study Methodology

3.6.2.2.1 Vegetation Survey

To conduct the vegetation survey a variation of the belt transect method was used. A belt transect is a long, narrow, rectangular plot or elongated quadrant. It is used to examine areas submitted to changing vegetation where quadrants are not practical. Most of the sampling locations chosen were subject to succession; therefore, the belt transect was ideal to document these changes.

In three of the sampling locations a single transect was laid out visually in a representative habitat/community area as close to the sediment sampling point as possible. The area around the Area B Pond included three separate, distinct communities (wooded pond edge, open pond edge, shrubby pond edge); therefore, a transect was set in each of the communities.

Once the transect was laid out plants within each area were categorized (tree, sapling, shrub, vine, herb). Dominant plants, in this case those covering 30 to 50 percent of the area, were identified. Identification of each plant to genus and species was made in the field. Unidentified plants were collected for analysis in the office. Data were recorded on field data sheets. Lists of species expected at the site were used for confirmation of information. These lists are included as Appendix D.

3.6.2.2.2 Faunal Observations

During the week-long field survey observations of site wildlife were made to identify birds, mammals, reptiles, and amphibians present. The study focused primarily on birds because they are common, visible, active, and relatively easy to identify by sight. The composition and number of species present are indications of the availability of food and cover. By their behavior, birds also indicate if they are breeding in the area. In addition, "Birds ... are sensitive indicators of the environment, a sort of 'Ecological litmus paper,' ... (Peterson, 1968). Mammals, reptiles, and amphibians were also observed or signs of their presence (i.e., tracks, scat, eggs) were observed.

Faunal observations were conducted at observation points and along lines between points. Wildlife was identified in the field and notations made on data collection sheets. Observations were staggered so that areas were examined at different times of day; each area was examined at least once in the morning when birds were most active.

Results of the field survey are included in Section 4.0 of this report.

SECTION 4
PHYSICAL RESULTS

4.0 PHYSICAL RESULTS OF THE REMEDIAL INVESTIGATION

The physical characteristics of the subsurface at Camp Allen Landfill were investigated through the use of surface and subsurface geophysics, soil borings and monitoring well installation, periodic water level measurements, and aquifer testing. Evaluation included not only data from this and previous environmental investigations, but also from geotechnical borings completed prior to construction of the Brig in Area A. Other physical features which may be impacted by or have an impact upon the hydrology of the Camp Allen Landfill area are also discussed. These include nearby residential and industrial groundwater wells, as well as on-site utility lines and potential off-site contamination sources.

4.1 Subsurface Geology

4.1.1 Geophysical Investigation

In October 1983, a geophysical investigation was undertaken in the southern portion of Area A to identify buried metallic objects over a 15-acre area in which construction activities had been proposed. The survey indicated that the area contained numerous buried metallic objects in the shallow subsurface (Malcolm Pirnie, 1984). The presence of metallic objects such as sheet metal, crane cable and reinforcing bars in concrete was also confirmed in the same study during borehole drilling activities at the site.

As discussed in Section 3.0 (Remedial Investigation Field Activities), a geophysical survey including electromagnetism, resistivity, gamma logging, and ground penetrating radar was conducted at the onset of the investigation. A combination of geophysical techniques was utilized in order to better define subsurface conditions. Findings of the geophysical surveys conducted at Areas A and B of the Camp Allen Landfill Site were compiled into a Geophysical Report, which is presented in Appendix E. General findings of the geophysical survey performed at Areas A and B are discussed below.

Area A Geophysical Findings

The geophysical investigation completed in Area A during 1992 was undertaken primarily to evaluate the continuity of the confining clay layer between the water table aquifer and the Yorktown Aquifer. The presence of fill materials (landfill contents) and buried metallic objects was also evaluated as part of the study but was a secondary objective since the configuration of the Area A Landfill is already fairly well defined. Geophysical coverage and data interpretations are summarized in Figure 4-1.

The electromagnetic and resistivity point test results indicate that the confining clay may have been absent or breached east of Area A (along line 200), west and north of Area A (along line 500), and south of Area A along line 400 (Figure 4-1). Clay was also generally absent in the vicinity of sounding PT-1 along the eastern portion of line 300 in the upper 20 to 24 feet of sediments, although this may not indicate if the confining clay layer is present at a greater depth.

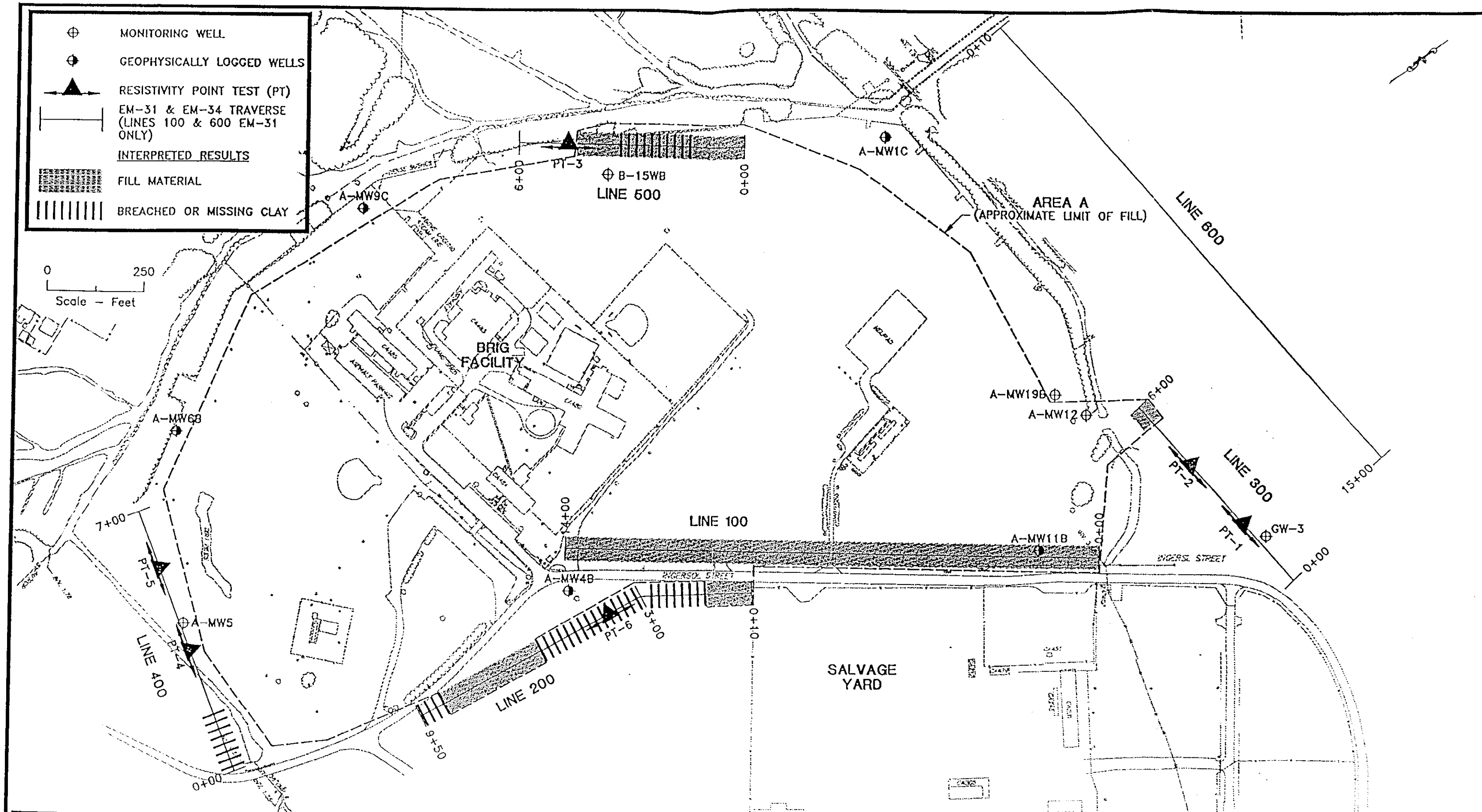
Fill materials were also noted along all or portions of lines 100, 200, 300, and 500 (Figure 4-1). Occasionally metallic materials were noted in these areas. Line 600, along the northernmost portion of the Area A study area, did not find fill materials to a depth of 15 to 20 feet below grade.

Borehole geophysical logging was performed at five monitoring well locations (A-MW1C, A-MW4B, A-MW6B, A-MW9C, and A-MW11B). These wells were logged with a combination natural gamma and EM induction sonde. Results of the logging program correlate with newly installed monitoring well location lithologic descriptions and surface geophysical results.

In general, the confining clay unit was identified in all five wells which were logged; however, thinning of the unit is apparent at well location A-MW4B immediately adjacent to the breached confining clay unit location identified along electromagnetic Line 200 (Figure 4-1). Results of the borehole geophysical logging also provide supporting documentation as to the variability of the unconsolidated sediments of the Columbia Group and Yorktown Formation.

Area B Geophysical Findings

The geophysical investigation completed in 1992 in Area B was conducted to delineate areas of buried debris and metallic objects within and adjacent to Area B. Potential locations of subsurface boreholes were also evaluated with respect to potential drilling hazards.



REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	084-602

GEOPHYSICAL INVESTIGATION
CAMP ALLEN LANDFILL – AREAS A AND B
NORFOLK, VIRGINIA
PREPARED FOR BAKER ENVIRONMENTAL, INC

WESTON GEOPHYSICAL CORP.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.
WESTON GEOPHYSICAL CORP. IS A WHOLLY OWNED SUBSIDIARY OF BAKER ENVIRONMENTAL, INC.

AREA A
GEOPHYSICAL COVERAGE, INTERPRETED EM AND POINT TEST RESULTS

SCALE GRAPHIC
DATE 7/93

FIGURE
4-1

The results of the geophysical survey of Area B are shown in Figure 4-2. Using electromagnetic terrain conductivity and magnetometry, several suspected disposal areas were identified. These include:

- Southeast portion of the area, just north and west of the Jersey Barrier. This fill had unusually high conductivity values.

- Northeast portion of the area, with buried metallic objects throughout. This area of fill may extend to the north of the study, into the vegetation surrounding the pond.

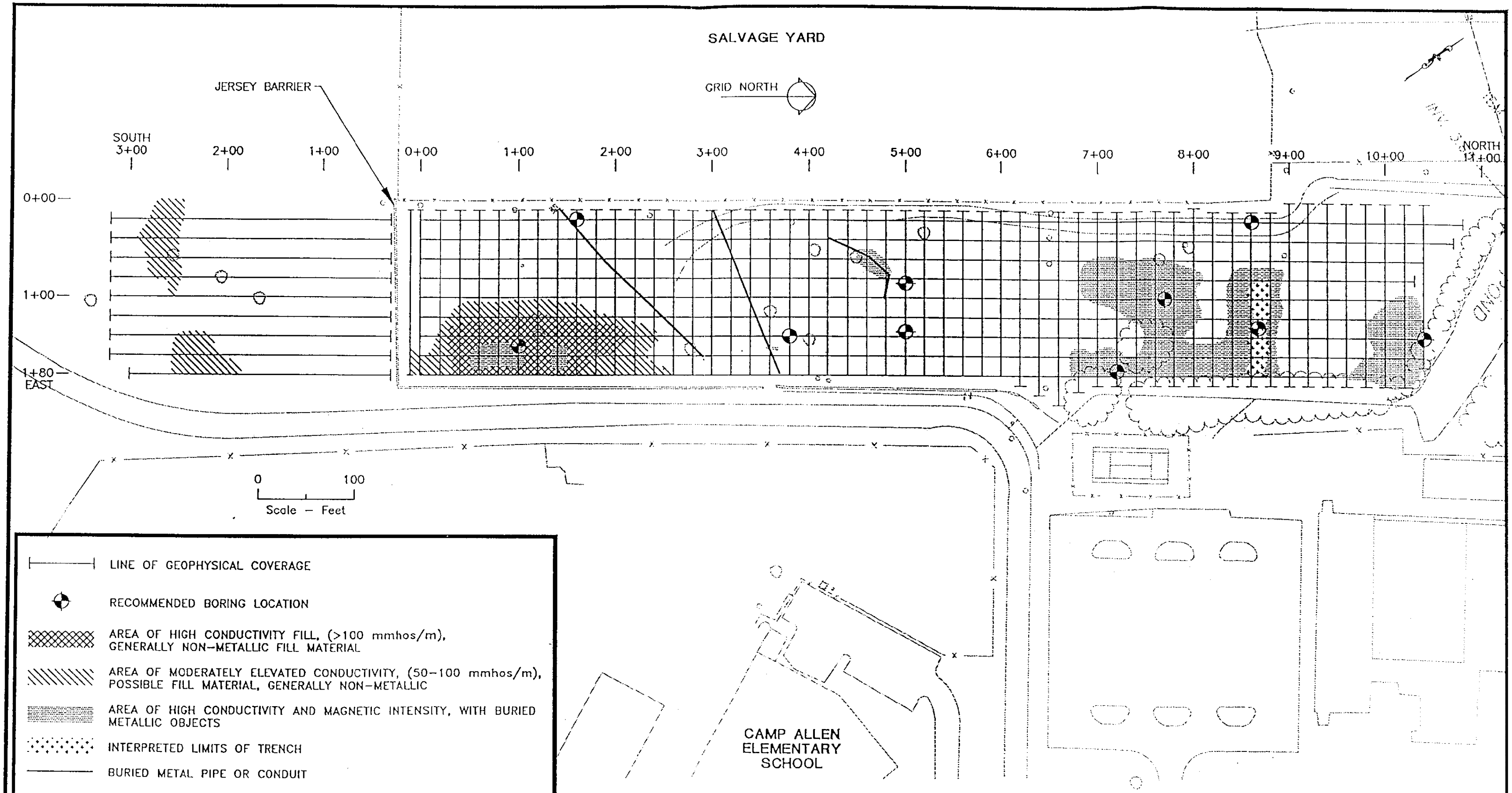
- An east to west trending area within the northeastern portion of Area B which contains a concentration of buried metallic objects. This is interpreted as an old disposal trench.

- An area of moderately elevated conductivity values was found southwest of the Jersey Barrier, outside the limits of Area B. This area may represent natural variations in the character of the lithology, or may indicate possible fill material.

Ground penetrating radar was used to delineate buried objects at specific borehole locations. As a result, three borehole locations were moved to nearby locations to avoid drilling into unknown buried objects.

4.1.2 Subsurface Boring and Well Construction Data

The primary means for investigating and understanding subsurface geology and hydrogeology is through the drilling and logging of boreholes (and installation of monitoring wells for groundwater studies). Records of the subsurface lithology, well completion details, geotechnical characteristics (blow counts), and other physical features such as color, grain size, moisture content, and indications of contamination are recorded on test boring logs/well construction forms, as appropriate. The logs are presented in Appendix F and are subdivided as follows based upon the company completing the investigation and the purpose of the borings and/or wells:



REVISIONS			GEOPHYSICAL INVESTIGATION CAMP ALLEN LANDFILL – AREAS A AND B NORFOLK, VIRGINIA PREPARED FOR BAKER ENVIRONMENTAL, INC	Baker Baker Environmental, Inc. WESTON GEOPHYSICAL CORP. IS A WHOLLY OWNED SUBSIDIARY OF BAKER ENVIRONMENTAL, INC.	AREA B GEOPHYSICAL COVERAGE, INTERPRETED EM AND MAGNETIC RESULTS	FIGURE 4-2
	DATE	7/93	WESTON GEOPHYSICAL CORP. Coraopolis, Pennsylvania		SCALE GRAPHIC	DATE 7/93
	SCALE	GRAPHIC				
	DRAWN	GLB				
	REVIEWED	TEA				
	S.O.#	19084				
	CADD#	084-603				

Company	Years Completed	Description
Malcolm Pirnie, Inc.	1983-1987	1. B-2, B-3, B-6, B-8, B-10, B-12, B-14, B-18, and B-19: Gas monitoring stations 2. B-1W, B-4W, B-5W, B-7W, B-9W, B-11W, B-13W, B-15W(A), B-16W, B-17W, and B-20W: Shallow aquifer monitoring wells - Area A 3. GW-1, GW-2, and GW-3: Shallow aquifer monitoring wells, Area A 4. GW-4, GW-5, and GW-6: Shallow aquifer monitoring wells, Area B 5. GW-7: Off-site (1 mile) Deep aquifer monitoring well
CH_2M Hill	1991	1. A-MW4A, A-MW5, A-MW6A, A-MW7, A-MW8A, A-MW9A, A-MW10A, A-MW11A, and A-MW12: Area A shallow aquifer monitoring wells 2. A-MW1B, A-MW4B, A-MW6B, A-MW9B, A-MW10B, and A-MW11B: Area A deep aquifer monitoring wells 3. B-MW1, B-MW2A, B-MW3A, B-MW7, B-MW8A, B-MW9A, B-MW10, and B-MW11A: Area B shallow aquifer monitoring wells 4. B-MW2B, B-MW3B, and B-MW5B: Area B deep aquifer monitoring wells
Baker Environmental, Inc.	1992	1. SBA-1 through SBA-8: Area A source characterization borings 2. SBB-1 through SBB-10: Area B source characterization borings 3. TBA-1 through TBA-11: Area A geologic borings 4. B-20WSS: Area A shallow monitoring well 5. A-MW1C, A-MW8B, A-MW9C, A-MW13B, A-MW14B, A-MW15B, A-MW16B, A-MW17B, A-MW18B, A-MW19B, A-MW20B (abandoned), B-15WB, and A-P8: Area A deep aquifer monitoring wells 6. B-MW12, B-MW13, B-MW14, B-MW15, B-MW16, B-MW17, B-MW18A, and B-MW19A: Area B shallow aquifer monitoring wells 7. B-MW8B, B-MW9B, B-MW11B, B-MW18B (abandoned), and B-MW19B - Area B deep aquifer monitoring wells

A summary of monitoring well completion details including ground surface and top of casing elevation, well depths, and screened intervals is presented in Tables 4-1 and 4-2 for Areas A

TABLE 4-1

WELL COMPLETION DETAIL SUMMARY - AREA A
DEEP AQUIFER (YORKTOWN) WELLS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Well Number	Year Install.	Company Install.	Diameter (Inches)	T.O.C. Elevation Feet, MSL	G. S. Elevation Feet, MSL	Depth Of Well From G. S.	Top Of Screen From G. S.	Top Of Screen Elevation Feet, MSL	Bottom Of Screen From G. S.	Bottom Of Screen Elevation Feet, MSL
A-MW1B	1991	2	2	12.91	11.2	55	43.5	-32.3	53.5	-42.3
A-MW1C	1992	3	2	13.68	11.73	137	120.6	-108.87	130.6	-118.87
A-MW4B	1991	2	2	13.58	11.23	60	47	-35.77	57	-45.77
A-MW6B	1991	2	2	12.07	9.05	60	50	-40.95	60	-50.95
A-MW8B	1992	3	4	9.62	7.82	67	53.5	-45.68	63.5	-55.68
A-P8	1992	3	2	9.52	7.89	67	55.7	-47.81	65.7	-57.81
A-MW9B	1991	2	2	9.08	7.28	60	50	-42.72	60	-52.72
A-MW9C	1992	3	2	13.61	11.14	137	104.8	-93.66	114.8	-103.66
A-MW10B	1991	2	2	8.73	5.95	65	55	-49.05	65	-59.05
A-MW11B	1991	2	2	14.43	12.98	64	54	-41.02	64	-51.02
A-MW13B	1992	3	2	10.19	10.41	67	54	-43.59	64	-53.59
A-MW14B	1992	3	2	10.48	10.83	67	54	-43.17	64	-53.17
A-MW15B	1992	3	2	8.67	6.03	67	55	-48.97	65	-58.97
A-MW16B	1992	3	2	9.58	7.55	65	55	-47.45	65	-57.45
A-MW17B	1992	3	2	9.05	7.44	66	56	-48.56	66	-58.56
A-MW18B	1992	3	2	9.69	7.38	76	65.3	-57.92	75.3	-67.92
A-MW19B	1992	3	2	14.55	12.17	65	54.1	-41.93	64.1	-51.93
B-15WB	1992	3	2	10.31	8.44	132	115	-106.56	125	-116.56

G. S. = Ground Surface

Notes: 1 = Malcolm Pirnie, Inc.
2 = CH2M Hill
3 = Baker Environmental, Inc.

Well B-MW19B has two separate screen intervals in the same well.

TABLE 4-1

WELL COMPLETION DETAIL SUMMARY - AREA A
SHALLOW AQUIFER (WATER TABLE) WELLS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Well Number	Year Install.	Company Install.	Diameter (Inches)	T.O.C. Elevation Feet, MSL	G. S. Elevation Feet, MSL	Depth Of Well From G. S.	Top Of Screen From G. S.	Top Of Screen Elevation Feet, MSL	Bottom Of Screen From G. S.	Bottom Of Screen Elevation Feet, MSL
GW-1	1983	1	2	13.46	11.53	24	4	7.53	24	-12.47
GW-2	1983	1	2	15.08	13.34	24	4	9.34	24	-10.66
GW-3	1983	1	2	14.28	12.51	24	4	8.51	24	-11.49
B-1W	1983	1	2	13.5	12.73	24	4	8.73	24	-11.27
B-2	1983	1	2	15.65	12.68	24	NA	NA	NA	NA
B-3	1983	1	2	15.48	12.22	24	NA	NA	NA	NA
B-4W	1983	1	2	14.26	12.64	24	2	10.64	24	-11.36
B-5W	1983	1	2	11.54	10.19	26	2	8.19	22	-11.81
B-6	1983	1	2	15.34	12.45	24	NA	NA	NA	NA
B-7W	1983	1	2	14.35	13.42	24	4	9.42	24	-10.58

G. S. = Ground Surface
All wells constructed of PVC except B-20WSS, which is constructed of stainless steel

Note: 1 = Malcolm Pirnie, Inc.
2 = CH2M Hill
3 = Baker Environmental, Inc.
NA = Not Applicable; completed as open borehole

TABLE 4-1 (Continued)

WELL COMPLETION DETAIL SUMMARY - AREA A
SHALLOW AQUIFER (WATER TABLE) WELLS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Well Number	Year Install.	Company Install.	Diameter (Inches)	T.O.C. Elevation Feet, MSL	G. S. Elevation Feet, MSL	Depth Of Well From G. S.	Top Of Screen From G. S.	Top Of Screen Elevation Feet, MSL	Bottom Of Screen From G. S.	Bottom Of Screen Elevation Feet, MSL
B-8	1983	1	2	15.56	12.58	24	NA	12.58	NA	12.58
B-9W	1983	1	2	15.32	13.31	24	2	11.31	22	-8.69
B-10	1983	1	2	15.65	13.45	24	NA	NA	NA	NA
B-11W	1983	1	2	17.45	15.6	24	2	13.6	22	-6.4
B-12	1983	1	2	19.29	16.3	24	NA	NA	NA	NA
B-13W	1983	1	2	17.83	16.13	24	4	12.13	24	-7.87
B-15WA	1983	1	2	9.99	8.44	24	4	4.44	24	-15.56
B-16W	1983	1	2	15.32	13.84	24	4	9.84	24	-10.16
B-17W	1983	1	2	13.3	11.92	24	4	7.92	24	-12.08
B-20W	1983	1	2	15.19	12.97	26	2	10.97	22	-9.03
A-MW4A	1991	2	2	13.63	11.55	20	10	1.55	20	-8.45
A-MW5	1991	2	2	7.07	5.29	25	10	-4.71	25	-19.71

G. S. = Ground Surface
All wells constructed of PVC except B-20WSS, which is constructed of stainless steel

Note: 1 = Malcolm Pirnie, Inc.
2 = CH2M Hill
3 = Baker Environmental, Inc.
NA = Not Applicable; completed as open borehole

TABLE 4-1 (Continued)

WELL COMPLETION DETAIL SUMMARY - AREA A
SHALLOW AQUIFER (WATER TABLE) WELLS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Well Number	Year Install.	Company Install.	Diameter (Inches)	T.O.C. Elevation Feet, MSL	G. S. Elevation Feet, MSL	Depth Of Well From G. S.	Top Of Screen From G. S.	Top Of Screen Elevation Feet, MSL	Bottom Of Screen From G. S.	Bottom Of Screen Elevation Feet, MSL
A-MW6A	1991	2	2	11.56	9.04	20	10	-9.6E-1	20	-10.96
A-MW7	1991	2	2	7.75	5.81	25	10	-4.19	20	-14.19
A-MW8A	1991	2	2	9.76	7.37	30	13	-5.63	23	-15.63
A-MW9A	1991	2	2	9.57	7.35	22	12	-4.65	22	-14.65
A-MW10A	1991	2	2	8.28	6.05	20	10	-3.95	20	-13.95
A-MW11A	1991	2	2	14.81	13.05	25	15	-1.95	25	-11.95
A-MW12	1991	2	2	12.54	10.48	20	10	4.8E-1	20	-9.52
B-20WSS	1992	3	2	15.01	13.6	25	15	-1.4	25	-11.4

G. S. = Ground Surface
All wells constructed of PVC except B-20WSS, which is constructed of stainless steel

Note: 1 = Malcolm Pirnie, Inc.
2 = CH2M Hill
3 = Baker Environmental, Inc.
NA = Not Applicable; completed as open borehole

TABLE 4-2

WELL COMPLETION DETAIL SUMMARY - AREA B
DEEP AQUIFER (YORKTOWN) WELLS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Well Number	Year Install.	Company Install.	Diameter (Inches)	T.O.C. Elevation Feet, MSL	G. S. Elevation Feet, MSL	Depth Of Well From G. S.	Top Of Screen From G. S.	Top Of Screen Elevation Feet, MSL	Bottom Of Screen From G. S.	Bottom Of Screen Elevation Feet, MSL
B-MW2B	1991	2	2	11.04	8.33	61	51	-42.67	61	-52.67
B-MW3B	1991	2	2	9.97	10.03	60	50	-39.97	60	-49.97
B-MW5B	1991	2	2	13.4	11.32	60	50	-38.68	60	-48.68
B-MW8B	1992	3	2	13.53	11.82	69	55	-43.18	65	-53.18
B-MW9B	1992	3	2	12.17	12.31	67	55.4	-43.09	65.4	-53.09
B-MW11B	1992	3	2	9.51	9.71	68	55	-45.29	65	-55.29
B-MW19B*	1992	3	2	12.88	10.41	67	35.1	-24.69	45.1	-34.69
					10.41		55.1	-44.69	65.1	-54.69

G. S. = Ground Surface

Notes: 1 = Malcolm Pirnie, Inc.
2 = CH2M Hill
3 = Baker Environmental, Inc.

Well B-MW19B has two separate screen intervals in the same well.

TABLE 4-2

WELL COMPLETION DETAIL SUMMARY - AREA B
SHALLOW AQUIFER (WATER TABLE) WELLS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Number	Year Install.	Company Install.	Diameter (Inches)	T.O.C. Elevation Feet, MSL	G. S Elevation Feet, MSL	Depth Of Well From G. S.	Top Of Screen From G. S.	Top Of Screen Elevation Feet, MSL	Bottom Of Screen From G.S.	Bottom Of Screen Elevation Feet, MSL
B-MW1	1991	2	2	9.19	9.48	30	12	-2.52	22	-12.52
B-MW2A	1991	2	2	10.72	8.21	20	10	-1.79	20	-11.79
B-MW3A	1991	2	2	9.3	9.51	20	10	-4.9E-1	20	-10.49
B-MW7	1991	2	2	12.65	5.81	30	12	-6.19	22	-16.19
B-MW8A	1991	2	2	14.17	11.72	20	10	1.72	20	-8.28
B-MW9A	1991	2	2	12.38	12.55	30	17	-4.45	27	-14.45
B-MW10	1991	2	2	9.51	9.75	30	13	-3.25	23	-13.25
B-MW11A	1991	2	2	9.55	9.77	25	10	-2.3E-1	20	-10.23
B-MW12	1992	3	2	8.97	9.26	14	4	5.26	14	-4.74
B-MW13	1992	3	2	9.75	9.93	14	4	5.93	14	-4.07
B-MW14	1992	3	2	9.8	10.2	16	6	4.2	16	-5.8
B-MW15	1992	3	2	7.62	8.44	16	6	2.44	16	-7.56
B-MW16	1992	3	2	8.21	8.52	16	6	2.52	16	-7.48
B-MW17	1992	3	2	8.24	8.25	14	4	4.25	14	-5.75
B-MW18A	1992	3	2	11.66	9.11	15	3.9	5.21	13.9	-4.79
B-MW19A	1992	3	2	12.84	10.31	15	4.9	5.41	14.9	-4.59
GW-4	1983	1	2	11.42	9.75	24	4	5.75	24	-14.25
GW-5	1983	1	2	12.69	11.02	24	4	7.02	24	-12.98
GW-6	1983	1	2	11.21	10.07	24	4	6.07	24	-13.93

G.S. = Ground Surface

Notes: 1 = Malcolm Pirnie, Inc.
2 = CH2M Hill
3 = Baker Environmental, Inc.

Well B-MW19B has two separate screen intervals in the same well.

and B, respectively. Please note that not all of these wells were suitable or accessible for groundwater sampling or hydrologic studies, but are summarized here for completeness.

In addition to the above-listed borings and wells, geotechnical boring logs generated for the preconstruction assessment of Area A (Brig construction) were also utilized to evaluate the presence or absence of the confining clay unit between the shallow (Columbia Group) and deep (Yorktown) aquifers. These logs are not included in Appendix F because of poor reproduction quality. They are, however, discussed in more detail in Section 4.1.4.

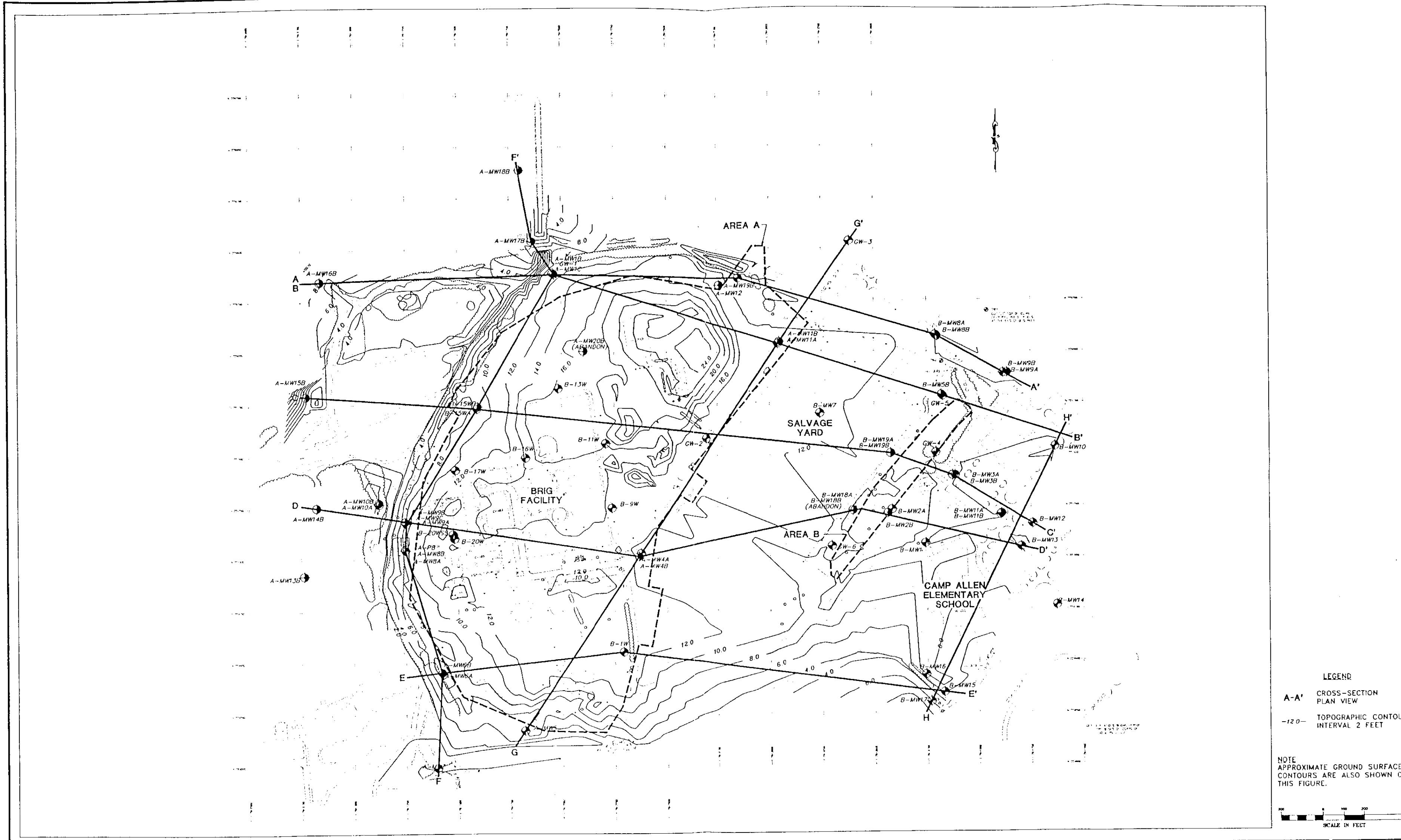
4.1.3 Well Development

All monitoring wells installed by Baker as part of the RI were developed prior to sampling. Wells were developed in general accordance with the procedures outlined in the Final Project Plans for Camp Allen Landfill (Baker, April 1992). Information recorded during development included the rate and volume of water removed, pH, specific conductivity, temperature, and water clarity. These data are summarized on well development summary sheets found in Appendix G.

4.1.4 Lithology Cross-Sections

Eight cross-sections were completed across Areas A and B to define the subsurface stratigraphy. The locations of the cross-sections are shown on Figure 4-3. The cross-sections show the generalized stratigraphy in terms of primary soil types (sand, silt, and clay). Fill materials are indicated where present. The approximate ground surface along the cross-section and the shallow ditches around the Camp Allen Landfill are also indicated. Groundwater elevations from the Round 6 measurements are also shown for both the shallow and deep aquifers. Figures 4-4 through 4-11 show cross-sections A-A' through H-H', respectively.

The subsurface geology beneath Camp Allen Landfill investigated as part of this RI consists of the Columbia Group (Pleistocene), the Yorktown Formation (Miocene), and the Calvert Formation (Miocene). The Columbia Group consists of the sands, silts and clays beneath the soil cover or fill materials at the site. This group of sediments is approximately 30 to 50 feet thick. At the site, sand is the predominant lithology, with lesser amounts of silt and clay. The sand varies from fine to coarse-grained, is generally greyish to light brown with varying amounts of brown to orange streaking. The silts and clays tend to be grey or greenish grey and



REVISIONS		
	DATE	7/93
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	DRAWN	GLB
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	S.O.#	19084
	CADD#	GRNDCONT

NORTH

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NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

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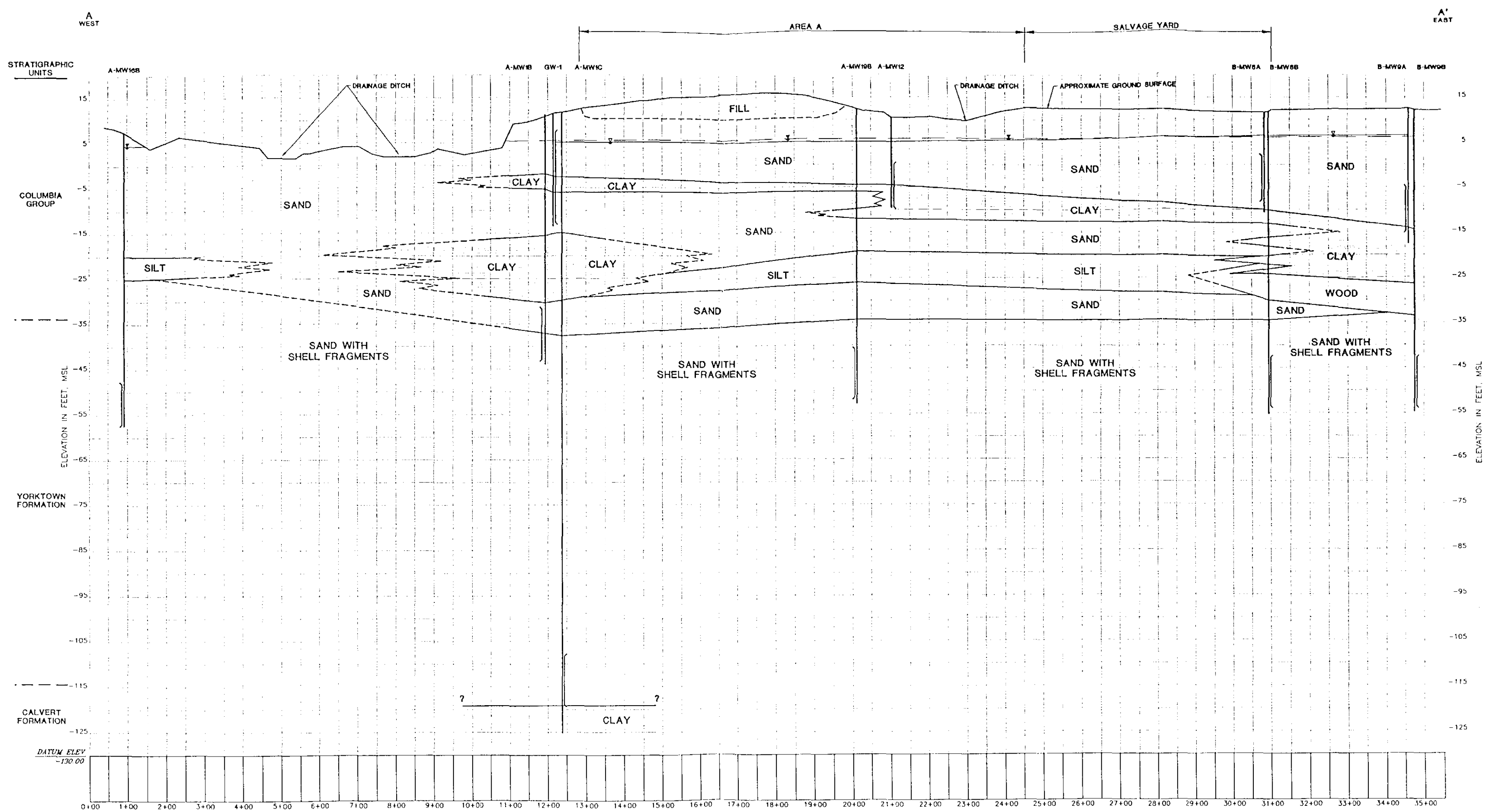
CROSS-SECTION LOCATIONS

SCALE GRAPHIC | DATE 7/93

FIGURE
4-3



NOTES:

1. FILL MATERIAL IN UPPER 5 TO 15 FEET OF SECTION APPROXIMATED ONLY.
2. SUBSURFACE LITHOLOGIES SHOWN IN CROSS-SECTIONS KNOWN AT BOREHOLE LOCATIONS ONLY. LITHOLOGIES BETWEEN BOREHOLES ARE INTERPOLATED AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

LEGEND

- GROUNDWATER ELEVATION – WATER TABLE AQUIFER
- GROUNDWATER ELEVATION – YORKTOWN AQUIFER
- (WATER LEVELS MEASURED 12/17/92 AND 12/18/92)
- } WELL SCREEN INTERVAL

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

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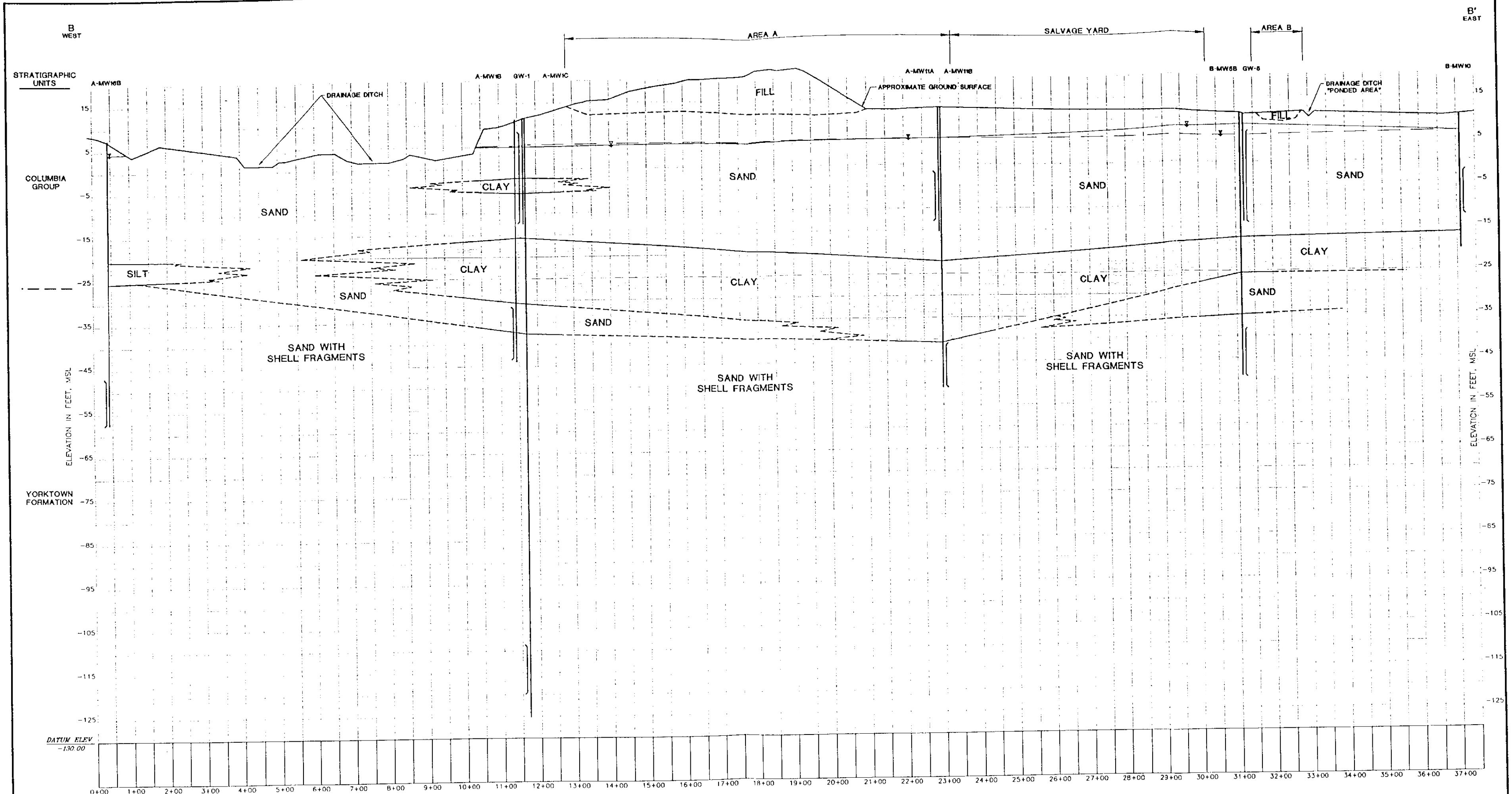
CROSS-SECTION A-A'

SCALE AS SHOWN DATE 7/93

FIGURE 4-4



NOTES:

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2. SUBSURFACE LITHOLOGIES SHOWN IN CROSS-SECTIONS KNOWN AT BOREHOLE LOCATIONS ONLY. LITHOLOGIES BETWEEN BOREHOLES ARE INTERPOLATED AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

LEGEND

GROUNDWATER ELEVATION - WATER TABLE AQUIFER
GROUNDWATER ELEVATION - YORKTOWN AQUIFER
(WATER LEVELS MEASURED 12/17/92 AND 12/18/92)
WELL SCREEN INTERVAL

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

REVISIONS		
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	SCALE	AS SHOWN
	DRAWN	GLB
	REVIEWED	TEA
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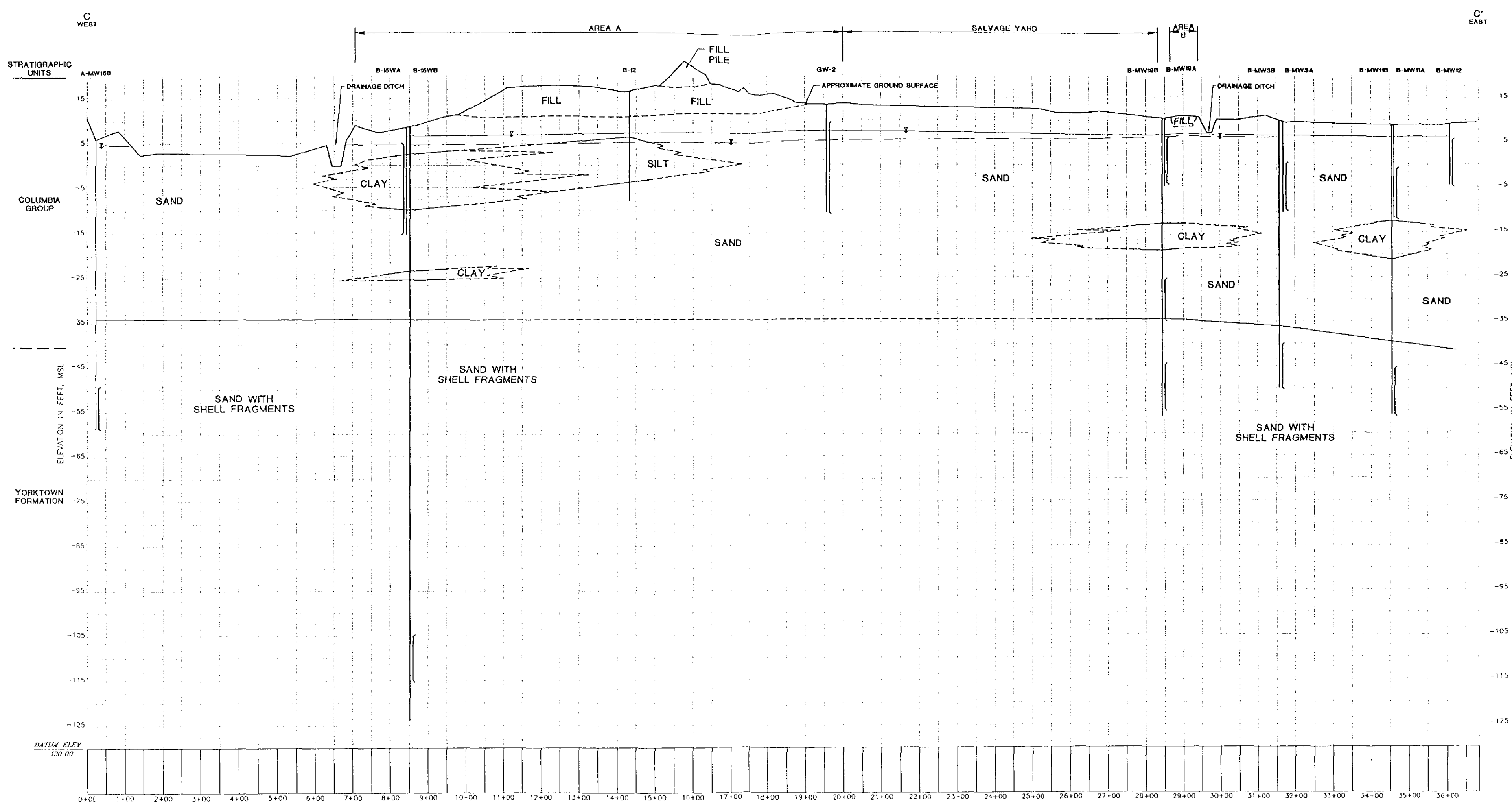
CROSS-SECTION B-B'

SCALE AS SHOWN DATE 7/93

FIGURE 4-5



NOTES:

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2. SUBSURFACE LITHOLOGIES SHOWN IN CROSS-SECTIONS KNOWN AT BOREHOLE LOCATIONS ONLY. LITHOLOGIES BETWEEN BOREHOLES ARE INTERPOLATED AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

LEGEND

GROUNDWATER ELEVATION – WATER TABLE AQUIFER
GROUNDWATER ELEVATION – YORKTOWN AQUIFER
(WATER LEVELS MEASURED 12/17/92 AND 12/18/92)
) WELL SCREEN INTERVAL

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	AS SHOWN
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	REVIEWED	TEA
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	CADD#	084-SECC

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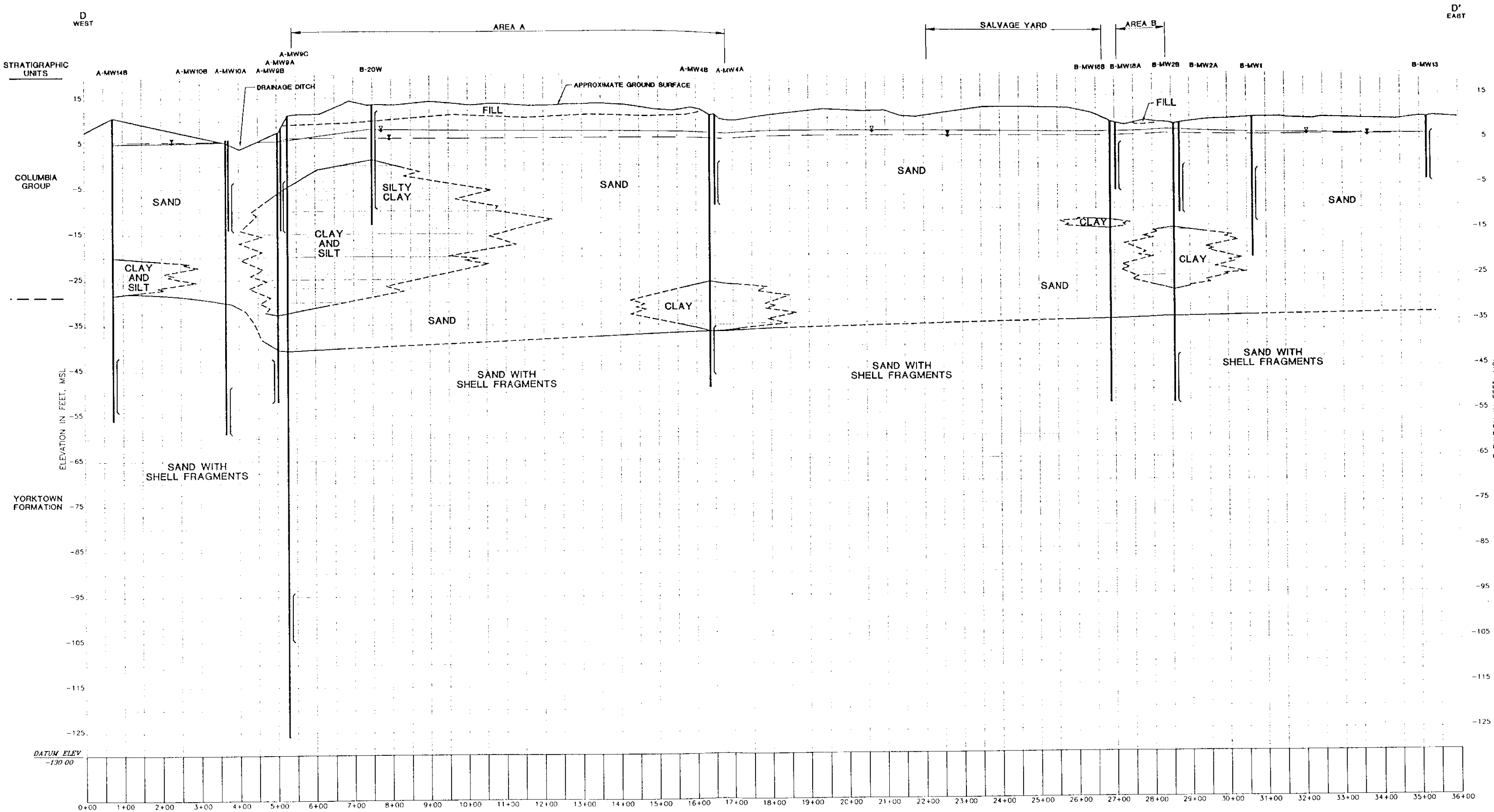
CROSS-SECTION C-C'

SCALE AS SHOWN
DATE 7/93

FIGURE
4-6



NOTES:

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2. SUBSURFACE LITHOLOGIES SHOWN IN CROSS-SECTIONS KNOWN AT BOREHOLE LOCATIONS ONLY. LITHOLOGIES BETWEEN BOREHOLES ARE INTERPOLATED AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

LEGEND

- GROUNDWATER ELEVATION – WATER TABLE AQUIFER
- GROUNDWATER ELEVATION – YORKTOWN AQUIFER
- (WATER LEVELS MEASURED 12/17/92 AND 12/18/92)
- WELL SCREEN INTERVAL

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

REVISIONS		
DATE	7/93	NORTH
SCALE	AS SHOWN	
DRAWN	CLB	
REVIEWED	TEA	
S.O.#	19084	
CADD#	084-SECD	

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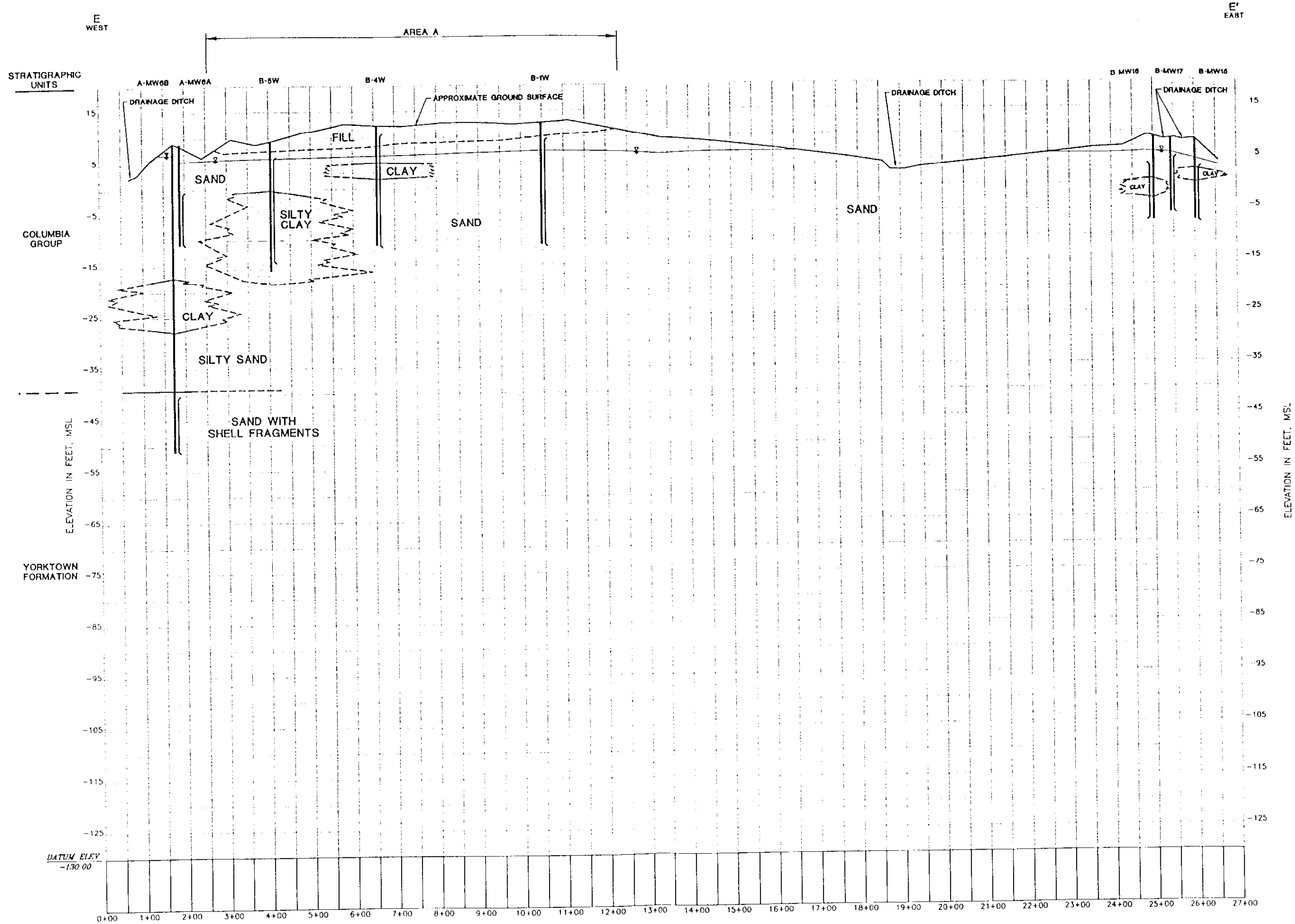
CROSS-SECTION D-D'

SCALE AS SHOWN DATE 7/93

FIGURE 4-7



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LEGEND

- GROUNDWATER ELEVATION – WATER TABLE AQUIFER
- GROUNDWATER ELEVATION – YORKTOWN AQUIFER
- (WATER LEVELS MEASURED 12/17/92 AND 12/18/92)
- WELL SCREEN INTERVAL

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

REVISIONS		
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SCALE	AS SHOWN	
DRAWN	GLB	
REVIEWED	TEA	
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CADD#	084-SECE	

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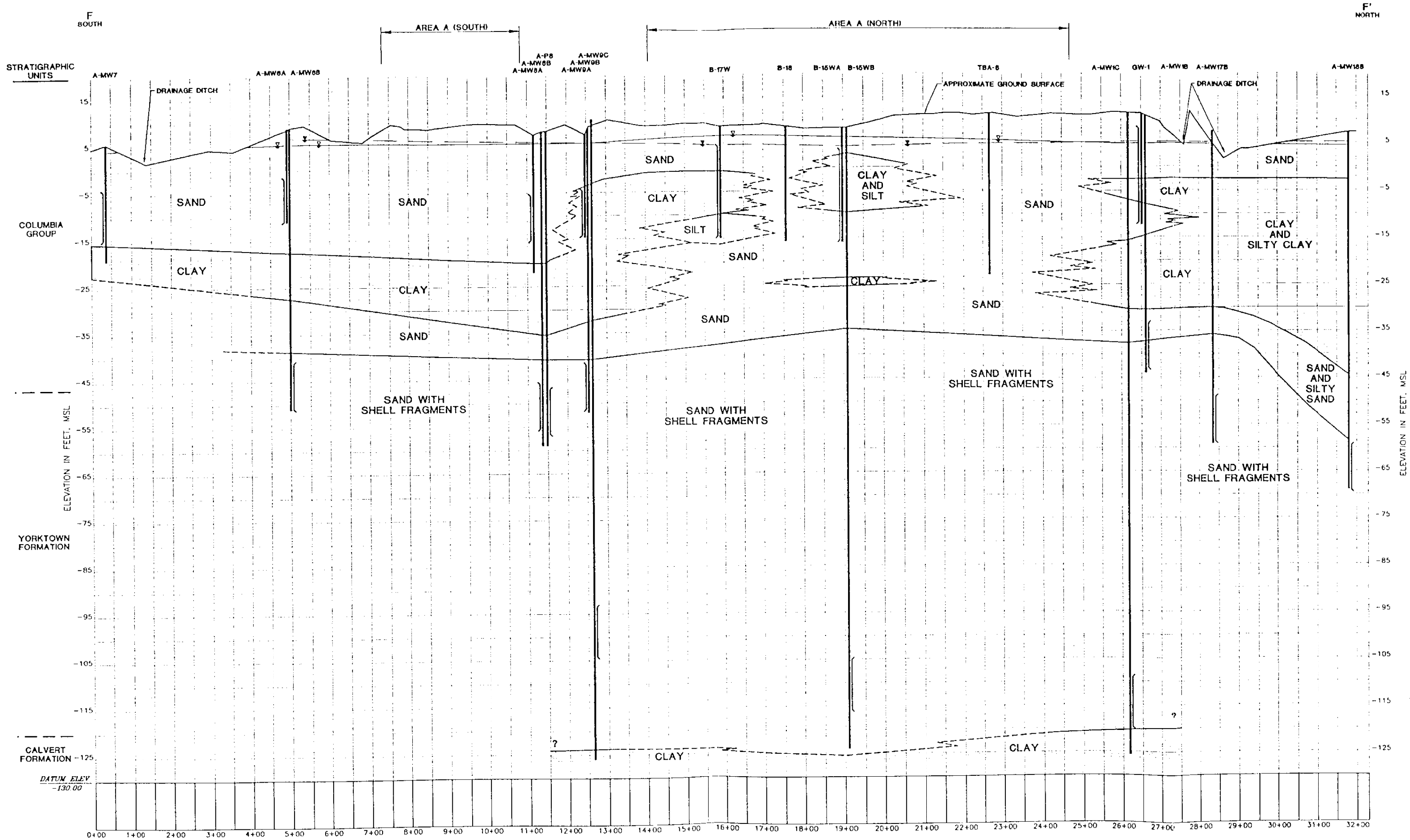
CROSS-SECTION E-E'

FIGURE 4-8

SCALE AS SHOWN DATE 7/93



LEGEND

- GROUNDWATER ELEVATION – WATER TABLE AQUIFER
- GROUNDWATER ELEVATION – YORKTOWN AQUIFER
- (WATER LEVELS MEASURED 12/17/92 AND 12/18/92)
-) WELL SCREEN INTERVAL

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

NOTES:

1. FILL MATERIAL IN UPPER 5 TO 15 FEET OF SECTION APPROXIMATED ONLY.
2. SUBSURFACE LITHOLOGIES SHOWN IN CROSS-SECTIONS KNOWN AT BOREHOLE LOCATIONS ONLY. LITHOLOGIES BETWEEN BOREHOLES ARE INTERPOLATED AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

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	DATE	7/93	
	SCALE	AS SHOWN	
	DRAWN	GLB	
	REVIEWED	TEA	
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	CADD#	084-SECF	

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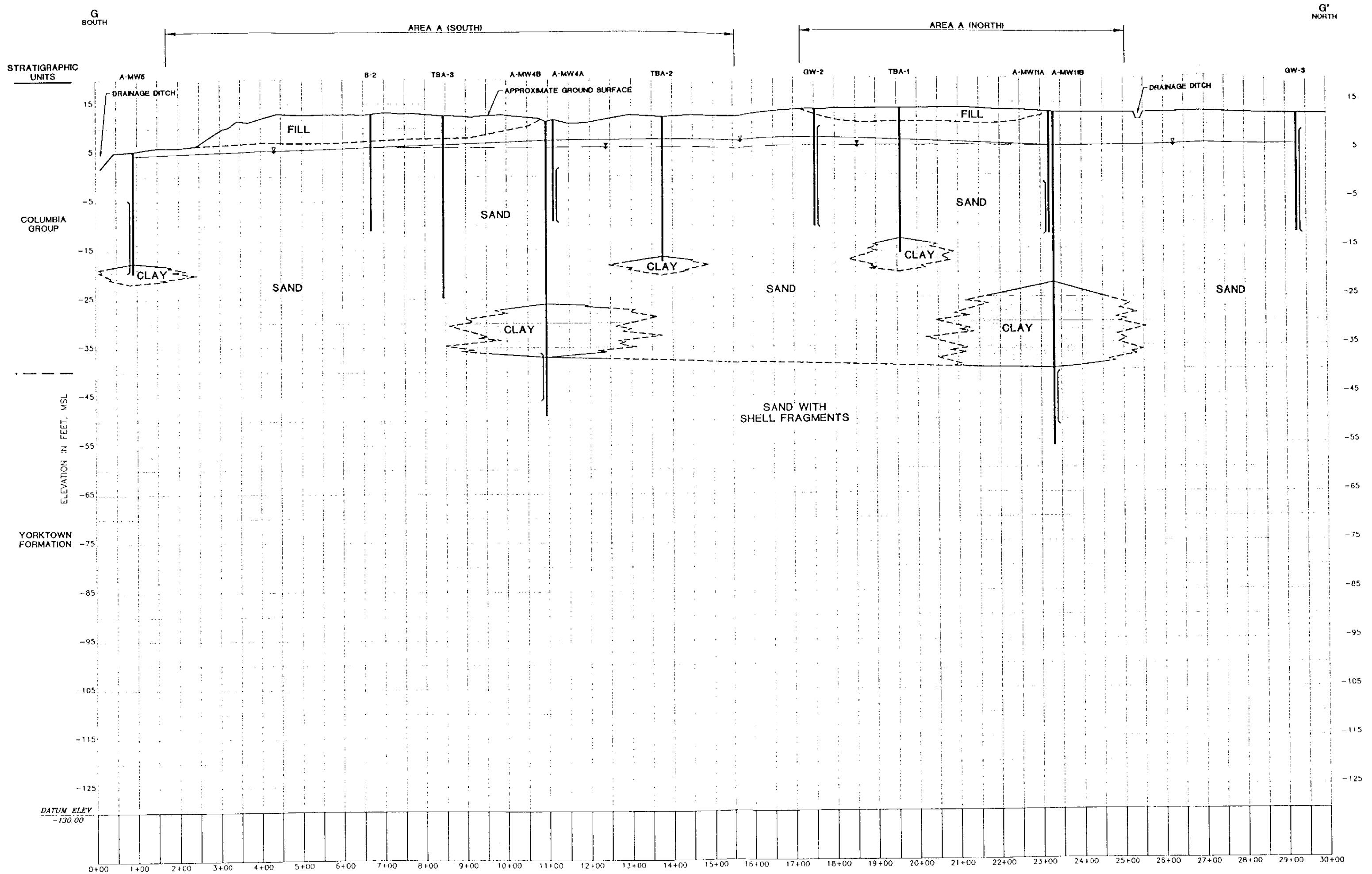
CROSS–SECTION F–F'

SCALE AS SHOWN DATE 7/93

FIGURE
4–9



NOTES:

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2. SUBSURFACE LITHOLOGIES SHOWN IN CROSS-SECTIONS KNOWN AT BOREHOLE LOCATIONS ONLY. LITHOLOGIES BETWEEN BOREHOLES ARE INTERPOLATED AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

LEGEND

GROUNDWATER ELEVATION – WATER TABLE AQUIFER
GROUNDWATER ELEVATION – YORKTOWN AQUIFER
(WATER LEVELS MEASURED 12/17/92 AND 12/18/92)
WELL SCREEN INTERVAL

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	AS SHOWN
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	084-SECG

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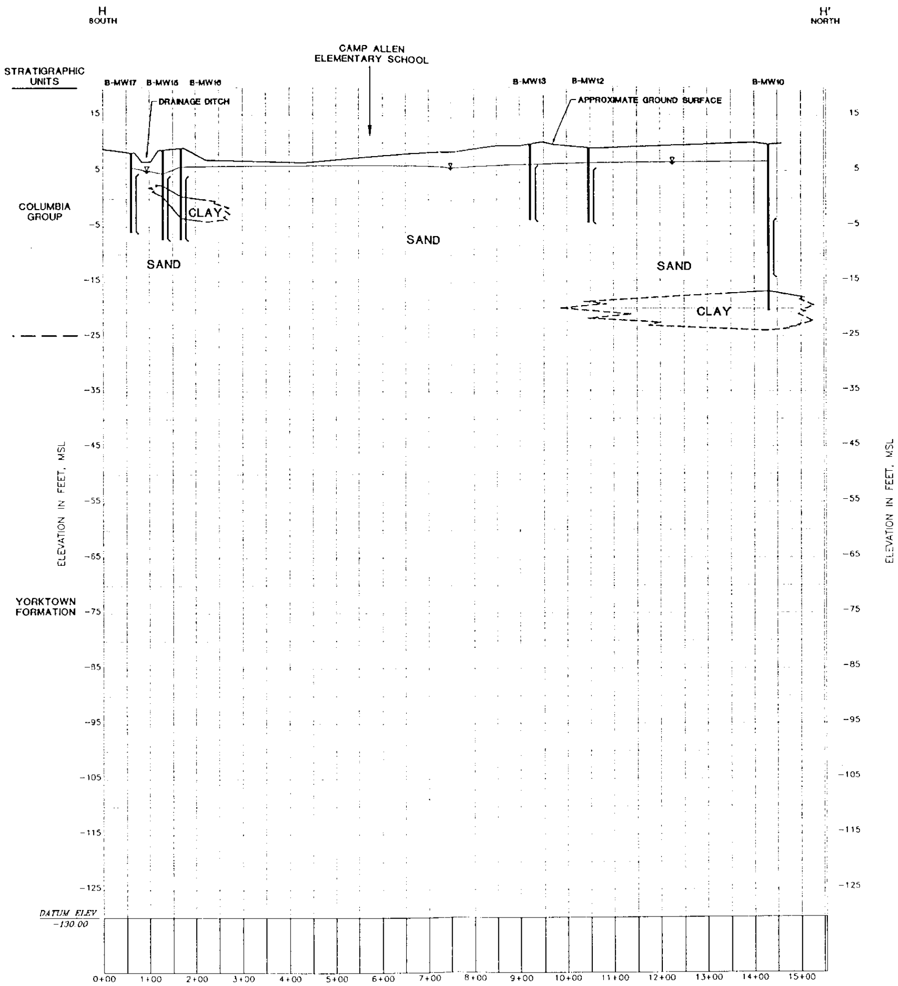
CROSS-SECTION G-G'

SCALE AS SHOWN DATE 7/93

FIGURE 4-10



NOTES:

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LEGEND

GROUNDWATER ELEVATION – WATER TABLE AQUIFER (WATER LEVELS MEASURED 12/17/92 AND 12/18/92)

WELL SCREEN INTERVAL

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

REVISIONS		
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	SCALE	AS SHOWN
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	084-SECH

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SECTION H-H'

SCALE AS SHOWN   DATE 7/93

FIGURE 4-11

may contain significant portions of plant or woody material (see eastern end of Section A-A', Figure 4-4). A clay unit near the base of this group (referred to as the confining clay) is present at some locations but is not ubiquitous across either Area A or Area B. The presence and thickness of this confining clay is discussed further in Section 4.1.5 below.

At many locations, 5 to 10 or more feet of sand is found beneath the confining clay, but above the shell hash and sand generally recognized as the top of the Yorktown Formation (see Sections A-A', D-D', and F-F', Figures 4-4, 4-7, and 4-9, respectively, as examples). This sand is similar to the sands above the clay (if present), although lenses or layers of gravel may also be present.

The unconfined or water table aquifer is found in the Columbia Group sediments. Groundwater is generally found at depths of between 5 and 10 feet below grade. Discussion of the characteristics of the shallow aquifer is found in Section 4.2.1 below.

The Yorktown Formation, as mentioned above, is characterized by sand with abundant shell fragments. It is highly distinctive and was located in all deeper borings at the site, between depths of about 40 to 65 feet below grade. Two well borings completely penetrated the Yorktown (A-MW9C and A-MW1C). These borings, shown on Section F-F' (Figure 4-9), indicate that the average thickness of the Yorktown Formation beneath the site is about 82 feet.

The Yorktown Formation is also known as the Yorktown Aquifer, a regional water-bearing zone frequently tapped for its groundwater resources. The Yorktown Aquifer is also referred to as the deep aquifer beneath the Camp Allen Landfill. Its characteristics are discussed in Section 4.2.2 below.

Beneath the Yorktown Formation is the Calvert Group. Its upper portion is a clay unit ("blue clay") which acts as a confining unit with lower portions of the Yorktown Aquifer. At the Camp Allen Landfill Site, two deep borings shown on cross-section F-F' just penetrate the upper 2 to 5 feet of the "blue clay." The clay is greyish green, stiff, moist, and contained scattered shell fragments or sand and silt. The thickness of the Calvert Group was not determined as part of this investigation.

4.1.5 Continuity of the Confining Clay Layer

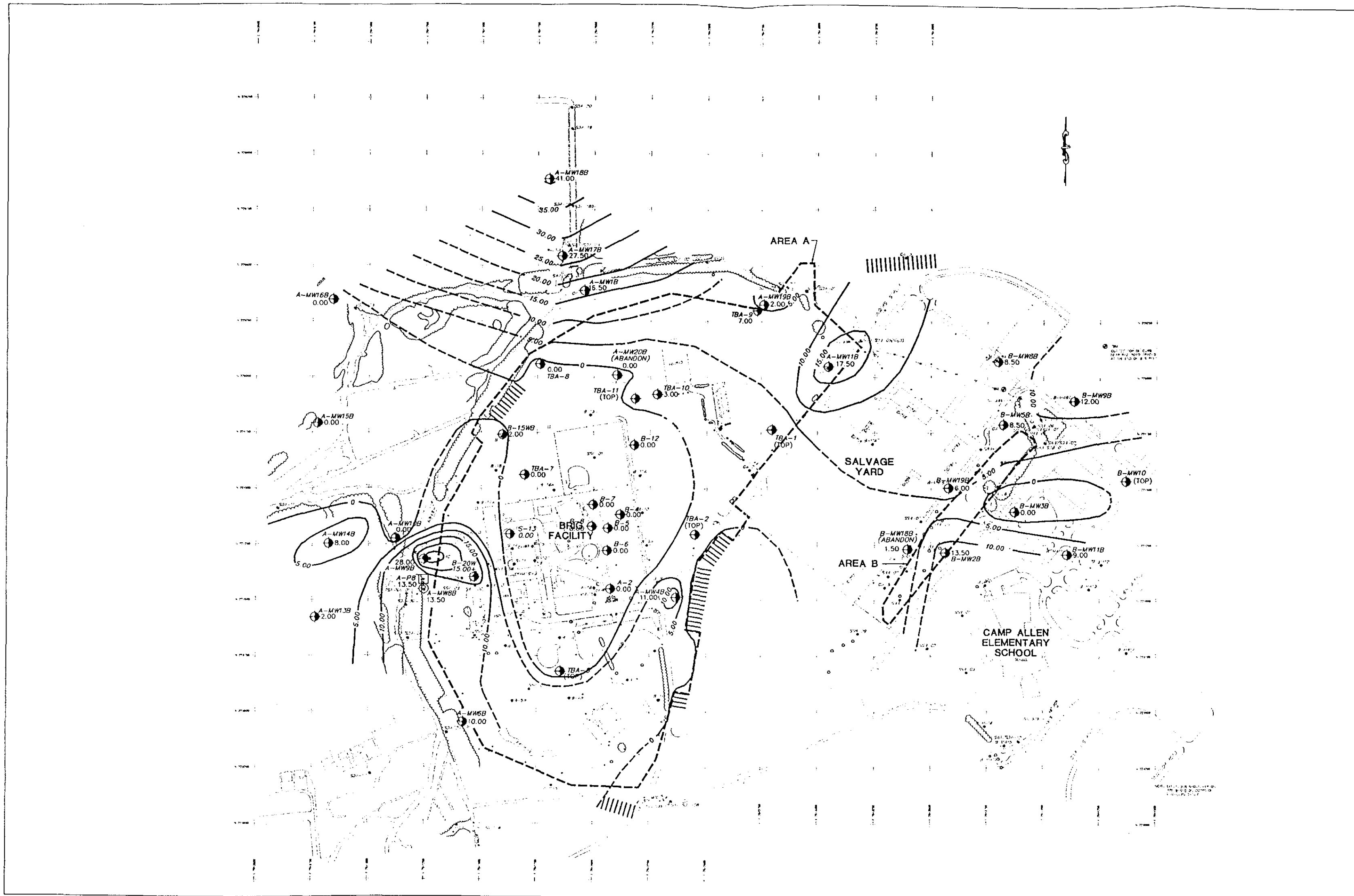
The confining clay layer in the Columbia Group, which regionally separates the water table aquifer from the Yorktown Aquifer, is poorly developed, absent, or has been breached beneath several portions of both Areas A and B. Several cross-sections illustrate the discontinuous nature of the clay. Section A-A' (Figure 4-4) shows clay absent at A-MW16B, two distinct clay layers at A-MW1B and C, and only the upper, thinner portion of the clay at A-MW19B. Traversing to the east, the clay interfingers with sand and silt and thickens to greater than 10 feet at B-MW9B.

Section B-B' (Figure 4-5) shows that the clay is thick and probably continuous from A-MW1C to B-MW10. However, further south, both sections C-C' and D-D' show the confining clay as discontinuous beneath both Areas A and B (Figures 4-6 and 4-7). Note the abrupt lithology changes from wells B-MW19B to B-MW3B to B-MW11B, where the confining clay is not present in well B-MW3B but is present in both nearby wells (Figure 4-6).

Two locations at Area A have thickened clay sections -- A-MW9B/9C and A-MW17B and 18B. In cross-section D-D' (Figure 4-7), the thickened clay at A-MW9B/9C does not appear to be connected to the clay in A-MW4B because a geotechnical boring (A-2, not shown on cross-section) located to the west of A-MW4B did not contain clay. A breach in the clay to the east of A-MW4B was also noted by the surface geophysical investigation (see Section 4.1.1). The second thick clay section occurs in the most northern part of the study area as shown in section F-F' (Figure 4-9). It appears that the clay thickens to the north, in the direction of Willoughby Bay. Also note on section F-F' the discontinuous nature of the clay between A-MW9C and B-15WB. Traversing from south to north, the upper portion of the formation remains a clay, while the lower portion changes to primarily a sandy lithology with a thin clay layer.

To better visualize the presence or absence of the confining clay, a clay isopach map (Figure 4-12) was developed. The clay thicknesses were determined from boring logs and are summarized in Table 4-3. Note that where nested wells were located and indicated differing clay thicknesses, the average of the two borings was usually plotted. Also, only clay layers which were found below 10 to 15 feet below grade (which was considered the confining clay layer) were used in the calculation unless the clay was continuous throughout the borehole.

The isopach map indicates that the confining clay layer is poorly developed or absent in large portions of Area A and a small portion of Area B (Figure 4-12). Several of the borings



LEGEND

|||||| BREACHED OR MISSING CLAY. (AS IDENTIFIED IN THE GEOPHYSICAL SURVEY)

NOTES:
CONTOUR INTERVAL = 5 FEET.
CLAY THICKNESS NOTED NEXT TO DATA POINTS.

"TOP" INDICATES ONE OR TWO FEET OF CLAY WAS SAMPLED PRIOR TO TERMINATION OF BOREHOLE.

SCALE IN FEET

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	DRAWN	GLB
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NORTH

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ISOPACH MAP – CONFINING CLAY LAYER

SCALE GRAPHIC

DATE 7/93

FIGURE
4-12

TABLE 4-3

SUMMARY OF CLAY THICKNESSES
CAMP ALLEN LANDFILL

Location - Area A	Thickness
A-MW16B	0
A-MW15B	0
A-MW14B	8 feet
A-MW13B	2 feet
A-MW6B	10 feet
A-MW8B	13.5 feet
A-P8	13.5 feet
A-MW9B	28 feet
B-20W	at least 15 feet
B-15WB	2 feet
TBA-8	0
A-MW1B	16.5 feet
A-MW17B	27.5 feet
A-MW18B	41 feet
TBA-7	0
A-MW20B	0
TBA-11	Top only
TBA-10	3 feet
S-13	0
TBA-5	Top (at least 4 feet)
TBA-4	At least 6 feet
A-2	0
B-4	0
B-5	0
B-6	0
B-7	0
B-8	0
A-MW4B	11 feet
TBA-2	Top
TBA-1	Top
TBA-9	7 feet
A-MW19B	2 feet
A-MW11B	17.5 feet

Location - Area B	Thickness
B-MW18B	1.5 feet
B-MW19B	6 feet
B-MW5B	8.5 feet
B-MW8B	8.5 feet
B-MW9B	12 feet
B-MW3B	0
B-MW11B	9 feet
B-MW2B	13.5 feet

completed to at least 47 feet below grade as part of the Brig construction indicated only sand and silt in the subsurface (A-2, S-13, B-4, B-5, B-6, and B-7). North of the Brig, one boring (A-MW20B) did not encounter clay, with other nearby borings just ending in the top of the clay or finding less than 5 feet of clay. The clay is also apparently missing near the central portion of Area B (at B-MW3B). It is also apparently thin or absent in the southern portion of the Salvage Yard and to the south/southwest of the Salvage Yard.

The isopach map also shows the highly variable thickness in other areas; for example, the clay is very thick (about 28 feet) at A-MW9B/9C, while just to the west across the ditch at A-MW10B the clay is absent. Also, the clay thickens significantly to the north of Area A (toward Willoughby Bay).

The absence of clay, in general, correlates with the former position of Bousch Creek (see Figure 2-4 in Section 2.5.2). Prior to the area being developed, Bousch Creek may have cut through portions of the confining clay. The variations in lithology across the Camp Allen Landfill area are also due to the generally heterogeneous nature of nearshore marine deposition. Thus, in some portions of the study area, the clay layer may be absent or reduced in thickness not because it was cut through by Bousch Creek, but rather because depositional conditions resulted in coarse-grained materials (silts and sands) rather than clays. Given these two considerations regarding localized thinning/absence of the confining clay, Baker has elected to show an estimated "zero thickness" contour to somewhat define the absence of clay. At the same time, however, the confining clay unit should be considered incompetent or leaky whenever its thickness is less than 5 feet.

As part of the geologic investigation of the confining clay, four separate samples of clay from near the top of the confining clay layer were collected and evaluated for grain size, moisture content, liquid and plastic limits, and specific gravity. The data indicate that all four samples are classified as "CL" in the Unified Soil Classification System and are considered silty clays. All four samples also contained 30 to 40 percent sand-size particles. A summary of these results is presented in Appendix H.

4.1.6 Source Characterization Summary: Area A

As discussed in Section 4.1.5, a series of geotechnical borings were advanced at Area A in April 1970 prior to construction of the Brig facility. Review of the logs with respect to thickness of landfilled wastes indicates that waste in the vicinity of the Brig ranged from approximately 2 feet to 15 feet in thickness. Table 4-4 presents a Waste Profile Summary.

From a total of 17 borings, 10 borings indicated waste thickness as less than 5 feet, five borings revealed waste to be 5 to 10 feet thick, and two borings indicated waste to be 11 to 15 feet thick. Based on the random location and coverage of the geotechnical borings, this is considered to be a typical waste profile throughout Area A. This is further supported by historical record reviews. Previous operations at Area A included both soils borrow and landfilling activities, which would account for varying waste elevations.

A review of groundwater elevations relative to the waste layer indicates that fill materials are primarily above the water table (as evident in most borings). Boring logs for A-17, S-10 and S-14 show that wastes were landfilled several feet below the water table. A typical waste profile, based on the geotechnical boring logs, is presented in Figure 4-13.

4.1.7 Source Characterization Summary: Area B

Source characterization activities at Area B including a review of historical information and soil gas survey results (CH_2M Hill, 1992), a geophysical survey, and source characterization borings; these data indicate primarily three areas of apparent disposal. These areas are best illustrated by the interpreted EM and magnetic results of the geophysical survey as shown on Figure 4-14. The area on the western side of Area B appears to be a concentrated pocket of high conductivity fill of a nonmetallic nature. Underground utilities (water line and storm sewer) are apparent directly east of this area.

Toward the middle portion of Area B, it appears as if a scrap underground storage tank (UST) has been buried at this location. This is further supported by the presence of what appears to be associated UST piping. The third area (on the eastern side of Area B) is a zone of buried metallic objects which also gives indications of trenching remnants.

Based on historical accounts of the Salvage Yard Fire and subsequent trench and fill operations at Area B and recent investigation activities, fire wastes were apparently buried in three primary trench areas. Trenches were, according to historical accounts as well as this investigation, basically rectangular in shape (varying dimensions -- see Figure 4-14). Trenches reportedly extended to a depth of approximately 8 feet below ground surface. On average, this is approximately 3 feet below the water table surface.

TABLE 4-4

CAMP ALLEN LANDFILL RI/FS
WASTE PROFILE SUMMARY

Boring No.	Surface Elevation (msl)	Top of Waste Elevation (msl)	Bottom of Waste Elevation (msl)	Waste Thickness (feet)	Depth to Groundwater "at 24 hours" (msl)
A1	12.7	11.7	7.7	4.0	5.5
A2	12.7	11.7	8.7	3.0	6.0
A3	12.2	11.2	8.2	3.0	5.6
A16	12.0	11.0	7.5	3.5	7.0
A17	13.0	12.0	3.0	9.0	6.6
B4	13.0	12.0	8.5	3.5	7.5
B5	12.8	11.8	9.8	2.0	6.3
B6	13.0	12.0	6.0	6.0	6.6
B7	15.5	14.5	8.5	6.0	7.0
B8	13.2	12.2	9.2	3.0	6.5
B9	13.2	12.2	7.2	5.0	8.3
S10	13.0	12.0	-1.5	13.5	6.5
S11	14.1	13.1	11.1	2.0	6.5
S12	13.7	12.7	7.7	5.0	6.5
S13	14.2	13.2	10.2	3.0	6.5
S14	15.3	14.3	-0.7	15.0	8.0
S15	13.8	12.8	9.3	3.5	6.8

msl = feet above (or below) Mean Sea Level
Assume one foot soil cap.

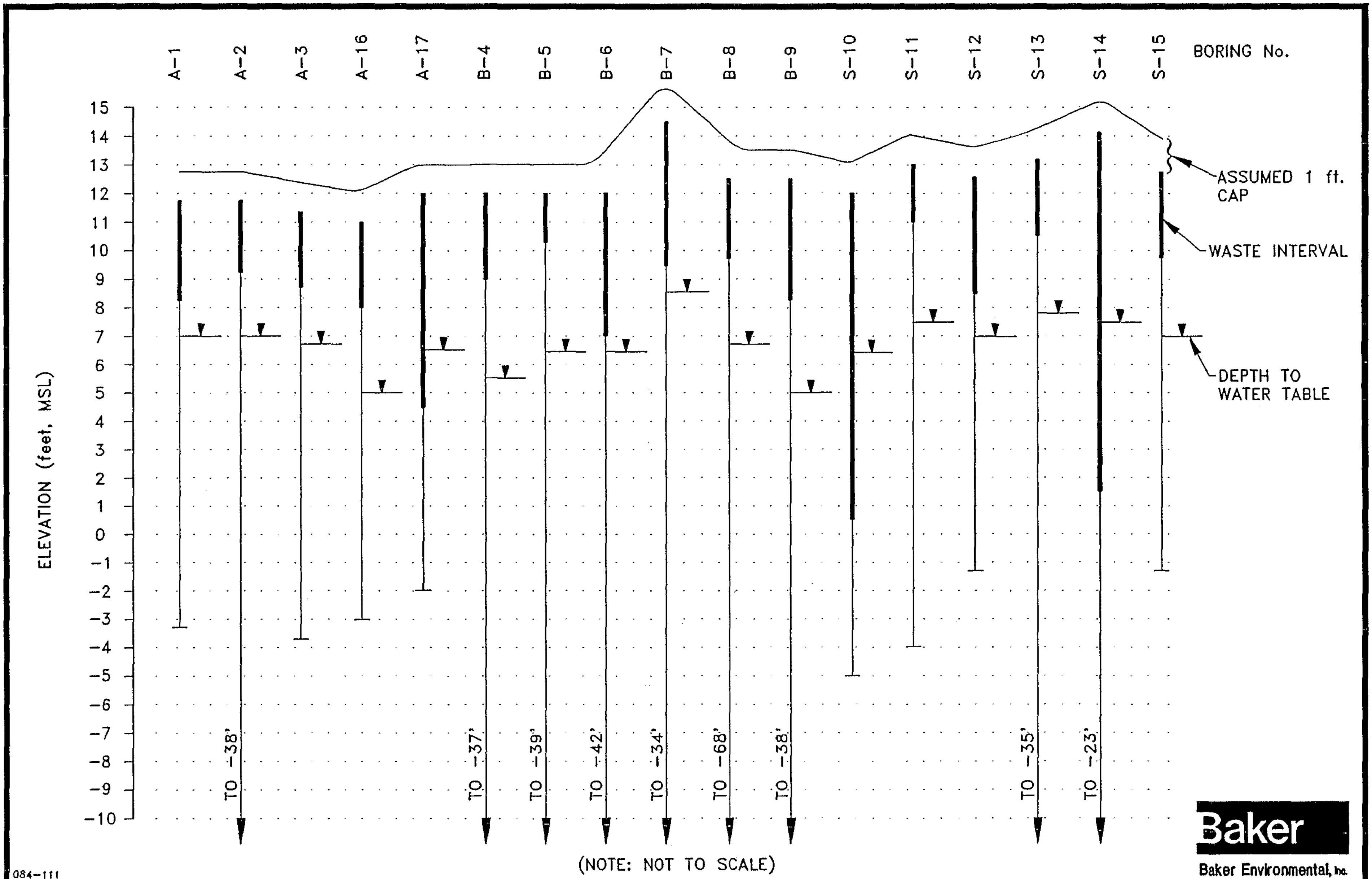
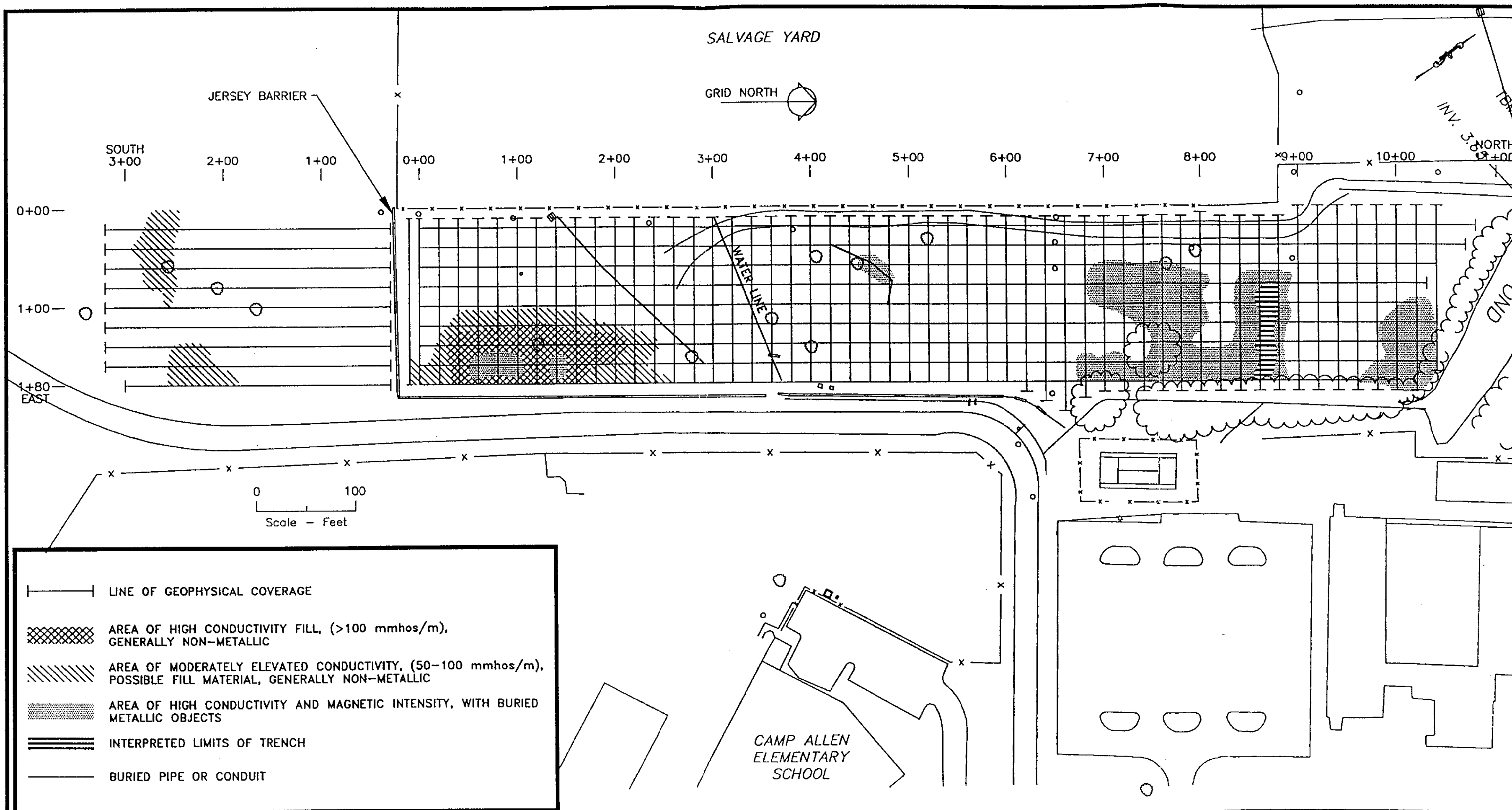


FIGURE 4-13
TYPICAL WASTE PROFILE
AREA A
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

SOURCE: LANTDIV DRAWING Nos. 84321 & 84332 (1973)



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SCALE GRAPHIC
DRAWN GLB
REVIEWED
S.O.# 19084
CADD# 084-501

GEOPHYSICAL INVESTIGATION
CAMP ALLEN LANDFILL - AREA B
NORFOLK, VIRGINIA
PREPARED FOR BAKER ENVIRONMENTAL, INC

WESTON GEOPHYSICAL CORP.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.
WESTON GEOPHYSICAL CORP. IS A WHOLLY OWNED SUBSIDIARY OF BAKER ENVIRONMENTAL, INC.

FIGURE 4-14
PRIMARY AREAS OF WASTE DISPOSAL
AREA B

SCALE GRAPHIC
DATE 7/93

FIGURE
4-14

4.2 Hydrogeology

The hydrogeology of the Camp Allen Landfill area has been evaluated through measurement of water levels and aquifer testing (slug tests and a pumping test) of the shallow (water table) and deeper (Yorktown) aquifers. Also, periodic rainfall measurements were collected, and a tidal study was completed by a previous consultant. These data were also evaluated with respect to site hydrogeology.

Seven separate sets (or rounds) of water level measurements were completed at the Camp Allen Landfill Site between May 1992 and January 1993. However, data gathered during Rounds 1 through 4 were incomplete, primarily because water levels were not measured in all wells (additional wells were being installed concurrently with some measurement rounds). The data from Rounds 1 through 4 are presented in Appendix I. Data from Rounds 5, 6, and 7 also presented in Appendix I and are plotted as groundwater contour maps below to yield a more complete picture of groundwater flow direction and gradients.

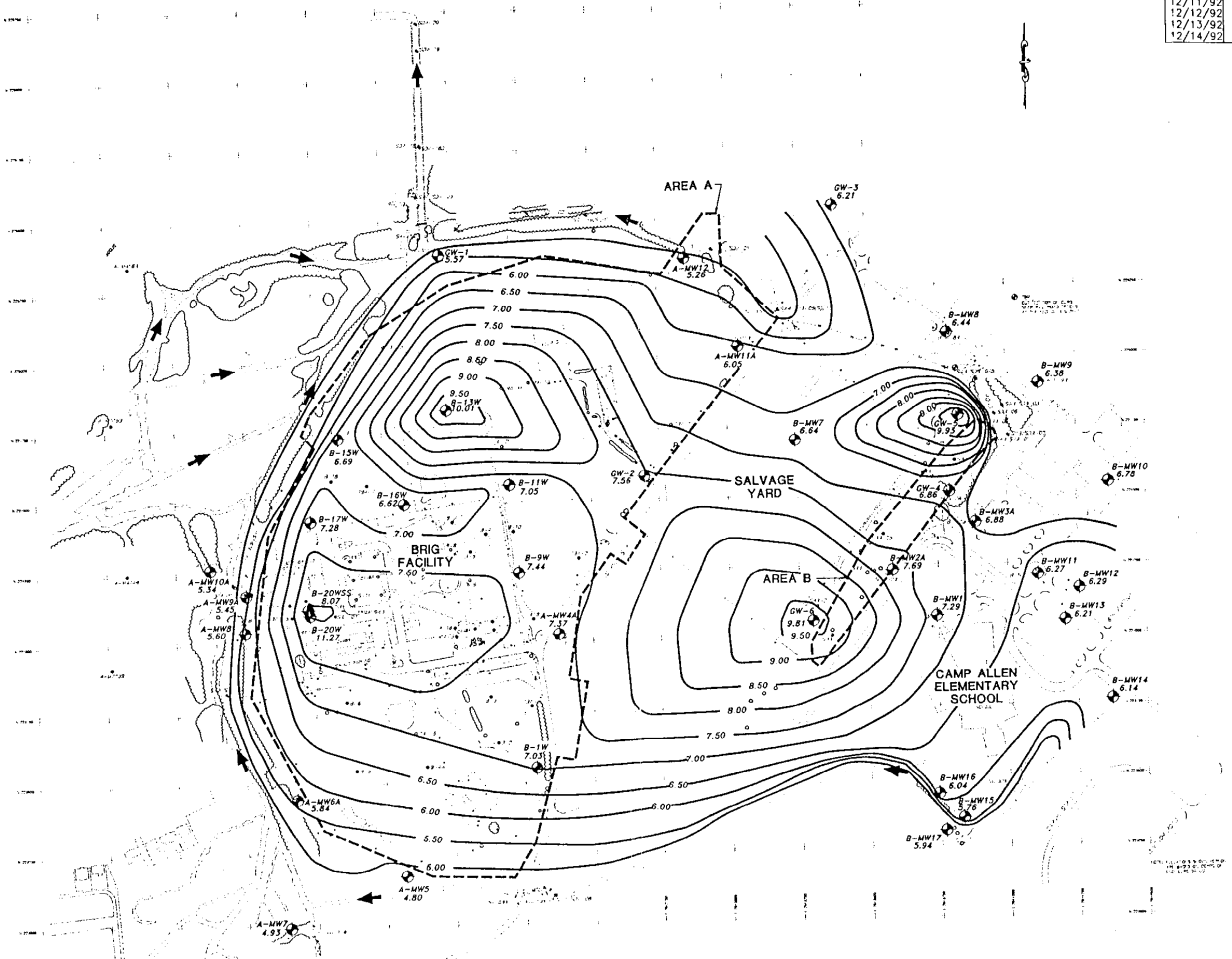
4.2.1 Water Table Aquifer

Flow Directions and Gradients

The water table aquifer beneath the Camp Allen Landfill Site is unconfined and usually encountered between 5 and 10 feet below grade. Groundwater elevations within the aquifer are influenced by topography, surface drainage, rainfall, and tides. Figures 4-15 through 4-17 show data gathered during Rounds 5, 6, and 7, respectively. Groundwater flow in the shallow aquifer mimics surface topography, and is generally radial, away from high areas toward the surface drainage system (ditches) around both Areas A and B. Gradients vary significantly across the area and tend to be steeper near the surface drainage features (about 0.01 feet/foot near B-20WSS and A-MW9A in Area A and also about 0.01 near GW-5 and GW-4 in Area B). Across the central portion of Area A, and portions of Area B and the Salvage Yard, the gradients are less steep (about 0.0003) with the overall flow direction still toward the surface ditches.

