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Fort Monmouth, New Jersey

Remedial Investigation Report

CW-3A Landfill Site

Fort Monmouth, New Jersey

January 7, 2005

REMEDIAL INVESTIGATION REPORT
FOR THE CW-3A LANDFILL SITE
FORT MONMOUTH, NEW JERSEY

PREPARED FOR:

UNITED STATES ARMY FORT MONMOUTH
DIRECTORATE OF PUBLIC WORKS
BUILDING 167
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EXECUTIVE SUMMARY

VERSAR, Inc. (VERSAR) has been contracted by the United States (U.S.) Army Installation, Fort Monmouth (Fort Monmouth), Directorate of Public Works (DPW), Fort Monmouth, New Jersey to prepare a Remedial Investigation Report (RIR) for the CW-3A Landfill site based on work conducted by VERSAR in 2001, TECOM-Vinnell Services (TVS) in 1997-2001 and Roy F. Weston, Inc. (Weston) in 1995. This report addresses the Remedial Investigation (RI) activities conducted at the CW-3A Landfill site to investigate soil and groundwater conditions from December 1997 through January 2001.

The CW-3A Landfill site consists of a former historic landfill in the Charles Wood Area. It is bounded by Pearl Harbor Avenue to the west, an unnamed tributary of Wampum Brook to the north, a wooded area to the east and the Pulse Power Facility to the south. The approximate area of the CW-3A Landfill site is 116,000 ft^2 (2.6 acres). The unnamed tributary of Wampum Brook flows along the northern boundary of the CW-3A Landfill site for a distance of approximately 600 feet. The tributary is choked with thick vegetation and fallen trees with man-made debris scattered along its banks.

The Weston Site Investigation (SI) report, *Site Investigation, Fort Monmouth, New Jersey, Main Post and Charles Wood Areas, Site Investigation Report* (December 1995), presents the results of field investigation activities that were conducted at 13 sites at the Main Post Area and eight sites at the Charles Wood Area. The results of the investigation of the CW-3A Landfill site are included in the Weston SI report. Initial field investigation activities were conducted between November 1994 and March 1995. The field investigation activities included surface geophysical investigations, surface and subsurface soil sampling, groundwater monitoring well installation and sampling and tidal monitoring. The Weston SI report was used as the basis for the supplemental remedial investigations of the CW-3A Landfill site described in the following sections of this report.

The 1995 Weston SI report indicated that the CW-3A Landfill site was originally planned to be sampled as part of Weston's field investigation activities at the Main Post and Charles Wood areas between November 1994 and March 1995. These activities included surface geophysical investigations, surface and subsurface soil sampling, groundwater monitoring well installation and sampling and tidal monitoring. However, the 1995 Weston SI report noted that the presence of construction debris prevented any sampling from being completed at the CW-3A Landfill site. Consequently, to determine if historic subsurface disposal had occurred at the CW-3A Landfill site, Weston conducted geophysical investigations utilizing magnetic measurements (MAG), electromagnetic measurements (EM), and ground penetrating radar (GPR). These geophysical investigations revealed various "anomalies" indicative of buried ferrous materials at a depth of 2-3 feet below ground surface (bgs). As a result, Weston recommended that exploratory trenching be conducted at the CW-3A Landfill site to verify the presence of subsurface