The effect of rainfall on the shallow aquifer is shown by comparing Round 5 and Round 6 contour maps (Figures 4-15 and 4-16, respectively). Round 5 data were collected on December 12 and 13, 1992, one day after a 1.86 inch rainfall event. It also rained 0.25 inches over the

RAINFALL GAUGE READINGS		
DATE	DAILY RAINFALL (IN)	CUMULATIVE RAINFALL (IN)
12/07/92	0.000	31.445
12/08/92	0.000	31.445
12/09/92	0.000	31.445
12/10/92	0.005	31.450
12/11/92	1.860	33.310
12/12/92	0.190	33.500
12/13/92	0.040	33.540
12/14/92	0.000	33.540



LEGEND

SURFACE WATER FLOW DIRECTION

NOTES
CONTOUR INTERVAL = 0.5 FEET
ELEVATIONS MEASURED IN FEET, MSL.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	RND5SHAL

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

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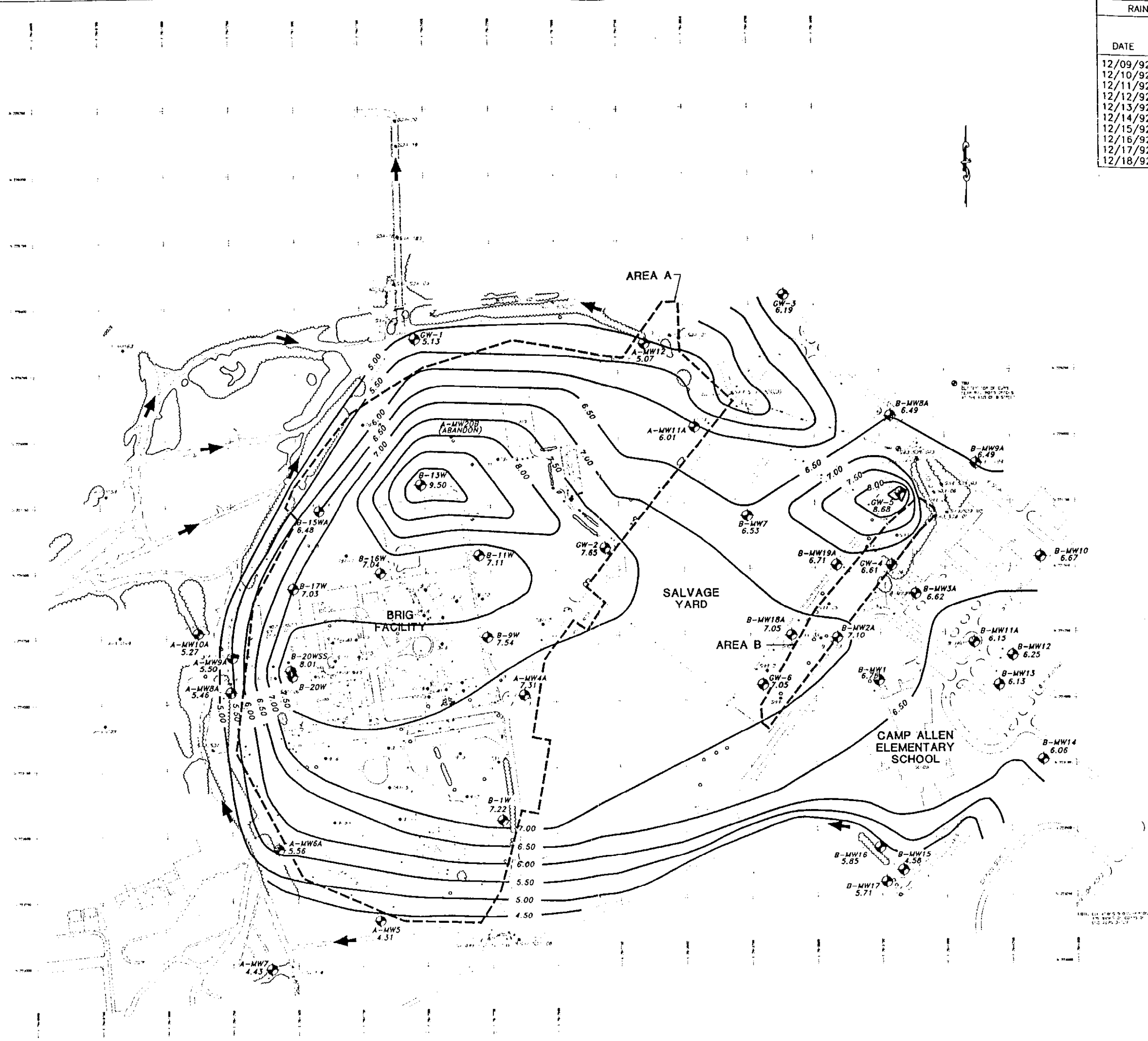
ROUND 5 SHALLOW GROUNDWATER CONTOURS
GROUNDWATER ELEVATIONS MEASURED BETWEEN 12/12/92 AND 12/13/92

SCALE GRAPHIC
DATE 7/93

FIGURE
4-15



RAINFALL GAUGE READINGS		
DATE	DAILY RAINFALL (IN)	CUMULATIVE RAINFALL (IN)
12/09/92	0.000	31.445
12/10/92	0.005	31.450
12/11/92	1.860	33.310
12/12/92	0.190	33.500
12/13/92	0.040	33.540
12/14/92	0.000	33.540
12/15/92	0.000	33.540
12/16/92	0.000	33.540
12/17/92	0.000	33.540
12/18/92	0.020	33.560

LEGEND

SURFACE WATER FLOW DIRECTION

NOTES
CONTOUR INTERVAL = 0.5 FEET
ELEVATIONS MEASURED IN FEET, MSL.

SCALE IN FEET

REVISIONS

DATE	7/93
SCALE	GRAPHIC
DRAWN	GLB
REVIEWED	TEA
S.O.#	19084
CADD#	RN06SHAL

NORTH

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NORFOLK NAVAL BASE
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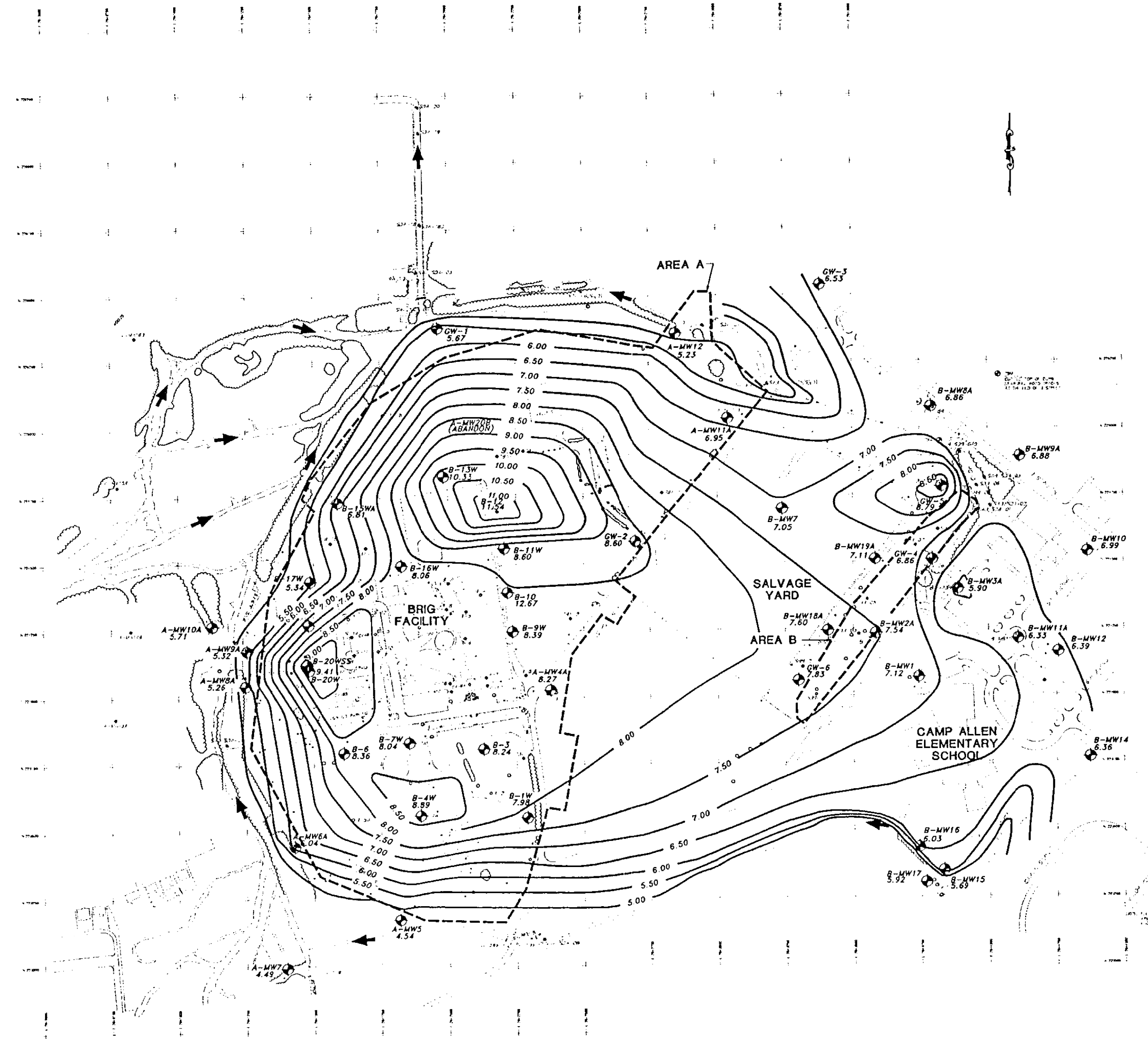
ROUND 6 SHALLOW GROUNDWATER CONTOURS
GROUNDWATER ELEVATIONS MEASURED BETWEEN 12/17/92 AND 12/18/92

SCALE GRAPHIC | DATE 7/93

FIGURE
4-16

RAINFALL GAUGE READINGS		
DATE	DAILY RAINFALL (IN)	CUMULATIVE RAINFALL (IN)
1/16/93	0.85	5.26
1/17/93	0.00	5.26
1/18/93	0.00	5.26
1/19/93	TRACE	5.26
1/20/93	0.00	5.26
1/21/93	0.29	5.55
1/22/93	0.11	5.66
1/23/93	0.00	5.66
1/24/93	0.16	5.82
1/25/93	0.00	5.82
1/26/93	0.00	5.82



LEGEND

➔ SURFACE WATER FLOW DIRECTION

NOTES
CONTOUR INTERVAL = 0.5 FEET
ELEVATIONS MEASURED IN FEET, MSL.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	RND7SHAL

NORTH

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NORFOLK, VIRGINIA

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ROUND 7 SHALLOW GROUNDWATER CONTOURS
GROUNDWATER ELEVATIONS MEASURED 1/26/93

SCALE GRAPHIC
DATE 7/93

FIGURE
4-17

December 12-13, 1992, time period. Round 6 data were collected December 17-18, 1992, and no rainfall occurred between the two events. In Area B at well GW-6, groundwater is significantly higher as indicated in Round 5 than in Round 6. This change is probably due to a nearby storm sewer grating (shown on the figure but not indicated as a utility line) that probably allows rapid infiltration of large volumes of water into the shallow aquifer near GW-6. As discussed in Section 3.0, voided near-surface conditions were apparent in this general vicinity. Also, surface geophysical results shown on Figure 4-14 indicate a probable utility line (abandoned) traversing across Area B from the storm drain to the east. Within a few days, however, the water in the aquifer near GW-6 has flowed away from the area (see Figure 4–16, Round 6 data). A discussion of the underground utilities found at Areas A, B, and the Salvage Yard is located in Section 4.3 below. Also note that overall, water levels decreased in many wells from Round 5 to Round 6 (especially at the groundwater highs), indicating drainage of the shallow aquifer. Round 7 data were collected on January 26, 1993. A rainfall event occurred on January 24, 1993, approximately 36 hours prior to data collection. The precipitation event produced 0.16 inches of rainfall. Between January 1 and January 25, 1993, a total of 5.82 inches of rainfall fell in the Camp Allen area. Generally, water levels increased in the majority of shallow wells from Round 6 to Round 7 indicating the process of active infiltration. Infiltration is directly attributed to precipitation during the previous 30 day period at the Camp Allen area prior to data collection. Rainfall data are summarized in Appendix I. In general, fluctuations in the water table are considered minimal in the Camp Allen area. Water levels are expected to rise during the months of July and August when the heaviest precipitation occurs.

The surface water drainage ditches around most of Area A and the ponded water adjacent to Area B have an influence on the flow path of the shallow aquifer. As mentioned above, the shallow aquifer flows radially away from topographic highs toward the drainage ditches. The shallow aquifer discharges (at least a portion of its flow) into the ditches, as evidenced by seeps and by steeper groundwater gradients near the ditches. Although comprehensive water elevations in the ditches and ponded areas were not measured as part of this study, data from the tidal study (discussed below) and ground surface elevations measured during surveying of the site indicate that the water level in the ditches fluctuates with the tide. Elevation of the surface water would vary depending upon locations, and it is estimated at 2.5 to 4.5 or 5 feet MSL around Area A, and probably 3.5 to 4.5 to 5 feet MSL around Area B. This conclusion was reached by estimating the base of the ditches (about 1.5 to 2 feet around Area A, probably 2.5 to 3 feet in the ponded area at Area B) and using estimated surface water level of 1.5 to 3.5 feet MSL from the tidal study (see Section 4.2.3). Also, groundwater elevations in wells adjacent to the ditches tend to be about 4.5 to 6 feet MSL, consistent with slightly lower water levels in the ditches.

4.2.1.2 Aquifer Testing - Slug Tests

Aquifer testing in the shallow aquifer consisted of rising and falling head slug tests performed at seven shallow monitoring wells: B-20WSS (Area A) and B-MW12, B-MW13, B-MW14, B-MW15, B-MW16, and B-MW17 (Area B). The data were gathered in general accordance with procedures outlined in the Final Project Plans (Baker, April 1992). Data were analyzed using Geraghty and Miller's AQTESOLV computer program (Version 1.1) using the Bouwer and Rice method. For wells with the water level within the screened interval, the modified Bouwer and Rice method (1989) was utilized for analysis. Graphs and calculations are presented in Appendix J.

Results of the data analyses are summarized in Table 4-5. In Area A, the hydraulic conductivity calculated was 223 gallons per day per square foot (GPD/ft^2) as an average of the rising and falling head tests. The transmissivity averaged 2000 GPD/ft for a saturated thickness of 9 feet, typical of a silty sand to a sand (Freeze and Cherry, 1979). This correlates with the visual observations (as recorded on boring/well construction logs) made in the field during drilling.

In Area B, average hydraulic conductivity values varied from a low of 2 GPD/ft^2 at B-MW15 to a high of 726 GPD/ft^2 at B-MW12 (Table 4-5). Using a saturated thickness of approximately 17 feet (derived from the average depth of clay at location B-MW11B), average transmissivities varied from 30 GPD/ft to 12,300 GPD/ft. At three locations (B-MW14, B-MW15, and B-MW16), transmissivities were low, with an average of 200 GPD/ft. This is typical of a sandy silt. For three other wells tested (B-MW12, B-MW13, and B-MW17), transmissivities were much higher, averaging 4800 GPD/ft. This is typical of a sand. These range of values illustrate the variable nature of the shallow aquifer and are expected given the complex marine estuarine environment of the Columbia Group.

The estimated groundwater seepage velocity was calculated for the shallow aquifer using the following equation:

$$v = \frac{ki}{ne}$$

where: v = seepage velocity (in feet/day)

k = aquifer hydraulic conductivity (in feet/day)

i = hydraulic gradient (in feet/foot)

ne = effective porosity of the aquifer, estimated at 0.3 (30 percent)

For Area A, the average k value is about 28 feet/day (from slug test analyses). Depending upon the hydraulic gradient, the velocity can vary from about one foot/day (higher hydraulic gradient of 0.01) to about 0.03 feet/day (lower hydraulic gradient of 0.0003).

In Area B, two ranges of hydraulic conductivity were noted from aquifer slug tests: an average lower k value of 1.9 feet/day and a higher average k value of 36 feet/day. Using an i value of 0.01, the average velocity can vary from about 0.6 feet/day to 1.2 feet/day.

4.2.2 Yorktown Aquifer

4.2.2.1 Groundwater Flow Direction and Gradient

The Yorktown (or deep) Aquifer at the Camp Allen Landfill Site is generally found between 50 to 100 feet below grade and is under confined or semi-confined conditions, depending upon location and the presence or absence of the confining clay layer. Groundwater contour maps for Rounds 5, 6, and 7 are shown in Figures 4-18, 4-19, and 4-20, respectively. These maps show that in Area A, deep groundwater flow is generally toward the northwest at gradients of about 0.0007 feet/foot. In Area B, water elevations are relatively flat, with a very slight gradient (about 9×10^{-5} feet/foot) to the northeast and east.

Groundwater elevations influenced by rainfall, as evidenced by the changes in elevations recorded in Round 5 (just after significant rainfall) versus Round 6 (see Appendix I for water level data). Water levels decrease between the two rounds from less than 0.1 foot to nearly 1 foot, depending upon location. Groundwater elevations recorded during Round 7 confirm the influence of precipitation during the preceding 30 day period prior to data collection (see Appendix I for rainfall data and Section 4.2.1). Water levels generally increased in the deep wells from Round 6 to 7 indicating the presence of a recharge area resulting from active infiltration in areas where the confining unit is breached or poorly represented.

TABLE 4-5

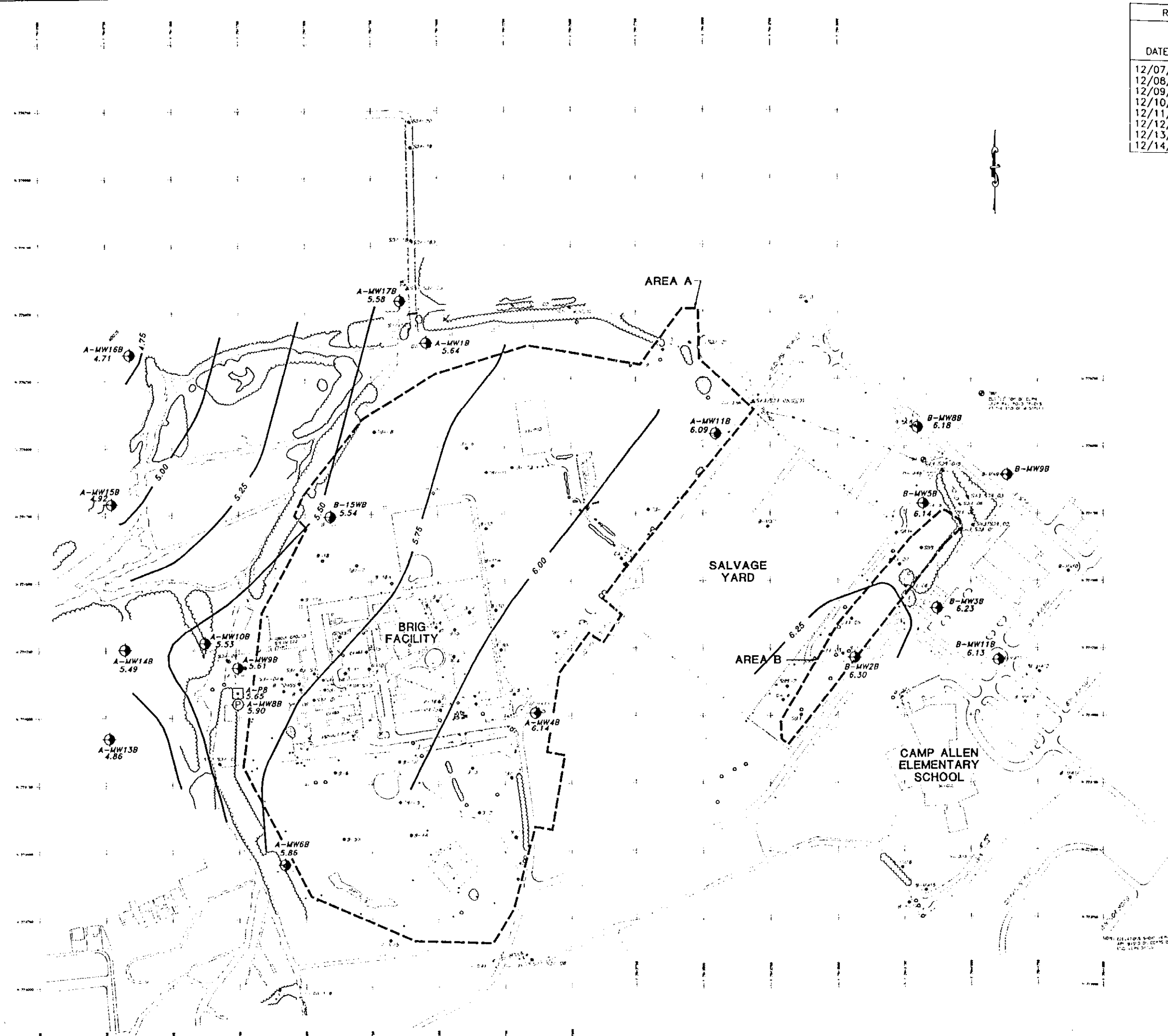
SLUG TEST RESULTS - AREAS A AND B
SHALLOW (UNCONFINED) AQUIFER
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Well Number	Hydraulic Conductivity (K) (ft/min)	Hydraulic Conductivity (K) (GPD/ft^2)	Average Hydraulic Conductivity (GPD/ft^2)	Transmissivity* (T) (GPD/ft)	Average Transmissivity* (T) (GPD/ft)
Area A					
B-20 WSSR*	1.73E-02	187	223	1,700	2,000
B-20WSSF*	2.40E-02	259		2,300	
Area B					
B-MW12R**	6.74E-02	726	726	12,300	12,300
B-MW13R**	1.94E-02	209	209	3,600	3,600
B-MW14R*	1.84E-03	20	19	300	300
B-MW14F*	1.77E-03	19		300	
B-MW15R*	1.91E-04	2	2	30	30
B-MW15F*	2.15E-04	2		30	
B-MW16R*	1.92E-03	21	20	400	400
B-MW16F*	1.87E-03	20		400	
B-MW17R*	1.32E-02	142	74	2,400	1,240
B-MW17F*	4.91E-04	5		80	

Notes:

* Bouwer and Rice method using Aqtesolv.
** Bouwer and Rice method (modified).
The suffix R following the well number denotes a rising head test.
The suffic F following the well number denotes a falling head test.
The transmissivity is based on a saturated thickness of 9.0 feet for Area A and 17 feet for Area B and has been rounded to the nearest 10 or 100, as appropriate.

RAINFALL GAUGE READINGS		
DATE	DAILY RAINFALL (IN)	CUMULATIVE RAINFALL (IN)
12/07/92	0.000	31.445
12/08/92	0.000	31.445
12/09/92	0.000	31.445
12/10/92	0.005	31.450
12/11/92	1.860	33.310
12/12/92	0.190	33.500
12/13/92	0.040	33.540
12/14/92	0.000	33.540



NOTES
CONTOUR INTERVAL = 0.25 FEET
ELEVATIONS MEASURED IN FEET, MSL.

SCALE IN FEET

REVISIONS		
DATE	7/93	
SCALE	GRAPHIC	
DRAWN	GLB	
REVIEWED	TEA	
S.O.#	19084	
CADD#	RND5DEEP	

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

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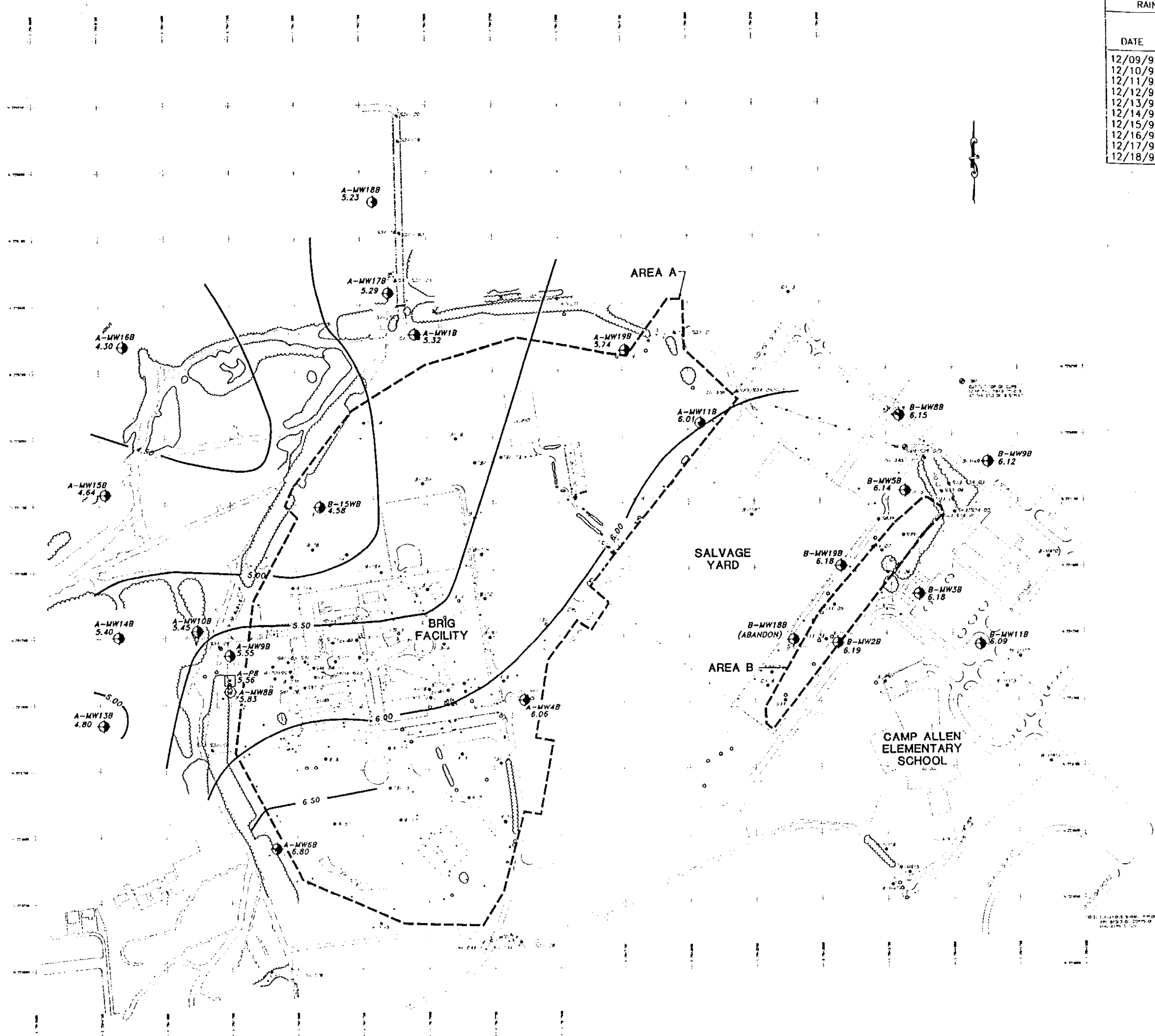
ROUND 5 DEEP GROUNDWATER CONTOURS
GROUNDWATER ELEVATIONS MEASURED BETWEEN 12/12/92 AND 12/13/92

SCALE GRAPHIC
DATE 7/93

FIGURE
4-18

RAINFALL GAUGE READINGS		
DATE	DAILY RAINFALL (IN)	CUMULATIVE RAINFALL (IN)
12/09/92	0.000	31.445
12/10/92	0.005	31.450
12/11/92	1.860	33.310
12/12/92	0.190	33.500
12/13/92	0.040	33.540
12/14/92	0.000	33.540
12/15/92	0.000	33.540
12/16/92	0.000	33.540
12/17/92	0.000	33.540
12/18/92	0.020	33.560



NOTES
CONTOUR INTERVAL = 0.5 FEET
ELEVATIONS MEASURED IN FEET, MSL.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	RND6DEEP

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
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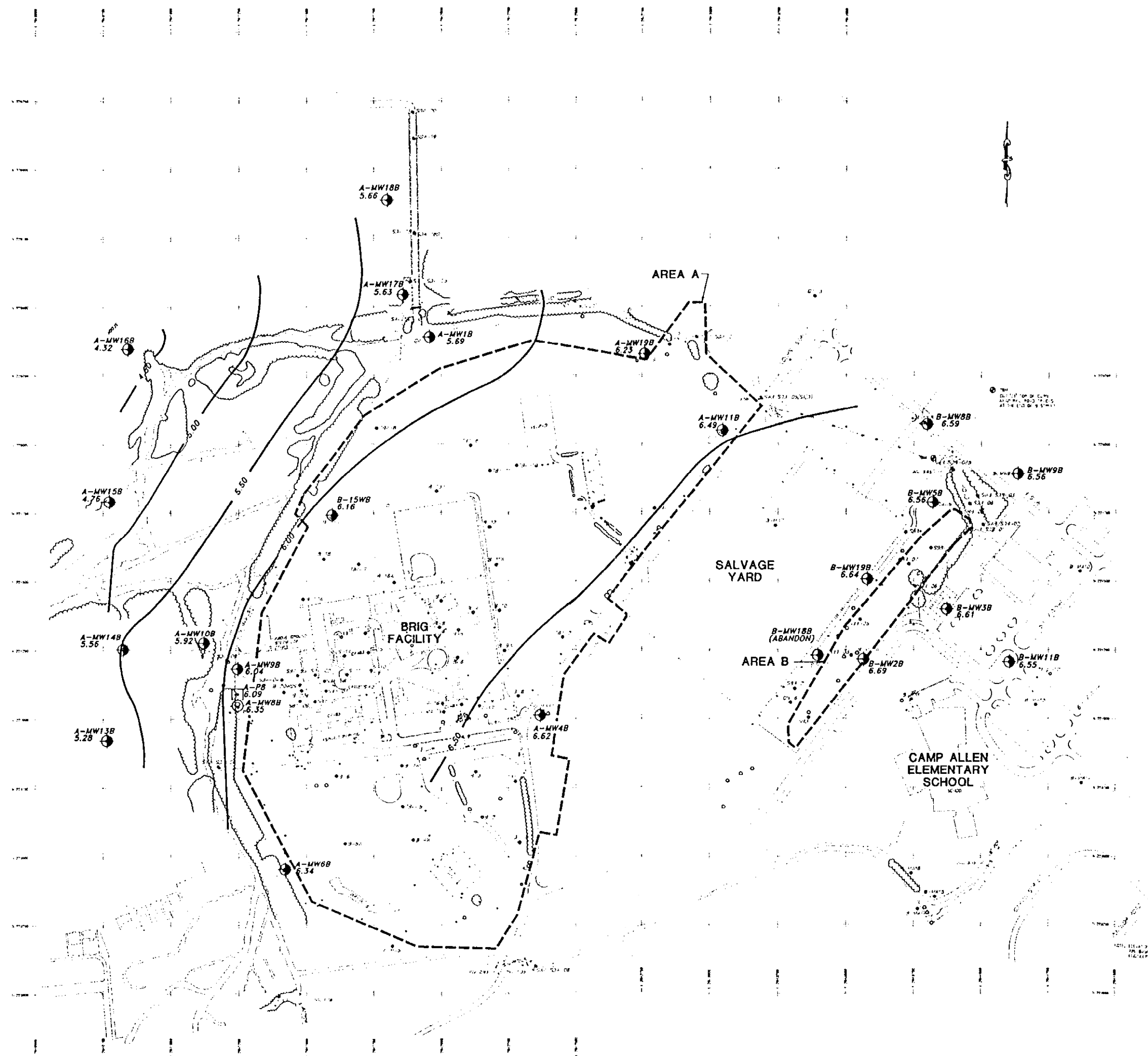
ROUND 6 DEEP GROUNDWATER CONTOURS
GROUNDWATER ELEVATIONS MEASURED BETWEEN 12/17/92 AND 12/18/92

SCALE GRAPHIC DATE 7/93

FIGURE
4-19

RAINFALL GAUGE READINGS		
DATE	DAILY RAINFALL (IN)	CUMULATIVE RAINFALL (IN)
1/16/93	0.85	5.26
1/17/93	0.00	5.26
1/18/93	0.00	5.26
1/19/93	TRACE	5.26
1/20/93	0.00	5.26
1/21/93	0.29	5.55
1/22/93	0.11	5.66
1/23/93	0.00	5.66
1/24/93	0.16	5.82
1/25/93	0.00	5.82
1/26/93	0.00	5.82



NOTES
CONTOUR INTERVAL = 0.5 FEET
ELEVATIONS MEASURED IN FEET, MSL.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	RND7DEEP

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
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Baker Environmental, Inc.

ROUND 7 DEEP GROUNDWATER CONTOURS
GROUNDWATER ELEVATIONS MEASURED 1/26/93

SCALE GRAPHIC
DATE 7/93

FIGURE
4-20

Comparison of groundwater elevation in the shallow and deep aquifers is shown on the cross-sections presented in Section 4.1 (Figures 4-4 through 4-11). Water levels are generally similar between the two aquifers, with the difference between levels on the order of about 0.2 feet or less. In some places, the deeper aquifer elevation is higher than the shallow aquifer, while in other locations the shallow aquifer elevation is higher than in the deep aquifer. This supports the observation that the confining layer between the shallow and deep aquifer is absent or ineffective in many areas of the site.

4.2.2.2 Aquifer Testing - Slug Tests

Aquifer testing using rising and falling head slug test techniques was performed at ten wells in Area A and three wells in Area B screened in the Yorktown Aquifer. The slug tests were performed in general accordance with the procedures outlined in the Final Project Plans (Baker, April 1992). Data were analyzed using the Copper et al. method found in the AQTESOLV computer program; details of the data analysis are found in Appendix J.

In Area A, seven of the ten wells evaluated (A-MW8B, A-P8, A-MW13B, A-MW14B, A-MW15B, A-MW16B, and A-MW17B) are screened near the top of the Yorktown Aquifer (see Table 4-1 for screened interval depths). Average hydraulic conductivity varied from 50 to 300 GPD/ft^2 (Table 4-6). Corresponding transmissivities varied from 4200 to 25,600 GPD/ft; assuming an aquifer thickness of 88.6 feet. Average transmissivity was 9700 GPD/ft, typical of silty sand to sand.

The three remaining deep wells at Area A (A-MW1C, A-MW9C, and B-MW15B) are screened near the base of the Yorktown Aquifer. Two of these wells (A-MW9C and B-MW15B) had low transmissivities and hydraulic conductivities (less than 10 GPD/ft for transmissivity; less than 1 GPD/ft^2 for hydraulic conductivity). Table 4-6 summarizes these results. These values are more typical of silty, clayey material rather than sandy materials. The third well, A-MW1C, had higher transmissivity and hydraulic conductivity values (1300 GPD/ft and 20 GPD/ft^2, respectively), more typical of silty or sandy aquifer material.

The average storativities for these 10 wells range over six orders of magnitude, from 1.5×10^{-3} to 6.8×10^{-9}, with an average of 2.86×10^{-4}. This average value as in the typical range of 5×10^{-3} to 5×10^{-5} for confined or semi-confined aquifers (Freeze and Cherry, 1979).

TABLE 4-6

SLUG TEST RESULTS - AREAS A AND B
YORKTOWN (DEEP) AQUIFER
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Well Number	Transmissivity (T) (ft2/min)	Transmissivity (T) (GPD/ft)	Hydraulic Conductivity (K) (GPD/ft2)	Average Hydraulic Conductivity (GPD/ft2)	Transmissivity* (T) (GPD/ft)	Average Transmissivity* (T) (GPD/ft)
Area A						
A-MW1CR	1.09E-01	1,200	1,300	20	4.90E-06	5.84E-06
A-MW1CF	1.29E-01	1,400			6.78E-06	
A-MW8BR	1.62E+00	17,400	25,600	300	1.00E-08	1.00E-08
A-MW8BF	3.14E+00	33,800			1.00E-08	
A-P8R	1.32E+00	14,200	10,200	100	9.90E-09	9.95E-09
A-P8F	5.79E-01	6,200			1.00E-08	
A-MW9CR	8.52E-05	1	1	0.01	1.32E-03	1.32E03
A-MW9CF	--	--			--	
A-MW13BR	3.53E-01	3,400	5,950	50	1.00E-08	1.00E-08
A-MW13BF	7.88E-01	8,500			1.00E-08	
A-MW14BR	6.74E-01	7,300	7,550	100	1.00E-08	1.00E-08
A-MW14BF	7.22E-01	7,800			1.00E-08	
A-MW15BR	1.02E+00	11,000	8,750	100	1.00E-08	6.89E-09
A-MW15BF	6.30E-01	6,500			3.77E-09	
A-MW17BR	--	--	4,200	50	--	1.18E-05
A-MW17BF	3.91E-01	4,200			1.18E-05	
B-15WBR	9.28E-04	10	6	0.05	2.08E-03	1.52E-03
B-15WBF	9.35E-05	1			9.50E-04	
Area B						
B-MW8BR	1.62E-01	1,700	1,650	20	1.97E-07	3.56E-06
B-MW8BF	1.46E-01	1,600			6.91E-06	
B-MW9BR	5.84E-02	600	3,450	50	8.61E-04	4.30E-04
B-MW9BF	5.86E-01	6,300			1.00E-08	
B-MW11BR	2.68E-01	2,900	5,500	50	1.00E-08	1.00E-08
B-MW11BF	7.53E-01	8,100			1.00E-08	

Notes:

The suffix R following the well number denotes a rising head test.
The suffix F following the well number denotes a falling head test.
The hydraulic conductivity is based on a saturated thickness of 88.6 feet.
The T and K values have been rounded to the nearest multiple of 10, as appropriate.

Table 4-6

Rising and falling head slug tests were also performed on three wells in Area B (B-MW8B, B-MW9B, and B-MW11B). All three of these wells are screened near the top of the Yorktown Aquifer. Results of the slug tests for these wells are comparable to the wells in Area A, with average transmissivities ranging from 1650 to 5500 GPD/ft, and hydraulic conductivity values ranging from 20 to 50 GPD/ft^2. The average transmissivity for Area B is 3500 GPD/ft, and the average hydraulic conductivity is 40 GPD/ft^2 (see Appendix J for details of slug test analysis).

The storativity values calculated for the three wells in Area B range from 4.3×10^{-6} to 1×10^{-8}, with an average of 1.44×10^{-4}. This is also a typical value for semi-confined or confined aquifers.

Groundwater seepage velocities in Area A were determined using an overall average k value from the pumping test results (described below) for an i value of 0.0007, k value of 36 feet/day, the velocity would be 0.08 feet/day. In Area B, the gradient was very flat. To be conservative, an i value of 0.0007 was used, along with a k value of 0.45 feet/day (from slug test data). The velocity calculated is 0.001 feet/day.

4.2.2.3 Aquifer Testing - Pumping Test

A 25-hour constant rate pumping test was performed on the Yorktown Aquifer to develop and estimate the hydrogeologic parameters at the site. Monitoring well A-MW8B was used as the pumping well and several wells in both the shallow aquifer and the Yorktown Aquifer were also monitoring to evaluate the response of the aquifer. After the 25 hours, a 300 minute recovery test was also completed and the data analyzed to evaluate aquifer hydraulic characteristics. Details of the procedures used and data analysis are presented in Appendix K, including graphs and calculations from the pumping and recovery tests, plus pre-pumping step-drawdown test calculations.

Data gathered for the pumping test were analyzed by three different methods: the Jacob Straight Line Method, the Hantush Modified Method, and Walton's Type Curve Method for Leaky Aquifers. Results from the Jacob Straight Line Method are summarized in Table 4-7. For wells screened in the shallow aquifer, transmissivities vary from 64,000 to 112,100 GPD/ft (average 80,050 GPD/ft), and storativities were on the order of 3.7×10^{-3}. However, the response (drawdown) in the shallow aquifer wells was small and variable. Therefore, the reliability of the shallow aquifer T and S data is suspect. Additional detail can be found in Appendix K.

TABLE 4-7

PUMPING TEST RESULTS - JACOB STRAIGHT LINE METHOD
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Monitoring Well Number	Radial Distance From Pumping Well (ft)	Drawdown Phase			Recovery Phase		
		Transmissivity T (GPD/ft)	Storativity S	Well Function u	Transmissivity T (GPD/ft)	Storativity S	Well Function u
Shallow Wells - Screened in the surficial unconfined aquifer							
A-MW8A	21.76	NR	NR	NR	NR	NR	NR
A-MW9A	110.1	NR	NR	NR	NR	NR	NR
A-MW10A (early) A-MW10A (late)	236.59	64,000 1,800 (1)	3.79E-03 2.79E-02 (1)	0.005984 0.1683 (1)	112,100 N/A	3.70E-03 N/A	0.003329 N/A
B-20W	241.1	NR	NR	NR	NR	NR	NR
B-20WSS	239.16	22,000 (1)	1.18E-02 (1)	0.0561 (1)	NR	NR	NR
Middle Depth Wells - Screened in the top/middle of the Yorktown Aquifer							
A-MW8B**	0.167	12,700**	9.48E-08**	**	28,000	6.96E+2*	**
A-P8	11.64	24,000	3.50E-06	0.010098	28,000	1.23E-01	0.001029
A-MW9B	117.75	29,000	6.45E-05	5.61E-05	31,000	2.35E-03	0.00187
A-MW10B (early) A-MW10B (late)	243.49	34,000 19,000	3.31E-04 6.25E-03	0.001029 0.035156	37,000 N/A	7.18E-04 N/A	0.002057 N/A
Deep Well - Screened at the bottom of the Yorktown Aquifer							
A-MW9C (early) A-MW9C (late)	121.16	17,000 12,000 (1)	6.70E-03 3.10E-02 (1)	0.010098 0.70034 (1)	16,000 N/A	6.42E-04 N/A	0.001029 N/A

Notes:

NR - No response to the pumping well
N/A - Not Applicable
*** - Pumping Well
** - Not applicable to the drawdown phase of the pumping well
* - Unrealistic result; storativity cannot be greater than one
(1) - u greater than 0.05; therefore the calculated T and S values are unreliable

Transmissivities calculated from data collected from the middle depth wells (monitoring wells screened near the top or middle of the Yorktown Aquifer) were relatively consistent and ranged from 19,000 GPD/ft to 37,000 GPD/ft with an average of about 28,800 GPD/ft. Storativities ranged from 0.123 to 3.50 x 10^{-6} with an average of 1.9 x 10^{-2}. This value is greater than the range typical of confined conditions indicating potentially semi-confined aquifer conditions. Note that due to the range in S, semi-confined conditions may be defined as leakage through a confining layer, interspersed zones of confined and unconfined conditions (i.e., a discontinuous clay layer), or a combination of the two.

Transmissivities calculated from data collected from the deep well, A-MW9C, screened near the bottom of the Yorktown Aquifer were somewhat lower than those from the middle depths. The values of T calculated from monitoring well A-MW9C were relatively consistent, ranging from 16,000 GPD/ft to 17,000 GPD/ft with an average of about 16,500 GPD/ft. The somewhat lower transmissivity values from A-MW9C may be due to clay lenses or other relatively low permeable zones inhibiting the vertical flow through the aquifer (i.e., from the deep portion of the aquifer to the shallow portion where the pump was set). These lower T values also may be a manifestation of the inapplicability of the Jacob Method to non-horizontal groundwater flow. Storativities for A-MW9C ranged from 6.70 x 10^{-3} to 6.42 x 10^{-4}, within the range typical of confined to semi-confined aquifers.

The Hantush Modified Method was also used to evaluate the drawdown data from the constant discharge test. This method was chosen because it is generally applicable to an aquifer behaving under confined to semi-confined or leaky conditions as indicated by the storativity values calculated from the Jacob Method and also from the slug test data. Details of the assumptions and calculations used for this method are provided in Appendix K.

A summary of the results using the Hantush Modified Method is presented in Table 4-8. For the shallow wells, sufficient response for application of this method was observed only in monitoring well A-MW10A for the drawdown portion of the constant discharge test. Application of the Hantush Modified Method to data collected from this well yielded a transmissivity in the shallow aquifer of 34,800 GPD/ft and a storativity of 4.39 x 10^{-3}.

Transmissivities calculated from data collected from the middle depth wells (monitoring wells screened near the top or middle of the Yorktown Aquifer) were relatively consistent and ranged from 14,500 GPD/ft to 29,000 GPD/ft with an average of about 21,500 GPD/ft.

TABLE 4-8

PUMPING TEST RESULTS - HANTUSH MODIFIED METHOD
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Monitoring Well Number	Radial Distance From Pumping Well (ft)	Drawdown Phase			Recovery Phase		
		Transmissivity T (GPD/ft)	Storativity S	Beta B	Transmissivity T (GPD/ft)	Storativity S	Beta B
Shallow Wells - Screened in the surficial unconfined aquifer							
A-MW8A	21.76	NR	NR	NR	NR	NR	NR
A-MW9A	110.1	NR	NR	NR	NR	NR	NR
A-MW10A	236.59	34,800	4.39E-03	0.05	NR	NR	NR
B-20W	241.1	NR	NR	NR	NR	NR	NR
B-20WSS	239.16	NR	NR	NR	NR	NR	NR
Middle Depth Wells - Screened in the top/middle of the Yorktown Aquifer							
A-MW8B**	0.167	NR	NR	NR	25,600	767*	0.00
A-P8	11.64	14,500	7.96E-05	0.01	15,800	1.04E-01	0.20
A-MW9B	117.75	16,700	9.87E-05	0.10	24,900	2.83E-03	0.00
A-MW10B	243.49	24,200	4.85E-04	0.00	29,000	8.91E-04	0.02
Deep Well - Screened at the bottom of the Yorktown Aquifer							
A-MW9C	121.16	7,600	3.26E-03	0.40	1,700	6.61E-05	0.00

Notes:

NR - No response to the pumping well.
N/A - Not Applicable
** - Pumping Well
* - Unrealistic result; storativity cannot be greater than one.

Storativities ranged from 0.104 to 7.96 x 10^{-5}, within the range typical of semi-confined to confined aquifers. These T and S values are comparable to those calculated by the Jacob Method.

Beta values also are determined by the Hantush Method. Beta is a function of the hydraulic conductivity and storativity of semi-confining or leaky aquifer zones. This parameter gives an indication as to whether there is leakage through a confining unit. For example, values of beta equal to 0 indicate little or no leakage through a confining unit, whereas values of beta greater than 0 indicate some degree of leakage. For the middle depth wells, the beta values ranges from 0 to 0.2. These values confirm the assumption that confined to semi-confined aquifer conditions prevail at the site.

Transmissivities calculated from data collected from the deep well, A-MW9C, screened near the bottom of the Yorktown Aquifer were somewhat lower than those from the middle depths. The values of T calculated from monitoring well A-MW9C ranged from 1,700 GPD/ft to 7,600 GPD/ft with an average of about 4,650 GPD/ft. The somewhat lower transmissivity values from A-MW9C may be due to clay lenses or other relatively low permeable zones inhibiting the vertical flow through the aquifer (i.e., from the deep portion of the aquifer to the shallow portion where the pump was set). These lower T values also may be a manifestation of the inapplicability of the Hantush Modified Method to non-horizontal groundwater flow. Storativities ranged from 3.26 x 10^{-3} to 6.61 x 10^{-5}, within the range typical of confined to semi-confined aquifers. Similarly, beta values ranged from 0 to 0.4, again confirming this observation.

Note that the results from the Hantush Method for the deep well A-MW9C are somewhat lower than those calculated by the Jacob Method. The reason for this could be the difficulty of fitting a curve or straight line to data with a relatively high variance.

The third method of analysis of the pumping test data utilized was Walton's Type Curve Method. This method was chosen because it is also applicable to an aquifer which is semi-confined and there is unsteady flow to a well. The data calculated using Walton's Type Curve Method are shown in Table 4-9.

For the shallow wells, sufficient response for application of this method was observed only in monitoring well A-MW10A. Application of Walton's Type Curve Method to data collected from this well yielded a transmissivity in the shallow aquifer ranging from 27,200 GPD/ft to

TABLE 4-9

PUMPING TEST RESULTS - WALTON'S TYPE CURVE METHOD
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Monitoring Well Number	Radial Distance From Pumping Well (ft)	Drawdown Phase			Recovery Phase		
		Transmissivity T (GPD/ft)	Storativity S	Leakance $(Days)^{-1}$	Transmissivity T (GPD/ft)	Storativity S	Leakance $(Days)^{-1}$
Shallow Wells - Screened in the surficial unconfined aquifer							
A-MW8A	21.76	NR	NR	NR	NR	NR	NR
A-MW9A	110.1	NR	NR	NR	NR	NR	NR
A-MW10A	236.59	27,215	4.06E-03	3.214	128,073	1.70E-04	0
B-20W	241.1	NR	NR	NR	NR	NR	NR
B-20WSS	239.16	NR	NR	NR	NR	NR	NR
Middle Depth Wells - Screened in the top/middle of the Yorktown Aquifer							
A-MW8B**	0.167	NR	NR	NR	25,615	7.7E+02*	0
A-P8	11.64	6,967	1.53E-03	0.486	24,883	1.64E-01	0
A-MW9B	117.75	21,772	1.22E-04	113	25,615	3.02E-03	0
A-MW10B	243.49	22,918	5.17E-04	28.74	27,215	8.86E-04	96.82
Deep Well - Screened at the bottom of the Yorktown Aquifer							
A-MW9C	121.16	12,807	6.48E-03	4.585	11,612	6.17E-04	5.057

Notes:

NR - No response to the pumping well.
N/A - Not Applicable
** - Pumping Well
* - Unrealistic result; storativity cannot be greater than one.

128,100 GPD/ft, with an average of 77,600 GPD/ft. The storativity ranged from 4.06 x 10^{-3} to 1.70 x 10^{-4} with an average of 2.12 x 10^{-3}. Leakage, or the ability of a confining layer to transmit water also is calculated by Walton's Type Curve Method. The leakage calculated for the drawdown phase of the constant discharge test for A-MW10A was 3.21 per day.

Transmissivities calculated from data collected from the middle depth wells (monitoring wells screened near the top or middle of the Yorktown Aquifer) were relatively consistent and ranged from 21,800 GPD/ft to 27,200 GPD/ft with an average of about 24,700 GPD/ft. The exception was the transmissivity calculated for the pumping phase of the test for monitoring well A-P8, which was 6,967 GPD/ft. Storativities ranged from 1.64 x 10^{-1} to 1.22 x 10^{-4}, with an average of 2.83 x 10^{-2}, within the range typical of semi-confined aquifers. These T and S values are comparable to those calculated by the Jacob and Hantush Methods.

The leakage calculated for the middle depth wells ranged from 0 per day to 96.82 per day, with the highest two values (28.74 and 96.82 per day) calculated for monitoring well A-MW10B. The leakage values indicate varying aquifer conditions, from confined conditions in the vicinity of A-P8 to leaky or semi-confined conditions toward location A-MW10B.

Transmissivities calculated from data collected from the deep well, A-MW9C, screened near the bottom of the Yorktown Aquifer were somewhat lower than those from the middle depths. The values of T calculated from monitoring well A-MW9C ranged from 11,600 GPD/ft to 12,800 GPD/ft with an average of about 12,200 GPD/ft. The somewhat lower transmissivity values from A-MW9C may be due to clay lenses or other relatively low permeable zones inhibiting the vertical flow through the aquifer (i.e., from the deep portion of the aquifer to the shallow portion where the pump was set). These lower T values also may be a manifestation of the inapplicability of the Walton Method to non-horizontal groundwater flow. Storativities ranged from 6.48 x 10^{-3} to 6.17 x 10^{-4}, within the range typical of confined to semi-confined aquifers. Similarly, the leakage range is from 4.59 to 5.06, confirming this observation.

4.2.2.4 Summary of Aquifer Test Results

The constant discharge pumping test results were analyzed using three standard methods: the Jacob's Straight Line Method, the Hantush Modified Method, and Walton's Type Curve Method. All three of the methods yielded relatively consistent transmissivity and storativity values for each the shallow, middle (top and middle of the Yorktown Aquifer) and deep (bottom of the Yorktown Aquifer) aquifers. Additionally, the Hantush and Walton Methods gave strong indications that the Yorktown Aquifer is confined to semi-confined depending on location with respect to the areas of poorly developed or breached confining clay.

The average transmissivities in the shallow aquifer, as calculated by the above mentioned three evaluation methods, ranged from 34,800 to 80,050 GPD/ft. This range is typical of a silty sand to sandy aquifer. The average transmissivities for the middle aquifer were somewhat lower, ranging from 21,500 to 28,800 GPD/ft, typical of a sandy silt to a silty sand aquifer. Similarly, the average transmissivity for the deep aquifer ranged from 4,650 to 16,500 GPD/ft, typical of a sandy silt aquifer.

4.2.3 Tidal Study

A study to monitor the effects of the tides on the surface water and groundwater at the Camp Allen Landfill Site was undertaken by CH_2M Hill as part of the Interim Remedial Investigation. Data received from CH_2M Hill were in tabular format and did not indicate the dates of monitoring or the monitoring locations (i.e., specific wells and surface water locations). Based upon knowledge of the site, it appears that two different surface water locations, four different shallow aquifer monitoring wells and one deep aquifer monitoring well were evaluated. Monitoring took place for approximately 150 hours, with measurements recorded every one-half hour. A complete set of data plots is provided in Appendix L. Also included in Appendix L are excerpts from a Boush Creek Water Level Survey (Old Dominion University, 1988). In general, this study confirms the Boush Creek remnant channels as tidal and is in general agreement with measurements performed by CH_2M Hill.

The following general observations were made from the available data:

- Both the shallow aquifer and surface water locations show similar patterns, with twice daily changes in water elevations reflecting tidal influence.
- Apparent surface water elevations vary about 1.5 to 2 feet.
- Apparent shallow aquifer elevations vary between 0.05 and 0.1 feet.
- At approximately 70 to 72 hours after initiation of monitoring, there is a noticeable increase in elevation in all the apparent shallow aquifer monitoring locations. This

increase is on the order of 0.2 to 0.3 feet. In the surface water locations, the increase is about 0.5 feet.

- The apparent deep aquifer monitoring location does not appear to show daily tidal influence. Also, the apparent increase in water elevations seen in the surface water and shallow aquifer locations is not seen in the deep aquifer, rather, an overall decrease in water elevation is noted from the time period of 55 to 80 hours after initiation of monitoring. The magnitude of this change is about 0.8 feet. Please note that these data were limited to a qualitative evaluation, as specific details of the study were not available.

4.3 Other Physical Features

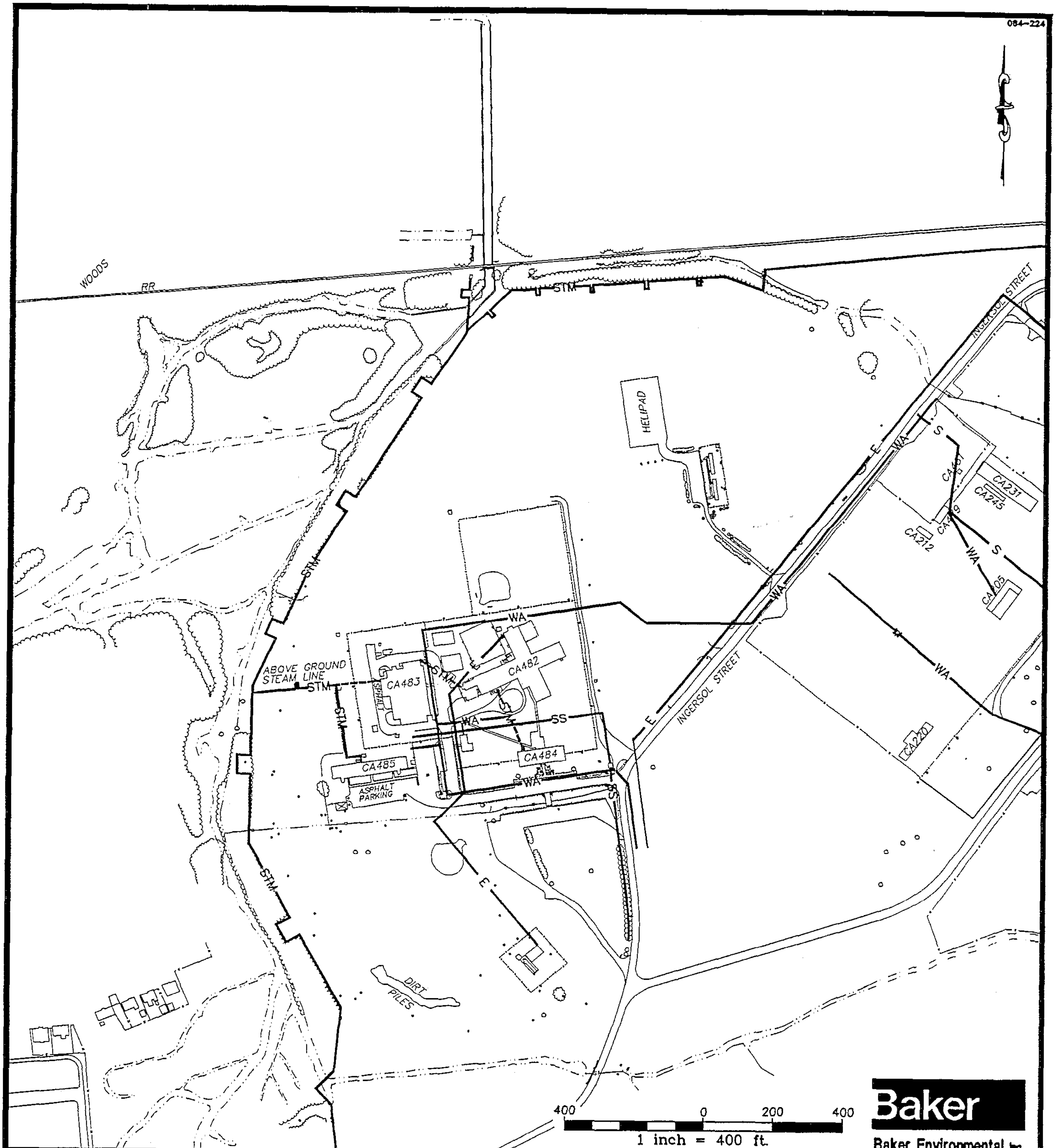
4.3.1 Utility Conduits

Several underground utility conduits are present in the vicinity of Area A as determined from reviewing Public Works Commission (PWC) utility maps, as well as results of utility clearances conducted by the PWC prior to drilling activities. MISS UTILITY was contacted for clearance of cable and telephone lines, as well as other lines not under Naval jurisdiction. Refer to Figure 4-21 for utilities found at Area A. A short description of identified underground utilities follows:

- Electric Lines - The Brig facility is serviced by an underground electric line which connects to the substation located at the southern end of the site. In addition, underground lines are present along the perimeter and serve to power the Brig yard fenceline security lights.

- Steam Lines - Overhead or surface steam lines are found along the western and northern boundaries of the Area A Landfill. One line (western side of Brig) branches off underground to service various heating requirements of the Brig.

- Sanitary Sewer - A sanitary sewer is located at the Brig and is oriented in an east/west direction. The line eventually turns south outside the eastern Brig fence and runs along Ingersol Street. A sanitary sewer pump station is located outside the Brig Facilities fenceline.



LEGEND

—SS— APPROXIMATE LOCATION OF SANITARY SEWER
—S— APPROXIMATE LOCATION OF STORM SEWER
—STM— APPROXIMATE LOCATION OF STEAM LINE
----STM---- APPROXIMATE LOCATION OF UNDERGROUND STEAM LINE
—E— APPROXIMATE LOCATION OF ELECTRIC LINE
—WA— APPROXIMATE LOCATION OF WATER LINE

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 4-21
EXISTING UTILITIES
LOCATION MAP
CAMP ALLEN LANDFILL AREA A

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

- Water Lines - The Brig facility is serviced by an underground water line which enters the facility just south of the northern baseball field, extends to service the Brig Facility building and exits the facility along the entrance road off of Ingersol Street.

- Cable TV - No underground lines are located in the vicinity of Area A.

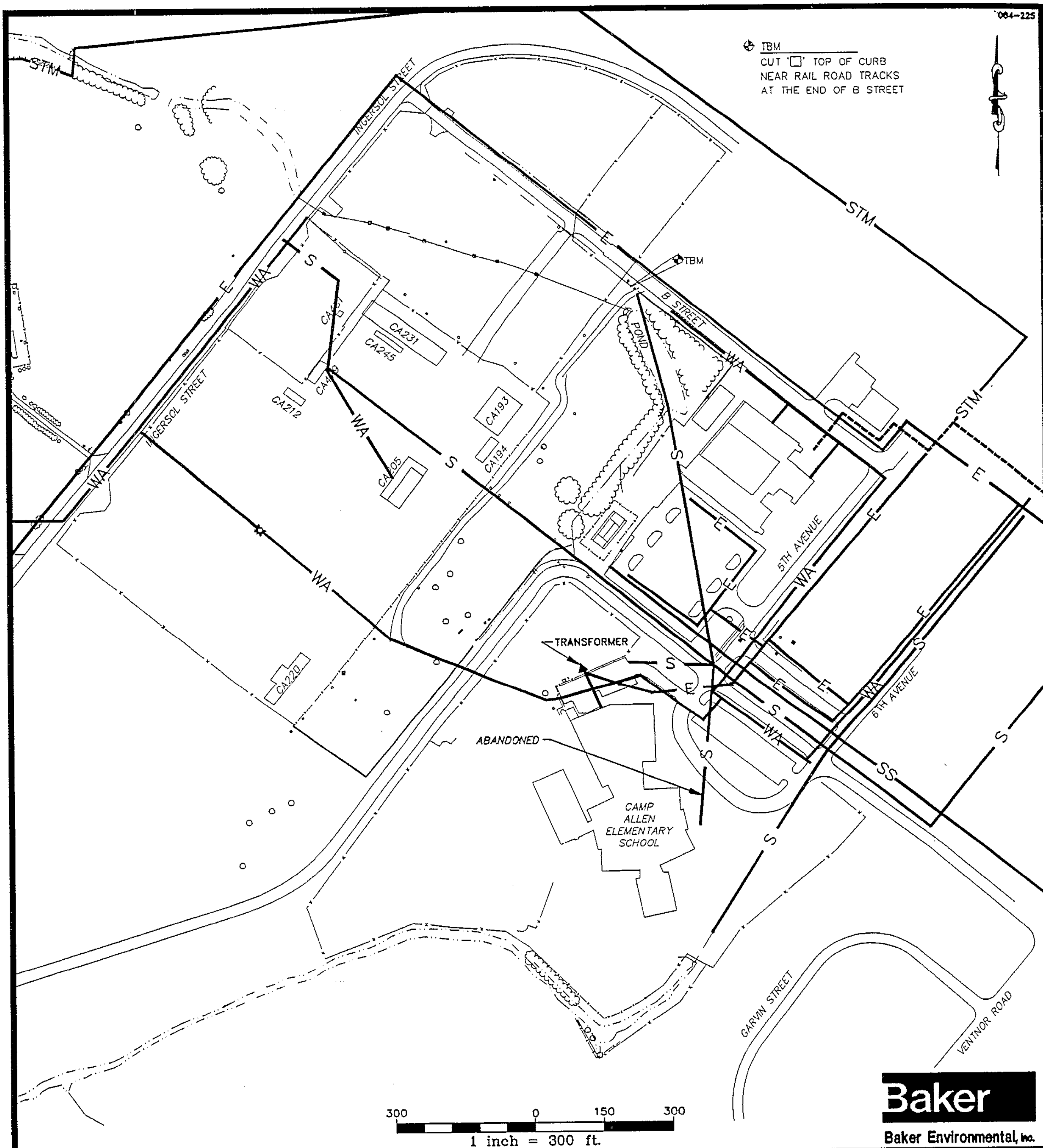
- Telephone - No underground lines are located in the vicinity of Camp Allen.

Underground utility conduits are present throughout the vicinity of Area B, as determined from reviewing PWC utility maps, as well as results of utility checks conducted by the PWC prior to drilling activities. MISS UTILITY was contacted for clearance of cable and telephone lines, as well as other lines not under Naval jurisdiction. Refer to Figure 4-22 for utilities found at Area B. The following is a short discussion of the location of each utility:

- Electric Lines - Underground electric lines for street lighting are situated along the north side of B Street, along the perimeter of the Camp Elmore Marine Barracks parking lot, and along the east side of Fifth Avenue. The line crosses C Street and enters the Camp Allen Elementary School from a transformer located adjacent to the northern parking area. The underground network of electric lines continues on to service buildings situated further southeast towards Sixth and Seventh Avenues.

- Steam Lines - Overhead steam lines are located east from Ingersol Street. At Fifth Avenue, the line turns south and then transfers underground along and across B Street servicing United States Marine Corps (USMC) building heating needs.

- Storm Sewer - An underground storm sewer conduit originating at the western end of the Salvage Yard and continuing southeast through Area B and along the northern side of C Street. Secondary storm sewer networks throughout the Salvage Yard reportedly drain into this storm sewer. Other storm sewer lines drain A Street, Sixth and Seventh Avenues. At Sixth Avenue and C Street, the sewers connect and flow is directed toward the drainage area behind the Camp Allen Elementary School. An abandoned storm sewer, reportedly left in place, originates near the ponded area northeast of Area B and continues in a southern direction towards the Camp Allen Elementary School. The storm sewer reportedly terminates in an area adjacent to the eastern side of the school.



LEGEND

- ——SS—— APPROXIMATE LOCATION OF SANITARY SEWER
- ——S—— APPROXIMATE LOCATION OF STORM SEWER
- ——STM—— APPROXIMATE LOCATION OF STEAM LINE
- ----STM---- APPROXIMATE LOCATION OF UNDERGROUND STEAM LINE
- ——E—— APPROXIMATE LOCATION OF ELECTRIC LINE
- ——WA—— APPROXIMATE LOCATION OF WATER LINE

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 4-22
EXISTING UTILITIES
LOCATION MAP
CAMP ALLEN LANDFILL AREA B

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

- Sanitary Sewer - Only one sanitary sewer line was identified in the vicinity of Area B. This sewer line trends parallel to the storm sewer line and originates southeast of Area B along C Street. A portion of the sewer line along C Street was reportedly replaced in August 1992. During December 1992, additional work was performed on the newly installed sewer line segments along C Street. Excavation and dewatering operations were included.

- Water Lines - A network of underground water lines are located adjacent to Area B, accommodating Fifth Avenue and B Street water needs. The water line along C Street trends through Area B, on through the Salvage Yard and is connected to the water line situated along Ingersol Street.

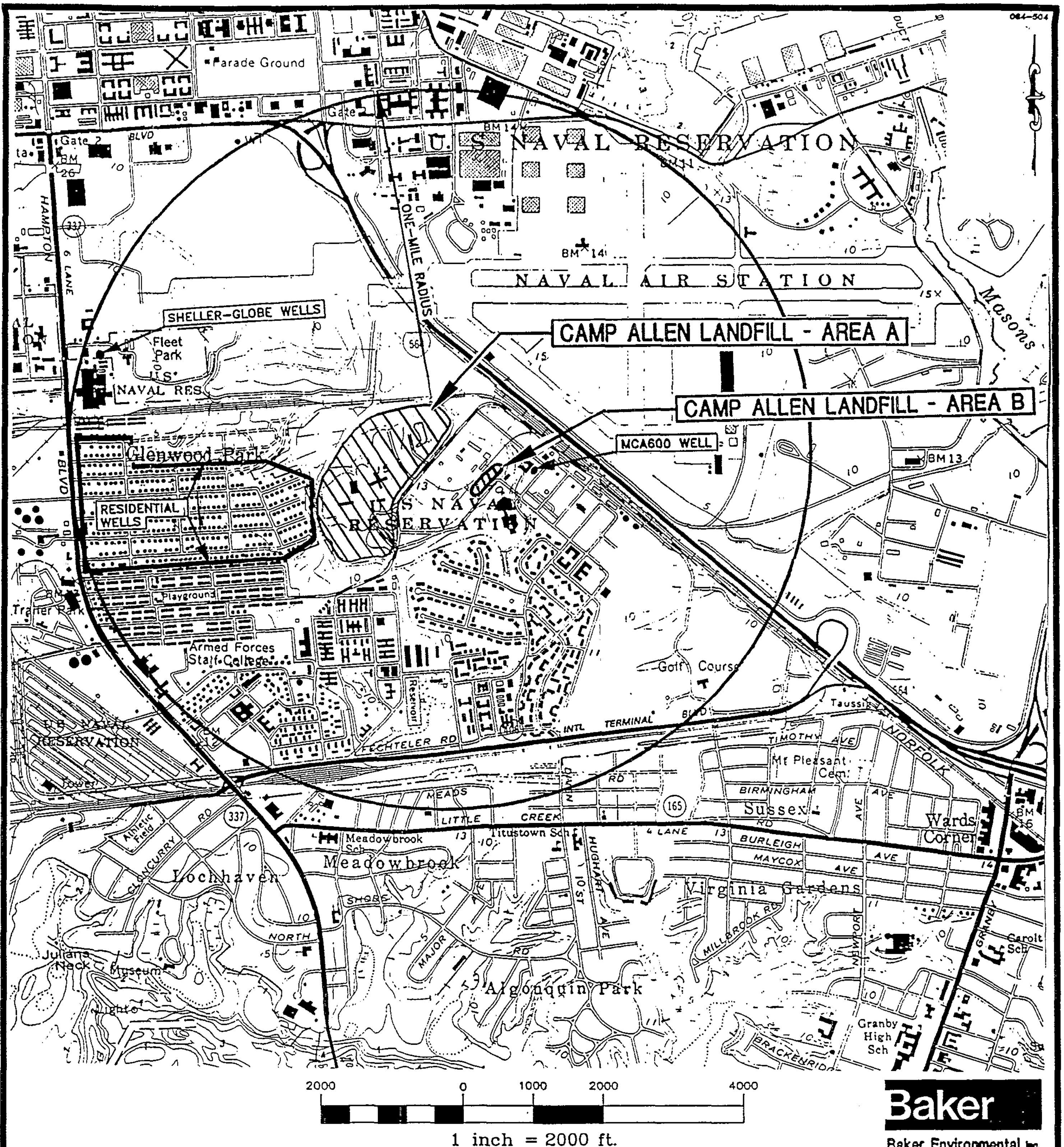
- Cable TV - No underground cable lines are located in the vicinity of Area B.

- Telephone - No underground telephone lines are located in the vicinity of Area B.

4.3.2 Nearby Pumping Well Inventory

In order to inventory nearby wells, pumping and injection wells within a one-mile radius of the site were identified. This search was accomplished by contacting Virginia's State Water Control Board (SWCB) and by reviewing well information records pertaining to operational and environmental considerations of the Norfolk Naval Base. Appendix M contains a copy of the print-out provided by the SWCB detailing two pumping wells identified approximately one mile northwest of the site. These wells are reported to be 125 deep and withdraw about 100,000 gallons of water per day from the Yorktown Aquifer for industrial purposes. The owner of the two wells is the Sheller-Globe Corporation.

Additionally, a non-potable well used for lawn watering and reported to be 110 feet deep (screen interval is reportedly set in the Yorktown Aquifer) is located southeast of Area B of the Camp Allen Landfill near Building MCA600. This well was sampled during Confirmation Study activities and was reported to be "clean". The well is reported to have been out of service since 1991. Finally, approximately 60 residential wells have been identified in the residential community of Glenwood Park. These wells are reported to be shallow (water table aquifer) and are for non-potable uses (i.e., lawn watering) only. As discussed in Section 3.0, a residential well sampling program (two phases) has been performed. Figure 4-23 presents the general locations of these nearby pumping wells.



NOTE: LOCATION OF PUMPING WELLS OBTAINED FROM THE VIRGINIA STATE WATER CONTROL BOARD

FIGURE 4-23
PUMPING WELL LOCATION MAP
CAMP ALLEN LANDFILL

SOURCE: VIRGINIA STATE WATER CONTROL BOARD AND LANTDIV

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

4.3.3 Potential Off-Site Sources

Several "potential off-site sources" of contamination have been identified in the vicinity of Area A and Area B of the Camp Allen Landfill. A total of 12 USTs are reported to be or have been operational in the nearby vicinity. The following discusses each UST:

USTs have been identified at Building NH-35 of the Atlantic Fleet Headquarters Support Facility in the south central portion of the Naval Station (and immediately south of the Area A Landfill). Five USTs have been located in the area of Building NH-35:

- One 5,000-gallon steel tank formerly containing unleaded gasoline,
- One 5,000-gallon steel tank formerly containing premium grade unleaded gasoline
- Two 550-gallon steel tanks formerly containing waste oil
- One 10,000-gallon steel tank containing unleaded gasoline

The two 5,000-gallon USTs were reportedly installed in 1957 and taken out of service in 1990. They still remain in the ground. The waste oil tank was taken out of service approximately seven or eight years ago. Reportedly, it was emptied and filled with sand. The 10,000-gallon UST was installed in 1973, failed a tightness test in 1992, and was removed. These USTs are being addressed by the Naval Base under SWCB's UST regulatory program. Currently, the site is at the Proposed Corrective Action Plan stage.

In addition to the USTs located south of the Camp Allen Landfill, two USTs were identified within the Brig Facility. One 550-gallon gasoline tank (known to have leaked) was removed from service in December 1992. It is not known when the tank was installed (mid-1970s likely), or if the gasoline was leaded or unleaded. One 250-gallon diesel fuel tank (currently in service) passed a tank tightness test in 1992. These USTs are mentioned here as potential sources of contamination at Area A in addition to the landfilled materials.

One 250-gallon heating oil tank is located adjacent to the Administration Building (CA479) at the Camp Allen Salvage Yard. Information available indicates that this tank is presently out of service.

Three USTs have been located east of the gymnasium building at Camp Elmore (MCA603). Two 4,000 gallon steel tanks (one diesel and one unleaded gasoline) and one 1,000 gallon steel oil tank are currently in service and had passed a tank tightness test in 1992.

One active UST has been identified adjacent to the Camp Allen Elementary School. This tank is reported to be a 10,000 gallon steel #2 heating oil tank which was installed in 1970. Although the UST has not undergone tank tightness testing, a "site check" consisting of the installation of four monitoring wells and subsequent groundwater sampling resulted in no detections of petroleum-related constituents.

In addition to USTs, several other potential off-site sources of contamination have been identified in the vicinity. In general, two primary areas potentially impact site conditions. These potential sources consist of the Camp Allen Salvage Yard and a seepage area, identified during the geoprobe groundwater survey, on the southern bank of the drainage area behind the Elementary School.

The Salvage Yard is currently undergoing a PA/SI. Results of the assessment and investigation were not available for summary; however, as a general indication, Salvage Yard activities have included storage of waste oils and chemicals, over age chemicals, and scrape industrial/commercial equipment. Also, miscellaneous incineration was a past practice and various recycling activities currently are performed at the facility.

During the Geoprobe Investigation, a seepage area was identified on the southern bank of the drainage ditch located behind the school. The source of the seep appears to originate from under the Bright Street cul-de-sac area adjacent to the drainage ditch. Field sampling activities indicate detections of trichloroethylene and total dichloroethylene. Analytical results of the Geoprobe Survey are discussed in Section 5.0.

Figure 4-24 presents potential off-site source locations and Section 6.0 (Nature and Extent) discusses potential relationships between site and potential offsite detections of contamination.

4.4 Groundwater Model Summary

A groundwater model was used to generate a mathematical representation of Areas A and B of the Camp Allen Landfill. The purpose of the modeling activity was to develop a tool for the

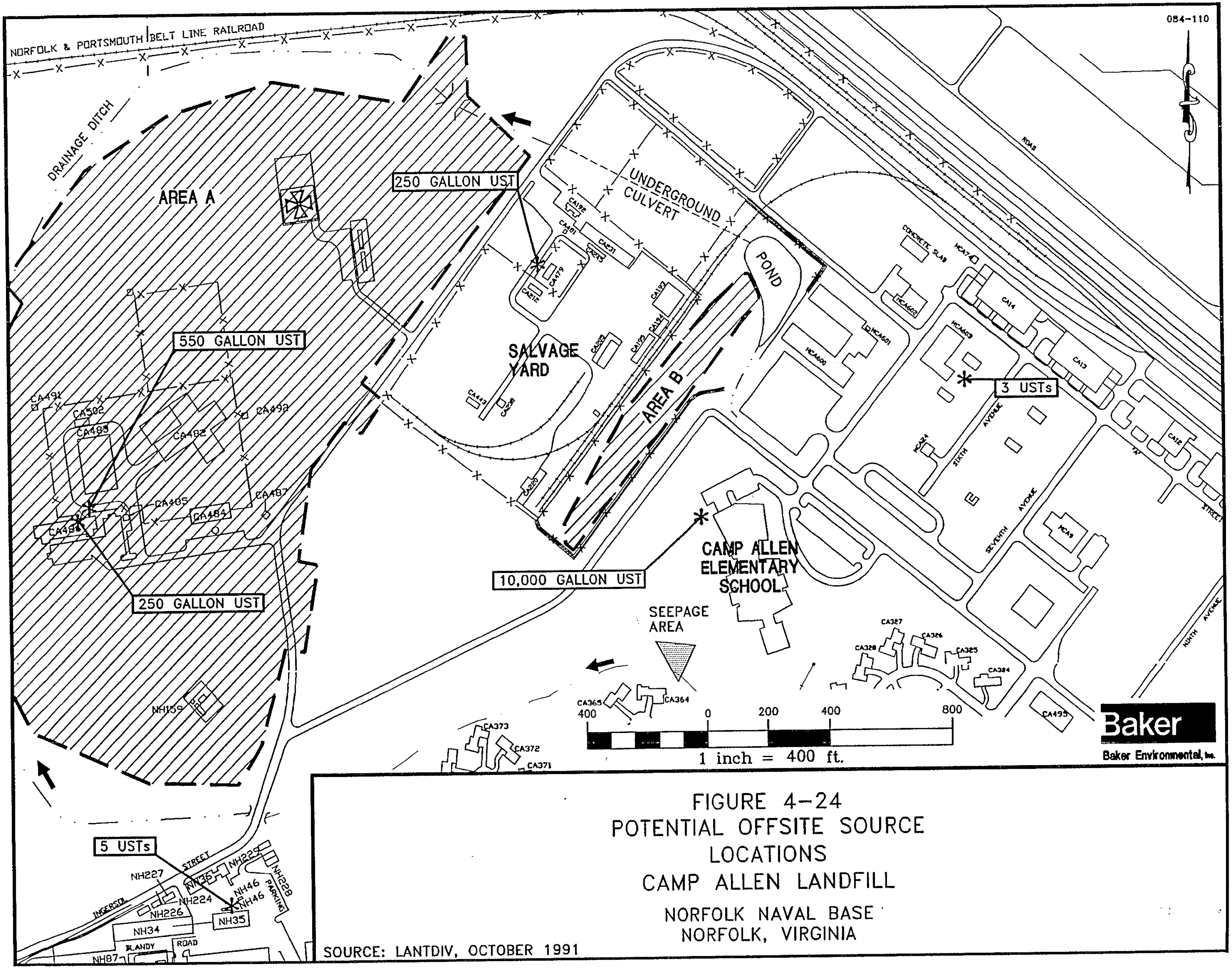


FIGURE 4-24
POTENTIAL OFFSITE SOURCE
LOCATIONS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

SOURCE: LANTDIV, OCTOBER 1991

evaluation of various remedial action alternatives, specifically technologies/alternatives applicable to the capture and/or recovery of contaminated groundwater. The results of the modeling will be used to evaluate the implementability, effectiveness, and cost of various groundwater cleanup alternatives. A detailed discussion of the modeling activity including input parameters, model verification and the results of various pumpage scenarios (i.e., recovery well locations, pumping rates, etc.) is presented in the Feasibility Study. As such the following provides only a general overview of this activity.

The physical results of the RI, as presented in Section 4.0 of this report, indicate that the Camp Allen Site hydrogeology may be characterized as a dual, unconfined-confined aquifer system separated by a discontinuous semi-confining clay layer. Evaluation of the site conditions also indicated that this site would be amenable to computer modeling using the code developed by McDonald and Harbaugh in 1984 titled "A Modular Three-Dimensional Finite Difference Ground-Water Flow Model" (MODFLOW), as modified by Geraghty and Miller (1988). MODFLOW is a three dimensional finite difference computer model capable of simulating both confined and unconfined aquifer conditions as well as surface water-groundwater interactions.

Model input was based on the geological and hydrogeological information as presented in Section 4.0. The primary information used as input consisted of boring and well construction logs, groundwater elevation measurements, slug test results, pumping test results, precipitation measurements and site survey data. This information was input with respect to the finite difference grid covering an areal extent of approximately 250 acres (inclusive of both Areas A and B).

The Camp Allen Site model depth was extended from the ground surface to a confining layer located approximately 135 feet below the ground surface. The vertical portion of the finite difference grid was divided into four layers to represent: (1) the shallow unconfined aquifer and surface water features; (2) the semiconfining unit consisting of sand and clay lenses; (3) the upper portion of the deep, confined aquifer; and (4) the lower portion of the deep, confined aquifer. The model was calibrated to yield output (i.e. hydraulic head) consistent with measured groundwater elevations in the shallow and deep aquifers.

Model verification also was performed by comparison of several measured field conditions with the model output. These conditions included measured groundwater elevations coupled with precipitation events, and local pumping test results. Reasonable response to these selected aquifer stresses indicates that the model provides a representative simulation of the aquifer system.

As discussed above, this model will be used in the Feasibility Study as the basis of addressing contaminated groundwater. A detailed discussion of the model construct and the output from various pumping scenarios will be presented in an Appendix to the Feasibility Study.

4.5 Results of the Benthic Macroinvertebrate Field Sampling

The following section presents the results of the ecological investigation, including the field water quality measurements, the biotic and abiotic characteristics at the sampling locations, and the benthic macroinvertebrates that were collected at Camp Allen. The results of the vegetation surveys and wildlife observations are also covered.

4.5.1 Water Quality

Table 4-10 summarizes the field water quality measurements collected at the biological stations. Water quality parameters included salinity, conductivity, dissolved oxygen, pH, and temperature.

The salinity at Stations BC01, BC02, and BC03 was 0, 0.2, and 0.1 ppt, respectively, and the conductivity at these stations was 400, 355, and 650 micromho/cm, respectively. The dissolved oxygen at these stations was 9.1, 13, and 1.8 mg/L, and the pH was 7.55, 7.28, and 7.13 S.U. Finally, the temperature at these stations was 33, 28, and 27°C, respectively.

The salinity at Stations BC04 and BC05 was 6.2 ppt, at the bottom and 5.0 ppt at the surface of station BC05. The conductivity at Stations BC04 and BC05 was 10,500 and 11,800 micromho/cm at the bottom, and 9,900 micromho/cm at the surface of BC05, respectively. The dissolved oxygen at these stations was 10.5 and 17.2 mg/L at the bottom and 11.1 and >20 µg/L at the surface. Finally, the pH of those stations was 7.93, and 9.03 S.U. The temperature at these stations was 25 and 32°C, respectively.

TABLE 4-10

WATER QUALITY MEASUREMENTS FROM AQUATIC SAMPLING STATIONS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Station	Salinity (ppt)	Conductivity (micromho/cm)	DO (mg/L)	pH (S.U.)	Temperature (deg. C)
BC01	0	400	9.1	7.55	33
BC02	0.2	355	13	7.28	28
BC03	0.1	650	1.8	7.13	27
BC04	6.2	10,500	10.5 (11.1)*	7.93	25
BC05	6.2 (5.0)*	11,800 (9,900)*	17.2 (>20)*	9.03	32

ppt - Parts per thousand
mg/L - Milligrams per liter
S.U. - Standard Units
deg. C - Degrees Celsius
Note: All measurements were conducted at the water bottom except where noted.
* - Measurement recorded from water surface

4.5.2 Biotic and Abiotic Characteristics

This section contains a summary of the biotic and abiotic characteristics at each of the stations. Refer the field data sheets in Appendix N for more detailed information. The riparian vegetation adjacent to the stations is discussed below in the terrestrial section. Stations BC01, BC02, and BC03 were located in fresh waters while Stations BC04 and BC05 were located in tidally-influenced waters. All the waters had a relatively negligible velocity.

Station BC01 was located in the Area B ponded area, approximately 30 to 40 feet upstream of Station BC02. The pond was approximately 20-25 feet wide at this location and approximately six inches deep. There was extensive submerged aquatic vegetation (SAV) at this station, primarily consisting of pondweed with small spike rushes and duckweed. The sediments in Samples BC01L and BC01M were sandy, with black organic debris (leaves, twigs), while Sample BC01R was mostly black organic debris with some decaying grasses. The sediments had a hydrogen sulfide odor and the water was turbid. Small mosquito fish were observed in the water.

Station BC02 was located in the ponded area, slightly downstream of the landfill seep. The pond was approximately 25-30 feet wide at this location, and approximately six to twelve inches deep. Submerged aquatic vegetation (primarily pondweed) was present on the west side of the pond, but there was less extensive SAV in the middle and right side of the pond. The sediments in all three samples were sandy, with black organic debris. The sediments had a slight hydrogen sulfide odor. The turbid water had an oil sheen only on the west side of the pond. This sheen also was noticed along the same bank, approximately 40 to 50 feet downstream in the pond. Small mosquito fish were observed in the water.

Station BC03 was located in the drainage ditch, downstream of the pond in Area A. The ditch was approximately eight feet wide at this location, and approximately two to three inches deep. There was no SAV at the sampling location; however, extensive SAV was located three to four feet upstream of the station. The sediments in Sample BC03R were a brown silty muck with some organic debris, while the sediments in Samples BC03M and BC03L were a mixture of sand and brown organic debris. The sediments had a normal odor, and there was a slight oil sheen on the turbid water. Small mosquito fish were observed in the water. Miscellaneous litter (e.g., tires, rims, misc. metals) was observed in the drainage ditch approximately 15 to 20 feet downstream of this station. There was no evidence of possible contaminant migration from Navy property to private property resulting from the miscellaneous litter. The drainage ditch is wholly situated on Navy property. The northern portion of the ditch borders a narrow strip of land owned by the Norfolk and Portsmouth Belt Line Railroad, which bisects Camp Allen Area A and Navy Air Station (NAS) property. Based on surface water flow direction and shallow groundwater discharge points, it appears that surface water and shallow groundwater flow direction in this area would be from the railroad property northward toward Navy (NAS) property.

Station BC04 was located in the drainage ditch adjacent to the marsh area in Area A. The ditch was approximately 25 to 30 feet wide at this location, and approximately six inches deep. There was no SAV at the station. The sediments in all three samples were a black silt with some organic debris. The sediments had a slight odor, and there were a moderate amount of sediment oils, probably from natural decomposition. The water was slightly turbid. Small mosquito fish were observed in the water, and fiddler crabs were observed on the banks. The tide was rising at the time of the sampling.

Station BC05 was located in the drainage ditch adjacent to Glenwood Park in Area A. The ditch was approximately eight feet wide at this location, and approximately 12 inches deep. There was no SAV at the station. The sediments in Samples BC05L and BC05M were a black sand/silt with some organic debris. Sample BC05R was rocky, with a mixture of sand and organic debris. There was sample refusal at four inches due to a boulder or riprap in the drainage ditch. The sediments had a normal odor, and the water was turbid. Fiddler crabs were observed on the banks. The tide was coming in at the time of the sampling. This station was located downstream of an active construction site (the Breezy Point Apartments).

4.5.3 Grain Size Analysis

Samples were collected for grain size analysis from the middle location of each of the five benthic macroinvertebrate sampling locations. The results of the grain size analysis are provided in Appendix N.

Due to matrix interference, none of the samples could be analyzed for percent silt, percent clay, and percent colloids. The sediments collected from BC01 and BCO2 were coarse, with the most coarse sediments were collected at Station BC02. The finest sediments were collected at Station BC05, followed by sediments collected at BC04 and BC03.

4.5.4 Benthic Macroinvertebrates

Table 4-11 contains a systematic listing of the all the benthic macroinvertebrates collected at Camp Allen. Appendix N contains the laboratory bench sheets from RMC Environmental Services. Individuals were identified to family or sub-family levels. The results of the benthic macroinvertebrate sampling at each station are presented in the following sections. The results are based on the total of the three replicate samples.

Three phyla were represented in the collections from Station BC01: Annelida, Arthropoda, and Mollusca (see Table 4-12). Eight families of benthic macroinvertebrates from these three phyla were collected at this station. Of these three phyla, 96 percent of the individuals were annelids, 2.4 percent of the individuals were mollusks, and 1.6 percent of the individuals were arthropods. The number of individuals collected at Station BC01 was 750, and the taxon density was 32,438 individuals per square meter.

Four phyla were represented in the collections from Station BC02: Annelida, Arthropoda, Platyhelminthes, and Mollusca (see Table 4-12). Seven families of benthic macroinvertebrates from these four phyla were collected at this station. Of these four phyla, 90.4 percent of the individuals were annelids, 6.6 percent of the individuals were mollusks, 2.1 percent of the individuals were plathyhelminthes, and 0.9 percent of the individuals were arthropods. The number of individuals collected at Station BC02 was 2,215, and the density of individuals was 95,800 individuals per square meter.

Four phyla were represented in the collections from Station BC03: Annelida, Arthropoda, Platyhelminthes, and Mollusca (see Table 4-12). Six families of benthic macroinvertebrates from these four phyla were collected at this station. Of these four phyla, 91.5 percent of the individuals were annelids, 8.1 percent of the individuals were arthropods, 0.3 percent of the individuals were mollusks, and 0.1 percent of the individuals were plathyhelminthes. The number of individuals collected at Station BC03 was 1,270, and the density of individuals was 54,928 individuals per square meter.

Three phyla were represented in the collections from Station BC04: Annelida, Arthropoda, and Platyhelminthes (see Table 4-12). Six families of benthic macroinvertebrates from these three phyla were collected at this station. Of these three phyla, 78.2 percent of the individuals were annelids, 21.4 percent of the individuals were arthropods, and 0.4 percent of the

TABLE 4-11

SYSTEMATIC LIST OF BENTHIC MACROINVERTEBRATES
CAMP ALLEN LANDFILL, NORFOLK VIRGINIA

Species	Systematic Classification
ARTHROPODA	Phylum
Insecta	Class
Diptera	Order
Ceratopogonidae	Family
Chironomidae	Family
Chironominae	Sub-family
Tanypodinae	Sub-family
Psychodidae	Family
Odonata	Order
Coenagrionidae	Family
Coleoptera	Order
Haliplidae	Family
Scirtidae	Family
Hydrophilidae	Family
ANNELIDA	Phylum
Oligochaeta	Class
Tubificida	Order
Tubificidae	Family
Polychaeta	Class
Phyllodocida	Order
Nereidae	Family
Spionida	Order
Spionidae	Family
PLATYHELMINTHES	Phylum
Turbellaria	Class
Tricladida	Order
Planariidae	Family
MOLLUSCA	Phylum
Bivalvia	Class
Veneroida	Order
Sphaeriidae	Family
MOLLUSCA	Phylum
Gastropoda	Class
Basommatophora	Order
Physidae	Family
Planorbidae	Family

TABLE 4-12

SUMMARY DATA - BENTHIC MACROINVERTEBRATES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Species	Station BC01L	Station BC01R	Station BC01M	Station BC01[1]	Percent of Individuals
ARTHROPODA Insecta					1.6
Diptera					
Ceratopogonidae	1			1	0.1
Chironomidae					
Chironominae		5	2	7	0.9
Tanypodinae					
Psychodidae					
Odonata					
Coenagrionidae		1		1	0.1
Coleoptera					
Haliplidae			3	3	0.4
Scirtidae					
Hydrophilidae					
ANNELIDA Oligochaeta					96.0
Tubificida					
Tubificidae	98	136	486	720	96.0
Polychaeta					
Phyllodocida					
Nereidae					
Spionida					
Spionidae					
PLATYHELMINTHES Turbellaria					0
Tricladida					
Planariidae					
MOLLUSCA					2.4
Bivalvia					
Veneroida					
Sphaeriidae		3		3	0.4
Gastropoda					
Basommatophora					
Physidae	4	2	2	8	1.1
Planorbidae		3	4	7	0.9
Number of Families	3	6	5	8	
Number of Individuals	103	150	497	750	
Density (indiv./M^2)	13,364	19,463	64,487	32,438	

(1) Total of three replicates

TABLE 4-12 (Continued)

SUMMARY DATA - BENTHIC MACROINVERTEBRATES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Species	Station BC02L	Station BC02R	Station BC02M	Station BC02	Percent of Individuals
ARTHROPODA					0.9
Insecta					
Diptera					
Ceratopogonidae					
Chironomidae					
Chironominae	2	6	10	18	0.8
Tanypodinae					
Psychodidae			1	1	0
Odonata					
Coenagrionidae					
Coleoptera					
Haliplidae					
Scirtidae					
Hydrophilidae					
ANNELIDA					90.4
Oligochaeta					
Tubificida					
Tubificidae	821	836	346	2003	90.4
Polychaeta					
Phyllodocida					
Nereidae					
Spionida					
Spionidae					
PLATYHELMINTHES					2.1
Turbellaria					
Tricladida					
Planariidae	4	39	4	47	2.1
MOLLUSCA					6.6
Bivalvia					
Veneroida					
Sphaeriidae	2	3		5	0.2
Gastropoda					
Basommatophora					
Physidae	14	10	3	27	1.2
Planorbidae	92	16	6	114	5.1
Number of Families	6	6	6	7	
Number of Individuals	935	910	370	2,215	
Density (indiv./M^2)	121,318	118,074	48,008	95,800	

TABLE 4-12 (Continued)

SUMMARY DATA - BENTHIC MACROINVERTEBRATES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Species	Station BC03L	Station BC03R	Station BC03M	Station BC03	Percent of Individuals
ARTHROPODA Insecta					8.1
Diptera					
Ceratopogonidae					
Chironomidae					
Chironominae	1	2	5	8	0.6
Tanypodinae	29	14	51	94	7.4
Psychodidae					
Odonata					
Coenagrionidae					
Coleoptera					
Haliplidae					
Scirtidae	1			1	0.1
Hydrophilidae					
ANNELIDA Oligochaeta					91.5
Tubificida					
Tubificidae	708	19	435	1162	91.5
Polychaeta					
Phyllodocida					
Nereidae					
Spionida					
Spionidae					
PLATYHELMINTHES Turbellaria					0.1
Tricladida					
Planariidae			1	1	0.1
MOLLUSCA Bivalvia					0.3
Veneroida					
Sphaeriidae					
Gastropoda					
Basommatophora					
Physidae		1	3	4	0.3
Planorbidae					
Number of Families	4	4	5	6	
Number of Individuals	739	36	495	1,270	
Density (indiv./M^2)	95,887	4,671	64,227	54,928	

TABLE 4-12 (Continued)

SUMMARY DATA - BENTHIC MACROINVERTEBRATES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Species	Station BC04L	Station BC04R	Station BC04M	Station BC04	Percent of Individuals
ARTHROPODA Insecta					21.4
Diptera					
Ceratopogonidae					
Chironomidae					
Chironominae	27	5	23	55	21.0
Tanypodinae					
Psychodidae					
Odonata					
Coenagrionidae					
Coleoptera					
Haliplidae					
Scirtidae					
Hydrophilidae		1		1	0.4
ANNELIDA Oligochaeta					78.2
Tubificida					
Tubificidae	21	83	30	134	51.1
Polychaeta					
Phyllodocida					
Nereidae	12	42	16	70	26.7
Spionida					
Spionidae		1		1	0.4
PLATYHELMINTHES Turbellaria					0.4
Tricladida					
Planariidae		1		1	0.4
MOLLUSCA Bivalvia					
Veneroida					
Sphaeriidae					
Gastropoda					
Basommatophora					
Physidae					
Planorbidae					
Number of Families	3	6	3	6	
Number of Individuals	60	133	69	262	
Density (indiv./M^2)	7,785	17,257	8,953	11,332	

TABLE 4-12 (Continued)

SUMMARY DATA - BENTHIC MACROINVERTEBRATES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Species	Station BC05L	Station BC05R	Station BC05M	Station BC05	Percent of Individuals
ARTHROPODA Insecta					12.1
Diptera					
Ceratopogonidae					
Chironomidae					
Chironominae	32	19	36	87	11.9
Tanypodinae			2	2	0.3
Psychodidae					
Odonata					
Coenagrionidae					
Coleoptera					
Haliplidae					
Scirtidae					
Hydrophilidae					
ANNELIDA Oligochaeta					87.9
Tubificida					
Tubificidae	246	140	259	645	87.9
Polychaeta					
Phyllodocida					
Nereidae					
Spionida					
Spionidae					
PLATYHELMINTHES Turbellaria					
Tricladida					
Planariidae					
MOLLUSCA Bivalvia					
Veneroida					
Sphaeriidae					
Gastropoda					
Basommatophora					
Physidae					
Planorbidae					
Number of Families	2	2	3	3	
Number of Individuals	278	159	297	734	
Density (indiv./M^2)	36,071	20,631	38,536	31,746	

individuals were plathyhelminthes. The number of individuals collected at Station BC04 was 262, and the density of individuals was 11,332 individuals per square meter.

Two phyla were represented in the collections from Station BC05: Arthropoda and Annelida (see Table 4-12). Three families of benthic macroinvertebrates from these two phyla were collected at this station. Of these three families, 87.9 percent of the individuals were annelids, and 12.1 percent of the individuals were arthropods. The number of individuals collected at Station BC05 was 734, and the density of individuals was 31,746 individuals per square meter.

Of the organisms identified, some pollution-tolerant species were observed. However, pollution-tolerant species would be expected to be found in a developed area such as Camp Allen. The taxonomic laboratory did not report any abnormalities in the benthic macroinvertebrate collections.

Figure 4-25 graphically displays the number of families from the sampling stations, while Figure 4-26 graphically displays the numbers of individuals from the sampling stations. Finally, Figure 4-27 graphically displays the density of individuals from the sampling stations.

4.5.5 Results of the Terrestrial Investigation

During the week-long terrestrial field study at the Camp Allen Landfill, four separate areas were investigated. The study methodology is included in Section 3.6 of this report and results of the investigation are presented in the following sections.

4.5.5.1 Area B Pond

The first area investigated was the ponded area at Area B (see Figure 3-18). From a terrestrial standpoint, the pond was the most complex of the four areas because three different habitats bordered it. To the north-northeast the pond was bordered by a wooded area, to the south-southwest it was bordered by a shrubby woods edge succeeding to woods, and to the south it was bordered by a small open field area. Because of these three distinct areas three separate transects were run; two of these transects, the woods edge and open area, also included submerged aquatic vegetation that was present.

Figure 4-25
Number of Taxonomic Families vs Station Number
Camp Allen Landfill, Norfolk, Virginia

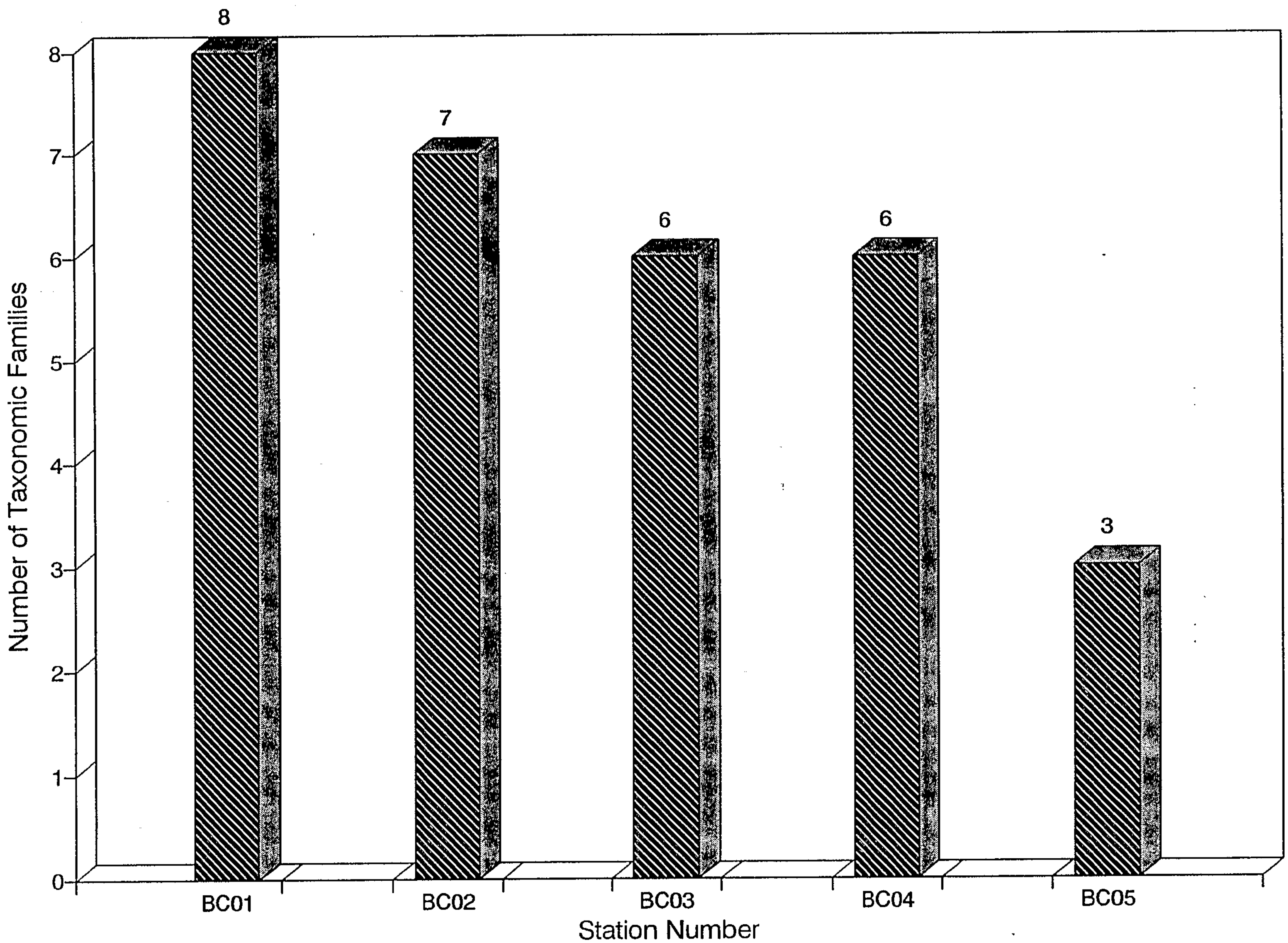


Figure 4-26
Number of Individuals vs Station Number
Camp Allen Landfill, Norfolk, Virginia

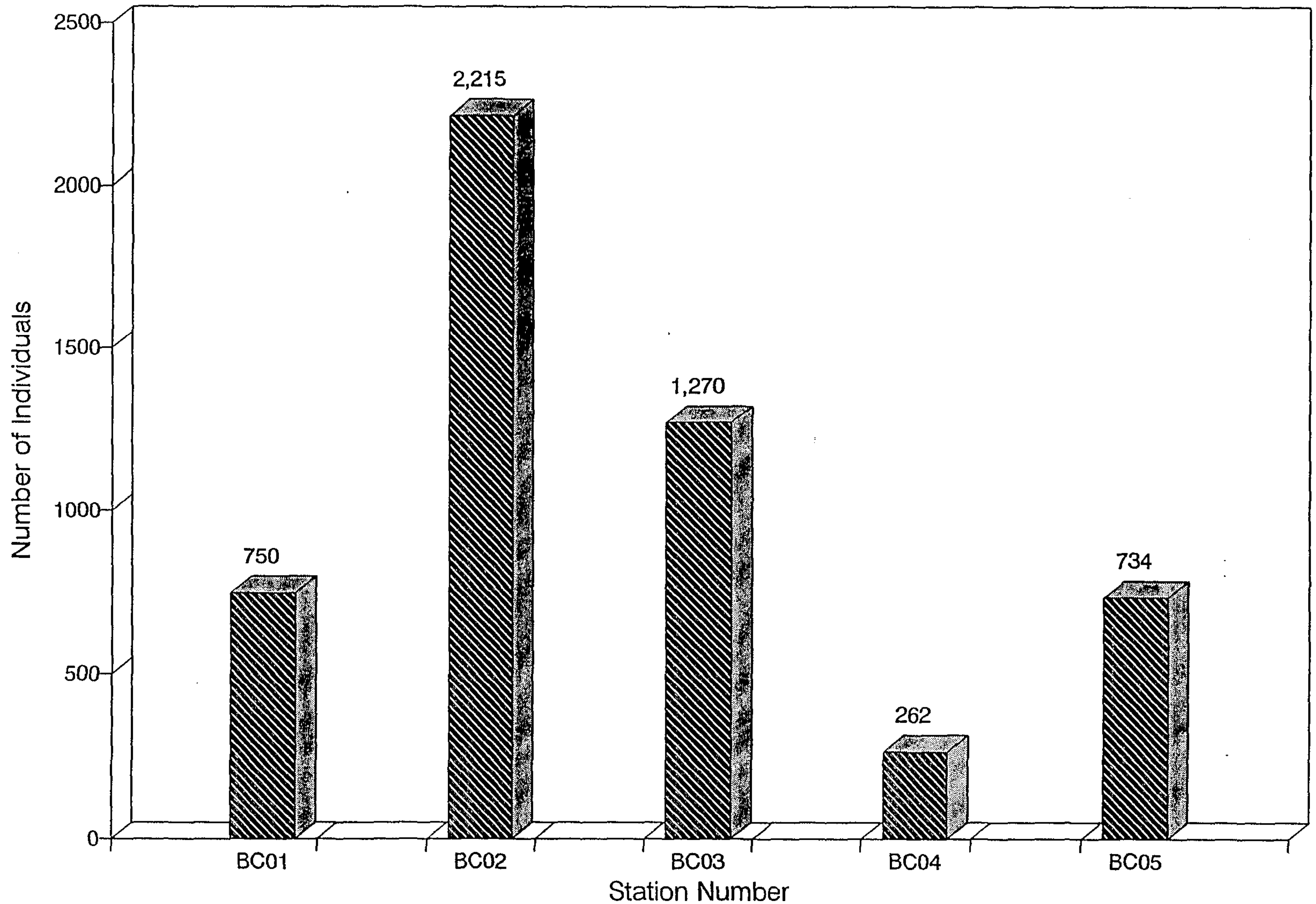
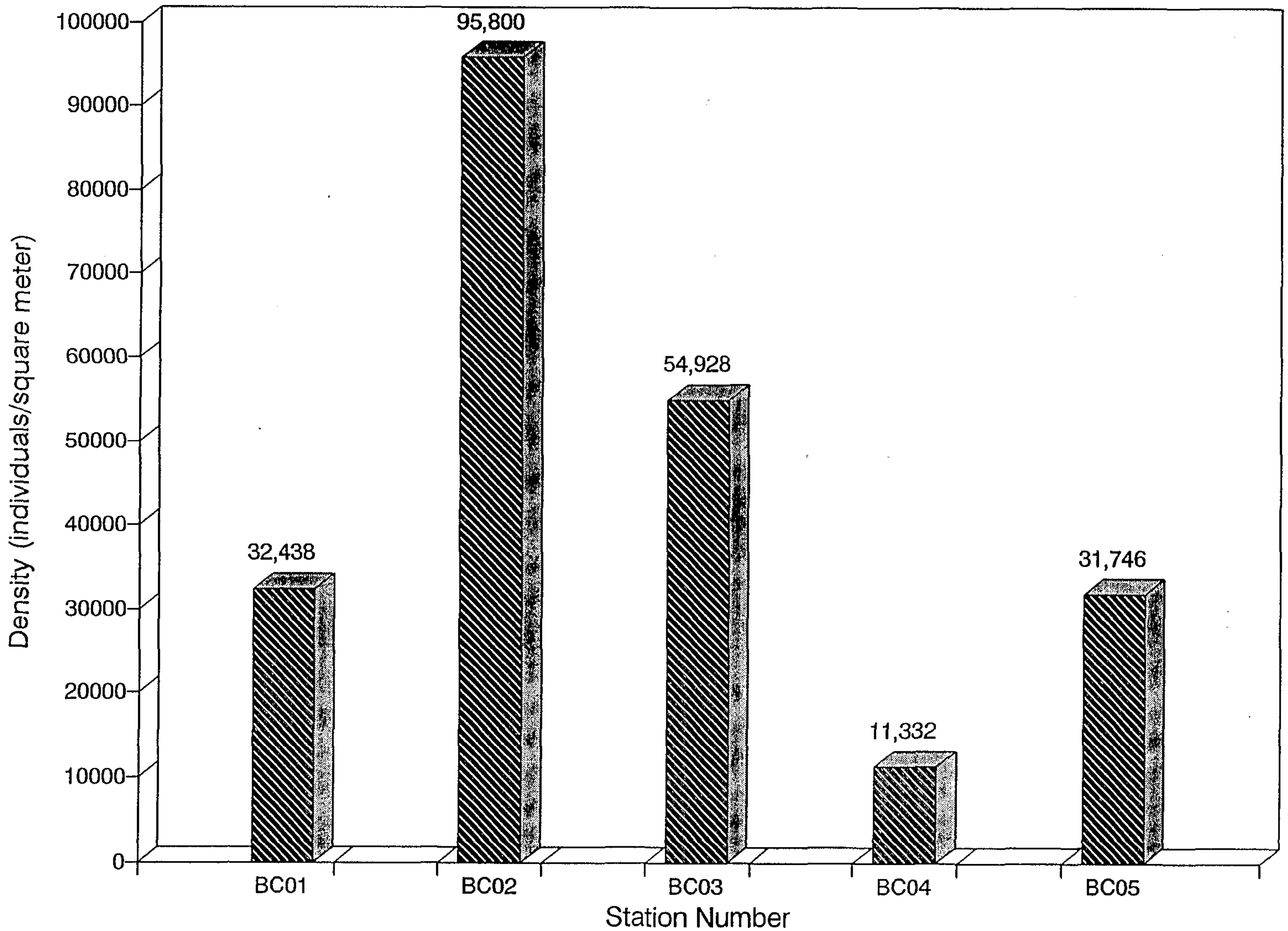


Figure 4-27
Density of Individuals vs Station Number
Camp Allen Landfill, Norfolk, Virginia



The wooded border of the pond was dominated by trees but the species were well mixed. Trees present in the transect included the following:

Black Locust	Robinia pseudo-acacia
Water Oak	Quercus nigra
Sassafras	Sassafras albidum
Common Persimmon	Diospyros virginiana
Sweet Gum	Liquidamber styraciflua
Black Cherry	Prunus serrotina
Tulip Poplar	Liriodendron tulipifera
Loblolly Pine	Pinus taeda
Shagbark Hickory	Carya ovata
Red Cedar	Juniperus virginiana

Most of the saplings that were identified in the transect through the wooded border of the pond were younger specimens of the trees that were present. Flowering dogwood (Cornus florida) was also identified in the understory layer of the woods.

Woody vines as a class dominated the ground layer of the wooded border, although no vine species was clearly dominant. The vine layer of the woods included the following species:

Japanese Honeysuckle	Lonicera japonica
Common Greenbriar	Smilax rotundifolia
Virginia Creeper	Parthenocissus quinquefolia
Sand Grape	Vitis nepestris

Because the woody vines dominated the ground layer, the only plants present at this level were seedlings of the trees that were present in the canopy.

The shrubby woods edge border of the pond was dominated by large saplings of sweet gum (Liquidamber styraciflua). Red mulberry (Morus rubra) was also present but not dominant. Shrubs were also present, although none of the three species was dominant. These shrubs included shining sumac (Rhus copallina), smooth sumac (Rhus glabra), and blackberry (Rubus allegheniensis).

Six species of woody vines were present in the understory layer of the woods edge. Of the six Japanese honeysuckle (Lonicera japonica) appeared to be dominant in the transect. The other species included the following:

Virginia Creeper	Parthenocissus quinquefolia
Trumpet Creeper	Campsis radicans
Sand Grape	Vitis rupestris
Wild Grape	Vitis sp.
Poison Ivy	Rhus radicans

Herbaceous plants and grasses were present at the ground layer in this transect. None of these plants was clearly dominant. Species in this layer included the following:

Giant Reed	Phragmites
Dogbane	Apocynum androsaemifolium
Sweet White Clover	Trifolium repens
Field Garlic	Allium vineale
Downy Brome Grass	Bromus tectorum
Panic Grass	Panicum sp.

At the open border of the pond no trees were present, although three species of saplings or shrubs were identified. These included black locust (Robinia pseudo-acacia), black willow (Salix nigra), and blackberry (Rubus allegheniensis). None of these species were dominant. One woody vine, wild grape (Vitis sp.) was present.

This open border of the pond was dominated by grasses including Paspalum, orchard grass (Dactylis glomerata), and downy brome grass (Bromis tectorum). The following herbaceous plants were also present:

Curled Dock	Rumex crispus
Dock	Rumex sp.
Common Reed	Phragmites
False Nettle	Boehmeria cylindrica
Field Bindweed	Convolvulus arvensis
Field Garlic	Allium vineale
Soft Rush	Juncus effusus
Apple Mint	Mentha
Indian Strawberry	Duchesnea indica
Virginia Wild Rye	Elymus virginicus
Hop Sedge	Carex pseudo-cyperus
Bur-reed	Sparganium sp.

In addition to the terrestrial vegetation at the pond some submerged aquatic vegetation was present. Pondweed (Potamogeton) was clearly dominant while secondary species included spike rush (Eleocharis sp.), duckweed (Lemna minor), and water pennywort (Hydrocotyle americana). The spike rush was approximately three to five inches high and was growing on the mats of pondweed.

Wildlife using the pond area was observed from several points throughout the week of field study. A common muskrat (Ondatra zibethicus) was swimming near the inflow area of the pond and frogs were heard jumping from the bank into the water. No frogs were caught, so identification was not possible; however, they may have been green frogs (Rana clamitans) based upon their size and the habitat. A cottontail rabbit (Sylvilagus floridanus) was observed in the field bordering the pond.

Birds were common in the pond area and a total of 14 species was observed during the field study. These species are as follows:

Mourning Dove	Zenaidra macroura
Robin	Turdus migratorius
Purple Grackle	Quiscalus quiscula
House Sparrow	Passer domesticus domesticus
Pigeon	Columba livia
Killdeer	Charadrius vociferus
Starling	Sternus vulgaris vulgaris
Cardinal	Richmondena cardinalis
Mockingbird	Mimus polyglotus polyglotus
Carolina Wren	Thryothorus ludovicianus
Carolina Chickadee	Parus carolinensis
Kingbird	Tyrannus tyrannus
Yellow-billed Cuckoo	Coccyzus americanus americanus
Yellow-shafted Flicker	Colaptes auratus

During previous field tasks team members noted that snowy egrets (Leucophoyx thula) were feeding on mosquito fish at the pond. The birds were observed several times.

4.5.5.2 Drainage Ditch in Area A Near the Landbridge

The second area studied was along the drainage ditch in Area A not far from the landbridge connecting two fields. This area is shown in Figure 3-19.

This area was primarily open; however, trees, shrubs, and vines were growing along the drainageway where the terrain was too rough to be mowed regularly. The fields on both sides of the drainage ditch were mowed often. The transect used to evaluate the vegetation in this area was placed from the edge of the drainage ditch to the open field. Several scattered trees were present including red mulberry (Morus rubra), black cherry (Prunus serrotina), and black willow (Salix nigra). No saplings or shrubs were present, but woody vines were present. These vines covered the ground in some areas and two species, Japanese honeysuckle (Lonicera japonica) and poison ivy (Rhus radicans) were dominant. The honeysuckle was particularly dominant in the shady areas under the trees. Virginia creeper (Parthenocissus quinquefolia) was also present.

In the open, sunny area of the transect grasses were clearly dominant. They included meadow fescue (Festuca elatior) and purple finger grass (Digitaria filiformus). Other herbaceous plants and grasses present included the following:

Queen Anne's Lace	Daucus carota
Field Thistle	Cirsium discolor
Field Garlic	Allium vineale
Asiatic Dayflower	Commelimma commumis
Common Evening Primrose	Oenothera biennis
Velvet Grass	Holcus lanatus
Fescue Sedge	Carex festucacea
Cultivated Barley	Hordeum sativum
Hyssop-leaved Thoroughwort	Bupatorium hyssopifolium
Common White Clover	Trifolium repens
Pokeberry	Phytolacca americana

In addition, submerged aquatic vegetation was present throughout much of the drainage ditch. This was identified as mild water pepper (Polygonum hydropiperoides).

No mammals or mammal signs were observed at this location. However, snapping turtles (Chelydra serpentina) were common. Six of the turtles were seen basking in the sun partially submerged in the sediment and vegetation. During the site visit a female painted turtle (Chrysemys picta marginata) was observed digging a nesting hole along the edge of the drainage ditch. A black rat snake (Elaphe obsoleta obsoleta) was also observed during the site visit. Finally, bullfrogs (Rana catesbeiana) were heard at the drainage ditch.

Ten species of birds were seen from observation points along the drainage ditch. These included the following:

Red-winged blackbird	Agelaius phoeniceus
Common crow	Corvus brachyrhynchos
Killdeer	Charadrius vociferus
Mourning Dove	Zenaidura macroura
Purple Grackle	Quiscalus quiscula
Starling	Sternus vulgaris vulgaris
Barn Swallow	Hirundo rutica erythrogaster
Mockingbird	Mimus polyglotus polyglotus
Robin	Turdus migratorius
Cardinal	Richmondena cardinalis

The starlings are present as a large flock of approximately 50 birds. From their behavior (i.e., singing to mark territory) the red-winged blackbirds may be nesting in the nearby marsh.

4.5.5.3 Drainage Ditch Area A Near Spartina/Phragmites Marsh

The drainage ditch in Area A (Figure 3-20) is bordered on one side by a major wetland and on the other side by mowed fields. The wetland area, a Spartina and Phragmites marsh, was not studied as part of the vegetation survey. However, wildlife observations were conducted in the area surrounding the marsh.

The transect in this area ran from the edge of the drainage ditch along the marsh to the edge of the mowed field. The edge of the ditch along the marsh was dominated by Phragmites and no other vegetation was present. On higher ground, trees and shrubs were well mixed. Five species of trees and four shrub species were identified as follows:

Willow Oak	Quercus phellos
Sweet Gum	Liquidamber styraciflua
American Holly	Ilex opaca
Black Cherry	Prunus serrotina
Shining Sumac	Rhus copallina
Common Wax Myrtle	Myrica cerifera
Blackberry	Rubus allegheniensis
Elderberry	Sambucus canadensis
Groundsel-tree	Zaccharis halimifolia

Between the belt of shrubs bordering the ditch and the open field woody vines were the dominant vegetation type. Of the vines Japanese honeysuckle (Lonicera japonica) was clearly dominant. Secondary vines included Virginia creeper (Parthenocissus quinquefolia), poison ivy (Rhus radicans), trumpet creeper (Campsis radicans), and common greenbriar (Smilax rotundifolia).

The edge of the field in this location was apparently mowed regularly and mowing was taking place during the site visit. Woody vines were no longer present in the mowed areas but Phragmites dominated some of the area along the mowed edge and appeared as colonies among the grasses and herbaceous plants that were also present. The only other plant present among the Phragmites was field bindweed (Convolvulas arvensis), which was able to climb the Phragmites stalks and successfully compete with the dominant reeds. Herbaceous plants that were identified in the transect along the edge of the field include the following:

Hedge Bindweed	Convolvulus sepium
Curly Dock	Rumex crispus
English Plantain	Plantago lanceolata
Field Garlic	Allium vineale
Common St. Johnswort	Hypericum perforatum
Vetch	Vicia sp.

Three mammals were observed in the area or identified by sign: raccoon (Procyon lotor), gray squirrel (Sciurus carolinensis), and opossum (Didelphis marsupialis). The raccoons appear to be feeding on fiddler crabs, which are numerous in the marsh. Raccoon tracks were observed in the marsh and raccoon scat that incorporated fiddler crab shells was found during earlier field investigations. During the site visit a snapping turtle (Chelydra serpentina) was observed swimming in the drainage ditch.

Birds were numerous in the saplings along the drainage ditch, in the open field, and along the marsh. The following species were identified:

Killdeer	Charadrius vociferus
Mourning Dove	Zenaidra macroura
Robin	Turdus migratorius
Laughing Gull	Lauras patricilla
Starling	Sternus vulgaris vulgaris
Yellow-shafted Flicker	Colaptes auratus
Mockingbird	Mimus polyglotus polyglotus
Red-winged Blackbird	Agelaius phoeniceus
Purple Grackle	Quiscalus quiscula
Common Crow	Corvus brachyrhynchos
Song Sparrow	Melospiza melodia
Goldfinch	Spinus tristus tristus
Cardinal	Richmondena cardinalis
Barn Swallow	Hirundo rustica erythrogaster
Blue Jay	Cyanocitta cristata

Rufous-sided Towhee	Pipilo erythrophthalmus
Yellowthroat	Geothlypis trichas

During the site visit a yellow-breasted chat (Icteria virens) was heard calling in the marsh and an indigo bunting (Passerina cyanea) was observed in the saplings along the drainage ditch. Of the birds observed, several appeared to be nesting in the area. Both the red-winged blackbirds and the yellowthroat were singing to mark territory and the starlings may have been roosting and nesting in structures that were part of utility lines.

4.5.5.4 Drainage Ditch in Area A Near Glenwood Park

This study area was located between the brig and Glenwood Park (Figure 3-21). Because the benthic macroinvertebrate sampling location was in an area that had been recently disturbed, an area farther south was selected for the vegetation and wildlife surveys. This undisturbed area would give a more representative overview. The marsh between the brig and Glenwood Park was not included in the vegetation survey, although wildlife around and over the marsh was observed as part of the faunal study.

The transect for the vegetation survey was run in an area between the edge of the marsh and the fence separating the base from Glenwood Park beyond the gate at the end of Beechwood Avenue. The transect represented a clear transition from open ground through woods edge to mixed coniferous/deciduous woods. Succession was clearly taking place as seedling trees were growing in the open area and the edge of the woods.

The vegetation in the open area between the edge of the marsh and the edge of the woods was a mixture of herbaceous plants, scattered grasses, woody vines, and shrubs mixed with seedling trees. Several of the herbaceous plants present were probably garden escapes; the residents of the nearby housing apparently use the wooded area to dispose of clippings and discarded plants. Herbaceous plants and grasses present in the transect through open area included the following:

Sowthistle	Sonchus oleraceus
Hawkweed	Hieraceum sp.
Goldenrod	Solidago sp.
Broom Sedge	Andropogon virginicus
Yucca	Yucca filimentosa
Daylily	Hemerocalis flava
Giant Reed	Phragmites sp.
Daisy Fleabane	Erigeron annuus

Panic Grass	Panicum sp.
Perennial Sweetpea	Lathyrus latifolia
Slender Bush Clover	Lespedeza virginica

Woody vines were present in the open area and in the woods edge. None of the vines were dominant. Six species were identified:

Wild Grape	Vitis sp.
Bullbriar	Smilax bona-nox
Trumpet Creeper	Campsis radicans
Poison Ivy	Rhus radicans
Common Greenbriar	Smilax rotundifolia
Japanese Honeysuckle	Lonicera japonica

Seedling trees, saplings, and shrubs dominated the edge of the woods. Eleven species of young trees were identified including the following:

Black Locust	Robinia pseudo-acacia
Silk Tree	Albizzia julibrissin
Sweet Gum	Liquidamber styraciflua
Willow Oak	Quercus phellos
Black Cherry	Prunus serrotina
Water Oak	Quercus nigra
Live Oak	Quercus virginiana
Sassafras	Sassafras albidum
Loblolly Pine	Pinus taeda
Southern Red Oak	Quercus rubra
Flowering Dogwood	Cornus florida

In addition, the following shrubs were present:

Shining Sumac	Rhus copallina
Groundsel-tree	Zaccharis halimifolia
Blackberry	Rubus allegheniensis
Multiflora Rose	Rosa multiflora

In the wooded area trees were the dominant vegetation type, although no one species was dominant. Nine species of trees were identified in the transect through the woods; many of the trees present in the woods were also present in the woods edge. They included the following:

Loblolly Pine	Pinus taeda
Sweet Gum	Liquidamber styraciflua
Sassafras	Sassafras albidum
Willow Oak	Quercus phellos
Tree of Heaven	Alianthus altissima
Black Locust	Robinia pseudo-acacia

Black Cherry	Prunus serrotina
Magnolia	Magnolia grandifolia
Silk Tree	Albizzia julibrissin

Blackberry (Rubus allegheniensis) and multiflora rose (Rosa multiflora) were present in the understory as were six species of woody vines. These vines along with seedling trees dominated the understory. The following woody vines were identified:

Poison Ivy	Rhus radicans
Virginia Creeper	Parthenocissus quinquefolia
Trumpet Creeper	Campsis radicans
Japanese Honeysuckle	Lonicera japonica
Common Greenbriar	Smilax rotundifolia
Wild Grape	Vitis sp.

The only species of mammal observed in this area was a gray squirrel that was feeding on black cherries at the woods edge. A squirrel's nest was also observed in the woods. Birds, however, were plentiful in the area. Bird observations were conducted in the woods, at the woods edge, and across the marsh from the brig side of the field. The following birds were identified:

Blue Jay	Cyanocitta cristata
Carolina Chickadee	Parus carolinensis
Common Crow	Corvus brachyrhynchos
Red-winged Blackbird	Agelaius phoeniceus
Barn Swallow	Hirundo rustica erythrogaster
Laughing Gull	Larus atricilla
Robin	Turdus migratorius
Mourning Dove	Zenaidura macroura
Purple Grackle	Quiscalus quiscula
Mockingbird	Mimus polyglotus polyglotus
Great Blue Heron	Ardea herodius
Yellow-shafted Flicker	Colaptes auratus
Carolina Wren	Thryothrous ludovicianus
Killdeer	Charadrius vociferous
Starling	Sternus vulgaris vulgaris
Yellowthroat	Geothlypis trichas
Sparrow Hawk	Falco sparverius
Crested Flycatcher	Myiarchus crinitus

4.5.5.5 Migratory Bird Survey

The Norfolk, Virginia area is located along the eastern flyway used by birds during spring and fall migrations. Birds that use this flyway include ducks and other waterfowl, shorebirds, raptors, and neo-tropical migrants like warblers, vireos, orioles, and hummingbirds. Several areas on the Camp Allen Landfill may be attractive resting and feeding stops for migrating birds, particularly for migrating neo-tropical species.

Because the ecological field study was not conducted during spring or fall migration, no observations of actual migrants could be made. However, the Virginia Society of Ornithology was contacted and asked to provide information on possible migrants. The society provided names of several experienced local ornithologists. One of these, Ms. Teta Kain, was contacted and provided an annotated list of potential migrants that might be seen at Camp Allen. Ms. Kain is the editor of The Raven, the journal of the Virginia Society of Ornithology and the secretary/compiler of the Virginia records committee of the society. She is also the editor of the Virginia and Washington, D.C. area report for the annual Christmas Count for American Bird. (The Christmas Count is a national bird survey conducted yearly by the National Audubon Society.)

The list of potential migratory birds appearing on the Camp Allen Landfill is included in Appendix O of this report.

SECTION 5
ANALYTICAL RESULTS

5.0 ANALYTICAL RESULTS OF REMEDIAL INVESTIGATION

This section presents the analytical results of subsurface soil, surface soil, sediment, surface water, and groundwater samples (two aquifer systems) collected at the Camp Allen Landfill. Documentation regarding the collection of samples was recorded on chain-of-custody forms that accompanied the samples to the laboratory. Chain-of-custody forms and custody seals were utilized to track the handling of samples subsequent to collection. Chain-of-custody forms are presented in Appendix P. The chain-of-custody forms are presented according to CLP and non-CLP samples collected in Rounds 1, 2, and 3; air program samples (Rounds A, B, and C); and non-NEESA samples collected in and around the Camp Allen Landfill Site. Chain-of-custody forms are used to prevent sample tampering and to trace the path of a sample in the event of suspected, off-site contamination. In general, sample shipments were received intact by the NEESA/CLP Laboratory. Chain-of-custody and custody seal documentation is recorded per NEESA-approved laboratory requirements. Contract Laboratory Program analyses were performed by Wadsworth Alert Laboratories, Canton, Ohio via a basic ordering agreement under Navy CLEAN's Installation Restoration Program. Duplicate sample results have been averaged with the environmental sample to obtain a mean concentration and are reported accordingly. Quantitation limits and detection limits were evaluated by an independent data validator (AWD Technologies) for all of the compounds assessed. Therefore, some compounds may have been eliminated from further consideration because they are believed to be absent from the specific media. The following sections discuss and present specific contaminants detected in the samples collected from the Camp Allen Landfill Area A and Area B. Appendix Q provides analytical summaries furnished by the data validator. Raw analytical data for this program has been retained by Baker. In addition, one copy will be provided to LANTDIV subsequent to receiving this report. Data validation qualifiers have been presented as a cover sheet with the data validation analytical summaries. Please reference this Appendix for explanations regarding data qualifiers.

Based on the information contained in the Data Validation Summary and the data review presented above, the analytical results for the samples collected at the Camp Allen Landfill are considered representative of site conditions with the assurance that no inadvertent contamination has taken place. In general, all data are acceptable for use as part of this study and have been presented as such.

5.1 Analytical Results for Area A

Analytical results of soil, sediment, surface water, and groundwater samples collected at the Camp Allen Landfill Area A are presented on Tables 5-1 through 5-39. Tables have been developed based on parameter and media representing results for the samples collected at Area A of the Camp Allen Landfill Site. For the purpose of this study essential elements (aluminum, calcium, magnesium, potassium, and sodium) have been eliminated from discussion in this section as they are typically found at elevated concentrations in tidally-influenced coastal plain areas. Also, please note that each media is addressed as an individual subsection, and all data tables relevant to that media follow that specific subsection.

5.1.1 Source Characterization Subsurface Soil Sample Results

A total of eight subsurface soil samples were collected from locations in and around the Camp Allen Landfill area during Round 2. Each soil sample was numbered sequentially from SBA-01 through SBA-08. A summary of Round 2 subsurface soil samples is presented in Table 5-1.

Volatile organic compounds were detected in six subsurface soil samples collected in Round 2 sampling efforts. Table 5-2 provides a complete listing of compounds detected and their corresponding concentrations. Methylene chloride; 1,1-dichloroethene; and 1,2-dichloroethene were detected in one sample (SBA-07DUP) at concentrations of 4J µg/kg, 17 µg/kg, and 384J µg/kg, respectively. Acetone was also detected in one sample (SBA-06) at a concentration of 490J µg/kg. Carbon disulfide was detected in two samples (SBA06 and SBA-07DUP) at concentrations of 13J µg/kg and 22 µg/kg, respectively. One sample (SBA-08) contained 2-butanone at a concentration of 17,000J µg/kg. One sample (SBA-06) contained 1,1,1-trichloroethane at a concentration of 63 µg/kg. Toluene was detected in five samples (SBA-01, SBA-03, SBA-04, SBA-06, and SBA-07) with concentrations ranging from 15J µg/kg to 3,000,000 µg/kg. Ethylbenzene was detected in three samples (SBA-01, SBA-04, and SBA-06) at concentrations ranging from 21J µg/kg to 45,000J µg/kg. Five samples (SBA-01, SBA-03, SBA-04, SBA-06, and SBA-07DUP) contained xylenes, (total) at concentrations ranging from 30 µg/kg to 340,000 µg/kg.

Semivolatile organic compounds were identified in seven subsurface soil samples. Table 5-3 provides a complete listing of compounds detected and the corresponding concentrations. Acenaphthene was detected in three samples (SBA-01, SBA-06, and SBA-07DUP) at concentrations ranging from 53.5J µg/kg to 5,600J µg/kg. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, indeno(1,2,-cd)pyrene, and pyrene were detected in one sample (SBA-07DUP) at concentrations of 165J µg/kg, 165J µg/kg, 172.5J µg/kg, 149.5J µg/kg, 155J µg/kg, 166J µg/kg, 176.5J µg/kg, 151J µg/kg, and 49.5J µg/kg, respectively. Bis(2-ethylhexyl)phthalate was detected in four samples (SBA-03, SBA-06, SBA-07DUP, and SBA-08) at concentrations ranging from 95.5J µg/kg to 17,000 µg/kg. Two samples (SBA-01 and SBA-07DUP) contained concentrations of dibenzofuran at 1,700J µg/kg and 43J µg/kg, respectively. Two samples (SBA-07DUP and SBA-08) contained concentrations of diethyl phthalate at concentrations of 195J µg/kg and 95K µg/kg, respectively. Four samples (SBA-01, SBA-03, SBA-07DUP, and SBA-08) contained concentrations of 2,4-dimethylphenol ranging from 530K µg/kg to 41,000 µg/kg. Three samples (SBA-01, SBA-07DUP, and SBA-08) contained concentrations of fluorene ranging from 35J µg/kg to 1,300J µg/kg. Isophorone was detected in one sample (SBA-08) at a concentration of 680K µg/kg. Six samples (SBA-01, SBA-03, SBA-04, SBA-06, SBA-07DUP, and SBA-08) contained concentrations of 2-methylnaphthalene ranging from 305J µg/kg to 21,000 µg/kg. Three samples (SBA-03, SBA-04, and SBA-07DUP) contained concentrations of 2-methylphenol ranging from 151J µg/kg to 6,400J µg/kg. Two samples (SBA-03 and SBA-07DUP) contained concentrations of 4-methylphenol at 5,500J µg/kg and 161J µg/kg, respectively. Naphthalene was detected in seven samples (SBA-01, SBA-02, SBA-03, SBA-04, SBA-06, SBA-07DUP, and SBA-08) at concentrations ranging from 34J µg/kg to 32,000 µg/kg. Phenanthrene was detected in three samples (SBA-06, SBA-07DUP, and SBA-08) ranging from 48J µg/kg to 370J µg/kg.

Pesticide/PCB compounds were detected in all eight of the subsurface soil samples collected, as depicted in Table 5-4. One sample (SBA-08) contained concentrations of delta-BHC and heptachlor epoxide at 1.4K µg/kg and 2.7K µg/kg, respectively. Endosulfan I was detected in two samples (SBA-06 and SBA-08) at concentrations of 15K µg/kg and 2.3K µg/kg, respectively. Seven samples (SBA-01, SBA-02, SBA-03, SBA-04, SBA-06, SBA-07DUP, and SBA-08) contained dieldrin at concentrations ranging from 1.09K µg/kg to 89K µg/kg. Four samples (SBA-03, SBA-06, SBA-07, and SBA-08) contained concentrations of 4,4'-DDE ranging from 2.5K µg/kg to 16J µg/kg. Endosulfan II was detected in one sample (SBA-04) at a concentration of 3.1K µg/kg. Five samples (SBA-01, SBA-03, SBA-04, SBA-05, SBA-07DUP, and SBA-08) contained concentrations of 4,4'-DDD ranging from 4.9K µg/kg to 20K µg/kg. Endosulfan sulfate was detected in one sample (SBA-07DUP) at a concentration of 1.54J µg/kg. One sample (SBA-05) contained 4,4'-DDT at a concentration of 11K µg/kg. Endrin aldehyde was detected in four samples at concentrations ranging from 3.8K µg/kg to

34k µg/kg. Aroclor 1254 was detected in one sample (SBA-04) at a concentration of 1600 µg/kg. Aroclor 1260 was detected in five samples (SBA-01, SBA-03, SBA-06, SBA-07, and SBA-08) ranging from 49.5 µg/kg to 1,800 µg/kg.

Two subsurface soil samples were collected in Round 3 and numbered sequentially following the numbering of the subsurface soil samples from Round 2. Soil samples were numbered SBA-10 and SBA-11. Table 5-5 provides a complete summary of the samples and the analyses requested.

One sample (SBA-11) from Round 3 subsurface soil samples contained carbon disulfide, an organic compound, at a concentration of 4J µg/kg, as depicted in Table 5-6.

Semivolatile organic compounds were present in both subsurface soil samples collected in Round 3 sampling efforts. Table 5-7 provides a complete listing of compounds detected and the corresponding concentrations. Both samples (SBA-10 and SBA-11) contained the following semivolatile organic compounds at the following respective concentrations: acenaphthene, 78J µg/kg and 100 µg/kg; chrysene, 53J µg/kg and 26J µg/kg; fluoranthene, 150J µg/kg and 34J µg/kg; 2-methylnaphthalene, 620 µg/kg and 40J µg/kg; phenanthrene, 190J µg/kg and 37J µg/kg; and pyrene, 180J µg/kg and 31J µg/kg. One sample (SBA-10) contained the following compounds at the following concentrations: benzo(a)anthracene, 45J µg/kg; benzo(b)fluoranthene, 41J µg/kg; and butyl benzyl phthalate, 25J µg/kg. One sample (SBA-11) contained bis(2-ethylhexyl) phthalate, 220J µg/kg; dibenzofuran, 30J µg/kg; diethyl phthalate, 73J µg/kg; and fluorene, 35J µg/kg.

Pesticide/PCB compounds were also detected in both subsurface soil samples collected in Round 3 sampling efforts. Table 5-8 provides a complete listing of compounds detected and the corresponding concentrations. Both samples (SBA-10 and SBA-11) contained the following compounds at the respective concentrations: endosulfan I, 2.3L µg/kg and 0.84J µg/kg; 4,4'-DDE, 8.4L µg/kg and 2.3J µg/kg; 4,4'-DDD, 5.8L µg/kg and 0.88J µg/kg; and alpha-chlordane, 2.6L µg/kg and 1.0J µg/kg. One sample (SBA-10) contained Aroclor-1254 at 92L µg/kg and endrin at 2.7J µg/kg.

TABLE 5-1
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SBA-01	X	X	X				X	X	X				MS/MSD
SBA-02	X	X	X				X	X	X				
SBA-03	X	X	X				X	X	X				
SBA-04	X	X	X				X	X	X				
SBA-05	X	X	X				X	X	X				
SBA-06	X	X	X				X	X	X				
SBA-07	X	X	X				X	X	X				
SBA-08	X	X	X				X	X	X				
SBA-09	X	X	X				X	X	X				DUP OF SBA-07

TABLE 5-2
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBA-01 5/27/92 ug/kg	SBA-02 5/27/92 ug/kg	SBA-03 5/28/92 ug/kg	SBA-04 5/28/92 ug/kg
Methylene chloride	170000 U	15 UJ	25000 U	5700 U
Acetone	170000 U	15 U	25000 U	5700 U
Carbon disulfide	170000 U	15 UJ	25000 U	5700 U
1,1-dichloroethene	170000 U	15 UJ	25000 U	5700 U
1,2-dichloroethene	170000 U	15 UJ	25000 U	5700 U
2-butanone	170000 U	15 UJ	25000 U	5700 U
1,1,1-trichloroethane	170000 U	15 UJ	25000 U	5700 U
Toluene	3000000	15 UJ	35000	19000
Ethylbenzene	45000 J	15 UJ	25000 U	3500 J
Xylenes(total)	340000	15 UJ	20000 J	38000

TABLE 5-2
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBA-05 5/28/92 ug/kg	SBA-06 5/28/92 ug/kg	SBA-07DUP 5/28/92 ug/kg	SBA-08 5/28/92 ug/kg
Methylene chloride	16 U	41 U	4 J	27000 U
Acetone	16 U	490 J	16 U	27000 U
Carbon disulfide	16 U	13 J	22	27000 U
1,1-dichloroethene	16 U	41 U	17	27000 U
1,2-dichloroethene	16 U	41 U	384 J	27000 U
2-butanone	16 U	41 U	16 U	17000 J
1,1,1-trichloroethane	16 U	63	16 U	27000 U
Toluene	16 U	15 J	1310	27000 U
Ethylbenzene	16 U	21 J	16 U	27000 U
Xylenes(total)	16 U	130	30	27000 U

TABLE 5-3
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBA-01 5/27/92 ug/kg	SBA-02 5/27/92 ug/kg	SBA-03 5/28/92 ug/kg	SBA-04 5/28/92 ug/kg	SBA-05 5/28/92 ug/kg	SBA-06 5/28/92 ug/kg	SBA-07 DUP 5/28/92 ug/kg	SBA-08 5/28/92 ug/kg
Acenaphthene	5600 J	510 U	6700 U	4600 U	530 U	490 J	53.5 J	1000 U
Benzo(a)anthracene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	165 J	1000 U
Benzo(a)pyrene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	165 J	1000 U
Benzo(b)fluoranthene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	172.5 J	1000 U
Benzo(g,h,i)perylene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	149.5 J	1000 U
Benzo(k)fluoranthene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	155.5 J	1000 U
Bis(2-ethylhexyl)phthalate	6800 U	510 U	13000	4600 U	530 U	17000	95.5 J	760 K
Butylbenzylphthalate								
Chrysene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	166 J	1000 U
Dibenzofuran	1700 J	510 U	6700 U	4600 U	530 U	5500 U	43 J	1000 U
Diethylphthalate	6800 U	510 U	6700 U	4600 U	530 U	5500 U	195 J	95 K
Dimethylphenol,2,4-	6700 J	510 U	41000	4600 U	530 U	5500 U	1100	530 K
Fluoranthene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	176.5 J	1000 U
Fluorene	1300 J	510 U	6700 U	4600 U	530 U	5500 U	35 J	70 K
Indeno(1,2,3-cd)pyrene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	151 J	1000 U
Isophorone	6800 U	510 U	6700 U	4600 U	530 U	5500 U	540 U	680 K
Methylnaphthalene,2-	21000	510 U	1900 J	2000 J	530 U	1300 J	305 J	1100 K
Methylphenol,2-	6800 U	510 U	6400 J	4400 J	530 U	5500 U	151 J	1000 U
Methylphenol,4-	6800 U	510 U	5500 J	4600 U	530 U	5500 U	161 J	1000 U
Naphthalene	32000	34 J	8200	20000	530 U	1800 J	630	3400 K
Phenanthrene	6800 U	510 U	6700 U	4600 U	530 U	370 J	48 J	110 K
Pyrene	6800 U	510 U	6700 U	4600 U	530 U	5500 U	49.5 J	1000 U

TABLE 5-4
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
PESTICIDE/PCB, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBA-01 5/27/92 ug/kg	SBA-02 5/27/92 ug/kg	SBA-03 5/28/92 ug/kg	SBA-04 5/28/92 ug/kg	SBA-05 5/29/92 ug/kg	SBA-06 5/28/92 ug/kg	SBA-07DUP 5/28/92 ug/kg	SBA-08 5/28/92 ug/kg
BHC,delta-	31 U	10 U	13 U	9.1 U	2.6 U	25 U	2.65 U	1.4 K
Heptachlor epoxide	31 U	10 U	13 U	9.1 U	2.6 U	25 U	2.65 U	2.7 K
Endosulfan I	31 U	10 U	13 U	9.1 U	2.6 U	15 K	2.65 U	2.3 K
Dieldrin	24 K	3 K	66 K	89 K	5.3 U	40 K	1.09 K	5.6 K
DDE,4,4'-	61 U	21 U	16 J	18 U	5.3 U	9.5 K	3.2 K	2.5 K
Endosulfan II	61 U	21 U	27 U	3.1 K	5.3 U	49 U	5.3 U	7.1 U
DDD,4,4'-	20 K	21 U	6.4 J	4.9 K	10	49 U	7.7 JK	16 K
Endosulfan sulfate	61 U	21 U	27 U	18 U	5.3 U	49 U	1.54 J	7.1 U
DDT,4,4'-	61 U	21 U	27 U	18 U	11 K	49 U	5.3 U	7.1 U
Endrin aldehyde	21 K	21 U	25 J	18 U	5.3 U	34 K	5.3 U	3.8 K
Aroclor-1254	610 U	210 U	270 U	1600	53 U	490 U	53 U	71 U
Aroclor-1260	1200	210 U	1200	180 U	53 U	1800	49.5	190

TABLE 5-5
ROUND 3
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SBA-10	X	X	X				X	X	X				
SBA-11	X	X	X				X	X	X				(1)

Note: (1) No duplicate obtained due to limited volume. Please note MS/MSD was not obtained due to limited volume.

TABLE 5-6
ROUND 3
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBA-10 12/14/92 ug/kg	SBA-11 12/14/92 ug/kg
Methylene chloride	14 U	12 U
Acetone	14 U	12 U
Carbon disulfide	14 U	4 J
1,1-dichloroethene	14 U	12 U
1,2-dichloroethene	14 U	12 U
2-butanone	14 U	12 U
1,1,1-trichloroethane	14 U	12 U
Toluene	14 U	12 U
Ethylbenzene	14 U	12 U
Xylenes(total)	14 U	12 U

TABLE 5-7
ROUND 3
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBA-10 12/15/92 ug/kg	SBA-11 12/15/92 ug/kg
Acenaphthene	78 J	100 J
Benzo(a)anthracene	45 J	460 U
Benzo(a)pyrene	430 U	460 U
Benzo(b)fluoranthene	41 J	460 U
Benzo(g,h,i)perylene	430 U	460 UJ
Benzo(k)fluoranthene	430 U	460 U
Bis(2-ethylhexyl)phthalate	430 U	220 J
Butylbenzylphthalate	25 J	460 U
Chrysene	53 J	26 J
Dibenzofuran	430 U	30 J
Diethylphthalate	430 U	73 J
Dimethylphenol,2,4-	430 U	460 U
Fluoranthene	150 J	34 J
Fluorene	430 U	35 J
Indeno(1,2,3-cd)pyrene	430 U	460 UJ
Isophorone	430 U	460 U
Methylnaphthalene,2-	620	40 J
Methylphenol,2-	430 U	460 U
Methylphenol,4-	430 U	460 U
Naphthalene	430 U	460 U
Phenanthrene	190 J	37 J
Pyrene	180 J	31 J

TABLE 5-8
ROUND 3
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
PESTICIDE/PCB, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBA-10 12/15/92 ug/kg	SBA-11 12/15/92 ug/kg
BHC,delta-	2.2 UL	2.3 U
Heptachlor epoxide	2.2 UL	2.3 U
Endosulfan I	2.3 L	0.84 J
Dieldrin	4.3 UL	4.6 U
DDE,4,4'-	8.4 L	2.3 J
Endosulfan II	4.3 UL	4.6 U
DDD,4,4'-	5.8 L	0.88 J
Endosulfan sulfate	4.3 UL	4.6 U
DDT,4,4'-	4.3 UL	4.6 U
Endrin aldehyde	4.3 UL	4.6 U
Aroclor-1254	92 L	46 U
Aroclor-1260	43 UL	46 U
Endrin	2.7 J	4.6 U
Chlordane,alpha-	2.6 L	1.0 J

5.1.2 Surface Soil Sample Results

A total of five surface soil samples were collected in and around the Camp Allen Landfill during Round 3 sampling activities. Table 5-9 provides a complete summary of samples collected and analyses requested. Surficial soil samples were numbered sequentially from SSA-01 through SSA-05. Volatile organic compounds were not detected in any of the surficial soils, as depicted in Table 5-10.

Semivolatile organic compounds were identified in all five soil samples collected. Table 5-11 provides a complete list of compounds detected and the corresponding concentrations. Phenanthrene was detected in two samples (SSA-02 and SSA-04) at 25J µg/kg and 36J µg/kg, respectively. Fluoranthene and pyrene were detected in all five samples (SSA-01, SSA-02, SSA-03, SSA-04, and SSA-05) at concentrations ranging from 23J µg/kg to 96J µg/kg and 29J µg/kg to 89J µg/kg, respectively. Benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene were detected in four samples (SSA-02, SSA-03, SSA-04, and SSA-05) at concentrations ranging from 27J µg/kg to 69J µg/kg; 20J µg/kg to 76J µg/kg; 27J µg/kg to 110J µg/kg; and 19J µg/kg to 48J µg/kg, respectively. Benzo(k)fluoranthene was detected in two samples (SSA-03 and SSA-04) at concentrations of 37J µg/kg and 51J µg/kg, respectively. Indeno(1,2,3-cd)pyrene was detected in one sample (SSA-04) at a concentration of 25J µg/kg.

Pesticide/PCB compounds were also identified in all five surface soil samples. Table 5-12 provides a complete list of compounds detected and the corresponding concentrations. Aldrin was detected in one sample (SSA-02) at a concentration of 9.1 µg/kg. Heptachlor epoxide and dieldrin were detected in two samples (SSA-01 and SSA04) at concentrations of 0.69J µg/kg and 2.4J µg/kg and 1.1J µg/kg and 27K µg/kg, respectively. One sample (SSA-01) contained endosulfan I at a concentration of 0.61J µg/kg. Five samples (SSA01, SSA-02, SSA-03, SSA-04, and SSA-05) contained 4,4'-DDE and alpha-chlordane at concentrations ranging from 0.5J µg/kg to 14 µg/kg and 0.46J µg/kg to 3.1K µg/kg, respectively. Three samples (SSA-01, SSA-02, and SSA-04) contained 4,4'-DDD at concentrations ranging from 3.1K µg/kg to 6.2L µg/kg. Two samples (SSA-01 and SSA-02) contained 4,4'-DDT at concentrations of 1.7J µg/kg and 3.9J µg/kg, respectively. Two samples (SSA-03 and SSA-04) also contained gamma-chlordane at concentrations of 1.4J µg/kg and 3.8K µg/kg, respectively. Four samples (SSA-02, SSA-03, SSA-04, and SSA-05) contained concentrations of Aroclor-1260 at concentrations ranging from 13J µg/kg to 420L µg/kg.

Metals were identified in all five surface soil samples. Table 5-13 provides a complete list of compounds detected and the corresponding concentration ranges. The following compounds were detected in all five samples at the various concentration ranges: arsenic, 1.9K mg/kg to 70 mg/kg; barium, 38.2J mg/kg to 1,050J mg/kg; chromium, 8.9 mg/kg to 121 mg/kg; iron, 4,920 mg/kg to 20,800 mg/kg; lead, 13.2 mg/kg to 683 mg/kg; manganese, 39.5 mg/kg to 128 mg/kg; and vanadium, 15.2 mg/kg to 78.7 mg/kg. Three samples (SSA-02, SSA-03, and SSA-04) contained the following compounds at the following concentration ranges: cadmium, 22.2 mg/kg to 88.9 mg/kg; copper, 104 mg/kg to 477 mg/kg; mercury, 0.29 mg/kg to 0.77 mg/kg; thallium, 0.52 mg/kg to 0.92 mg/kg; and zinc 204 mg/kg to 916 mg/kg. Two samples (SSA-02 and SSA-03) contained cobalt at concentrations of 7.7 mg/kg and 18.3 mg/kg, respectively. Nickel was detected in four samples (SSA-02, SSA-03, SSA-04, and SSA-05) at concentrations ranging from 7.1 mg/kg to 84.1 mg/kg.

TABLE 5-9
ROUND 3
SURFACE SOIL SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SSA-01	X	X	X	X			X	X	X	X			
SSA-02	X	X	X	X			X	X	X	X			
SSA-03	X	X	X	X			X	X	X	X			
SSA-04	X	X	X	X			X	X	X	X			
SSA-05	X	X	X	X			X	X	X	X			(1)

Note: (1) Duplicate sample obtained from Area B for surface soils.

TABLE 5-10
ROUND 3
SURFACE SOIL SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SSA-01 12/9/92 ug/kg	SSA-02 12/9/92 ug/kg	SSA-03 12/9/92 ug/kg	SSA-04 12/9/92 ug/kg	SSA-05 12/9/92 ug/kg

NO HITS

TABLE 5-11
ROUND 3
SURFACE SOIL SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample No. Date Collected Units	SSA-01 12/9/92 ug/kg	SSA-02 12/9/92 ug/kg	SSA-03 12/9/92 ug/kg	SSA-04 12/9/92 ug/kg	SSA-05 12/9/92 ug/kg
Phenanthrene	410 U	25 J	430 U	36 J	370 U
Fluoranthene	29 J	58 J	67 J	96 J	23 J
Pyrene	29 J	60 J	89 J	85 J	30 J
Benzo(a)anthracene	410 U	37 J	69 J	55 J	21 J
Chrysene	410 U	46 J	76 J	71 J	20 J
Benzo(b)fluoranthene	410 U	55 J	89 J	110 J	27 J
Benzo(k)fluoranthene	410 U	450 U	37 J	51 J	370 U
Benzo(a)pyrene	410 U	29 J	42 J	48 J	19 J
Indeno(1,2,3-cd)pyrene	410 UJ	450 UJ	430 UJ	25 J	370 UJ

TABLE 5-12
ROUND 3
SURFACE SOIL SAMPLE RESULTS
PESTICIDE/PCB, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample No. Date Collected Units	SSA-01 12/9/92 ug/kg	SSA-02 12/9/92 ug/kg	SSA-03 12/9/92 ug/kg	SSA-04 12/9/92 ug/kg	SSA-05 12/9/92 ug/kg
Aldrin	2.1 UL	9.1	2.2 UL	2.5 U	1.8 UL
Heptachlor epoxide	0.69 J	2.3 U	2.2 UL	2.4 J	1.8 UL
Endosulfan I	0.61 J	2.3 U	2.2 UL	2.5 U	1.8 UL
Dieldrin	1.1 J	4.5 U	4.3 UL	27 K	3.7 UL
4,4'-DDE	6.1 L	14	4.2 J	1 J	0.5 J
4,4'-DDD	6.2 L	4 J	4.3 UL	3.1 K	3.7 UL
4,4'-DDT	1.7 J	3.9 J	4.3 UL	5 U	3.7 UL
Alpha-Chlordane	0.55 J	0.56 J	2.2 L	3.1 K	0.46 J
Gamma-Chlordane	2.1 UL	2.3 U	1.4 J	3.8 K	1.8 UL
Aroclor-1260	41 UL	83	420 L	180 K	13 J

TABLE 5-13
ROUND 3
SURFACE SOIL SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample No. Date Collected Units	SSA-01 12/9/92 mg/kg	SSA-02 12/9/92 mg/kg	SSA-03 12/9/92 mg/kg	SSA-04 12/9/92 mg/kg	SSA-05 12/9/92 mg/kg
Aluminum	7080	7820	9880	6260	3640
Arsenic	1.9 K	25.9	70	41.1	5.2
Barium	38.2 J	394 J	1050 J	309 J	39.4 J
Cadmium	1 U	22.2	88.9	34.7	0.9 U
Calcium	896 J	2280 J	3990 J	18500 J	20200 J
Chromium	8.9	38.5	121	42.4	9.8
Cobalt	2.5 U	7.7	18.3	3 U	2.2 U
Copper	2 U	477	169	104	2 U
Iron	4920	20800	17900	10800	8080
Lead	19.6	246	683	234	13.2
Manganese	39.5	96.1	128	82.8	76.6
Mercury	0.12 U	0.29	0.44	0.77	0.12 U
Nickel	3 U	34.6	84.1	12.6	7.1
Thallium	0.24 U	0.52	0.82	0.92	0.22 U
Vanadium	17.6	52.4	78.7	42.6	15.2
Zinc	5 U	916	564	204	5 U

5.1.3 Sediment Sample Results

A total of 23 sediment samples were collected in Round 2 sampling activities. Each sediment sample, including duplicate samples, was numbered sequentially (SDA-01 through SDA-24). Please note that SDA-23 was not collected due to field modifications. Table 5-14 presents a complete summary of samples collected and the requested analyses. For the purpose of this study three samples (SDA-08, SDA-12(S), and SDA-12(D)) were evaluated with Area B sediment samples because of their proximity to the landfill. Samples have been denoted with an S (shallow) or a D (deep) signifying sample depth. Table 5-15 provides a complete list of compounds detected and the corresponding concentrations. Arsenic, chromium, and mercury were detected in all but two samples (SDA-11 and SDA-16D) at concentrations ranging from 5.1 mg/kg to 590 mg/kg, 38 mg/kg to 3000 mg/kg and 0.2 mg/kg to 3 mg/kg, respectively. Cadmium was detected in fourteen samples (SDA-01 through SDA-06, SDA-10D, SDA-13, SDA-14SDUP, SDA-15, and SDA-18S through SDA-20S) at concentrations ranging from 6 mg/kg to 180 mg/kg. Lead was detected in every sample at concentrations ranging from 13 mg/kg to 1,000 mg/kg. Seven samples (SDA-01, SDA-03, SDA-09, SDA-14SDUP, and SDA-18S through SDA-19S) contained silver at concentrations ranging from 3.1 mg/kg to 110 mg/kg. Vanadium was detected in all but four samples (SDA-11, SDA-14DDUP, SDA-16D, and SDA-17) at concentrations ranging from 2 mg/kg to 190 mg/kg.

A total of five sediment samples were collected in Round 3 sampling activities. Each sediment sample was numbered sequentially (SDA-26 through SDA-30) following the sediment sample numbers from Round 2. Table 5-16 presents a complete summary of samples collected and the requested analyses.

Volatile organic compounds were detected in four sediment samples collected in Round 3 sampling efforts. Table 5-17 provides a complete list of compounds detected and the corresponding concentrations. Carbon disulfide was detected in one sample (SDA-26) at a concentration of 6J µg/kg. Three samples (SDA-26, SDA-28, and SDA-30DUP) contained 2-butanone at concentrations ranging from 16 µg/kg to 42.5 µg/kg. Chlorobenzene was detected in one sample at a concentration of 6J µg/kg.

Semivolatile organic compounds were detected in four of the five samples collected. Table 5-18 provides a complete list of compounds detected and the corresponding concentrations. One sample (SDA-27) contained the following compounds at the respective concentrations: acenaphthene, 45J µg/kg; anthracene, 71J µg/kg; and carbazole, 46J µg/kg. Four samples

(SDA-26, SDA-27, SDA-29, and SDA-30DUP) contained the following compounds at the respective concentration ranges: phenanthrene, 27J µg/kg to 300J µg/kg; fluoranthene, 64J µg/kg to 1,100J µg/kg; benzo(a)anthracene, 42J µg/kg to 500J µg/kg; chrysene, 38J µg/kg to 570J µg/kg; benzo(b)fluoranthene, 53J µg/kg to 670J µg/kg; benzo(a)pyrene, 36J µg/kg to 320J µg/kg; and pyrene, 63J µg/kg to 850J µg/kg. One sample (SDA-29) contained concentrations of the following compounds at the respective concentrations: butyl benzyl phthalate, 170J µg/kg and bis(2-ethylhexyl)phthalate, 4100 µg/kg. Benzo(k)fluoranthene was detected in three samples (SDA-27, SDA-29, and SDA-30DUP) at concentrations ranging from 48J µg/kg to 220J µg/kg. Two samples (SDA-27 and SDA-29) contained indeno(1,2,3-cd)pyrene at 74J µg/kg and 190J µg/kg and benzo(g,h,i)perylene at 54J µg/kg and 170J µg/kg, respectively.

Pesticide/PCB compounds were detected in five sediment samples collected in Round 3. Table 5-19 provides a complete list of compounds detected and the corresponding concentrations. Two samples (SDA-26 and SDA-27) contained the following compounds at the respective concentrations: alpha-BHC, 19L µg/kg and 62 µg/kg; beta-BHC, 17L µg/kg and 55 µg/kg; and delta-BHC, 10L µg/kg and 180 µg/kg. Gamma-BHC was detected in four samples (SDA-26, SDA-27, SDA-28, and SDA-30DUP) at concentrations ranging from 0.74J µg/kg to 130 µg/kg. Endosulfan I was detected in four samples (SDA-26, SDA-27, SDA-28, and SDA-29) at concentrations ranging from 1.2J µg/kg to 15 µg/kg. One sample (SDA-27) contained dieldrin and endrin aldehyde at concentrations of 14L µg/kg and 32 µg/kg, respectively. Five samples (SDA-26, SDA-27, SDA-28, SDA-29 and SDA-30DUP) contained the following compounds at the respective concentration ranges: 4,4'-DDE, 17.8J µg/kg to 110 µg/kg; 4,4'-DDD, 13 µg/kg to 120L µg/kg; 4,4'-DDT, 8.35 µg/kg to 73L µg/kg; alpha-chlordane, 1.695J to 64L µg/kg; and gamma-chlordane, 1.35J µg/kg to 69L µg/kg. Aroclor-1260 was detected in four samples (SDA-26, SDA-27, SDA-28, and SDA-30DUP) at concentrations ranging from 27J µg/kg to 1500 µg/kg.

TABLE 5-14
ROUND 2
SEDIMENT SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID (1)	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM (2)	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM (2)	COMMENTS
SDA-01						X						X	
SDA-02						X						X	
SDA-03						X						X	
SDA-04						X						X	
SDA-05						X						X	
SDA-06						X						X	
SDA-07						X						X	
SDA-08						X						X	MS/MSD
SDA-09						X						X	
SDA-10(S)						X						X	
SDA-10(D)						X						X	
SDA-11						X						X	
SDA-12(S)						X						X	
SDA-12(D)						X						X	
SDA-13						X						X	
SDA-14(S)						X						X	
SDA-14(D)						X						X	
SDA-15						X						X	

Notes:
(1) S- Shallow (0-6")
D- Deep (6-12")
(2) SM- Selected Metals

TABLE 5-14
ROUND 2
SEDIMENT SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID (1)	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM (2)	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM (2)	COMMENTS
SDA-16(S)						X						X	
SDA-16(D)						X						X	
SDA-17						X						X	
SDA-18(S)						X						X	
SDA-18(D)						X						X	
SDA-19						X						X	
SDA-20(S)						X						X	
SDA-20(D)													NOT COLLECTED
SDA-21(S)						X						X	DUP OF SDA-14(S)
SDA-22(D)						X						X	DUP OF SDA-14(D)
SDA-23(S)						X						X	DUP OF SDA-12(S)
SDA-24						X						X	

Notes:
(1) S- Shallow (0-6")
D- Deep (6-12")
(2) SM- Selected Metals

TABLE 5-15
ROUND 2
SEDIMENT SAMPLE RESULTS
SELECTED METALS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDA-01 5/11/92 mg/kg	SDA-02 5/11/92 mg/kg	SDA-03 5/03/92 mg/kg	SDA-04 5/04/92 mg/kg	SDA-05 5/04/92 mg/kg	SDA-06 5/12/92 mg/kg	SDA-07 5/12/92 mg/kg	SDA-09 5/12/92 mg/kg
Arsenic	100	170	29	32	53	9.1	16	590
Cadmium	72	32	19	6	8.1	11	3 U	3 U
Chromium	200	110	220	120	160	120	42	120
Lead	1000	270	99	96	130	31	130	130
Mercury	3	1.6	0.3	0.3	0.5	0.2	0.5	0.5
Silver	13	2 U	6.4	2 U	2 U	0.8 U	2 U	3.1
Vanadium	170	180	62	61	80	2	53	68

TABLE 5-15
ROUND 2
SEDIMENT SAMPLE RESULTS
SELECTED METALS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDA-10S 5/11/92 mg/kg	SDA-10D 5/11/92 mg/kg	SDA-11 5/11/92 mg/kg	SDA-13 5/04/92 mg/kg	SDA-14S DUP 5/04/92 mg/kg	SDA-14D DUP 5/04/92 mg/kg	SDA-15 5/04/92 mg/kg
Arsenic	31	42	2 U	24	88	71	31
Cadmium	3 U	17	0.9 U	6.3	111 J	2 U	6.2
Chromium	220	280	8 U	140	879.5	39.5	88
Lead	180	45	23	78	458.5	14	67
Mercury	0.4	0.8	0.2 U	0.2	0.3	1.1 J	0.2
Silver	2 U	3.6 U	0.9 U	2 U	27 J	2 U	2 U
Vanadium	74	190	2 U	53	50.5	2 U	2

TABLE 5-15
ROUND 2
SEDIMENT SAMPLE RESULTS
SELECTED METALS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDA-16S 5/11/92 mg/kg	SDA-16D 5/11/92 mg/kg	SDA-17 5/12/92 mg/kg	SDA-18S 5/03/92 mg/kg	SDA-18D 5/03/92 mg/kg	SDA-19S 5/03/92 mg/kg	SDA-20S 5/03/92 mg/kg	SDA-24 5/12/92 mg/kg
Arsenic	57	2 U	5.1	51	50	35	30	42
Cadmium	3 U	3 U	1 U	160	180	9.5	6.3	3 U
Chromium	43	8 U	38	3000	1700	170	110	61
Lead	130	13	63	570	540	120	91	170
Mercury	0.3	0.2 U	0.2	0.7	1	0.3	0.2	0.6
Silver	2 U	0.6 U	1 U	110	49	5	2 U	2 U
Vanadium	2	2 U	2 U	120	74	78	62	67

TABLE 5-16
ROUND 3
SEDIMENT SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T	MET. D	SM	VOA	SVOA	PEST/PCB	MET. T	MET. D	SM	COMMENTS
SDA-26	X	X	X				X	X	X				
SDA-27	X	X	X				X	X	X				
SDA-28	X	X	X				X	X	X				
SDA-29	X	X	X				X	X	X				MS/MSD
SDA-30	X	X	X				X	X	X				
SDA-31	X	X	X				X	X	X				DUP OF SDA-30

Note: SDA-25 not collected due to field modifications.

TABLE 5-17
ROUND 3
SEDIMENT SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDA-26 12/9/92 ug/kg	SDA-27 12/9/92 ug/kg	SDA-28 12/9/92 ug/kg	SDA-29 12/9/92 ug/kg	SDA-30DUP 12/9/92 ug/kg
Carbon disulfide	6 J	28 U	13 U	36 U	27.5 U
2-butanone	21	83	16	36 U	42.5
Chlorobenzene	20 U	6 J	13 U	36 U	27.5 U

TABLE 5-18
ROUND 3
SEDIMENT SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample No. Date Collected Units	SDA-26 12/9/92 ug/kg	SDA-27 12/9/92 ug/kg	SDA-28 12/9/92 ug/kg	SDA-29 12/9/92 ug/kg	SDA-30 DUP 12/9/92 ug/kg
Acenaphthene	560 U	45 J	410 U	2000 U	575 U
Phenanthrene	27 J	270 J	410 U	300 J	39.5 J
Anthracene	560 U	71 J	410 U	2000 U	575 U
Carbazole	560 U	46 J	410 U	2000 U	575 U
Fluoranthene	64 J	460 J	410 U	1100 J	160 J
Butylbenzylphthalate	560 U	900 U	410 U	170 J	575 U
Benzo(a)anthracene	42 J	220 J	410 U	500 J	81.5 J
Chrysene	38 J	200 J	410 U	570 J	107 J
Bis(2-ethylhexyl)phthalate	560 U	900 U	410 U	4100	575 U
Benzo(b)fluoranthene	53 J	230 J	410 U	670 J	95 J
Benzo(k)fluoranthene	560 U	100 J	410 U	220 J	48 J
Benzo(a)pyrene	36 J	170 J	410 U	320 J	61 J
Indeno(1,2,3-cd)pyrene	560 UJ	74 J	410 UJ	190 J	575 UJ
Benzo(g,h,i)perylene	560 UJ	54 J	410 UJ	170 J	575 UJ
Pyrene	63 J	320 J	410 U	850 J	138.5 J

TABLE 5-19
ROUND 3
SEDIMENT SAMPLE RESULTS
PESTICIDE/PCB AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample No. Date Collected Units	SDA-26 12/9/92 ug/kg	SDA-27 12/9/92 ug/kg	SDA-28 12/9/92 ug/kg	SDA-29 12/9/92 ug/kg	SDA-30DUP 12/9/92 ug/kg
Alpha-BHC	19 L	62	2 U	9.8 UL	3.35 U
Beta-BHC	17 L	55	2 U	9.8 UL	3.35 U
Delta-BHC	10 L	180	2 U	9.8 UL	3.35 U
Gamma-BHC	44 L	130	0.74 J	9.8 UL	2.305 J
Endosulfan I	2.3 L	15	1.2 J	3.2 J	3.35 U
Dieldrin	5.6 UL	14 L	4.1 U	20 UL	6.75 U
4,4'-DDE	95 L	110	36	84 L	17.8 J
4,4'-DDD	120 L	93	13	89 L	13.15 J
4,4'-DDT	73 L	14 L	9.5	20 L	8.35
Endrin aldehyde	5.6 UL	32	4.1 U	20 UL	6.75 U
Alpha-Chlordane	64 L	20	2.2	7.6 J	1.695 J
Gamma-Chlordane	69 L	13	2	4.8 J	1.35 J
Aroclor-1232	56 UL	93 UL	41 U	200 UL	67.5 U
Aroclor-1260	350 L	1500	52	200 UL	27 J

5.1.4 Surface Water Sample Results

Eleven surface water samples were collected in Round 2 sampling efforts. Each surface water sample was numbered sequentially from SWA-01 through SWA-08. In addition, SWA-11, SWA-12 and SWA-17 were collected. Table 5-20 provides a complete list of the samples and the requested analyses. It should be noted for the purpose of this study that SWA-08 and SWA-12 are not considered part of Area A because of their proximity to Area B. Therefore, only nine surface water samples have been evaluated as part of Area A.

Volatile organic compounds were detected in three of the surface water samples collected. Table 5-21 provides a complete list of compounds and the corresponding concentrations. Two samples (SWA-01 and SWA-02) contained the following compounds at the respective concentrations: 1,2-dichloroethene, 4J µg/L and 3J µg/L and trichloroethene, 3J µg/L and 2J µg/L. One sample (SWA-07) contained xylenes (total) at a concentration of 3J µg/L.

Semivolatile organic compounds were identified in four samples. Table 5-22 provides a complete list of compounds and the corresponding concentrations. Di-n-butyl phthalate was detected in three samples (SWA-01, SWA-02, and SWA-07) at concentrations ranging from 0.5J µg/L to 1J µg/L. Bis(2-ethylhexyl)phthalate was detected in four samples (SWA-01, SWA-02, SWA-06, and SWA-07) at concentrations ranging from 0.8J µg/L to 3J µg/L.

Pesticide/PCB compounds were detected in six samples. Table 5-23 provides a complete list of compounds detected and the corresponding concentrations. Alpha-BHC was detected in one sample (SWA-03DUP) at a concentration of 0.0155J µg/L. Delta-BHC was detected in one sample (SWA-02) at a concentration of 0.025J µg/L. One sample (SWA-01) contained the following compounds at the respective concentrations: dieldrin, 0.027J µg/L; 4,4'-DDE, 0.069J µg/L; endrin, 0.07J µg/L; endrin aldehyde, 0.047J µg/L; alpha-chlordane, 0.015J µg/L; gamma-chlordane, 0.024J µg/L and Aroclor-1254, 0.44J µg/L. Five samples (SWA-01, SWA-03DUP, SWA-04, SWA-11, and SWA-17) contained 4,4'-DDD at concentrations ranging from 0.008J µg/L to 0.26L µg/L. Heptachlor epoxide was detected in two samples (SWA-11 and SWA-17) at concentrations of 0.006J µg/L and 0.003J µg/L, respectively.

Total metals were detected in all nine samples. Table 5-24 provides a complete list of compounds detected and the corresponding concentrations. Arsenic was detected in two samples (SWA-01 and SWA-02) at concentrations of 64.2 µg/L and 19.5 µg/L, respectively. Barium was detected in all but two samples (SWA-03DUP and SWA-04) at concentrations ranging from 39.1 µg/L to 409 µg/L. Chromium was detected in two samples (SWA-01 and SWA-04) at concentrations of 104 µg/L and 12 µg/L, respectively. One sample (SWA-01) contained the following compounds at the following concentrations: cobalt, 13.2 µg/L; nickel, 57 µg/L; silver, 12 µg/L; and vanadium, 103 µg/L. Copper was detected in three samples (SWA-01, SWA-11, and SWA-17) at concentrations ranging from 5.1 µg/L to 446 µg/L. Iron and manganese were detected in all of the surface water samples at concentrations ranging from 1,230 µg/L to 78,300 µg/L and 99.6J µg/L to 697 µg/L, respectively. Lead was detected in three samples (SWA-01, SWA-02, and SWA-06) at concentrations ranging from 1L µg/L to 800 µg/L. Mercury was detected in three samples (SWA-01, SWA-03DUP, and SWA-17) at concentrations ranging from 0.205 µg/L to 3.9 µg/L. Zinc was detected in four samples (SWA-01, SWA-02, SWA-06, and SWA-07) at concentrations ranging from 20.3J µg/L to 1,860J µg/L.

Dissolved metals were detected in all nine samples. Table 5-25 provides a complete list of compounds detected and the corresponding concentrations. Arsenic was detected in two samples (SWA-01F and SWA-02F) at concentrations of 6.5 µg/L and 11.8 µg/L, respectively. Barium was detected in all but two samples (SWA-03FDUP and SWA-04F) at concentrations ranging from 27.8 µg/L to 97.4 µg/L. Cobalt was detected in two samples (SWA-03FDUP and SWA-04F) at concentrations of 6.45 µg/L and 8.9 µg/L, respectively. Copper and thallium were detected in one sample (SWA-17F) at concentrations of 3.7 µg/L and 5 µg/L, respectively. Iron was detected in six samples (SWA-01F, SWA-02F, SWA-03FDUP, SWA-06F, SWA-11F, and SWA-17F) at concentrations ranging from 146 µg/L to 2,500 µg/L. Lead and silver were detected in one sample (SWA-01) at concentrations of 2.7 µg/L and 2.9 µg/L, respectively. Manganese was detected in all of the samples at concentrations ranging from 88.7J µg/L to 246 µg/L. Zinc was detected in four samples (SWA-01F, SWA-02F, SWA-06F, and SWA-07F) at concentrations ranging from 12.9J µg/L to 55.7J µg/L.

TABLE 5-20
ROUND 2
SURFACE WATER SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID (1)	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SWA-01	X	X	X	X	X		X	X	X	X	X		
SWA-02	X	X	X	X	X		X	X	X	X	X		
SWA-03	X	X	X	X	X		X	X	X	X	X		MS/MSD
SWA-04	X	X	X	X	X		X	X	X	X	X		
SWA-05	X	X	X	X	X		X	X	X	X	X		
SWA-06	X	X	X	X	X		X	X	X	X	X		
SWA-07	X	X	X	X	X		X	X	X	X	X		
SWA-08	X	X	X	X	X		X	X	X	X	X		
SWA-09	X	X	X	X	X		X	X	X	X	X		DUP OF SWA-03
SWA-11	X	X	X	X	X		X	X	X	X	X		
SWA-12	X	X	X	X	X		X	X	X	X	X		
SWA-17	X	X	X	X	X		X	X	X	X	X		

Note: (1) SWA-10, 13, 14, 15, and 16 not collected due to field modifications.

TABLE 5-21
ROUND 2
SURFACE WATER SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-01 5/11/92 ug/L	SWA-02 5/11/92 ug/L	SWA-03DUP 5/03/92 ug/L	SWA-04 5/04/92 ug/L	SWA-05 5/04/92 ug/L
1,2-dichloroethene	4 J	3 J	10 U	10 U	10 U
Trichloroethene	3 J	2 J	10 U	10 U	10 U
Xylenes(total)	10 U	10 U	10 U	10 U	10 U

TABLE 5-21
ROUND 2
SURFACE WATER SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-06 5/12/92 ug/L	SWA-07 5/12/92 ug/L	SWA-11 6/2/92 ug/L	SWA-17 6/2/92 ug/L
1,2-dichloroethene	10 U	10 U	10 U	10 U
Trichloroethene	10 U	10 U	10 U	10 U
Xylenes(total)	10 U	3 J	10 U	10 U

TABLE 5-22
ROUND 2
SURFACE WATER SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-01 5/11/92 ug/L	SWA-02 5/11/92 ug/L	SWA-03 DUP 5/03/92 ug/L	SWA-04 5/04/92 ug/L	SWA-05 5/04/92 ug/L
Butylphthalate,di-n-	0.7 J	0.5 J	5 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	3 J	3 J	10 U	10 U	10 U

TABLE 5-22
ROUND 2
SURFACE WATER SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-06 5/12/92 ug/L	SWA-07 5/12/92 ug/L	SWA-11 6/2/92 ug/L	SWA-17 6/2/92 ug/L
Butylphthalate,di-n-	10 U	1 J	10 U	10 U
Bis(2-ethylhexyl)phthalate	0.8 J	2 J	10 U	10 U

TABLE 5-23
ROUND 2
SURFACE WATER SAMPLE RESULTS
PESTICIDE/PCB, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-01 5/11/92 ug/L	SWA-02 5/11/92 ug/L	SWA-03DUP 5/03/92 ug/L	SWA-04 5/04/92 ug/L	SWA-05 5/04/92 ug/L	SWA-06 5/12/92 ug/L	SWA-07 5/12/92 ug/L
BHC,alpha-	0.05 UL	0.05 UL	0.0155 J	0.05 U	0.05 UL	0.05 UL	0.05 UL
BHC,delta-	0.05 UL	0.025 J	0.05 UL	0.05 U	0.05 UL	0.05 UL	0.05 UL
Dieldrin	0.027 J	0.1 UL	0.1 UL	0.1 U	0.1 UL	0.1 UL	0.1 UL
DDE,4,4'-	0.069 J	0.1 UL	0.1 UL	0.1 U	0.1 UL	0.1 UL	0.1 UL
Endrin	0.07 J	0.1 UL	0.1 UL	0.1 U	0.1 UL	0.1 UL	0.1 UL
DDD,4,4'-	0.26 L	0.1 UL	0.098 J	0.012 J	0.1 UL	0.1 UL	0.1 UL
Endrin aldehyde	0.047 J	0.1 UL	0.1 UL	0.1 U	0.1 UL	0.1 UL	0.1 UL
Chlordane,alpha-	0.015 J	0.05 UL	0.05 UL	0.05 U	0.05 UL	0.05 UL	0.05 UL
Chlordane,gamma-	0.024 J	0.05 UL	0.05 UL	0.05 U	0.05 UL	0.05 UL	0.05 UL
Aroclor-1254	0.44 J	1 UL	1 UL	1 U	1 UL	1 UL	1 UL

TABLE 5-23
ROUND 2
SURFACE WATER SAMPLE RESULTS
PESTICIDE/PCB, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-11 6/02/92 ug/L	SWA-17 6/02/92 ug/L
Heptachlor epoxide	0.006 J	0.003 J
DDD,4,4'-	0.008 J	0.009 J

TABLE 5-24
ROUND 2
SURFACE WATER SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-01 5/11/92 ug/L	SWA-02 5/11/92 ug/L	SWA-03DUP 5/03/92 ug/L	SWA-04 5/04/92 ug/L	SWA-05 5/04/92 ug/L
Aluminum	20300 J	18 U	1010 J	18 U	726 J
Antimony	18 U	18 U	18 U	18 U	18 U
Arsenic	64.2	19.5	2 U	2 U	2 U
Barium	409	117	3 U	3 U	43.5
Beryllium	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U
Calcium	119000	77400	114500	152000	98600 J
Chromium	104	8 U	8 U	12	8 U
Cobalt	13.2	8 U	8 U	8 U	8 U
Copper	446	2 U	2 U	2 U	2 U
Iron	78300	7890	2455 J	1230 J	2700 J
Lead	800	1.2	1 U	5 UL	1 U
Magnesium	18200	23600	193000	375000	152000
Manganese	697	267	200 J	99.6 J	213 J
Mercury	3.9	0.2 U	0.205	0.2 U	0.2 U
Nickel	57	11 U	11 U	11 U	11 U
Potassium	10400	15700	72300	144000	54500
Selenium	10 UL	2 UL	0 R	0 R	0 R
Silver	12	2 U	2 U	2 U	2 U
Sodium	25700	67600	1770000 J	3880000 J	1310000 J
Thallium	5 U	5 U	5 UL	R	5 UL
Vanadium	103	4 U	4 U	4 U	4 U
Zinc	1860 J	20.3 J	5 U	5 U	5 U

TABLE 5-24
ROUND 2
SURFACE WATER SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-06 5/12/92 ug/L	SWA-07 5/12/92 ug/L	SWA-11 6/02/92 ug/L	SWA-17 6/02/92 ug/L
Aluminum	429 J	18 U	18 U	746
Antimony	18 U	18 U	18 U	18 U
Arsenic	4 UL	2 UL	4 U	4 U
Barium	43.3	43.2	39.1	41.3
Beryllium	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U
Calcium	123000	80000	57400	72200
Chromium	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U
Copper	2 U	2 U	5.1	6.4
Iron	1600	2370	4620	4850
Lead	1 L	1 U	1 U	1 U
Magnesium	233000	74900	85800	139000
Manganese	196	221	271	169
Mercury	0.2 U	0.2 U	0.2 U	0.27
Nickel	11 U	11 U	11 U	11 U
Potassium	73600	25500	29100	48200
Selenium	10 UL	10 UL	2 UL	2 U
Silver	2 U	2 U	2 U	2 U
Sodium	2180000	573000	654000	1220000
Thallium	5 UL	1 UL	1 UL	5 U
Vanadium	4 U	4 U	4 U	4 U
Zinc	61 J	29.9 J	5 U	5 U

TABLE 5-25
ROUND 2
SURFACE WATER SAMPLE RESULTS
METALS, DISSOLVED, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-01F 5/11/92 ug/L	SWA-02F 5/11/92 ug/L	SWA-03FDUP 5/03/92 ug/L	SWA-04F 5/04/92 ug/L	SWA-05F 5/04/92 ug/L
Aluminum	18 U	18 U	18 U	18 U	18 U
Antimony	18 U	18 U	18 U	18 U	18 U
Arsenic	6.5	11.8	2 U	2 U	2 U
Barium	95.7	97.4	3 U	3 U	39.6
Beryllium	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U
Calcium	97800	70700	113500	147000	89100 J
Chromium	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	6.45	8.9	8 U
Copper	2 U	2 U	2 U	2 U	2 U
Iron	817	2500	282.5	10 U	10 U
Lead	2.7	1 U	1 U	1 UL	1 UL
Magnesium	13400	21800	197000	362000	141000
Manganese	219	240	181.5 J	88.7 J	192 J
Mercury	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Nickel	11 U	11 U	11 U	11 U	11 U
Potassium	6300	14500	73350	141000	50600
Selenium	10 UL	2 UL		R	R
Silver	2 U	2 U	2 U	2 U	2 U
Sodium	23600	62300	1830000 J	3690000 J	1260000 J
Thallium	1 U	1 U	5 UL	R	5 UL
Vanadium	4 U	4 U	4 U	4 U	4 U
Zinc	19 J	15.6 J	5 U	5 U	5 U

TABLE 5-25
ROUND 2
SURFACE WATER SAMPLE RESULTS
METALS, DISSOLVED, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWA-06F 5/12/92 ug/L	SWA-07F 5/12/92 ug/L	SWA-11F 6/02/92 ug/L	SWA-17F 6/02/92 ug/L
Aluminum	18 U	18 U	18 U	18 U
Antimony	18 U	18 U	18 U	18 U
Arsenic	4 UL	2 UL	4 U	4 U
Barium	40.9	37.4	34.1	27.8
Beryllium	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U
Calcium	122000	72700	54100	65100
Chromium	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U
Copper	2 U	2 U	2 U	3.7
Iron	146	10 U	255	410
Lead	1 UL	1 U	1 UL	1 UL
Magnesium	231000	67900	80900	126000
Manganese	191	200	246	147
Mercury	0.2 U	0.2 U	0.2 U	0.2 U
Nickel	11 U	11 U	11 U	11 U
Potassium	72500	22900	27400	43200
Selenium	10 UL	10 UL	2 UL	2 UL
Silver	2.9	2 U	2 U	2 U
Sodium	2080000	479000	546000	1090000
Thallium	5 UL	1 UL	1 UL	5
Vanadium	4 U	4 U	4 U	4 U
Zinc	55.7 J	12.9 J	5 U	5 U

5.1.5 Groundwater Sample Results

During Round 2 detection limits for volatile organic compounds were 10 µg/L in accordance with CLP protocol. However, the detection limit was higher than the MCLs for some of the compounds to be analyzed. Therefore, to provide lower detection limits, modifications were incorporated into the original CLP method for the Round 3 sampling event. The modification involved increasing the purge volume from 5 ml to 25 ml. The detection limit achieved using this modification was then five times lower than the original CLP method except for the detection limit of some of the common laboratory contaminants. This lower detection limit permitted all compounds to be evaluated against the Federal MCLs.

Due to the variation in detection limits, Round 2 and Round 3 volatile organic compounds have been evaluated separately for the purposes of this study. All other analyses have been evaluated collectively for both rounds. In addition, evaluations are based on the shallow and deep aquifer systems for all analyses.

A total of 32 (17 shallow and 15 deep) groundwater samples were collected in Round 2 sampling activities. Groundwater samples were numbered sequentially from GWA-201 through GWA-232. Table 5-26 presents a complete list of samples and the requested analyses.

A total of 18 (1 shallow and 17 deep) groundwater samples were collected in Round 3 sampling activities. Groundwater samples were numbered sequentially from GWA-301 through GWA-318. Table 5-27 presents a complete list of samples and the requested analyses.

Volatile organic compounds were detected in five shallow groundwater samples during Round 2 sampling activities. Table 5-28 provides a complete list of compounds detected and the corresponding concentrations. Vinyl chloride was detected in three samples (GWA-210, GWA-212, and GWA-215) ranging from 2J µg/L to 3,300 µg/L. Methylene chloride was detected in one sample (GWA-231) at a concentration of 57J µg/L. Acetone was detected in two samples (GWA-210 and GWA-231) at concentrations of 2,600 µg/L and 160 µg/L, respectively. Four samples (GWA-210, GWA-215, GWA-225, and GWA-231) had concentrations of 1,2-dichloroethene ranging from 3J µg/L to 6,100 µg/L. One sample (GWA-225) contained 1,2-dichloroethane at a concentration of 3J µg/L. One sample (GWA-210) contained 2-butanone and benzene at a concentration of 4,300 µg/L and 310J µg/L, respectively. Two samples (GWA-215 and GWA-231) contained trichloroethene at concentrations of 18 µg/L and 1,800 µg/L, respectively. Two samples (GWA-210 and GWA-231) contained

4-methyl-2-pentanone, toluene, and xylenes (total) at concentrations of 16,000 µg/L and 220 µg/L; 5,400 µg/L and 1,200 µg/L; and 250J µg/L and 130J µg/L, respectively. One sample (GWA-215) contained tetrachloroethene at a concentration of 4J µg/L.

Volatile organic compounds were detected in one shallow groundwater sample collected in Round 3, as depicted in Table 5-29. One sample (GWA-312) contained tetrachloroethene and xylenes (total) at concentrations of 620 µg/L and 80 µg/L, respectively.

Volatile organic compounds were identified in eight deep groundwater samples collected in Round 2 sampling activities. Table 5-30 provides a complete list of compounds detected and the corresponding concentrations. Vinyl chloride and trichloroethene were detected in five samples (GWA-206, GWA-213, GWA-226DUP, GWA-230, and GWA-219) at concentrations ranging from 11 µg/L to 100 µg/L and 2.5J µg/L to 100 µg/L, respectively. Seven samples (GWA-206, GWA-209, GWA-213, GWA-226DUP, GWA-230, GWA-219, and GWA-228) contained 1,2-dichloroethene at concentrations ranging from 2J µg/L to 540 µg/L. Two samples (GWA-213 and GWA-230) contained 1,2-dichloroethane at concentrations of 38J µg/L and 15 µg/L, respectively. Benzene was detected in one sample (GWA-223) at a concentration of 3J µg/L.

Volatile organic compounds were identified in 13 deep groundwater samples collected in Round 3 sampling activities. Table 5-31 provides a complete list of compounds detected and the corresponding concentration. Five samples (GWA-304, GWA-307, GWA-305DUP, GWA-311, and GWA-315) contained vinyl chloride at concentrations ranging from 1J µg/L to 14 µg/L. Eleven samples (GWA-307, GWA-309, GWA-305DUP, GWA-311, GWA-315, GWA-313, GWA-318, GWA-317DUP, GWA-301, GWA-303, and GWA-304) contained 1,2-dichloroethene at concentrations ranging from 1J µg/L to 290 µg/L. Chloroform was detected in two samples (GWA-317DUP and GWA-318) at concentrations of 1J µg/L and 8 µg/L, respectively. Two samples (GWA-301 and GWA-307) contained 1,2-dichloroethane at concentrations of 23 µg/L and 10 µg/L, respectively. One sample (GWA-318) contained 2-butanone and tetrachloroethene at concentrations of 2J µg/L and 14 µg/L, respectively. Six samples (GWA-318, GWA-317DUP, GWA-05DUP, GWA-307, GWA-311, and GWA-315) contained trichloroethene at concentrations ranging from 6.5 µg/L to 16 µg/L. Toluene was detected in one sample (GWA-306) at a concentration of 1J µg/L. One sample (GWA-318) contained xylenes (total) at a concentration of 1J µg/L. Benzene was detected in one sample (GWA-310DUP) at a concentration of 1J µg/L.

Semivolatile organic compounds were identified in 13 shallow groundwater samples collected in Rounds 2 and 3. Table 5-32 provides a complete list of compounds detected and the corresponding concentrations. Acenaphthene was detected in one sample (GWA-217) at a concentration of 1J µg/L. Four samples (GWA-212, GWA-217, GWA-220, and GWA-225) contained bis(2-ethylhexyl)phthalate at concentrations ranging from 0.5J µg/L to 13 µg/L. Three samples (GWA-207, GWA-211, and GWA-232DUP) contained di-n-butyl phthalate at concentrations ranging from 0.4J µg/L to 0.9J µg/L. Six samples (GWA-202, GWA-205, GWA-211, GWA-217, GWA-218, and GWA-232DUP) contained diethyl phthalate at concentrations ranging from 0.6J µg/L to 6J µg/L. Two samples (GWA-210 and GWA-231) contained 2,4-dimethylphenol; 2-methylphenol; and 4-methylphenol at concentrations of 1,400J µg/L and 25J µg/L; 1,800J µg/L and 280 µg/L; and 21,000 µg/L and 100 µg/L, respectively. Naphthalene was detected in one sample (GWA-231) at a concentration of 4J µg/L. Phenol was detected in seven samples (GWA-202, GWA-205, GWA-207, GWA-210, GWA-211, GWA-222, and GWA-231) at concentrations ranging from 0.5J µg/L to 1,800J µg/L.

Semivolatile organic compounds were identified in 12 deep groundwater samples collected in Rounds 2 and 3. Table 5-33 provides a complete list of compounds detected and the corresponding concentrations. Bis(2-chloroethyl)ether was detected in one sample (GWA-226DUP) at a concentration of 2J µg/L. Seven samples (GWA-206, GWA-213, GWA-221, GWA-226DUP, GWA-227, GWA-219, and GWA-223) contained bis(2-ethylhexyl)phthalate at concentrations ranging from 0.6J µg/L to 3.5J µg/L. Four samples (GWA-219, GWA-223, GWA-226DUP, and GWA-230) contained di-n-butyl phthalate at concentrations ranging from 0.8J µg/L to 2J µg/L. Two samples (GWA-216DUP and GWA-318) contained diethyl phthalate at concentrations of 5.3J µg/L and 0.8J µg/L, respectively. Naphthalene was detected in two samples (GWA-317 and GWA-318) at concentrations of 0.85J µg/L and 1J µg/L, respectively. One sample (GWA-226DUP) contained 2,2'-oxybis(1-chloropropane) at a concentration of 4.5J µg/L. Phenol was detected in three samples (GWA-221, GWA-228, and GWA-317DUP) at concentrations ranging from 0.6J µg/L to 7.5J µg/L. One sample (GWA-318) contained 1,2,4-trichlorobenzene at a concentration of 0.5J µg/L.

Pesticide/PCB compounds were identified in five shallow groundwater samples collected in Rounds 2 and 3. Table 5-34 provides a complete list of compounds detected and the corresponding concentrations. Aldrin was detected in one sample (GWA-220) at a concentration of 0.026J µg/L. Three samples (GWA-201, GWA-210 and GWA-222) contained heptachlor epoxide at concentrations ranging from 0.004J µg/L to 0.14L µg/L. One sample

(GWA-210) contained 4,4'-DDD at a concentration of 0.11L µg/L. Gamma-chlordane was detected in one sample (GWA-211) at a concentration of 0.007J µg/L.

Pesticide/PCB compounds were identified in three deep groundwater samples collected in Rounds 2 and 3. Table 5-35 provides a complete list of compounds detected and the corresponding concentrations. Heptachlor epoxide was detected in two samples (GWA-216 and GWA-221) at concentrations of 0.0065J µg/L and 0.004J µg/L, respectively. One sample (GWA-229) contained 4,4'-DDT at a concentration of 0.016J µg/L.

Total metals were detected in 17 shallow groundwater samples collected in Rounds 2 and 3. Table 5-36 provides a complete list of metals detected and the corresponding concentrations. Antimony was detected in one sample (GWA-212) at a concentration of 31 µg/L. Arsenic was detected in all but one sample (GWA-208) at concentrations ranging from 3.8L µg/L to 309 µg/L. The following metals were detected in all of the samples at the respective concentration ranges: barium, 27 µg/L to 7,270 µg/L; iron, 4,040J µg/L to 226,000 µg/L; and manganese, 80 µg/L to 2,760J µg/L. Beryllium was detected in three samples (GWA-210, GWA-231, and GWA-232DUP) at concentrations ranging from 3.9 µg/L to 10.6 µg/L. Cadmium was detected in three samples (GWA-210, GWA-215, and GWA-218) at concentrations ranging from 9.3 µg/L to 45.9 µg/L. Chromium was detected in all but three samples (GWA-208, GWA-211, and GWA-220) at concentrations ranging from 15.7 µg/L to 353 µg/L. Cobalt was detected in four samples (GWA-207, GWA-210, GWA-231, and GWA-232DUP) at concentrations ranging from 10 µg/L to 84.2 µg/L. Copper was detected in all but two samples (GWA-208 and GWA-220) at concentrations ranging from 5.4 µg/L to 356 µg/L. Lead was detected in all but five samples (GWA-202, GWA-203, GWA-211, GWA-217, and GWA-220) at concentrations ranging from 1.8 µg/L to 381L µg/L. Mercury was detected in five samples (GWA-201, GWA-203, GWA-212, GWA-215, and GWA-232DUP) at concentrations ranging from 0.205L µg/L to 0.52 µg/L. Nickel was detected in 10 samples (GWA-201, GWA-203, GWA-207, GWA-210, GWA-212, GWA-218, GWA-222, GWA-225, GWA-231, and GWA-232DUP) at concentrations ranging from 11.4 µg/L to 352 µg/L. Silver was detected in one sample (GWA-212) at a concentration of 5 µg/L. Vanadium was detected in all but two samples (GWA-208 and GWA-211) at concentrations ranging from 7.6 µg/L to 396 µg/L. Zinc was detected in all but one sample (GWA-220) at concentrations ranging from 33J µg/L to 1,090J µg/L.

Dissolved metals were detected in 17 shallow groundwater samples. Table 5-37 provides a complete list of metals detected and the corresponding concentrations. Arsenic was detected in all but five samples (GWA-201F, GWA-203F, GWA-208F, GWA-218F, and GWA-225F) at concentrations ranging from 2.2L µg/L to 200L µg/L. Barium was detected in all but three samples (GWA-202F, GWA-222F, and GWA-231F) at concentrations ranging from 15 µg/L to 6,060 µg/L. Copper was detected in five samples (GWA-201F, GWA-207F, GWA-210F, GWA-231F, and GWA-232FDUP) at concentrations ranging from 2.05 µg/L to 19.2 µg/L. Iron was detected in all but four samples (GWA-201F, GWA-202F, GWA-203F, and GWA-208F) at concentrations ranging from 158 µg/L to 55,400 µg/L. Lead was detected in one sample (GWA-208F) at a concentration of 1.6 µg/L. Manganese was detected in all but one sample (GWA-201F) at concentrations ranging from 33.9 µg/L to 2,630 µg/L. Nickel was detected in one sample (GWA-231F) at a concentration of 63.8 µg/L. Vanadium was detected in two samples (GWA-202F and GWA-217F) at concentrations of 5.1 µg/L and 5.3 µg/L, respectively. Zinc was detected in seven samples (GWA-207F, GWA-208F, GWA-210F, GWA-211F, GWA-212F, GWA-231F, and GWA-232FDUP) at concentrations ranging from 12.4 µg/L to 61.3 µg/L.

Total metals were detected in 17 deep groundwater samples. Table 5-38 provides a complete list of metals detected and the corresponding concentrations. Arsenic was detected in all but two samples (GWA-219 and GWA-228) at concentrations ranging from 1.4 µg/L to 64.35 µg/L. Barium was detected in all of the samples at concentrations ranging from 16 µg/L to 243.5J µg/L. Cadmium was detected in one sample (GWA-216DUP) at a concentration of 6.5 µg/L. Chromium was detected in nine samples (GWA-204DUP, GWA-206, GWA-209, GWA-213, GWA-216DUP, GWA-224, GWA-226DUP, GWA-228, and GWA-229) at concentrations ranging from 7.15 µg/L to 165.5 µg/L. Copper was detected in seven samples (GWA-204DUP, GWA-216DUP, GWA-221, GWA-223, GWA-224, GWA-226DUP, and GWA-230) at concentrations ranging from 3.85 µg/L to 56.7 µg/L. Iron was detected in all but one sample (GWA-317DUP) at concentrations ranging from 672 µg/L to 248,500 µg/L. Lead was detected in all but five samples (GWA-214, GWA-219, GWA-221, GWA-227, GWA-317DUP) at concentrations ranging from 0.95 µg/L to 44.2 µg/L. Manganese was detected in all but two samples (GWA-317DUP and GWA-318) at concentrations ranging from 41.55J µg/L to 2,170 µg/L. Mercury was detected in two samples (GWA-216DUP and GWA-228) at concentrations of 0.155L µg/L and 0.34 µg/L, respectively. Nickel was detected in three samples (GWA-216DUP, GWA-219, and GWA-228) at concentrations ranging from 13.5 µg/L to 50.65 µg/L. Vanadium was detected in eight samples (GWA-204DUP, GWA-206, GWA-209, GWA-213, GWA-216DUP, GWA-221, GWA-228, and GWA-229) at concentrations ranging from 4.85 µg/L to 355.5 µg/L. Zinc was detected in all but three samples (GWA-227, GWA-318DUP, and GWA-317) at concentrations ranging from 34.5 µg/L to 367 µg/L.

Dissolved metals were detected in 17 deep groundwater samples collected during Round 2 and 3 sampling efforts. Table 5-39 provides a complete list of metals detected and the corresponding concentrations. Arsenic was detected in six samples (GWA-204FDUP, GWA-214F, GWA-223F, GWA-224, GWA-230F, and GWA-318F) at concentrations ranging from 1.2 µg/L to 5 µg/L. Barium was detected in all but one sample (GWA-228F) at concentrations ranging from 6.2 µg/L to 155 µg/L. Copper was detected in three samples (GWA-204FDUP, GWA-226FDUP, and GWA-230F) at concentrations ranging from 3.15 µg/L to 5.1 µg/L. Iron was detected in six samples (GWA-206F, GWA-213F, GWA-216FDUP, GWA-221F, GWA-219F, and GWA-229F) at concentrations ranging from 89 µg/L to 2,720 µg/L. Manganese was detected in all but four samples (GWA-223F, GWA-229F, GWA-317FDUP, and GWA-318F) at concentrations ranging from 24 µg/L to 284 µg/L. Zinc was detected in eight samples (GWA-204FDUP, GWA-206F, GWA-219F, GWA-223F, GWA-224F, GWA-226FDUP, GWA-228F, and GWA-230F) at concentrations ranging from 9.1 µg/L to 34 µg/L.

TABLE 5-26
ROUND 2
GROUNDWATER SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

			CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SHALLOW	DEEP	SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T	MET. D	SM	VOA	SVOA	PEST/PCB	MET. T	MET. D	SM	COMMENTS
B-1W		GWA-201	X	X	X	X	X		X	X	X	X	X		
A-MW5		GWA-202	X	X	X	X	X		X	X	X	X	X		
A-MW7		GWA-203	X	X	X	X	X		X	X	X	X	X		
	A-MW9C	GWA-204	X	X	X	X	X		X	X	X	X	X		
A-MW9A		GWA-205	X	X	X	X	X		X	X	X	X	X		
	A-MW9B	GWA-206	X	X	X	X	X		X	X	X	X	X		
A-MW8A		GWA-207	X	X	X	X	X		X	X	X	X	X		MS/MSD
A-MW6A		GWA-208	X	X	X	X	X		X	X	X	X	X		
	A-MW6B	GWA-209	X	X	X	X	X		X	X	X	X	X		
B-20W		GWA-210	X	X	X	X	X		X	X	X	X	X		
B-17W		GWA-211	X	X	X	X	X		X	X	X	X	X		
B-15WA		GWA-212	X	X	X	X	X		X	X	X	X	X		
	A-MW1B	GWA-213	X	X	X	X	X		X	X	X	X	X		
	A-MW1C	GWA-214	X	X	X	X	X		X	X	X	X	X		
A-MW11A		GWA-215	X	X	X	X	X		X	X	X	X	X		
	A-MW11B	GWA-216	X	X	X	X	X		X	X	X	X	X		
A-MW12A		GWA-217	X	X	X	X	X		X	X	X	X	X		
GW-3		GWA-218	X	X	X	X	X		X	X	X	X	X		
	A-MW10B	GWA-219	X	X	X	X	X		X	X	X	X	X		

TABLE 5-26
ROUND 2
GROUNDWATER SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

			CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SHALLOW	DEEP	SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T	MET. D	SM	VOA	SVOA	PEST/PCB	MET. T	MET. D	SM	COMMENTS
GW-2		GWA-220	X	X	X	X	X		X	X	X	X	X		
	AMW4B	GWA-221	X	X	X	X	X		X	X	X	X	X		
A-MW4A		GWA-222	X	X	X	X	X		X	X	X	X	X		
	AMW-14B	GWA-223	X	X	X	X	X		X	X	X	X	X		
	A-MW13B	GWA-224	X	X	X	X	X		X	X	X	X	X		
GW-1		GWA-225	X	X	X	X	X		X	X	X	X	X		MS/MSD
	AMW-8B	GWA-226	X	X	X	X	X		X	X	X	X	X		
	B-15WB	GWA-227	X	X	X	X	X		X	X	X	X	X		MS/MSD
	A-MW15B	GWA-228	X	X	X	X	X		X	X	X	X	X		
	A-MW16B	GWA-229	X	X	X	X	X		X	X	X	X	X		MS/MSD
	A-MW17B	GWA-230	X	X	X	X	X		X	X	X	X	X		
B-20WSS		GWA-231	X	X	X	X	X		X	X	X	X	X		
A-MW10A		GWA-232	X	X	X	X	X		X	X	X	X	X		
	A-MW11B	GWA-233	X	X	X	X	X		X	X	X	X	X		DUP OF A-MW11B
	A-MW9C	GWA-234	X	X	X	X	X		X	X	X	X	X		DUP OF A-MW9C
	A-MW8B	GWA-235	X	X	X	X	X		X	X	X	X	X		DUP OF A-MW8B
A-MW10A		GWA-236	X	X	X	X	X		X	X	X	X	X		DUP OF A-MW10A

TABLE 5-27
ROUND 3
GROUNDWATER SAMPLE SUMMARY
AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

			CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SHALLOW	DEEP	SAMPLE ID	VOA	SVOA (1)	PEST/PCB (1)	MET. T. (1)	MET. D. (1)	SM	VOA	SVOA (1)	PEST/PCB (1)	MET. T. (1)	MET. D. (1)	SM	COMMENTS
	A-MW1B	GWA-301	X						X						
	A-MW4B	GWA-302	X						X						
	A-MW6B	GWA-303	X						X						
	A-MW9B	GWA-304	X						X						
	A-MW10B	GWA-305	X						X						
	A-MW11B	GWA-306	X						X						
	A-MW17B	GWA-307	X						X						
	A-MW16B	GWA-308	X						X						
	A-MW15B	GWA-309	X						X						MS/MSD
	A-MW14B	GWA-310	X						X						
	A-MW13B	GWA-311	X						X						
B-20WSS		GWA-312	X						X						
	AP-8	GWA-313	X						X						
	A-MW9C	GWA-314	X						X						
	B-15WB	GWA-315	X						X						
	A-MW1C	GWA-316	X						X						
	A-MW18B	GWA-317	X	X	X	X	X		X	X	X	X	X		MS/MSD
	A-MW19B	GWA-318	X	X	X	X	X		X	X	X	X	X		
	A-MW18B	GWA-320	X	X	X	X	X		X	X	X	X	X		DUP OF A-MW18B
	A-MW14B	GWA-321	X						X						DUP OF A-MW14B
	A-MW10B	GWA-322	X						X						DUP OF A-MW10B

Note: (1) Only installed wells during round 3 field efforts CLP parameters analyzed.

TABLE 5-28
ROUND 2
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-201 6/13/92 ug/L	GWA-202 6/14/92 ug/L	GWA-203 6/15/92 ug/L	GWA-205 6/15/92 ug/L	GWA-207 6/17/92 ug/L	GWA-208 6/16/92 ug/L
Vinyl chloride	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U
1,2-dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U
2-butanone	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	10 U	10 U	10 U	10 U	10 U	10 U
Benzene	10 U	10 U	10 U	10 U	10 U	10 U
4-methyl-2-pentanone	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	10 U	10 U	10 U	10 U	10 U	10 U
Toluene	10 U	10 U	10 U	10 U	10 U	10 U
Xylene(total)	10 U	10 U	10 U	10 U	10 U	10 U

TABLE 5-28
ROUND 2
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-210 6/17/92 ug/L	GWA-211 6/18/92 ug/L	GWA-212 6/15/92 ug/L	GWA-215 6/13/92 ug/L	GWA-217 6/13/92 ug/L	GWA-218 6/13/92 ug/L
Vinyl chloride	3300	10 U	2 J	9 J	10 U	10 U
Methylene chloride	830 U	10 U	10 U	10 U	10 U	10 U
Acetone	2600	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene	6100	10 U	10 U	40	10 U	10 U
1,2-dichloroethane	830 U	10 U	10 U	10 U	10 U	10 U
2-butanone	4300	10 U	10 U	10 U	10 U	10 U
Trichloroethene	830 U	10 U	10 U	18	10 U	10 U
Benzene	310 J	10 U	10 U	10 U	10 U	10 U
4-methyl-2-pentanone	16000	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	830 U	10 U	10 U	4 J	10 U	10 U
Toluene	5400	10 U	10 U	10 U	10 U	10 U
Xylene(total)	250 J	10 U	10 U	10 U	10 U	10 U

TABLE 5-28
ROUND 2
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-220 6/13/92 ug/L	GWA-222 6/13/92 ug/L	GWA-225 6/14/92 ug/L	GWA-231 6/18/92 ug/L	GWA-232DUP 6/18/92 ug/L
Vinyl chloride	10 U	10 U	10 U	140 U	10 U
Methylene chloride	10 U	10 U	10 U	57 J	10 U
Acetone	10 U	10 U	10 U	160	10 U
1,2-Dichloroethene	10 U	10 U	3 J	1600	10 U
1,2-dichloroethane	10 U	10 U	3 J	140 U	10 U
2-butanone	10 U	10 U	10 U	10 U	10 U
Trichloroethene	10 U	10 U	10 U	1800	10 U
Benzene	10 U	10 U	10 U	140 U	10 U
4-methyl-2-pentanone	10 U	10 U	10 U	220	10 U
Tetrachloroethene	10 U	10 U	10 U	140 U	10 U
Toluene	10 U	10 U	10 U	1200	10 U
Xylene(total)	10 U	10 U	10 U	130 J	10 U

TABLE 5-29
ROUND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no.	GWA-312
Date collected	12/18/92
Units	ug/L
Tetrachloroethene	620
Xylenes(total)	80

TABLE 5-30
ROUND 2
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-206 6/15/92 ug/L	GWA-209 6/16/92 ug/L	GWA-213 6/14/92 ug/L	GWA-216DUP 6/13/92 ug/L	GWA-221 6/12/92 ug/L	GWA-226DUP 6/17/92 ug/L
Vinyl chloride	35	10 U	100	10 U	10 U	13.5
1,2-dichloroethene	170	2 J	540	10 U	10 U	23
1,2-dichloroethane	11 U	10 U	38 J	10 U	10 U	10 U
Trichloroethene	10 J	10 U	100	10 U	10 U	2.5 J
Benzene	11 U	10 U	50 U	10 U	10 U	10 U

TABLE 5-30
ROUND 2
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-230 6/18/92 ug/L	GWA-204DUP 6/16/92 ug/L	GWA-214 6/14/92 ug/L	GWA-219 6/19/92 ug/L	GWA-223 6/17/92 ug/L	GWA-224 6/17/92 ug/L
Vinyl chloride	22	10 U	10 U	11	10 U	10 U
1,2-dichloroethene	110	10 U	10 U	70	10 U	10 U
1,2-dichloroethane	15	10 U	10 U	10 U	10 U	10 U
Trichloroethene	33	10 U	10 U	10	10 U	10 U
Benzene	10 U	10 U	10 U	10 U	3 J	10 U

TABLE 5-30
ROUND 2
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-228 6/19/92 ug/L	GWA-229 6/19/92 ug/L	GWA-227 6/15/92 ug/L
Vinyl chloride	10 U	10 U	10 U
1,2-dichloroethene	2 J	10 U	10 U
1,2-dichloroethane	10 U	10 U	10 U
Trichloroethene	10 U	10 U	10 U
Benzene	10 U	10 U	10 U

TABLE 5-31
ROUND 3
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-313 12/18/92 ug/L	GWA-318 12/18/92 ug/L	GWA-317DUP 12/18/92 ug/L	GWA-301 12/15/92 ug/L	GWA-302 12/15/92 ug/L	GWA-303 12/15/92 ug/L	GWA-304 12/15/92 ug/L	GWA-306 12/15/92 ug/L
Vinyl chloride	14 U	2 U	2 U	20 U	2 U	2 U	14	2 U
1,2-dichloroethene	8 J	5	8.5	290	2 U	1 J	110	2 U
Chloroform	14 U	8	1 J	20 U	2 U	2 U	7 U	2 U
1,2-dichloroethane	14 U	2 U	2 U	23	2 U	2 U	7 U	2 U
2-butanone	71 U	2 J	10 U	100 U	10 U	10 U	36 U	10 U
Trichloroethene	14 U	14	13.5	20 U	2 U	2 U	7 U	2 U
Tetrachloroethene	14 U	4	2 U	20 U	2 U	2 U	7 U	2 U
Toluene	14 U	2 U	2 U	20 U	2 U	2 U	7 U	1 J
Xylenes(total)	14 U	1 J	2 U	20 U	2 U	2 U	7 U	2 U
Benzene	14 U	2 U	2 U	20 U	2 U	2 U	7 U	2 U

TABLE 5-31
ROUND 3
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-307 12/15/92 ug/L	GWA-309 12/15/92 ug/L	GWA-314 12/15/92 ug/L	GWA-316 12/15/92 ug/L	GWA-305DUP 12/15/92 ug/L	GWA-308 12/15/92 ug/L	GWA-310DUP 12/15/92 ug/L	GWA-311 12/15/92 ug/L	GWA-315 12/16/92 ug/L
Vinyl chloride	8	2 U	2 U	2 U	8	2 U	2 U	1 J	1 J
1,2-dichloroethene	59	3	2 U	2 U	49	2 U	2 U	4	7
Chloroform	4 U	2 U	2 U	2 U	3 U	2 U	2 U	2 U	2 U
1,2-dichloroethane	10	2 U	2 U	2 U	3 U	2 U	2 U	2 U	2 U
2-butanone	20 U	10 U	10 U	10 U	17 U	10 U	20 U	10 U	2 U
Trichloroethene	16	2 U	2 U	2 U	10.5	2 U	2 U	6.5	12
Tetrachloroethene	4 U	2 U	2 U	2 U	3 U	2 U	2 U	2 U	2 U
Toluene	4 U	2 U	2 U	2 U	3 U	2 U	2 U	2 U	2 U
Xylenes(total)	4 U	2 U	2 U	2 U	3 U	2 U	2 U	2 U	2 U
Benzene	4 U	2 U	2 U	2 U	3 U	2 U	1 J	2 U	2 U

TABLE 5-32
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-201 6/13/92 ug/L	GWA-202 6/14/92 ug/L	GWA-203 6/15/92 ug/L	GWA-205 6/15/92 ug/L	GWA-207 6/17/92 ug/L	GWA-208 6/16/92 ug/L
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 UJ	10 U	10 U	13	0.5 J	10 U
Butylphthalate,di-n-	10 U	10 U	10 U	10 U	0.9 J	10 U
Diethylphthalate	10 U	0.7 J	10 U	6 J	10 U	10 U
Dimethylphenol,2,4-	10 U	10 U	10 U	10 U	10 U	10 U
Methylphenol,2-	10 U	10 U	10 U	10 U	10 U	10 U
Methylphenol,4-	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	0.5 J	10 U	0.6 J	0.7 J	10 U

TABLE 5-32
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-210 6/17/92 ug/L	GWA-211 6/18/92 ug/L	GWA-212RE 6/15/92 ug/L	GWA-215 6/13/92 ug/L	GWA-217 6/13/92 ug/L	GWA-218 6/13/92 ug/L
Acenaphthene	4000 U	10 U	10 U	10 U	1 J	10 U
Bis(2-ethylhexyl)phthalate	4000 U	10 U	1 J	10 U	0.8 J	10 U
Butylphthalate,di-n-	4000 U	0.4 J	10 U	10 U	10 U	10 U
Diethylphthalate	4000 U	0.6 J	10 U	10 U	0.7 J	1 J
Dimethylphenol,2,4-	1400 J	10 U	10 U	10 U	10 U	10 U
Methylphenol,2-	1800 J	10 U	10 U	10 U	10 U	10 U
Methylphenol,4-	21000	10 U	10 U	10 U	10 U	10 U
Naphthalene	4000 U	10 U	10 U	10 U	10 U	10 U
Phenol	1800 J	0.9 J	10 U	10 U	10 U	10 U

TABLE 5-32
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-220 6/13/92 ug/L	GWA-222 6/13/92 ug/L	GWA-225 6/14/92 ug/L	GWA-231 6/18/92 ug/L	GWA-232RE DUP 6/18/92 ug/L
Acenaphthene	10 U	10 U	10 U	40 U	10 U
Bis(2-ethylhexyl)phthalate	1 J	10 UJ	1 J	40 U	10 U
Butylphthalate,di-n-	10 U	10 U	10 U	40 U	0.8 J
Diethylphthalate	10 U	10 U	10 U	40 U	3.5 J
Dimethylphenol,2,4-	10 U	10 U	10 U	25 J	10 U
Methylphenol,2-	10 U	10 U	10 U	280	10 U
Methylphenol,4-	10 U	10 U	10 U	100	10 U
Naphthalene	10 U	10 U	10 U	4 J	10 U
Phenol	10 U	0.7 J	10 U	4 J	10 U

TABLE 5-33
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-204 DUP 6/16/92 ug/L	GWA-206 6/15/92 ug/L	GWA-209 6/16/92 ug/L	GWA-213 6/14/92 ug/L	GWA-214 6/14/92 ug/L	GWA-216 DUP 6/13/92 ug/L
Bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	1 J	10 UJ	1 J	10 U	10 U
Butylphthalate,di-n-	10 U	10 U	10 U	10 U	10 U	7.5 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	5.3 J
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U
Oxybis(1-chloropropane),2,2'-	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	10 U	10 U	10 U	10 U
Trichlorobenzene,1,2,4-	10 U	10 U	10 U	10 U	10 U	10 U

TABLE 5-33
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-221 6/12/92 ug/L	GWA-226 DUP 6/17/92 ug/L	GWA-227 6/15/92 ug/L	GWA-230 6/18/92 ug/L	GWA-317 DUP 12/18/92 ug/L	GWA-318 12/18/92 ug/L
Bis(2-chloroethyl)ether	10 U	2 J	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	2 J	3.5 J	0.6 J	10 U	10 U	10 U
Butylphthalate,di-n-	10 U	0.8 J	10 U	2 J	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	0.8 J
Naphthalene	10 U	10 U	10 U	10 U	0.85 J	1 J
Oxybis(1-chloropropane),2,2'-	10 U	4.5 J	10 U	10 U	10 U	10 U
Phenol	2 J	10 U	10 U	10 U	7.5 J	10 R
Trichlorobenzene,1,2,4-	10 U	10 U	10 U	10 U	10 U	0.5 J

TABLE 5-33
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
SEMIVOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-219 6/19/92 ug/L	GWA-223 6/17/92 ug/L	GWA-224 6/17/92 ug/L	GWA-228 6/19/92 ug/L	GWA-229 6/19/92 ug/L
Bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	3 J	2 J	10 U	10 U	10 U
Butylphthalate,di-n-	2 J	0.8 J	10 U	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U
Oxybis(1-chloropropane),2,2'-	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	10 U	0.6 J	10 U
Trichlorobenzene,1,2,4-	10 U	10 U	10 U	10 U	10 U

TABLE 5-34
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
PESTICIDE/PCBS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-201 6/13/92 ug/L	GWA-202 6/14/92 ug/L	GWA-203 6/15/92 ug/L	GWA-205 6/15/92 ug/L	GWA-207 6/17/92 ug/L	GWA-208 6/16/92 ug/L
Aldrin	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL
Heptachlor epoxide	0.004 J	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL
4,4'-ddd	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 UL
Gamma-chlordane	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL

TABLE 5-34
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
PESTICIDE/PCBS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-210 6/17/92 ug/L	GWA-211 6/18/92 ug/L	GWA-212 6/15/92 ug/L	GWA-215 6/13/92 ug/L	GWA-217 6/13/92 ug/L	GWA-218 6/13/92 ug/L
Aldrin	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL
Heptachlor epoxide	0.14 L	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL
4,4'-ddd	0.11 L	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 UL
Gamma-chlordane	0.05 UL	0.007 J	0.05 UL	0.05 UL	0.05 UL	0.05 UL

TABLE 5-34
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
PESTICIDE/PCBS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-220 6/13/92 ug/L	GWA-222 6/13/92 ug/L	GWA-225 6/14/92 ug/L	GWA-231 6/18/92 ug/L	GWA-232DUP 6/18/92 ug/L
Aldrin	0.026 J	0.05 UL	0.05 U	0.05 UL	0.05 UL
Heptachlor epoxide	0.05 UL	0.005 J	0.05 U	0.05 UL	0.05 UL
4,4'-ddd	0.1 UL	0.1 UL	0.1 U	0.1 UL	0.1 UL
Gamma-chlordane	0.05 UL	0.05 UL	0.05 U	0.05 UL	0.05 UL

TABLE 5-35
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
PESTICIDE/PCBS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-204DUP 6/16/92 ug/L	GWA-206 6/15/92 ug/L	GWA-209 6/16/92 ug/L	GWA-213 6/14/92 ug/L	GWA-214 6/14/92 ug/L	GWA-216DUP 6/13/92 ug/L
Heptachlor epoxide	0.05 UL	0.05 UL	0.05 UL	0.05 U	0.05 U	0.0065 J
4,4'-ddt	0.1 UL	0.1 UL	0.1 UL	0.1 U	0.1 U	0.1 UL

TABLE 5-35
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
PESTICIDE/PCBS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-221 6/12/92 ug/L	GWA-226DUP 6/17/92 ug/L	GWA-227 6/15/92 ug/L	GWA-230 6/18/92 ug/L	GWA-317DUP 12/18/92 ug/L	GWA-318 12/18/92 ug/L
Heptachlor epoxide	0.004 J	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 U
4,4'-ddt	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 U

TABLE 5-35
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
PESTICIDE/PCBS, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-219 6/19/92 ug/L	GWA-223 6/17/92 ug/L	GWA-224 6/17/92 ug/L	GWA-228 6/19/92 ug/L	GWA-229 6/19/92 ug/L
Heptachlor epoxide	0.05 U	0.05 U	0.05 U	0.05 U	0.05 UL
4,4'-ddt	0.1 U	0.1 U	0.1 U	0.1 U	0.016 J

TABLE 5-36
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-201 6/13/92 ug/L	GWA-202 6/14/92 ug/L	GWA-203 6/15/92 ug/L	GWA-205 6/15/92 ug/L	GWA-207 6/17/92 ug/L	GWA-208 6/16/92 ug/L
Aluminum	71000	15800	31300 J	29600 J	56400	4780 J
Antimony	18 UL	18 UL	18 UL	18 U	18 UL	18 U
Arsenic	103 L	10.3 L	8.6 L	309	19.3 J	2 U
Barium	403 J	59.5 J	140 J	517	774	27
Beryllium	2 U	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U	3 U
Calcium	65400	89700	47300	46500	138000	72200
Chromium	93.9	21	53.2	38.8	67.6	8 U
Cobalt	8 U	8 U	8 U	8 U	10	8 U
Copper	44.4	12.8	16	22	41.4	2 U
Iron	56600	24200	16000	106000	94200	4040 J
Lead	43.6	1 U	1 U	21.8	55.9 J	1.8
Magnesium	16000	73900	22300	90200	157000	1 U
Manganese	677	399	338	583	498 J	80
Mercury	0.22 L	0.2 UL	0.23 L	0.2 U	0.2 UL	0.2 U
Nickel	31.8	11 U	19.2	11 U	30.7	11 U
Potassium	6250	33800	6710	20600 J	40900 J	2570 J
Selenium	10 UL	10 UL	R	10 UL	10 UL	10 U
Silver	2 U	2 U	2 U	2 U	2 U	2 U
Sodium	12600	204000	139000	949000	1420000	35000
Thallium	1 UL	1 UL	1 UL	5 U	5 UL	1 U
Vanadium	181	39.3	71.9	72	133	4 U
Zinc	155	108	180	92 J	127	33 J

TABLE 5-36
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-210 6/17/92 ug/L	GWA-211 6/18/92 ug/L	GWA-212 6/15/92 ug/L	GWA-215 6/13/92 ug/L	GWA-217 6/13/92 ug/L	GWA-218 6/13/92 ug/L
Aluminum	80600	222	33400 J	40100	6500 J	26200
Antimony	18 U	18 U	31	18 UL	18 UL	18 UL
Arsenic	200 L	21.4 L	34.1	11.7 L	158 L	30.6 L
Barium	7270	37.8	259	105 J	154 J	285 J
Beryllium	10.6	2 U	2 U	2 U	2 U	2 U
Cadmium	45.9	3 U	3 U	17.1	3 U	9.3
Calcium	337000	182000	184000	50700	103000	55300
Chromium	187	8 U	65.8	55.6	15.7	52.5
Cobalt	84.2	8 U	8 U	8 U	8 U	8 U
Copper	279	5.4	356	32.3	12.2	38.7
Iron	138000	7490	51600 J	39100	46300	119000
Lead	298 L	1 UL	237	27.2	1 U	208
Magnesium	144000	50000	55300	53300	45000	7270
Manganese	2760 J	196 J	730	1100	275	174
Mercury	0.2 UL	0.2 UL	0.52	0.28 L	0.2 UL	0.2 UL
Nickel	114	11 U	85	11 U	11 U	11.4
Potassium	118000	36300 J	46200 J	8800	38100	4210
Selenium	10 UL	10 UL	10 UL	10 UL	0 R	10 U
Silver	2 U	2 U	5	2 U	2 U	2 U
Sodium	1260000	151000	145000	107000	169000	16100
Thallium	5 UL	1 UL	1 UL	1 UL	1 UL	1 U
Vanadium	396	4 U	116	118	31.9	72.5
Zinc	807	822	1090 J	501	140	362

TABLE 5-36
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-220 6/13/92 ug/L	GWA-222 6/13/92 ug/L	GWA-225 6/14/92 ug/L	GWA-231 6/18/92 ug/L	GWA-232DUP 6/18/92 ug/L
Aluminum	797	73500	32900	132000	98750
Antimony	18 UL	18 UL	18 UL	18 U	18 U
Arsenic	4.5 L	44.3 L	3.8 L	68.1 L	12.85 L
Barium	52 J	437 J	178 J	570	384.5
Beryllium	2 U	2 U	2 U	6.7	3.9
Cadmium	3 U	3 U	3 U	3 U	3 U
Calcium	117000	60400	52500	110000	38150
Chromium	8 U	89.2	48.5	353	120
Cobalt	8 U	8 U	8 U	75.9	18.25
Copper	2 U	45.4	39.8	183	49.4
Iron	20000	57800	75700	226000	139000
Lead	1 U	31.7	35.5	381 L	22.65 L
Magnesium	53000	14000	40900	260000	12750
Manganese	650	186	786	2060 J	382.5 J
Mercury	0.2 UL	0.2 UL	0.2 UL	0.2 UL	0.205 L
Nickel	11 U	24.2	13.2	352	36
Potassium	103000	9970	22600	120000	7060 J
Selenium	0 R	0 R	10 UL	10 UL	10 UL
Silver	2 U	2 U	2 U	2 U	2 U
Sodium	195000	8530	124000	2140000	21500
Thallium	1 UL	1 UL	1 UL	5 UL	1 UL
Vanadium	7.6	199	95.7	344	262.5
Zinc	5 U	229	178	562	270

TABLE 5-37
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, DISSOLVED, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-201F 6/13/92 ug/L	GWA-202F 6/14/92 ug/L	GWA-203F 6/15/92 ug/L	GWA-205F 6/15/92 ug/L	GWA-207F 6/17/92 ug/L	GWA-208F 6/16/92 ug/L
Aluminum	18 U	18 U	18 U	59 U	18 U	59 U
Antimony	18 U	18 U	18 U	18 U	18 U	18 U
Arsenic	2 U	3.8	2 U	173	19.7 L	2 U
Barium	22.8	3 U	62.6	336	681	15
Beryllium	2 U	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U	3 U
Calcium	64200	88000	46600	40800	134000	67000
Chromium	8 U	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U	8 U
Copper	19.2	2 U	2 U	2 U	3.1	2 U
Iron	10 U	10 U	10 U	48000	51800	10 U
Lead	1 UL	1 UL	1 UL	1 UL	1 U	1.6
Magnesium	12200	71000	20800	83700	178000	1 U
Manganese	3 U	233	285	437	352	55
Mercury	0.2 UL	0.2 UL	0.2 UL	0.2 U	0.2 UL	0.2 U
Nickel	11 U	11 U	11 U	11 U	11 U	11 U
Potassium	2430	31700	4570	18000	40300	2020 J
Selenium	10 U	R	2 UL	10 UL	2 UL	10 U
Silver	2 U	2 U	2 U	2 U	2 U	2 U
Sodium	11100	206000	139000	901000	1860000	29800
Thallium	1 UL	1 UL	1 UL	5 U	5 UL	1 U
Vanadium	4 U	5.1	4 U	4 U	4 U	4 U
Zinc	5 U	5 U	5 U	5 U	21.9	22

TABLE 5-37
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, DISSOLVED, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-210F 6/17/92 ug/L	GWA-211F 6/18/92 ug/L	GWA-212F 6/15/92 ug/L	GWA-215F 6/13/92 ug/L	GWA-217F 6/13/92 ug/L	GWA-218F 6/13/92 ug/L
Aluminum	18 U	18 U	18 U	18 U	18 U	18 U
Antimony	18 U	18 U	18 U	18 U	18 U	18 U
Arsenic	200 L	15.5 L	4.9	2.7	153	2 U
Barium	6060	34.4	62	22.2	131	83.3
Beryllium	2 U	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U	3 U
Calcium	353000	190000	167000	50100	105000	50600
Chromium	8 U	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U	8 U
Copper	4.9	2 U	2 U	2 U	2 U	2 U
Iron	55400	4060	330	4980	37200	419
Lead	1 U	1 U	1 U	1 UL	1 UL	1 UL
Magnesium	135000	54000	46400	51000	45300	5570
Manganese	2630	197	350	1010	243	53.6
Mercury	0.2 UL	0.2 UL	0.2 U	0.2 UL	0.2 UL	0.2 UL
Nickel	11 U	11 U	11 U	11 U	11 U	11 U
Potassium	104000	38700	39000	6320	38100	2260
Selenium	10 UL	10 UL	10 UL	R	10 UL	2 UL
Silver	2 U	2 U	2 U	2 U	2 U	2 U
Sodium	1340000	162000	134000	108000	174000	14600
Thallium	5 UL	1 UL	1 UL	1 UL	1 UL	1 UL
Vanadium	4 U	4 U	4 U	4 U	5.3	4 U
Zinc	37	61.3	34	5 U	5 U	5 U

TABLE 5-37
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, DISSOLVED, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-220F 6/13/92 ug/L	GWA-222F 6/13/92 ug/L	GWA-225F 6/14/92 ug/L	GWA-231F 6/18/92 ug/L	GWA-232FDUP 6/18/92 ug/L
Aluminum	18 U	18 U	18 U	18 U	18 U
Antimony	18 U	18 U	18 U	18 U	18 U
Arsenic	2.2 L	3.6 L	2 U	11.8 L	5.65 L
Barium	29.2	3 U	89.4	3 U	40.3
Beryllium	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U
Calcium	119000	54200	52900	101000	33500
Chromium	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U
Copper	2 U	2 U	2 U	14.2	2.05
Iron	9570	158	8490	398	1490
Lead	1 UL	1 UL	1 UL	1 U	1 U
Magnesium	54800	8270	38900	242000	8390
Manganese	651	33.9	711	198	109
Mercury	0.2 UL	0.2 UL	0.2 UL	0.2 UL	0.2 UL
Nickel	11 U	11 U	11 U	63.8	11 U
Potassium	109000	4470	20100	107000	2425
Selenium	10 UL	2 U	10 UL	10 UL	2 UL
Silver	2 U	2 U	2 U	2 U	2 U
Sodium	204000	6960	128000	2360000	20600
Thallium	1 UL	1 UL	1 UL	5 UL	1 UL
Vanadium	4 U	4 U	4 U	4 U	4 U
Zinc	5 U	5 U	5 U	12.4	15.8

TABLE 5-38
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-204DUP 6/16/92 ug/L	GWA-206 6/15/92 ug/L	GWA-209 6/16/92 ug/L	GWA-213 6/14/92 ug/L	GWA-216DUP 6/13/92 ug/L	GWA-221 6/12/92 ug/L
Aluminum	1220	4080 J	5640 J	8560 J	46900	563 J
Antimony	18 UL	18 U	18 U	18 U	18 U	18 UL
Arsenic	5.05 L	6.3	9.5	19.3	64.35 L	4.1 L
Barium	33.1	82	115	164	243.5 J	160 J
Beryllium	2 U	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	6.5	3 U
Calcium	55950	134000	245000	290000	450500	295000
Chromium	7.15	26.6	47.3	25.9	165.5	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U	8 U
Copper	3.85	2 U	2 U	2 U	56.7	13.8
Iron	4405	44900	81200 J	50500 J	248500	5940
Lead	0.95 L	7.1	13.7	9.8	44.2	1 U
Magnesium	21600	6470	10100	13000	24200	9450
Manganese	41.55 J	441	876	490	2170	308
Mercury	0.2 UL	0.2 U	0.2 U	0.2 U	0.155 L	0.2 UL
Nickel	11 U	11 U	11 U	11 U	50.65	11 U
Potassium	16700 J	5380 J	3770 J	3980 J	7540	4900
Selenium	10 UL	10 UL	10 UL	10 UL	10 UL	10 UL
Silver	2 U	2 U	2 U	2 U	2 U	2 U
Sodium	426500	263000	139000	223000	93300	169000
Thallium	1 UL	1 UL	1 U	1 UL	1 UL	1 UL
Vanadium	4.85	61	146	64	355.5	7.8
Zinc	36.9	80 J	90 J	117 J	367	125

TABLE 5-38
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-226DUP 6/17/92 ug/L	GWA-230 6/18/92 ug/L	GWA-214 6/14/92 ug/L	GWA-227 6/15/92 ug/L	GWA-318 12/18/92 ug/L	GWA-317DUP 12/18/92 ug/L
Aluminum	3095	1190	18 U	18 U	1120	18 U
Antimony	18 UL	18 U	18 U	18 U	17 U	17 U
Arsenic	4.7 L	5.3 L	6.5	4	2	1.4
Barium	138.5	106	16	29	44.4 J	52.5 J
Beryllium	2 U	2 U	2 U	2 U	1 U	1 U
Cadmium	3 U	3 U	3 U	3 U	4 U	4 U
Calcium	215500	327000	55700	49000	108000	155500
Chromium	7.2	8 U	8 U	8 U	9 U	9 U
Cobalt	8 U	8 U	8 U	8 U	10 U	10 U
Copper	7.55	7.3	2 U	2 U	2 U	2 U
Iron	13250	4420	2070 J	1950 J	672	10 U
Lead	2.4 L	1 L	1 U	1 UL	10.7	1 U
Magnesium	10310	7400	10900	40200	1 U	3180
Manganese	256 J	95 J	47	107	3 U	3 U
Mercury	0.2 UL	0.2 UL	0.2 U	0.2 U	0.2 U	0.2 U
Nickel	11 U	11 U	11 U	11 U	12 U	12 U
Potassium	6930 J	4910 J	9680 J	25400 J	15800	9715
Selenium	10 UL	10 UL	10 UL	10 UL	1 UL	1 UL
Silver	2 U	2 U	2 U	2 U	3 U	3 U
Sodium	361000	198000	199000	582000	139000	75450
Thallium	5 UL	6 L	1 UL	1 UL	1 U	1 U
Vanadium	4 U	4 U	4 U	4 U	4 U	4 U
Zinc	39.05	34.5	38 J	5 U	5 U	5 U

TABLE 5-38
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
METALS, TOTAL, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-219 6/19/92 ug/L	GWA-223 6/17/92 ug/L	GWA-224 6/17/92 ug/L	GWA-228 6/19/92 ug/L	GWA-229 6/19/92 ug/L
Aluminum	506	2000	1430	4970	8500
Antimony	18 U	18 UL	18 UL	18 U	18 U
Arsenic	2 U	4.8 L	10.4 L	2 U	26.7
Barium	62.5	26.8	24.6	76.9	144
Beryllium	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U
Calcium	116000	83400	71700	94600	461000
Chromium	8 U	8 U	15.2	27	27.7
Cobalt	8 U	8 U	8 U	8 U	8 U
Copper	2 U	10.4	5.3	2 U	2 U
Iron	5200	10300	11600	62300	62400
Lead	1 U	2.3 L	1.7 L	15.3	8.6
Magnesium	5270	2380	3120	6950	13600
Manganese	145	124 J	274 J	1010	779
Mercury	0.2 U	0.2 UL	0.2 UL	0.34	0.2 U
Nickel	16.6	11 U	11 U	13.5	11 U
Potassium	4280	2760 J	1600 J	2660	6620
Selenium	0 R	10 UL	2 UL	0 R	0 R
Silver	2 UL	2 U	2 U	2 UL	2 UL
Sodium	249000	14300	13900	43600	461000
Thallium	1 U	1 UL	1 UL	1 U	1 UL
Vanadium	4 U	4 U	4 U	81.2	103
Zinc	38.1 J	83.9	76.1	91.2 J	61 J

TABLE 5-39
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
METALS, DISSOLVED, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-204FDUP 6/16/92 ug/L	GWA-206F 6/15/92 ug/L	GWA-209F 6/16/92 ug/L	GWA-213F 6/14/92 ug/L	GWA-214F 6/14/92 ug/L	GWA-216FDUP 6/13/92 ug/L
Aluminum	18 U	59 U	59 U	59 U	59 U	18 U
Antimony	18 U	18 U	18 U	18 U	18 U	18 U
Arsenic	2.25 L	2 U	2 U	2 U	4.9	2 U
Barium	27.8	53	79	129	13	40.9
Beryllium	2 U	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U	3 U
Calcium	47300	93700	146000	279000	50500	89800
Chromium	8 U	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U	8 U
Copper	3.15	2 U	2 U	2 U	2 U	2 U
Iron	10 U	95	10 U	2720	10 U	217.5
Lead	1 U	1 U	1 U	1 UL	1 U	1 UL
Magnesium	25200	1 U	5580	12700	10600	5355
Manganese	55.75	79	78	244	24	79.75
Mercury	0.2 UL	0.2 U	0.2 U	0.2 U	0.2 U	0.2 UL
Nickel	11 U	11 U	11 U	11 U	11 U	11 U
Potassium	18750	4780	2970	3620	9420	2400
Selenium	10 UL	10 U	10 UL	10 UL	10 UL	2 UL
Silver	2 U	2 U	2 U	2 U	2 U	2 U
Sodium	513500	257000	147000	257000	195000	93900
Thallium	1 UL	1 UL	1 U	1 UL	1 UL	1 UL
Vanadium	4 U	4 U	4 U	4 U	4 U	4 U
Zinc	9.1	34	5 U	5 U	5 U	5 U

TABLE 5-39
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
METALS, DISSOLVED, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-221F 6/12/92 ug/L	GWA-226FDUP 6/17/92 ug/L	GWA-230F 6/18/92 ug/L	GWA-227F 6/15/92 ug/L	GWA-318F 12/18/92 ug/L	GWA-317FDUP 12/18/92 ug/L
Aluminum	18 U	18 U	18 U	59 U	693	15 U
Antimony	18 U	18 U	18 U	18 U	17 U	17 U
Arsenic	2 U	2 UL	2.7 L	2 U	1.2	1 U
Barium	155	101.5	104	28	39.8	47.85
Beryllium	2 U	2 U	2 U	2 U	1 U	1 U
Cadmium	3 U	3 U	3 U	3 U	4 U	4 U
Calcium	301000	190000	336000	43300	104000	142000
Chromium	8 U	8 U	8 U	8 U	9 U	9 U
Cobalt	8 U	8 U	8 U	8 U	10 U	10 U
Copper	2 U	3.15	5.1	2 U	2 U	2 U
Iron	2130	10 U	10 U	10 U	10 U	10 U
Lead	1 UL	1 U	1 U	1 UL	1 U	1 U
Magnesium	9360	9140	7280	37700	1 U	1054.5 J
Manganese	284	213.5	158	69	3 U	3 U
Mercury	0.2 UL	0.2 UL	0.2 UL	0.2 U	0.2 U	0.2 U
Nickel	11 U	11 U	11 U	11 U	12 U	12 U
Potassium	6400	7210	5220	25700	16100	10300
Selenium	10 UL	10 UL	10 UL	10 UL	1 UL	5 U
Silver	2 U	2 U	2 U	2 U	3 U	3 U
Sodium	177000	367000	207000	550000	140000	78350
Thallium	1 UL	5 UL	5 UL	1 UL	1 U	1 U
Vanadium	4 U	4 U	4 U	4 U	4 U	4 U
Zinc	5 U	9.4	18.9	5 U	3 U	3 U

TABLE 5-39
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
METALS, DISSOLVED, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWA-219F 6/19/92 ug/L	GWA-223F 6/17/92 ug/L	GWA-224F 6/17/92 ug/L	GWA-228F 6/19/92 ug/L	GWA-229F 6/19/92 ug/L
Aluminum	18 U	18 U	18 U	18 U	18 U
Antimony	18 U	18 U	18 U	18 U	18 U
Arsenic	2 U	2.9 L	5 L	2 U	2 U
Barium	55.5	6.2	11.4	3 U	82.5
Beryllium	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U
Calcium	94300	16600	55200	74200	328000
Chromium	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U
Copper	2 U	2 U	2 U	2 U	2 U
Iron	828	10 U	10 U	10 U	89
Lead	1 U	1 U	1 U	1 U	1 U
Magnesium	4690	763	1990	2720	5050
Manganese	114	3 U	69.3	103	3 U
Mercury	0.2 U	0.2 UL	0.2 UL	0.2 U	0.2 U
Nickel	11 U	11 U	11 U	11 U	11 U
Potassium	4010	2950	1470	1920	5840
Selenium	R	2 UL	2 UL	R	R
Silver	2 UL	2 U	2 U	2 UL	2 UL
Sodium	247000	13800	12800	41500	452000
Thallium	1 U	1 UL	1 UL	1 U	1 UL
Vanadium	4 U	4 U	4 U	4 U	4 U
Zinc	18.4	14.3	11.7	19	5 U

5.2 Analytical Results for Area B

Analytical results of soil, sediment, surface water, and groundwater samples collected at the Camp Allen Landfill Area B are presented on Tables 5-40 through 5-76. Tables have been developed based on parameter and media results for the samples collected at Area B of the Camp Allen Landfill Site. For the purpose of this study, essential elements (aluminum, calcium, magnesium, potassium, and sodium) have been eliminated from discussion in this section as they are typically found at elevated concentrations in tidally influenced coastal plain areas. Also, please note that each media is addressed as an individual subsection, and all data tables relevant to that media follow that specific subsection.

5.2.1 Source Characterization Subsurface Soil Sample Results

A total of 10 subsurface soil samples were collected from locations on and around the landfill area. Each soil sample was numbered sequentially from SBB-01 through SBB-10. A summary of Round 2 subsurface soil samples is presented in Table 5-40. For the purpose of this study essential elements (aluminum, calcium, magnesium, potassium, and sodium) have been eliminated from discussion in this section as they are typically found in coastal plain areas.

Volatile organic compounds were identified in five subsurface soil samples collected in Round 2 sampling efforts. Table 5-41 provides a complete listing of compounds detected and the corresponding concentrations. Vinyl chloride was detected in one sample (SBB-05) at 16 µg/kg. Methylene chloride was also detected in one sample (SBB-08) at 200 µg/kg. Acetone was detected in three samples (SBB-05, SBB-06, and SBB-07) at concentrations ranging from 170J µg/kg to 6,000J µg/kg. One soil sample (SBB-05) contained 12 µg/kg of 1,1-dichloroethane. Four soil samples (SBB-04, SBB-05, SBB-07, and SBB-08) exhibited concentrations of 1,2-dichloroethene and 4-methyl-2-pentanone ranging from 4J µg/kg to 4,300 µg/kg and from 61 µg/kg to 2,200 µg/kg, respectively. One soil sample (SBB-04) contained 1,2-dichloroethane at a concentration of 25J µg/kg. One soil sample (SBB-06) contained 10,000J µg/kg of 2-butanone. Two samples (SBB-04 and SBB-05) exhibited concentrations of 1,1,1-trichloroethane and benzene at 15J µg/kg and 8J µg/kg and 250 µg/kg and 26 µg/kg, respectively. Trichloroethane was detected in two samples (SBB-04 and SBB-07) at concentrations of 27J µg/kg and 3,100 µg/kg, respectively. Toluene was detected in four samples (SBB-04, SBB-05, SBB-06, and SBB-08) ranging from 14 µg/kg to 16,000 µg/kg. Ethylbenzene was detected in one sample (SBB-06) at a concentration of 30,000 µg/kg.

Xylenes (total) were detected in three samples (SBB-05, SBB-06, and SBB-08) at concentrations ranging from 4J µg/kg to 200,000 µg/kg.

Semivolatile organic compounds were identified in seven subsurface soil samples. Table 5-42 provides a complete list of compounds detected and the corresponding concentrations. Bis(2-ethylhexyl)phthalate was detected in one sample (SBB-10DUP) at a concentration of 61J µg/kg. One sample (SBB-06) contained di-n-butyl phthalate; 1,2-dichlorobenzene; 2-methylnaphthalene; naphthalene; and phenanthrene at concentrations of 830J µg/kg, 6,500 µg/kg, 3,300J µg/kg, 14,000 µg/kg, and 230J µg/kg, respectively. Six samples (SBB-02, SBB-03, SBB-04, SBB-08, SBB-09, and SBB-10DUP) contained diethyl phthalate at concentrations ranging from 23J µg/kg to 95J µg/kg. Two samples (SBB-07 and SBB-08) contained 2-methylphenol at concentrations of 180J µg/kg and 46J µg/kg, respectively. One sample (SBB-07) contained 4-methylphenol at 650J µg/kg. Three samples (SBB-04, SBB-07, and SBB-08) contained concentrations of phenol ranging from 25J µg/kg to 13,000 µg/kg.

Pesticide and PCB compounds were identified in one subsurface soil sample (SBB-06). Table 5-43 provides a complete list of compounds detected and the corresponding concentrations. The following compounds were detected at the respective concentrations in one subsurface soil sample (SBB-06); endosulfan I, 78 µg/kg; dieldrin, 1,500 µg/kg; 4,4'-DDE, 14J µg/kg; endosulfan II, 17J µg/kg; 4,4'-DDD, 3,800 µg/kg; endrin aldehyde, 12J µg/kg; and Aroclor-1254, 9,500 µg/kg.

Total metals were detected in all 10 of the subsurface soil samples collected. Table 5-44 provides a complete list of compounds detected and the corresponding concentrations. Antimony was detected in all but two samples (SBB-06 and SBB-10DUP) at concentrations ranging from 0.02 mg/kg to 8L mg/kg. The following metals were detected in all of the samples at the respective concentration ranges: arsenic, 0.66 mg/kg to 60.5 mg/kg; barium, 7 mg/kg to 1,480 mg/kg; iron, 2,010 mg/kg to 22,700 mg/kg; lead, 2.1mg/kg to 19.8J mg/kg; manganese, 6.8 mg/kg to 63.5J mg/kg; nickel, 2.275 mg/kg to 38.7 mg/kg; and zinc, 5.6 mg/kg to 47.9J mg/kg. The following metals were detected in all but two samples (SBB-06 and SBB-10DUP) at the respective concentration ranges: beryllium, 0.44 mg/kg to 5.6 mg/kg; cadmium, 0.67 mg/kg to 1.3 mg/kg; chromium, 5.9 mg/kg to 24.9 mg/kg; cobalt, 1.8 mg/kg to 16.2 mg/kg; copper, 1.9 mg/kg to 63.6 mg/kg; mercury, 0.1 mg/kg to 0.68 mg/kg; thallium, 0.45 mg/kg to 2 mg/kg; and vanadium, 6.2 mg/kg to 149 mg/kg. Selenium was detected in six samples (SBB-01, SBB-02, SBB-03, SBB-05, SBB-08, and SBB-09) at concentrations ranging from 0.46 mg/kg to 5.7J mg/kg. Silver was detected in all but three samples (SBB-01, SBB-06, and SBB-10DUP) at concentrations ranging from 0.44 mg/kg to 0.49 mg/kg.

TABLE 5-40
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE SUMMARY
AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SBB-01	X	X	X	X			X	X	X	X			
SBB-02	X	X	X	X			X	X	X	X			
SBB-03	X	X	X	X			X	X	X	X			
SBB-04	X	X	X	X			X	X	X	X			
SBB-05	X	X	X	X			X	X	X	X			
SBB-06	X	X	X	X			X	X	X	X			MS/MSD
SBB-07	X	X	X	X			X	X	X	X			
SBB-08	X	X	X	X			X	X	X	X			
SBB-09	X	X	X	X			X	X	X	X			
SBB-10	X	X	X	X			X	X	X	X			
SBB-11	X	X	X	X			X	X	X	X			DUP OF SBB-10

TABLE 5-41
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBB-01RE 5/19/92 ug/kg	SBB-02 5/19/92 ug/kg	SBB-03 5/19/92 ug/kg	SBB-04 5/19/92 ug/kg	SBB-05 5/19/92 ug/kg
Vinyl chloride	18 UJ	11 U	12 U	40 U	16
Methylene chloride	18 UJ	11 U	12 U	40 U	12 U
Acetone	18 U	11 U	12 U	40 U	170 J
1,1-dichloroethane	18 UJ	11 U	12 U	40 U	12
1,2-dichloroethene	18 UJ	11 U	12 U	420	79
1,2-dichloroethane	18 UJ	11 U	12 U	25 J	12 U
2-butanone	18 UJ	11 U	12 U	40 U	12 U
1,1,1-trichloroethane	18 UJ	11 U	12 U	15 J	8 J
Trichloroethene	18 UJ	11 U	12 U	27 J	12 U
Benzene	18 UJ	11 U	12 U	250	26
T-1,3-dichloropropene	18 UJ	11 U	12 U	40 U	12 U
4-methyl-2-pentanone	18 UJ	11 U	12 U	250	120
Toluene	18 UJ	11 U	12 U	85	68
Ethylbenzene	18 UJ	11 U	12 U	40 U	12 U
Xylenes(total)	18 UJ	11 U	12 U	40 U	4 J

TABLE 5-41
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBB-06 5/18/92 ug/kg	SBB-07 5/18/92 ug/kg	SBB-08 5/18/92 ug/kg	SBB-09 5/18/92 ug/kg	SBB-10 DUP 5/18/92 ug/kg
Vinyl chloride	15000 U	1500 U	12 U	11 U	12 U
Methylene chloride	15000 U	1500 U	200	11 U	12 U
Acetone	6000 J	1900	12 U	11 U	12 U
1,1-dichloroethane	15000 U	1500 U	12 U	11 U	12 U
1,2-dichloroethene	15000 U	4300	4 J	11 U	12 U
1,2-dichloroethane	15000 U	1500 U	12 U	11 U	12 U
2-butanone	10000 J	1500 U	12 U	11 U	12 U
1,1,1-trichloroethane	15000 U	1500 U	12 U	11 U	12 U
Trichloroethene	15000 U	3100	12 U	11 U	12 U
Benzene	15000 U	1500 U	12 U	11 U	12 U
T-1,3-dichloropropene	15000 U	1500 U	12 U	11 U	12 U
4-methyl-2-pentanone	15000 U	2200	61	11 U	12 U
Toluene	16000	1500 U	14	11 U	12 U
Ethylbenzene	30000	1500 U	12 U	11 U	12 U
Xylenes(total)	200000	1500 U	5 J	11 U	12 U

TABLE 5-42
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBB-01 5/19/92 ug/kg	SBB-02 5/19/92 ug/kg	SBB-03 5/19/92 ug/kg	SBB-04 5/19/92 ug/kg	SBB-05 5/19/92 ug/kg
Bis(2-ethylhexyl)phthalate	580 U	380 U	410 U	400 U	390 U
Butylphthalate,di-n-	580 U	380 U	410 U	400 U	390 U
Dichlorobenzene,1,2-	580 U	380 U	410 U	400 U	390 U
Diethylphthalate	580 U	48 J	23 J	95 J	390 U
Methylnaphthalene,2-	580 U	380 U	410 U	400 U	390 U
Methylphenol,2-	580 U	380 U	410 U	400 U	390 U
Methylphenol,4-	580 U	380 U	410 U	400 U	390 U
Naphthalene	580 U	380 U	410 U	400 U	390 U
Phenanthrene	580 U	380 U	410 U	400 U	390 U
Phenol	580 U	380 U	410 U	25 J	390 U

TABLE 5-42
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBB-06 5/18/92 ug/kg	SBB-07 5/18/92 ug/kg	SBB-08 5/18/92 ug/kg	SBB-09 5/18/92 ug/kg	SBB-10 DUP 5/18/92 ug/kg
Bis(2-ethylhexyl)phthalate	3900 UJ	2000 U	390 U	380 U	61 J
Butylphthalate,di-n-	830 J	2000 U	390 U	380 U	330 U
Dichlorobenzene,1,2-	6500	2000 U	390 U	380 U	390 U
Diethylphthalate	3900 U	2000 U	34 J	26 J	60 J
Methylnaphthalene,2-	3300 J	2000 U	390 U	380 U	390 U
Methylphenol,2-	3900 U	180 J	46 J	380 U	390 U
Methylphenol,4-	3900 U	650 J	390 U	380 U	390 U
Naphthalene	14000	2000 U	390 U	380 U	390 U
Phenanthrene	230 J	2000 U	390 U	380 U	390 U
Phenol	3900 U	13000	28 J	380 U	390 U

TABLE 5-43
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
PESTICIDE/PCBS, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBB-01 5/19/92 ug/kg	SBB-02 5/19/92 ug/kg	SBB-03 5/19/92 ug/kg	SBB-04 5/19/92 ug/kg	SBB-05 5/19/92 ug/kg
Endosulfan I	2.9 U	1.9 U	2 U	2 U	2 U
Dieldrin	5.8 U	3.8 U	4.1 U	4 U	3.9 U
DDE,4,4'-	5.8 U	3.8 U	4.1 U	4 U	3.9 U
Endosulfan II	5.8 U	3.8 U	4.1 U	4 U	3.9 U
DDD,4,4'-	5.8 U	3.8 U	4.1 U	4 U	3.9 U
Endrin aldehyde	5.8 U	3.8 U	4.1 U	4 U	3.9 U
Aroclor-1254	58 U	38 U	41 U	40 U	39 U

TABLE 5-43
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
PESTICIDE/PCBS, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBB-06 5/18/92 ug/kg	SBB-07 5/18/92 ug/kg	SBB-08 5/18/92 ug/kg	SBB-09 5/18/92 ug/kg	SBB-10 DUP 5/18/92 ug/kg
Endosulfan I	78	2 U	2 U	1.9 U	1.95 U
Dieldrin	1500	3.9 U	3.9 U	3.8 U	4 U
DDE,4,4'-	14 J	3.9 U	3.9 U	3.8 U	4 U
Endosulfan II	17 J	3.9 U	3.9 U	3.8 U	4 U
DDD,4,4'-	3800	3.9 U	3.9 U	3.8 U	4 U
Endrin aldehyde	12 J	3.9 U	3.9 U	3.8 U	4 U
Aroclor-1254	9500	39 U	39 U	38 U	39 U

TABLE 5-44
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBB-01 5/19/92 mg/kg	SBB-02 5/19/92 mg/kg	SBB-03 5/19/92 mg/kg	SBB-04 5/19/92 mg/kg	SBB-05 5/19/92 mg/kg
Aluminum	14600	8200	3360	5050	6090
Antimony	8 L	4.1	4.4	4.5	4.3
Arsenic	60.5 J	2.2	5.7	0.98	1
Barium	1480	27	7	12.1	14.6
Beryllium	5.6	0.45	0.49	0.49	0.48
Cadmium	1.3	0.68	0.74	0.74	0.72
Calcium	9290	311	352	517	544
Chromium	24.9	8.6	6	7.5	6.4
Cobalt	16.2	1.8	2	2	1.9
Copper	63.6	3.8	2.1	2.8	3.1
Iron	22700	6530	3820	3340	3880
Lead	19.8 J	4.6	3.1	2.9	3.1
Magnesium	2180	487	399	438	358
Manganese	63.5 J	47.2	14.6	12.1	12.3
Mercury	0.68	0.1	0.12	0.13	0.13
Nickel	38.7	5.2	3.5	4.3	3.9
Potassium	2230	316	389	423	320
Selenium	5.7 J	0.47	0.5	0.48 UL	0.47
Silver	0.73 U	0.45	0.49	0.49	0.48
Sodium	1250	515	399	552	561
Thallium	2	0.47	0.45	0.65	0.64
Vanadium	149	12.8	10.2	9.5	9.3
Zinc	47.9 J	17.1	7.9	18.6	13.2

TABLE 5-44
ROUND 2
SOURCE CHARACTERIZATION SUBSURFACE SOIL SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SBB-06 5/18/92 mg/kg	SBB-07 5/18/92 mg/kg	SBB-08 5/18/92 mg/kg	SBB-09 5/18/92 mg/kg	SBB-10DUP 5/18/92 mg/kg
Aluminum	10100	15500	3440	7140	9720
Antimony	4.2 UL	0.02	4.1	4	4.2 UL
Arsenic	0.78	2.5	0.66	1.1	1.4
Barium	32.9	41.9	9.5	19.2	30.45
Beryllium	0.47 U	0.49	0.46	0.44	0.47 U
Cadmium	0.7 U	0.73	0.69	0.67	0.705 U
Calcium	1240	782	361	302	499
Chromium	8 U	18.3	6.5	5.9	8 U
Cobalt	1.9 U	2	1.8	1.8	1.85 U
Copper	2 U	5.8	1.9	3.1	2 U
Iron	7150	13500	2010	3380	10145
Lead	6.2	8.6	2.1	5.5	6.55
Magnesium	432	938	314	477	577.5
Manganese	17.1	17.2	9.2 J	6.8	12.25
Mercury	0.12 U	0.11	0.1	0.1	0.115 U
Nickel	3.3	4.7	3.3	4.8	2.275
Potassium	451	682	276	329	355
Selenium	0.46 UL	0.48 UL	0.46	0.47	0.465 UL
Silver	0.47 U	0.49	0.46	0.44	0.47 U
Sodium	39 U	402	243	312	185.75
Thallium	1 U	0.5	0.59	0.56	1 U
Vanadium	4 U	26.6	6.2	10.4	4 U
Zinc	5.6	26	6	6.1	14.25

5.2.2 Surface Soil Sample Results

Surficial soils for Area B have been divided into two separate groups; each group correlates with a specific sampling round. The first group consists of soil samples collected at the Camp Allen Elementary School (CAES) during Round 2 sampling activities. Three samples were collected and numbered sequentially from SSB-01 through SSB-03. A summary of the surface soil samples collected at the CAES is presented in Table 5-45. Table 5-46 provides a complete list of compounds detected and the corresponding concentrations. Two samples (SSB-02 and SSB-03) contained antimony at 5.7L mg/kg and 7.8L mg/kg and mercury at 0.16K mg/kg and 0.24K mg/kg, respectively. The following metals were detected in all three samples at the respective concentration ranges: arsenic, 4L mg/kg to 25.1L mg/kg; barium, 42.8J mg/kg to 410J mg/kg; chromium, 11.7 mg/kg to 869 mg/kg; cobalt, 3.7 mg/kg to 7.5 mg/kg; copper, 12.9 mg/kg to 28.3 mg/kg; iron, 6,880 mg/kg to 8,700 mg/kg; lead, 18.1J mg/kg to 213J mg/kg; manganese, 41.9 mg/kg to 61.2 mg/kg; nickel, 9.5 mg/kg to 18.7 mg/kg; vanadium, 19 mg/kg to 128 mg/kg; and zinc, 5 mg/kg to 2570 mg/kg. Mercury was detected in two samples (SSB-02 and SSB-03) at concentrations of 0.16K mg/kg and 0.24K mg/kg, respectively. Selenium was detected in two samples (SSB-01 and SSB-02) at concentrations of 0.78 mg/kg and 1.2 mg/kg, respectively.

The second group consists of soil samples collected at and around the Area B landfill during Round 3 sampling efforts. Five samples were collected and numbered sequentially from SSB-05 through SSB-09 following the numbers from the surface soil samples from Round 2. A summary of surface soil samples collected in Round 3 is presented in Table 5-47.

Volatile organic compounds were identified in two samples collected during Round 3. Table 5-48 provides a complete list of compounds detected and the corresponding concentrations. One sample (SSB-05DUP) contained 2-butanone at a concentration of 61 µg/kg. Methylene chloride was also detected in one sample (SSB-07) at a concentration of 54 µg/kg. No other volatiles organic compounds were detected in any of the surface soils affiliated with Area B.

Semivolatile organic compounds were detected in three surface soil samples. Table 5-49 provides a complete list of compounds detected and the corresponding concentrations. One sample (SSB-06) contained naphthalene and butyl benzyl phthalate at concentrations of 29J µg/kg and 17J µg/kg, respectively. Phenanthrene was detected in one sample (SSB-08) at a concentration of 70J µg/kg. Three samples (SSB-06, SSB-07, and SSB-08) contained the following compounds at the following concentration ranges: fluoranthrene, 27J µg/kg to 150J µg/kg; pyrene, 27J µg/kg to 130J µg/kg; benzo(a)anthracene, 24J µg/kg to 75J µg/kg; chrysene, 28J µg/kg to 73J µg/kg; benzo(b)fluoranthene, 56J µg/kg to 99J µg/kg; benzo(k)fluoranthene, 21J µg/kg to 38J µg/kg; Benzo(a)pyrene, 30J µg/kg to 68J µg/kg; indeno(1,2,3-cd)pyrene, 24J µg/kg to 45J µg/kg; and benzo(g,h,i)perylene, 19J µg/kg to 40J µg/kg.

Pesticide/PCB compounds were detected in five surface soil samples. Table 5-50 provides a complete list of compounds detected and the corresponding concentrations. Two samples (SSB-07 and SSB-08) contained aldrin at a concentration of 0.79J µg/kg and 5.8L µg/kg, respectively. One sample (SSB-09) contained heptachlor epoxide and dieldrin at concentrations of 1.5J µg/kg and 5.2 µg/kg, respectively. Endosulfan I was detected in four samples (SSB-05DUP, SSB-06, SSB-07, and SSB-08) at concentrations ranging from 0.44J µg/kg to 8.4L µg/kg. Four samples (SSB-05DUP, SSB-06, SSB-07 and SSB-09) contained 4,4'-DDE at concentrations ranging from 6.1 µg/kg to 20L µg/kg. Two samples (SSB-05DUP and SSB-09) contained 4,4'-DDD at concentrations of 8.9L µg/kg and 1.6J µg/kg, respectively. Two samples (SSB-06 and SSB-09) contained concentrations of 4,4'-DDT at concentrations of 16L µg/kg and 1.4J µg/kg, respectively. Alpha-chlordane was detected in five samples (SSB-05DUP, SSB-06, SSB-07, SSB-08, and SSB-09) at concentrations ranging from 1.45J µg/kg to 22L µg/kg. Gamma-chlordane was detected in three samples (SSB-05DUP, SSB-07, and SSB-09) at concentrations ranging from 0.43J µg/kg to 1.9 µg/kg. Aroclor-1260 was detected in five samples (SSB-05DUP, SSB-06, SSB-07, SSB-08, and SSB-09) at concentrations ranging from 26J µg/kg to 780L µg/kg.

Total metals were detected in all of the soil samples collected in Round 3 sampling efforts. Table 5-51 provides a complete list of compounds detected and the corresponding concentrations. The following metals were detected in all of the samples at the following concentration ranges: arsenic, 2.5 mg/kg to 13.8 mg/kg; chromium, 7.9 mg/kg to 44.3 mg/kg; iron, 4,540 mg/kg to 13,600 mg/kg; lead, 29.6 mg/kg to 251 mg/kg; manganese, 23.2 mg/kg to 102 mg/kg; mercury, 0.12 mg/kg to 0.77 mg/kg; vanadium, 10.2 mg/kg to 19.8 mg/kg and zinc, 5 mg/kg to 405 mg/kg. Four samples (SSB-05DUP, SSB-06, SSB-07, and SSB-08) contained the following metals at the following concentration ranges: cadmium, 1.5 mg/kg to 20.5 mg/kg; copper, 16.6 mg/kg to 87.8 mg/kg; and nickel, 4.15 mg/kg to 25.3 mg/kg. Barium was detected in three samples (SSB-05DUP, SSB-06, and SSB-08) at concentrations ranging from 17.65J µg/kg to 44.4 J mg/kg. Cobalt and thallium were detected in one sample (SSB-06) at a concentration of 6.7 mg/kg and 0.23 mg/kg, respectively.

TABLE 5-45
ROUND 2
ELEMENTARY SCHOOL SURFACE SOIL SAMPLE SUMMARY
AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SSB-01				X						X			
SSB-02				X						X			
SSB-03				X						X			MS/MSD

TABLE 5-46
ROUND 2
ELEMENTARY SCHOOL SURFACE SOIL SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SSB-01 5/02/92 mg/kg	SSB-02 5/02/92 mg/kg	SSB-03 5/02/92 mg/kg
Aluminum	5630	9120	7440
Antimony	0 R	5.7 L	7.8 L
Arsenic	4 L	25.1 L	8.2 L
Barium	192 J	410 J	42.8 J
Beryllium	0.46 U	0.46 U	0.46 U
Cadmium	0.95 U	0.95 U	31.3
Calcium	19900 J	4810 J	4270 J
Chromium	13.4	11.7	869
Cobalt	3.7	4.7	7.5
Copper	13.4	28.3	12.9
Iron	8700	8530	6880
Lead	51.9 J	18.1 J	213 J
Magnesium	1010	869	611
Manganese	61.2	53.5	41.9
Mercury	0.12 U	0.16 K	0.24 K
Nickel	9.5	18.7	10.9
Potassium	676	1710	582
Selenium	0.78	1.2	0.46 U
Silver	2 U	2 U	2 U
Sodium	39 U	39 U	39 U
Thallium	1 U	1 U	1 U
Vanadium	42.8	128	19
Zinc	120	5	2570

TABLE 5-47
ROUND 3
SURFACE SOIL SAMPLE SUMMARY
AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SSB-05	X	X	X	X			X	X	X	X			
SSB-06	X	X	X	X			X	X	X	X			
SSB-07	X	X	X	X			X	X	X	X			MS/MSD
SSB-08	X	X	X	X			X	X	X	X			
SSB-09	X	X	X	X			X	X	X	X			
SSB-10	X	X	X	X			X	X	X	X			DUP OF SSB-05 (1)

Note: (1) Duplicate is also a quality control sample for surface soil samples from Area A.

TABLE 5-48
ROUND 3
SURFACE SOIL SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SSB-05DUP 12/8/92 ug/kg	SSB-06 12/8/92 ug/kg	SSB-07 12/8/92 ug/kg	SSB-08 12/8/92 ug/kg	SSB-09 12/8/92 ug/kg
Methylene chloride	17 U	11 U	54	14 U	11 U
2-butanone	61	11 U	11 U	14 U	11 U

TABLE 5-49
ROUND 3
SURFACE SOIL SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL , NORFOLK, VIRGINIA

Sample No. Date Collected Units	SSB-05 DUP 12/8/92 ug/kg	SSB-06 12/8/92 ug/kg	SSB-07 12/8/92 ug/kg	SSB-08 12/8/92 ug/kg	SSB-09 12/8/92 ug/kg
Naphthalene	490 U	29 J	350 U	610 U	360 U
Phenanthrene	490 U	390 U	350 U	70 J	360 U
Fluoranthene	490 U	49 J	27 J	150 J	360 U
Pyrene	490 U	49 J	27 J	130 J	360 U
Butylbenzylphthalate	490 U	17 J	350 U	610 U	360 U
Benzo(a)anthracene	490 U	53 J	24 J	75 J	360 U
Chrysene	490 U	69 J	28 J	73 J	360 U
Benzo(b)fluoranthene	490 U	99 J	56 J	95 J	360 U
Benzo(k)fluoranthene	490 U	37 J	21 J	38 J	360 U
Benzo(a)pyrene	490 U	54 J	30 J	68 J	360 U
Indeno(1,2,3-cd)pyrene	490 UJ	45 J	24 J	38 J	360 UJ
Benzo(g,h,i)perylene	490 UJ	39 J	19 J	40 J	360 UJ

TABLE 5-50
ROUND 3
SURFACE SOIL SAMPLE RESULTS
PESTICIDE/PCB, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample No. Date Collected Units	SSB-05DUP 12/8/92 ug/kg	SSB-06 12/8/92 ug/kg	SSB-07 12/8/92 ug/kg	SSB-08 12/8/92 ug/kg	SSB-09 12/8/92 ug/kg
Aldrin	2.45 UL	2 UL	0.79 J	5.8 L	1.8 U
Heptachlor epoxide	2.45 UL	2 UL	1.8 U	3 UL	1.5 J
Endosulfan I	1.9 J	1.2 J	0.44 J	8.4 L	1.8 U
Dieldrin	4.9 UL	3.9 UL	3.5 U	6.1 UL	5.2
4,4'-DDE	20 L	10 L	7.9	6.1 UL	6.1
4,4'-DDD	8.9 L	3.9 UL	3.5 U	6.1 UL	1.6 J
4,4'-DDT	4.9 UL	16 L	3.5 U	6.1 UL	1.4 J
Endrin ketone	1.62 UL	3.9 UL	3.5 U	6.1 UL	3.6 U
Alpha-Chlordane	1.45 J	7.1 L	1.5 J	22 L	2.8
Gamma-Chlordane	1.1 J	2 UL	0.43 J	3 UL	1.9
Aroclor-1260	255 L	320 L	160	780 L	26 J

TABLE 5-51
ROUND 3
SURFACE SOIL SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SSB-05DUP 12/8/92 mg/kg	SSB-06 12/8/92 mg/kg	SSB-07 12/8/92 mg/kg	SSB-08 12/8/92 mg/kg	SSB-09 12/8/92 mg/kg
Aluminum	4975	4870	1680	3180	4730
Antimony	5.6 UL	3.7 UL	3.8 UL	4.8 UL	3.8 UL
Arsenic	13.8	5.8	2.5	2.6	2.6
Barium	17.65 J	33.2 J	1 U	44.4 J	1 U
Beryllium	0.33 U	0.22 U	0.22 U	0.28 U	0.22 U
Cadmium	3.05	12.8	1.5	20.5	0.9 U
Calcium	1600 J	31400 J	6580 J	1850 J	2950 J
Chromium	16.05	24.3	13.5	44.3	7.9
Cobalt	3.3 U	6.7	2.2 U	2.8 U	2.2 U
Copper	32.7	16.6	39.8	87.8	2 U
Iron	7695	10400	13600	4540	4680
Lead	73.35	251	75.3	150	29.6
Magnesium	14 U	14 U	14 U	14 U	14 U
Manganese	23.2	102	62	70.5	34
Mercury	0.355	0.17	0.16	0.77	0.12
Nickel	4.15	25.3	7.9	15.3	2.7 U
Potassium	192 U	192 U	192 U	192 U	192 U
Selenium	0.655 UL	0.43 UL	0.44 UL	0.55 UL	0.45 UL
Silver	0.84 U	0.84 U	0.84 U	0.84 U	0.67 U
Sodium	39 U	39 U	39 U	39 U	39 U
Thallium	0.33 U	0.23	0.22 U	0.28 U	0.22 U
Vanadium	18.6	18.6	11.3	19.8	10.2
Zinc	5	5	5	405	5

5.2.3 Sediment Sample Results

Eight sediment samples, including shallow and deep samples, were collected in Round 2 sampling efforts. Each sediment sample was numbered sequentially SDB-01 through SDB-06. Table 5-52 presents a summary of sediment samples and the requested analyses.

Volatile organic compounds were identified in all eight sediment samples. Table 5-53 provides a complete list of compounds detected and the corresponding concentrations. Vinyl chloride was detected in three samples (SDB-01, SDB-04D, and SDB-06) at concentrations ranging from 11J µg/kg to 60 µg/kg. Methylene chloride was detected in two samples (SDB-04SDUP and SDB-06) at concentrations of 103.5J µg/kg and 23J µg/kg, respectively. Five samples (SDB-01, SDB-03, SDB-04SDUP, SDB-04DDUP, and SDB-05D) contained concentrations of acetone ranging from 120 µg/kg to 3,550 µg/kg. Carbon disulfide was detected in two samples (SDB-03 and SDB-05D) at concentrations of 22J µg/kg and 29J µg/kg, respectively. Two samples (SDB-01 and SDB-06) contained 1,1-dichloroethane and benzene at concentrations of 8J µg/kg and 15J µg/kg and 14J µg/kg and 62 µg/kg, respectively. Seven samples (SDB-01, SDB-03, SDB-04SDUP, SDB-04DDUP, SDB-05S, SDB-05D, and SDB-06) contained 1,2-dichloroethene and trichloroethene at concentrations ranging from 11J µg/kg to 345 µg/kg and 3J µg/kg to 520 µg/kg, respectively. One sample (SDB-01) contained 1,2-dichloroethane and xylenes (total) at a concentration of 20 µg/kg and 4J µg/kg, respectively. Seven samples (SDB-01, SDB-02, SDB-03, SDB-04SDUP, SDB-04DDUP, SDB-05D, and SDB-06) contained concentrations of 2-butanone ranging from 17 µg/kg to 1,950 µg/kg. Tetrachloroethene was detected in two samples (SDB-04SDUP and SDB-04DDUP) at concentrations of 81J µg/kg and 150 µg/kg, respectively. Chlorobenzene was detected in one sample (SDB-05D) at a concentration of 27J µg/kg.

Semivolatile organic compounds were detected in all eight sediment samples collected in Round 2 sampling efforts. Table 5-54 provides a complete list of compounds detected and the corresponding concentrations. Phenol was detected in two samples (SDB-01 and SDB-04SDUP) at concentrations of 73J µg/kg and 2,500J µg/kg, respectively. One sample (SDB-06) contained the following compounds at the following concentrations: 1,4-dichlorobenzene, 45J µg/kg; 1,2-dichlorobenzene, 49J µg/kg and 2-methylnaphthalene, 30J µg/kg. Three samples (SDB-01, SDB-04SDUP, and SDB-04DDUP) contained 4-methylphenol at concentrations ranging from 310J µg/kg to 19,000 µg/kg. One sample (SDB-04SDUP) contained 2,4-dimethylphenol at a concentration of 380J µg/kg. Two samples (SDB-05D and SDB-06) contained naphthalene at concentrations of 200J µg/kg and 46J µg/kg, respectively. Acenaphthene was detected in two samples (SDB-05S and SDB-05D) at concentrations of 430J µg/kg and 4,100 µg/kg, respectively. Three samples (SDB-02, SDB-03, and SDB-04SDUP) contained phenanthrene at concentrations ranging from 86J µg/kg to 220J µg/kg. Di-n-butyl phthalate was detected in one sample (SDB-04SDUP) at a concentration of 1300J µg/kg. Six samples (SDB-02, SDB-03, SDB-04SDUP, SDB-04DDUP, SDB-05S, and SDB-05D) contained fluoranthene and pyrene at concentrations ranging from 52J µg/kg to 1,000J µg/kg and 39J µg/kg to 800J µg/kg, respectively. Four samples (SDB-02, SDB-03, SDB-04SDUP, and SDB-05D) contained benzo(a)anthracene at concentrations ranging from 50J µg/kg to 250J µg/kg. Five samples (SDB-02, SDB-03, SDB-04SDUP, SDB-04DDUP, and SDB-05D) contained chrysene and benzo(b)fluoranthene at concentrations ranging from 50J µg/kg to 460J µg/kg and 74J µg/kg to 460J µg/kg, respectively. Bis(2-ethylhexyl)phthalate was detected in five samples (SDB-03, SDB-04SDUP, SDB-04DDUP, SDB-05S, and SDB-05D) at concentrations ranging from 390J µg/kg to 5,300 µg/kg. Benzo(k)fluoranthene was detected in three samples (SDB-02, SDB-03, and SDB-04SDUP) at concentrations ranging from 25J µg/kg to 160J µg/kg. Benzo(a)pyrene was detected in four samples (SDB-02, SDB-03, SDB-04SDUP, and SDB-04DDUP) at concentrations ranging from 48J µg/kg to 230J µg/kg.

Pesticide/PCB compounds were identified in all eight of the sediment samples collected. Table 5-55 provides a complete list of compounds detected and the corresponding concentrations. Aldrin was detected in three samples (SDB-04SDUP, SDB-04DDUP, and SDB-05D) at concentrations ranging from 3.4J µg/kg to 14 µg/kg. Two samples (SDB-04SDUP and SDB-05S) contained heptachlor epoxide at concentrations of 3.98J µg/kg and 1.2J µg/kg, respectively. Four samples (SDB-01, SDB-02, SDB-04SDUP, and SDB-06) contained endosulfan I at concentrations ranging from 0.72J µg/kg to 6.7J µg/kg. All eight samples contained the following compounds at the following concentration ranges: dieldrin, 3.1J µg/kg to 86K µg/kg; 4,4'-DDE, 4.9J µg/kg to 850 µg/kg; and 4,4'-DDD, 15 µg/kg to 4200 µg/kg. Endrin was detected in three samples (SDB-02, SDB-04DDUP, and SDB-05D) at concentrations ranging from 0.87J µg/kg to 25J µg/kg. Methoxychlor was detected in one sample (SDB-01) at a concentration of 4.6J µg/kg. Endrin aldehyde was detected in three samples (SDB-01, SDB-03, and SDB-06) at concentrations ranging from 4.1J µg/kg to 180K µg/kg. One sample (SDB-05D) contained gamma-BHC and endrin ketone at concentrations of 1.2J µg/kg and 1.1J µg/kg, respectively. Two samples (SDB-04DDUP and SDB-05D) contained 4,4'-DDT at concentrations of 2,495 µg/kg and 1.1J µg/kg, respectively. Five samples (SDB-03, SDB-04SDUP, SDB-04DDUP, SDB-05S, and SDB-06) contained alpha-chlordane at concentrations ranging from 0.68J µg/kg to 31K µg/kg. Gamma-chlordane was detected in six samples (SDB-01, SDB-03, SDB-04SDUP, SDB-05S, SDB-05D, and SDB-06) at concentrations ranging from 2.4J µg/kg to 56K µg/kg. Aroclor-1248 was detected in three samples (SDB-04SDUP, SDB-05S, and SDB-05D) at concentrations ranging from 21J µg/kg to 170J µg/kg. Aroclor-1254 was detected in seven samples (SDB-01, SDB-03, SDB-04S, SDB-04DDUP, SDB-05S, SDB-05D, and SDB-06) at concentrations ranging from 170 µg/kg to 7,600 µg/kg.

Total metals were identified in eight sediment samples collected in Round 2 sampling efforts. Table 5-56 provides a complete list of metals detected and the corresponding concentrations. Antimony was detected in one sample (SDB-03) at a concentration of 16L mg/kg. Arsenic, mercury, and vanadium were detected in all but one sample (SDB-02) at concentrations ranging from 3.2 mg/kg to 52.45 mg/kg, 0.25 mg/kg to 19.35 mg/kg, and 6.8 mg/kg to 542K mg/kg, respectively. Barium was detected in all but one sample (SDB-06) at concentrations ranging from 22.1 mg/kg to 211J mg/kg. Two samples (SDB-01 and SDB-04DDUP) contained beryllium at concentrations of 0.76 mg/kg and 0.4925 mg/kg, respectively. Six samples (SDB-01, SDB-03, SDB-04SDUP, SDB-04DDUP, SDB-05S, and SDB-05D) contained cadmium and nickel at concentrations ranging from 1.5 mg/kg to 41.9 mg/kg and 9.7 mg/kg to 1,255 mg/kg, respectively. Five samples (SDB-03, SDB-04SDUP, SDB-04DDUP, SDB-05S, and SDB-05D) contained cobalt at concentrations ranging from 3.3 mg/kg to 216J mg/kg. The following metals were detected in all of the samples at the respective concentration ranges: chromium, 1.9 mg/kg to 225 mg/kg; copper, 12.8 mg.kg to 22,700 mg/kg; iron, 170J mg/kg to 83,300 mg/kg; lead, 23.1J mg/kg to 1,750 mg/kg; and manganese, 0.26 mg/kg to 246 mg/kg. Silver was detected in two samples (SDB-03 and SDB-04SDUP) at concentrations of 10 mg/kg and 14.95 mg/kg, respectively.

TABLE 5-52
ROUND 2
SEDIMENT SAMPLE SUMMARY
AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID (1)	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SDB-01	X	X	X	X			X	X	X	X			
SDB-02	X	X	X	X			X	X	X	X			
SDB-03	X	X	X	X			X	X	X	X			
SDB-04(S)	X	X	X	X			X	X	X	X			MS/MSD
SDB-04(D)	X	X	X	X			X	X	X	X			MS/MSD
SDB-05(S)	X	X	X	X			X	X	X	X			
SDB-05(D)	X	X	X	X			X	X	X	X			
SDB-06	X	X	X	X			X	X	X	X			
SDB-07(S)	X	X	X	X			X	X	X	X			DUP OF SDB-04(S)
SDB-08(D)	X	X	X	X			X	X	X	X			DUP OF SDB-04(D)

(1) (S) Shallow - (0-6") and (D) Deep - (6-12")

TABLE 5-53
ROUND 2
SEDIMENT SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDB-01 4/30/92 ug/kg	SDB-02 4/30/92 ug/kg	SDB-03 4/30/92 ug/kg	SDB-04SDUP 4/29/92 ug/kg	SDB-04DDUP 4/29/92 ug/kg	SDB-05S 4/28/92 ug/kg	SDB-05D 4/28/92 ug/kg	SDB-06 4/30/92 ug/kg
Vinyl chloride	44	13 U	37 U	230 U	11 J	12 U	57 U	60
Methylene chloride	15 U	13 U	37 U	103.5 J	33.5 U	12 U	57 U	23 J
Acetone	120	13 U	610	3550	470	12 U	520	37 U
Carbon disulfide	15 U	13 U	22 J	230 U	33.5 U	12 U	29 J	37 U
1,1-dichloroethane	8 J	13 U	37 U	230 U	33.5 U	12 U	57 U	15 J
1,2-dichloroethene	130	13 U	11 J	345	62.5 J	11 J	26 J	230
1,2-dichloroethane	20	13 U	37 U	230 U	33.5 U	12 U	57 U	37 U
2-butanone	24	17	250	1950	155	12 U	120	67
Trichloroethene	71	13 U	13 J	96 J	36	3 J	12 J	520
Benzene	14 J	13 U	37 U	230 U	33.5 U	12 U	57 U	62
Tetrachloroethene	15 U	13 U	37 U	81 J	150	12 U	57 U	37 U
Chlorobenzene	15 U	13 U	37 U	230 U	33.5 U	12 U	27 J	37 U
Xylenes(total)	4 J	13 U	37 U	230 U	33.5 U	12 U	57 U	37 U

TABLE 5-54
ROUND 2
SEDIMENT SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDB-01 4/30/92 ug/kg	SDB-02 4/30/92 ug/kg	SDB-03 4/30/92 ug/kg	SDB-04S DUP 4/29/92 ug/kg	SDB-04D DUP 4/29/92 ug/kg	SDB-05S 4/28/92 ug/kg	SDB-05D 4/28/92 ug/kg	SDB-06 4/30/92 ug/kg
Phenol	73 J	420 U	2400 U	2500 J	5950 U	790 U	3800 U	490 U
Dichlorobenzene,1,4-	1000 U	420 U	2400 U	4400 U	5950 U	790 U	3800 U	45 J
Dichlorobenzene,1,2-	1000 U	420 U	2400 U	4400 U	5950 U	790 U	3800 U	49 J
Methylphenol,4-	310 J	420 U	2400 U	19000	420 J	790 U	3800 U	490 U
Dimethylphenol,2,4-	1000 U	420 U	2400 U	380 J	5950 U	790 U	3800 U	490 U
Naphthalene	1000 U	420 U	2400 U	4400 U	5950 U	790 U	200 J	46 J
Methylnaphthalene,2-	1000 U	420 U	2400 U	4400 U	5950 U	790 U	3800 U	30 J
Acenaphthene	1000 U	420 U	2400 U	4400 U	5950 U	430 J	4100	490 U
Phenanthrene	1000 U	86 J	200 J	220 J	5950 U	790 U	3800 U	490 U
Butylphthalate,di-n-	1000 U	420 U	2400 U	1300 J	5950 U	790 U	3800 U	490 U
Fluoranthene	1000 U	130 J	630 J	500 J	495 J	52 J	1000 J	490 U
Pyrene	1000 U	75 J	350 J	330 J	375 J	39 J	800 J	490 U
Benzo(a)anthracene	1000 U	50 J	190 J	170 J	5950 U	790 U	250 J	490 U
Chrysene	1000 U	50 J	350 J	295 J	300 J	790 U	460 J	490 U
Bis(2-ethylhexyl)phthalate	1000 U	420 U	5300	4650	3100 J	390 J	1900 J	490 U
Benzo(b)fluoranthene	1000 U	74 J	390 J	290 J	460 J	790 U	330 J	490 U
Benzo(k)fluoranthene	1000 U	25 J	140 J	160 J	5950 U	790 U	3800 U	490 U
Benzo(a)pyrene	1000 U	48 J	210 J	210 J	230 J	790 U	3800 U	490 U

TABLE 5-55
ROUND 2
SEDIMENT SAMPLE RESULTS
PESTICIDE/PCB, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDB-01 4/30/92 ug/kg	SDB-02 4/30/92 ug/L	SDB-03 4/30/92 ug/L	SDB-04S DUP 4/29/92 ug/kg	SDB-04D DUP 4/29/92 ug/kg	SDB-05S 4/28/92 ug/kg	SDB-05D 4/28/92 ug/kg	SDB-06 4/30/92 ug/L
Aldrin	2.5 U	2.1 U	31 U	5.95 J	3.4 J	7.9 U	14	2.5 U
Heptachlor epoxide	2.5 U	2.1 U	31 U	3.98 J	19 U	1.2 J	3.8 U	2.5 U
Endosulfan I	2.3 J	0.72 J	31 U	6.7 J	19 U	7.9 U	3.8 U	5.6
Dieldrin	15	3.6 J	86 K	13.45 J	28 J	9.9 J	62	3.1 J
DDE,4,4'-	12	4.9	850	23.5 J	225 L	13 J	85	36 K
Endrin	5.1 U	0.87 J	62 U	10.75 U	25 J	16 U	11	5 U
DDD,4,4'-	54	15	4200	79	3350 J	310	380	100 K
Methoxychlor	4.6 J	21 U	310 U	53 U	190 U	79 U	38 U	25 U
Endrin aldehyde	4.1 J	4.2 U	180 K	10.75 U	120 U	16 U	7.7 U	8.3
BHC,gamma-	2.5 U	2.1 U	31 U	5.3 U	19 U	7.9 U	1.2 J	2.5 U
DDT,4,4'-	5.1 U	3.3 U	62 U	10.75 U	2495	16 U	1.1 J	3.3 U
Endrin ketone	5.1 U	3.3 U	62 U	10.75 U	37 U	16 U	1.1 J	5 U
Chlordane,alpha-	2.5 U	0.38 U	31 K	4.95 J	22 J	2.4 J	3.8 U	0.68 J
Chlordane,gamma-	3	2.1 U	56 K	4.05 J	27 U	4.3 J	16	2.4 J
Aroclor-1248	51 U	42 U	620 U	107.5 U	170 J	21 J	68 J	50 U
Aroclor-1254	260	42 U	7600	225 J	2100	170	980	200

TABLE 5-56
ROUND 2
SEDIMENT SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDB-01 4/30/92 mg/kg	SDB-02 4/30/92 mg/kg	SDB-03 4/30/92 mg/kg	SDB-04S DUP 4/29/92 mg/kg	SDB-4D DUP 4/29/92 mg/kg	SDB-05S 4/28/92 mg/kg	SDB-05D 4/28/92 mg/kg	SDB-06 4/30/92 mg/kg
Aluminum	2120	1040	26800	13600 L	8970 L	1470	2090	2040
Antimony	0 R	0 R	16 L	16.6 U	18 U	4.1 UL	18 U	0 R
Arsenic	8.6 L	2 U	25.2 L	52.45	39.5	3.2	18.8	6.3 L
Barium	211 J	31.6 J	171 J	141.5	61	22.1	36.7	3 U
Beryllium	0.76	0.5 U	3 U	1.75 U	0.4925	0.46 U	0.46 U	0.58 U
Cadmium	11.8	0.75 U	41.9	13.7	14.25	1.5	11.8	0.87 U
Calcium	13400 J	2740 J	3170 J	3525	1910	509	2000	820 J
Chromium	12.9	3	225	52.65	9.5	31.2	1.9	6.1
Cobalt	2.5 U	2 U	20.8	8.4	131 J	3.3	216 J	2.3 U
Copper	32.7	41.4	298	301 J	22700	553 J	9330	12.8
Iron	8710	3180	40700	83300	211 J	5880	170 J	5240
Lead	61.9 J	26.9 J	497 J	383 J	1750	36.5 J	512	23.1 J
Magnesium	436	1 U	4950	2870	89.8	367	50.7	295
Manganese	33.9	9.8	246	208.5	0.4	51.2	0.26	12.5
Mercury	0.35 K	0.13 U	1.4 K	0.5175	19.35	0.25	11.1	0.26 K
Nickel	9.7	2.7 U	42.3	22.65	1255	25.6	341	3.2 U
Potassium	287	104	3870	2110	3.95	274	22	184
Silver	2 U	2 U	10	14.95	2 U	2 U	2 U	2 U
Sodium	39 U	39 U	39 U	708.5	42.8	39 U	10.6	39 U
Vanadium	37	4 U	130	76.6	434.5 K	6.8	542 K	10.4
Zinc	244	80.4	1020	857 K		244 K		43.2

TABLE 5-56
ROUND 2
SEDIMENT SAMPLE RESULTS
SELECTED METALS, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SDA-08 5/12/92 mg/kg	SDA-12S 6/02/92 mg/kg	SDA-12D 6/02/92 mg/kg
Arsenic	23	2 U	6.4
Cadmium	3U	0.65U	3 U
Chromium	34	2 U	21
Lead	94	2 U	310
Mercury	0.6	0.15 U	0.8
Silver	1.5U	0.65U	1 U
Vanadium	58	2 U	2 U

NOTE: SDA-08 and SDA-12 have been included as part of Area B for the purpose of this study.

5.2.4 Surface Water Sample Results

Seven surface water samples were collected in Round 2 sampling efforts associated with Area B. The samples were numbered sequentially SWB-01 through SWB-05. Table 5-57 presents a summary of surface water samples collected and the requested analyses. In addition, SWA-08 and SWA-12 were included as part of the Area B study because of their proximity to the Camp Allen Landfill Area B site.

Volatile organic compounds were identified in five of the samples collected. Table 5-58 provides a complete list of compounds detected and the corresponding concentrations. Four samples (SWB-01, SWB-03, SWB-04DUP, and SWB-05) contained concentrations of vinyl chloride ranging from 6J µg/L to 22 µg/L. Carbon disulfide was detected in one sample (SWB-03) at a concentration of 3J µg/L. Two samples (SWB-01 and SWB-03) contained 1,1-dichloroethane and 1,2-dichloroethane at concentrations of 3J µg/L and 2J µg/L and 8J µg/L and 3J µg/L, respectively. Four samples (SWB-01, SWB-03, SWB-04DUP, and SWB-05) contained 1,2-dichloroethene and trichloroethene at concentrations ranging from 15 µg/L to 46 µg/L and 20 µg/L to 45 µg/L, respectively. Chloroform was detected in two samples (SWB-02 and SWB-03) at concentrations of 24 µg/L and 3J µg/L, respectively. One sample (SWB-04DUP) contained 2-butanone at a concentration of 4.5J µg/L. Bromodichloromethane was detected in one sample (SWB-02) at a concentration of 6J µg/L. Benzene was detected in three samples (SWB-01, SWB-03, and SWB-04DUP) at concentrations ranging from 3J µg/L to 12 µg/L. Tetrachloroethene was detected in one sample (SWB-05) at a concentration of 6J µg/L.

Semivolatile organic compounds were detected in four surface water samples collected. Table 5-59 provides a complete list of compounds detected and the corresponding concentrations. One sample (SWB-01) contained phenol and 4-methylphenol at concentrations of 0.9J µg/L and 3J µg/L, respectively. Two samples (SWB-01 and SWA-12) contained 2,4-dimethylphenol at concentrations of 1J µg/L and 2J µg/L, respectively. Acenaphthene was detected in one sample (SWB-05) at a concentration of 0.7J µg/L. Di-n-butyl phthalate was detected in one sample (SWB-04DUP) at a concentration of 3J µg/L. Bis(2-ethylhexyl)phthalate was detected in two samples (SWB-04DUP and SWB-05) at concentrations of 7J µg/L and 2J µg/L, respectively. Diethyl phthalate was detected in one sample (SWA-12) at a concentration of 0.9J µg/L.

Pesticide/PCB compounds were detected in five samples. Table 5-60 provides a complete list of compounds detected and the corresponding concentrations. Gamma-BHC was detected in two samples (SWB-04DUP and SWB-05) at concentrations of 0.0065J µg/L and 0.013J µg/L, respectively. Four samples (SWB-03, SWB-05, SWA-08, and SWA-12) contained 4,4'-DDD at concentrations ranging from 0.007J µg/L to 0.038J µg/L. One sample (SWA-12) contained 4,4'-DDE at a concentration of 0.02J µg/L.

Total metals were identified in all surface water samples collected in Round 2 sampling efforts. Table 5-61 provides a complete list of metals detected and the corresponding concentrations. Antimony and copper were detected in one sample (SWA-12) at concentrations of 20.6 µg/L and 27.1 µg/L, respectively. Arsenic was detected in all but one sample (SWB-02) at concentrations ranging from 4.05 µg/L to 11.5K µg/L. The following metals were detected in all of the surface water samples at the following concentrations: barium, 33.2 µg/L to 197 µg/L; iron, 539 µg/L to 14,300 µg/L; lead, 1.4J µg/L to 53.6 µg/L; manganese, 18.6 µg/L to 574 µg/L; and zinc, 49.1J µg/L to 202J µg/L. Nickel was detected in one sample (SWB-01) at a concentration of 15 µg/L. Vanadium was detected in two samples (SWB-03 and SWB-04DUP) at concentrations of 4.1 µg/L and 5.8 µg/L, respectively.

Dissolved metals were identified in all surface water samples collected in Round 2 sampling efforts. Table 5-62 provides a complete list of metals detected and the corresponding concentrations. Arsenic was detected in three samples (SWB-01F, SWB-04FDUP, and SWB-05F) at concentrations ranging from 2.8 µg/L to 4.1 µg/L. Barium was detected in all but one sample (SWB-03F) at concentrations ranging from 16.4 µg/L to 151 µg/L. Copper was detected in one sample (SWA-12) at a concentration of 2.1 µg/L. Iron was detected in all but one sample (SWB-02) at concentrations ranging from 95 µg/L to 775 µg/L. Lead and vanadium were detected in one sample (SWB-04FDUP) at a concentrations of 1.625 µg/L and 3.2 µg/L, respectively. Manganese was detected in all of the samples at concentrations ranging from 17.4 µg/L to 287 µg/L. Zinc was detected in all but one sample (SWA-12) at concentrations ranging from 28.6 µg/L to 111 µg/L.

TABLE 5-57
ROUND 2
SURFACE WATER SAMPLE SUMMARY
AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
SWB-01	X	X	X	X	X		X	X	X	X	X		
SWB-02	X	X	X	X	X		X	X	X	X	X		
SWB-03	X	X	X	X	X		X	X	X	X	X		
SWB-04	X	X	X	X	X		X	X	X	X	X		MS/MSD
SWB-05	X	X	X	X	X		X	X	X	X	X		
SWB-06	X	X	X	X	X		X	X	X	X	X		DUP OF SWB-04

TABLE 5-58
ROUND 2
SURFACE WATER SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWB-01 4/30/92 ug/L	SWB-02 4/30/92 ug/L	SWB-03 4/30/92 ug/L	SWB-04DUP 4/29/92 ug/L	SWB-05 4/28/92 ug/L	SWA-08 5/12/92 ug/L	SWA-12 6/2/92 ug/L
Vinyl chloride	22	10 U	11	6 J	6 J	10 U	10 U
Carbon disulfide	10 U	10 U	3 J	10 U	10 U	10 U	10 U
1,1-dichloroethane	3 J	10 U	2 J	10 U	10 U	10 U	10 U
1,2-dichloroethene	46	10 U	28	15	20	10 U	10 U
Chloroform	10 U	24	3 J	10 U	10 U	10 U	10 U
1,2-dichloroethane	8 J	10 U	3 J	10 U	10 U	10 U	10 U
2-butanone	10 U	10 U	10 U	4.5 J	10 U	10 U	10 U
Bromodichloromethane	10 U	6 J	10 U	10 U	10 U	10 U	10 U
Trichloroethene	30	10 U	45	21.5	20	10 U	10 U
Benzene	12	10 U	6 J	3 J	10 U	10 U	10 U
Tetrachloroethene	10 U	10 U	10 U	10 U	6 J	10 U	10 U

TABLE 5-59
ROUND 2
SURFACE WATER SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWB-01 4/30/92 ug/L	SWB-02 4/30/92 ug/L	SWB-03 4/30/92 ug/L	SWB-04 DUP 4/29/92 ug/L	SWB-05RE 4/28/92 ug/L	SWA-08 5/12/92 ug/L	SWA-12 6/2/92 ug/L
Phenol	0.9 J	10 U	10 U	10 U	10 U	10 U	10 U
Methylphenol,4-	3 J	10 U	10 U	10 U	10 U	10 U	10 U
Dimethylphenol,2,4-	1 J	10 U	10 U	10 U	10 U	10 U	2 J
Acenaphthene	10 U	10 U	10 U	10 U	0.7 J	10 U	10 U
Butylphthalate,di-n-	10 U	10 U	10 U	3 J	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	7 J	2 J	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	0.9 J

TABLE 5-60
ROUND 2
SURFACE WATER SAMPLE RESULTS
PESTICIDE/PCB AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWB-01 4/30/92 ug/L	SWB-02 4/30/92 ug/L	SWB-03 4/30/92 ug/L	SWB-04 DUP 4/29/92 ug/L	SWB-05 4/28/92 ug/L	SWA-08 5/12/92 ug/L	SWA-12 6/02/92 ug/L
BHC,gamma-	0.05 UL	0.05 U	0.05 U	0.0065 J	0.013 J	0.05 UL	0.05 U
DDD,4,4'-	0.1 UL	0.1 U	0.007 J	0.1 U	0.02 J	0.032 J	0.038 J
DDE,4,4'-	0.1 UL	0.1 U	0.1 U	0.1 U	0.1 UL	0.1 UL	0.02 J

TABLE 5-61
ROUND 2
SURFACE WATER SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWB-01 4/30/92 ug/L	SWB-02 4/30/92 ug/L	SWB-03 4/30/92 ug/L	SWB-04DUP 4/29/92 ug/L	SWB-05 4/28/92 ug/L	SWA-08 5/12/92 ug/L	SWA-12 6/02/92 ug/L
Aluminum	690	18 U	18 U	18 U	18 U	1400 J	4020
Antimony	18 U	18 U	18 U	18 U	18 U	18 U	20.6
Arsenic	6.7	2 U	4.3	4.05	5.3	7.9	11.5 K
Barium	197	33.2	58.9	57.45	52.9	36.5	46.3
Beryllium	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Calcium	106000	19600	33500	35250	48800	86300	22800
Chromium	8 U	8 U	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U	8 U	8 U
Copper	2 U	2 U	2 U	2 U	2 U	2 U	27.1
Iron	8780	539	6440	7605	5080	7140	14300
Lead	15.8 J	1.4 J	5.9 J	5.2 J	3.3 J	8.6	53.6
Magnesium	11400	2420	8250	8340	10000	27000	7670
Manganese	272	18.6	184	181.5	212	353	574
Mercury	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Nickel	15	11 U	11 U	11 U	11 U	11 U	11 U
Potassium	13600	2670	3400	3355	4750	8810	3200
Selenium	20 UL	2 UL	2 UL	2 UL	20 UL	10 UL	2 UL
Silver	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Sodium	31400	19300	26800	25100	22200	109000	22100
Thallium	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Vanadium	4 U	4 U	4.1	5.8	4 U	4 U	4 U
Zinc	202 J	146 J	60.8 J	78.35 J	49.1 J	66 J	199 J

TABLE 5-62
ROUND 2
SURFACE WATER SAMPLE RESULTS
METALS, DISSOLVED, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	SWB-01F 4/30/92 ug/L	SWB-02F 4/30/92 ug/L	SWB-03F 4/30/92 ug/L	SWB-04FDUP 4/29/92 ug/L	SWB-05F 4/28/92 ug/L	SWA-08F 5/12/92 ug/L	SWA-12F 6/02/92 ug/L
Aluminum	18 U	18 U	18 U	18 U	18 U	18 U	18 U
Antimony	18 U	18 U	18 U	18 U	18 U	18 U	18 U
Arsenic	2.8	2 U	2 U	2 U	3.7	4.1	2 U
Barium	151	28	3 U	43.95	44.8	22	16.4
Beryllium	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Cadmium	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Calcium	101000	19300	32500	29950	44500	76200	24100
Chromium	8 U	8 U	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U	8 U	8 U
Copper	2 U	2 U	2 U	2 U	2 U	2 U	2.1
Iron	535	10 U	386	775	95	210	636
Lead	1 U	1 U	1 U	1.625	1 U	1 U	1 U
Magnesium	11400	2310 J	8080 J	6980 J	9230 J	23700	6700
Manganese	253	17.4	177	147.5	190	287	107
Mercury	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Nickel	11 U	11 U	11 U	11 U	11 U	11 U	11 U
Potassium	13700	2610	236 U	2790	4350	7540	2380
Selenium	20 UL	2 UL	2 UL	2 UL	2 UL	10 UL	2 U
Silver	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Sodium	30900	18200 J	27200 J	20800 J	21300 J	96000	20100
Thallium	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Vanadium	4 U	4 U	4 U	3.2	4 U	4 U	4 U
Zinc	28.6	111	57.8	41.65	42.3	45 J	5 U

5.2.5 Groundwater Sample Results

During Round 2 detection limits for volatile organic compounds were at 10 µg/L in accordance with CLP protocol. However, these detection limits were higher than MCLs for some of the compounds analyzed. Therefore, to provide lower detection limits, modifications were incorporated into the original CLP method for the Round 3 sampling event. The modification involved increasing the purge volume from 5 ml to 25 ml. The detection limit achieved using this modification was then five times lower than the original CLP Method except for the detection limit of some of the common laboratory contaminants. This lower detection limit permitted all compounds to be evaluated against the Federal MCLs.

Because of the variation in detection limits, Round 2 and Round 3 volatile organic compounds have been evaluated separately for the purposes of this study. All other analyses have been evaluated collectively for both rounds. In addition, evaluations are based on the shallow and deep aquifer systems for all analyses.

A total of 23 samples (17 shallow and 6 deep) groundwater samples were collected in Round 2 sampling activities. Groundwater samples were numbered sequentially from GWB-201 through GWB-222 and GWB-225. Table 5-63 presents a complete list of samples and the requested analyses.

A total of 16 (9 shallow and 7 deep) groundwater samples were collected in Round 3 sampling activities. Groundwater samples were numbered sequentially from GWB-301 through GWB-313 and from GWB-317 through GWB-320. Table 5-64 presents a complete list of samples and the requested analyses.

Volatile organic compounds were detected in six shallow groundwater samples during Round 2. Table 5-65 provides the compounds detected and the corresponding concentrations. Vinyl chloride was detected in three samples (GWB-204, GWB-205, and GWB-221) at concentrations ranging from 300 µg/L to 940J µg/L. Two samples (GWB-205 and GWB-221) contained 1,1-dichloroethene at concentrations of 37 µg/L and 51 µg/L, respectively. Two samples (GWB-205 and GWB-213) contained 1,1-dichloroethane at concentrations of 89 µg/kg and 3J µg/kg, respectively. Three samples (GWB-204, GWB-205, and GWB-221) contained 1,2-dichloroethene and benzene at concentrations ranging from 418 µg/L to 1,600 µg/L and 20J µg/L to 410 µg/L. Five samples (GWB-04, GWB-05, GWB-216, GWB-219DUP, and GWB-221) contained 1,2-dichloroethane at concentrations ranging from 2J µg/L to 180 µg/L.

One sample (GWB-205) contained 1,1,1-trichloroethane at a concentration of 30J µg/L. Trichloroethene was detected in four samples (GWB-204, GWB-205, GWB-216, and GWB-221) at concentrations ranging from 3J µg/L to 520 µg/L. Two samples (GWB-205 and GWB-216) contained tetrachloroethene at concentrations of 8J µg/L and 10J µg/L, respectively. Chlorobenzene was detected in one sample (GWB-219DUP) at a concentration of 48 µg/L.

Nine shallow groundwater samples were collected in Round 3 sampling efforts. Table 5-66 provides a list of compounds detected and the corresponding concentrations. Vinyl chloride was detected in one sample (GWB-311DUP) at a concentration of 315 µg/L. Acetone was detected in two samples (GWB-304DUP and GWB-311DUP) at concentrations of 1,250 µg/L and 57J µg/L, respectively. One sample (GWB-311DUP) contained the following compounds at the following concentrations: 1,1-dichloroethene, 32.5 µg/L; 1,2-dichloroethane, 62 µg/L; trichloroethene, 230 µg/L; and benzene, 11J µg/L. Two samples (GWB-311DUP and GWB-312) contained 1,2-dichloroethene at concentrations 230 µg/L and 1J µg/L, respectively. One sample (GWB-304DUP) contained 4-methyl-2-pentanone at a concentration of 525J µg/L. Tetrachloroethene was detected in one sample (GWB-317) at a concentration of 4 µg/L. Ethylbenzene was detected in one sample (GWB-319) at a concentration of 18 µg/L. Two samples (GWB-304DUP and GWB-319) contained xylenes (total) at concentrations of 115J µg/L and 140 µg/L, respectively.

Six deep groundwater samples were collected in Round 2 sampling efforts. Table 5-67 provides a list of compounds detected and the corresponding concentrations. Volatile organic compounds were identified in four samples. Three samples (GWB-203, GWB-206, and GWB-214) contained 1,2-dichloroethene at concentrations ranging from 4J µg/L to 9 µg/L. Two samples (GWB-206 and GWB-217) contained 1,2-dichloroethane at concentrations of 130J µg/L and 450 µg/L, respectively. Trichloroethene was detected in two samples (GWB-206 and GWB-214) at concentrations of 3J µg/L and 35 µg/L, respectively.

Seven deep groundwater samples were collected in Round 3 sampling efforts. Table 5-68 provides a list of compounds and the corresponding concentrations. Volatile organic compounds were detected in five samples. Vinyl chloride was detected in two samples (GWB-302 and GWB-307) at concentrations of 2 µg/L and 3 µg/L. Four samples (GWB-302, GWB-303, GWB-307, and GWB-320) contained concentrations of 1,2-dichloroethene and trichloroethene ranging from 3 µg/L to 16 µg/L and 4 µg/L to 18 µg/L, respectively. Chloroform and benzene were detected in one sample (GWB-320) at concentrations of 1J µg/L and 12 µg/L, respectively. Four samples (GWB-301, GWB-302, GWB-307, and GWB-320) contained

1,2-dichloroethane at concentrations ranging from 2 µg/L to 170 µg/L. Toluene and xylenes (total) were detected in one sample (GWB-307) at concentrations of 1J µg/L for both compounds.

Semivolatile organic compounds were detected in 16 shallow groundwater samples collected in Round 2 and 3 sampling efforts. Table 5-69 provides a list of compounds detected and the corresponding concentrations. Acenaphthene was detected in two samples (GWB-204 and GWB-207) at concentrations of 2J µg/L and 76 µg/L, respectively. Bis(2-chloroethyl)ether was detected in one sample (GWB-221) at a concentration of 8J µg/L. Bis(2-ethylhexyl)phthalate was detected in five samples (GWB-213, GWB-215, GWB-220, GWB-221, and GWB-225DUP) at concentrations ranging from 1.45J µg/L to 5J µg/L. Dibenzofuran was detected in one sample (GWB-207) at a concentration of 7J µg/L. Three samples (GWB-204, GWB-205, and GWB-208) contained concentrations of 1,2-dichlorobenzene ranging from 3J µg/L to 16 µg/L. Two samples (GWB-204 and GWB-205) contained 1,4-dichlorobenzene at concentrations of 3J µg/L and 2J µg/L, respectively. Seven samples (GWB-201, GWB-204, GWB-205, GWB-207, GWB-210, GWB-212, and GWB-215) contained diethyl phthalate at concentrations ranging from 0.6J µg/L to 2J µg/L. One sample (GWB-204) contained 2,4-dimethylphenol at a concentration of 0.6J µg/L. Fluorene and pyrene were detected in one sample (GWB-207) at concentrations of 0.5J µg/L and 0.8J µg/L, respectively. Three samples (GWB-205, GWB-215, and GWB-319) contained 2-methylnaphthalene at concentrations ranging from 0.6J µg/L to 8J µg/L. One sample (GWB-215) contained 4-methylphenol and phenanthrene at concentrations of 13 µg/L and 0.9J µg/L, respectively. Four samples (GWB-05, GWB-07, GWB-215, and GWB-319) contained naphthalene at concentrations ranging from 1J µg/L to 4J µg/L. One sample (GWB-221) contained N-nitrosodiphenylamine and 2,2'-oxybis(1-chloropropane) at concentrations of 1J µg/L and 4J µg/L, respectively. Seven samples (GWB-204, GWB-205, GWB-215, GWB-216, GWB-218, GWB-219DUP, and GWB-225DUP) contained phenol at concentrations ranging from 0.6J µg/L to 14 µg/L.

Semivolatile organic compounds were detected in six deep groundwater samples collected in Rounds 2 and 3. Table 5-70 provides a list of compounds detected and the corresponding concentrations. Phenol was detected in three samples (GWB-203, GWB-217, and GWB-320) at concentrations ranging from 0.8J µg/L to 6J µg/L. Diethyl phthalate was detected in three samples (GWB-206, GWB-209DUP, and GWB-217) at concentrations ranging from 0.6J µg/L to 1.9J µg/L. One sample (GWB-319) contained 2-methylnaphthalene and naphthalene at concentrations of 8J µg/L and 2J µg/L, respectively.

Pesticide/PCB compounds were identified in nine shallow groundwater samples collected. Table 5-71 provides a list of compounds detected and the corresponding concentrations. One sample (GWB-205) contained alpha-BHC and gamma-BHC at concentrations of 0.005J µg/L and 0.15 µg/L, respectively. One sample (GWB-215) contained the following compounds at the following concentrations: delta-BHC, 0.014J µg/L; 4,4'-DDD, 0.14 µg/L; and endrin aldehyde, 0.009J µg/L. Heptachlor epoxide was detected in two samples (GWB-210 and GWB-213) at concentrations of 0.006J µg/L and 0.005J µg/L, respectively. Five samples (GWB-317, GWB-202, GWB-205, GWB-208, and GWB-216) contained dieldrin at concentrations ranging from 0.007J µg/L to 0.94L µg/L. Two samples (GWB-215 and GWB-225DUP) contained 4,4'-DDE at concentrations of 0.047J µg/L and 0.0135J µg/L, respectively. Endrin was detected in one sample (GWB-208) at a concentration of 0.031J µg/L. One sample (GWB-202) contained 4,4'-DDT at a concentration of 0.015J µg/L.

Pesticide/PCB compounds were identified in two deep groundwater samples collected. Table 5-72 provides a list of compounds detected and the corresponding concentrations. Heptachlor epoxide was detected in one sample (GWB-209DUP) at a concentration of 0.0105J µg/L. One sample (GWB-206) contained concentrations of dieldrin and 4,4'-DDD at 0.009J µg/L and 0.018J µg/L, respectively.

Total metals were identified in 19 shallow groundwater samples collected during Rounds 2 and 3 sampling efforts. Table 5-73 provides a list of compounds detected and the corresponding concentrations. The following metals were detected in all of the samples collected at the following concentrations: barium, 35.6 µg/L to 1,740 µg/L; iron, 7,940 µg/L to 734,500 µg/L and manganese, 152 µg/L to 4,880 µg/L. Antimony was detected in two samples (GWB-207 and GWB-215) at concentrations of 28.7 µg/L and 21.6L µg/L, respectively. Arsenic was detected in all but four samples (GWB-205, GWB-218, GWB-210, and GWB-225DUP) at concentrations ranging from 7.6 µg/L to 93.6 µg/L. Beryllium was detected in seven samples (GWB-201, GWB-202, GWB-204, GWB-207, GWB-216, GWB-219DUP, and GWB-225DUP) at concentrations ranging from 2.3 µg/L to 18.5 µg/L. Cadmium was detected in five samples (GWB-201, GWB-207, GWB-213, GWB-219DUP, and GWB-225DUP) at concentrations ranging from 2.25 µg/L to 17.8 µg/L. Chromium was detected in all but seven samples (GWB-202, GWB-205, GWB-208, GWB-210, GWB-212, GWB-216, and GWB-218) at concentrations ranging from 32.6 µg/L to 774.5 µg/L. Cobalt was detected in eight samples (GWB-201, GWB-202, GWB-204, GWB-216, GWB-219DUP, GWB-225DUP, GWB-317, and GWB-319) at concentrations ranging from 14.6 µg/L to 202.5 µg/L. Copper was detected in all but one sample (GWB-205) at concentrations ranging from 5.9 µg/L to 380 µg/L. Lead was detected in all but three samples (GWB-205, GWB-212, and GWB-213) at concentrations ranging from 1 µg/L to 1020 µg/L. Mercury was detected in six samples (GWB-207, GWB-219DUP, GWB-221, GWB-222, GWB-225DUP, and GWB-317) at concentrations ranging from 0.16 µg/L to 3 µg/L. Nickel was detected in nine samples (GWB-201, GWB-202, GWB-204, GWB-207, GWB-208, GWB-212, GWB-216, GWB-218, GWB-219DUP, GWB-225DUP, and GWB-319) at concentrations ranging from 11 µg/L to 433 µg/L. Silver was detected in three samples (GWB-201, GWB-222, and GWB-225DUP) at concentrations ranging from 2 µg/L to 3 µg/L. Vanadium was detected in all but three samples (GWB-210, GWB-212 and GWB-213) at concentrations ranging from 22.4 µg/L to 1,610 µg/L. Zinc was detected in all but five samples (GWB-208, GWB-210, GWB-212, GWB-213, and GWB-319) at concentrations ranging from 96 µg/L to 1,550J µg/L.

Dissolved metals were identified in 19 shallow groundwater samples collected in Round 2 and 3 sampling efforts. Table 5-74 provides a list of compounds detected and the corresponding concentrations. Antimony was detected in one sample (GWB-215F) at a concentration of 32.9 µg/L. Arsenic was detected in six samples (GWB-202F, GWB-212F, GWB-215F, GWB-222F GWB-317F, and GWB-319F) at concentrations ranging from 3.4 µg/L to 51.1 µg/L. Barium was detected in all but three samples (GWB-213F, GWB-215F, and GWB-317F) at concentrations ranging from 8 µg/L to 96.5 µg/L. Chromium was detected in two samples (GWB-208F and GWB-215F) at concentrations of 10.4 µg/L and 22.2 µg/L, respectively. Cobalt was detected in three samples (GWB-205F, GWB-216F, and GWB-219FDUP) at concentrations ranging from 10.3 µg/L to 13.55 µg/L. Copper was detected in five samples (GWB-201F, GWB-207F, GWB-210F, GWB-212F, and GWB-219DUP) at concentrations ranging from 2.2 µg/L to 10.5 µg/L. Iron was detected in all but two samples (GWB-220 and GWB-222F) at concentrations ranging from 164 µg/L to 64,600 µg/L. Manganese was detected in all of the samples at concentrations ranging from 36 µg/L to 1,385 µg/L. Vanadium was detected in eight samples (GWB-201F, GWB-202F, GWB-204F, GWB-205F, GWB-215F, GWB-216F, GWB-218F, and GWB-219FDUP) at concentrations ranging from 3 µg/L to 29.9 µg/L. Zinc was detected in two samples (GWB-222F and GWB-225FDUP) at concentrations of 22 µg/L and 16.75 µg/L, respectively.

Total metals were identified in seven deep groundwater samples collected during Round 2 and 3 sampling efforts. Table 5-75 provides a list of compounds detected and the corresponding concentrations. Three samples (GWB-206, GWB-209DUP, and GWB-214) contained the following metals at the following concentration ranges: antimony, 14.5 µg/L to 25.2L µg/L; chromium, 16.85 µg/L to 542K µg/L; copper, 22.25 µg/L to 225 µg/L; and lead, 2.95 µg/L to

183 µg/L. Arsenic was detected in five samples (GWB-203, GWB-206, GWB-211, GWB-214, and GWB-320) at concentrations ranging from 2.7 µg/L to 194L µg/L. The following metals were detected in all of the samples at the following concentration ranges: barium, 33.8 µg/L to 569 µg/L; iron, 9120 µg/L to 428,000 µg/L; and manganese, 162 µg/L to 4740K µg/L. Two samples (GWB-206 and GWB-214) contained the following metals at the following concentrations: beryllium, 11.2 µg/L and 10.5 µg/L; cadmium, 30.8 µg/L and 20.9 µg/L; cobalt, 99.2 µg/L and 181 µg/L; and silver, 2.9 µg/L and 3.2 µg/L. Three samples (GWB-203, GWB-206, and GWB-214) contained nickel at concentrations ranging from 12 µg/L to 203 µg/L. Vanadium was detected in five samples (GWB-203, GWB-206, GWB-211, GWB-214, and GWB-217) at concentrations ranging from 4 µg/L to 769K µg/L. Zinc was detected in five samples (GWB-203, GWB-206, GWB-209DUP, GWB-211, and GWB-214) at concentrations ranging from 87.25J µg/L to 985 µg/L.

Dissolved metals were identified in seven deep groundwater samples during Round 2 and 3 sampling efforts. Table 5-76 provides a list of compounds detected and the corresponding concentrations. Arsenic was detected in one sample (GWB-320F) at a concentration of 1.3 µg/L. Barium and manganese were detected in all of the samples at the respective concentration ranges 16.8 µg/L to 96 µg/L and 29.3 µg/L to 356 µg/L. Iron was detected in four samples (GWB-203F, GWB-214F, GWB-217F, and GWB-320F) at concentrations ranging from 496 µg/L to 6,450 µg/L. Vanadium was detected in five samples (GWB-203F, GWB-206F, GWB-211F, GWB-214F, and GWB-217F) at concentrations of 4 µg/L.

TABLE 5-63
ROUND 2
GROUNDWATER SAMPLE SUMMARY
AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

			CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SHALLOW	DEEP	SAMPLE ID	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	VOA	SVOA	PEST/PCB	MET. T.	MET. D.	SM	COMMENTS
B-MW13		GWB-201	X	X	X	X	X		X	X	X	X	X		
B-MW12		GWB-202	X	X	X	X	X		X	X	X	X	X		
	B-MW11B	GWB-203	X	X	X	X	X		X	X	X	X	X		
B-MW11A		GWB-204	X	X	X	X	X		X	X	X	X	X		
B-MW3A		GWB-205	X	X	X	X	X		X	X	X	X	X		
	B-MW3B	GWB-206	X	X	X	X	X		X	X	X	X	X		
B-MW7		GWB-207	X	X	X	X	X		X	X	X	X	X		
B-MW10		GWB-208	X	X	X	X	X		X	X	X	X	X		
	B-MW9B	GWB-209	X	X	X	X	X		X	X	X	X	X		
B-MW9A		GWB-210	X	X	X	X	X		X	X	X	X	X		MS/MSD
	B-MW8B	GWB-211	X	X	X	X	X		X	X	X	X	X		
B-MW8A		GWB-212	X	X	X	X	X		X	X	X	X	X		
GW-5		GWB-213	X	X	X	X	X		X	X	X	X	X		
	BMW-5B	GWB-214	X	X	X	X	X		X	X	X	X	X		
GW-4		GWB-215	X	X	X	X	X		X	X	X	X	X		
B-MW2A		GWB-216	X	X	X	X	X		X	X	X	X	X		
	B-MW2B	GWB-217	X	X	X	X	X		X	X	X	X	X		
GW-6		GWB-218	X	X	X	X	X		X	X	X	X	X		MS/MSD
B-MW1		GWB-219	X	X	X	X	X		X	X	X	X	X		
B-MW14		GWB-220	X	X	X	X	X		X	X	X	X	X		
B-MW15		GWB-221	X	X	X	X	X		X	X	X	X	X		
B-MW16		GWB-222	X	X	X	X	X		X	X	X	X	X		
	B-MW9B	GWB-223	X	X	X	X	X		X	X	X	X	X		DUP OF B-MW9B
B-MW1		GWB-224	X	X	X	X	X		X	X	X	X	X		DUP OF B-MW1
B-MW17		GWB-225	X	X	X	X	X		X	X	X	X	X		
B-MW17		GWB-226	X	X	X	X	X		X	X	X	X	X		DUP OF B-MW17

TABLE 5-64
ROUND 3
GROUNDWATER SAMPLE SUMMARY
AREA B
CAMP ALLEN LANDFILL

			CLP ANALYSIS REQUESTED						CLP ANALYSIS RECEIVED						
SHALLOW	DEEP	SAMPLE ID	VOA	SVOA (1)	PEST/PCB (1)	MET. T. (1)	MET. D. (1)	SM	VOA	SVOA (1)	PEST/PCB (1)	MET. T. (1)	MET. D. (1)	SM	COMMENTS
	B-MW2B	GWB-301	X						X						
	B-MW3B	GWB-302	X						X						
	B-MW5B	GWB-303	X						X						MS/MSD
GW-4		GWB-304	X						X						
	B-MW8B	GWB-305	X						X						
	B-MW9B	GWB-306	X						X						
	B-MW11B	GWB-307	X						X						
B-MW12		GWB-308	X						X						
B-MW13		GWB-309	X						X						
B-MW14		GWB-310	X						X						
B-MW15		GWB-311	X						X						
B-MW16		GWB-312	X						X						
B-MW17		GWB-313	X						X						
GW-4		GWB-314	X						X						DUP OF GW-4
B-MW15		GWB-315	X						X						DUP OF B-MW15
B-MW18A		GWB-317	X	X	X	X	X		X	X	X	X	X		
B-MW19A		GWB-319	X	X	X	X	X		X	X	X	X	X		
	B-MW19B	GWB-320	X	X	X	X	X		X	X	X	X	X		

Note: (1) Only newly wells installed during Round 3 field efforts had CLP parameters analyzed.

TABLE 5-65
ROUND 2
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-201 6/11/92 ug/L	GWB-202 6/11/92 ug/L	GWB-204 6/11/92 ug/L	GWB-205 6/11/92 ug/L	GWB-207 6/10/92 ug/L	GWB-208 6/10/92 ug/L
Vinyl chloride	10 U	10 U	940 J	300	10 U	10 U
1,1-dichloroethene	10 U	10 U	120 U	37	10 U	10 U
1,1-dichloroethane	10 U	10 U	120 U	89	10 U	10 U
1,2-dichloroethene	10 U	10 U	1600	460	10 U	10 U
1,2-dichloroethane	10 U	10 U	58 J	180	10 U	10 U
1,1,1-trichloroethane	10 U	10 U	120 U	30 J	10 U	10 U
Trichloroethene	10 U	10 U	44 J	520	10 U	10 U
Benzene	10 U	10 U	29 J	410	10 U	10 U
Tetrachloroethene	10 U	10 U	120 U	8 J	10 U	10 U
Chlorobenzene	10 U	10 U	120 U	33 U	10 U	10 U

TABLE 5-65
ROUND 2
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-210 6/10/92 ug/L	GWB-212 6/10/92 ug/L	GWB-213 6/13/92 ug/L	GWB-215 6/13/92 ug/L	GWB-216 6/12/92 ug/L	GWB-218 6/12/92 ug/L
Vinyl chloride	10 U	10 U	10 U	420 U	10 U	10 U
1,1-dichloroethene	10 U	10 U	10 U	420 U	10 U	10 U
1,1-dichloroethane	10 U	10 U	3 J	420 U	10 U	10 U
1,2-dichloroethene	10 U	10 U	10 U	420 U	10 U	10 U
1,2-dichloroethane	10 U	10 U	10 U	420 U	6 J	10 U
1,1,1-trichloroethane	10 U	10 U	10 U	420 U	10 U	10 U
Trichloroethene	10 U	10 U	10 U	420 U	3 J	10 U
Benzene	10 U	10 U	10 U	420 U	10 U	10 U
Tetrachloroethene	10 U	10 U	10 U	420 U	10 J	10 U
Chlorobenzene	10 U	10 U	10 U	420 U	10 UJ	10 U

TABLE 5-65
ROUND 2
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-219DUP 6/11/92 ug/L	GWB-220 6/14/92 ug/L	GWB-221 6/14/92 ug/L	GWB-222 6/14/92 ug/L	GWB-225DUP 6/14/92 ug/L
Vinyl chloride	10 U	10 U	370	10 U	10 U
1,1-dichloroethene	10 U	10 U	51	10 U	10 U
1,1-dichloroethane	10 U	10 U	33 U	10 U	10 U
1,2-dichloroethene	10 U	10 U	418	10 U	10 U
1,2-dichloroethane	2 J	10 U	120	10 U	10 U
1,1,1-trichloroethane	10 U	10 U	33 U	10 U	10 U
Trichloroethene	10 U	10 U	510	10 U	10 U
Benzene	10 U	10 U	20 J	10 U	10 U
Tetrachloroethene	10 U	10 U	33 U	10 U	10 U
Chlorobenzene	48	10 U	33 U	10 U	10 U

TABLE 5-66
ROUND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-304DUP 12/14/92 ug/L	GWB-308 12/14/92 ug/L	GWB-309 12/14/92 ug/L	GWB-310 12/14/92 ug/L	GWB-311DUP 12/14/92 ug/L
Vinyl chloride	100 U	2 U	2 U	2 U	315
Acetone	1250	10 U	10 U	10 U	57 J
1,1-dichloroethene	100 U	2 U	2 U	2 U	32.5
1,2-dichloroethene	100 U	2 U	2 U	2 U	230
1,2-dichloroethane	100 U	2 U	2 U	2 U	62
Trichloroethene	100 U	2 U	2 U	2 U	230
Benzene	100 U	2 U	2 U	2 U	11 J
4-methyl-2-pentanone	525 J	10 U	10 U	10 U	100 U
Tetrachloroethene	100 U	2 U	2 U	2 U	20 U
Ethylbenzene	100 U	2 U	2 U	2 U	20 U
Xylenes(total)	115 J	2 U	2 U	2 U	20 U

TABLE 5-66
ROUND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-312 12/14/92 ug/L	GWB-313 12/16/92 ug/L	GWB-317 12/16/92 ug/L	GWB-319 12/16/92 ug/L
Vinyl chloride	2	2 U	2 U	4 U
Acetone	10 U	10 U	10 U	18 U
1,1-dichloroethene	2 U	2 U	2 U	4 U
1,2-dichloroethene	1 J	2 U	2 U	4 U
1,2-dichloroethane	2 U	2 U	2 U	4 U
Trichloroethene	2 U	2 U	2 U	4 U
Benzene	2 U	2 U	2 U	4 U
4-methyl-2-pentanone	10 U	10 U	10 U	18 U
Tetrachloroethene	2 U	2 U	4	4 U
Ethylbenzene	2 U	2 U	2 U	18
Xylenes(total)	2 U	2 U	2 U	140

TABLE 5-67
ROUND 2
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-203 6/11/92 ug/L	GWB-206 6/11/92 ug/L	GWB-209DUP 6/10/92 ug/L	GWB-211 6/11/92 ug/L	GWB-214 6/12/92 ug/L	GWB-217 6/12/92 ug/L
1,2-dichloroethene	7 J	4 J	10 U	10 U	9	33 U
1,2-dichloroethane	10 U	130 J	10 U	10 U	10 U	450
Trichloroethene	10 U	3 J	10 U	10 U	35	33 U

TABLE 5-68
ROUND 3
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-301 12/14/92 ug/L	GWB-302 12/14/92 ug/L	GWB-303 12/14/92 ug/L	GWB-305 12/14/92 ug/L	GWB-306 12/14/92 ug/L	GWB-307 12/14/92 ug/L	GWB-320 12/16/92 ug/L
Vinyl chloride	14 U	2	2 U	2 U	2 U	3	2 U
1,2-dichloroethene	14 U	4	3	2 U	2 U	9	16
Chloroform	14 U	2 U	2 U	2 U	2 U	2 U	1 J
1,2-dichloroethane	170	38	2 U	2 U	2 U	2	3
Trichloroethene	14 U	4	14	2 U	2 U	7	18
Benzene	14 U	2 U	2 U	2 U	2 U	2 U	12
Toluene	14 U	2 U	2 U	2 U	2 U	1 J	2 U
Xylenes(total)	14 U	2 U	2 U	2 U	2 U	1 J	2 U

TABLE 5-69
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-201 6/11/92 ug/L	GWB-202 6/11/92 ug/L	GWB-204 6/11/92 ug/L	GWB-205 6/11/92 ug/L	GWB-207 6/10/92 ug/L	GWB-208 6/10/92 ug/L	GWB-210 6/10/92 ug/L
Acenaphthene	10 U	10 U	2 J	10 U	76	10 U	10 U
Bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 UJ	10 UJ	10 U	10 U	10 U	10 UJ	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	7 J	10 U	10 U
Dichlorobenzene,1,2-	10 U	10 U	16	3 J	10 U	4 J	10 U
Dichlorobenzene,1,4-	10 U	10 U	3 J	2 J	10 U	10 U	10 U
Diethylphthalate	0.6 J	10 U	1 J	2 J	1 J	10 U	0.9 J
Dimethylphenol,2,4-	10 U	10 U	0.6 J	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	0.5 J	10 U	10 U
Methylnaphthalene,2-	10 U	10 U	10 U	2 J	10 U	10 U	10 U
Methylphenol,4-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	4 J	1 J	10 U	10 U
Nitrosodiphenylamine,N-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Oxybis(1-chloropropane),2,2'-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	0.7 J	6 J	10 U	10 U	10 U
Pyrene	10 UJ	10 UJ	10 U	10 U	0.8 J	10 UJ	10 U

TABLE 5-69
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-212 6/10/92 ug/L	GWB-213 6/13/92 ug/L	GWB-215 6/13/92 ug/L	GWB-216 6/12/92 ug/L	GWB-218 6/12/92 ug/L	GWB-219 DUP 6/11/92 ug/L	GWB-220 6/14/92 ug/L
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	2 J	2 J	10 UJ	10 UJ	10 U	2 J
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dichlorobenzene,1,2-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dichlorobenzene,1,4-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	0.7 J	10 U	10 U	0.7 J	10 U	10 U	10 U
Dimethylphenol,2,4-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylnaphthalene,2-	10 U	10 U	0.6 J	10 U	10 U	10 U	10 U
Methylphenol,4-	10 U	10 U	13	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	3 J	10 U	10 U	10 U	10 U
Nitrosodiphenylamine,N-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Oxybis(1-chloropropane),2,2'-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenanthrene	10 U	10 U	0.9 J	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	14	0.6 J	0.6 J	5.4 J	10 U
Pyrene	10 U	10 U	10 U	10 U	10 UJ	10 U	10 U

TABLE 5-69
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-221 6/14/92 ug/L	GWB-222 6/14/92 ug/L	GWB-225 DUP 6/14/92 ug/L	GWB-317 12/16/92 ug/L	GWB-319 12/16/92 ug/L
Acenaphthene	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethyl)ether	8 J	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	5 J	10 U	1.45 J	10 U	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	10 U
Dichlorobenzene,1,2-	10 U	10 U	10 U	10 U	10 U
Dichlorobenzene,1,4-	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U
Dimethylphenol,2,4-	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U
Methylnaphthalene,2-	10 U	10 U	10 U	10 U	8 J
Methylphenol,4-	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	2 J
Nitrosodiphenylamine,N-	1 J	10 U	10 U	10 U	10 U
Oxybis(1-chloropropane),2,2'-	4 J	10 U	10 U	10 U	10 U
Phenanthrene	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	5.35 J	10 U	10 U
Pyrene	10 U	10 U	10 U	10 U	10 U

TABLE 5-70
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
SEMIVOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-203 6/11/92 ug/L	GWB-206 6/11/92 ug/L	GWB-209 DUP 6/10/92 ug/L	GWB-211 6/11/92 ug/L	GWB-214 6/12/92 ug/L	GWB-217 6/12/92 ug/L	GWB-320 12/16/92 ug/L
Phenol	0.8 J	10 U	10 U	10 U	10 U	1 J	6 J
Diethylphthalate	10 U	1 J	1.9 J	10 U	10 U	0.6 J	10 U
Methylnaphthalene, 2-	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U

TABLE 5-71
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
PESTICIDE/PCBS, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-317 12/16/92 ug/L	GWB-319 12/16/92 ug/L	GWB-201 6/11/92 ug/L	GWB-202 6/11/92 ug/L	GWB-204 6/11/92 ug/L	GWB-205 6/11/92 ug/L	GWB-207 6/10/92 ug/L
BHC,alpha-	0.05 UL	0.05 UL	0.05 U	0.05 U	0.05 U	0.005 J	0.05 U
BHC,delta-	0.05 UL	0.05 UL	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
BHC,gamma-	0.05 UL	0.05 UL	0.05 U	0.05 U	0.05 U	0.15	0.05 U
Heptachlor epoxide	0.05 UL	0.05 UL	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Dieldrin	0.022 J	0.1 UL	0.1 U	0.009 J	0.1 U	0.043 J	0.1 U
DDE,4,4'-	0.1 UL	0.1 UL	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Endrin	0.1 UL	0.1 UL	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
DDD,4,4'-	0.1 UL	0.1 UL	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
DDT,4,4'-	0.1 UL	0.1 UL	0.1 U	0.015 J	0.1 U	0.1 U	0.1 U
Endrin aldehyde	0.1 UL	0.1 UL	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U

TABLE 5-71
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
PESTICIDE/PCBS, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-208 6/10/92 ug/L	GWB-210 6/10/92 ug/L	GWB-212 6/10/92 ug/L	GWB-213 6/13/92 ug/L	GWB-215 6/13/92 ug/L	GWB-216 6/12/92 ug/L	GWB-218 6/12/92 ug/L
BHC,alpha-	0.05 UL	0.05 U	0.05 U	0.05 UL	0.05 UL	0.05 U	0.05 U
BHC,delta-	0.05 U	0.05 U	0.05 U	0.05 UL	0.014 J	0.05 U	0.05 U
BHC,gamma-	0.05 U	0.05 U	0.05 U	0.05 UL	0.05 UL	0.05 U	0.05 U
Heptachlor epoxide	0.05 U	0.006 J	0.05 U	0.005 J	0.05 UL	0.05 U	0.05 U
Dieldrin	0.94 L	0.1 U	0.1 U	0.1 UL	0.1 U	0.007 J	0.1 U
DDE,4,4'-	0.1 UL	0.1 U	0.1 U	0.1 UL	0.047 J	0.1 U	0.1 U
Endrin	0.031 J	0.1 U	0.1 U	0.1 UL	0.1 UL	0.1 U	0.1 U
DDD,4,4'-	0.1 UL	0.1 U	0.1 U	0.1 UL	0.14	0.1 U	0.1 U
DDT,4,4'-	0.1 UL	0.1 U	0.1 U	0.1 UL	0.1 R	0.1 U	0.1 U
Endrin aldehyde	0.1 UL	0.1 U	0.1 U	0.1 UL	0.009 J	0.1 U	0.1 U

TABLE 5-71
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
PESTICIDE/PCBS, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-219 DUP 6/10/92 ug/L	GWB-220 6/14/92 ug/L	GWB-221 6/14/92 ug/L	GWB-222 6/14/92 ug/L	GWB-225 DUP 6/14/92 ug/L
BHC,alpha-	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL
BHC,delta-	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL
BHC,gamma-	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL
Heptachlor epoxide	0.05 UL	0.05 UL	0.05 UL	0.05 UL	0.05 UL
Dieldrin	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 UL
DDE,4,4'-	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.0135 J
Endrin	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 UL
DDD,4,4'-	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 UL
DDT,4,4'-	0.1 UL	0.1 U	0.1 U	0.1 UL	0.075 UL
Endrin aldehyde	0.1 UL	0.1 UL	0.1 UL	0.1 UL	0.1 UL

TABLE 5-72
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
PESTICIDE/PCBS, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-203 6/11/92 ug/L	GWB-206 6/11/92 ug/L	GWB-209 DUP 6/10/92 ug/L	GWB-211 6/11/92 ug/L	GWB-214 6/12/92 ug/L	GWB-217 6/12/92 ug/L	GWB-320 12/21/92 ug/L
Heptachlor epoxide	0.05 U	0.05 U	0.0105 J	0.05 U	0.05 U	0.05 U	0.05 UL
Dieldrin	0.1 U	0.009 J	0.05 UL	0.1 U	0.1 U	0.1 U	0.1 UL
DDD,4,4'-	0.1 U	0.018 J	0.1 UL	0.1 U	0.1 U	0.1 U	0.1 UL

TABLE 5-73
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-201 6/11/92 ug/L	GWB-202 6/11/92 ug/L	GWB-204 6/11/92 ug/L	GWB-205 6/11/92 ug/L	GWB-216 6/12/92 ug/L	GWB-218 6/12/92 ug/L
Aluminum	162000	51100	88800	8230	63900	37600
Antimony	18 UL	18 UL	18 UL	18 UL	18 UL	18 UL
Arsenic	27.2 L	20 L	32 L	2 U	24.1 L	2 U
Barium	296	210	228	46.1	176	255
Beryllium	6.3	2.3	4.1	2 U	3.3	2 U
Cadmium	17.8	3 U	3 U	3 U	3 U	3 U
Calcium	44900	35900	12000	98800	18700	108000
Chromium	244 K	8 U	141 K	8 U	8 U	8 U
Cobalt	37.1	15.2	14.6	8 U	25.8	8 U
Copper	110	50.6	59.2	2 U	38.1	37.7
Iron	249000	86700	183000	23200	64700	51500
Lead	92.5	60.2	44.8	1 U	38.5	35
Magnesium	27600	19600	32500	19100	14900	16000
Manganese	810 K	889 K	906 K	1270 K	865 K	805 K
Mercury	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Nickel	68.2	23.9	27.6	11 U	37.5	17.5
Potassium	16400	8160	12200	8030	7960	8680
Silver	2.4	2 U	2 U	2 U	2 U	2 U
Sodium	12900	12500	62300	36100	19000	15500
Vanadium	596 K	267 K	297 K	22.4 K	175 K	110 K
Zinc	393 K	355 K	231 K	168 K	331 K	206 K

TABLE 5-73
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-220 6/14/92 ug/L	GWB-221 6/14/92 ug/L	GWB-222 6/14/92 ug/L	GWB-213 6/13/92 ug/L	GWB-215 6/13/92 ug/L	GWB-207 6/10/92 ug/L
Aluminum	93000 J	127000	24500 J	3040 J	6660 J	192000
Antimony	18 U	18 U	18 U	18 U	21.6 L	28.7
Arsenic	10.2	16.1 J	7.6	26.6	22.6 L	17
Barium	194	253	145	614	71.2 J	704
Beryllium	2 U	2 U	2 U	2 U	2 U	6.7
Cadmium	3 U	3 U	3 U	6.3	3 U	10.9
Calcium	53500	60400	126000	161000	126000	192000
Chromium	166	213	32.6	96.2	82.1	264
Cobalt	8 U	8 U	8 U	8 U	8 U	8 U
Copper	51	65	17	14	13.6	339
Iron	108000	147000	19900 J	178000	15600	119000
Lead	61.2	41.3	11.4	1 U	23.2	1020
Magnesium	17200	53100	20800	6000	9400	45800
Manganese	381	1690	182	268	262	907
Mercury	0.2 U	0.27	0.34	0.2 UL	0.2 UL	1.6
Nickel	11 U	11 U	11 U	11 U	11 U	107
Potassium	10600 J	15400 J	6970 J	5230	13700	39200
Silver	2 U	2 U	2	2 U	2 U	2 U
Sodium	7860	222000	54500	33300	72400	56300
Vanadium	356	359	4 U	38	45.5	461
Zinc	193 J	266 J	96 J	5 U	100	1550 J

TABLE 5-73
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-208 6/10/92 ug/L	GWB-210 6/10/92 ug/L	GWB-212 6/10/92 ug/L	GWB-219DUP 6/11/92 ug/L	GWB-225DUP 6/14/92 ug/L	GWB-317 12/16/92 ug/L	GWB-319 12/16/92 ug/L
Aluminum	22800	2650	905	135500	610000	135000	83000
Antimony	18 U	18 U	18 U	18 UL	18 U	17 U	17 U
Arsenic	11.6	2 U	93.6	24.4 L	10 U	15	8.5
Barium	78.3	59.3	35.6	279	1740	389 J	230 J
Beryllium	2 U	2 U	2 U	6.5	18.5	1 U	1 U
Cadmium	3 U	3 U	3 U	2.25	10	4 U	4 U
Calcium	15400	26400	37800	105100	74100	31000	90500
Chromium	8 U	8 U	8 U	217.5 K	774.5	165	98
Cobalt	8 U	8 U	8 U	33.4	202.5	29.7	22.6
Copper	14.7	11.7	5.9	76.65	380	100	39.2
Iron	26200	7940	33500	162000	734500	106000	61900
Lead	6.1 K	1	1 U	54.4	312	70.8	26.2
Magnesium	6920	7250	8340	53550	126500	18200	15900
Manganese	164	831	152	1815 K	4880	591	573
Mercury	0.2 U	0.2 U	0.2 U	0.16	3	0.45	0.2 U
Nickel	12.4	11 U	11	59.15	433	12 U	47.1
Potassium	4280	3040	3200	15650	45900 J	13400	10000
Silver	2 U	2 U	2 U	2 U	2	3 U	3 U
Sodium	17600	23700	23200	15250	41800	7830	8600
Vanadium	58.2	4 U	4 U	412.5 K	1610	334	160
Zinc	5 U	5 U	5 U	403 JK	1355 J	248	3 U

TABLE 5-74
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, DISSOLVED, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB201F 6/11/92 ug/L	GWB202F 6/11/92 ug/L	GWB204F 6/11/92 ug/L	GWB205F 6/11/92 ug/L	GWB216F 6/12/92 ug/L	GWB218F 6/12/92 ug/L	GWB222F 6/14/92 ug/L
Aluminum	201	59 U	59 U	59 U	59 U	59 U	59 U
Antimony	18 U	18 U	18 U	18 U	18 U	18 U	18 U
Arsenic	2 U	16.4	2 U	2 U	2 U	2 U	3.4
Barium	13.4	49.9	53.3	26.4	21.7	64.2	14
Calcium	39400	33800	11300	97300	13600	108000	124000
Chromium	8 U	8 U	8 U	8 U	8 U	8 U	8 U
Cobalt	8 U	8 U	8 U	10.3	13.3	8 U	8 U
Copper	10.5	2 U	2 U	2 U	2 U	2 U	2 U
Iron	18100	27900	64600	5500	1740	536	10 U
Magnesium	10900	14300	24800	17900	7680	13100	18500
Manganese	275	704	715	1180	573	595	85
Potassium	3470	3930	3510	7240	2530	5870	5420
Sodium	10700	11000	64600	34000	15300	14300	54900
Vanadium	4	4	4	4	4	4	4 U
Zinc	5 U	5 U	5 U	5 U	5 U	5 U	22

TABLE 5-74
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, DISSOLVED, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB221F 6/14/92 ug/L	GWB220F 6/14/92 ug/L	GWB212F 6/10/92 ug/L	GWB210F 6/10/92 ug/L	GWB208F 6/10/92 ug/L	GWB207F 6/10/92 ug/L
Aluminum	59 U	59 U	59 U	59 U	59 U	59 U
Antimony	18 U	18 U	18 U	18 U	18 U	18 U
Arsenic	2 U	2 U	51.1	2 U	2 U	2 U
Barium	24	8	28	47	22.7	96.5
Calcium	54700	47800	35200	26500	15100	146000
Chromium	8 U	8 U	8 U	8 U	10.4	8 U
Cobalt	8 U	8 U	8 U	8 U	8 U	8 U
Copper	2 U	2 U	2.7	2.2	2 U	5.1
Iron	482	10 U	23500	3460	1080	542
Magnesium	38900	5820	7860	7090	5200	24900
Manganese	1130	47	132	825	107	247
Potassium	6120	1530	3050	2680	2080	20500
Sodium	227000	5990	21500	21200	16600	51400
Vanadium	4 U	4 U	4 U	4 U	4 U	4 U
Zinc	5 U	5 U	5 U	5 U	5 U	5 U

TABLE 5-74
ROUNDS 2 AND 3
GROUNDWATER SHALLOW SAMPLE RESULTS
METALS, DISSOLVED, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB215F 6/13/92 ug/L	GWB213F 6/13/92 ug/L	GWB219FDUP 6/11/92 ug/L	GWB225FDUP 6/14/92 ug/L	GWB317F 12/16/92 ug/L	GWB319F 12/16/92 ug/L
Aluminum	59 U	59 U	59 U	59 U	15 U	15 U
Antimony	32.9	18 U	18 U	18 U	17 U	17 U
Arsenic	14.1	2 U	2 U	2 U	8.8	7.8
Barium	3 U	3 U	15.8	21	1 U	23.5
Calcium	141000	98500	101900	41800	24900	88900
Chromium	22.2	8 U	8 U	8 U	9 U	9 U
Cobalt	8 U	8 U	13.55	8 U	10 U	10 U
Copper	2 U	2 U	3.95	2 U	2 U	2 U
Iron	164	176	2375	995.5	1200	1780
Magnesium	9300	5100	40150	31400	3440 J	7390 J
Manganese	221	36	1385	517.5	143	291
Potassium	14000	5040	4335	4880	2690	4030
Sodium	75500	35500	13550	41250	6470	7160
Vanadium	29.9	4 U	3	4 U	4 U	4 U
Zinc	5 U	5 U	5 U	16.75	3 U	3 U

TABLE 5-75
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
METALS, TOTAL, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-206 6/11/92 ug/L	GWB-214 6/12/92 ug/L	GWB-217 6/12/92 ug/L	GWB-320 12/16/92 ug/L	GWB-203 6/11/92 ug/L	GWB-211 6/11/92 ug/L	GWB-209DUP 6/10/92 ug/L
Aluminum	146000	40000	1290	15 U	2840	6200	5970
Antimony	18.3 L	25.2 L	18 UL	17 U	18 UL	18 UL	14.5
Arsenic	194 L	93.8 L	2 U	2.7	20.7 L	14.8 L	2 U
Barium	569	150	106	98.6 J	33.8	66.3	53.8
Beryllium	11.2	10.5	2 U	1 U	2 U	2 U	2 U
Cadmium	30.8	26.9	3 U	4 U	3 U	3 U	3 U
Calcium	705000	408000	199000	167000	63000	147000	55250
Chromium	542 K	232 K	8 U	9 U	8 U	8 U	16.85
Cobalt	99.2	181	8 U	10 U	8 U	8 U	8 U
Copper	225	31.8	2 U	2 U	2 U	2 U	22.25
Iron	428000	382000	11000	9120	13700	26900	10900
Lead	183	53.6	1 U	1 U	1 U	1 U	2.95
Magnesium	41800	20200	9040	13300	3110	5270	3300
Manganese	4270 K	4740 K	242 K	373	218 K	293 K	162
Nickel	179	203	11 U	12 U	12	11 U	11 U
Potassium	15700	7480	6650	3730	2240	2400	2565
Silver	2.9	3.2	2 U	3 U	2 U	2 U	2 U
Sodium	24900	42000	149000	139000	24100	15300	13950
Vanadium	769 K	426 K	4	4 U	24.2 K	48.4 K	4 U
Zinc	576 K	985 K	5 U	3 U	199 K	205 K	87.25 J

TABLE 5-76
ROUNDS 2 AND 3
GROUNDWATER DEEP SAMPLE RESULTS
METALS, DISSOLVED, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample no. Date collected Units	GWB-206F 6/11/92 ug/L	GWB-214F 6/12/92 ug/L	GWB-217F 6/12/92 ug/L	GWB-320F 12/16/92 ug/L	GWB-203F 6/11/92 ug/L	GWB-211F 6/11/92 ug/L	GWB-209FDUP 6/10/92 ug/L
Arsenic	2 U	2 U	2 U	1.3	2 U	2 U	2 U
Barium	43.8	16.8	96	94.1	18.6	29.2	26.15
Calcium	74600	59900	197000	170000	48300	62200	45400
Iron	10 U	641	4150	6450	496	10 U	10 U
Magnesium	2710	5690	8310	13200 J	1940	2220	2235
Manganese	110	134	198	356	85.3	29.3	46.3
Potassium	2180	3000	6080	3980	1430	1710	1865
Sodium	18700	40700	155000	146000	22000	13400	12250
Vanadium	4	4	4	4 U	4	4	4 U

5.3 Air Sampling Program Results

5.3.1 Quality Control Procedures

To date, NEESA has not approved a laboratory for the analysis of air samples; therefore, the selection of the laboratory subcontractor for air analyses was based on the laboratory's qualifications, personnel experience in the analysis of air samples, the availability of the laboratory equipment, and the cost effectiveness of the analyses as determined by a competitive bidding process. International Technology Analytical Services of Cincinnati, Ohio was chosen to perform the analyses according to Level E QA/QC Protocols after a review of the laboratory's Quality Assurance Plan was performed. NEESA was notified of the laboratory chosen for the project.

The samples were analyzed via GC/MS SCAN, which provided detection limits ranging from 0.2 to 0.8 parts per billion by volume (ppbv). However, those samples which required dilution had detection limits ranging from 10 to 240 ppbv. The analytical results were validated by AWD Technologies prior to submission for risk analysis.

5.3.2 Presentation of Results

The results from the analyses are presented in Table 5-77. The detection limits are not included as they varied for each analysis. One field blank per sampling event was provided to accommodate quality assurance requirements. The results of the three blanks were evaluated for contamination and were all qualified as non-detect. Canister data sheets and final flow calculations are presented in Appendix R and S, respectively.

TABLE 5-77
SUMMARY OF AIR SAMPLING RESULTS
BRIG FACILITY
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	AA-01			AA-02			AA-03			AA-04			AA-05			AA-06		
CHEMICAL NAME	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Dichlorodifluoromethane	0.5	0.7	0.4	2.2	1.9	ND	0.5	0.7	ND	0.7	0.8	ND	0.6	ND	ND	ND	ND	0.5
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.8	0.8	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	0.9	ND	ND	ND	ND	ND	0.6	ND	ND	0.6	ND	ND	ND	ND	ND	ND	ND
Freon 113	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	1.5	1	0.8	1.3	ND	ND	1.2	0.6	0.4	1.6	0.6	23	1.2	ND	380	ND	ND	0.4
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.8	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	10	9	2.1	16	29	13	6.1	2.1	1.8	4.4	1.8	0.7	140	180	ND	3400	8.2	5.5
Benzene	0.4	0.7	0.5	0.4	ND	ND	0.4	0.6	0.5	0.4	0.7	0.5	0.7	ND	ND	ND	ND	0.5
Toluene	2.2	3.4	2.4	1.7	2.7	1	0.7	1.2	0.8	3.2	2.5	1.5	3.7	39	110	ND	5.3	0.6
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	ND
m-/p-Xylene	ND	ND	ND	0.4	0.9	ND	0.4	0.7	0.3	0.9	ND	0.6	100	6	58	ND	ND	0.4
o-Xylene	ND	ND	ND	ND	ND	ND	ND	0.3	ND	0.4	1	ND	24	32	19	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND	8.9	ND	ND	ND	ND
1,4-Dichlorobenzene	1.8	2.1	2.3	1.1	2.5	1.1	ND	ND	ND	1.5	ND	0.6	ND	ND	ND	ND	ND	ND
Benzyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	ND	ND	ND	ND	ND	ND	ND
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.4	0.4	ND	0.7	ND	ND	ND	0.4	0.3	6.5	3.7	3.4	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	ND	ND	0.4	ND	ND	ND	ND	ND	ND	0.6	0.3	0.4	0.5	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	1.5	0.9	0.9	ND	ND	ND	ND	0.4	0.3	1.2	0.9	0.9	1.6	ND	ND	21	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Note: All analytical results reported in parts per billion by volume.

TABLE 5-77
SUMMARY OF AIR SAMPLING RESULTS
BRIG FACILITY
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	AA-07			AA-08			AA-09			AA-10			AA-11			AA-12		
CHEMICAL NAME	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Dichlorodifluoromethane	0.6	0.8	0.6	0.5	0.4	0.5	0.6	0.5	0.6	0.6	0.5	2.7	0.5	0.4	0.5	ND	ND	0.7
Chloromethane	ND	0.7	0.7	0.9	ND	ND	1	ND	1	1.1	ND	0.8	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	0.5	ND	ND	0.6	ND	ND	0.6	ND	ND	0.6	ND	ND	ND	ND
Freon 113	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	1.3	0.4	.3J	1.3	ND	0.5	1.2	ND	0.4	1.5	0.4	0.7	2.9	30	17	0.8	1.4	0.9
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	3.2	0.6	0.8	5.7	0.5	.4J	13	2.3	1.5	5.1	1.7	1.4	7.6	1.6	1.1	8.5	1.4	0.9
Benzene	0.5	1	0.6	0.5	0.8	0.6	0.6	0.8	0.7	0.5	0.7	0.6	0.4	0.8	0.6	0.6	0.7	0.7
Toluene	0.9	2.1	1.1	7.8	2	5.9	1.5	1.7	1.3	1.6	1.9	1.9	1.5	1.9	1.9	4.5	160	670
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	0.3	ND	0.7	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	0.4	0.4	0.6	0.5
m-/p-Xylene	0.4	1.1	0.4	2.8	0.8	0.4	2	0.8	0.5	0.7	0.8	0.5	0.8	0.8	2.4	1.5	2.3	1.4
o-Xylene	ND	0.4	ND	1.2	ND	ND	0.6	ND	ND	ND	0.3	ND	ND	0.4	1.2	0.4	0.7	0.4
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	20	26	ND	ND	ND	ND	ND	ND
Benzyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND	29	42	ND
Trichlorofluoromethane	0.3	0.3	0.4	ND	ND	0.3	0.4	0.4	0.4	0.8	0.5	1.6	0.3	0.4	0.4	ND	0.2	ND
1,3,5-Trimethylbenzene	ND	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	4.4	ND	ND	ND
1,2,4-Trimethylbenzene	ND	0.6	ND	1.7	0.4	ND	0.3	0.4	ND	0.3	0.4	ND	0.6	2.2	7.8	0.2	0.5	ND
1,2,4- Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND

Note: All analytical results reported in parts per billion by volume.

TABLE 5-77
SUMMARY OF AIR SAMPLING RESULTS
CAMP ALLEN ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	AB-01			AB-02			AB-03			AB-04			AB-05		
CHEMICAL NAME	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Dichlorodifluoromethane	0.4	0.7	0.4	ND	0.8	0.3	ND	1.1	0.5	ND	1.1	0.7	0.5	0.5	0.6
Chloromethane	ND	0.7	ND	ND	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	0.8	0.8	0.8	0.3	0.4	0.4	0.5	0.7	0.5	0.8	0.7	0.5	0.6	0.4	0.5
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	27	7.9	2.9	9.5	2.6	2.7	10	9.8	2.2	17	18	6.4	11	23	3.4
Benzene	0.4	0.6	0.6	0.4	0.6	0.7	0.5	0.7	0.6	0.4	0.6	0.6	0.5	0.7	0.6
Toluene	1.4	1.6	1.6	1.9	1.7	2	1.1	1.4	1.3	1.2	1.9	1.6	1.2	2	1.7
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m-/p-Xylene	0.4	0.6	0.6	0.5	0.7	0.6	0.4	0.7	0.5	0.4	0.8	0.6	0.4	0.8	0.6
o-Xylene	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	0.6	0.2	0.2	0.5	0.5	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.6	0.3	0.3	ND	0.3	0.3	0.5	0.7	0.4	0.4	ND	0.4	ND	0.4	0.4
1,3,5- Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4- Trimethylbenzene	ND	ND	0.3	ND	0.3	0.3	ND	ND	0.3	ND	ND	ND	ND	ND	ND
1,2,4- Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	0.3	ND	0.3	0.3	ND	ND	0.3	ND	ND	ND	ND	ND	ND

Note: All analytical results reported in parts per billion by volume.

TABLE 5-77
SUMMARY OF AIR SAMPLING RESULTS
AMBIENT
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	A-01			A-02			A-03			A-04			A-05		
CHEMICAL NAME	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Dichlorodifluoromethane	ND	0.6	0.4	0.3	0.6	0.4	0.4	0.6	0.4	0.5	0.7	0.3	0.5	0.6	0.4
Chloromethane	ND	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	0.6	ND	ND	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	1	0.3	0.4	1.2	0.3	ND	0.5	ND	0.3	0.5	0.8	0.4	0.9	ND	0.3
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	11	2	2.3	3.3	ND	0.5	3.7	ND	0.9	4.8	8.7	1.8	14	ND	0.6
Benzene	0.5	0.6	0.6	0.4	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.7	0.4	0.7	0.5
Toluene	1.2	0.9	0.9	1.2	1.2	0.8	1	1	1	1	1.6	1.1	1	1	0.7
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m-/p-Xylene	ND	0.5	0.4	0.7	0.6	0.4	0.4	0.6	0.5	0.4	0.7	0.5	ND	0.6	0.3
o-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND
Benzyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND
1,3,5- Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4- Trimethylbenzene	ND	ND	0.3	ND	0.3	0.3	ND	ND	0.3	ND	ND	ND	ND	ND	ND
1,2,4- Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	ND	ND	0.3	ND	0.3	0.3	ND	ND	0.3	ND	ND	ND	ND	ND	ND

Note: All analytical results reported in parts per billion by volume.

5.4 Quality Assurance Results

The quality of data collected during sampling Rounds 2 and 3 at Camp Allen Landfill Areas A and B has been determined by its accuracy and precision against prescribed requirements and specifications, and by its usefulness in assisting decision-making with confidence. The quality of the data collected is presented/evaluated in the following sections with respect to the associated blanks.

5.4.1 Data Validation Report

The quality of organic analytical data was evaluated by the following parameters: GC/MS tuning and performance, internal standards, initial calibrations, continuing calibrations, surrogate spikes, matrix spikes, laboratory and field blanks, compound identification, and compound quantitation. The quality of inorganic analytical data was evaluated by the following parameters: initial and continuing calibrations, interference check samples, matrix spikes, laboratory control samples, ICP serial dilutions, and compound quantitation. Areas of concern with respect to data usability are discussed below. For a complete summary of the QA/QC samples collected during Rounds 2 and 3 see Appendix T.

5.4.2 Trip Blanks

The analytical results of the trip blanks were utilized to assess possible contamination of sample containers prior to use and during transport to and storage at the Camp Allen Landfill Site and possible cross-contamination of samples during transport back to the laboratory. In addition, the trip blanks were used to determine whether the contaminants detected in environmental samples were introduced during transport or whether the contaminants detected were representative of conditions at the site. In order for compounds detected in both environmental samples and trip blanks (or blanks of any kind) to be attributed to site contamination, the concentration in the environmental sample must be, at a minimum, ten times greater than the concentration detected in the blank for common laboratory contaminants (USEPA, 1991).

A total of 54 trip blanks were sent to the laboratory for analysis. One trip blank was transported in each container in which samples for volatile analysis were to be shipped. Trip blanks accompanied groundwater (34 trip blanks), surface water/sediment (13 trip blanks), soil/sediment (6 trip blanks), and rinsate (1 trip blank) samples to the laboratory.

Concentrations of acetone, 2-butanone, and methylene chloride (common laboratory contaminants) were detected in trip blanks associated with sampling activities at the Camp Allen Landfill Site. Therefore, positive results in environmental samples for acetone, 2-butanone, and methylene chloride which are less than ten times the blank concentrations are qualified with a "B". Concentrations detected in environmental samples which were less than ten times that of the trip blank were not assumed to be site related. In summary, all concentrations qualified with a "B" are due to blank contamination and should not be associated with the site. Please note that the "B" qualifier takes precedence under current USEPA guidelines; therefore, concentrations qualified with a "B" have not been evaluated as part of this study.

5.4.3 Field Blanks

Field blanks are samples which are taken in the field during related sampling activities. Analysis of the sample will indicate whether contamination was introduced into the samples during the collection process. Because field blanks and environmental samples are collected under similar conditions, the results of the field blank analyses are used to indicate the presence of external contaminants (i.e., drill rig, aircraft exhaust, or dust particles) that may have been introduced into samples during collection. In addition, the field blanks are utilized to determine whether the contaminants detected in the environmental samples were contributed by conditions independent of the Camp Allen Landfill Site and to determine constituents present in the decontamination water. Field blank contamination during transport is assessed by the evaluation of trip blanks.

All organic concentrations in the field blanks were undetected with the exception of chloroform (72 µg/L) and bromodichloromethane (15 µg/L), which were detected in the potable water field blank. These two compounds can be attributed to the chlorination process during municipal water treatment. Inorganic constituents found in field blanks were typical of those found in tap water. In summary, it can be assumed that no contamination was introduced into the samples during the collection process.

5.4.4 Equipment Blanks/Rinsates

The results from the analyses of the equipment blanks were used to assess the efficiency of equipment decontamination procedures in preventing cross-contamination between samples and to determine if the contaminants detected in the environmental samples were contributed by the sampling equipment or were representative of conditions at the Camp Allen Landfill Site.

All parameter concentrations in the equipment blanks were undetected with the exception of acetone, 2-butanone, carbon disulfide, and toluene (common laboratory contaminants). These compounds were all detected at levels which attribute them to laboratory practices. In summary, it can be assumed that equipment decontamination procedures were adequate and no cross-contamination occurred between sample points.

5.4.5 Field Replicates

The field replicate is a second sample (or set of samples) collected from one sample location and labeled for the laboratory as if it were a unique sample. The results of the field replicate analyses were used to assess the precision of the field sampling methods as well as a check on the analytical procedures. The results are mathematically compared to determine the relative percent difference of the soil/sediment sample and associated replicate. Relative percent difference (RPD) is a measure of the precision of the sample results. Soil/sediment data with an RPD of less than 35 percent can be considered reliable because soil/sediment is not a homogeneous media.

If RPD results exceeded the quality control limit applied to soil/sediment, there were no results to report; therefore, no data were qualified based on the RPD. Where replicate results exceeded recommended criteria, results were considered estimated and biased according to the recovery of analytical spike results. The RPDs for some of the replicate compounds exceeded the percent advisory quality control and, therefore, have been qualified as estimated based on the data validator's evaluation (see Appendix Q for detail). In general, the difference between the environmental sample and the field replicate (two analytical runs) is acceptable and has been qualified accordingly.

5.4.6 Field Duplicates

The results of the field duplicate analyses were used to assess the precision of the laboratory and the consistency in the field sampling methods. Surface water and groundwater data with an RPD less than 20 percent can be considered reliable.

If RPD results exceeded the quality control limit applied to water there were no results to report; therefore, no data were qualified based on the RPD. Where duplicate results exceeded recommended criteria, results were considered estimated and biased according to the recovery of analytical spike results. The RPDs for some of the duplicate compounds exceeded the percent advisory quality control and therefore have been qualified as estimated based on the data validator's evaluation (see Appendix Q for detail). In general, the difference between the environmental sample and the field duplicate (two analytical runs) are acceptable and have been qualified accordingly.

5.4.7 Matrix Spike/Matrix Spike Duplicate

Matrix spike/matrix spike duplicates are the formulas for calculating confidence limits and the coefficient of variation. The confidence limit should be determined for all data. A matrix spike describes a procedure in which a target compound at a known concentration is added to the sample during laboratory preparation to measure the accuracy of the analysis procedure. A matrix spike duplicate is a second run to determine the precision of the analysis.

Analytical and matrix spike recoveries for some metals were less than the quality control limit in the initial and rerun analyses. Therefore, quantitation limits were qualified "R" unreliable and have not been evaluated as part of this study. Matrix spike/matrix spike duplicate results for several compounds failed to meet quality control criteria and have been qualified accordingly. In summary, the analyses performed can be considered accurate and precise.

5.4.8 Summary

The data validation reports for the samples collected at the Camp Allen Landfill Site are presented in Appendix Q. The appendix is three-fold, presenting the data validation reports for Round 2, Round 3, and the air program, respectively. Several analytical results were qualified as estimated (J) because the reported concentrations were less than the required detection limits or the quality control criteria were not met. Parameters that were analyzed but were not detected, were qualified with a "U" where the associated numerical value is the sample detection limit. In general, all data are acceptable for use as part of this study and have been presented as such.

5.5 Feasibility Study Sampling Results

Sections 5.5.1 through 5.5.4 list in a tabular format the analytical results of the feasibility study samples for both Areas A and B for Rounds 2 and 3. Section 5.5.5 lists the results for the surface water hardness samples that were collected from Areas A and B for Round 3.

5.5.1 Feasibility Sample Results, Area A, Round 2

Table 5-78 lists all Area A samples obtained during Round 2 and their respective analytical results. Samples designated with SWA and GWA are surface water and groundwater samples, respectively. Both shallow and deep well numbers have been included to show distinction between the aquifer systems. Some well numbers will be listed twice; this reflects the collection of duplicate samples.

5.5.2 Feasibility Sample Results, Area B, Round 2

Table 5-79 lists Area B groundwater (GWB) samples collected during Round 2 and their respective analytical results. Both shallow and deep well numbers have been included to show distinction between the aquifer systems. Some well numbers will be listed twice; this reflects the collection of duplicate samples.

5.5.3 Feasibility Sample Results, Area A, Round 3

Table 5-80 list the feasibility samples collected in Area A during Round 3 and their respective analytical results. Sample numbers have been provided and have the following designations; sediment (SDA), surface soil (SSA), surface water (FSA-SW), shallow ground water (FSA-GWS), and deep ground water (FSA-GWD). Both shallow and deep well numbers have been included to show distinction between the aquifer systems. TOC values are expressed in mg/kg for solids (dry weight) and mg/L for liquids.

5.5.4 Feasibility Sample Results, Area B, Round 3

Table 5-81 lists the feasibility samples collected in Area B during Round 3 and their respective analytical results. Sample numbers have been provided and have the following designations; surface soil (SSB), surface water (FSB-SW), shallow groundwater (FSB-GWS), and deep groundwater (FSB-GWD). Both shallow and deep well numbers have been included to show distinction between the aquifer systems. TOC values are expressed in mg/kg for solids (dry weight) and mg/L for liquids.

5.5.5 Surface Water Hardness Sample Results, Areas A and B, Round 3

Table 5-82 lists the surface water sample locations, along with their corresponding sample hardness concentrations. Section 3.5.5 describes the hardness sample test kit procedures that were used to obtain the results.

TABLE 5-78

FEASIBILITY STUDY ANALYTICAL RESULTS FOR
AREA A, ROUND 2, SURFACE WATER AND GROUNDWATER SAMPLES

Sample Number	Shallow Well Number	Deep Well Number	Chloride (mg/L)	Sulfate (mg/L)	Alkalinity, Total (mg/L)
SWA-01	---	—	24	49	280
SWA-02	---	—	80	69	240
SWA-03	---	—	2,400	420	140
SWA-04	---	—	7,300	1,000	100
SWA-05	---	—	2,800	410	140
SWA-06	---	—	5,800	600	110
SWA-07	---	—	1,200	170	ND
SWA-08	---	—	180	65	68
SWA-09	---	—	3,600	540	140
SWA-11	---	—	1,300	230	82
SWA-12	---	—	23	27	75
SWA-17	---	—	2,200	290	110
GWA-201	B-1W		8	47	180
GWA-202	A-MW5		440	8	480
GWA-203	A-MW7		310	87	52
GWA-204		A-MW9C	660	120	250
GWA-205	A-MW9A		1,700	45	560
GWA-206		A-MW9B	290	120	480
GWA-207	A-MW8		4,800	61	550
GWA-208	A-MW6A		98	ND	90
GWA-209		A-MW6B	440	27	160
GWA-210	B-20W		2,500	11	920
GWA-211	B-17W		250	450	330
GWA-212	B-15W		210	180	590
GWA-213		A-MW1B	860	74	200
GWA-214		A-MW1C	370	26	170
GWA-215	A-MW11A		98	230	280

ND = Non-detect

TABLE 5-78 (Continued)

FEASIBILITY STUDY ANALYTICAL RESULTS FOR
AREA A, ROUND 2, SURFACE WATER AND GROUNDWATER SAMPLES

Sample Number	Shallow Well Number	Deep Well Number	Chloride (mg/L)	Sulfate (mg/L)	Alkalinity, Total (mg/L)
GWA-216		A-MW11B	240	5	260
GWA-217	A-MW12		250	51	660
GWA-218	GW-3		14	39	130
GWA-219		A-MW10B	260	110	360
GWA-220	GW-2		170	ND	1,100
GWA-221		A-MW4B	710	220	100
GWA-222	A-MW4A		5	52	140
GWA-223		A-MW14B	22	11	100
GWA-224		A-MW13B	21	5	100
GWA-225	GW-1		130	83	430
GWA-226		A-MW8B	520	200	460
GWA-227		B-15WB	990	130	310
GWA-228		A-MW15B	120	10	140
GWA-229		A-MW16B	1,300	95	230
GWA-230		A-MW17B	760	62	40
GWA-231	B-20WSS		6,100	32	960
GWA-232	A-MW10		72	19	ND
GWA-233		A-MW11B	320	5	270
GWA-234		A-MW9C	650	100	250
GWA-235		A-MW8B	520	200	470
GWA-236	A-MW10		80	18	ND

ND = Non-detect

TABLE 5-79

FEASIBILITY STUDY ANALYTICAL RESULTS FOR AREA B, ROUND 2, GROUNDWATER SAMPLES

Sample Number	Shallow Well Number	Deep Well Number	Chloride (mg/L)	Sulfate (mg/L)	Alkalinity, Total (mg/L)
GWB-201	B-MW13		17	51	96
GWB-202	B-MW12		28	9	140
GWB-203		B-MW11B	18	8	160
GWB-204	B-MW11		63	270	22
GWB-205	B-MW3		25	130	230
GWB-206		B-MW3B	62	10	670
GWB-207	B-MW7		33	120	580
GWB-208	B-MW10		21	54	ND
GWB-209		B-MW9B	10	5	150
GWB-210	B-MW9		30	76	39
GWB-211		B-MW8B	34	8	140
GWB-212	B-MW8		27	65	90
GWB-213	GW-5		5	64	280
GWB-214		B-MW5B	49	17	350
GWB-215	GW-4		80	290	430
GWB-216	B-MW2		19	62	29
GWB-217		B-MW2B	490	81	160
GWB-218	GW-6		11	35	290
GWB-219	B-MW1		15	390	54
GWB-220	B-MW14		11	25	130
GWB-221	B-MW15		380	62	260
GWB-222	B-MW16		110	36	310
GWB-223		B-MW9B	10	ND	150
GWB-224	B-MW1		17	380	78
GWB-225	B-MW17		36	37	240
GWB-226	B-MW17		36	85	260

ND = Non-detect

TABLE 5-80

FEASIBILITY STUDY ANALYTICAL RESULTS FOR
AREA A, ROUND 3, SURFACE WATER, GROUNDWATER, SEDIMENT, AND
SOIL SAMPLES

Sample Number	Shallow Well Number	Deep Well Number	TOC (mg/kg, mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)
SDA-26	---	---	72,000	NA	NA	NA
SDA-27	---	---	91,000	NA	NA	NA
SDA-28	---	---	10,000	NA	NA	NA
SDA-29	---	---	65,000	NA	NA	NA
SDA-30	---	---	34,000	NA	NA	NA
SSA-01	---	---	34,000	NA	NA	NA
SSA-02	---	---	27,000	NA	NA	NA
SSA-03	---	---	29,000	NA	NA	NA
SSA-04	---	---	29,000	NA	NA	NA
SSA-05	---	---	6,200	NA	NA	NA
FSA-SW-01	---	---	5	42	9	64
FSA-GWS-01	B-20WSS		26	43,000	83	140
FSA-GWD-01		A-MW17B	2	24	ND	ND

NA = Not analyzed
ND = Non-detect

TABLE 5-81

FEASIBILITY STUDY ANALYTICAL RESULTS FOR
AREA B, ROUND 3, SURFACE WATER, GROUNDWATER, AND SOIL SAMPLES

Sample Number	Shallow Well Number	Deep Well Number	TOC (mg/kg, mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)
SSB-05	---	---	19,000	NA	NA	NA
SSB-06	---	---	14,000	NA	NA	NA
SSB-07	---	---	6,000	NA	NA	NA
SSB-08	---	---	11,000	NA	NA	NA
SSB-09	---	---	5,000	NA	NA	NA
FSB-SW-01	---	---	7	82	16	36
FSB-GWS-01	B-MW15		10	3,300	5	31
FSB-GWD-01		B-MW3B	1	520	ND	ND

NA = Not analyzed
ND = Non-detect

TABLE 5-82

SURFACE WATER HARDNESS RESULTS
AREAS A AND B, ROUND 3

Sample Identification	Sample Concentration Calcium Carbonate (mg/L)
A1	320
A2	570
B1	160
B2	175

5.6 Residential Well Sampling Program Results

During 1991, CH_2M Hill, Inc. (CH_2M Hill) conducted an investigation of the shallow groundwater in the Glenwood Park area. CH_2M Hill sampled residential wells numbered RW-1 through RW-55. In 1992, Baker conducted a supplemental investigation of the residential wells sampled by CH_2M Hill in the Glenwood Park area. Sampling of three additional wells (RW-56, RW-57, and RW-58) was anticipated to address other requests for well sampling by Glenwood Park residents. However, one well (RW-58) was not sampled due to complications incurred during the field effort (this well contained a broken water pump). One sample (RW-59) was a duplicate of RW-56. All well samples were analyzed for CLP volatile organic compounds.

Table 5-83 presents the analytical results from both investigations. Four samples (RW-22, RW-39, RW-55, and RW-56) were found to contain volatile organic compounds. Tetrachloroethene was detected in one sample (RW-22) at a concentration of 10 µg/L. Two samples (RW-39 and RW-55) contained 2-butanone at concentrations of 76 µg/L and 10 µg/L, respectively. One sample (RW-55) contained 1,2-dichloroethane at a concentration of 38 µg/L. One well (RW-56) contained acetone at a concentration of 4B µg/L. Please note that acetone was detected in the lab blank and was not detected in the duplicate sample. No other volatile organic compounds were detected in the wells sampled under this investigation. Appendix U provides results of field parameters (pH, temperature, and specific conductivity) obtained during sampling efforts.

5.7 Field Verification of Groundwater Sampling Results

Field verification of groundwater contamination was conducted to better define the locations and depths of the remaining monitoring well points. Therefore, a local non-NEESA certified laboratory (Environmental Testing Services, Inc. [ETS]) was used to analyze the samples on an accelerated turnaround basis. Samples were analyzed via EPA Method 601 or EPA Method 624, as volatile organic compounds were the contaminants of concern. EPA Method 601 was utilized in the upper extremity of the deep aquifer to obtain results from water suspected to contain petroleum distillates or secondary solvents. EPA Method 624 was utilized in the deepest wells to obtain results from water suspected to contain greater than 19 percent chlorinated solvents (known sinkers). Additionally, in order to characterize groundwater generated during well development and purging and aquifer testing, a "worst case" groundwater sample was submitted to ETS for "Full Toxicity Characteristic Leaching

Procedure (TCLP)" parameters. Appendix V contains the laboratory reports for Area A and Area B, Round 1 groundwater sample results.

5.7.1 Area A Round 1 Groundwater Sample Results

A total of nine deep groundwater samples were collected from locations in and around the Camp Allen Landfill Area A during Round 1. Each sample was numbered sequentially from GWA-101 through GWA-112. It should be noted that GWA-104, GWA-105 and GWA-108 samples are affiliated with Area B and their results are presented in Section 5.7.2.

Two groundwater samples (GWA-101 and GWA-102) were analyzed via EPA Method 624. Toluene was detected in one sample (GWA-101) at a concentration of 4.3 µg/L. Methylene chloride was detected in the remaining sample (GWA-102) at a concentration of 131 µg/L.

Seven groundwater samples (GWA-103, GWA-106, GWA-107, GWA-109, GWA-110, GWA-111, and GWA-112) were analyzed via EPA Method 601. Methylene chloride was detected in one sample (GWA-110) at a concentration of 5 µg/L. One sample (GWA-111) contained the following compounds at the following concentrations: chloromethane, 10 µg/L; 1,2-dichloroethane, 6 µg/L; and trichloroethane, 29 µg/L. The duplicate sample (GWA-113) associated with GWA-111 contained the following compounds at the following concentrations: chloromethane, 11 µg/L; 1,2-dichloroethane, 5 µg/L; and trichloroethane, 25 µg/L. Volatile organic compounds were not detected in any other samples. Table 5-84 provides a list of compounds detected and the associated concentrations.

Analytical results for the groundwater sample analyzed for TCLP parameters are presented in Appendix V. Results indicated groundwater generated during site activities was nonhazardous (far below regulatory levels). Only one compound was detected (vinyl chloride, 0.028 mg/L).

5.7.2 Area B Round 1 Groundwater Sample Results

A total of three deep groundwater samples were collected from locations in and around the Camp Allen Landfill Area B. As stated previously the samples were numbered GWA-104, GWA-105, and GWA-108. Vinyl chloride was detected in one sample (GWA-104) at a concentration of 3 µg/L. Methylene chloride was detected in one sample (GWA-105) at a concentration of 5 µg/L. No other volatile organic compounds were detected. Table 5-85 provides a list of compounds detected and the associated concentrations.

5.7.3 Area B Geoprobe Investigation Results

Analytical results of the geoprobe investigation at the Camp Allen Landfill Area B are presented on Table 5-86. Phase I consisted of 35 groundwater samples and 3 duplicate samples collected using the geoprobe system. Phase II consisted of 20 groundwater samples and 2 duplicates collected using the geoprobe system. Samples were collected at depths ranging from 8 to 18 feet. Sample depths were established based on the groundwater elevation. During Phase I each sample was numbered sequentially from GW-01 through GW-35. During Phase II each sample was numbered sequentially from GW-36 through GW-57. The groundwater samples were analyzed by modified USEPA SW-846 Methods 8010/8020. Appendix W contains the Geoprobe Groundwater Survey Reports (Phase I and Phase II) prepared by Burlington Environmental. For purposes of presenting geoprobe investigation environmental results, QC blanks, duplicates, and miscellaneous samples identified in the Phase I and Phase II Reports are not included in the discussion to follow.

During Phase I, groundwater samples from 35 probe hole locations were collected and analyzed. Three duplicate groundwater samples and fifteen blanks were also analyzed. Samples were analyzed for the following compounds:

- Benzene
- cis-1,2-dichloroethylene
- trans-1,2-dichloroethylene
- Trichloroethylene

For the purposes of this study cis- and trans-1,2-dichloroetylene have been combined to provide total dichloroethylene.

Benzene was detected in five samples at concentrations ranging from 1 µg/L to 42 µg/L. Six samples contained benzene at concentrations less than 1 µg/L.

Sixteen samples contained cis-1,2-dichloroethylene at concentrations ranging from 1 µg/L to 166 µg/L. In addition, two samples had detections of cis-1,2-dichloroethylene at concentrations less than 1 µg/L.

Trichloroethylene was detected in eleven samples at concentrations ranging from 1 µg/L to 148 µg/L. Three samples contained trichloroethylene at concentrations less than 1 µg/L. During Phase II, groundwater samples from 20 probe hole locations were collected and analyzed. Three duplicate groundwater samples and fifteen blanks were also analyzed. Samples were analyzed for the following compounds:

- Benzene
- cis-1,2-dichloroethylene
- trans-1,2-dichloroethylene
- Trichloroethylene

For the purposes of this study cis- and trans-1,2-dichloroethylene have been combined to provide total dichloroethylene.

Benzene was detected in one sample at a concentration of 2 µg/L. No other samples contained benzene. Trichloroethylene was detected in five samples at concentrations ranging from 3 µg/L to 79 µg/L.

Six samples contained cis-1,2-dichloroethylene at concentrations ranging from 1 µg/L to 158 µg/L. In addition, one sample had a detection of cis-1,2-dichloroethylene at a concentration less than 1 µg/L.

In summary, Geoprobe Investigation results provided information needed for locating additional shallow monitoring wells at Area B during Round 2 activities. Additionally, this information was evaluated in determining patterns of detected constituents in the shallow groundwater, as presented in Section 6.0 (Nature and Extent of Contamination).

TABLE 5-83

GROUNDWATER RESULTS - RESIDENTIAL WELLS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Residential Well Number	Street Address	Comments
RW-1	327 Forrest Avenue	ND
RW-2	314 Forrest Avenue	ND
RW-3	318 Forrest Avenue	ND
RW-4	317 Beechwood Avenue	ND
RW-5	425 Woodview Avenue	ND
RW-6	126 Forrest Avenue	ND
RW-7	333 Forrest Avenue	ND
RW-8	332 Rogers Avenue	ND
RW-9	434 Woodview Avenue	ND
RW-10	401 Woodview Avenue	ND
RW-11	421 Woodview Avenue	ND
RW-12	311 Woodview Avenue	ND
RW-13	503 Woodview Avenue	ND
RW-14	331 Beechwood Avenue	ND
RW-15	326 Beechwood Avenue	ND
RW-16	203 Woodview Avenue	ND
RW-17	134 Woodview Avenue	ND
RW-18	217 Beechwood Avenue	ND
RW-19	204 Rogers Avenue	ND
RW-20	337 Beechwood Avenue	ND
RW-21	209 Beechwood Avenue	ND
RW-22	400 Beechwood Avenue	Tetrachloroethene 10 µg/L
RW-23	505 Beechwood Avenue	ND
RW-24	504 Woodview Avenue	ND
RW-25	515 Woodview Avenue	ND

Source: CH_2M Hill, 1991.
ND = Not detected

TABLE 5-83 (Continued)

GROUNDWATER RESULTS - RESIDENTIAL WELLS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Residential Well Number	Street Address	Comments
RW-26	218-A Glendale Avenue	ND
RW-27	223 Glendale Avenue	ND
RW-28	228 Glendale Avenue	ND
RW-29	136 Greenbrier Avenue	ND
RW-30	334 Beechwood Avenue	ND
RW-31	212 Glendale Avenue	ND
RW-32	420 Woodview Avenue	ND
RW-33	343 Glendale Avenue	ND
RW-34	313 Rogers Avenue	ND
RW-35	411 Woodview Avenue	ND
RW-36	500 Woodview Avenue	ND
RW-37	533 Beechwood Avenue	ND
RW-38	323 Rogers Avenue	ND
RW-39	136 Rogers Avenue	2-Butanone (MEK) 76 µg/L
RW-40	330 Glendale Avenue	ND
RW-41	431 Glendale Avenue	ND
RW-42	516 Woodview Avenue	ND
RW-43	525 Beechwood Avenue	ND
RW-44	503 Glendale Avenue	ND
RW-45	405 Woodview Avenue	ND
RW-46	411 Forrest Avenue	ND
RW-47	325 Glendale Avenue	ND
RW-48	242 Beechwood Avenue	ND
RW-49	342 Glendale Avenue	ND

Source: CH_2M Hill, 1991.
*Baker Environmental, Inc., 1992.
ND = Not detected

TABLE 5-83 (Continued)

GROUNDWATER RESULTS - RESIDENTIAL WELLS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Residential Well Number	Street Address	Comments
RW-50	237 Beechwood Avenue	ND
RW-51	222 Beechwood Avenue	ND
RW-52	215 Glendale Avenue	ND
RW-53	340 Rogers Avenue	ND
RW-54	131 Rogers Avenue	ND
RW-55	505 Forrest Avenue	1,2-Dichloroethane 38 µg/L 2-Butanone (MEK) 10 µg/L
RW-56*	400 Glendale Avenue	Acetone 4.0B µg/L
RW-57*	314 Rogers Avenue	ND
RW-58*	135 Glendale Avenue	Not sampled, faulty pump
RW-59*	Duplicate of RW-56	ND

Source: CH_2M Hill, 1991.
*Baker Environmental, Inc., 1992.
ND = Not detected

TABLE 5-84

ROUND 1
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA A
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample Number[1]	Monitoring Well	Analytical Method	Results
GWA-101	A-MW1C	EPA 624	Toluene 4.3 ppb
GWA-102	A-MW9C	EPA 624	Methylene chloride 131 ppb
GWA-103	B-15WB	EPA 601	ND
GWA-106	A-MW13B	EPA 601	ND
GWA-107	A-MW14B	EPA 601	ND
GWA-109	A-MW15B	EPA 601	ND
GWA-110	A-MW8B	EPA 601	Methylene chloride 5 ppb
GWA-111	A-MW17B	EPA 601	Chloromethane 10 ppb 1,2-Dichloroethane 6 ppb Trichloroethane 29 ppb
GWA-112	A-MW16B	EPA 601	ND
GWA-113	Duplicate of A-MW17B	EPA 601	Chloromethane 11 ppb 1,2-Dichloroethane 5 ppb Trichloroethane 25 ppb

(1) Samples GWA-104, GWA-105, and GWA-108 are affiliated with Area B.
ND = Non-detect

TABLE 5-85

ROUND 1
GROUNDWATER DEEP SAMPLE RESULTS
VOLATILES, AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Sample Number	Monitoring Well	Analytical Method	Results	
GWA-104	B-MW11B	EPA 601	Vinyl chloride	3 ppb
GWA-105	B-MW8B	EPA 601	Methylene chloride	5 ppb
GWA-108	B-MW9B	EPA 601	ND	

ND = Non-detect

TABLE 5-86

GEOPROBE INVESTIGATION RESULTS
AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Geoprobe Sample Number	Detections		
	Dichloroethylene (total)	Benzene	Trichloroethylene
GW-01	ND	ND	ND
GW-02	ND	ND	ND
GW-03	ND	ND	ND
GW-04	ND	ND	ND
GW-05	ND	ND	ND
GW-06	ND	ND	ND
GW-07	ND	ND	ND
GW-08	166	8	13
GW-09	7	ND	18
GW-10	53	42	148
GW-11	ND	ND	ND
GW-12	<1	ND	ND
GW-13	ND	ND	ND
GW-14	3	<1	2
GW-15	ND	ND	ND
GW-16	<1	<1	ND
GW-17	ND	ND	ND
GW-18	ND	ND	ND
GW-19	ND	ND	ND
GW-20	1	ND	2
GW-21	ND	ND	ND
GW-22	ND	ND	ND
GW-23	26	1	3
GW-24	5	ND	2
GW-25	ND	ND	ND
GW-26	ND	ND	ND

ND = Non-detect

TABLE 5-86 (Continued)

GEOPROBE INVESTIGATION RESULTS
AREA B
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Geoprobe Sample Number	Detections		
	Dichloroethylene (total)	Benzene	Trichloroethylene
GW-27	3	<1	1
GW-28	9	<1	7
GW-29	9	3	1
GW-30	4	<1	ND
GW-31	2	ND	ND
GW-32	8	ND	<1
GW-33	6	<1	<1
GW-34	40	2	40
GW-35	5	ND	1
GW-36	<1	ND	ND
GW-37	ND	ND	ND
GW-38	ND	ND	ND
GW-39	ND	ND	ND
GW-40	ND	ND	ND
GW-41	ND	ND	ND
GW-42	ND	ND	ND
GW-43	ND	ND	ND
GW-44	ND	ND	ND
GW-45	ND	ND	ND
GW-46	ND	ND	ND
GW-47	ND	ND	ND
GW-48	ND	ND	ND
GW-49	22	ND	36
GW-50	ND	ND	ND
GW-51	ND	ND	ND
GW-52	36	ND	79
GW-53	58	ND	6
GW-54	158	2	22
GW-55	15	ND	3
GW-56	ND	ND	ND
GW-57	1	ND	ND

ND = Non-detect

SECTION 6
NATURE AND EXTENT

6.0 NATURE AND EXTENT OF CONSTITUENT MIGRATION

This section of the report provides an assessment of the nature and extent of constituent migration resulting from prior disposal practices at the Camp Allen Landfill. In addition, potential off-site sources of contamination identified during the study are also evaluated. Media of interest include: subsurface soils, surface soils, sediment, surface water, groundwater (shallow and deep aquifer systems), and air. Information generated as part of the previous site investigations, as well as data generated from the RI field activities, serves as the basis for this evaluation.

This evaluation will focus on the entire Camp Allen Landfill Site (Areas A and B) and will include the following significant elements:

- Identification of the concentrations of constituents of interest in subsurface soils, surface soils, sediment, drainage ditches/ponded area, and surface water.

- Definition of the horizontal and, where applicable, vertical extent of constituent contamination in site soils, sediment, and surface water.

- Identification of the concentration of constituents of interest in the shallow and deep aquifer systems.

- Definition of the horizontal extent of constituent migration in the groundwater.

- Definition of the vertical extent of constituent migration in the groundwater both within and between aquifer systems.

- Determination of site air quality (indoor and ambient) as it relates to constituents of interest.

The interpretation of nature and extent of constituent migration presented here has been based upon the results of previous investigations (Malcolm Pirnie and CH_2M Hill) as well as those performed by Baker. As discussed in Section 1.3 (Previous Investigations), Malcolm Pirnie conducted several phases of investigation from 1983 to 1987 (Malcolm Pirnie, 1984; Malcolm Pirnie, 1987; and Malcolm Pirnie, 1988) and CH_2M Hill conducted Interim RI activities during 1990 and 1991 (CH_2M Hill, 1992). In order to correlate analytical results for media of interest from previous investigations, these findings have been compiled into concise analytical summaries, which are presented in Appendix X. This appendix is subdivided into two sections, Malcolm Pirnie Analytical Summaries (1983-1986) and CH_2M Hill Analytical Summaries. Previous investigations are also summarized in Section 1.0.

To facilitate presentation of the results of this evaluation of nature and extent of constituent migration, the following constituent suites will be used: volatile organics, semivolatile organics, pesticide/PCBs, and inorganics. The extent to which each suite is discussed in the various sections which follow is based on its potential toxicity or the frequency/concentrations at which it was detected. The data depicted on the figures found in this section will reflect this presentation scheme.

The primary objectives of this study are as follows: (1) to adequately define the nature and extent of environmental impact at the Camp Allen Landfill, (2) to provide the necessary information to perform a public health and environmental risk assessment, and (3) to provide necessary information to screen alternatives to determine the most feasible methods for remediation, if necessary, of potential sources of risk to public health and safety and the environment. This section characterizes, based upon all available data, subsurface soil, surface soil, sediment, surface water, shallow and deep groundwater, and air quality with respect to specific constituents of concern.

For the purpose of conducting this study and discussion, the site has been divided into two primary areas and various secondary areas. The two primary areas include the Camp Allen Landfill Area A and Area B. Secondary areas of concern include: (1) drainage ditches that receive surface water runoff, groundwater discharge and seepage from both landfill areas and (2) potential off-site sources of contamination. In addition, both groundwater aquifer systems (shallow and deep) will be discussed in detail.

Overview of Area A and Area B Results

As anticipated from previous investigations, analytical results for volatiles, semivolatiles, pesticide/PCBs, and metals confirmed their presence in soils, sediment, surface water, and groundwater located in the vicinity of the Area A and Area B landfills. In some cases the constituents associated with the aforementioned analyses have exceeded various Federal and/or State standards and guidelines. In general, this contamination is largely attributed to past disposal practices and incineration activities in the Camp Allen Landfill area. Data generated during this RI also suggests the existence of several potential off-site contamination sources.

Data Comparisons to Standards and Criteria

As part of the RI evaluation process, analytical results have been compared to chemical-specific, Applicable Relevant and Appropriate Requirements (ARARs) or generally accepted criteria. Criteria used for the comparisons differ from ARARs in that ARARs are enforceable, while criteria are not mandatory requirements. Comprehensive ARAR comparisons, including chemical-specific, location-specific, and action-specific ARARs, will be included in the Feasibility Study based upon constituents of concern identified in the Risk Assessment Report for the Camp Allen Landfill Site.

Chemical-specific ARARs and criteria used for comparison varied with each sampled media as follows:

- Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States (United States Geological Survey, 1984), referred to as "USGS Background Criteria" were applied to soils sampled/analyzed in Rounds 2 and 3.

- National Oceanic and Atmospheric Administration (NOAA) Sediment Criteria; were applied to sediments sampled/analyzed in Rounds 2 and 3.

- Federal Ambient Water Quality Criteria (AWQC) and Water Quality Criteria (WQC) of the Commonwealth of Virginia, VR680-21-00 were applied to surface waters sampled/analyzed in Round 2.

- Federal Maximum Contaminant Level (MCL) and Water Quality Standards (WQS) for the Commonwealth of Virginia were applied to groundwater sampled/analyzed in Rounds 2 and 3.

A complete listing of comparisons has been included in Appendix Y. This appendix is divided in two sections; the first section contains comparisons related to sample results for Area A and the second section contains comparisons for Area B sample results. In general, samples collected during Rounds 2 and 3 have been combined by media and area in order to provide a comprehensive comparison. However, there is one exception to this format. As discussed in

Section 5.0, a preliminary evaluation of analytical results for samples collected during Round 2 resulted in the revision of project data quality objectives (DQOs). This revision consisted of the modification of the CLP analytical method for volatile organics for Round 3 groundwater sample analyses to attain lower detection limits required to meet the revised data quality objectives (DQOs). Therefore, analytical results for groundwater samples collected during Round 2 and Round 3 were not combined. Rather, they are compared to Federal and State MCLs separately.

6.1 Source Characterization (Area A and Area B)

6.1.1 Source Characterization (Area A)

Source characterization analytical results for subsurface soil samples collected during Round 2 at Area A show:

- Six of eight samples contained volatile organic compounds ranging in concentrations from 3J µg/kg to 3,000,000 µg/kg. The concentrations of total volatiles ranged from 55,000 µg/kg to 3,385,000 µg/kg. Based on reported materials disposed at Area A, volatile organic compounds detected are most likely related to waste solvent or fuel oil laden materials.

- Semivolatile organic compounds were detected in seven of the samples collected ranging in concentration from 34J µg/kg to 41,000 µg/kg. Concentrations of total semivolatiles ranged from 34 µg/kg to 76,000 µg/kg. Semivolatile organic compounds detected can be associated with plastics, crude oil, products of combustion from organic material and/or disinfectants. The diversity associated with the semivolatile compounds detected can most likely be attributed to incinerator ash or fly ash and miscellaneous landfill materials (i.e., fuel-laden materials).

- Pesticides/PCBs were detected in all eight samples at concentrations ranging from 1.09K µg/kg to 1800 µg/kg. Total pesticides ranged from 3 µg/kg to 113.4 µg/kg. Aroclor-1254 was detected in one sample at a concentration of 1,600 µg/kg and Aroclor-1260 was detected in five samples at concentrations ranging from 49.5 µg/kg to 1,800 µg/kg. Pesticide compounds were also detected at varying concentrations and can most likely be attributed to incinerator ash disposal and/or various applications which are resistant to biodegradation. PCB compounds are primarily used in transformers and capacitors as dielectric fluid. Additionally, PCBs are found in a variety of other applications such as heat transfer and hydraulic fluid; dye carriers in carbonless copy paper; plasticizers in paints, adhesives, and caulking compounds, all of which are potential landfill materials. PCBs persist and take several decades to decompose which supports the analytical findings based on past disposal practices.

Round 3 source characterization activities (collection and analysis of two subsurface soil samples for TCL parameters from boring location A-MW20B) were the result of a field modification. Because a nonstandard container was utilized for these particular samples, it is suspected (as described in detail in Section 3.1.2), that at least some of the analytical constituent concentrations are significantly understated. As discussed in Section 3.1.2, boring location A-MW20B was originally proposed as a deep groundwater monitoring well in order to better define the extent of volatile organic compounds detected in groundwater from the Yorktown Aquifer in the northern portion of Area A during Round 2. However, due to elevated PID and FID readings (organic vapors), grossly stained split spoon samples, and the absence of the confining clay unit at this location, well construction was abandoned and two subsurface soil samples exhibiting signs of contamination were instead submitted for TCL analyses. The sample volume was limited to the amount retrieved from the split spoon sampling device and samples were immediately sealed in glass sample jars after field description. The samples were then shipped to the laboratory in the sealed glass sample jars and were not transferred into required (teflon sealed) containers to avoid sample disturbance. The chain-of-custody record was duly noted.

Based on field observations, boring location A-MW20B was considered to be in a likely source area of the volatile organic compounds detected in the groundwater from the Yorktown Aquifer during Round 2 (see Appendix H for the Test Boring Record for A-MW20B). However, analytical results for the Area A, Round 3 source characterization samples revealed that volatile organic compounds were not detected at significant concentrations. This contradicts the documented field observations and is most likely the result of the escape of volatile compounds from the replacement containers prior to analysis at the laboratory.

Semivolatile organic compounds were detected in both samples at concentrations ranging from 25J µg/kg to 620 µg/kg. Total semivolatiles ranged from 626 µg/kg to 1,382 µg/kg. Pesticide/PCB compounds were detected in both samples at concentrations ranging from 0.84J µg/kg to 92L µg/kg.

Concentrations of volatiles, semivolatiles and pesticide/PCB compounds in these particular samples were noticeably less in Round 3 than in Round 2.

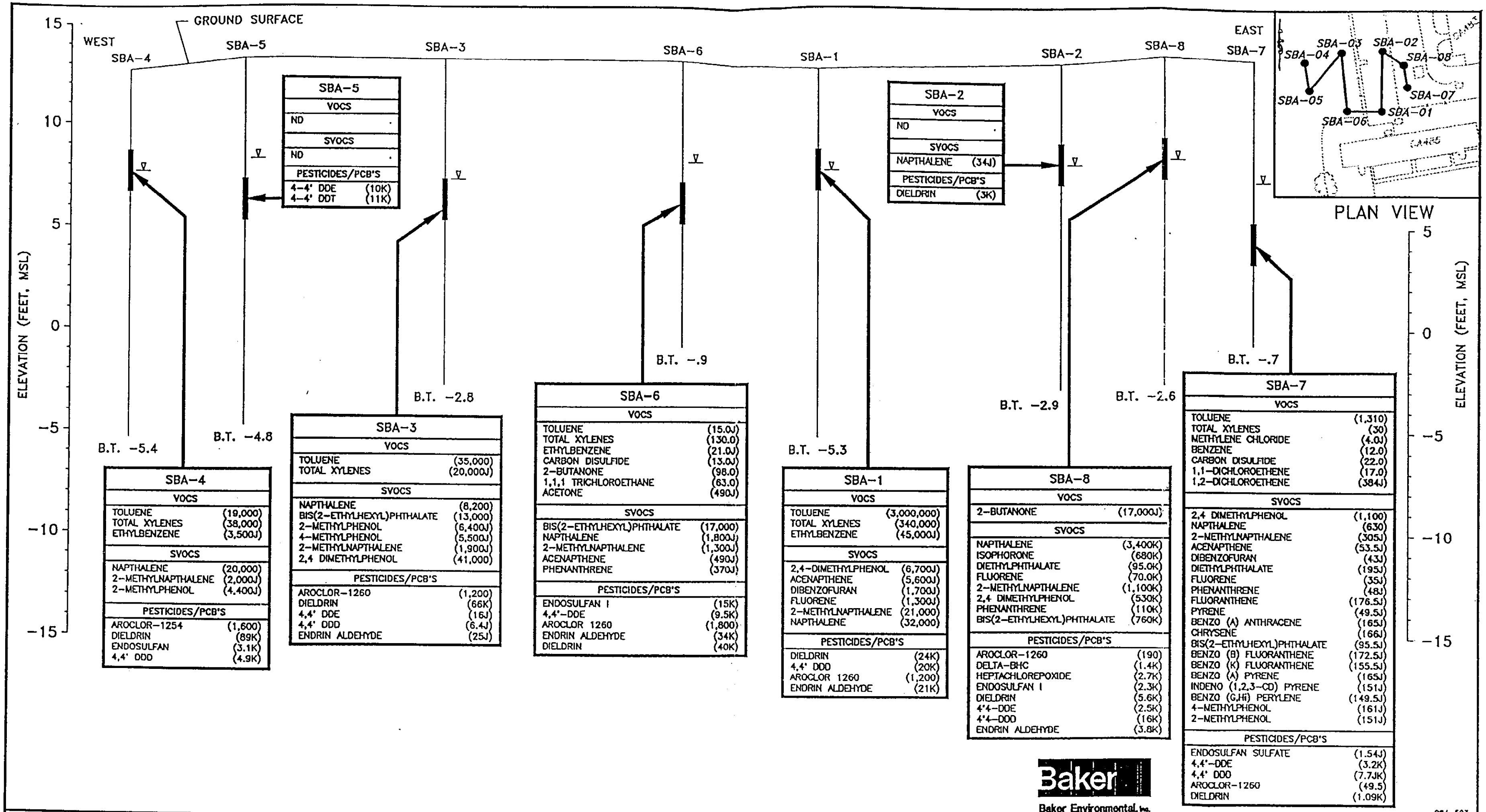
Based upon the source characterization sample results, volatile organic compounds are considered the primary constituents of concern. Five of the subsurface soil samples analyzed during Round 2, Area A source characterization contained volatiles at elevated levels. The distribution pattern of volatile concentrations in the subsurface soil indicates that a large area of volatile constituents are located in the 4 to 6 foot range of the eastern portion of Area A. Analytical data and PID field screening indicates that soil contamination is greatest near the water table and in some areas concentrations are consistent or slightly increasing with depth. This is an indication that the contamination is migrating with the groundwater and is not related to a surface release or application. Figure 6-1 illustrates soil boring cross-sections with respective concentrations and reference points (depth of samples) for source characterization results at Area A during Round 2.

Although results of Round 3 source characterization analyses did not indicate elevated volatile organic compound concentrations, these analytical results may have been understated, as noted above. Documented field observations strongly suggest a potential source area north of the Brig Facility. This likelihood is further supported by the groundwater sample analytical results portion of this section.

6.1.2 Source Characterization (Area B)

As discussed in Section 1.3.5, soil gas monitoring was performed by CH_2M Hill at and around the Area B landfill in April, 1991. Soil gas monitoring provided a quick means of waste site evaluation. Using this method, CH_2M Hill was able to preliminarily identify likely areas of underground contamination and general movement of detected constituents through the near-surface soil and fill materials.

In general, aromatic hydrocarbons, tetrachloroethane, and trichloroethane were detected primarily throughout the middle portion of Area B along the area in which the underground storm sewer crosses the site. Aromatic hydrocarbons and tetrachloroethane were also detected in isolated areas in the southwestern and northeastern portions of Area B. Cycloalkanes/alkenes (unsaturated aliphatic hydrocarbons) were detected in these isolated areas as well. Round 2 source characterization boring locations, as presented in Section 3.2.6,



LEGEND

∇	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. X'	BORING TERMINATED, ELEVATION MSL
▬	SAMPLE LOCATION
VOCS	VOLATILE ORGANIC COMPOUNDS
SVOCS	SEMI VOLATILE ORGANIC COMPOUNDS
ND	NOT DETECTED
	ALL UNITS IN ug/kg

40 0 20 40 80

Horizontal Scale: 1 inch = 40 ft.

5 0 2.5 5 10

Vertical Scale: 1 inch = 5 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 6-1
SOURCE CHARACTERIZATION SAMPLE RESULTS
AREA A
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

were based on these findings, as well as on the geophysical survey results performed prior to RI field activities.

Source characterization analytical results for subsurface soil samples collected during Round 2 at Area B show:

- Five of ten samples collected contained volatile organic compounds ranging in concentration from 4J µg/kg to 200,000 µg/kg. Total volatile concentrations ranged from 284 µg/kg to 262,000 µg/kg. The volatile organic compounds detected were significant and are most likely associated with waste solvents and fuel oils.

- Semivolatile organic compounds were detected in eight samples at concentrations ranging from 23J µg/kg to 14,000 µg/kg. Total semivolatiles ranged from 23 µg/kg to 24,860 µg/kg. The semivolatile organic compounds detected can be associated with plastics, crude oil, products of combustion from organic material and disinfectants. The semivolatile compounds detected were at low levels when compared with those detected in Area A.

- Pesticide compounds were detected in one sample (SBB-06) at concentrations ranging from 12J µg/kg to 3,800 µg/kg. This sample also contained 9,500 µg/kg of Aroclor-1254. Pesticide compounds were detected in this area at levels indicating a potential source. PCB compounds have been primarily used in transformers and capacitors as dielectric fluid. However, PCBs have also been used in a variety of other applications. The occurrence and distribution of the pesticide/PCB compounds suggests that SBB-06 is most likely one of the primary areas in which trench and fill operations occurred.

- Cadmium exceeded the USGS background criteria of 1.0 mg/kg in one sample (SBB-01, 1.3 mg/kg). The occurrence and distribution of cadmium can probably be attributed to wide dispersal at varying concentrations throughout the soils in the Camp Allen Area. No other metals exceeded available USGS background criteria concentrations. Commonly detected metals included arsenic, chromium, lead, and zinc.

In evaluating the aforementioned detections and considering the locations of the subsurface soil samples, one area (vicinity of SBB-06) is of particular concern as it contained significant concentrations of organics and inorganics.

Concentrations of volatiles, semivolatiles, pesticides/PCBs, and metals in subsurface soils at Area B are depicted on Figure 6-2. The distribution pattern of volatiles, semivolatiles, and pesticide/PCB compounds appears to be concentrated in two sections of Area B comprised of three sample locations (SBB-04 and SBB-06/SBB-07). Boring location SBB-04 is located adjacent to the Salvage Yard in an area where underground utilities cross toward the southeast. As disposal areas were not indicated in the immediate vicinity, detected concentrations may be attributable to potential migration of constituents in the groundwater from the Salvage Yard.

Borings SBB-06 and SBB-07 are located within the primary disposal area identified in the geophysical survey report. The significant detections of organic compounds further support that this location probably received the bulk of the wastes from the Salvage Yard fire.

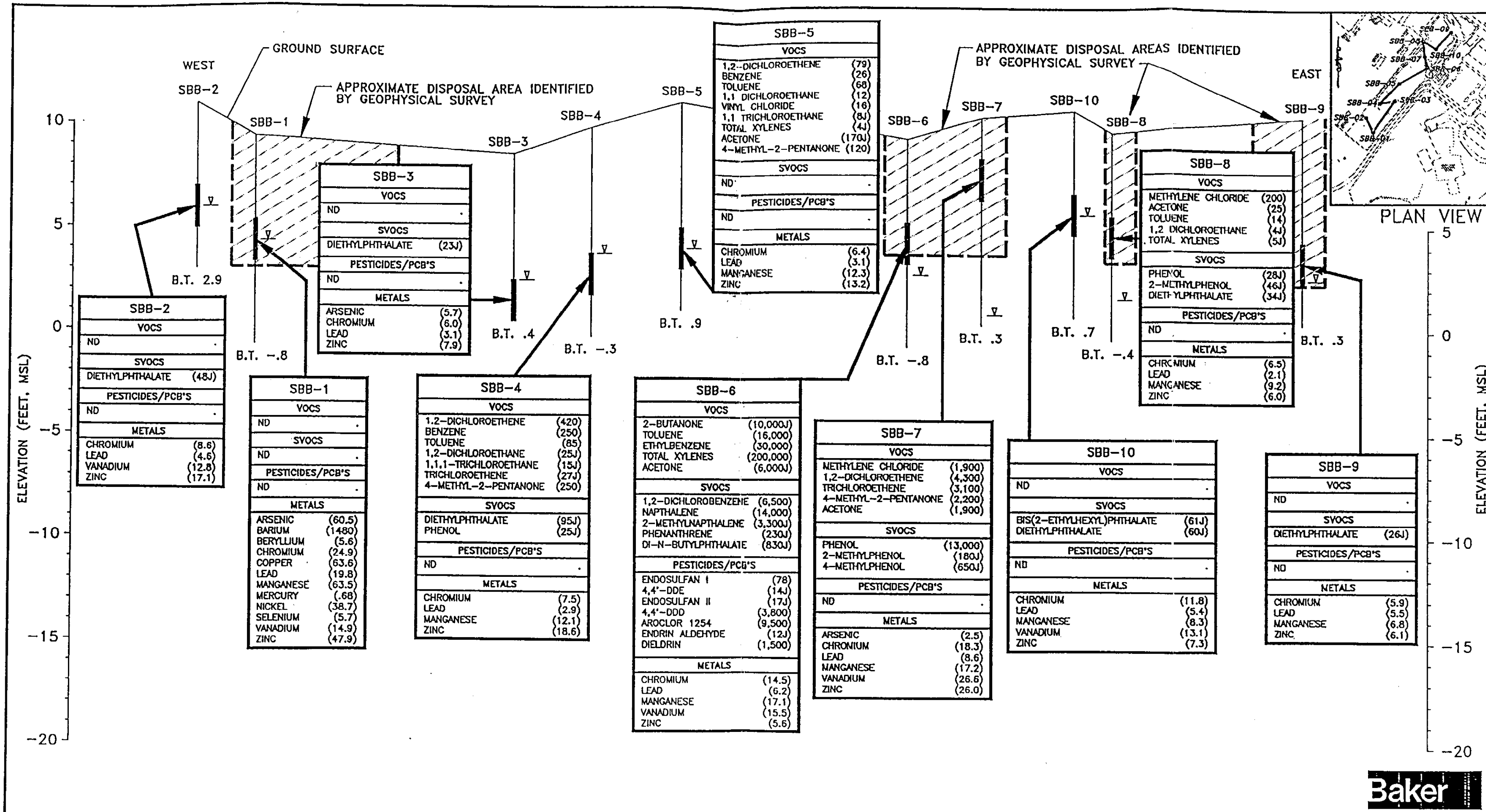
Significant detections of inorganic compounds appear to be concentrated in the area of boring location SBB-01, in the southwestern corner of Area B. Based on the geophysical survey results, this was another suspected disposal area containing pockets of metallic fill material surrounded by high conductivity nonmetallic fill.

It is interesting to note that the third area of high conductivity and magnetic intensity, the northeastern portion of Area B adjacent to the pond, was investigated by boring location SBB-09. Analytical results for the sample collected from this location did not contain significant organic or inorganic constituents. Based on the analytical data and field observations of concrete rubble and scrap rebar, this area is likely a zone of miscellaneous demolition debris.

6.2 Surface Soil Characterization (Area A and Area B)

6.2.1 Surface Soil Characterization (Area A)

During Round 3 sampling efforts, five surface soil samples were collected. Volatile organic compounds were not detected in any of the samples collected.



Baker

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LEGEND

∇	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. X'	BORING TERMINATED, ELEVATION MSL
▬	SAMPLE LOCATION
VOCS	VOLATILE ORGANIC COMPOUNDS
SVOCS	SEMI VOLATILE ORGANIC COMPOUNDS
ND	NOT DETECTED
	ALL UNITS IN ug/kg EXCEPT METALS (mg/kg)

90 0 45 90 180

Horizontal Scale: 1 inch = 90 ft.

5 0 2.5 5 10

Vertical Scale: 1 inch = 5 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 6-2
SOURCE CHARACTERIZATION SAMPLE RESULTS
AREA B
CAMP ALLEN LANDFILL

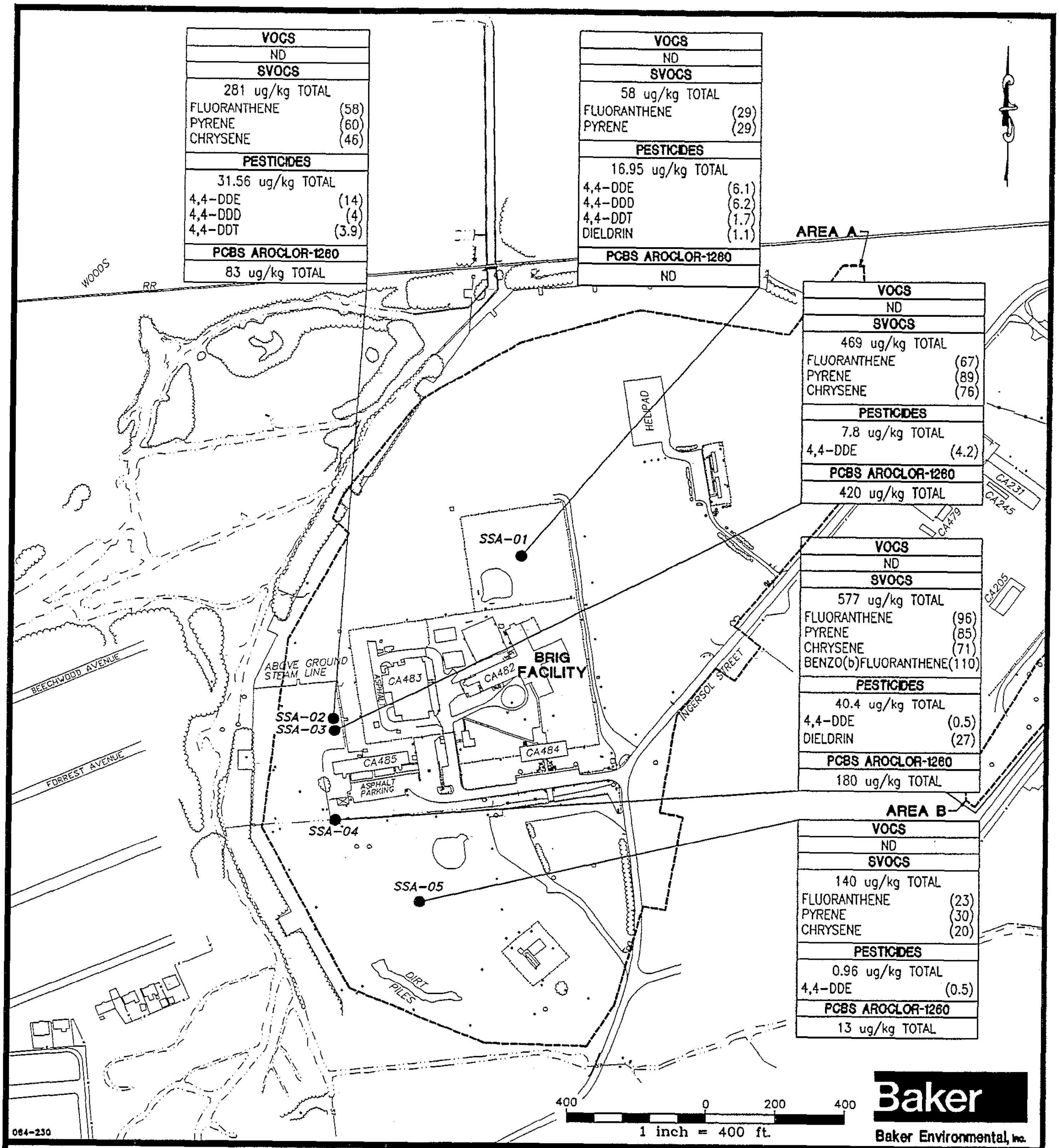
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

Semivolatile organic compounds were detected in all five samples at concentrations ranging from 19 µg/kg to 110 µg/kg. The concentration of total semivolatiles ranged from 58 µg/kg to 577 µg/kg. The highest concentration of total semivolatiles existed in the southwest corner (SSA-04) of the Brig Facility and decreased to the north, northeast, and southwest. The constituents detected in the surface soils do not directly correlate with those detected in the surrounding subsurface soils. Semivolatiles (in particular polyaromatic hydrocarbons-PAHs) could potentially be subject to airborne transport and subsequent deposition, especially during mechanical disturbances such as, vehicle and air traffic. PAHs can be considered ubiquitous in nature. The presence of PAHs in the surface soil may be the result of aerially deposited material, and the chemical and biological conditions in the soil which result in selective microbial degradation/breakdown.

Pesticides were also detected in all five surficial soil samples at concentrations ranging from 0.5 µg/kg to 14 µg/kg. The concentration of total pesticides ranged from 0.96 µg/kg to 31.56 µg/kg. The levels at which pesticides were detected could potentially be due to normal applications, given the fact that pesticides are very resistant to normal biodegradation. Aroclor-1260 was detected in four of the five samples at concentrations ranging from 13 µg/kg to 420 µg/kg. Adsorption of these contaminants to soil is the major fate of these contaminants in the environment. The absorption of these contaminants to soil is indicated by the virtual nonexistence of these contaminants in the aqueous samples.

Concentrations of volatile, semivolatile, and pesticide/PCB samples are depicted on Figure 6-3. The pesticide/PCB compounds detected can be considered uniform throughout the surficial soils in Area A, as concentrations did not vary significantly. However, compared with subsurface soil samples obtained in the vicinity of the surficial soil samples, constituents were found increasing with depth. The horizontal extent of constituent concentrations can be considered uniform as surface and subsurface soils had consistent detections throughout the respective media. However, the vertical concentration increases with depth as can be expected due to the nature of the landfill and as biodegradation occurs more rapidly at the surface.

Cadmium was detected in three of the five samples at concentrations ranging from 22.2 µg/kg to 88.9 µg/kg, exceeding USGS background criteria in all three instances. Lead was detected in all five samples ranging in concentration from 13.2 mg/kg to 683 mg/kg. Since site-specific background data for metals is not available, metals concentrations were compared to observed ranges of background metals in soils of the Eastern United States as presented in USGS Professional Paper 1270 (H.T. Shacklette and J.G. Boerngen, 1984). Only one sample



LEGEND

SSA-01 ●	SURFACE SOIL SAMPLE
ug/kg	MICROGRAM/KILOGRAM (ppb)
PCB	POLYCHLORINATED BIPHENYLS
SVOCS	SEMIVOLATILE ORGANIC COMPOUNDS
VOCS	VOLATILE ORGANIC COMPOUNDS
ND	NOT DETECTED

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 6-3
SURFACE SOIL SAMPLE RESULTS (ORGANICS)
AREA A
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

(SSA-03) exceeded USGS background levels for lead. Additional metals were detected; however, their occurrences and distribution can be considered natural based on comparisons to USGS background levels.

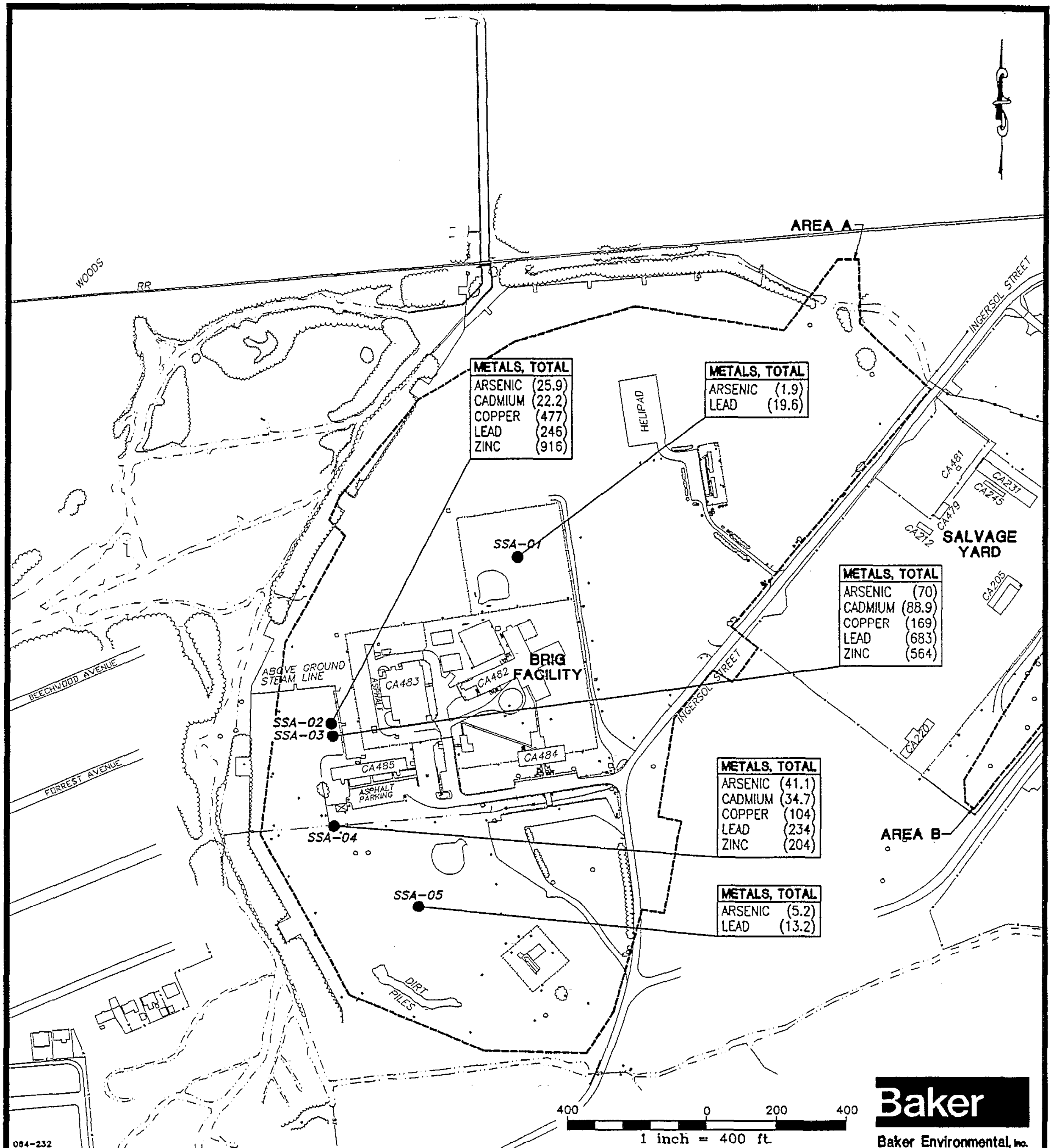
Figure 6-4 presents metals detected and the corresponding concentrations. Given that incineration activities were once performed in the Camp Allen area and that soil borrow pits in the vicinity were reportedly used for "landfill capping," elevated metal concentrations detected in the surficial soils atop Area A could potentially be related to past incineration activities. In addition, the metal content associated with the surface soils could also be attributed to the composition of fill material used.

6.2.2 Surface Soil Characterization (Area B)

During Round 3, five surface soil samples were collected. Results of analytical data indicate that organic compound concentrations were below method detection limits. With the exception of common laboratory contaminants, no other VOCs were detected.

Three samples contained semivolatile organic compounds at concentrations ranging from 17J µg/kg to 150J µg/kg. Total semivolatiles ranged in concentration from 256 µg/kg to 777 µg/kg. The constituents and concentrations detected in the surficial soils were consistent from Area A to Area B, indicating that the surface composition is uniform in both landfills. Semivolatiles (PAHs) could potentially be subject to airborne transport and subsequent deposition, especially during mechanical disturbances such as vehicle and air traffic. As stated previously, PAHs are ubiquitous in nature. The presence of PAHs in the soil may be the result of aerially deposited material, and the chemical and biological conditions in the soil which result in selective microbial degradation/breakdown.

The pesticide/PCB compounds detected can be considered uniform throughout the surficial soils in Area B as concentrations did not vary significantly. Pesticides were detected in all five surficial soil samples at concentrations ranging from 0.43J µg/kg to 22L µg/kg. Total pesticides ranged from 11.06 µg/kg to 36.2 µg/kg. The constituents and concentrations detected correlated with those detected in Area A surface soils. In addition, all of the surficial soils in Area B contained pesticides, whereas only one subsurface soil sample (SBB-06) contained pesticide constituents which were significantly higher. Aroclor-1260 was detected in Area B surface soils at concentrations which were consistent with those detected in Area A surface soils.



LEGEND

SSA-01 ● SURFACE SOIL SAMPLE

NOTE: ALL RESULTS ARE PRESENTED IN mg/kg (ppm).

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 6-4
SURFACE SOIL SAMPLE RESULTS
(INORGANICS)
AREA A
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

Concentrations of volatile, semivolatile, and pesticide/PCB samples are depicted on Figure 6-5 and can be considered uniform throughout the surficial soil samples in Area B, as concentrations did not vary significantly. However, compared with subsurface soil samples obtained in the vicinity of surficial soil samples, constituents were found to be increasing with depth in select areas. This increase with depth can be expected due to the nature of the landfill and as biodegradation occurs more rapidly at the surface.

During Round 2, three surface soil samples were collected south of Area B in the vicinity of the Camp Allen Elementary School and analyzed for selected metals. Cadmium was detected in one sample (SSB-03) at a concentration of 31.3 mg/kg, exceeding the USGS background criteria. Additional metals were detected; however, the concentrations and distribution can likely be considered naturally occurring in soils. No other metals detected in Round 2 surface soil samples exceeded available USGS background criteria.

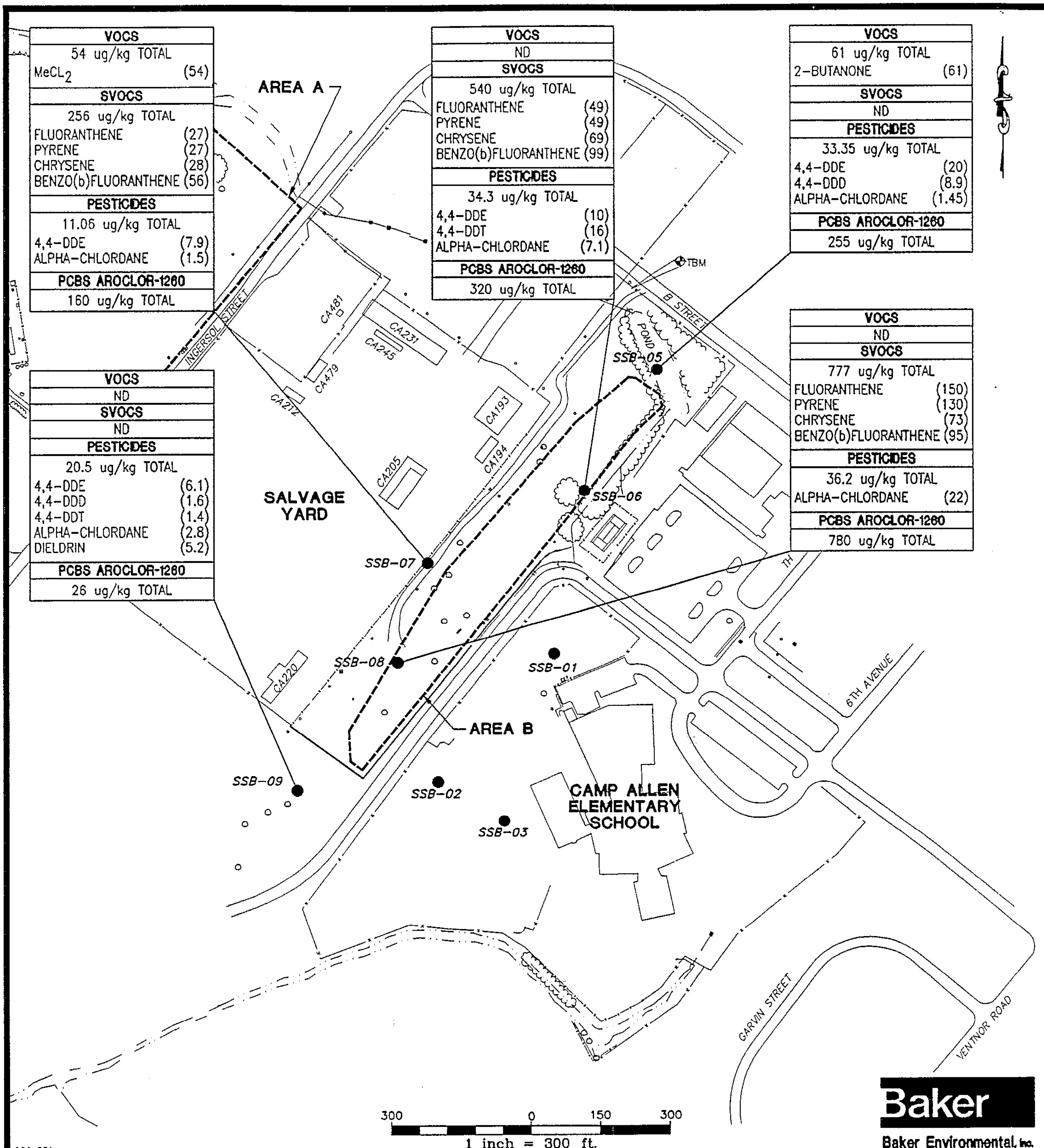
During Round 3, four samples collected in the immediate vicinity of Area B contained cadmium at concentrations ranging from 1.5 mg/kg to 20.5 mg/kg. Cadmium concentrations exceeded USGS background criteria in all four samples. In addition, other metals including aluminum and iron were detected in several samples; however, they did not exceed USGS background criteria.

Figure 6-6 presents metals detected and the corresponding concentrations. Elevated cadmium concentrations detected in the surficial soils atop or near Area B are possibly connected to previous incineration activities in the Camp Allen area. In addition, the metal content associated with the surface soils could also be attributed to the composition of fill material used.

6.3 Sediment Characterization (Areas A and B)

6.3.1 Sediment Characterization - Organics

A discussion of the nature and extent of organic constituents detected in sediment samples from the drainage ditches surrounding Areas A and B is presented below. During Interim RI activities performed in April of 1991, CH_2M Hill performed a limited sediment sampling program (See Appendix X). RI results, as well as Interim RI findings are included in the evaluation. Figure 6-7 presents sample locations and organic compound analytical results for

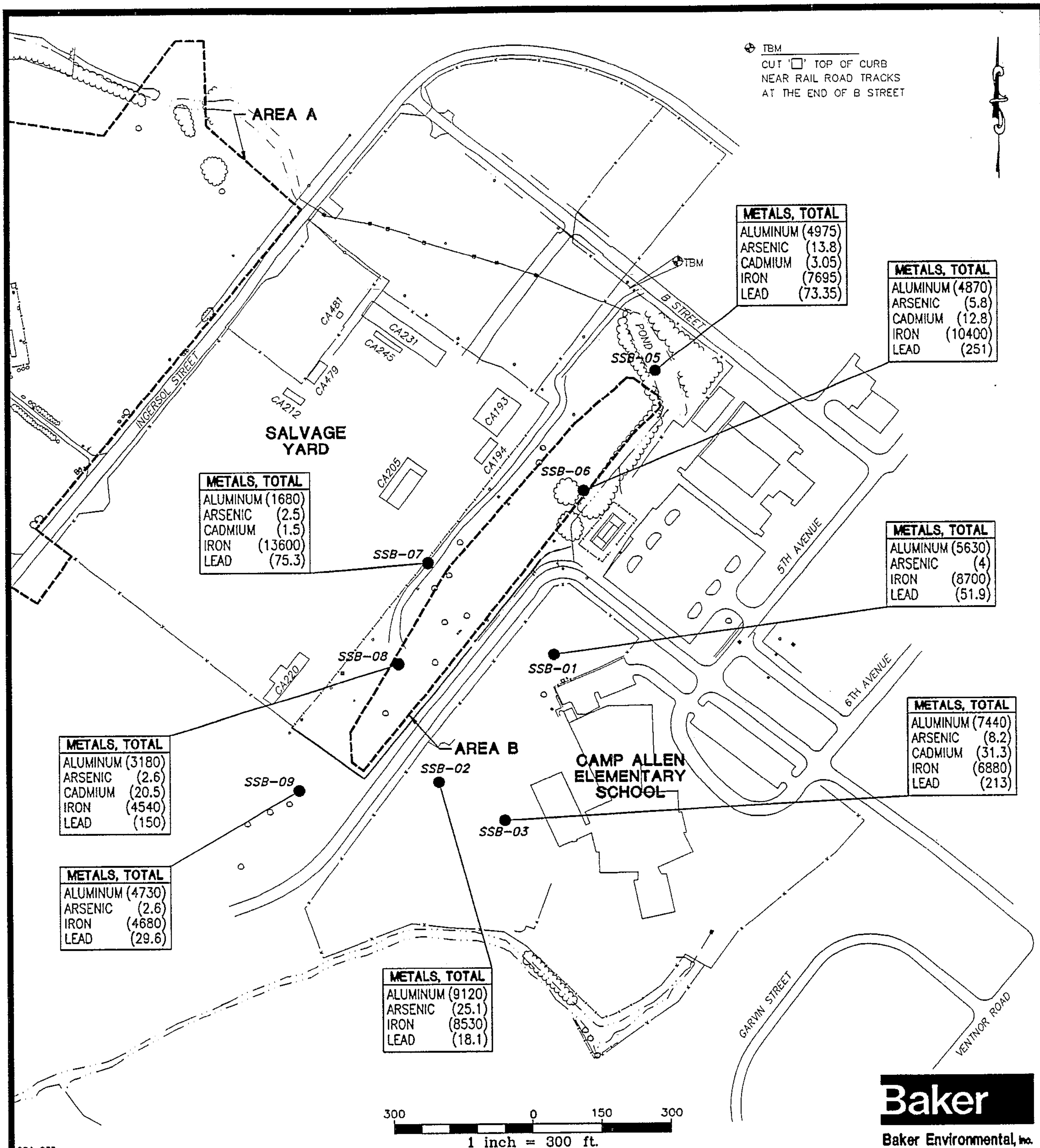


LEGEND

SSB-05 ●	SURFACE SOIL SAMPLE LOCATION
ug/kg	MICROGRAMS/KILOGRAMS (ppb)
PCB	POLYCHLORINATED BIPHENYLS
$MeCL_2$	METHYLENE CHLORIDE
SVOCS	SEMIVOLATILE ORGANIC COMPOUNDS
VOCS	VOLATILE ORGANIC COMPOUNDS
ND	NOT DETECTED

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 6-5
SURFACE SOIL SAMPLE RESULTS (ORGANICS)
AREA B
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



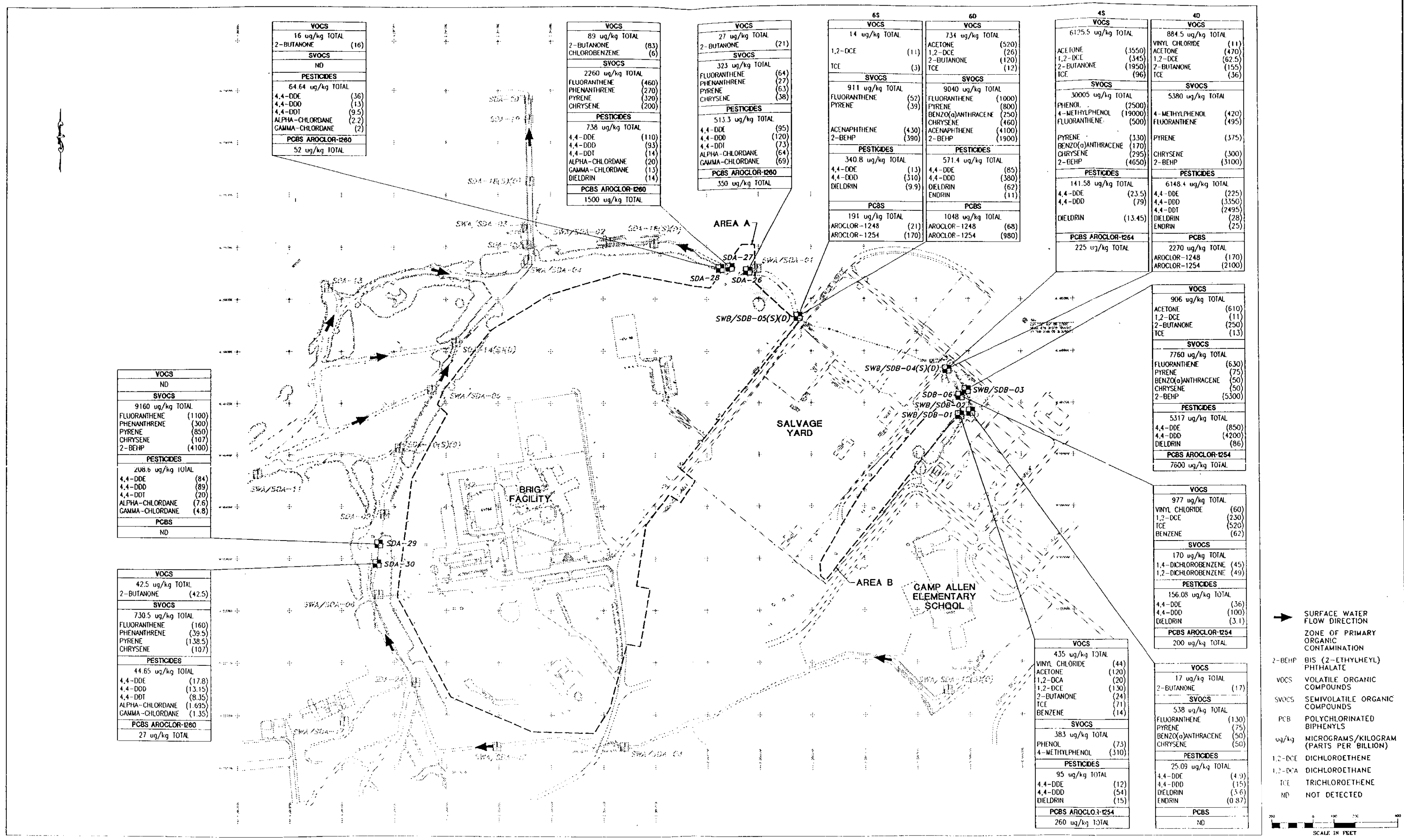
LEGEND

SSB-05 ● SURFACE SOIL SAMPLE LOCATION

NOTE: ALL RESULTS ARE PRESENTED IN mg/kg (ppm).

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 6-6
SURFACE SOIL SAMPLE RESULTS
(INORGANICS)
AREA B
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



REVISIONS		NORTH	CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	SEDIMENT SAMPLE RESULTS AREAS A AND B (ORGANICS)	FIGURE 6-7
	DATE 7/93 SCALE GRAPHIC DRAWN GLB REVIEWED TEA S.O.# 19084 CADD# 084-236				SCALE GRAPHIC DATE 7/93	

sediment samples collected at both Area A and Area B. This figure presents total organic concentrations and primary constituents detected for each organic parameter group (volatile, semivolatile, pesticide, and PCBs). In addition, Figure 6-7 provides zones of primary organic contamination, depicted by shaded areas.

6.3.1.1 Sediment Characterization (Organics) Area A

During Round 3 sampling efforts, four of five samples contained volatile organic compounds ranging in concentrations from 6J µg/kg to 83 µg/kg. The only constituent detected was chlorobenzene. Chlorobenzene, a colorless, flammable liquid formed by combining chlorine with benzene and used in organic synthesis as a solvent and as a chemical intermediate was detected at 6 µg/kg in one sample (SDA-27). This isolated occurrence may be attributed to a localized "pocket," as chlorobenzene was not detected at significant quantities in any other sampled media in this area.

Semivolatile organic compounds were detected in four samples ranging in concentrations from 27J µg/kg to 4,100 µg/kg. The concentrations of total semivolatiles for Area A sediment samples ranged from 323 µg/kg to 9,160 µg/kg. Four semivolatile constituents; phenanthrene, fluoranthene, benzo(a)anthracene, and chrysene, were detected in one sample (SDA-29) exceeding Federal standards. In addition, phenanthrene exceeded Federal standards in SDA-27. The presence of PAHs in the sediment may be the result of aerially deposited material and the chemical and biological conditions in the sediment resulting in microbial degradation. Surface runoff may also add to the presence of PAHs in the sediment.

Pesticide/PCB compounds were detected in all five sediment samples at moderate concentrations. Pesticide/PCB concentrations ranged from 1.2J µg/kg to 1,500 µg/kg. Five pesticide constituents; 4,4'-DDE; 4,4'-DDD; 4,4'-DDT; alpha-chlordane; and gamma-chlordane exceeded Federal standards in all five sediment samples. Dieldrin exceeded Federal standards in one sample (SDA-27). Aroclor-1260 was detected in one central area (SDA-27) at a concentration of 1,500 µg/kg. The organic constituents detected in sediments collected from the drainage ditches encompassing Area A were similar to those found at slightly higher levels in the surface soils. The concentrations correlate with levels detected in surface soils and may be a result of surface runoff resulting in particle deposition. In addition, volatile organic contaminants detected in the northeastern portion of Area A are suspected to be the result of surface water flow (via the underground culvert) from the Area B pond area.

6.3.1.2 Sediment Characterization (Organics) Area B

Based on data collected by CH_2M Hill in April 1991, volatiles detected in sediment samples from Area B were primarily limited to the northern portion of the site (ponded area). Vinyl chloride, 1,2-dichloroethene, and trichloroethene were the primary constituents detected and correlated with results obtained by Baker. RI findings are discussed in the sections below.

Volatile organic compounds were detected in all eight sediment samples collected. Concentrations ranged from 3J µg/kg to 3,550 µg/kg. Total volatile concentrations ranged from 14 µg/kg to 6,125.5 µg/kg. Vinyl chloride, benzene, trichloroethene, 1,2-dichlorethane, and 1,2-dichloroethene were detected at moderate levels in sediment samples. In addition, acetone and 2-butanone were detected in several samples at elevated levels. To date, generally accepted sediment quality criteria are not available for volatile organics. Sediments from the northern (SDB-04S and SDB-04D), southern (SDB-01) and the central (SDB-06) portion of the ponded area contained significant amounts of volatiles.

Semivolatile organic compounds were detected in all eight samples at concentrations ranging from 25J µg/kg to 19,000 µg/kg. Total semivolatile concentrations ranged from 170 µg/kg to 30,005 µg/kg. Five constituents including acenaphthene, fluoranthene, pyrene, benzo(a)anthracene, and chrysene were detected in samples exceeding Federal standards. All five constituents exceeded Federal standards in one sample (SDB-05S). Fluoranthene also exceeded Federal standards in one additional sample (SDB-03). The primary area of semivolatile contamination is in the deep sediments located in the northwest portion (SDB-05D) of the ponded area associated with Area B.

Pesticide/PCB compounds were detected in all eight samples collected at concentrations ranging from 0.68J µg/kg to 7,600 µg/kg. Total pesticide concentrations ranged from 25.09 µg/kg to 6,148.4 µg/kg. Total PCB concentrations ranged from 191 µg/kg to 7,600 µg/kg. Three constituents: dieldrin; 4,4'-DDD; and 4,4'-DDE; exceeded Federal standards in all eight sediment samples collected. In addition, 4,4'-DDT was detected in one sediment sample (SDB-04D) at a concentration of 2,495 µg/kg, exceeding Federal standards. Endrin was detected in three samples at concentrations ranging from 0.87 µg/kg to 25 µg/kg, exceeding Federal standards in two deep samples (SDB-04D and SDB-05D) and one shallow sample (SDB-02).

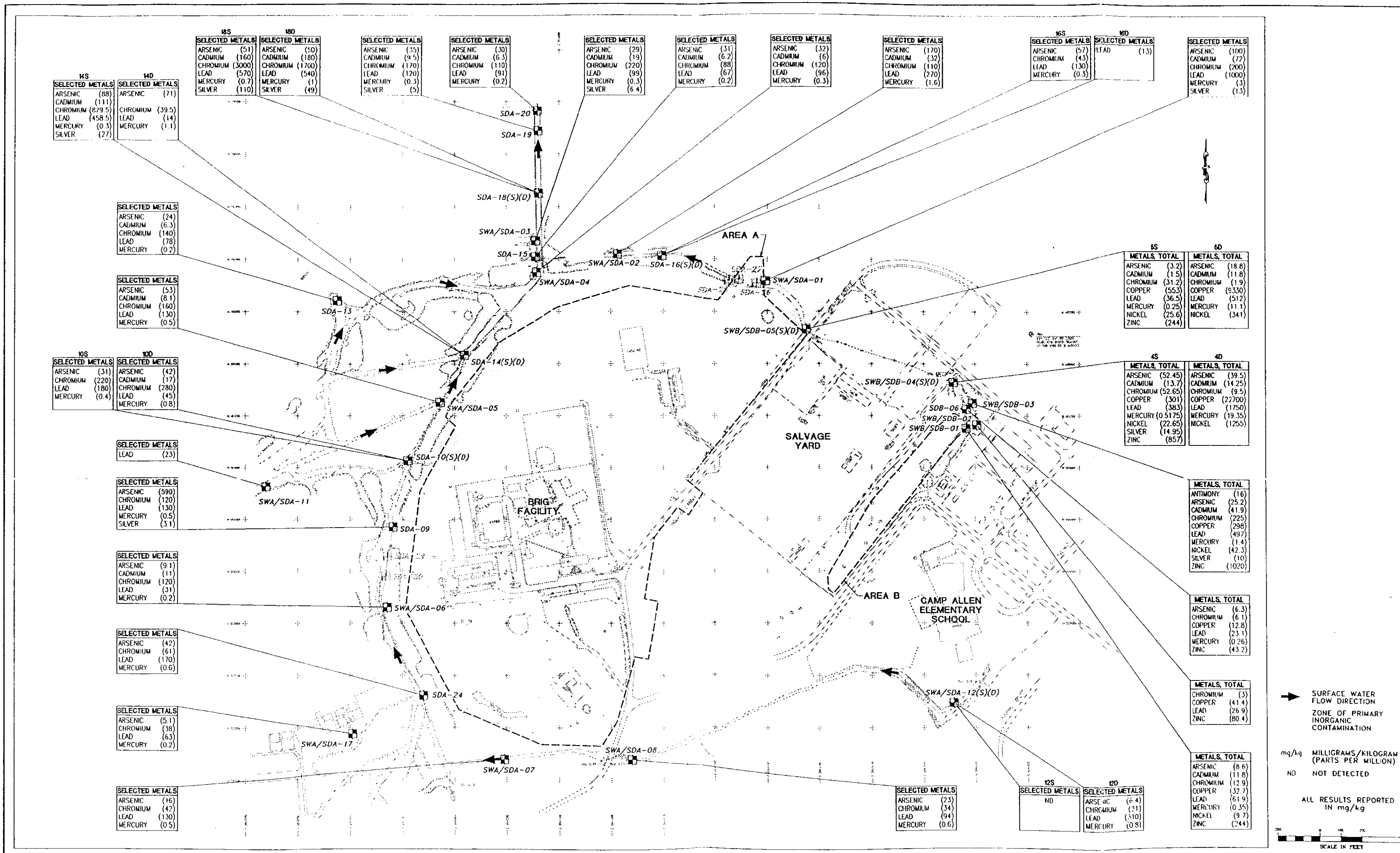
The surface water impoundment sediments east of Area B are impacted by organic constituents. In general, detected organic compound contamination decreased with depth in the sediment samples collected from the ponded area of the drainage ditch, but increased with depth in the northwest portion (SDB-05S and SDB-05D) of the drainage ditch associated with Area B. Additionally, sediment sample SDB-06 was collected in an area of active seepage. The seep's origin appears to be shallow groundwater discharge with a heavy iridescent sheen. The seep appeared to have a slow flow rate during periods of no precipitation; however, after periods of rainfall, discharge was noted to increase accordingly. The seep is located in the northern end of the disposal area adjacent to the ponded area identified during the geophysical survey at Area B.

6.3.2 Sediment Characterization - Inorganics

A discussion of the nature and extent of inorganic constituents detected in sediment samples from the drainage ditches surrounding Areas A and B is presented below. RI results, as well as Interim RI findings are included in the evaluation. Due to significantly variable inorganic parameter concentrations detected throughout the Camp Allen Area, this section's discussion of site conditions is limited to detections which exceeded inorganic sediment quality criteria. Figure 6-8 presents RI sample locations and inorganic analytical results for sediment samples collected at both Area A and Area B. This figure presents a listing of all constituents detected at each sample location. In addition to Figure 6-8, bar chart depictions of detected metal concentrations of all sediment samples (Areas A and B), including comparisons of results to Federal and State WQC are contained in Appendix Z. For ease of interpretation, sample locations have been arranged by normal flow, upstream to down stream locations. In addition, Figure 6-8 provides zones of primary inorganic constituent detections, depicted by shaded areas.

6.3.2.1 Sediment Characterization (Inorganics) Area A

Data collected by CH_2M Hill in April 1991, indicates that metal concentrations detected in sediment samples from Area A exceeded sediment quality criteria at all sample locations for cadmium, zinc, and lead. Other metal concentrations which exceeded criteria values included arsenic, copper, mercury, nickel, and silver. Although no apparent directional trend existed, elevated values were more common in the northern drainage ditch areas.



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	CADD#	084-237			

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SEDIMENT SAMPLE RESULTS
AREAS A AND B
(INORGANICS)

SCALE GRAPHIC | DATE 7/93

FIGURE 6-8

During Round 2 sampling efforts 23 samples were collected from shallow and deep sediments and analyzed for selected metals. Eight of these locations correlated with reported CH_2M Hill sample locations.

Arsenic was detected in 21 samples at concentrations ranging from 5.1 mg/kg to 590 mg/kg, exceeding sediment quality criteria in 12 of the samples. Cadmium was detected in 14 samples at concentrations ranging from 6 mg/kg to 180 mg/kg, exceeding sediment quality criteria in all 14 locations. Chromium was detected in 21 samples at concentrations ranging from 38 mg/kg to 3,000 mg/kg, exceeding sediment quality criteria in 16 samples. Lead was detected in all 23 samples at concentrations ranging from 13 mg/kg to 1,000 mg/kg, exceeding sediment quality criteria in 20 samples. Mercury was detected in 21 samples ranging in concentrations from 0.2 mg/kg to 3 mg/kg, exceeding sediment quality in all of the samples. Silver was detected in seven samples at concentrations ranging from 3.1 mg/kg to 110 mg/kg, exceeding sediment quality criteria in all of the samples.

Metal concentrations fluctuated with depth depending on the location. Although several of the metals detected exceeded sediment quality throughout Area A drainage ditches (i.e., arsenic, lead, mercury) no direct trend is apparent between metal constituents as metal concentrations increased and decreased in isolated areas. However, three sample locations do reveal "isolated accumulations". Elevated levels of arsenic, cadmium, chromium, and mercury were detected at sample locations SDA-10(S)(D), SDA-14(S)(D), and SDA-18(S)(D). Elevated levels of lead and silver were also detected at these locations on a variable basis.

Based on field documented notes, sediment thickness within the drainage ditches varied significantly. On average, sediment thickness ranged from one to two feet; however, many areas were found to contain very thick layers of sediment. This is true for the drainage ditch on the western side of Area A (SDA-10 and SDA-14). Sampling activities in this area were difficult, as the thick layer of sediments (possibly in excess of three or four feet), hampered mobility of the sampling team .

Taking into consideration previous incineration activities and incinerator ash disposal, which occurred in this area during the 1950s and 1960s, detected metal concentrations in the drainage ditch area sediments are likely the result of transport via surface runoff and accumulation in low spots or depressions. Variations in detected concentrations with depth could be the result of sediment disturbances resulting from development activities from the 1970s to the present, as well as from tidal influences. In addition, suspected groundwater discharged into drainage ditches is also a possible pathway of metal contamination in sediment samples.

6.3.2.2 Sediment Characterization (Inorganics) Area B

Data collected by CH_2M Hill in April 1991, indicates that metal concentrations detected in sediment samples from Area B exceeded sediment quality criteria at all sample locations for cadmium, zinc, and lead. Other metal concentrations which exceeded criteria values included arsenic, copper, mercury, and silver. The sample exhibiting the most exceedances was located at the northern- most portion of the ponded area.

During RI activities, metals were detected in 10 of 11 sediment samples. Antimony was detected in one sample (SDB-03) at a concentration of 16L mg/kg, exceeding the sediment criteria. Arsenic was detected in nine samples at concentrations ranging from 3.2 mg/kg to 52.45 mg/kg, with two exceedances. Cadmium was detected in six samples at concentrations ranging from 1.5 mg/kg to 41.9 mg/kg, exceeding the criteria value in five samples. Chromium was detected in 10 samples at concentrations ranging from 1.9 mg/kg to 225 mg/kg, exceeding the sediment criteria in one sample. Copper was detected in eight samples at concentrations ranging from 12.8 mg/kg to 22,700 mg/kg, exceeding the criteria value in five samples. Lead was detected in ten samples at concentrations ranging from 23.1 mg/kg to 1750 mg/kg, exceeding the criteria value in eight samples. Mercury was detected in nine samples at concentrations ranging from 0.25 mg/kg to 19.35 mg/kg; all nine exceeded the criteria value. Nickel was detected in six samples at concentrations ranging from 9.7 mg/kg to 1,255 mg/kg, with exceedances. Silver was detected in two samples at concentrations ranging from 10 mg/kg to 14.95 mg/kg, exceeding the sediment criteria in both samples. Zinc was detected in six samples at concentrations ranging from 43.2 mg/kg to 1,020 mg/kg, exceeding the criteria value in four samples.

Two sample locations (SDB-04SD and SDB-05SD) exhibited consistent exceedances of sediment quality criteria for cadmium, lead, and mercury. In general, detected concentrations increased with depth. As surface water drainage from the ponded area is restricted by a underground culvert, sediments appear to primarily accumulate at the northern end of the ponded area near the mouth of the drainage culvert (SDA-04). During heavy rainfall events, surface water laden with sediments is transported toward Area A via the culvert. Heavy portions of the sediment probably accumulate in the area beneath and behind the culvert's discharge (SDB-05).

As source characterization results for Area B did not indicate significant metal concentrations, previous incineration activities and incinerator ash disposal which occurred in this area during the 1950s and 1960s, are likely a contributing factor to the metals concentrations detected in Area B sediment samples. Because the ponded area is immediately adjacent to the Salvage Yard, another potential metals source could be from previous activities at the Salvage Yard.

Additionally, sediment data from areas nearby and adjacent to the Camp Allen Landfill site were retrieved from the U.S. Environmental Protection Agency's Storet System, a database of sampling sites and their associated data. This data is presented in Table 6-1 as a reference showing types and concentrations of inorganic constituents found in sediments near or in the vicinity of the site. The information was retrieved using specific Storet instruction sets in combination to select only the data requested for this retrieval. For this retrieval no beginning date was requested thus, storet assumed the beginning data was that of the oldest data available. No ending date was requested therefore, Storet assumed the ending date was that of the most recent data value found. In addition, no restrictions on depth or grab/composite samples were specified therefore, computations were performed without regard to data remarks. Station location was selected based on latitude and longitude coordinates or area surrounding a specified coordinate. Based on the information provided in the Storet System two areas within a one-mile radius of Camp Allen were identified. Two sediment sample results were obtained from the Naval Air Network Facility. Inorganic constituents analyzed consisted of arsenic, cadmium, chromium, copper, lead, nickel, zinc and mercury. The data obtained dated back to 1976 and were as recent as 1978. Table 6-1 presents the results associated with the sample points from the Naval Air Network Facility and Naval Air Rework Facility (Areas 1 and 2). Sample points were determined, based on latitude and longitude coordinates.

In most cases the organic constituents/values obtained from the Storet System were lower than values obtained from sediment samples collected from the Camp Allen Site. However, factors affecting the transport of inorganics in saturated soils are interactive and far more complex and numerous than those affecting the transport of organic contaminants. Please note that these samples were obtained more than ten years prior to those of the Camp Allen Site. Based on latitude and longitude coordinates, samples were obtained from a marshy area (most likely influenced by Willoughby Bay) approximately 1/2 mile northeast of the Camp Allen Site.

TABLE 6-1

STORET DATABASE
SEDIMENT SAMPLE RESULTS
METALS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Chemical	Unit	Analytical Results		
		Date (2-20-76)	Date (6-11-76)	Date (4-24-78)
Area 1				
Arsenic	mg/kg	6.70	6.70	46.1K
Cadmium	mg/kg	1.00	1.33	1.84
Chromium	mg/kg	63.29	60.00	69.60
Copper	mg/kg	32.00	33.69	36.00
Lead	mg/kg	50.00	57.00	59.90
Nickel	mg/kg	20.00	16.69	32.30
Zinc	mg/kg	263.00	220.00	207.00
Mercury	mg/kg	0.3	0.6	0.3
Area 2				
Arsenic	mg/kg	6.70	6.70	41.1K
Cadmium	mg/kg	12.69	3.67	7.80
Chromium	mg/kg	207.00	130.00	148.00
Copper	mg/kg	96.59	56.69	68.20
Lead	mg/kg	167.00	90.00	144.00
Nickel	mg/kg	36.69	26.69	32.90
Zinc	mg/kg	430.00	---	300.00
Mercury	mg/kg	0.6	0.6	0.4

K = Off-scale low. Actual value not known, but known to be less than value shown.
-- = No data value found.

6.4 Surface Water Characterization (Areas A and B)

Surface water samples were collected and analyzed for selected organic and inorganic parameters as part of the Confirmation Study performed by Malcolm Pirnie and the Interim RI performed by CH_2M Hill, and during the RI activities. Investigation results were evaluated to determine the potential impact of the Camp Allen Landfill Site on the surface water bodies that border the site. Previous investigation results and RI findings are discussed below.

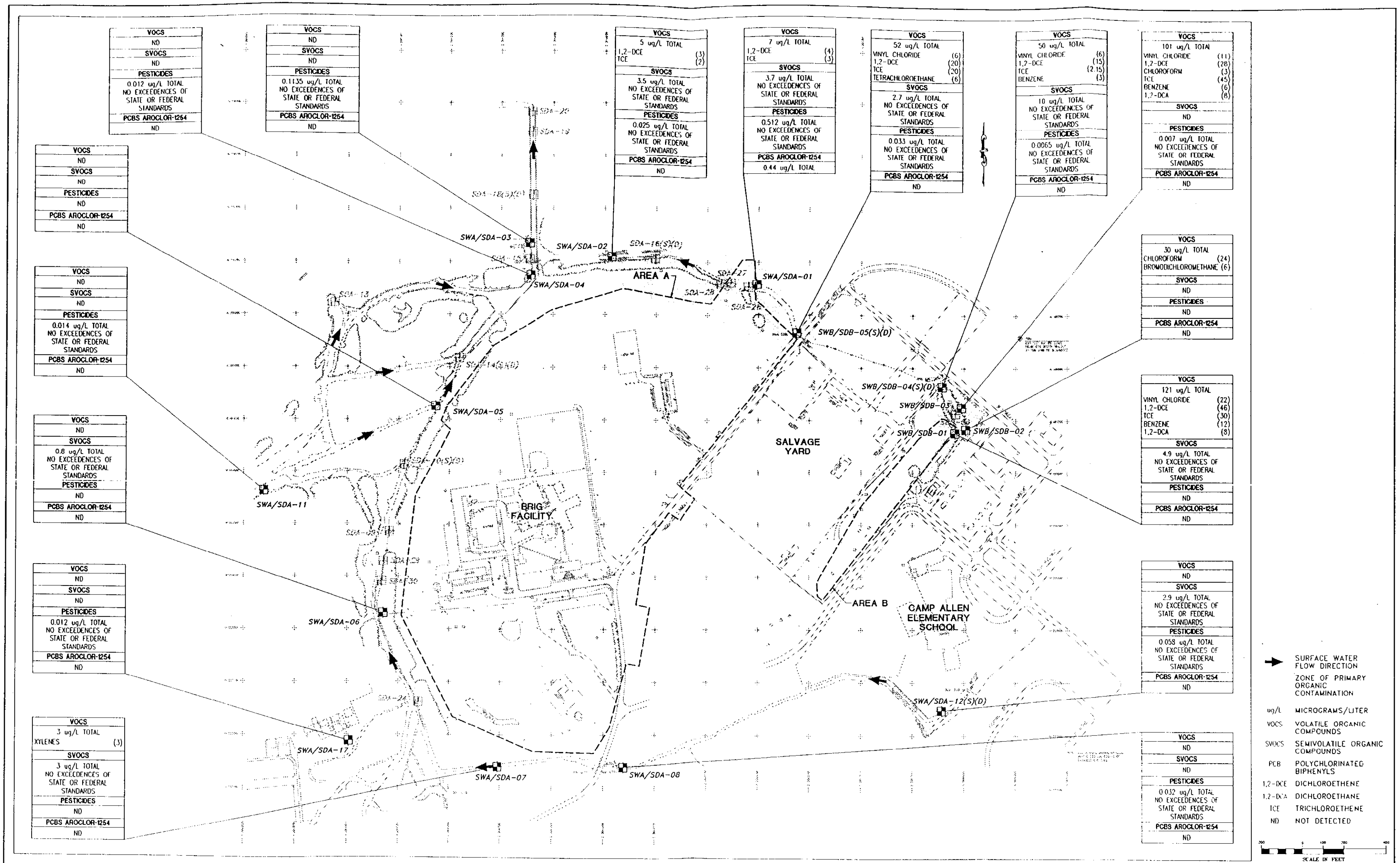
6.4.1 Surface Water Characterization - Organics

Based on data collected by Malcolm Pirnie (from December 1983 through June 1986) and CH_2M Hill (from April 1991) volatile organic constituents are prevalent in the ponded area at Area B and at Area A in the far northeastern portion of the drainage ditch where surface water from Area B is conveyed via the underground culvert. The occurrence, distribution, and concentrations of constituents detected directly correlate with results/data obtained by Baker. Figure 6-9 presents RI sample locations and organic analytical results for surface water collected at both Area A and Area B. In addition, Figure 6-9 provides zones of primary organic contamination, depicted by shaded areas.

6.4.1.1 Surface Water Characterization (Area A) Organics

As discussed above, previous investigations indicate that volatile organics are most prevalent in the surface water at the northeastern portion of Area A. Semivolatile and pesticide/PCB compounds were virtually nonexistent although minor detections of phenol were noted in the drainage ditches north of Area A during the Confirmation Study and the Interim RI. Pesticides were not detected during the Confirmation Study and were not analyzed during Interim RI activities. In addition, special analyses were run during two sampling episodes by Malcolm Pirnie, for xylene and ketone compounds (See Appendix X). No compounds were detected.

Round 2 sampling results for Area A revealed that three of nine surface water samples contained volatile organic compounds in low concentrations. Concentrations ranged from 2J µg/L to 4J µg/L. The concentrations of total volatiles from Area A surface water samples ranged from 3 µg/L to 7 µg/L. The northeastern portion of the drainage ditch contained the



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SURFACE WATER SAMPLE RESULTS
AREAS A AND B
(ORGANICS)

SCALE: GRAPHIC
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FIGURE
6-9

primary volatile contamination (trichloroethene and 1,2-dichloroethene) in surface water samples SWA-01 and SWA-02. Only one constituent 1,2-dichloroethene exceeded any Federal or State criteria. In addition, the southern portion of the drainage ditch contained a total volatile concentration of 3 µg/L comprised solely of total xylenes.

No semivolatile organic compounds were detected.

Pesticide/PCB compounds were detected in six samples ranging from 0.003J µg/L to 0.44J µg/L. Total pesticide concentrations ranged from 0.012 µg/L to 0.512 µg/L. Aroclor-1254 was detected in one sample (SWA-01) at a concentration of 0.44 µg/L. The low levels of pesticides detected in surface water can probably be attributed to surface runoff and/or shallow groundwater discharge. The isolated occurrence of PCBs may be attributed to a localized "pocket," as PCBs were not detected in any other surface water samples associated with Area A.

Given the above-mentioned analytical information, significant organic compound detections were primarily limited to surface water samples collected from the drainage ditch in the northeastern portion of Area A. Many of these detections correlate with sediment sample results in this area or surface water quality related to Area B as discussed in the following section.

6.4.1.2 Surface Water Characterization (Area B) Organics

As previously discussed, Confirmation Study and Interim RI results indicate that volatile organics are prevalent in the surface water at the ponded area northeast of Area B. Semivolatile and pesticide/PCB compounds were virtually nonexistent, although minor detections of phenol were identified. Pesticides were not detected during the Confirmation Study and were not analyzed during Interim RI activities. In addition, special analyses were run during two sampling episodes by Malcolm Pirnie, for xylene and ketone compounds (see Appendix X). None of these compounds were detected.

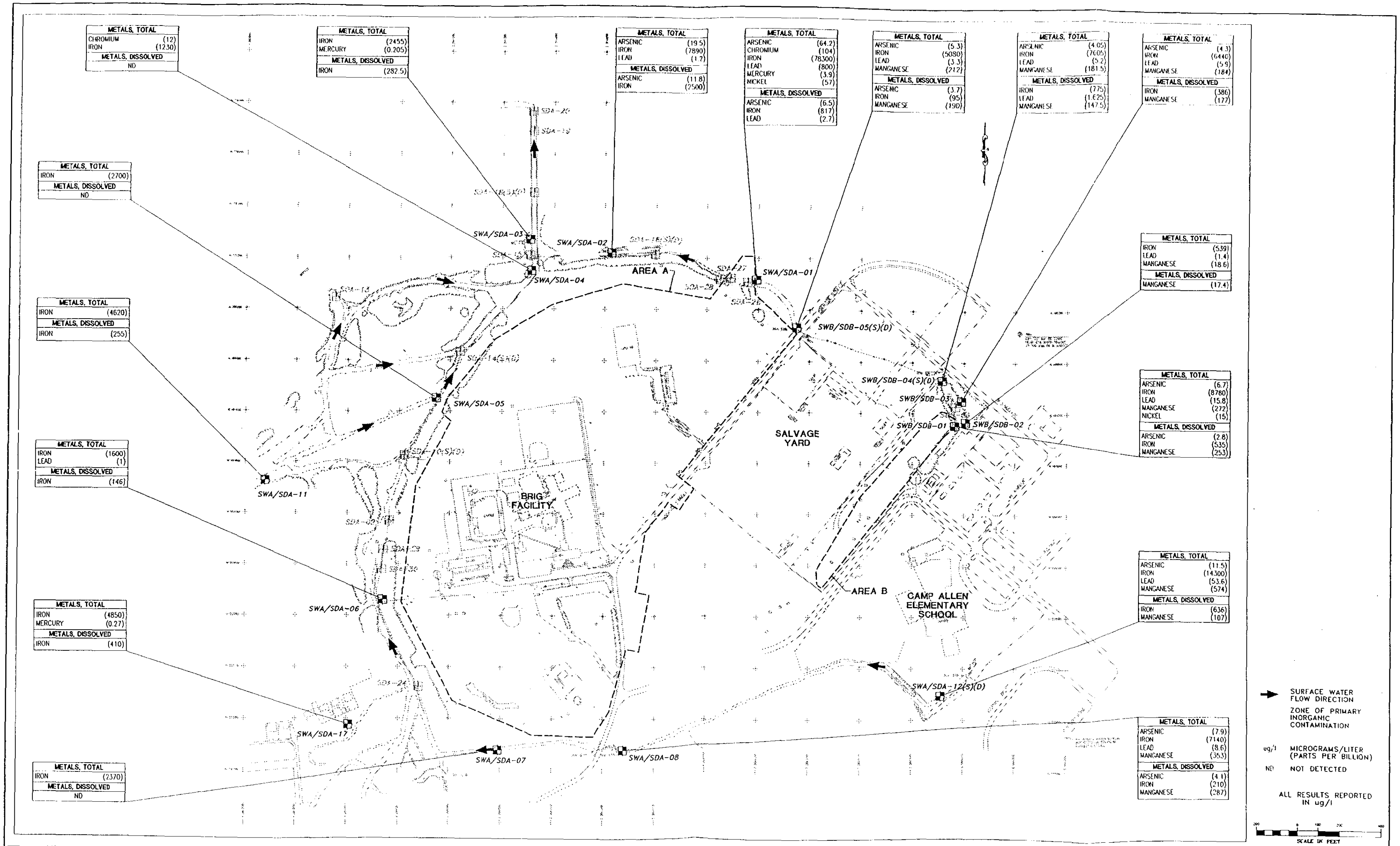
Volatile organic compounds were detected in five of seven samples at concentrations ranging from 2J µg/L to 46 µg/L. The concentration of total volatiles from Area B surface water samples ranged from 30 µg/L to 121 µg/L. The ponded area east of Area B and the drainage ditch northwest of Area B appear to be the most significantly impacted. Seven constituents exceeded either Federal or State criteria. The ponded area contained a vast majority of the constituents. Vinyl chloride; 1,2-dichlorethene; 1,2-dichloroethane; and benzene were detected in decreasing concentrations toward the southern end of the ponded area (SWB-01). Trichloroethane was detected at the highest levels in the central portion (SWB-03) near the area of active seepage and decreased in concentration at sample locations north and south. Chloroform and bromodichloromethane were detected at significant concentrations in the southeastern portion (SWB-02) of the ponded area and diminished to non-detectable in the northwest portion of the drainage ditch associated with Area B (SWB-05). These compounds were not detected at any other sample locations. No volatile organic compounds were detected in drainage ditches south of the ponded area. The constituents and levels at which they were detected can primarily be attributed to seepage from the Area B landfill. The amount of water routinely found in the ponded area suggests that groundwater may be discharging into the impoundment and acting as a carrier for contaminants, in addition to observed seeps or periods of precipitation.

Semivolatile organic compounds were detected in four of seven samples at concentrations ranging from 0.7J µg/L to 7J µg/L. Total semivolatiles ranged in concentrations from 2.7 µg/L to 10 µg/L. The low levels of semivolatiles detected in surface water may be attributed to groundwater discharge into the ponded area or seepage as contaminants detected were analogous to those found in subsurface soils. Photolysis and oxidation may be important removal mechanisms of semivolatile organic compounds in the surface water.

Pesticide/PCB compounds were detected in five of seven samples collected at concentrations ranging from 0.0065J µg/L to 0.038J µg/L. Total pesticide concentrations ranged from 0.007 µg/L to 0.058 µg/L. No PCB compounds were detected in surface water samples associated with Area B. The low levels of pesticides detected can probably be attributed to surface runoff or seepage as similar constituents were found in surface and subsurface soils.

6.4.2 Surface Water Characterization - Inorganics

A discussion of the nature and extent of inorganic constituents detected in surface water samples from the drainage ditches surrounding Areas A and B is presented below. RI results, as well as Interim RI findings are included in the evaluation. Due to significantly variable total metal concentrations detected throughout the Camp Allen Area, this section's discussion of site conditions is limited to detections which have exceeded Federal and State WQC. Where available, total versus dissolved metal concentration comparisons are evaluated in corresponding samples. Figure 6-10 presents RI sample locations and inorganic analytical



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Baker
Baker Environmental, Inc.

SURFACE WATER SAMPLE RESULTS
AREAS A AND B
(INORGANICS)

SCALE GRAPHIC
DATE 7/93

FIGURE
6-10

results for surface water samples collected at both Area A and Area B. This figure presents a listing of all constituents (total and dissolved) detected at each sample location. In addition to Figure 6-10, graphic illustrations of detected metal concentrations (total and dissolved) of all surface water samples (Areas A and B), including comparisons to Federal AWQC and State WQC are contained in Appendix Z. For ease of interpretation, sample locations have been arranged by normal flow, upstream to down stream locations. Figure 6-10 also provides zones of primary inorganic contamination depicted by shaded areas.

6.4.2.1 Surface Water Characterization (Area A) Inorganics

Based on data collected by Malcolm Pirnie (from December 1983 through June 1986), the occurrence, distribution, and concentrations of total metals detected in surface water samples collected during three separate sampling events, consistently indicate exceedances of Federal AWQCs for arsenic, cadmium, chromium, lead, mercury, and zinc in the northern portion of the drainage ditches at Area A. Other total metals were also detected at varying concentrations.

Data collected by CH_2M Hill in April 1991, indicate that total metal concentrations detected in surface water samples from Area A significantly exceeded AWQCs for total arsenic, chromium, lead, mercury, nickel, and zinc at various sample locations. Additional total metal concentrations exceeded applicable AWQCs as well; however, not at consistently elevated levels. Elevated total metal concentrations occurred primarily in the northern regions of Area A; however, exceedances were identified throughout the area. Dissolved metals fractions were not evaluated as part of the Interim RI.

Round 2 RI sample results indicate that total arsenic was detected at two locations at concentrations ranging from 19.5 µg/L to 64.2 µg/L, exceeding Federal AWQCs in both samples. Total chromium was detected in two samples at concentrations ranging from 12 µg/L to 104 µg/L, exceeding AWQCs in one of the samples. Total iron was detected in nine samples at concentrations ranging from 1,230 µg/L to 78,300 µg/L, exceeding AWQCs in all of the samples. Total lead was detected in three samples at concentrations ranging from 1L µg/L to 800 µg/L, exceeding AWQCs in one sample. Total mercury was detected in three samples at concentrations ranging from .205 µg/L to 3.9 µg/L, exceeding AWQCs in all three samples. Total nickel was detected in one sample at a concentration of 57 µg/L, exceeding the AWQC. Additional metals (total) were detected; however, the occurrence and distribution can be considered typical for surface water. The metals detected can most likely be associated with surface runoff or leaching from landfill materials. In addition, suspected groundwater discharge into drainage ditches is also a possible pathway of metal contamination in surface waters.

During Round 2 six samples contained dissolved iron at concentrations ranging from 146 µg/L to 2,500 µg/L, exceeding State WQC in three samples. Dissolved manganese was also detected in nine samples at concentrations ranging from 88.7J µg/L to 246 µg/L, exceeding WQCs for all samples. Additional metals (dissolved) were detected; however, the occurrence and distribution did not exceed WQCs and can be considered typical for surface water (see Appendix Z).

6.4.2.2 Surface Water Characterization (Area B) Inorganics

Based on data collected by Malcolm Pirnie (from December 1983 through June 1986), one surface water sampling point was located at Area B. Sample results indicate that exceedances of Federal AWQCs for total arsenic, cadmium, chromium, lead, mercury, and zinc were identified. Other total metals were also detected at varying concentrations.

Data collected by CH_2M Hill in April 1991, indicates that total metal concentrations detected in surface water samples from Area B again significantly exceeded Federal AWQCs for total arsenic, chromium, lead, mercury, nickel, and zinc at various sample locations. Additional total metal concentrations exceeded applicable AWQCs as well; however, not at consistently elevated levels. Dissolved metals fractions were not evaluated as part of the Interim RI.

Round 2 RI surface water sample results indicate that total arsenic was detected in six samples at concentrations ranging from 4.05 µg/L to 11.5K µg/L, exceeding AWQCs in all of the samples. Total iron was detected in seven samples at concentrations ranging from 539 µg/L to 14,300 µg/L, exceeding AWQCs in all of the samples. Total lead was detected in seven samples at concentrations ranging from 1.4J µg/L to 53.6 µg/L, exceeding AWQCs in one sample. Total nickel was detected in one sample at a concentration of 15 µg/L, exceeding the AWQC. Additional metals (total) were also detected; however, the occurrence and distribution can be considered typical for surface water. Additionally, general areas designated as upstream (background) had constituent concentrations relatively high as well.

Round 2 dissolved iron was detected in six samples at concentrations ranging from 95 µg/L to 775 µg/L, exceeding State WQCs in four samples. Dissolved manganese was detected in seven samples at concentrations ranging from 17.4 µg/L to 287 µg/L, exceeding WQCs in six samples. Additional metals (dissolved) were detected; however, the occurrence and distribution did not exceed WQCs and can be considered typical for surface water.

6.5 Groundwater - Water Table Aquifer

The concentration of constituents in the water table aquifer beneath the Camp Allen area was evaluated during Confirmation Study and Interim RI activities, in addition to the sampling and analysis performed as part of the RI. Results of the previous and current investigations are summarized below. As information related to groundwater quality in the study area is voluminous, representing numerous rounds of analytical data for many groundwater monitoring well locations, this section's format differs slightly from that of previous discussions. In this section, the hierarchy of data presentation/discussion will be as follows:

- Area (A or B)
- Constituent group (volatiles, etc.) within an area
- Chronological discussion of data -- Confirmation Study (earliest generated data); Interim RI; current RI (most recently generated data)

It is anticipated that this approach will provide the clearest understanding of groundwater quality concerns related to the water table aquifer around the Camp Allen area.

The Confirmation Study and Interim Remedial Investigation are described in Section 1.0 and analytical summaries for sampling programs are contained in Appendix X. RI findings related to primary constituents detected are graphically depicted using approximated isoconcentration maps which vary in contour interval depending on concentration ranges of detected constituents.

Based on data collected by Malcolm Pirnie during four separate rounds of water table aquifer groundwater sampling in the Confirmation Study, volatile organics were detected at significant concentrations in both areas. During Round 1 (December 1983), samples were analyzed for Priority Pollutant constituents and xylene. During Round 2 (August 1984), samples were also analyzed for Priority Pollutant constituents and screened for dioxin. During Round 3 (April 1986), groundwater was resampled for Priority Pollutants and special analyses (primarily xylenes and ketones). During Round 4 (June 1986), groundwater was sampled for ketones and ethylene dibromide only.

CH_2M Hill performed one round of groundwater sampling on the existing wells and wells installed as part of the Interim RI. As part of the Interim RI at Area A, groundwater from sixteen shallow monitoring wells was sampled and analyzed for volatile and semivolatile organic compounds, as well as total and dissolved metals. Interim RI activities at Area B included sampling and analysis of groundwater from 11 shallow monitoring wells for volatile organic compounds, semivolatile organic compounds, and total and dissolved metals.

This Remedial Investigation focused on organic and inorganic constituents in the shallow groundwater resulting from past disposal practices at Areas A and B. In addition, off-site constituent sources are evaluated.

As discussed in Section 3.0, shallow groundwater from a total of 57 Glenwood Park residential wells, all of which are reportedly non-potable wells screened in the water table aquifer, were sampled and analyzed for volatile organic constituents during 1991 and 1992. Figure 6-11 presents the 57 well locations which were sampled. Analytical results indicate landfill related contaminants are not migrating offsite of the Camp Allen Landfill via shallow groundwater.

As discussed in Sections 3.0 and 5.0, a geoprobe investigation was performed at Area B prior to the installation of additional shallow wells. Results of the investigation are presented in Figure 6-12. Investigation results strongly indicate volatile organic constituents are migrating southeast (downgradient) from the Area B disposal area. Based on subsurface utility information also depicted on Figure 6-12, contaminants appear to be migrating toward the drainage ditch located behind the Camp Allen Elementary School (CAES) via a preferred pathway introduced by less restrictive conditions (gravel fill) along the underground utility lines.

Shallow groundwater quality in the Camp Allen area is detailed in this section. To clearly identify groundwater quality conditions, a discussion of Areas A and B findings for each parameter grouping is followed by isoconcentration maps of total compound detections or individual parameter grouping, as appropriate. Results of initial "Round 1" activities related to the Glenwood Park residential well sampling program for Area A and the Geoprobe investigation performed at Area B will also be discussed.

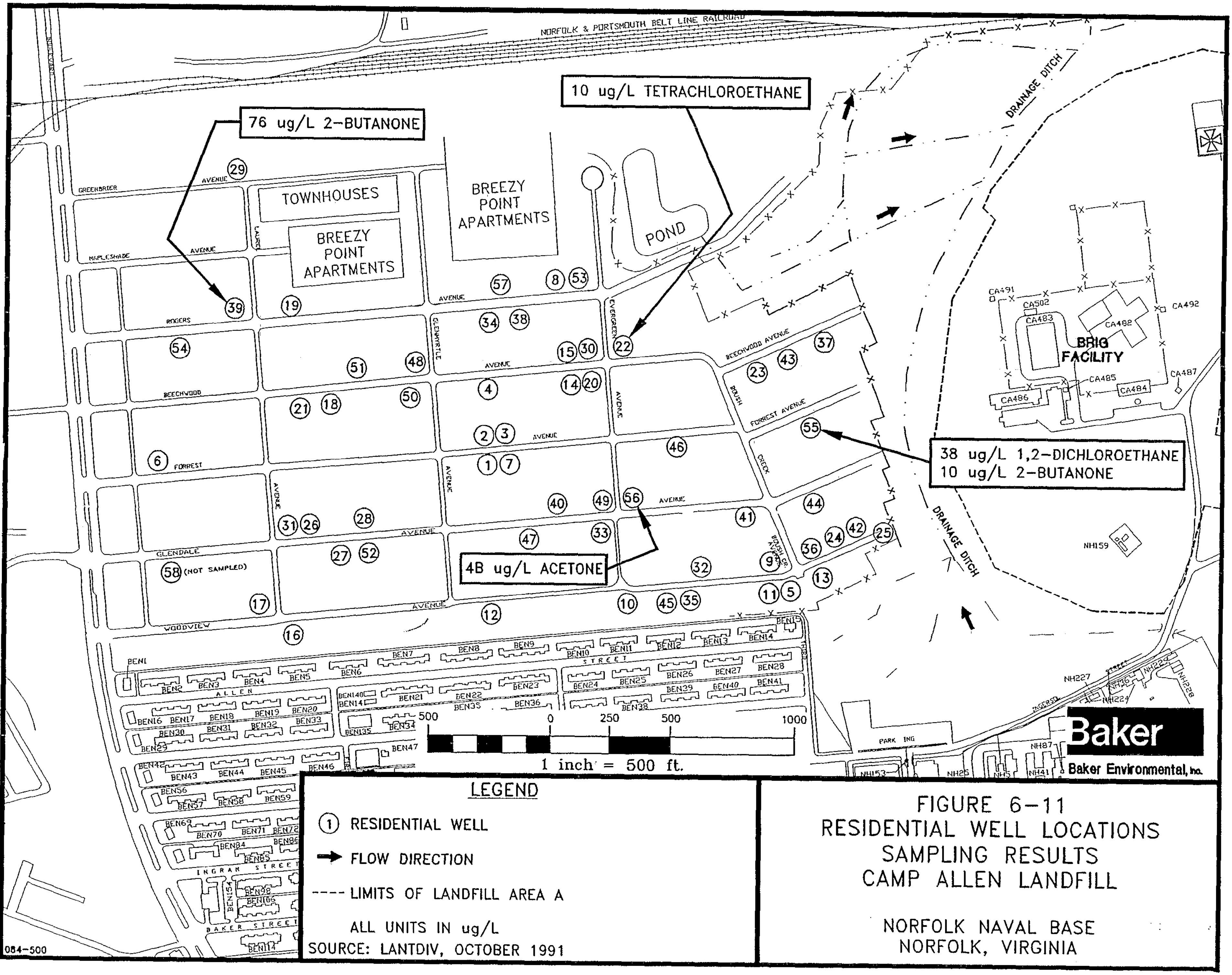
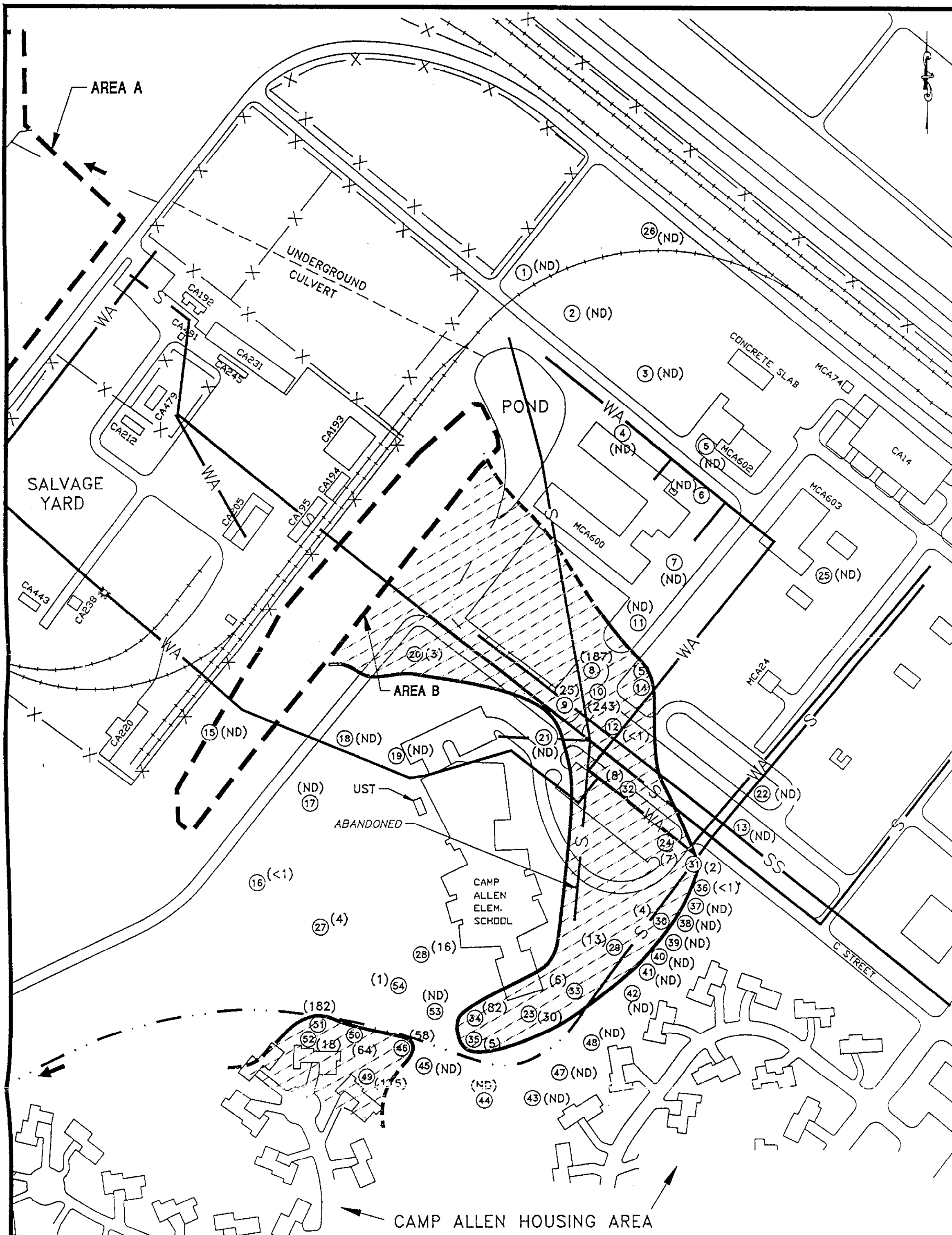


FIGURE 6-11
RESIDENTIAL WELL LOCATIONS
SAMPLING RESULTS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

①	GEOPROBE SAMPLE POINT
ND	NOT DETECTED
(18)	TOTAL VOLATILES (BENZENE, TRICHLOROETHANE, AND 1,2-DICHLOROETHANE (TOTAL))
—SS—	APPROXIMATE LOCATION OF SANITARY SEWER
—S—	APPROXIMATE LOCATION OF STORM SEWER
—WA—	APPROXIMATE LOCATION OF WATER LINE
	PRIMARY AREA OF DETECTED VOLATILES
←	STREAM FLOW DIRECTION

ALL UNITS ARE IN ug/L

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

200 0 100 200 400

1 inch = 200 ft.

Baker

Baker Environmental, Inc.

FIGURE 6-12
GEOPROBE INVESTIGATION RESULTS
AREA B
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

6.5.1 Area A

6.5.1.1 Volatile Organics

Confirmation Study

Groundwater samples collected from shallow wells in Area A were virtually free of volatile organic constituents in all four rounds, with the exception of well B-20W. Individual volatile constituent concentrations in B-20W ranged from 10 µg/L to 18,000 µg/L. Total volatile concentrations ranged from 10 µg/L to 71,980 µg/L. Many of the constituents detected exceeded Federal and state standards for drinking water aquifers (MCLs).

Interim Remedial Investigation

Volatile organic constituents were detected in groundwater samples from eight wells at concentrations ranging from 1J µg/L to 25,000 µg/L. Total volatile concentrations ranged from 2 µg/L to 63,980 µg/L.

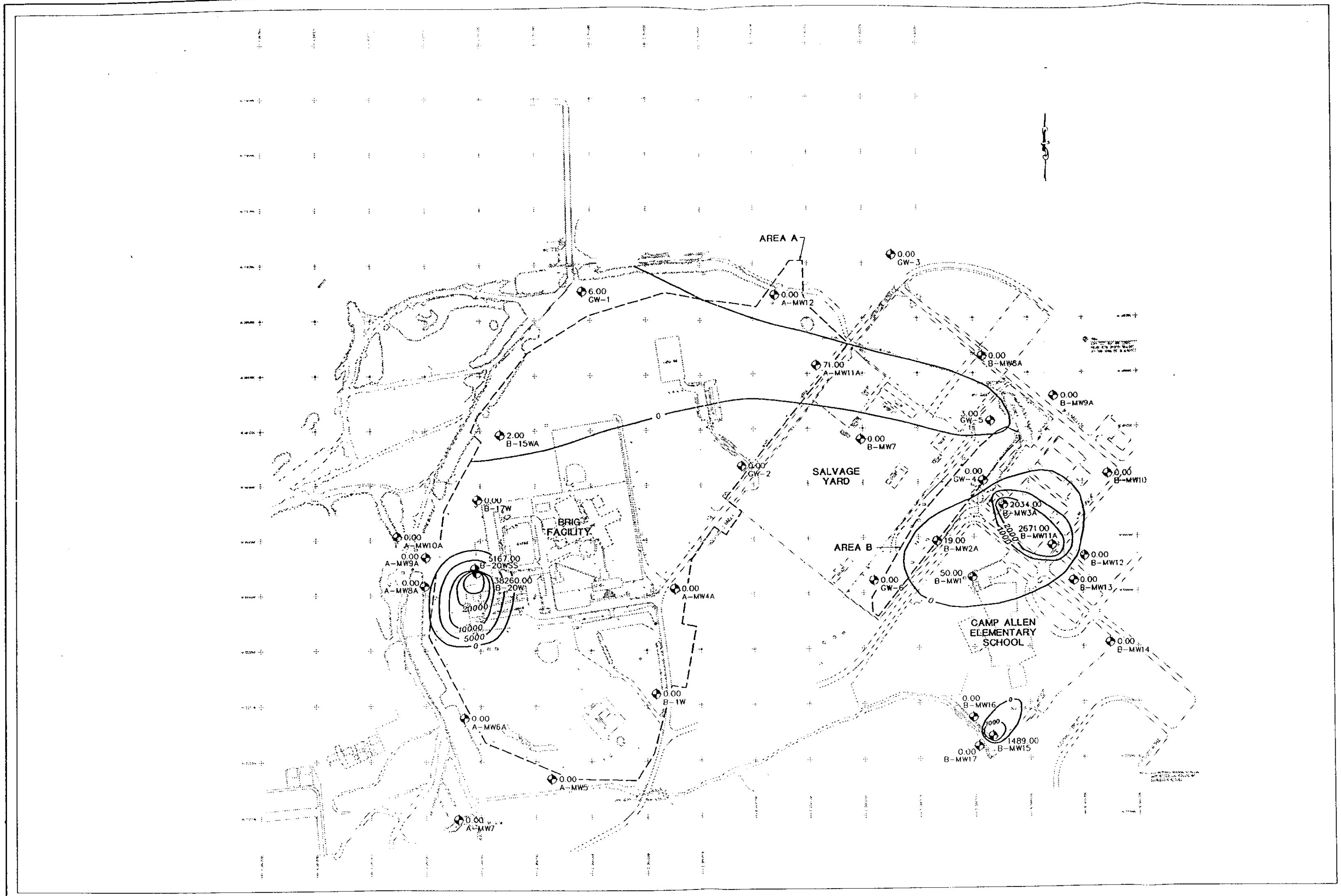
Remedial Investigation

During Round 2, groundwater from sixteen shallow wells in Area A was sampled for volatile compounds. Volatile constituents were detected in five samples at concentrations ranging from 2J µg/L to 16,000 µg/L. Total volatiles ranged from 2 µg/L to 38,260 µg/L.

Significant concentrations were found in samples collected from wells B-20W and B-20WSS east of the Brig Facility. Minor concentrations (less than 100 µg/L total volatiles) of volatiles were detected in isolated areas of the water table aquifer in Area A.

Groundwater from two locations, B-20W and B-20WSS, contained significant total VOCs (5100 to 38,260 µg/L). Several of the contaminants detected in groundwater at B-20W (vinyl chloride, 1,2-dichloroethene, MEK, MIBK, toluene, xylenes) were detected during previous investigations at elevated concentrations. Five constituents (vinyl chloride, methylene chloride, trichloroethane, benzene, and toluene) exceeded MCL standards.

In order to graphically depict the extent of volatile contamination detected, three isoconcentration maps have been developed. Figure 6-13 presents total volatile



NOTES

1. CONTOUR INTERVAL– MISC. AS LABELLED; UNITS OF ug/L
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS			NORTH	
	DATE	7/93		
	SCALE	GRAPHIC		
	DRAWN	GLB		
	REVIEWED	TEA		
	S.O.#	19084		
	CADD#	084-310		

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SHALLOW GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
TOTAL VOLATILES
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE
6–13

concentrations identified during Round 2 of the RI. As indicated on this figure, elevated volatile organic concentrations are centralized around the source area west of the Brig at Area A and downgradient of the source area at Area B.

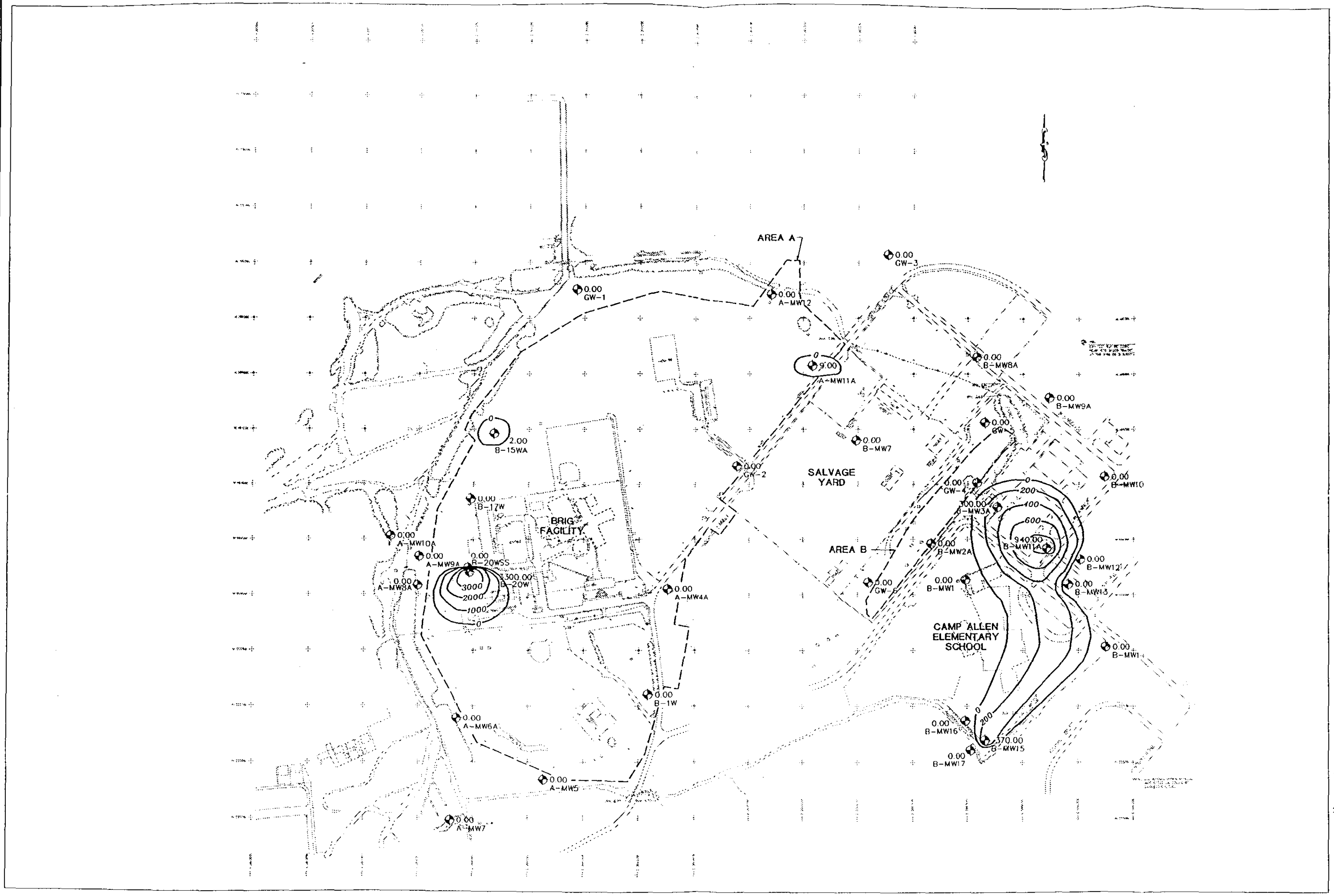
Two individual volatile organic compounds were also plotted to show the relative distribution of contamination - vinyl chloride and trichloroethene (TCE). These compounds were chosen because of their relative abundance in several media at the site and also because detected concentrations of these compounds in the shallow groundwater consistently exceeded the MCL standards.

Figure 6-14 presents vinyl chloride concentrations identified during Round 2 of the RI. At Area A, shallow groundwater in only three locations contained vinyl chloride (B-15WA, A-MW11A, and B-20W) with concentrations ranging from 2 µg/L to 3,300 µg/L. The Federal MCL for vinyl chloride is 2 µg/L, indicating that the three locations are at or above the MCL.

Figure 6-15 presents TCE concentrations detected in the shallow groundwater during Round 2. Results for TCE concentrations in Area A were similar to the vinyl chloride distribution. TCE was detected in two wells (A-MW11A and B-20WSS) exceeding the Federal MCL of standards. TCE, a solvent widely used in degreasing operations, may be described as a highly mobile chemical in all environmental media. This fact may explain why TCE is so pervasive in groundwater at the Camp Allen Landfill Site. In comparison to many other organic chemicals, TCE is readily soluble and thus easily transported from soils to groundwater. TCE was not detected in B-20W or B-20WSS in Rounds 2 and 3. Again, this situation is considered to be linked to the background information related to B-20W.

In Round 3, only well B-20WSS was sampled because it was close to the source area adjacent to the Brig and because it was a newly installed stainless steel monitoring well during Round 2 RI activities. Total volatile organic compound concentration was 700 µg/L, with different compounds detected (only tetrachloroethene and xylenes) in comparison to Round 2 results.

The most elevated detection of vinyl chloride was encountered in groundwater collected from B-20W (a PVC well constructed in 1984). It should be noted that well B-20WSS (the newly installed stainless steel well) did not contain vinyl chloride in Rounds 2 and 3. Based on a comparison of detected volatile organics in groundwater from both B-20W and B-20WSS, a strong correlation of most volatile constituents is present with the exception of vinyl chloride. Therefore, vinyl chloride concentrations in groundwater from B-20W are considered to be



NOTES

1. CONTOUR INTERVAL
1000 ug/L AT AREA A
200 ug/L AT AREA B

2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		NORTH
	DATE 7/93	
	SCALE GRAPHIC	
	DRAWN GLB	
	REVIEWED TEA	
	S.O.# 19084	
	CADD# 084-311	

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

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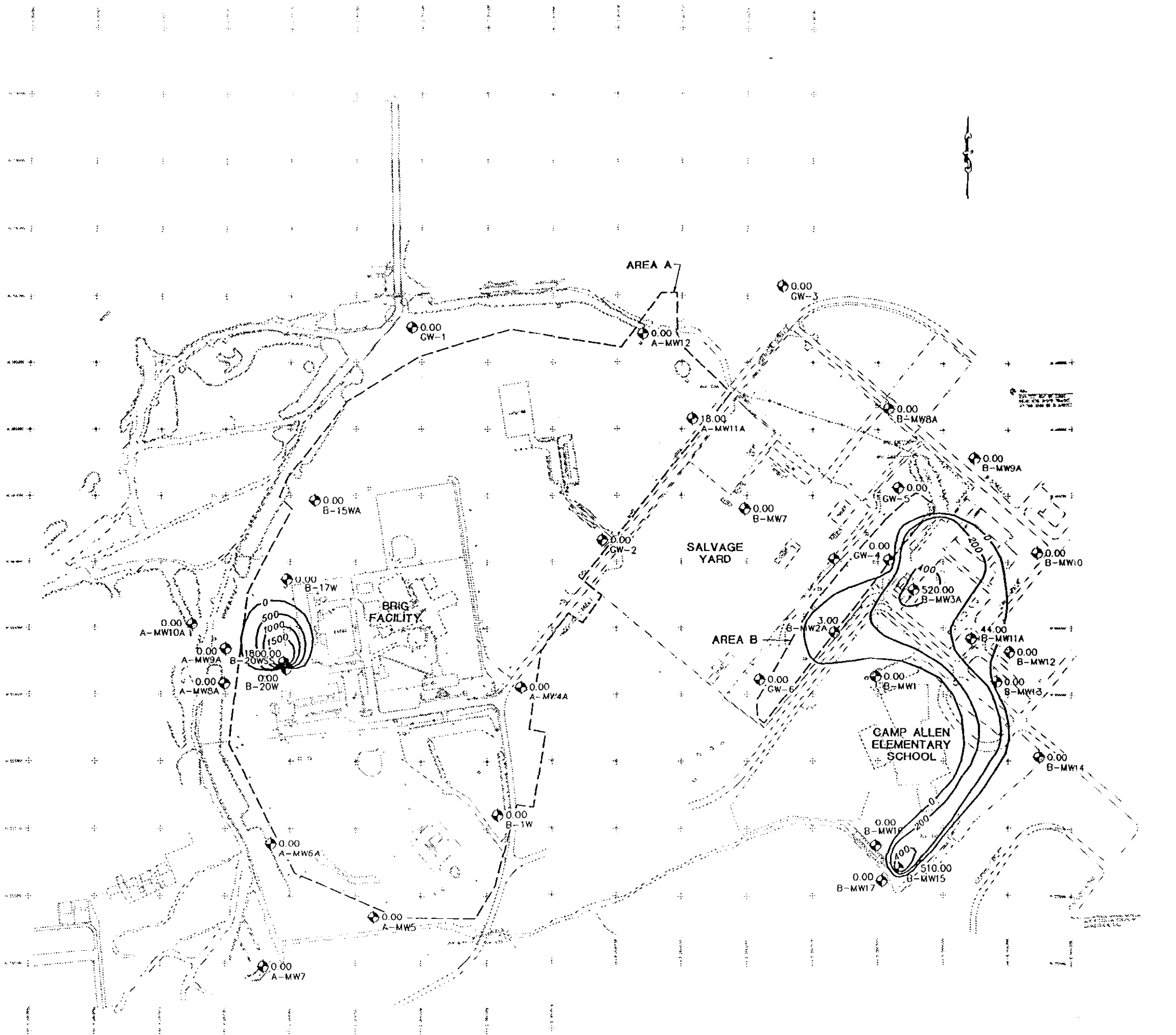
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SHALLOW GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
VINYL CHLORIDE
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE
6-14



NOTES

1. CONTOUR INTERVAL
   500 ug/L AT AREA A
   200 ug/L AT AREA B
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		NORTH	CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	SHALLOW GROUNDWATER SAMPLE RESULTS AREAS A AND B, ROUND 2 TCE ISOCONCENTRATION MAP	FIGURE 6-15
	DATE 7/93 SCALE GRAPHIC DRAWN GLB REVIEWED TEA S.O.# 19084 CADD# 084-320				SCALE GRAPHIC DATE 7/93	

falsely elevated (although they are probably present to a lesser extent) by the deterioration of the aged well. The primary microbial degradation products of volatile chlorinated hydrocarbons appear to result from reductive dechlorination (i.e., the replacement of chlorine by hydrogen) under anaerobic conditions. For example PCE is principally converted to TCE. TCE degrades mainly to DCE with traces of vinyl chloride evident.

6.5.1.2 Semivolatile Organics

Confirmation Study

Semivolatile organic constituents were detected in samples from three shallow wells (GW-2, GW-3 and B-20W) at concentrations ranging from 15 µg/L to 7,200 µg/L. Total semivolatile organic compounds were detected at concentrations ranging from 15 µg/L to 7,732 µg/L. Groundwater collected from one well (B-20W) contained significant concentrations in all three rounds.

Interim Remedial Investigation

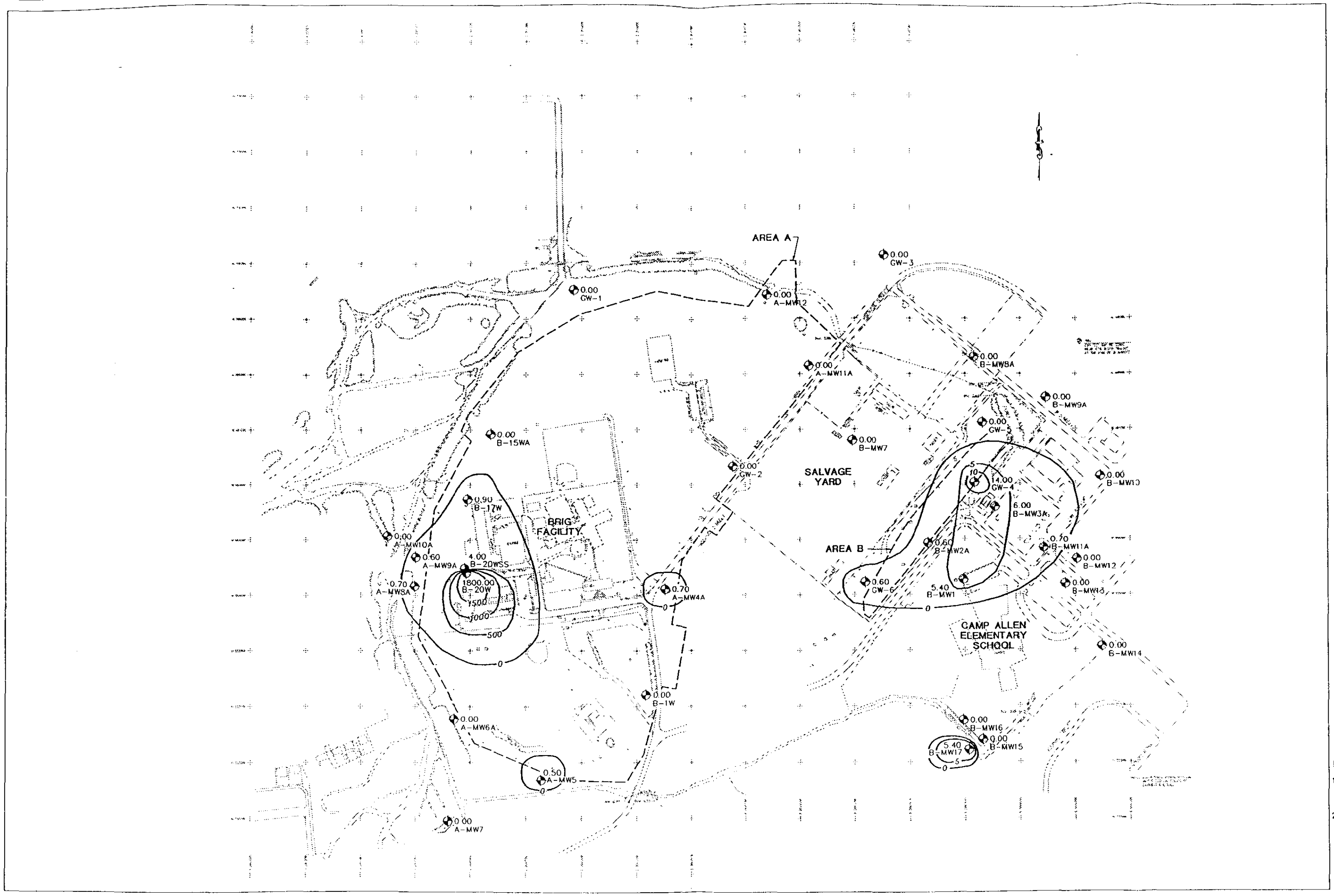
Semivolatile organic compounds were detected in two wells (A-MW10 and B-20W) at concentrations ranging from 4 µg/L to 33,000 µg/L. One well (B-20W) contained significant concentrations of semivolatile contaminants.

Remedial Investigation

In Area A, concentrations of phenol less than 1 µg/L were detected in groundwater collected from four wells (A-MW4A, A-MW5, A-MW8A, and A-MW9A). Higher concentrations were noted in samples collected from wells (B-20W and B-20WSS) at concentrations ranging from 4 µg/L to 1,800 µg/L. Phenol was not detected in any other samples.

Other constituents detected in groundwater from Area A include additional phenol compounds (2,4-dimethylphenol, 2- and 4-methylphenol), phthalate esters, and acenaphthene and naphthalene (PAHs). Most of these compounds were found at very low concentrations (1 to 5 µg/L for total SVOCs), except in samples collected from wells (A-MW9A, B-20W, and B-20WSS).

Figure 6-16 presents concentrations of phenol in the shallow groundwater at Areas A and B.



NOTES

1. CONTOUR INTERVAL
500 ug/L AT AREA A
5 ug/L AT AREA B

2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
DATE	7/93	
SCALE	GRAPHIC	
DRAWN	GLB	
REVIEWED	TEA	
S.O.#	19084	
CADD#	084-321	

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SHALLOW GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
PHENOL
ISOCONCENTRATION MAP

SCALE GRAPHIC DATE 7/93

FIGURE 6-16

As indicated on this figure, elevated phenol concentrations are centralized around the source area west of the Brig at Area A and downgradient of the source area at Area B. Patterns of detected levels mimic those identified for the volatile constituents, further supporting identified primary source areas and similarities in contaminant transport.

6.5.1.3 Pesticides/PCBs

Confirmation Study

No pesticide/PCBs were detected during this study.

Interim Remedial Investigation

Pesticide/PCBs were not analyzed as part of this investigation.

Remedial Investigation

During Rounds 2 and 3 at Area A, four different pesticides (aldrin, heptachlor epoxide, 4,4'-DDD, and gamma-chlordane) were detected in Area A shallow groundwater. Groundwater from five wells contained concentrations of pesticides. Samples from wells (B-1W, B-20W, and A-MW4A) contained concentrations of heptachlor epoxide which exceeded the state MCL for groundwater of 0.001 µg/L. Aldrin was detected in groundwater from well GW-2 at a concentration exceeding the state MCL of 0.003 µg/L.

PCBs were not detected in Area A groundwater. PCBs have low vapor pressures, low water solubilities, and high Koc and Kow values. The absorption of PCBs to soil is indicated by the absence of these contaminants from all groundwater samples collected at the Camp Allen Landfill Area A.

Based on the locations of detected pesticide constituents and the locations where pesticides were not detected in the shallow groundwater, no true correlation to potential site-related sources is apparent. Given the widespread land application of pesticide-related products in the area at large, detected values are probably a result of general pesticide usage, rather than landfilled materials at Area A.

6.5.1.4 Metals

Confirmation Study

Based on the magnetometer survey results of the Site Suitability Assessment as discussed in Section 4.0 (Geophysical Results), the southern and middle portions of Area A were noted to contain significant amounts of buried metallic wastes. This metallic landfill material is considered to be a potential source of total metal constituents in this area.

Metal constituents were detected in varying concentrations throughout Area A. Constituents detected at concentrations consistently above MCLs included: arsenic, cadmium, chromium, lead, mercury, and zinc. Groundwater collected from well locations B-20W and GW-3 exhibited the most significant levels and variety of detected total metals. Detected constituent concentrations were fairly consistent with time.

Groundwater collected from well locations GW-1 and GW-2 exhibited moderate exceedences of the above-mentioned metals during the first sampling round. In general, constituent concentrations decreased with time. In some cases, constituent concentrations were not detected in subsequent sampling rounds (arsenic, chromium, and mercury at GW-2).

Groundwater samples were also analyzed for other inorganic parameters on a selected basis (total phenols and total cyanide). Trace amounts of each were detected in samples collected from well locations GW-1 and GW-2, while higher concentrations were detected in samples collected from B-20W. Cyanide and phenol concentrations at this location decreased significantly between sampling rounds two and three.

Interim Remedial Investigation

Metal constituents were detected in varying concentrations in shallow groundwater throughout Area A. Aside from essential elements, primary constituents detected at concentrations consistently above MCLs included: arsenic, barium, cadmium, chromium, lead, and zinc. Groundwater collected from well locations B-20W, A-MW9"A, and A-MW12 exhibited the most significant levels and variety of detected total metals. In general, detected concentrations of corresponding dissolved metals were significantly reduced, if detected at all, with the exception of primarily arsenic and barium.

In order to address the most significant findings, discussions to follow are limited to detail regarding constituents which consistently exceeded corresponding MCLs (Federal and state). Essential elements (i.e., calcium, magnesium, etc.) are not discussed in this section; however, analytical results for these constituents are detailed in Section 5.0.

Metal constituents consistently detected in the shallow groundwater at Area A and Area B include arsenic, cadmium, chromium, lead, mercury, and zinc. Other inorganic constituents were also detected at concentrations above corresponding MCLs and will be discussed individually, as appropriate. ARAR comparisons of detected total metal concentrations in the shallow groundwater at Area A and Area B are presented in Appendix Y.

Metal constituents were detected in varying concentrations in shallow groundwater throughout Area A. Aside from essential elements, primary constituents detected at concentrations consistently above MCLs included: arsenic, barium, cadmium, chromium, lead, and zinc. Groundwater collected from well locations B-20W, A-MW9A, and A-MW12 exhibited the most significant levels and variety of detected total metals. In general, detected concentrations of corresponding dissolved metals were significantly reduced, if detected at all, with the exception of arsenic and barium.

At Area A, total arsenic was detected in concentrations exceeding the MCLs in monitoring wells A-MW9A, A-MW12, B-1W, B-20W, and B-20WSS. Detected levels were highest at A-MW9A, A-MW12, and B-20W.

Total cadmium concentrations, exceeding the MCLs, were detected in groundwater samples collected from A-MW7, A-MW11A, B-17W, and B-20W. Groundwater from B-20W exhibited the highest concentration.

Total chromium concentrations, exceeding the MCLs, were detected in groundwater samples collected from A-MW10A, B-20W, and B-20WSS. Groundwater from B-20WSS exhibited the highest concentration.

Total lead concentrations, exceeding the MCLs, were detected in groundwater samples collected from A-MW8A, B-15W, B-20W, B-20WSS, and GW-3. Groundwater from B-20WSS exhibited the highest concentration.

Although no total mercury concentrations exceeded the Federal MCL, the state MCL was exceeded in groundwater samples collected from A-MW7, A-MW10A, A-MW11A, B-1W, and B-15W. Groundwater from B-15W exhibited the highest concentration.

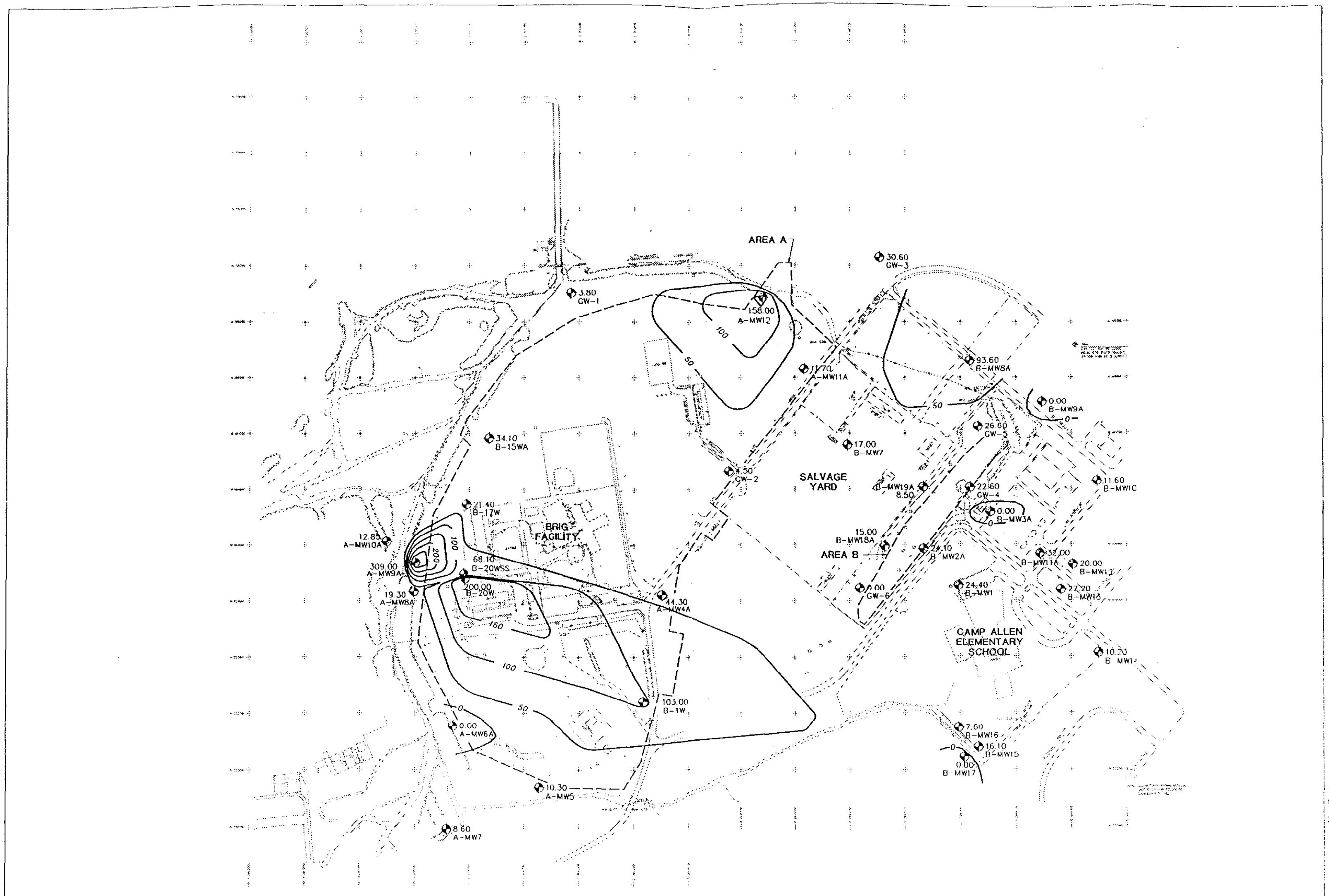
Total zinc concentrations detected in the shallow groundwater at Area A exceeded the MCLs in the vast majority of monitoring wells. The only locations were zinc concentrations in the groundwater were not detected or did not exceed the MCLs include A-MW6A and GW-2. The highest concentrations of zinc in the shallow groundwater were from wells B-15W, B-17W, and B-20W.

Figures 6-17, 6-18, 6-19, 6-20, 6-21, and 6-22 presents total concentrations of arsenic, cadmium, chromium, lead, zinc, and mercury, respectively, as they relate to Areas A and B. Discussions of the findings presented on each figure are discussed below. Specific information related to Area B is discussed in Section 6.5.2.4.

As depicted on Figure 6-17, total arsenic concentrations are primarily located in the shallow water beneath Area A. Two separate zones have been identified. The isoconcentration contour interval is 50 µg/L. The Federal and State MCL for total arsenic is also 50 µg/L. The most significant zone is concentrated at the western side of the Brig Facility with detected values decreasing toward the southeast. The second location of elevated total arsenic concentrations is situated in a localized portion in the northern part of Area A adjacent to the Salvage Yard.

Elevated total cadmium concentrations (Figure 6-18) have also been identified in two primary areas. Please note that the isoconcentration contour interval is 5 µg/L as is the Federal MCL for total cadmium. The first zone of detected total cadmium in the shallow groundwater is again located in the southern/southwestern portion of Area A. The second area is located in the vicinity of the Salvage Yard and the northeastern portion of Area A. Both of these areas correlate with the ones identified for total arsenic concentrations. Three isolated zones of significantly lower concentrations are also noted on Figure 6-18.

Total chromium concentrations (Figure 6-19) have been identified in the shallow groundwater in four primary areas. Please note that the isoconcentration contour interval is 100 µg/L as is the Federal MCL for total chromium. The first zone of detected total chromium is again located in the southern/southwestern portion of Area A. The second area is located in the

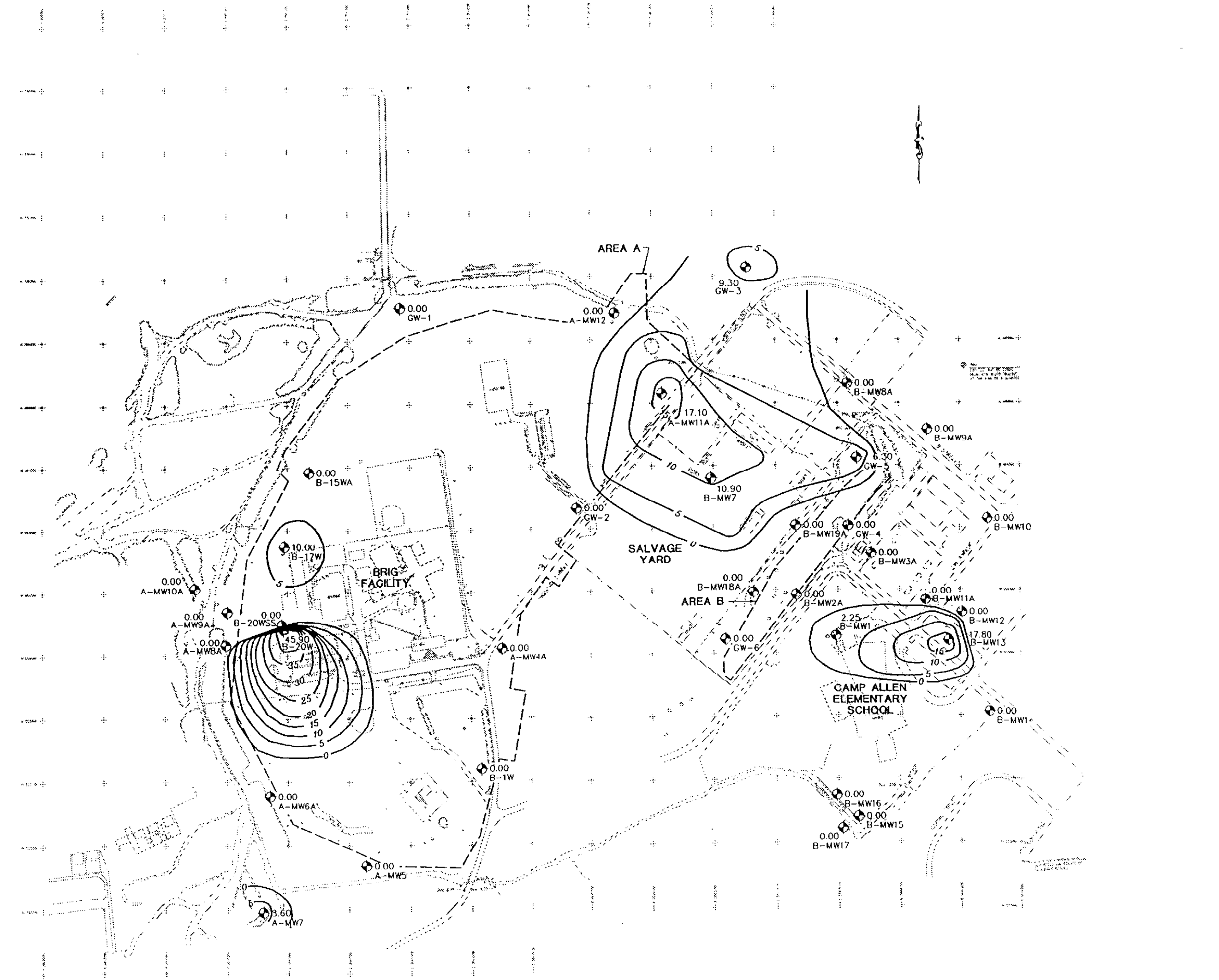


NOTES

1. CONTOUR INTERVAL = 50 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS			NORTH	CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA	Baker Baker Environmental, Inc.	SHALLOW GROUNDWATER SAMPLE RESULTS AREAS A AND B, ROUND 2 TOTAL ARSENIC ISOCONCENTRATION MAP	FIGURE 6-17
	DATE	7/93		BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania		SCALE GRAPHIC DATE 7/93	
	SCALE	GRAPHIC					
	DRAWN	GLB					
	REVIEWED	TEA					
	S.O.#	19084					
	CADD#	084-316					



NOTES

1. CONTOUR INTERVAL = 5 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	084-317

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

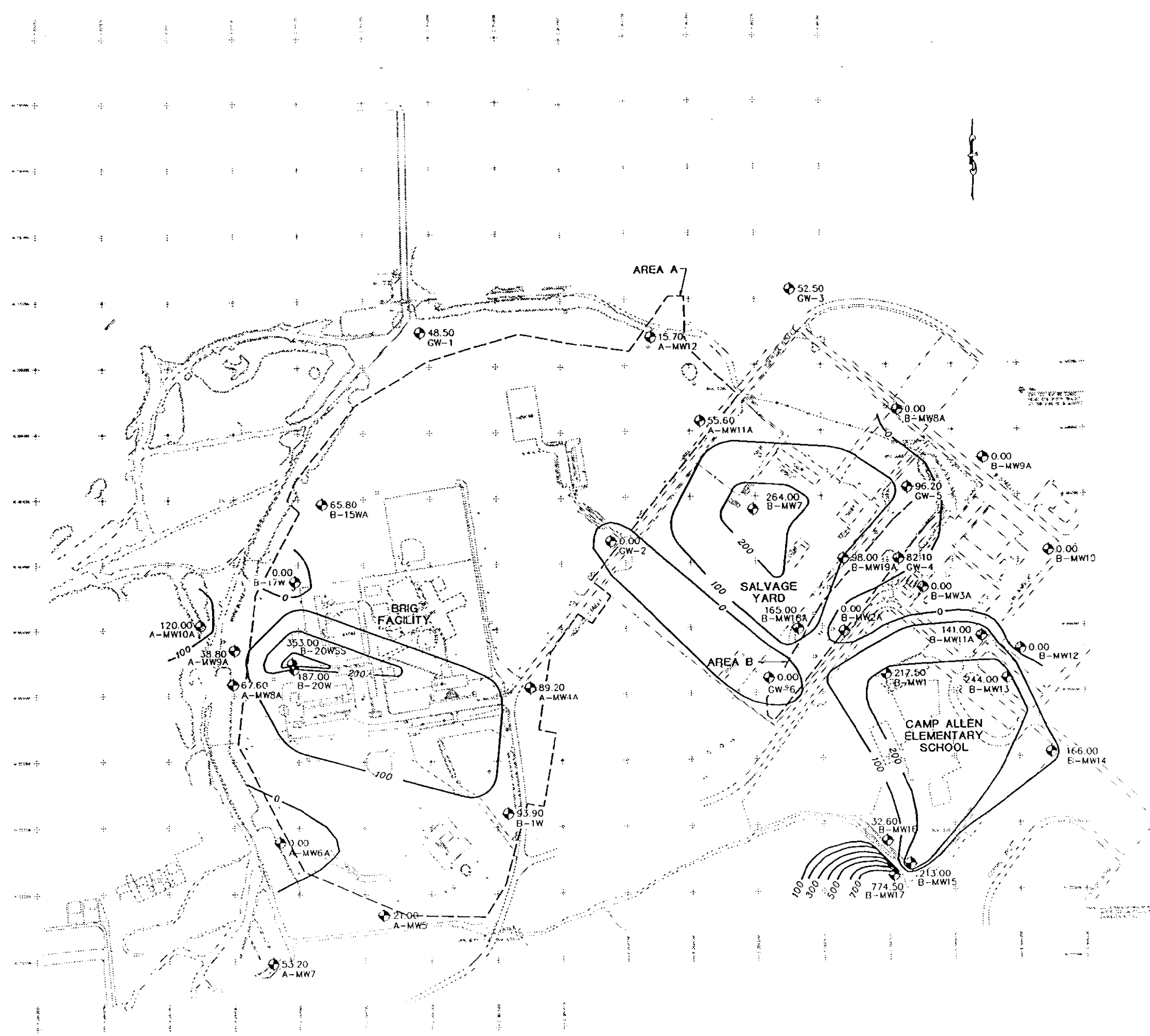
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SHALLOW GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
TOTAL CADMIUM
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE 6-18



NOTES

1. CONTOUR INTERVAL = 100 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19064
	CADD#	084-318

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

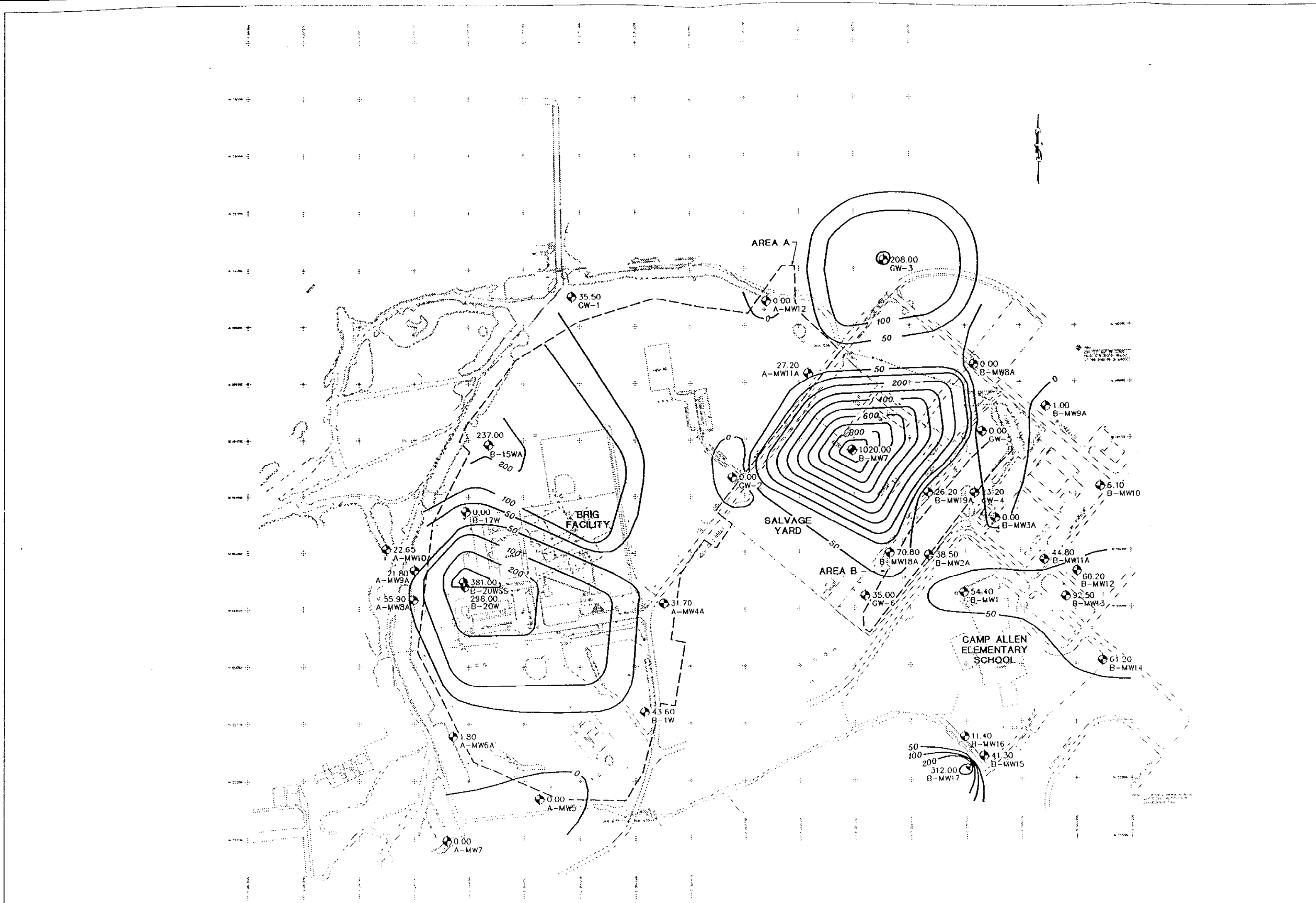
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SHALLOW GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
TOTAL CHROMIUM
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE
6-19

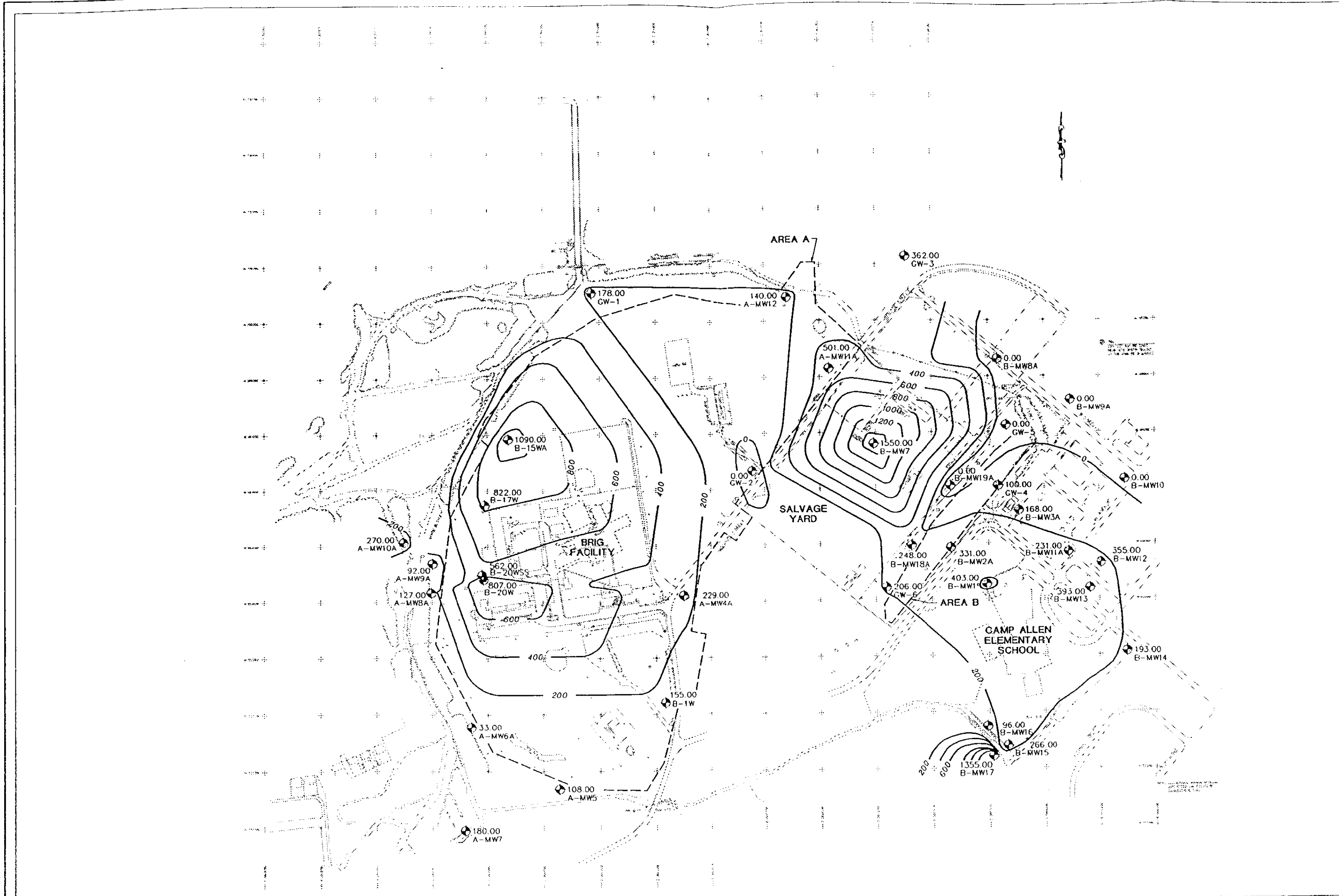


NOTES

1. CONTOUR INTERVAL– MISC. AS LABELLED; UNITS OF ug/L
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS			NORTH	CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA	Baker Baker Environmental, Inc.	SHALLOW GROUNDWATER SAMPLE RESULTS AREAS A AND B, ROUND 2 TOTAL LEAD ISOCONCENTRATION MAP	FIGURE 6–20
	DATE	7/93		BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania		SCALE GRAPHIC — DATE 7/93	
	SCALE	GRAPHIC					
	DRAWN	GLB					
	REVIEWED	TEA					
	S.O.#	19084					
	CADD#	084-319					



NOTES

1. CONTOUR INTERVAL = 200 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
DATE	7/93	
SCALE	GRAPHIC	
DRAWN	GLB	
REVIEWED	DEW	
S.O.#	19084	
CADD#	084-325	

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

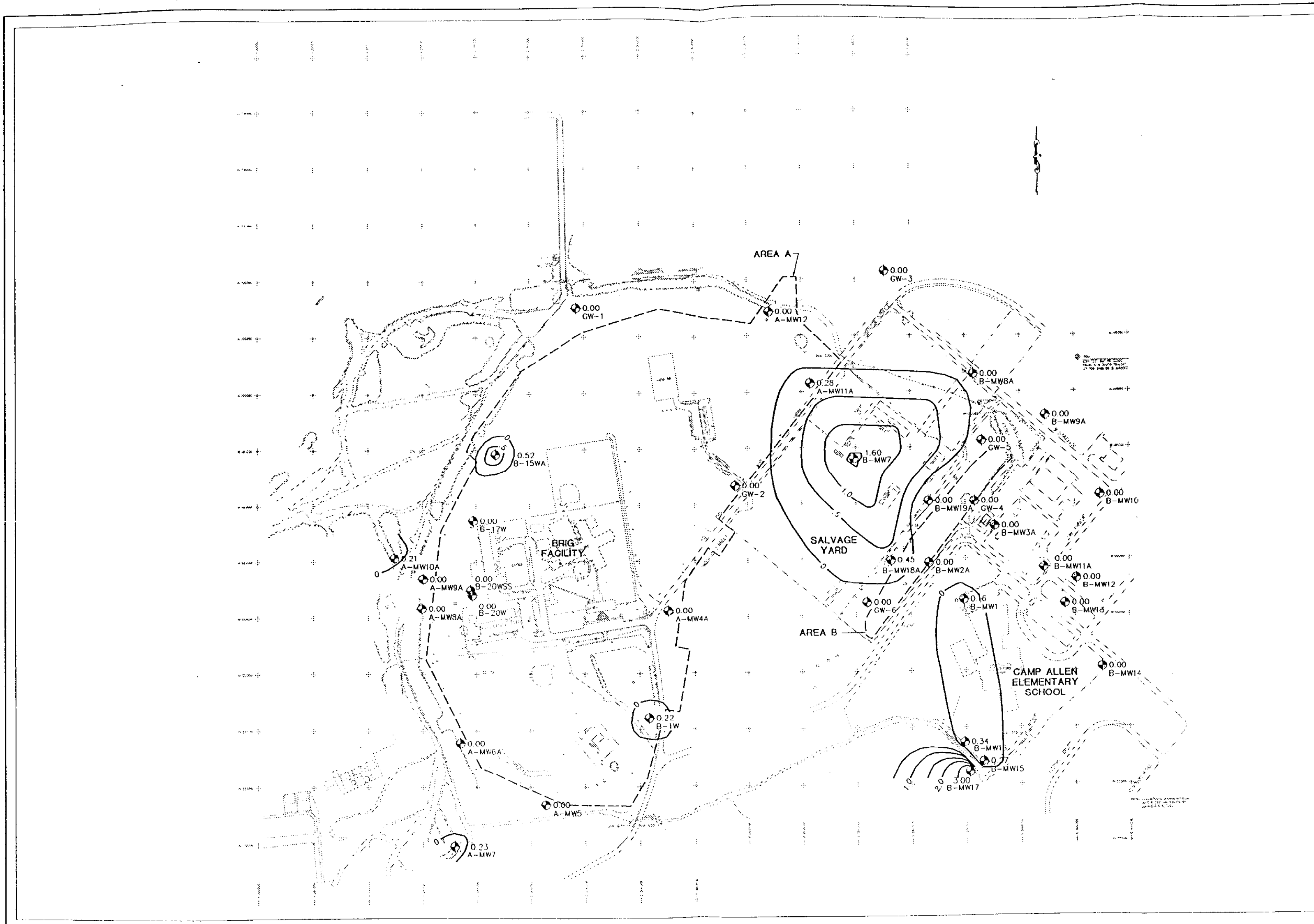
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SHALLOW GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
TOTAL ZINC
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE
6-21



NOTES

1. CONTOUR INTERVAL = .5 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
DATE	7/93	
SCALE	GRAPHIC	
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REVIEWED	TEA	
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NORTH

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SHALLOW GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
TOTAL MERCURY
ISOCONCENTRATION MAP

SCALE GRAPHIC DATE 7/93

FIGURE 6-22

vicinity of the Salvage Yard and the northeastern portion of Area A. The third area is located in the vicinity of the CAES and the fourth zone is located south of the CAES in the Capehart area.

As depicted on Figure 6-20, total lead concentrations have also been identified in the shallow groundwater in two primary areas. Although the Federal MCL is 15 µg/L, the isoconcentration contour interval was set at 100 µg/L due to the elevated total lead values detected. The first zone of detected total lead is primarily located in the southern/southwestern portion of Area A with detected values extending to the north. The second area is located in the vicinity of the Salvage Yard. Both of these areas correlate with the ones identified for total arsenic, cadmium, and chromium. Additionally, isolated areas of total lead were detected in the shallow groundwater northeast of Area A, southeast of Area B, and near the Capehart Military Housing.

Total zinc concentrations (Figure 6-21) have been identified in the shallow groundwater throughout Areas A and B. Four primary areas can be identified. Although the state MCL for total zinc is 50 µg/L, the isoconcentration contour interval was set at 100 µg/L due to the elevated total zinc values detected. The first zone of detected total zinc is centralized in Area A. The second area is located in the vicinity of the Salvage Yard and the northeastern portion of Area A. The remaining two areas are southeast of Area B and near the Capehart Military Housing.

Elevated total mercury concentrations (Figure 6-22) have been identified in two primary areas. The first area identified is located in the vicinity of the Salvage Yard. The second area is near the Capehart Military Housing. Several isolated detections are also apparent. The state MCL for total mercury is 0.05 µg/L. Due to elevated total mercury detected in the shallow groundwater, an isoconcentration contour interval of 0.5 was used.

Various total inorganic constituents (e.g., arsenic and chromium) were detected in groundwater samples collected from the shallow (water table) aquifer in concentrations exceeding State and Federal drinking water standards throughout the site. Comparisons of total versus dissolved metals detected in groundwater samples are presented in Appendix N.

In reviewing these comparisons, it is apparent that, with the exception of arsenic and zinc, dissolved phase inorganic contamination is not present in the shallow groundwater or is significantly less than the total parameters for the same well at the Camp Allen Landfill Site.

With the exception of one groundwater sample collected from well B-17W, dissolved phase zinc was not detected above Federal or state MCLs. However, dissolved metals (i.e., arsenic) were more prevalent in the shallow groundwater west of the Brig Facility than in other areas where the shallow groundwater was characterized.

Two isolated detections of dissolved phase arsenic were also detected in groundwater from wells (A-MW12 and B-MW8A) both of which are located adjacent to the Salvage Yard. A-MW12 is located northwest of the Salvage Yard and B-MW8A is located immediately north of the Salvage Yard.

However, based on comparisons of total verses dissolved metal concentrations and linear egression correlations between naturally occurring elements (i.e., iron and aluminum) and constituents of potential concern (e.g., arsenic and chromium), the inorganic contaminants in the Area A groundwater are believed to be associated with total suspended solids (turbidity) present in the wells and not representative of actual groundwater contamination.

6.5.2 Area B

6.5.2.1 Volatile Organics

Confirmation Study

During sampling activities at Area B, volatile organic compounds detected in shallow groundwater samples (GW-4 and GW-5) ranged in concentration from 11 µg/L to 24,000 µg/L. Total volatiles ranged from 17 µg/L to 28,187 µg/L. Only one groundwater sample collected at Area B (GW-4) contained significant concentrations of volatile organic constituents in the first three rounds.

Interim Remedial Investigation

Volatile organic constituents were detected in the water table aquifer in nine Area B wells at concentrations ranging from 1J µg/L to 3,200 µg/L. Total volatiles ranged from 1 µg/L to 6,759 µg/L. Three shallow wells (GW-4, B-MW3A, and B-MW11) contained significant concentrations of volatile constituents. Primary constituents included vinyl chloride, 1,2-dichloroethene, trichloroethene and benzene. The occurrence and distribution of volatile organic compounds suggests that contaminants from the Area B landfill are migrating with shallow groundwater flow in an east, southeast direction.

Remedial Investigation

At Area B, groundwater from seventeen shallow wells was analyzed for volatile compounds during Round 2. Volatile constituents were detected in six samples at concentrations ranging from 2J µg/L to 1600 µg/L. Total volatiles ranged from 2 µg/L to 2671 µg/L. Figures 6-13, 6-14, and 6-15 depict isoconcentration maps for total VOCs, vinyl chloride, and TCE, respectively. Discussions of results follow.

Groundwater samples from three wells (B-MW11A, B-MW3A and B-MW15) east and southeast of Area B, contained significant concentrations of volatile organic constituents (vinyl chloride; 1,2-dichloroethene; 1,2-dichloroethane; trichloroethene; and benzene). Vinyl chloride, 1,2-dichloroethane and benzene exceeded MCL standards for all three wells. Additionally, 1,1-dichloroethene exceeded MCL standards in groundwater collected from two wells (B-MW15 and B-MW3A). Tetrachloroethene exceeded MCL standards in two samples (B-MW2A and B-MW3A).

Please note that during Round 2, analytical results for groundwater collected from well GW-4 revealed no detectable volatile compounds. This is unusual since previous investigations indicated that groundwater collected from GW-4 had high contaminant levels. Groundwater from GW-4 was resampled during Round 3 in order to verify Round 2 results. Round 3 results did indicate detections of volatile organic compounds (total xylenes, acetone, and 4-methyl-2-pentanone). Round 3 results are further detailed below.

During Round 3, groundwater from the eight shallow wells installed during the RI and from GW-4 was sampled for volatile organic compounds in Area B. Volatile constituents were detected in five samples at concentrations ranging from 1J µg/L to 1250 µg/L. Total volatiles ranged from 3 µg/L to 1,890 µg/L.

Groundwater from one well (B-MW15) contained significant concentrations of volatile organic constituents (vinyl chloride, 1,1-dichloroethene, 1,2-dichloroethene, trichloroethane, and benzene) exceeding MCL standards for all constituents detected. The analytical results obtained from previous investigations, Round 2, and Round 3 sampling activities suggests that volatiles are migrating in an southeasterly direction from the Area B landfill.

Groundwater from two wells southeast of Area B, B-MW3A and B-MW11A, revealed elevated total VOCs (2,000 to 2,600 µg/L). Additionally, south of the Camp Allen Elementary School elevated total VOCs were also found (1,489 µg/L). Also, 50 µg/L total VOCs were found northwest of the elementary school at B-MW1. Groundwater samples from other locations around Area B, including within the Salvage Yard (B-MW7) and south of the school contained no detectable constituents.

Vinyl chloride was detected at three locations (B-MW3A, B-MW11A, and B-MW15), all at elevated concentrations exceeding the Federal MCL. During Round 3 (not shown on figure), locations not sampled in Round 2 (wells B-MW18A and B-MW19A installed during Round 3) had no detectable vinyl chloride. All other locations confirmed results obtained during Round 2 except at B-MW16, where 2 µg/L of vinyl chloride was detected in Round 3.

The highest TCE concentrations at Area B were found at locations B-MW3A, B-MW11A, and B-MW15 ranging in concentration from 44 µg/L to 520 µg/L. This is similar to the vinyl chloride occurrence and distribution. In Round 3, no additional TCE was detected, and the replication of analyses at B-MW15 confirmed the elevated TCE concentration.

6.5.2.2 Semivolatile Organics

Confirmation Study

Confirmation Study findings indicate that semivolatile organic constituents were detected in one sample (GW-4) at concentrations ranging from 44 µg/L to 190 µg/L. Total semivolatile concentrations ranged from 257 µg/L to 444 µg/L.

Interim Remedial Investigation

Based on Interim RI results only one well (GW-4) contained concentrations of semivolatile compounds. The total semivolatile concentration was 37 µg/L, with all constituents consisting of phenol or phenol-containing compounds.

Remedial Investigation

RI findings identified several different semivolatile compounds in groundwater samples collected from Area B, phthalates and PAHs. Additional semivolatile compounds were detected at low concentrations (1 to 5 µg/L total semivolatiles). Several samples contained semivolatile constituents; however, they did not exceed regulatory standards. Significant detections of semivolatile organic compounds were limited to phenol (see Figure 6-16).

The distribution and concentration of phenol in the shallow groundwater at Area B is more widespread and higher overall as compared to Area A. Low concentrations of SVOCs (less than 1 µg/L) were detected in samples collected from B-MW2A, GW-6 and B-MW11A. Higher values (5.4 µg/L to 14 µg/L) were found in samples from wells GW-4, B-MW3A and B-MW1.

Based on the similarity of the pattern of contaminant transport, and on physical characteristics identified in Section 4.0, the detected concentration of phenol contained in the groundwater from well B-MW17 does not appear to be related to Area B. Information available indicates an unrelated source area is potentially present to the south of this well location.

6.5.2.3 Pesticides/PCBs

Confirmation Study

No pesticide/PCBs were detected in any of the groundwater samples collected during this study.

Interim Remedial Investigation

Pesticide/PCBs were not analyzed as part of this investigation.

Remedial Investigation

During Rounds 2 and 3 at Area B, several pesticides were detected at concentrations ranging from 0.005J µg/L to 0.94 µg/L. Groundwater samples from 9 of the 19 wells sampled contained pesticide compounds. Dieldrin was detected in five samples from wells (B-MW3A, B-MW10, B-MW12, B-MW18A, and GW-4), exceeding the state MCL of 0.003 µg/L in all five. One groundwater sample from well (B-MW3A) contained gamma-BHC at a concentration exceeding the state MCL of 0.01 µg/L. Heptachlor epoxide was detected in two shallow wells (B-MW9A and GW-5) at concentrations exceeding the state MCL of 0.001 µg/L. Endrin was detected in one shallow well (B-MW10) at a concentration exceeding the state MCL of 0.004 µg/L. One shallow well (B-MW12) contained 4,4'-DDT at a concentration exceeding the state MCL of 0.001 µg/L.

Based on the locations of detected pesticide constituents and the locations where pesticides were not detected in the shallow groundwater, no true correlation to potential site-related sources is apparent. Given the widespread land application of pesticide-related products in the area at large, detected values are probably a result of general pesticide usage, rather than landfilled materials at Areas A and B. However, one connection can be made to the pesticide concentration detections in the shallow groundwater near the northeastern portion of Area B.

Based on source characterization activities at Area B discussed earlier in this section, GW-4 is located in the primary disposal area identified via geophysical survey results and analytical results of the source characterization program. Detections of pesticide constituents in subsurface soils in this area do correlate with the shallow groundwater results. Section 7.0 will further detail and summarize this interconnected relationship.

6.5.2.4 Metals

Confirmation Study

Metal constituents detected at concentrations exceeding corresponding MCLs included: arsenic, cadmium, chromium, lead, mercury, nickel, thallium, and zinc. In general, detected concentrations at Area B were less that those detected at Area A. Additionally, the majority of constituent concentrations significantly decreased with time. Groundwater collected from well locations GW-5 exhibited the most consistent concentrations, with cadmium and mercury concentrations increasing with time.

Area B groundwater samples were also analyzed for other inorganic parameters on a selected basis (total phenols and total cyanide). Trace amounts of each were detected in samples collected from well locations GW-5 and GW-7 during the first two sampling events, while higher concentrations were detected in samples collected from GW-4. Cyanide and phenol concentrations at this location increased from Rounds 1 and 2; however, decreased significantly between sampling Rounds 2 and 3.

Interim Remedial Investigation

Metal constituents were detected in varying concentrations throughout Area B. Aside from essential elements, primary constituents detected at concentrations above MCLs included: arsenic, cadmium, chromium, lead, and zinc. Groundwater collected from well location GW-5 exhibited the highest levels and variety of detected total metals. In general, detected concentrations of corresponding dissolved metals were significantly reduced, if they were detected at all.

Remedial Investigation

In order to address the most significant findings, discussions to follow are limited to detail regarding constituents which consistently exceeded corresponding MCLs (Federal and State). Essential elements (i.e., calcium, magnesium, etc.) are not discussed in this section; however, analytical results for these constituents are detailed in Section 5.0. Total concentrations of arsenic, cadmium, chromium, lead, zinc, and mercury, as they relate to both Areas A and B were presented previously on Figure 6-17, 6-18, 6-19, 6-20, 6-21, and 6-22, respectively.

At Area B, total arsenic was detected in concentrations exceeding the MCLs in monitoring well B-MW8A. Although other concentrations were detected, none exceeded MCLs.

Total cadmium concentrations, exceeding the MCLs, were detected in groundwater samples collected from B-MW7, B-MW13, and GW-5. Groundwater from B-MW13 exhibited the highest concentration.

Total chromium concentrations, exceeding the MCLs, were detected in groundwater samples collected from B-MW1, B-MW7, B-MW11A, B-MW13, B-MW15, B-MW17, B-MW18A, and B-MW19A. Groundwater from B-MW17 exhibited the highest concentration.

Total lead concentrations, exceeding the MCLs, were detected in groundwater samples collected from B-MW1, B-MW7, B-MW12, B-MW13, B-MW14, B-MW17, and B-MW18A. Groundwater from B-MW17 exhibited the highest concentration.

Total mercury concentrations exceeded both Federal and state MCLs, in groundwater collected from B-MW17. The state MCL was exceeded in groundwater samples collected from

B-MW1, B-MW7, B-MW15, B-MW16, B-MW17, and B-MW18A. Groundwater from B-MW17 exhibited the highest concentration.

Total zinc concentrations detected in the shallow groundwater at Area B exceeded the MCLs in the vast majority of monitoring wells. The only locations where zinc concentrations in the groundwater were not detected or did not exceed the MCLs include B-MW8A, B-MW9A, B-MW10, B-MW19A, and GW-5. The highest concentrations of zinc detected in the shallow groundwater, were from wells B-MW7 and B-MW17.

As discussed previously (Section 6.5.1.4), various zones exist in which selected total metals were detected in shallow groundwater.

In reviewing the total metal values detected in the shallow groundwater as a whole, a consistent pattern of elevated total metal values is apparent. Four general zones of elevated total metal concentrations in the shallow groundwater can be identified: (1) the southern to middle portion of Area A; (2) the Salvage Yard/northeast portion of Area A; (3) the Camp Allen Elementary School area; and (4) the northwestern portion of the Capehart Military Housing area. The area of total metal detections in the vicinity of the elementary school did not exhibit consistently elevated concentrations for all presented metal discussions. Cadmium, chromium, lead, and zinc were, however, detected at elevated concentrations. Considering the corresponding levels detected at the Salvage Yard and the abandoned storm sewer which reportedly accommodated Salvage Yard storm runoff during the 1970s, detected concentrations could possibly be remnants of the previous "tainted runoff" once directed to this area from the Salvage Yard. Detected total metal concentration in the Capehart Military Housing area were based on one well location. Based on RI findings, these detections are not considered to be site-related. Possible offsite sources to the south may exist.

Comparisons of detected total metal constituents, dissolved metal constituents, and corresponding Federal and state MCLs for the shallow groundwater samples collected at Areas A and B are presented in Appendix Z. These comparisons are in bar chart form with, for the most part, shallow monitoring wells separated by area (Area A and Area B).

Various total inorganic constituents (e.g., arsenic and chromium) were detected in groundwater samples collected from the shallow (water table) aquifer in concentrations exceeding State and Federal drinking water standards throughout the site. However, based on comparisons of total verses dissolved metal concentrations and linear egression correlations between naturally occurring elements (i.e., iron and aluminum) and constituents of potential concern (e.g., arsenic and chromium), the inorganic contaminants in the groundwater are believed to be associated with total suspended solids (turbidity) present in the wells and not representative of actual groundwater contamination. Additional investigation related to Salvage Yard and Capehart Military Housing areas is anticipated under separate study to further define offsite issues.

6.5.3 Residential Wells

As discussed in Section 6.5, groundwater from the majority of the wells was not found to contain detectable concentrations of volatile organic compounds, four of the wells did contain detectable levels (see Figure 6-11). The four locations (RW-22, RW-39, RW-55, and RW-56) where volatile organic constituents were detected are marked accordingly. Three of the locations (RW-22, RW-39, and RW-55) where detections were encountered were sampled by CH_2M Hill in 1991.

Based on results of the residential well sampling program and on findings of the RI, detected constituents appear to be isolated occurrences unrelated to disposal activities at Area A. Although 1,2-dichloroethane (detected in well 55) is a compound of concern in the groundwater near Area A, analytical results for groundwater collected from shallow monitoring wells (A-MW8A, A-MW9A, and A-MW10A) located between Area A and Glenwood Park suggest that no connection exists. Additionally, the drainage ditch located between Area A and Glenwood Park appears to be acting as a hydrogeologic boundary.

6.5.4 Other Potential Sources

Several potential "off-site" sources of contamination have been identified in the vicinity of the Camp Allen Landfill Site. These include:

- Twelve underground storage tanks (USTs)
- The Camp Allen Salvage Yard
- The seepage area on the southern bank of the drainage ditch located behind the elementary school

Several of the USTs are out of service. The active USTs contain either gasoline, diesel or heating oil. The status, locations and contents of the 12 USTs are described in Section 4.3.3.

Past releases from these tanks (if any occurred) could have impacted the shallow groundwater in this area.

The Camp Allen Salvage Yard Facility operations, which began in the early 1970s and continue today, are reported to have included various chemical, waste, and recyclable management activities. These activities appear to have impacted the shallow groundwater to some extent in this area.

The other potential off-site source is associated with a seepage area on the southern bank of the drainage ditch located behind the elementary school. The source is of unknown origin, but is most likely located south of the drainage ditch in the area of Capehart Military Housing. This area is currently being evaluated by Navy environmental personnel. The area south of the drainage ditch is monitored by a shallow well. Based on total metal constituent concentrations found in this well and the lack of consistently elevated metal constituent concentrations across the drainage ditch in the area of the elementary school, the metal contamination is believed to be related to an off-site source and not Area B.

6.6 Groundwater - Yorktown Aquifer

The concentration of constituents in the Yorktown Aquifer beneath the Camp Allen area has been evaluated during Confirmation Study activities (limited study), Interim RI activities, and RI activities. Results from the previous and current investigations are summarized below by area and by contaminant. In general, Confirmation Study, Interim RI, and RI findings are each detailed in separate subsections in order to present a basic understanding of groundwater quality concerns related to the groundwater regime around the Camp Allen area.

Previous investigation activities are described in Section 1.0 and analytical summaries for these sampling programs are contained in Appendix X. RI findings related to primary constituents detected are graphically depicted using approximated isoconcentration maps that vary in contour interval depending on concentration ranges of detected constituents.

During the Confirmation Study, Malcolm Pirnie conducted four separate rounds of groundwater sampling. During Round 1 (December 1983), samples were analyzed for Priority Pollutant constituents and xylene. During Round 2 (August 1984), samples were also analyzed for Priority Pollutant constituents and screened for dioxin. During Round 3 (April 1986), groundwater was resampled for Priority Pollutants and special analyses (primarily xylenes and ketones). During Round 4 (June 1986), groundwater was sampled for ketones and ethylene dibromide only. This study provided limited information on the Yorktown Aquifer (Deep Groundwater) because only two monitoring wells were used to determine deep groundwater quality. Confirmation Study groundwater analytical summaries are presented in Appendix X.

CH_2M Hill performed one round of groundwater sampling on the six deep monitoring wells installed at Area A as part of the Interim RI. Deep groundwater samples were collected and analyzed for volatiles, as well as for total and dissolved metals. Interim RI activities at Area B included sampling and analysis of groundwater from three deep monitoring wells installed as part of the Interim RI. Groundwater samples were collected and analyzed for volatile organic compounds and total and dissolved metals. Interim RI groundwater analytical summaries are presented in Appendix X.

Groundwater from all existing Yorktown Aquifer wells was sampled during Round 2 and Round 3 of the Remedial Investigation, with modified CLP methods used for analysis of Round 3 samples. These modified CLP methods resulted in lower VOC detection limits for Round 3 data. Primary constituents detected during the RI are graphically depicted using approximated isoconcentration maps which vary in contour interval depending on concentration ranges of detected constituents.

Please note that Round 3 was limited to volatile organic compound analysis, with the exception of wells installed during Round 3. Groundwater from deep wells installed during Round 3 was analyzed for TCL and TAL parameters. Each sampling round is therefore, discussed separately below. Also, data from the three wells screened near the bottom of the Yorktown Aquifer (A-MW1C, A-MW9C and B-MW15B) are not shown on the isoconcentration maps, but are discussed separately because they indicate the potential extent of (downward) vertical migration of constituents in the Yorktown Aquifer. The detectable concentrations from these three wells are not included in discussion of numbers of wells sampled in the Yorktown Aquifer. Rather, only those wells which are screened in the upper to middle portion of the Yorktown Aquifer are included in the numerical evaluation.

Analysis of deep groundwater samples for both total and dissolved metals was performed during RI activities. As indicated by previous investigation results, numerous metal constituents were detected in groundwater samples from two deep well locations during the Confirmation Study; however, in the Interim RI findings many of the detection limits were too low to be effective in this evaluation. In general, detected concentrations of corresponding dissolved metals were significantly reduced, if detected at all. Some dissolved values were observed to increase from corresponding total metal concentrations.

To address the most significant findings, discussions to follow are limited to detail regarding constituents that consistently exceeded corresponding MCLs (Federal and State). Essential elements (i.e., calcium, magnesium, etc.) are not discussed in this section; however, analytical results for these constituents are detailed in Section 5.0. Please note that the term "significant" refers to those constituents that are approximately 10 times the MCLs; the term "moderate" refers to those constituents that have exceeded both state and Federal MCLs.

6.6.1 Area A

6.6.1.1 Volatiles

Confirmation Study

Groundwater samples from well GW-7 were sampled during the four rounds of groundwater sampling conducted as part of the Confirmation Study. Well GW-7 is located near the Sheller Globe facility, approximately 3/4 mile northwest of the Camp Allen Landfill Site. GW-7 was reportedly completed in the Yorktown Aquifer.

Low concentrations of methylene chloride, toluene and bis(2ethylhexyl)phthalate were detected in Round 1 samples. The constituents detected and the respective concentrations suggest that they were likely laboratory contaminants. No other constituents were detected in any of the additional rounds of sampling.

Interim Remedial Investigation

Six deep wells were sampled for volatile constituents in Area A as part of the Interim RI. The results indicate that three wells (AMW4B, A-MW6B, and A-MW11B), contained only trace concentrations of various organic compounds. The three remaining wells (A-MW1B, AMW9B, and A-MW10B) contained high levels of contaminants, with total VOC concentrations ranging from 146 µg/L to 922 µg/L. The three constituents with highest concentrations in each well include 1,2-dichloroethene; vinyl chloride; and trichloroethene.

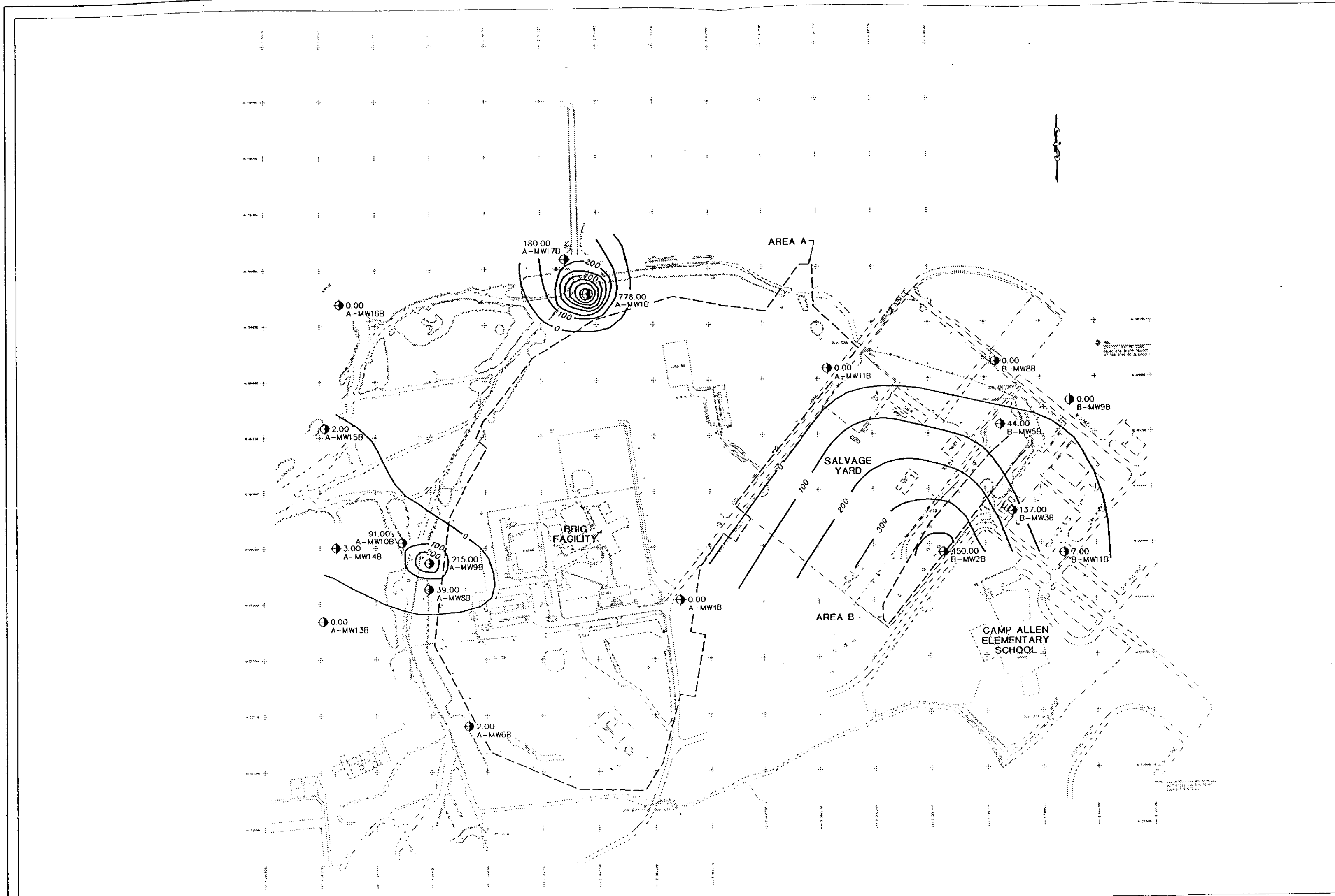
During Round 2 sampling efforts, groundwater from fifteen deep monitoring wells was sampled at Area A. Total VOC concentrations in the groundwater samples collected ranged from 3 µg/L to 778 µg/L and VOC constituents were detected in 8 of the 12 wells sampled. The highest concentrations were found near A-MW8B, A-MW9B, and A-MW10B, along the western portion of Area A. This is near or adjacent to shallow wells B-20W and B-20WSS, which had very high concentrations of VOCs. Elevated VOCs were also found at A-MW1B and A-MW17B, in the northern portion of Area A. Other locations around Area A, especially to the west and north, had trace levels of total VOCs.

Round 2 total VOC detections in groundwater from Areas A and B are presented on Figure 6-23. Three VOC plumes are identified, all of which correlate with previously discussed contamination in other media including shallow groundwater. Round 3 data further support this information, as additional deep monitoring wells were installed and followed by additional groundwater sampling.

Round 3 data for Area A depicts a similar distribution of total VOCs as was found in Round 2, often with lower total constituent concentrations (ranging from 1 µg/L to 313 µg/L). Detectable concentrations were found in groundwater from 12 of the 14 deep wells. Groundwater collected from monitoring well A-MW18B, installed north of Area A, as part of the Round 3 investigation, revealed reduced concentrations of total VOCs indicating this location is likely near the outer extent of the VOC plume north of Area A.

Groundwater collected from another newly installed well (A-MW19B) contained 34 µg/L of VOCs, with the nearby well A-MW11B groundwater sample showing only a trace amount (1 µg/L) of VOCs indicating a second source area of VOCs in the northern portion of Area A (see Section 6.2 Source Characterization). Groundwater collected from well B-15WB, screened in the lower part of the Yorktown Aquifer, contained 20 µg/L total VOCs. Groundwater samples from two other deeper wells (A-MW1C and AMW9C) were free from volatile constituents indicating VOC contamination is primarily limited to the upper portion of the Yorktown Aquifer at this time.

Round 3 total VOC concentrations in groundwater collected from Areas A and B are presented on Figure 6-24. Again, three VOC plumes are identified. All three correlate with previously discussed contamination. Round 3 data further defines these plumes as laboratory analytical



NOTES

1. CONTOUR INTERVAL = 100 UG/L.
2. NUMBER AT WELL LOCATION IS SUM OF VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN ug/L.
3. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

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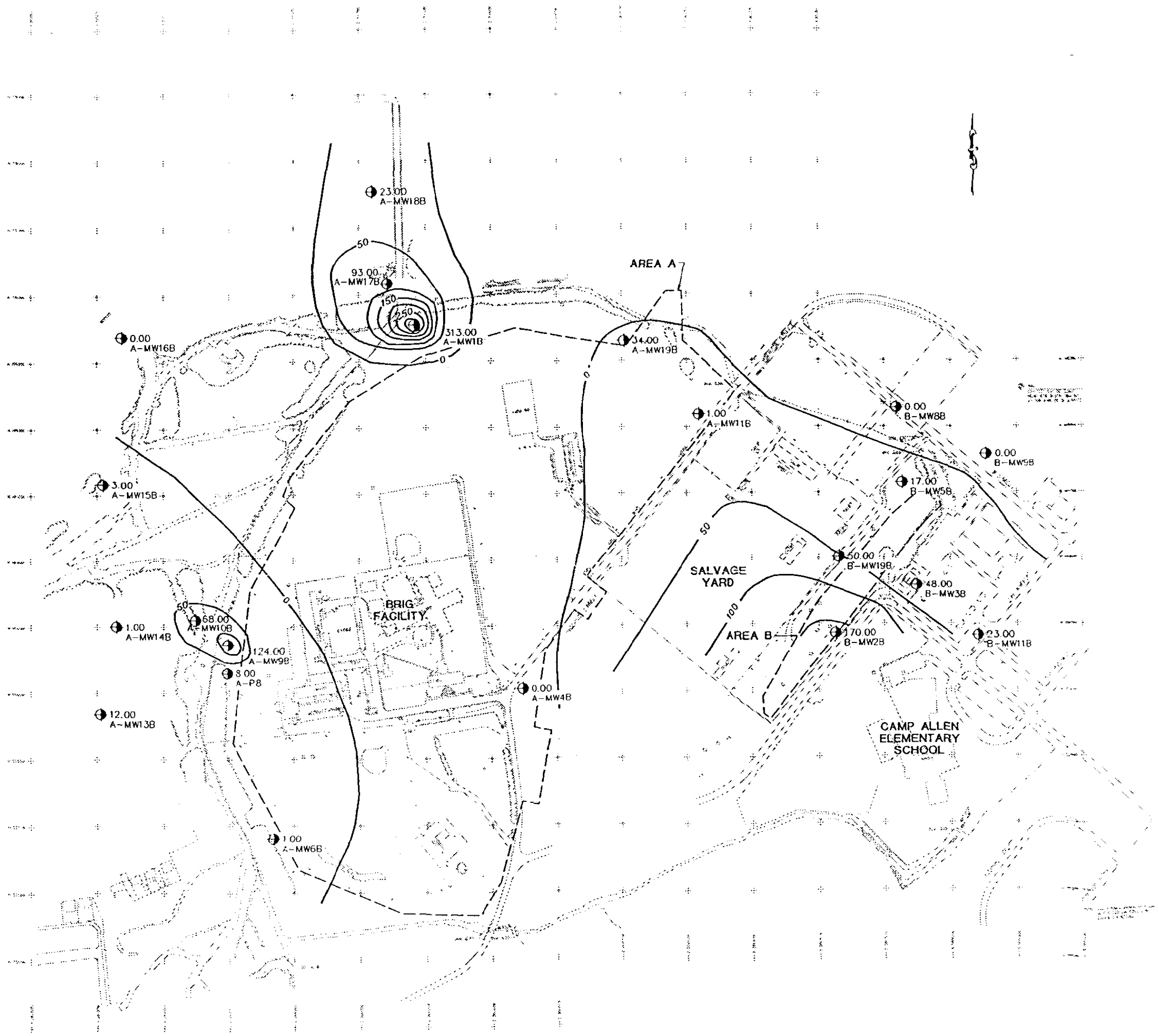
DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
TOTAL VOLATILES
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE 6-23



NOTES

1. CONTOUR INTERVAL = 50 ug/L.

2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

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DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 3
TOTAL VOLATILES
ISOCONCENTRATION MAP

SCALE GRAPHIC DATE 7/93

FIGURE 6-24

method detection limits were lowered during Round 3. Additionally, groundwater samples were collected from newly-installed well monitoring portions of the Yorktown Aquifer further away from the site. VOC detections near the apparent extent of identified VOC plumes are significantly lower near upgradient wells. At times, the detected results are of low estimated values or common laboratory-related contaminants or both.

VOCs detected in deep groundwater collected from the Camp Allen Landfill Site primarily included vinyl chloride and trichloroethene. Detected concentrations of these compounds are discussed below.

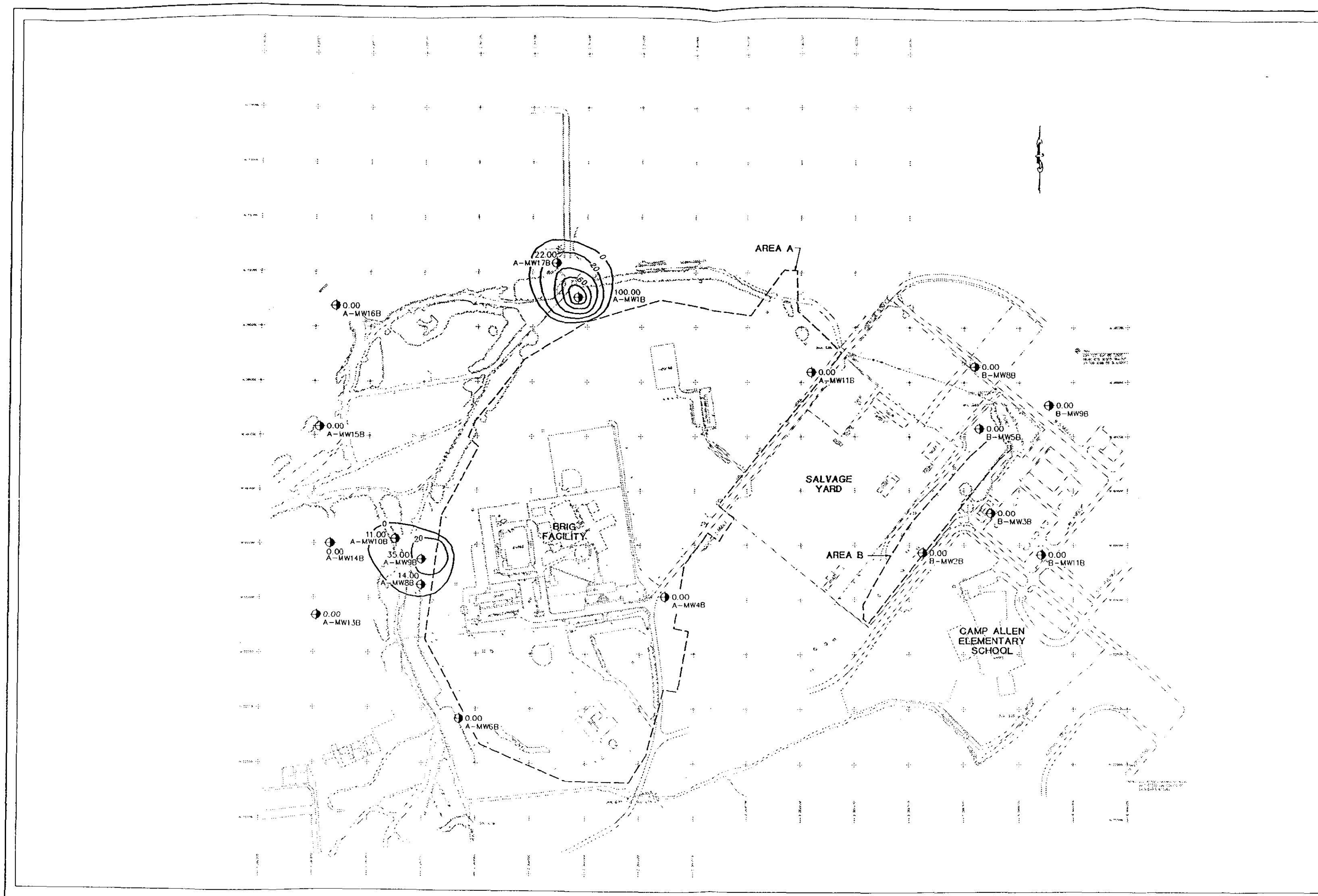
Vinyl chloride was detected in groundwater from 5 of the 12 deep wells sampled at Area A in Round 2, with concentrations ranging from 11 µg/L to 100 µg/L. All five samples exceeded the Federal MCL for groundwater of 2 µg/L. The highest vinyl chloride concentration was found at A-MW1B, at the northern part of Area A. Vinyl chloride has migrated off-site in a northerly direction to A-MW17B and also in a westerly direction to A-MW10B.

Vinyl chloride concentrations in groundwater collected from Areas A and B, during Round 2 sampling efforts, are presented on Figure 6-25. Two plumes are identified at Area A, both of which correlate with the total VOC plumes identified earlier. Vinyl chloride was not detected at Area B during Round 2.

Vinyl chloride concentrations varied from 1 µg/L to 14 µg/L in Area A during Round 3 and were found in groundwater from 4 of the 14 wells sampled. Results from three of the locations (A-MW17B, A-MW9B and A-MW10B) exceeded the Federal MCLs. Note that concentrations decreased significantly (from 100 µg/L to below method detection limits) at location A-MW1B. Other locations also revealed decreases in concentration from Round 2 to Round 3. At Area B, 1 µg/L of vinyl chloride was detected in groundwater from well B-15WB, screened near the lower portion of the Yorktown Aquifer.

Round 3 vinyl chloride concentrations in groundwater collected from Areas A and B are presented on Figure 6-26. Two plumes are identified at Area A, both of which correlate with the plumes identified earlier. Please note that vinyl chloride was detected at Area B during Round 3.

Trichloroethene (TCE) was detected in 4 of the 12 groundwater samples locations at Area A in Round 2, with concentrations ranging from 3 µg/L to 100 µg/L. Groundwater collected from



NOTES

1. CONTOUR INTERVAL = 20 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	084-314

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

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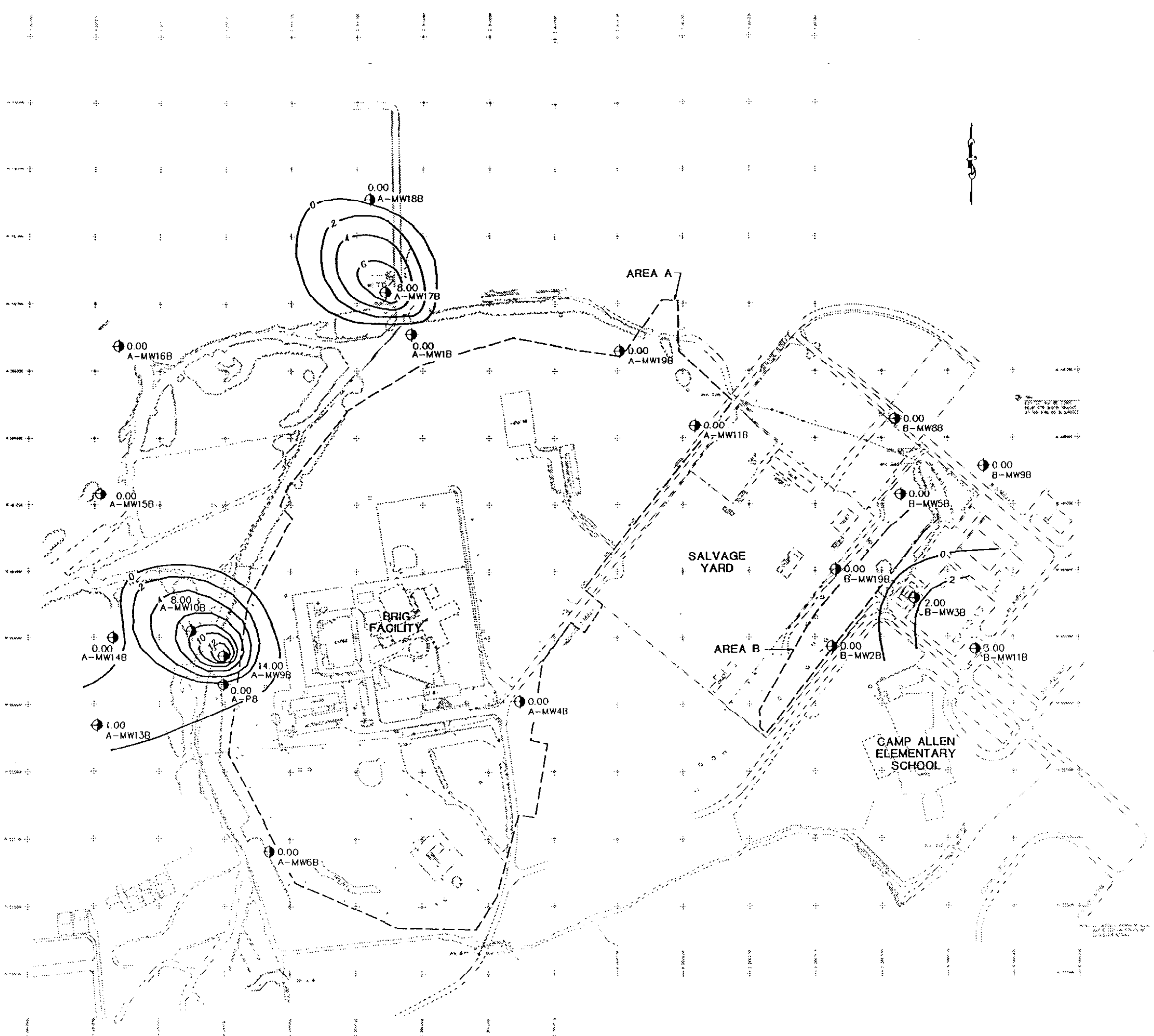
DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 2
VINYL CHLORIDE
ISOCONCENTRATION MAP

SCALE GRAPHIC
DATE 7/93

FIGURE
6-25



NOTES

1. CONTOUR INTERVAL = 2 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
DATE	7/93	NORTH
SCALE	GRAPHIC	
DRAWN	GLB	
REVIEWED	TEA	
S.O.#	19084	
CADD#	084-315	

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NORFOLK, VIRGINIA

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DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 3
VINYL CHLORIDE
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE
6-26

three wells (A-MW1B, A-MW17B, and A-MW10B) exceeded the Federal MCL of 5 µg/L for TCE in groundwater. Note that the highest concentrations were detected in the northern part of Area A. All other samples, including samples collected near the source area adjacent to the Brig Facility did not contain TCE.

Round 2 TCE concentrations in groundwater collected from Areas A and B are presented on Figure 6-27. Two plumes are identified at Area A, both of which correlate with the VOC plumes identified earlier.

During Round 3, groundwater collected from 6 of the 14 wells sampled at Area A contained detectable concentrations of TCE, ranging from 3 µg/L to 16 µg/L. Five of the six concentrations exceeded the Federal MCL of 5 µg/L for TCE in groundwater. Differences between Round 2 and Round 3 results include elevated TCE concentrations at well (A-MW17B) north of Area A. In addition, three samples collected from wells (A-MW18B and A-MW19B, not installed for Round 2 sampling, and A-MW13B), contained TCE at concentrations of 33 µg/L, 14 µg/L, and 7 µg/L, respectively. Also, 12 µg/L of TCE was detected in groundwater from well B-15WB, screened near the base of the Yorktown Aquifer.

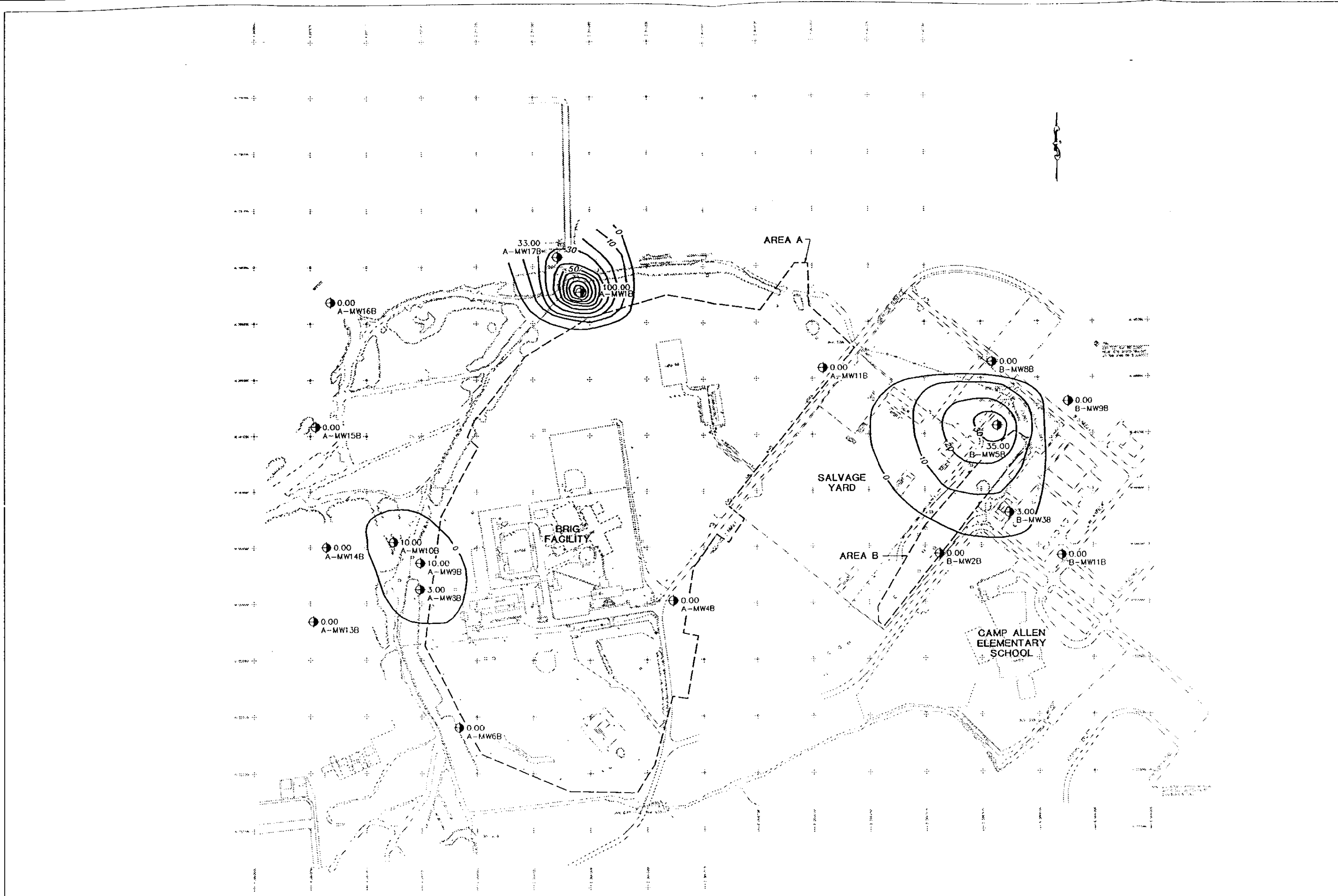
Round 3 TCE concentrations in groundwater collected from Areas A and B are presented on Figure 6-28. Two plumes are identified at Area A, both of which correlate with the VOC plumes identified earlier.

Only one other constituent (1,2-dichloroethane) detected at Area A during the two sampling events exceeded the Federal MCL. Groundwater samples from two deep wells (A-MW1B and A-MW17B) exceeded the Federal MCL of 5 µg/L for 1,2-dichloroethane in both rounds of sampling.

6.6.1.2 Semivolatiles

Confirmation Study

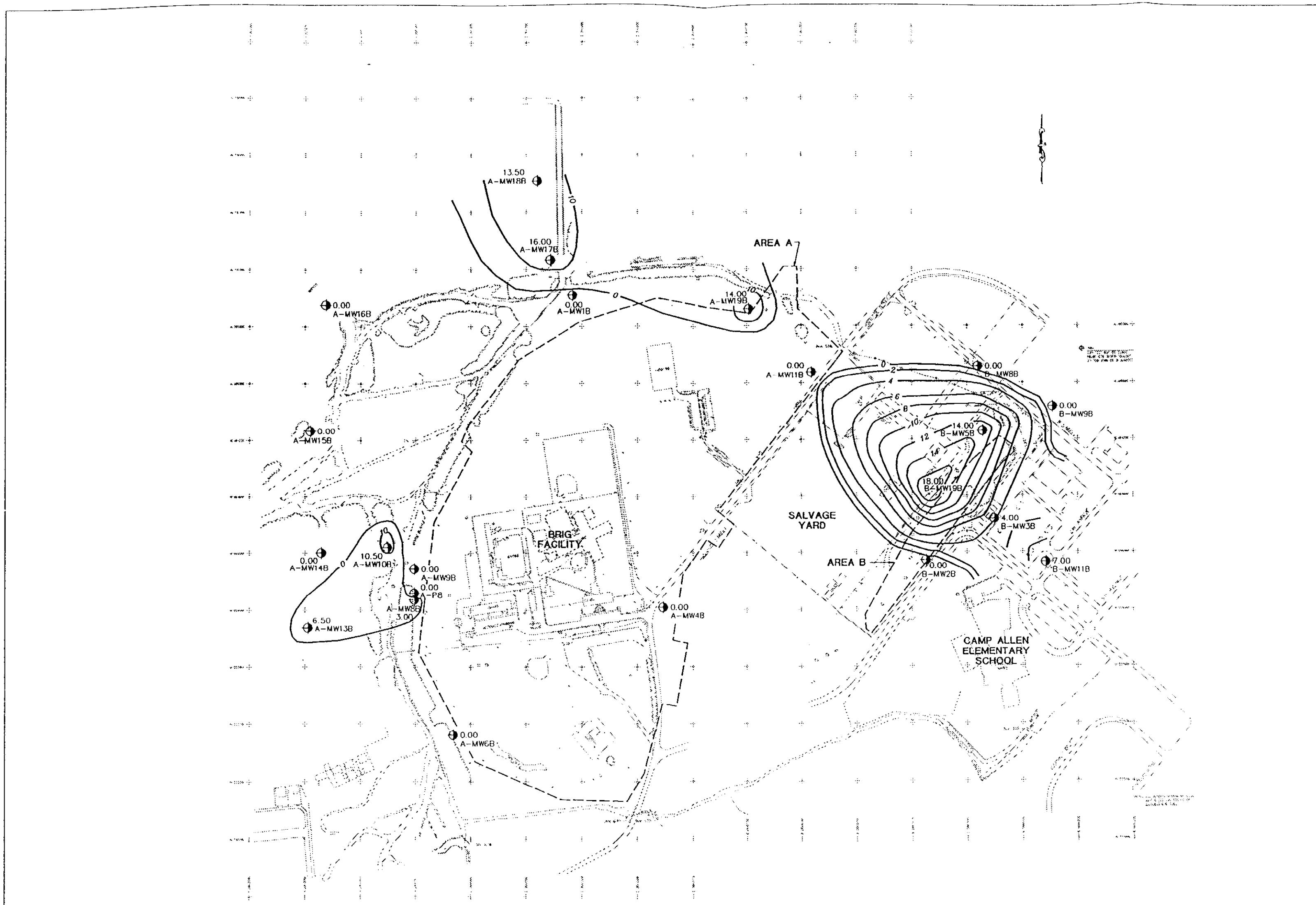
Low concentrations of bis (2ethylhexyl)phthalate were detected in Round 1 samples. The constituents detected and the respective concentrations suggest that they were likely laboratory contaminants. No other constituents were detected in any of the additional rounds of sampling.



NOTES

1. CONTOUR INTERVAL = 10 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

REVISIONS			NORTH	CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Baker Environmental, Inc.	DEEP GROUNDWATER SAMPLE RESULTS AREAS A AND B, ROUND 2 TCE ISOCONCENTRATION MAP	FIGURE 6-27
	DATE	7/93				SCALE GRAPHIC	
	SCALE	GRAPHIC				DATE 7/93	
	DRAWN	GLB					
	REVIEWED	TEA					
	S.O.#	19084					
	CADD#	084-322					



NOTES

1. CONTOUR INTERVAL
   10 ug/L AT AREA A
   2 ug/L AT AREA B
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	084-323

NORTH

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DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUND 3
TCE
ISOCONCENTRATION MAP

SCALE GRAPHIC DATE 7/93

FIGURE
6-28

Interim Remedial Investigation

Samples collected during the Interim Remedial Investigation were not analyzed for semivolatile organic compounds.

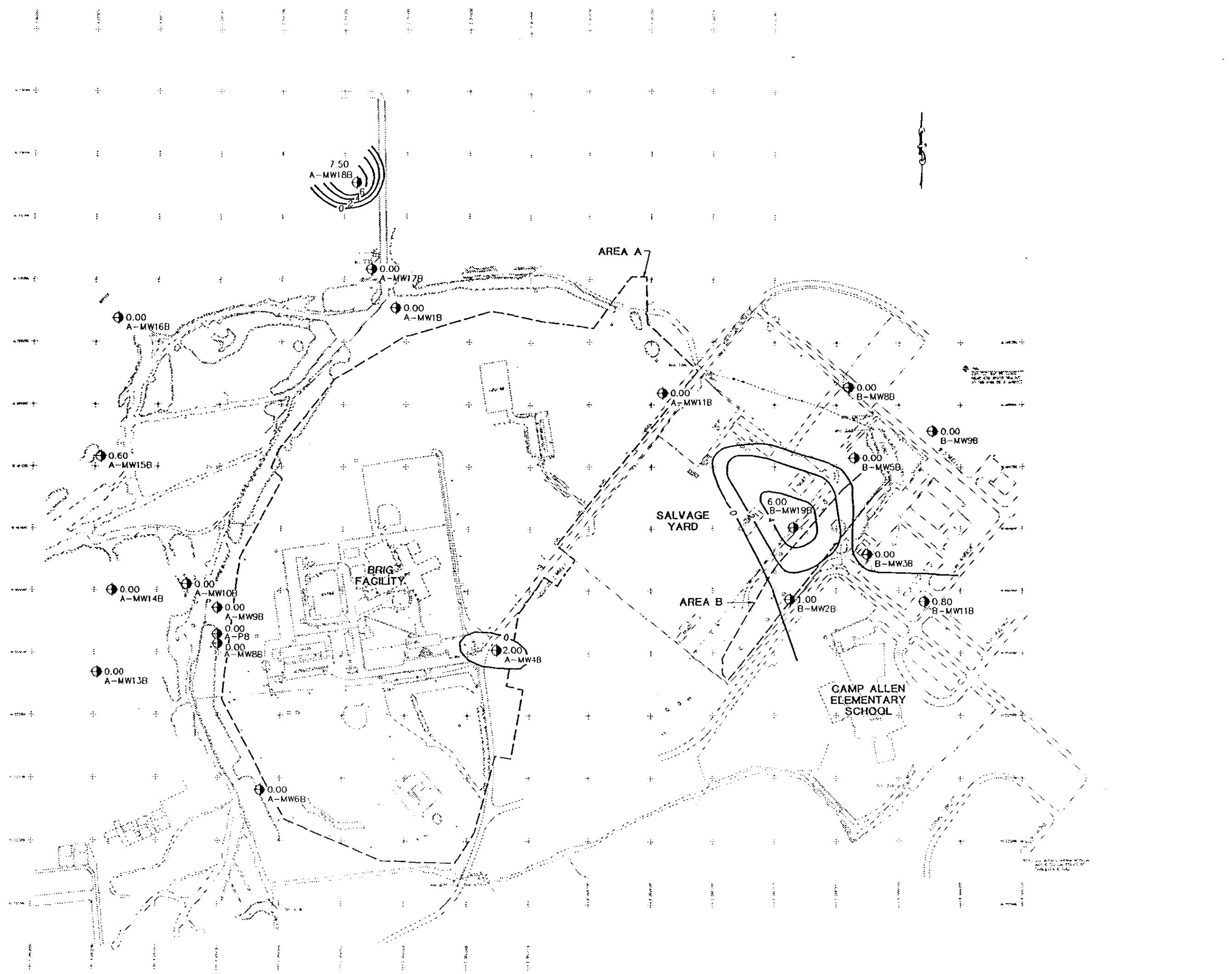
Remedial Investigation

Results and evaluation of the extent of SVOC contamination are combined for Rounds 2 and 3 (rather than presented separately as for the VOCs) because all wells were sampled only once for this class of compounds. Also, as for the water table aquifer, phenol is used as an indicator for the extent of SVOC contamination in the Yorktown Aquifer, and its concentration was shown in the figures described below. Other constituents detected will also be evaluated in a general manner below.

Groundwater from 14 deep wells was sampled at Area A during Rounds 2 and 3. Phenol was detected in three samples collected from deep wells (A-MW4B, A-MW15B, and A-MW18B), with concentrations ranging from 0.6 µg/L to 7.5J µg/L. Groundwater samples collected from wells (A-MW4B and A-MW18B) exceeded the state MCL of 1 µg/L, with concentrations of 2 µg/L and 7.5 µg/L, respectively. Groundwater collected from the three wells screened in the lower portion of the Yorktown Aquifer (A-MW1C, A-MW9C, and B-15WB) did not contain detectable concentrations of phenol (These wells did not contain detectable concentrations of SVOCs.)

Figure 6-29 presents concentrations of phenol in the shallow groundwater at Areas A and B. As indicated on this figure, elevated phenol concentrations are centralized beneath the eastern portion of the Salvage Yard and Area B. Also an isolated area east of the Brig Facility is indicated. In general, identified areas correlate to detected phenol concentrations in the water table aquifer.

Low concentrations of other compounds , such as phthalates, esters and PAHs were detected in groundwater at Area A. None of the detected compounds exceeded regulatory criteria. At Area B, only diethyl phthalate was detected in the Yorktown Aquifer. No regulatory criteria have been established for these compounds.



NOTES

1. CONTOUR INTERVAL = 2 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		NORTH	CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA	Baker	DEEP GROUNDWATER SAMPLE RESULTS AREAS A AND B, ROUNDS 2 AND 3 PHENOL ISOCONCENTRATION MAP	FIGURE
	DATE 7/93 SCALE GRAPHIC DRAWN GLB REVIEWED TEA S.O.# 19084 CADD# 084-324		BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker Environmental, Inc.	SCALE GRAPHIC DATE 7/93	6-29

6.6.1.3 Pesticides/PCBs

Confirmation Study

Sampling and analysis for pesticides/PCBs was not conducted during this study.

Interim Remedial Investigation

Sampling and analysis for pesticides/PCBs was not conducted during this investigation.

Remedial Investigation

Pesticides detected at Area A during the Round 2 and 3 sampling events include heptachlor epoxide and 4,4'-DDT. Groundwater from 3 of the 14 deep wells sampled contained pesticides. Heptachlor epoxide was found in two samples (A-MW4B and A-MW11B) at concentrations of 0.004J µg/L and 0.0065J µg/L, respectively. One sample (A-MW16B) contained 4,4'-DDT at a concentration of 0.016J µg/L. These values exceed the state MCLs of 0.001 µg/L for each compound. (No Federal regulatory criteria have been established for these compounds.) The well location where 4,4'-DDT was detected is located to the west of Area A and may be related to off-site conditions, since DDT was not found within or upgradient of Area A.

No pesticides were detected in the groundwater samples from wells (AMW1C, A-MW9C, and B-15WB) screened in the lower portion of the Yorktown Aquifer at Area A.

6.6.1.4 Metals

Confirmation Study

Total metal constituents detected during Round 1 included cadmium, chromium, copper, lead, nickel, thallium, and zinc. With the exception of copper, these constituents were detected at levels exceeding MCLs; however, none of the constituents were detected in all three sampling rounds. During Round 3, only total cadmium and lead were detected at concentrations of 30 µg/L and 140 µg/L, respectively.

Interim Remedial Investigation

Total metal constituents were detected in varying concentrations throughout Area A. Aside from essential elements, primary constituents detected included arsenic, cadmium, chromium, lead, and zinc. Although none of the total metal constituents were detected above corresponding MCLs, many of the detection limits were too high to be effective in this evaluation. In general, detected concentrations of corresponding dissolved metals were significantly reduced, if detected at all. Some dissolved values were observed to increase from corresponding total metal concentrations.

Remedial Investigation

Total metal constituents consistently detected in the deep groundwater at Area A and Area B include arsenic, chromium, lead, and zinc. Other inorganic constituents were also detected at concentrations above corresponding MCLs (beryllium, cadmium, and mercury) and will be discussed individually, as appropriate.

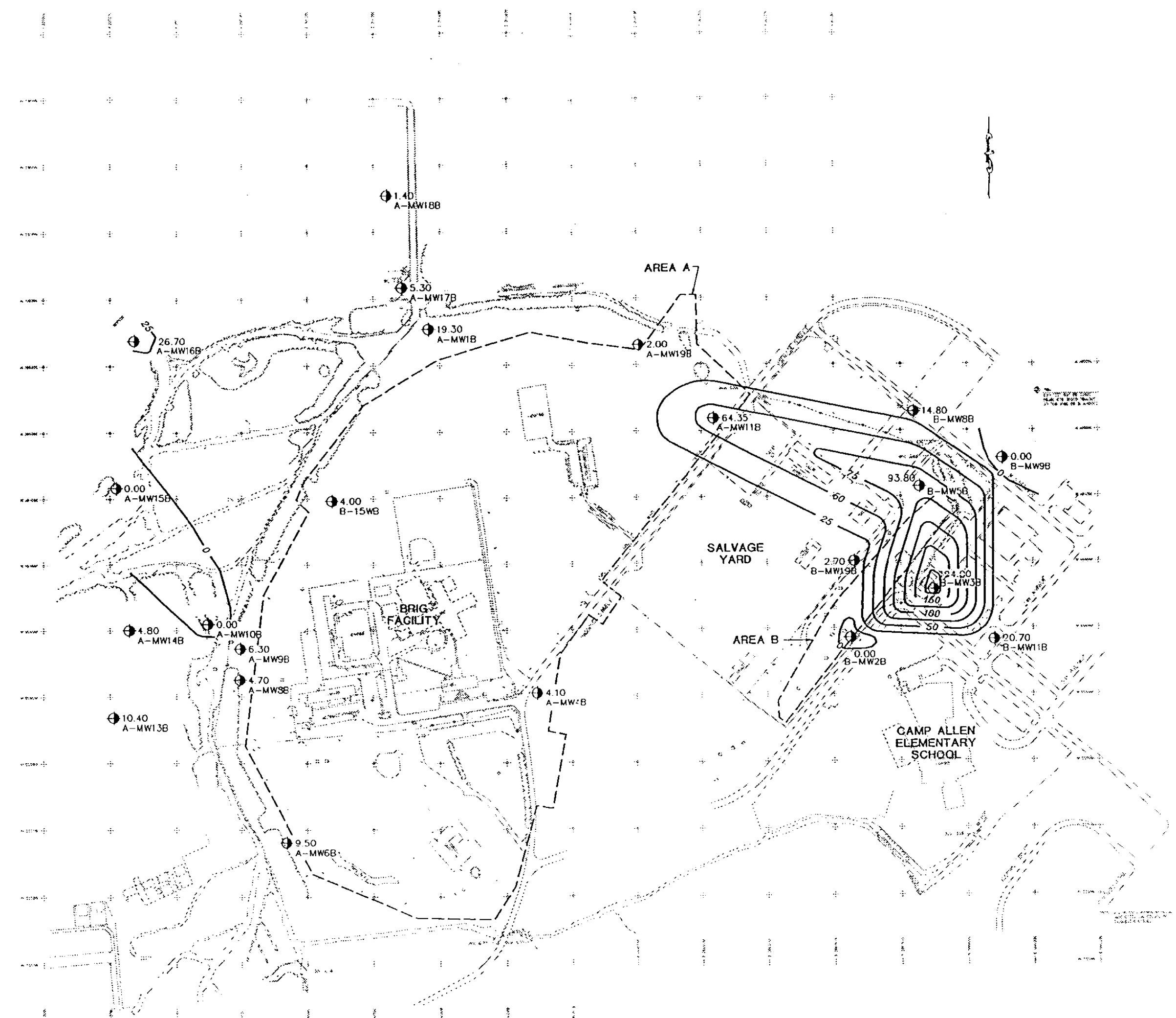
At Area A, total arsenic, chromium, and lead concentrations exceeding the corresponding MCLs were detected in the groundwater sample collected from monitoring well A-MW11B. Levels of these constituents were detected in numerous groundwater samples collected at Area A; however, all of the detections were well below Federal and State standards.

The MCL for total cadmium was exceeded in the groundwater sample collected from well A-MW11B. Cadmium was not detected in any other Area A groundwater samples.

Although total mercury concentrations did not exceed the Federal MCL, the state MCL was exceeded in groundwater samples collected from A-MW11B and A-MW15B. Groundwater from A-MW15B exhibited the highest concentration.

Total zinc concentrations detected in the deep groundwater at Area A exceeded the MCLs in the majority of monitoring wells. The only locations where zinc concentrations in the groundwater were not detected or did not exceed the MCLs include A-MW18B, A-MW19B, and B-15WB. The highest concentration of zinc in the deep groundwater was from well A-MW11B.

Figures 6-30, 6-31, 6-32, 6-33, 6-34, 6-35, and 6-36 present total concentrations for arsenic, beryllium, cadmium, chromium, mercury, lead, and zinc, respectively, as they relate to Areas



NOTES

1. CONTOUR INTERVAL = 25 ug/L.

2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	084-327

NORTH

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NORFOLK, VIRGINIA

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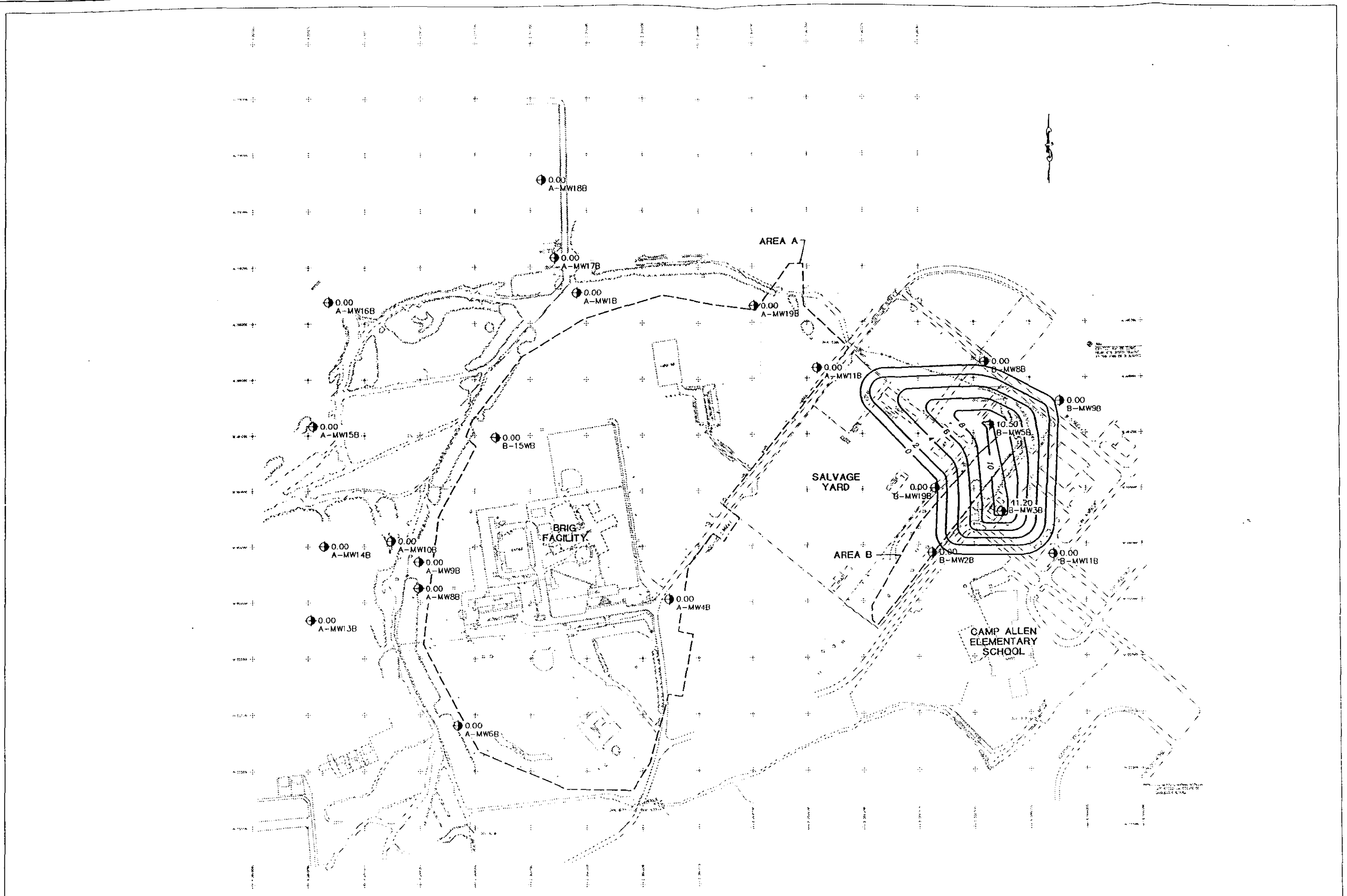
DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUNDS 2 AND 3
ARSENIC
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE
6-30



NOTES

1. CONTOUR INTERVAL = 2 ug/L.

2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
DATE	7/93	
SCALE	GRAPHIC	
DRAWN	GLB	
REVIEWED	TEA	
S.O.#	19084	
CADD#	084-328	

NORTH

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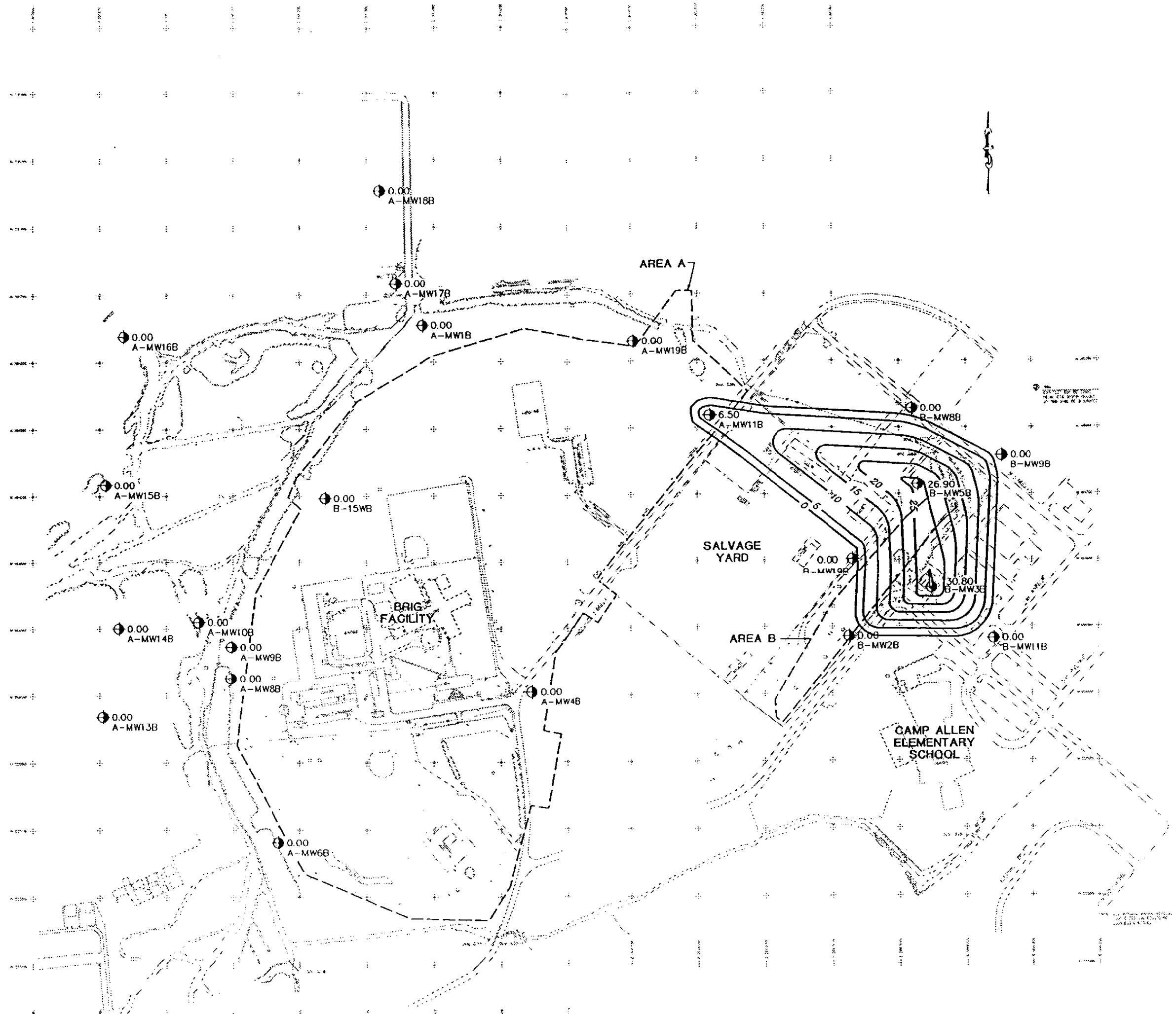
DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUNDS 2 AND 3
BERYLLIUM
ISOCONCENTRATION MAP

SCALE GRAPHIC DATE 7/93

FIGURE 6-31



NOTES

1. CONTOUR INTERVAL = 5 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
DATE	7/93	
SCALE	GRAPHIC	
DRAWN	GLB	
REVIEWED	TEA	
S.O.#	19084	
CADD#	084-329	

NORTH

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NORFOLK, VIRGINIA

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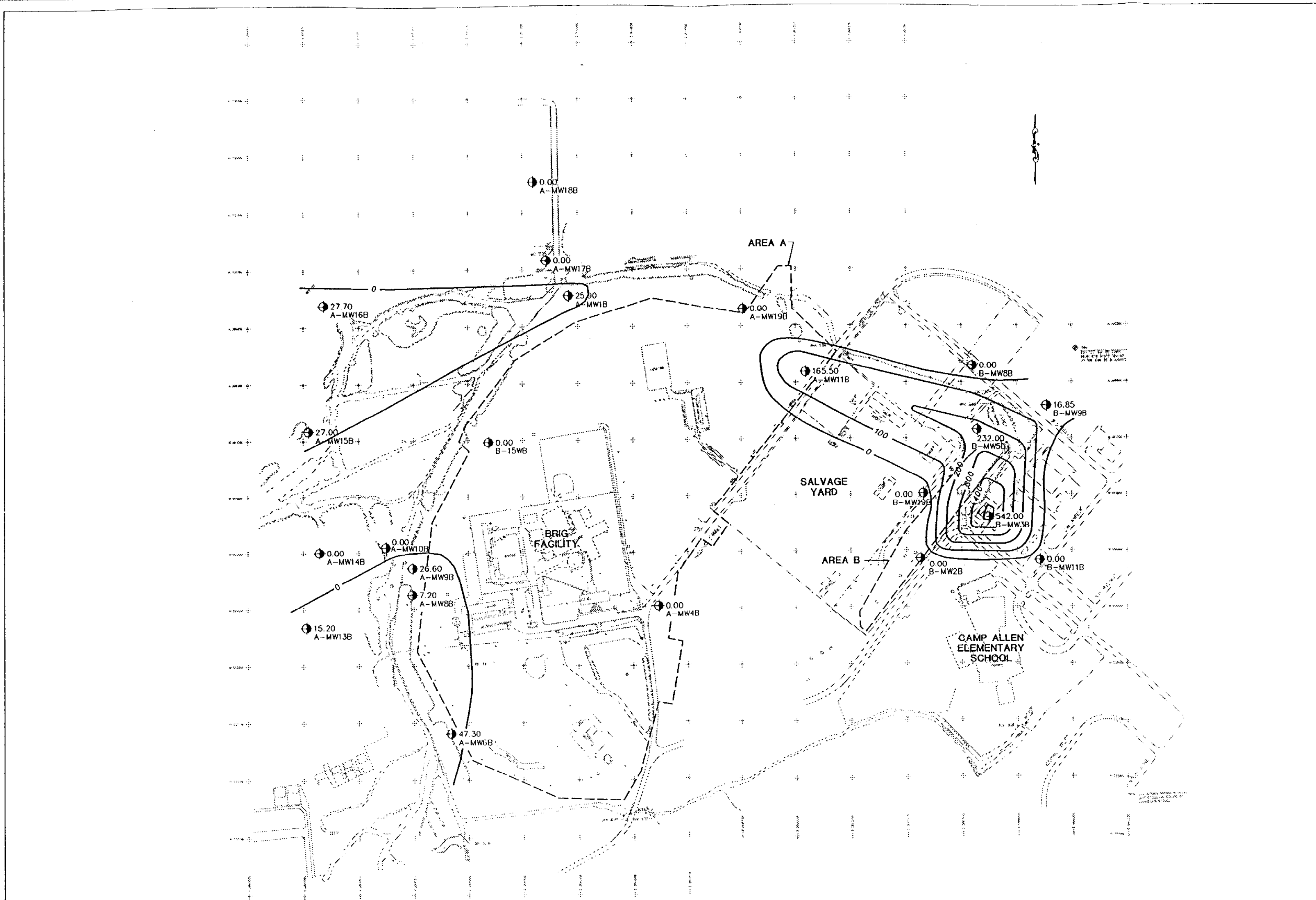
DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUNDS 2 AND 3
CADMIUM
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE 6-32

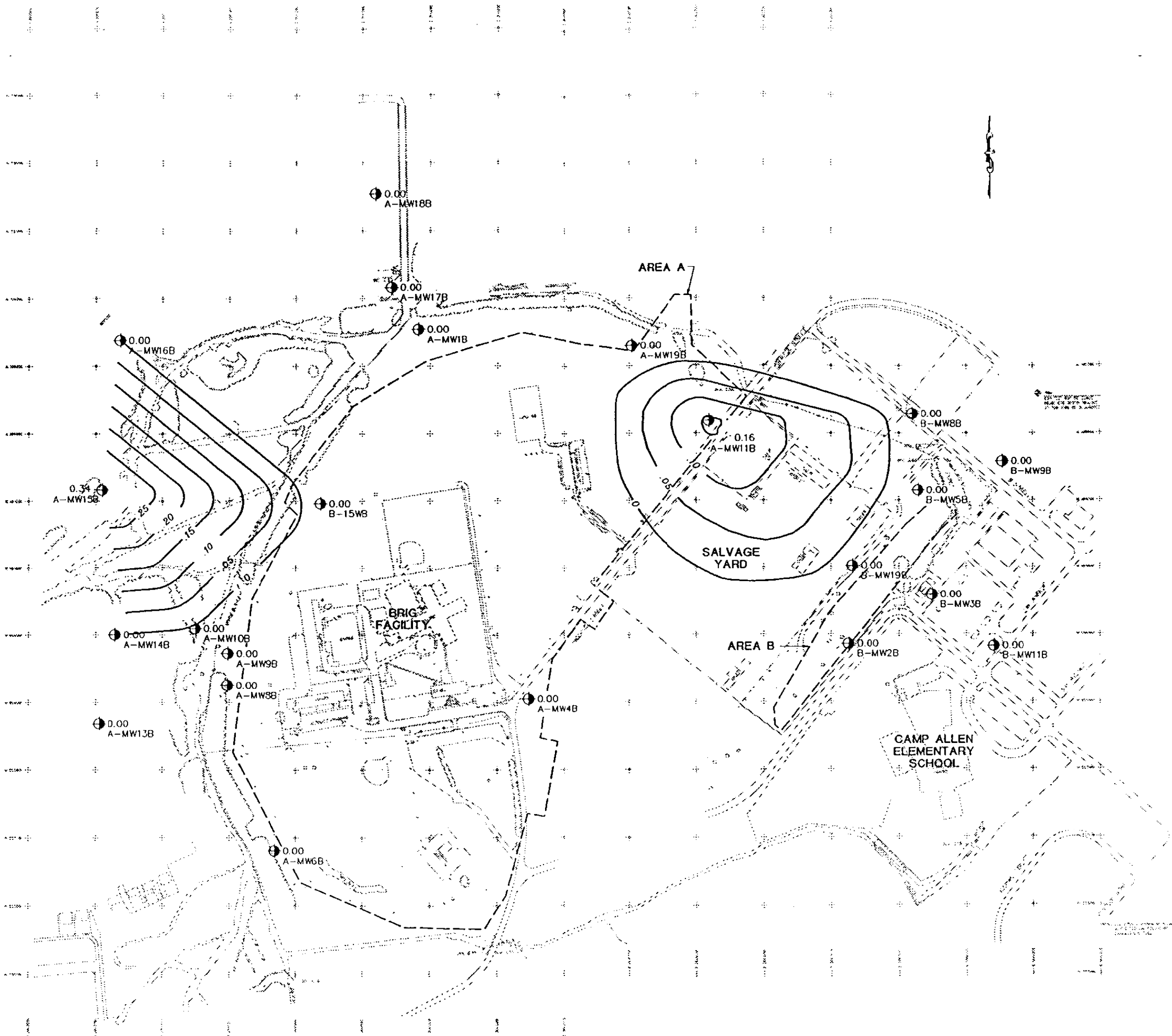


NOTES

1. CONTOUR INTERVAL = 100 ug/L
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS			NORTH					FIGURE
	DATE	7/93			CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA	Baker Baker Environmental, Inc.	DEEP GROUNDWATER SAMPLE RESULTS AREAS A AND B, ROUNDS 2 AND 3 CHROMIUM ISOCONCENTRATION MAP	6-33
	SCALE	GRAPHIC						
	DRAWN	GLB						
	REVIEWED	TEA			BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania		SCALE GRAPHIC	DATE 7/93
	S.O.#	19084						
	CADD#	084-330						



NOTES

1. CONTOUR INTERVAL = .05 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
DATE	7/93	
SCALE	GRAPHIC	
DRAWN	GLB	
REVIEWED	TEA	
S.O.#	19084	
CADD#	084-331	

NORTH

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NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
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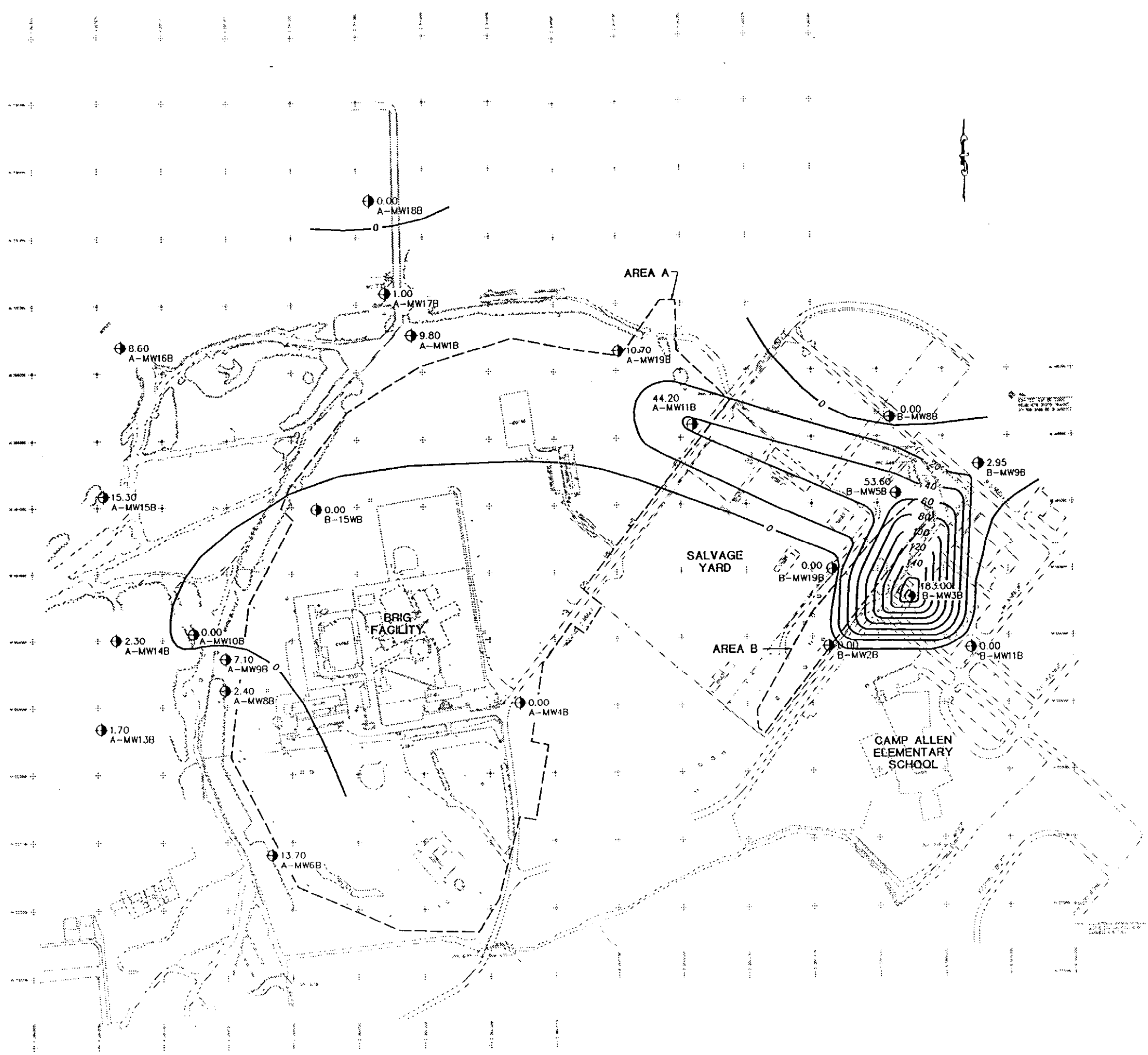
DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUNDS 2 AND 3
MERCURY
ISOCONCENTRATION MAP

SCALE GRAPHIC | DATE 7/93

FIGURE
6-34



NOTES

1. CONTOUR INTERVAL = 20 ug/L.
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		
	DATE	7/93
	SCALE	GRAPHIC
	DRAWN	GLB
	REVIEWED	TEA
	S.O.#	19084
	CADD#	084-332

NORTH

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NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
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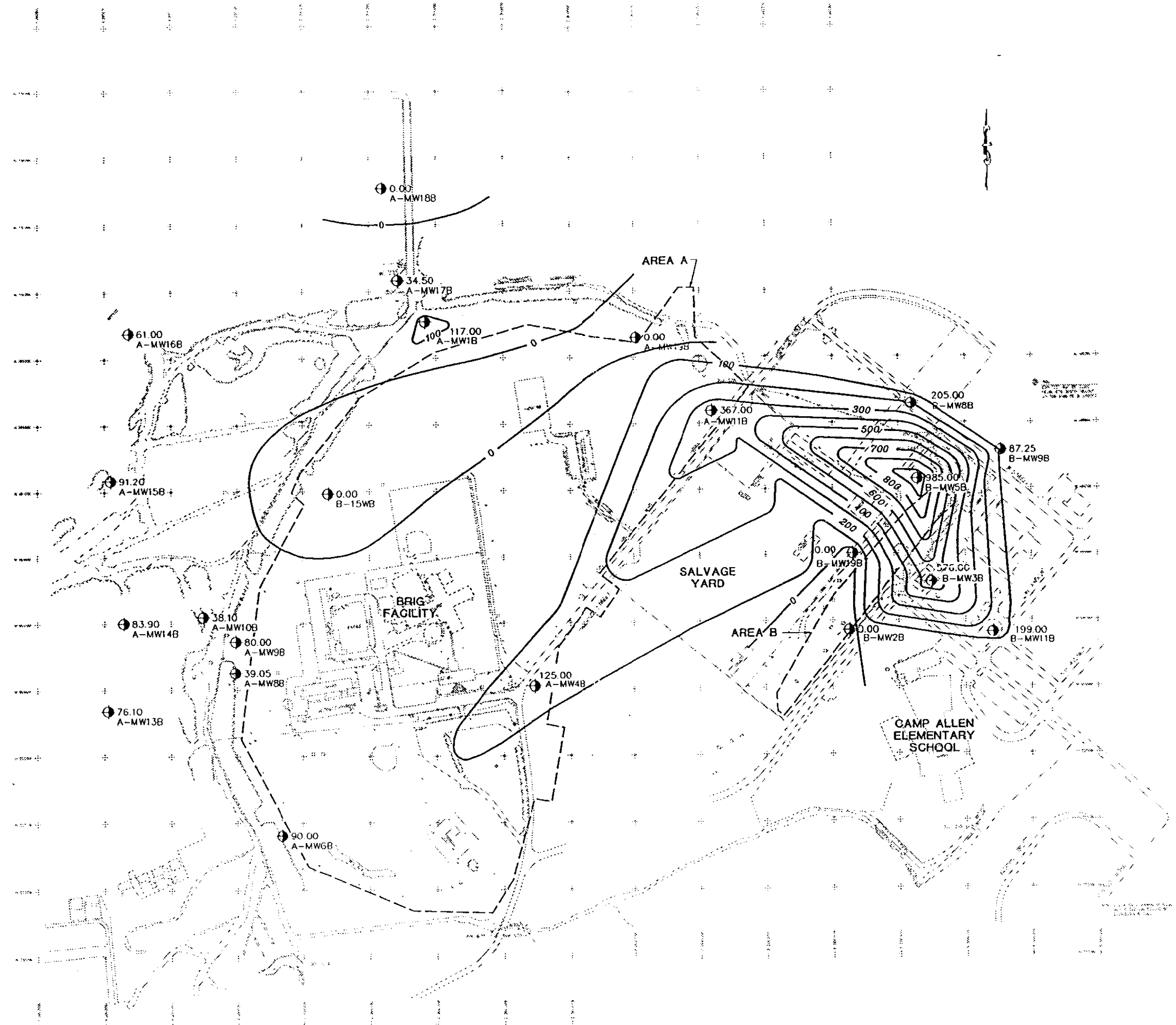
DEEP GROUNDWATER SAMPLE RESULTS
AREAS A AND B, ROUNDS 2 AND 3
LEAD
ISOCONCENTRATION MAP

SCALE GRAPHIC
DATE 7/93

FIGURE
6-35



NOTES

1. CONTOUR INTERVAL = 100 ug/L
2. ISOCONCENTRATION LINES ARE INTERPOLATED BETWEEN POINTS OF KNOWN CONCENTRATION AND MAY NOT REPRESENT ACTUAL FIELD CONDITIONS.

SCALE IN FEET

REVISIONS		NORTH	CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA	Baker Baker Environmental, Inc.	DEEP GROUNDWATER SAMPLE RESULTS AREAS A AND B, ROUNDS 2 AND 3 ZINC ISOCONCENTRATION MAP	FIGURE 6-36
	DATE 7/93 SCALE GRAPHIC DRAWN GLB REVIEWED TEA S.O.# 19084 CADD# 084-333		BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania		SCALE GRAPHIC DATE 7/93	

A and B. Discussions of the findings presented on each figure are discussed below. Details related to Area B findings are presented in Section 6.6.2.4.

As depicted on Figure 6-30, total arsenic concentrations are primarily located in the deep groundwater beneath Area B and the Salvage Yard. The isoconcentration contour interval is 50 µg/L. The MCL for total arsenic is also 50 µg/L.

Total beryllium concentrations (Figure 6-31) have also been identified in this area. Please note that the isoconcentration contour interval is 2 µg/L and the Federal MCL for total beryllium is 4 µg/L.

Significant total cadmium concentrations (Figure 6-32) have also been identified in this area. Please note that the isoconcentration contour interval is 5 µg/L as is the Federal MCL for total cadmium.

Total chromium concentrations (Figure 6-33) have been identified in the same area as arsenic, beryllium, and cadmium constituents. Please note that the isoconcentration contour interval is 100 µg/L as is the Federal MCL for total chromium.

Elevated total mercury concentrations (Figure 6-34) have been identified in two primary areas. The state MCL for total mercury is 0.05 µg/L as is the isoconcentration contour interval.

As depicted on Figure 6-35, total lead concentrations have also been identified in the deep groundwater. The Federal MCL is 15 µg/L and the isoconcentration contour interval was set at 20 µg/L due to the elevated total lead values detected.

Total zinc concentrations (Figure 6-36) have been identified in the deep groundwater throughout Area B, the Salvage Yard and portions of Area A. Although the State MCL for total zinc is 50 µg/L, the isoconcentration contour interval was set at 100 µg/L due to the elevated total zinc values detected.

6.6.2 Area B

6.6.2.1 Volatiles

Confirmation Study

Low concentrations of methylene chloride, toluene, and bis(2ethylhexyl)phthalate were detected in Round 1 samples. The constituents detected and the respective concentrations suggest that they were likely laboratory contaminants. No other constituents were detected in any of the additional rounds of sampling.

Organic compounds were not detected in any of the four rounds of sampling from well GW-EW, located near the Marine Barracks (Building MCA600) directly east/southeast of Area B. This is a non-potable well used for lawn watering. This well has been placed out of service since about 1990.

Interim Remedial Investigation

At Area B, three newly installed deep wells (B-MW2B, B-MW3B, and B-MW5B) were sampled during the Interim RI . All three wells contained VOCs, with the total concentrations ranging from 14 µg/L to 80 µg/L. Detected constituents with the highest concentrations include 1,2-dichloroethane (B-MW2B and B-MW3B); trichloroethene (B-MW3B and B-MW5B); and vinyl chloride (B-MW3B).

Remedial Investigation

Total VOCs at Area B in Round 2 ranged from 7 µg/L to 450 µg/L and were detected in groundwater from four of the six wells sampled within Area B (see Figure 6-23). Location B-MW2B had the highest total VOC concentration at 450 µg/L, with lesser amounts detected at B-MW5B (44 µg/L). Groundwater from two wells (B-MW3B and B-MW11B) associated with Area B had elevated total VOC concentrations. These two wells are nested with water table aquifer wells in which high VOC contamination in shallow groundwater samples was also detected. No VOCs were detected in the Yorktown Aquifer to the north/northeast of Area B.

Round 3 data from Area B were similar to the data collected in Round 2, with a range in concentration of 23 µg/L to 170 µg/L in groundwater in five of seven wells sampled (see

Figure 6-24). In general, lower overall concentrations of total VOCs in groundwater were noted in most wells with the exception of B-MW5B and B-MW11B. Concentrations increased in groundwater from well (B-MW5B) from 44 μg/L to 117 μg/L total VOCs, and at another well (B-MW11B) concentrations detected in groundwater increased from 7 μg/L to 23 μg/L. Groundwater from one additional well (B-MW19B) installed at Area B during Round 3 contained 50 μg/L total VOCs.

At Area B, vinyl chloride was not detected in groundwater collected from any of the deep wells during Round 2 (see Figure 6-25). In Round 3, however, vinyl chloride was detected in groundwater from B-MW3A and B-MW11A at concentrations of 2 μg/L and 3 μg/L, respectively (see Figure 6-26). No other samples were found to contain concentrations of vinyl chloride. It should be noted that lower detection limits were implemented in Round 3 to meet DQOs. In particular the detection limit for vinyl chloride decreased from 10 μg/L to 2 μg/L.

At Area B, groundwater from only two of the six deep wells sampled in Round 2 had detectable concentrations of TCE. One sample (B-MW5B) contained TCE at a concentration of 35 μg/L, exceeding the Federal MCL. The other well (B-MW3B) did not exceed the Federal MCL. No other exceedances occurred in the Yorktown Aquifer for TCE (see Figure 6-27).

In Round 3, groundwater samples from of the seven deep wells sampled at Area B contained TCE, ranging in concentration from 4 to 18 μg/L (see Figure 6-28). Three of the four locations detected concentrations exceeded the Federal MCL. One sample, from well B-MW11B, contained 7 μg/L TCE, whereas TCE was not detected from groundwater at this location in Round 2. Groundwater collected from the newly installed well, B-MW19A, contained 18 μg/L TCE in Round 3.

Concentrations of 1,2-DCA exceeded the Federal MCL at two deep wells (B-MW2B and B-MW3B) in Area B for both rounds of sampling. The Federal MCL for TCE was also exceeded at Area B in one deep well (B-MW5B) in Round 2 and in three deep wells (B-MW5B, B-MW11B, and B-MW19B) in Round 3. No other volatile organic compounds exceeded regulatory criteria.

6.6.2.2 Semivolatiles

Confirmation Study

No constituents of concern were detected in deep groundwater at Area B during the Confirmation Study.

Interim Remedial Investigation

Samples were not analyzed for semivolatiles during this investigation.

Remedial Investigation

Groundwater from seven deep wells was sampled at Area B between Rounds 2 and 3. Three locations were found to contain detectable amounts of phenol, with concentrations ranging from 0.8J µg/L to 6J µg/L. Two samples, from wells B-MW3B and B-MW19B, either met or exceeded the State MCL with concentrations of 1 µg/L and 6 µg/L, respectively (see Figure 6-29).

As indicated on the figure, elevated phenol concentrations are centralized beneath the eastern portion of the Salvage Yard and Area B. Diethyl phthalate was also detected; however, regulatory criteria have not been established for these compounds.

6.6.2.3 Pesticides/PCBs

Confirmation Study

No constituents of concern were detected during the Confirmation Study.

Interim Remedial Investigation

Samples were not analyzed for pesticides/PCBs during this investigation.

Remedial Investigation

Three pesticides were detected at Area B in the Round 2 and 3 sampling efforts, including heptachlor epoxide, dieldrin and 4,4'-DDD. These constituents were detected in groundwater collected from two of the seven wells sampled in Area B. Heptachlor epoxide was detected at B-MW9B at a concentration of 0.0105J µg/L. Dieldrin and 4,4'-DDD were detected at B-MW3B at concentrations of 0.009J µg/L and 0.018J µg/L, respectively. The heptachlor epoxide and dieldrin concentrations exceeded state MCLs for groundwater samples collected from B-MW9B and B-MW3B, respectively (for dieldrin the MCL is 0.003 µg/L). No regulatory criteria are established for 4,4'-DDD.

6.6.2.4 Metals

Confirmation Study

Total metal constituents detected during Round 1 included chromium, mercury, and zinc. Total zinc was detected in all three rounds at concentrations exceeding the MCL. Total mercury was not detected in the second or third rounds. Total chromium concentrations exceeded the MCL in Rounds 1 and 2; however, chromium was not detected in Round 3.

Interim Remedial Investigation

Total metal constituents were detected at varying concentrations throughout Area B. Aside from essential elements, primary total metal constituents detected included beryllium, lead, and zinc. Although none of the total metal constituents were detected above corresponding MCLs, many of the detection limits were too low to be effective in this evaluation. In general, detected concentrations of corresponding dissolved metals were significantly reduced, if detected at all. Some dissolved values were observed to increase from corresponding total metal concentrations.

Remedial Investigation

At Area B, total arsenic was detected in concentrations exceeding the MCLs in groundwater samples from monitoring wells B-MW3B and B-MW11B. Although other concentrations were detected, none exceeded MCLs.

Total beryllium, cadmium, chromium and lead concentrations, significantly exceeding corresponding MCLs, were detected in groundwater samples collected from B-MW3B and B-MW5B.

Total zinc concentrations detected in the deep groundwater at Area B exceeded the MCLs in the vast majority of monitoring wells. The only location where zinc concentrations in the groundwater were not detected was B-MW2B. The most significant concentrations of zinc in the groundwater were from wells B-MW3B and B-MW5B.

In reviewing the total metal values detected in the deep groundwater as a whole, a consistent pattern of elevated values is apparent. With the exception of mercury, total metal constituents are centralized in the vicinity of the Salvage Yard, extending over to the east of Area B and to the northwest portion of Area A.

Comparisons of detected total metal constituents, dissolved metal constituents, and corresponding Federal and State MCLs for the deep groundwater samples collected at Areas A and B are presented in Appendix Z. These comparisons are in bar chart form with, deep monitoring wells separated by area (Area A and Area B).

In reviewing these comparisons, it is apparent that dissolved phase inorganic contamination is not present in the deep groundwater at the Camp Allen Landfill Site. Although detected, dissolved phase zinc and arsenic were not at concentrations above Federal or State MCLs. Based on comparisons of total versus dissolved metal concentrations and linear egression correlations between naturally occurring elements and constituents of concern, the inorganic constituents detected in the groundwater are believed to be associated with suspended solids, present in the wells and not representative of actual groundwater contamination.

6.6.3 Other Potential Sources

The Salvage Yard Facility operations, which began in the early 1970s and continue today, are reported to have included various chemical, waste, and recyclable management activities. These activities could possibly be related to constituent detections in deep groundwater in this area. The Salvage Yard is currently undergoing a PA/SI.

6.7 Air Quality

6.7.1 Overview of Area A Results

As indicated in Table 6-2 volatile organic compounds detected in the air, at and around the Brig Facility, consisted of primarily chlorinated solvents, freons, and petroleum-related compounds. Twenty-two compounds were detected within the Brig Facility; eleven of which were also detected in the ambient environment.

Freon 113, chloroform, ethylbenzene, styrene, benzyl chloride, 1,3,5-trimethylbenzene, 1,2,4-trichlorobenzene, hexachlorobutadiene, tetrachloroethene, and freon 114 were detected sporadically throughout the Brig Facility in somewhat isolated areas. The chemical 1,2,4-trimethylbenzene which was not detected in the ambient environment, was detected on a consistent basis throughout the Brig Facility.

Based on analytical results and regulatory guidelines, the extent of air contamination related to the Brig Facility is isolated and has no correlating contaminant distribution or trend analyses between rounds with the exception of 1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene (coal tars). Overall, the concentrations for those compounds detected within the Brig Facility are not considered to be of concern when compared with those detected in the ambient environment, the OSHA PELs, and ACGIH TLVs.

6.7.2 Overview of Area B Results

Results of air sampling performed at the Camp Allen Elementary School (CAES) indicated the presence of eleven chemicals (Refer to Table 6-2). Of these eleven chemicals only one (1,2,4-trimethylbenzene) was not found in the ambient environment.

Two chemicals were found on a very infrequent basis, the chemical o-xylene was detected once at sampling location AB-02B (at 0.3ppb) while the chemical chloromethane was also detected only once, but at two sampling locations, AB-01B (at 0.7 ppb) and AB-02B (at 0.8 ppb). Two other chemicals (1,4-dichlorobenzene and 1,2,4-trimethylbenzene) were found intermittently at locations AB-01, AB-02 and AB-03 but remained undetected at AB-04 and AB-05.

The remainder of the detected chemicals consisted of dichlorodifluoromethane, methylene chloride, 1,1,1-trichloroethane (methyl chloroform), benzene, toluene, m-/p-xylene, and

TABLE 6-2
SUMMARY OF AIR SAMPLING RESULTS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	AA-01			AA-02			AA-03			AA-04			AA-05			AA-06			OSHA	ACGIH
CHEMICAL NAME	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	PEL	TLV
Dichlorodifluoromethane	0.5	0.7	0.4	2.2	1.9	ND	0.5	0.7	ND	0.7	0.8	ND	0.6	ND	ND	ND	ND	0.5	333,334	333,334
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.8	0.8	ND	ND	ND	ND	ND	ND	ND	16,667	16,667
Bromomethane	ND	0.9	ND	ND	ND	ND	ND	0.6	ND	ND	0.6	ND	ND	ND	ND	ND	ND	ND	1,667	1,667
Freon 113	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	333,334	333,334
Methylene Chloride	1.5	1	0.8	1.3	ND	ND	1.2	0.6	0.4	1.6	0.6	23	1.2	ND	380	ND	ND	0.4	8,334	16,667
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.8	ND	ND	ND	ND	ND	667	1,667
1,1,1-Trichloroethane	10	9	2.1	16	29	13	6.1	2.1	1.8	4.4	1.8	0.7	140	180	ND	3400	8.2	5.5	116,667	116,667
Benzene	0.4	0.7	0.5	0.4	ND	ND	0.4	0.6	0.5	0.4	0.7	0.5	0.7	ND	ND	ND	ND	0.5	334	3,334
Toluene	2.2	3.4	2.4	1.7	2.7	1	0.7	1.2	0.8	3.2	2.5	1.5	3.7	39	110	ND	5.3	0.6	33,334	16,667
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8,334	16,667
Ethylbenzene	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	ND	33,334	33,334
m-/p-Xylene	ND	ND	ND	0.4	0.9	ND	0.4	0.7	0.3	0.9	ND	0.6	100	6	58	ND	ND	0.4	33,334	33,334
o-Xylene	ND	ND	ND	ND	ND	ND	ND	0.3	ND	0.4	1	ND	24	32	19	ND	ND	ND	33,334	33,334
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND	8.9	ND	ND	ND	ND	16,667	16,667
1,4-Dichlorobenzene	1.8	2.1	2.3	1.1	2.5	1.1	ND	ND	ND	1.5	ND	0.6	ND	ND	ND	ND	ND	ND	25,000	25,000
Benzyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	ND	ND	ND	ND	ND	ND	ND	334	334
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	333,334	333,334
Trichlorofluoromethane	0.4	0.4	ND	0.7	ND	ND	ND	0.4	0.3	6.5	3.7	3.4	ND	ND	ND	ND	ND	ND	333,334	333,334
1,3,5-Trimethylbenzene	ND	ND	0.4	ND	ND	ND	ND	ND	ND	0.6	0.3	0.4	0.5	ND	ND	ND	ND	ND	8,334	8,334
1,2,4-Trimethylbenzene	1.5	0.9	0.9	ND	ND	ND	ND	0.4	0.3	1.2	0.9	0.9	1.6	ND	ND	21	ND	ND	8,334	8,334
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,667	1,667
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7	7

Note: All analytical results reported in parts per billion by volume.

TABLE 6-2
SUMMARY OF AIR SAMPLING RESULTS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	AA-07			AA-08			AA-09			AA-10			AA-11			AA-12			OSHA	ACGIH
CHEMICAL NAME	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	PEL	TLV
Dichlorodifluoromethane	0.6	0.8	0.6	0.5	0.4	0.5	0.6	0.5	0.6	0.6	0.5	2.7	0.5	0.4	0.5	ND	ND	0.7	333,334	333,334
Chloromethane	ND	0.7	0.7	0.9	ND	ND	1	ND	1	1.1	ND	0.8	ND	ND	ND	ND	ND	ND	16,667	16,667
Bromomethane	ND	ND	ND	ND	0.5	ND	ND	0.6	ND	ND	0.6	ND	ND	0.6	ND	ND	ND	ND	1,667	1,667
Freon 113	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	333,334	333,334
Methylene Chloride	1.3	0.4	.3J	1.3	ND	0.5	1.2	ND	0.4	1.5	0.4	0.7	2.9	30	17	0.8	1.4	0.9	8,334	16,667
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND	667	1,667
1,1,1-Trichloroethane	3.2	0.6	0.8	5.7	0.5	.4J	13	2.3	1.5	5.1	1.7	1.4	7.6	1.6	1.1	8.5	1.4	0.9	116,667	116,667
Benzene	0.5	1	0.6	0.5	0.8	0.6	0.6	0.8	0.7	0.5	0.7	0.6	0.4	0.8	0.6	0.6	0.7	0.7	334	3,334
Toluene	0.9	2.1	1.1	7.8	2	5.9	1.5	1.7	1.3	1.6	1.9	1.9	1.5	1.9	1.9	4.5	160	670	33,334	16,667
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8,334	16,667
Ethylbenzene	ND	0.3	ND	0.7	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND	0.4	0.4	0.6	0.5	33,334	33,334
m-/p-Xylene	0.4	1.1	0.4	2.8	0.8	0.4	2	0.8	0.5	0.7	0.8	0.5	0.8	0.8	2.4	1.5	2.3	1.4	33,334	33,334
o-Xylene	ND	0.4	ND	1.2	ND	ND	0.6	ND	ND	ND	0.3	ND	ND	0.4	1.2	0.4	0.7	0.4	33,334	33,334
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16,667	16,667
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	20	26	ND	ND	ND	ND	ND	ND	25,000	25,000
Benzyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	334	334
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND	29	42	ND	333,334	333,334
Trichlorofluoromethane	0.3	0.3	0.4	ND	ND	0.3	0.4	0.4	0.4	0.8	0.5	1.6	0.3	0.4	0.4	ND	0.2	ND	333,334	333,334
1,3,5-Trimethylbenzene	ND	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	4.4	ND	ND	ND	8,334	8,334
1,2,4-Trimethylbenzene	ND	0.6	ND	1.7	0.4	ND	0.3	0.4	ND	0.3	0.4	ND	0.6	2.2	7.8	0.2	0.5	ND	8,334	8,334
1,2,4- Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,667	1,667
Hexachlorobutadiene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND	7	7

Note: All analytical results reported in parts per billion by volume.

TABLE 6-2
SUMMARY OF AIR SAMPLING RESULTS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	AB-01			AB-02			AB-03			AB-04			AB-05			OSHA	ACGIH
CHEMICAL NAME	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	PEL	TLV
Dichlorodifluoromethane	0.4	0.7	0.4	ND	0.8	0.3	ND	1.1	0.5	ND	1.1	0.7	0.5	0.5	0.6	333,334	333,334
Chloromethane	ND	0.7	ND	ND	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16,667	16,667
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,667	1,667
Freon 113	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	333,334	333,334
Methylene Chloride	0.8	0.8	0.8	0.3	0.4	0.4	0.5	0.7	0.5	0.8	0.7	0.5	0.6	0.4	0.5	8,334	16,667
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	667	1,667
1,1,1-Trichloroethane	27	7.9	2.9	9.5	2.6	2.7	10	9.8	2.2	17	18	6.4	11	23	3.4	116,667	116,667
Benzene	0.4	0.6	0.6	0.4	0.6	0.7	0.5	0.7	0.6	0.4	0.6	0.6	0.5	0.7	0.6	334	3,334
Toluene	1.4	1.6	1.6	1.9	1.7	2	1.1	1.4	1.3	1.2	1.9	1.6	1.2	2	1.7	33,334	16,667
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8,334	16,667
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	33,334	33,334
m-/p-Xylene	0.4	0.6	0.6	0.5	0.7	0.6	0.4	0.7	0.5	0.4	0.8	0.6	0.4	0.8	0.6	33,334	33,334
o-Xylene	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	33,334	33,334
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16,667	16,667
1,4-Dichlorobenzene	0.6	0.2	0.2	0.5	0.5	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	25,000	25,000
Benzyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	334	334
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	333,334	333,334
Trichlorofluoromethane	0.6	0.3	0.3	ND	0.3	0.3	0.5	0.7	0.4	0.4	ND	0.4	ND	0.4	0.4	333,334	333,334
1,3,5- Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8,334	8,334
1,2,4- Trimethylbenzene	ND	ND	0.3	ND	0.3	0.3	ND	ND	0.3	ND	ND	ND	ND	ND	ND	8,334	8,334
1,2,4- Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,667	1,667
Hexachlorobutadiene	ND	ND	0.3	ND	0.3	0.3	ND	ND	0.3	ND	ND	ND	ND	ND	ND	7	7

Note: All analytical results reported in parts per billion by volume.

TABLE 6-2
SUMMARY OF AIR SAMPLING RESULTS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	A-01			A-02			A-03			A-04			A-05			OSHA	ACGIH
CHEMICAL NAME	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	PEL	TLV
Dichlorodifluoromethane	ND	0.6	0.4	0.3	0.6	0.4	0.4	0.6	0.4	0.5	0.7	0.3	0.5	0.6	0.4	333,334	333,334
Chloromethane	ND	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16,667	16,667
Bromomethane	ND	0.6	ND	ND	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,667	1,667
Freon 113	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	333,334	333,334
Methylene Chloride	1	0.3	0.4	1.2	0.3	ND	0.5	ND	0.3	0.5	0.8	0.4	0.9	ND	0.3	8,334	16,667
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	667	1,667
1,1,1-Trichloroethane	11	2	2.3	3.3	ND	0.5	3.7	ND	0.9	4.8	8.7	1.8	14	ND	0.6	116,667	116,667
Benzene	0.5	0.6	0.6	0.4	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.7	0.4	0.7	0.5	334	3,334
Toluene	1.2	0.9	0.9	1.2	1.2	0.8	1	1	1	1	1.6	1.1	1	1	0.7	33,334	16,667
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8,334	16,667
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	33,334	33,334
m-/p-Xylene	ND	0.5	0.4	0.7	0.6	0.4	0.4	0.6	0.5	0.4	0.7	0.5	ND	0.6	0.3	33,334	33,334
o-Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND	33,334	33,334
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	16,667	16,667
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND	25,000	25,000
Benzyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	334	334
Freon 114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	333,334	333,334
Trichlorofluoromethane	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	333,334	333,334
1,3,5- Trimethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8,334	8,334
1,2,4- Trimethylbenzene	ND	ND	0.3	ND	0.3	0.3	ND	ND	0.3	ND	ND	ND	ND	ND	ND	8,334	8,334
1,2,4- Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,667	1,667
Hexachlorobutadiene	ND	ND	0.3	ND	0.3	0.3	ND	ND	0.3	ND	ND	ND	ND	ND	ND	7	7

Note: All analytical results reported in parts per billion by volume.

trichlorofluoromethane. Excluding trichlorofluoromethane, each of these chemicals was consistently observed in both the CAES and ambient environment. Additionally, 1,1,1-trichloroethane, though found in both the CAES and ambient environment, had values that were consistently elevated when compared to other contaminants detected. However, the presence of both trichlorofluoromethane and 1,1,1-trichloroethane would not be considered unusual in an indoor environment (i.e., the CAES) since trichlorofluoromethane is commonly used as a propellant, refrigerant, and blowing agent for polymeric foams (Lewis, 1991), and 1,1,1-trichloroethane is used commonly as a solvent for oils, waxes, tars, cleaning precision instruments, and pesticides (Genium, June 1992). Specifically, 1,1,1-trichloroethane is used as a solvent for "Whitmire PT 565 Plus," a pyrethrin-based pesticide used at the CAES. Concentrations for the remaining chemicals are in line with those found in the ambient environment, are not considered to be of concern.

Overall, the concentration for each compound detected within the CAES, regardless of round or sampling station, is not considered to be of concern when compared to the concentration detected in the ambient environment, or to the corresponding OSHA PEL or ACGIH TLV.

SECTION 7
SUMMARY OF FINDINGS

7.0 SUMMARY OF RI FINDINGS

Based on site history, previous investigations (Malcolm Pirnie and CH_2M Hill), and RI findings, contamination from prior disposal practices at Area A and Area B of the Camp Allen Landfill Site has impacted subsurface soils, surface soils, sediment, surface water, and groundwater (Water Table and Yorktown Aquifer Systems) to various degrees. This section will provide a summary for each media examined and, where applicable, discuss collectively the findings for both areas.

In general, the primary constituents of concern are volatile organic compounds (VOCs). Other organic and inorganic contaminants were detected; however, the VOCs represent the majority of the constituents of concern. As the findings related to the Camp Allen Landfill area are very complex, a simplified listing of primary areas of detected contamination is presented in Table 7-1. Findings are presented by media and area (Area A and Area B).

In order to help visualize overall site conditions, two generalized site depictions have been developed. Figure 7-1 presents generalized groundwater flow patterns for both the Water Table and Yorktown Aquifer systems. Figure 7-2 presents a conceptualized cross section indicating generalized contaminant migration from the Camp Allen Landfill Site.

It must also be noted that potential contamination attributable to off-site sources has been identified. Potential off-site sources of contamination were primarily indicated in the Salvage Yard area and in the Capehart Military Housing area. Findings identified in Table 7-1 related to the areas of off-site contamination sources are duly noted.

7.1 Subsurface Soil

Primary constituents detected in Areas A and B subsurface soils appear to be volatiles and semivolatiles related to solvents and fuel oils. Figure 7-3 presents primary suspected source areas identified at the Camp Allen Landfill.

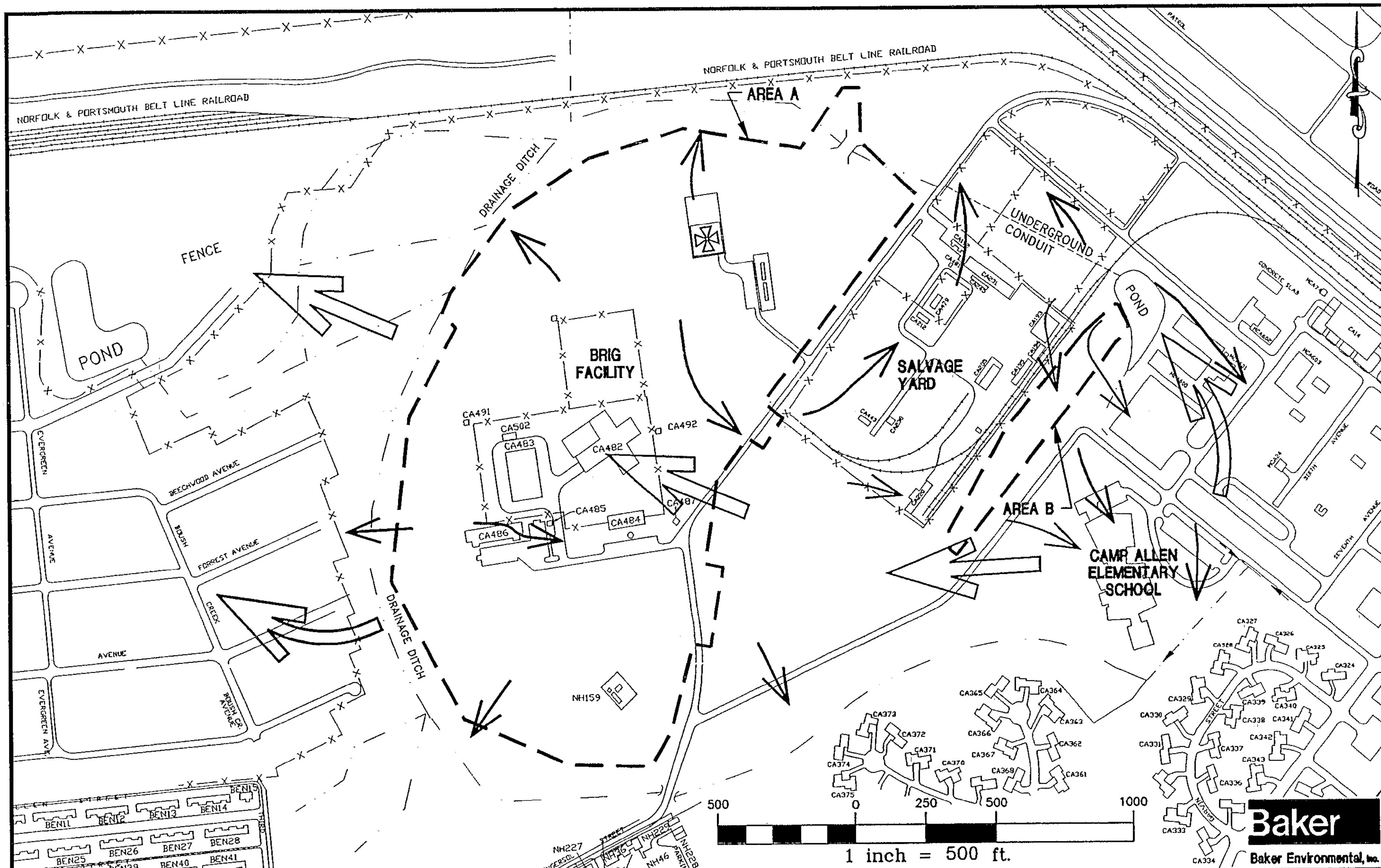
At Area A, volatile organic compounds were detected at significant concentrations in five samples at or below the top of the shallow aquifer. Semivolatiles appeared more prevalent in samples containing higher concentrations of volatiles. Pesticide compounds were detected at concentrations that would suggest that the occurrence and distribution is related to typical controlled applications.

TABLE 7-1

SUMMARY OF RI FINDINGS

Media	Area A	Area B
Subsurface Soil	VOCs ● West of Brig Facility ● North of Brig Facility	VOCs ● Middle portion of Area B
Surface Soil	Nominal findings	Nominal findings
Sediment	VOCs ● Northwest drainage ditch (Area B related)	VOCs ● Ponded area
	Metals ● Northeast drainage ditch (Area B related) (various constituents) ● Northern drainage ditch (various constituents) ● Northwestern drainage ditch (mercury plus others)	Metals ● Ponded area* (mercury plus others)
Surface Water	VOCs ● Northwest drainage ditch (Area B related)	VOCs ● Ponded area
	Metals ● Throughout Area A* (various constituents)	Metals ● Ponded area* ● Throughout drainage ditches*
Shallow Groundwater	VOCs ● West of Brig Facility ● North of Brig Facility	VOCs ● South/southeast of Area B ● Capehart Military Housing area*
Deep Groundwater	VOCs ● West of Brig Facility ● North of Brig Facility	VOCs ● Underneath Area B

*Potential off-site source



LEGEND

ASSUMED LANDFILL BOUNDARY

GENERAL DEEP GROUNDWATER FLOW DIRECTION (YORKTOWN AQUIFER)

GENERAL SHALLOW GROUNDWATER FLOW DIRECTION (WATER TABLE AQUIFER)

NOTE: INFORMATION DEPICTED ON THIS FIGURE IS GENERALIZED AND DOES NOT INDICATE ACTUAL DEFINED PATTERNS.

SOURCE: LANTDIV, OCTOBER 1991

084-513

FIGURE 7-1
GENERAL GROUNDWATER FLOW PATTERNS
CAMP ALLEN LANDFILL AREAS A & B

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

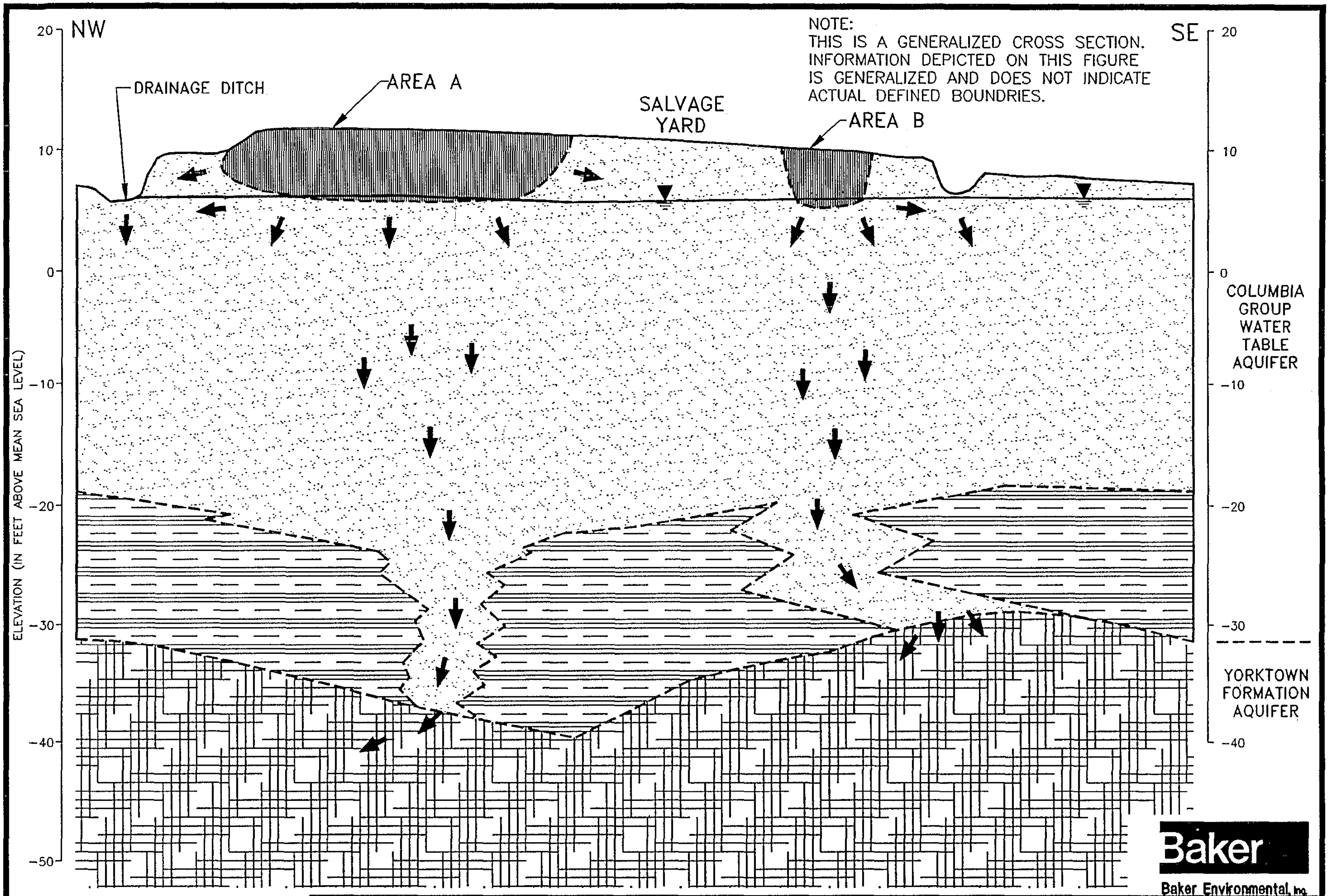
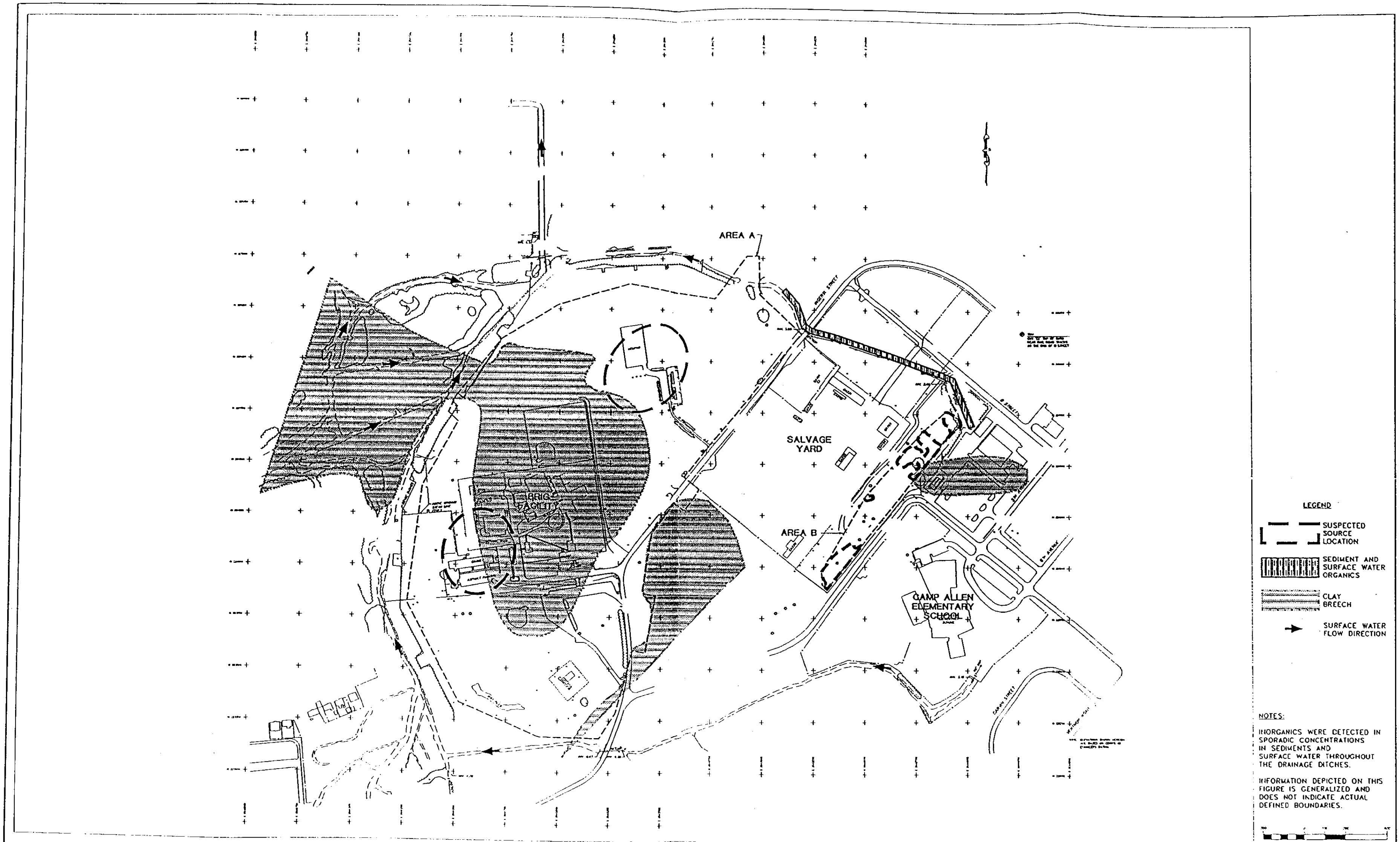


FIGURE 7-2
GENERALIZED CONTAMINATION MIGRATION
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



REVISIONS

DATE	7/93
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S.O.#	19084
CADD#	084-511

NORTH

CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

GENERALIZED AREAS OF SEDIMENT AND SURFACE WATER ORGANIC AND INORGANIC CONSTITUENTS

SCALE: GRAPHIC DATE: 7/93

FIGURE 7-3

In evaluating the aforementioned detections and considering the background information related to the source characterization samples, volatile organic compounds are considered the primary constituents of concern. Based on reported materials disposed at Area A, volatile organic compounds detected are most likely related to waste solvent or fuel oil-laden materials. Two primary suspected source areas of volatile constituents have been identified at Area A (Figure 7-3).

Source areas in Area B containing primarily solvent and fuel oil type contaminants have also been identified (see Figure 7-3). Volatile constituents were prevalent at three locations just above the water table. Semivolatiles were more prevalent at areas containing higher concentrations of volatiles. Pesticide/PCB compounds were nonexistent in subsurface soils with the exception of one location in the northeastern portion of Area B (SBB-06), which contained significant concentrations.

In evaluating the aforementioned detections and considering the locations of the subsurface soil samples, one area (vicinity of SBB-06) is of particular concern. The volatile organic compounds detected were significant and are most likely associated with waste solvents and fuel oils. The volatile constituents detected in Area A are somewhat analogous to those detected in Area B with the exception of vinyl chloride. Vinyl chloride was detected in only one subsurface soil sample (SBB-05). This suggests that materials of similar composition may have been disposed at both landfills.

Significant detections of inorganic compounds appear to be concentrated in the area of boring location SBB-01. This boring was located in the southwestern corner of Area B, adjacent to the Salvage Yard. Based on the geophysical survey results, this was another suspected disposal area containing "pockets of metallic fill material surrounded by high conductivity nonmetallic fill." Metals were only analyzed in Area B subsurface soils, since metals were not a suspected contaminant in Area A.

Four metals (chromium, lead, manganese, and zinc) were prevalent throughout the subsurface soils in Area B. In addition, arsenic and vanadium were detected in isolated areas at low concentrations. One sample (SBB-01), collected in the southern portion of Area B, contained several metals in addition to those previously mentioned, suggesting that incinerator ash or metal-containing waste may have been disposed in this area.

Given that incineration activities were once performed in the Camp Allen area and that soil borrow pits in the vicinity were reportedly used for "landfill capping," elevated metal concentrations detected in the subsurficial soils at Area B could be connected to incineration-related influences. It should be noted that regional background concentrations for various inorganic constituents are found to be somewhat elevated in the coastal plain region.

In both Area A and Area B subsurface soils, semivolatiles were more prevalent in soils containing higher concentrations of volatiles. Semivolatile constituents were also somewhat analogous between both areas, with varying concentrations. Pesticide/PCB compounds were analogous throughout many of the subsurface soil samples in Area A whereas, in Area B, pesticide/PCB compounds were found in an isolated area.

In summary, source areas of primary VOCs have been identified at or near the top of the water table aquifer in Area A and Area B. In isolated locations, wastes were identified within the shallow groundwater.

7.2 Surface Soil

No volatiles of manmade origin were detected in Area A or Area B surface soils. Semivolatile constituents and their concentrations were analogous for surface soils collected at the Area A and Area B landfill.

Pesticide/PCB compounds were detected throughout surface soils in Area A and Area B in trace amounts. In addition to 4,4'-DDT and the associated breakdown compounds found in both areas, dieldrin was detected more often in Area A and alpha-chlordane was detected more often in Area B. Detected pesticides compounds are likely due to typical land application.

Arsenic and lead were found consistently throughout surface soils in Area A and Area B with slightly higher concentrations in Area A. Cadmium, copper, and zinc were commonly found in Area A surface soils. Aluminum, cadmium, and iron were commonly found in Area B soils. In summary, Area A and Area B surface soils contain similar inorganic constituents and concentrations. Although detected concentrations exceeded background criteria at various locations, significant inorganic source areas are not indicated.

7.3 Sediment

Sediment in the drainage ditches surrounding Areas A and B was found to contain isolated areas of elevated levels of organic and inorganic constituents (see Figure 7-3).

Concentrations of volatile organic compounds were detected in sediment samples from the southern portion of the ponded area (Area B) and to the north and northwest (downstream) at the culvert discharging into the drainage ditch at the northeast portion of Area A. From this point on (downstream), volatile compound constituents decreased significantly. This suggests that contaminants may be migrating with surface water from Area B and either volatilizing, degrading, or being deposited with the sediment. Volatile compounds detected in sediment samples correlate with compounds detected in surface water and groundwater. This indicates that contaminants in the source area (Area B) are migrating with groundwater and being discharged into the surface water via seeps along the ponded area of the landfill. In general, the deeper sediment samples contained higher concentrations of volatile constituents as compared to shallow sediment samples.

Semivolatile organic compounds detected and their respective concentrations were somewhat similar for Area A and Area B sediments. Two areas impacted were the shallow and deep sediments in the northern portion of the ponded area and the discharge point from Area B to Area A (northeast portion of Area A). This can most likely be associated with seeps into the ponded area and the underground culvert (carrier for surface water from Area B to Area A). In the ponded area, the shallow sediments have higher concentrations than the deep sediments, and at the discharge point, deeper sediments contain higher concentrations.

Pesticide/PCB compounds were detected at various concentrations throughout sediment samples in Area A and Area B. 4,4'-DDT and its breakdown components were analogous at Area A and Area B, with the most significant concentration in the ponded area. Remaining pesticide concentrations were slightly higher in Area B as compared with Area A. In addition, Area B sediments contained dieldrin and endrin, whereas, Area A contained alpha- and gamma-chlordane. PCB concentrations were greater in Area B sediments than in Area A. The most significant amount of PCB contamination occurred in the shallow sediment at the center of the ponded area. PCB concentrations also increased with depth in sediment samples.

The organic constituents (with the exception of volatile organic compounds) detected in sediments collected from the drainage ditches encompassing Area A were similar to those found in the surface soils, but at slightly higher concentrations. The concentrations correlate with levels detected in surface soils and may be a result of surface particulate runoff and particle deposition in the drainage ditches.

The ponded area sediments east of Area B have also been impacted by organic constituents. In general, detected organic compound contamination decreased with depth in the sediment samples collected at the ponded area, but increased with depth in the northwest portion of the drainage ditch associated with Area B.

Five metals (arsenic, cadmium, chromium, lead, and mercury) were analogous to Area A and Area B, with the highest concentrations detected in Area A. In addition, Area A sediment contained copper and zinc in several samples. Metal concentrations decreased in the deep sediments in Area A and increased in the deep sediments affiliated with Area B.

Metal concentrations fluctuated with depth depending on the location. Although several of the metals detected exceeded sediment quality criteria throughout Area A drainage ditches, no direct trend is apparent between metal constituents as metal concentrations increased and decreased with depth in isolated areas.

Taking into consideration previous incineration activities and incinerator ash disposal which occurred in this area during the 1950s and 1960s, detected metal concentrations in the drainage ditch sediments are possibly the result of past transport via surface water runoff before the landfill was closed as well as accumulation of sediment in low spots or depressions. Given that the ponded area is immediately adjacent to the Salvage Yard, another potential source of impacted sediment is from previous activities associated with land use of the Salvage Yard. Additionally, regional background concentrations are reported to be somewhat elevated in the coastal plain region.

7.4 Surface Water

Surface water samples collected from Area A drainage ditches contained either trace amounts of volatiles or the volatile compounds were nondetectable. Surface water samples collected from the ponded area at Area B contained volatile organics trending in a similar pattern to that of the sediment volatiles (see Figure 7-3).

Semivolatile organic and pesticide/PCB compounds were either absent or detected in concentrations well below Federal or State standards in Areas A and B surface waters.

Based on previous incineration activities and incinerator ash disposal which occurred in this area during the 1950s and 1960s, detected metal concentrations in sediment and surface water samples collected from the drainage ditch network are possibly the result of transport via surface runoff and accumulation in low spots or depressions. Variations in detected concentrations with depth could be the result of sediment disturbances resulting from development activities of the 1970s to the present, as well as tidal influences and elevated background conditions. Potential additional influence from the Salvage Yard facility is also a possibility.

Consistent with the scope of work, the findings of the RI conducted at the Camp Allen Landfill Site will be utilized to develop and evaluate remedial measures, as appropriate.

Potential off-site sources appear to be contributing to surface water, sediment and groundwater contamination. The potential contributing off-site sources are either included for investigation or need to be included for future investigation under separate study.

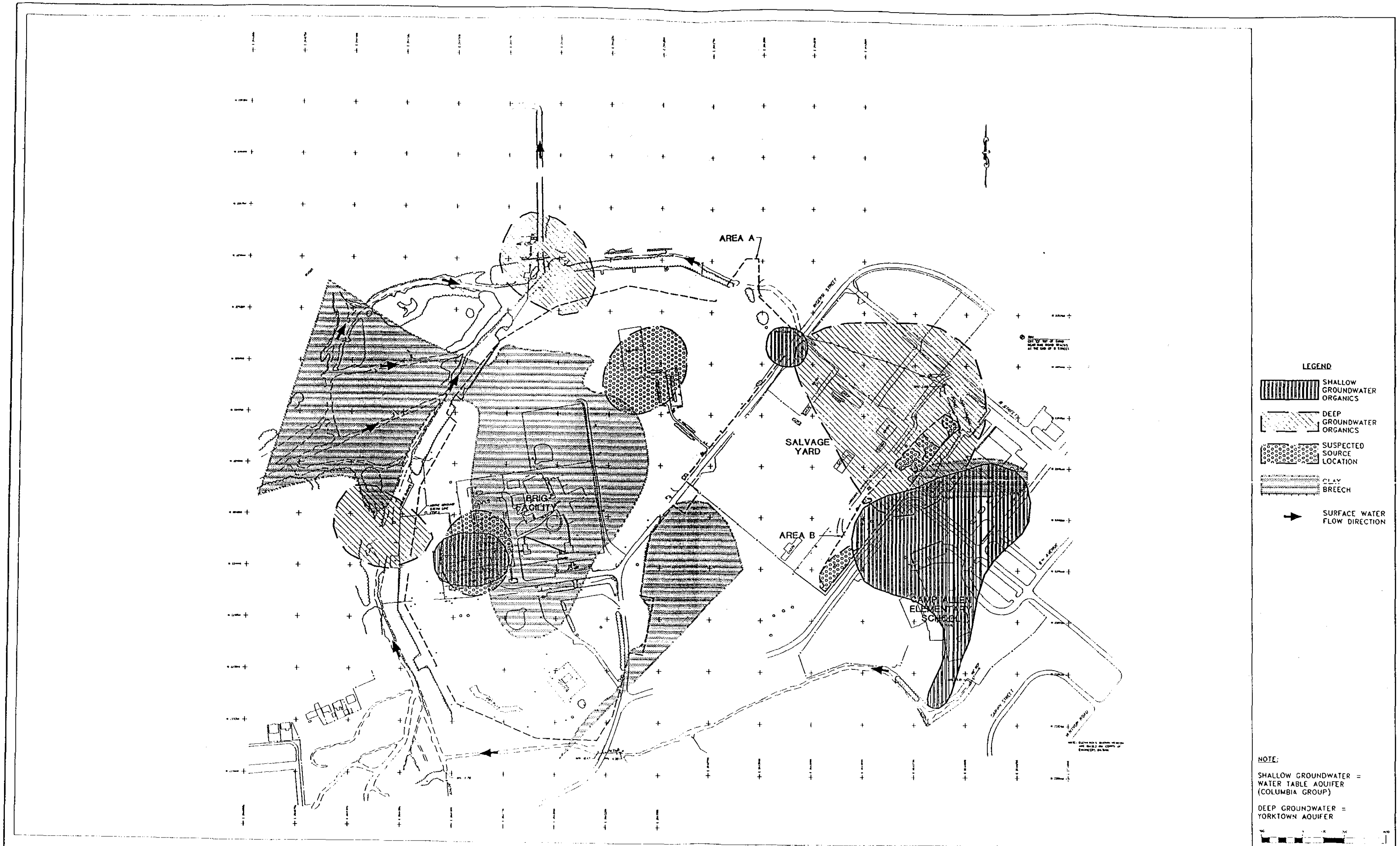
Constituents of concern appear to be seeping from the confines of the landfill and are migrating with groundwater flow in both the shallow and deep aquifer systems as discussed in the following section.

7.5 Groundwater

7.5.1 Shallow Groundwater

Areas of shallow groundwater contamination identified during RI activities are presented in Figure 7-4. The shallow groundwater at Area A is highly contaminated at locations B-20W and B-20WSS, located west of the Brig. This is at and/or adjacent to one or more source areas. Volatile contaminants include solvent-related compounds, vinyl chloride, ketones and BTX compounds.

A second suspected source area of volatile organic contamination was identified north of the Brig Facility. Volatile organic compounds were found in moderate concentrations in the shallow groundwater at the northeastern part of Area A (A-MW11A). Contaminants consist



REVISIONS			NORTH	CAMP ALLEN LANDFILL NORFOLK NAVAL BASE NORFOLK, VIRGINIA	Baker Baker Environmental, Inc.	GENERALIZED AREAS OF GROUNDWATER CONTAMINATION IN SHALLOW AND DEEP GROUNDWATER	FIGURE
	DATE	7/93					7-4
	SCALE	GRAPHIC					
	DRAWN	GLB					
	REVIEWED	DEW		BAKER ENVIRONMENTAL, Inc Coraopolis, Pennsylvania		SCALE GRAPHIC	DATE 7/93
	S.O. #	19084					
	CADD #	084-510					

of low concentrations of solvent-related compounds. This source area is believed to extend to the west towards the helipad area.

Semivolatile constituents detected in shallow groundwater were primarily phenol and phenolic compounds. Only trace amounts of phenol and other semivolatile compounds (such as phthalates) were found in the shallow groundwater at Area A.

Pesticides were detected at several wells (B-1W, B-17W, GW-2 and A-MW-4A) in Area A. Because these wells are located in various portions of Area A and had few or no other types of contaminants detected, it is likely that these pesticide concentrations are related to regional, sporadic concentrations rather than site-specific causes.

Distribution of volatile organic compounds at Area B show the highest concentrations southeast of Area B, along (or adjacent to) utility conduits beneath C Street (B-MW3A and B-MW11A). Well GW-4, within Area B, and west of the ponded area, also showed elevated concentrations of volatiles throughout several years of investigation-related sampling. Constituents include solvent-related compounds, vinyl chloride, BTX, ketones and chlorobenzene.

South of the Camp Allen Elementary School (CAES) one location (B-MW-15) also shows very elevated concentrations of volatiles, consisting primarily of vinyl chloride and solvents. These compounds appear to be migrating from Area B along existing utility lines along the eastern portion of the CAES, toward the south. This migration pathway was supported by the Geoprobe results.

Semivolatile constituents at Area B in the shallow groundwater were more varied as compared to Area A, and included not only phenols and phthalates, but also several different PAHs, ethers and dichlorobenzenes. Detected semivolatile constituents were distributed somewhat differently than for the volatile constituents, with the highest concentrations at GW-4, B-MW3A and B-MW1 (just north of CAES). Also, south of CAES, B-MW15 contained low concentrations of ethers. South of the drainage ditch, adjacent to Capehart Military Housing, phenol was detected at B-MW17.

Pesticides at Area B were detected in several wells at concentrations exceeding MCLs, including locations within Area B (GW-5 and B-MW18A) and outside Area B (B-MW3A, B-MW10, B-MW9A, B-MW12). The pesticides found outside Area B (exclusive of B-MW3A) may be related to off-site influence and/or regional pesticide values and these wells were generally free from other constituents in the groundwater.

Total inorganic constituents were detected in groundwater samples collected from the water table aquifer in concentrations exceeding state and Federal drinking water standards throughout the site. However, based on comparisons of total versus dissolved metal concentrations and linear regression correlations between naturally occurring elements (i.e., iron and aluminum) and constituents of concern (e.g., arsenic, chromium), the inorganic contaminants detected in the groundwater are believed to be associated with total suspended solids present in the well and not representative of actual groundwater contamination (see Appendix Z).

7.5.2 Deep Groundwater

Areas of contamination identified in the Yorktown Aquifer are presented in Figure 7-4. Both organic and inorganic constituents were identified. Contamination in the deep aquifer at Area A shows two areas of elevated volatile organic concentrations - west of the Brig (A-MW9B and A-MW10B) and north of Area A (at A-MW1B, A-MW17B and A-MW18B). Trace concentrations were also found further to the west of Area A, downgradient of the highly affected areas. Low concentrations were also found at A-MW19B, north and east of the helipad. Groundwater in the lower portion of the deep (Yorktown) aquifer was found to contain minor concentrations of volatile constituents at only B-15WB.

Semivolatile compounds in the deep aquifer at Area A were found at trace levels west of the Brig, west of Area A (A-MW15B) and east of the Brig (A-MW4B). Compounds detected include phenol, ethers, PAHs and phthalates. Semivolatile compounds were generally not found at A-MW1B and A-MW17B, but only further to the north at A-MW18B. No semivolatile compounds were detected in the wells screened in the lower part of the deep aquifer.

Pesticides in the deep groundwater at Area A were detected only along the eastern border (wells A-MW4B and A-MW11B). These wells are located east of the Brig and adjacent to the Salvage Yard, respectively. One well (A-MW16B) situated west of the site also contained low concentrations of pesticides. These detected pesticides may be related to regional concentrations of pesticides in the Yorktown Aquifer as source characterization activities did not identify consistent appreciable detections of pesticide compounds.

Volatile organic compounds in the deep aquifer at Area B show a different trend than in the shallow aquifer at Area B. The highest total volatile concentrations were found at well B-MW2B, along the southeastern portion of Area B. Concentrations decrease significantly to the northeast. This may be due to a source area noted in the geophysical investigation at the southeastern portion of Area B. Elevated volatile compound concentrations are also found at well B-MW3B, similar to the shallow aquifer. This is where the confining clay is missing in Area B.

At Area B, only phenol was detected in the deep groundwater at wells B-MW2A and B-MW19B. These are the same locations where high concentrations of volatile compounds were detected.

Pesticides in the deep aquifer at Area B were found at wells B-MW9B and B-MW3B. The detections at B-MW9B may again indicate that there are regional pesticide concentrations in the Yorktown Aquifer, as no other constituents were detected in this well.

Total inorganic constituents were detected in groundwater samples collected from the Yorktown Aquifer in concentrations exceeding state and Federal drinking water standards throughout the site. However, based on comparisons of total versus dissolved metal concentrations and linear regression correlations between naturally occurring elements (i.e., iron and aluminum) and constituents of concern (e.g., arsenic, chromium), the inorganic contaminants detected in the groundwater are believed to be associated with total suspended solids present in the well and not representative of actual groundwater contamination (see Appendix Z).

7.6 Air

Based on results of the Air Sampling Program performed at the Brig Facility and the Camp Allen Elementary School, no significant site-specific volatile air contaminants were detected.

7.7 Ecological Assessment

The ecological assessment included collection of physical water quality data, sampling and analysis of benthic macroinvertebrates, and qualitative evaluation of the terrestrial environment. A brief summary follows.

In most cases, physical water quality measurements (pH, salinity, dissolved oxygen, etc.) were within the ranges expected for waters in urban drainageways. Measurements that were outside the expected ranges were the result of natural conditions. Sediment grain size was also as expected.

Benthic macroinvertebrates were present in every benthic sample; populations in all samples appeared to be healthy. The number of individuals and taxa represented was consistent with healthy environments of the same type represented at Camp Allen. However, identification of organisms was conducted to family level only. These data were not sufficient for calculation of diversity indices or identification of tolerant and/or intolerant species.

The terrestrial environment also appeared to be unaffected by site contaminants. Gross effects of contamination (i.e., death or illness of wildlife, vegetative stress) were not observed. Although the terrestrial study was qualitative only, habitats appeared to be diverse and included species to be expected, particularly in an urban environment. Wildlife was breeding and reproducing on site and natural processes like habitat succession indicated that plants were germinating and competing successfully.

7.8 Summary

Based on site history, previous investigations, and RI findings, contamination from prior disposal practices at Area A and Area B of the Camp Allen Landfill has impacted subsurface soils, surface soils, sediment, surface water, and groundwater (water table and Yorktown Aquifer systems). In general, the primary COCs are volatile organic compounds (VOCs) and several inorganic constituents. Following is a general description of findings at the Camp Allen Landfill Site:

Area A

- Source characterization: VOCs were the predominant contaminants detected in the subsurface soils at Area A. In general, two primary source locations were indicated. The first area appears to be located in the western vicinity of the Brig facility. The second potential area appears to be located towards the northern/northeastern region of Area A.

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities.

- Surface water: Results indicate isolated areas of various inorganic constituent concentrations exceeding applicable standards/criteria. General background constituent concentrations are relatively high as well.

- Sediment: Results indicate isolated areas of various inorganic constituent concentrations exceeding applicable criteria. Inorganic contamination could be present in small, sporadic areas of the drainage ditches surrounding the area. Relatively high background constituent concentrations are apparent.

- Groundwater: Two primary areas of VOC contamination were identified at Area A. The first area is located towards the western portion of the Brig facility and the second area is located along the north portion of the site. Both shallow and deep groundwater contamination is present within these areas. Identified contaminants appear to correspond to source areas mentioned above.

- Residential well groundwater sampling: Analytical results indicate that site-related contaminants have not impacted the shallow (water table) groundwater in the Glenwood Park area. Shallow groundwater contamination appears to be limited to the western side of the Brig facility (located east of Glenwood Park).

- Air sampling: No significant site-specific volatile air contaminants were detected.

<u>Area B</u>

- Source characterization: VOCs were the predominant contaminants detected in the subsurface soils at Area B. In general, the primary source area is located in the middle portion of the site within the landfill.

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities.

- Surface water: Results indicate areas of various VOC and inorganic constituent concentrations exceeding applicable standards/criteria primarily in the eastern and northern portion of the ponded area.

- Sediment: Results indicate isolated areas of various VOC and inorganic constituent concentrations exceeding applicable criteria. Contamination could be present in areas of the ponded drainage way northeast of the site.

- Groundwater: One primary area of VOC contamination was identified at Area B. This area is located in the vicinity of the landfill, as well as near the southern border of the site, directly south of the Camp Allen Elementary School. Both shallow and deep groundwater contamination is present within this area. Identified contaminants correspond to the source area within the Area B landfill mentioned above.

- Residential wells: No residential wells are reportedly located in the vicinity of Area B.

- Air sampling: No significant site-specific volatile air contaminants were detected.

SECTION 8
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8.0 REFERENCES

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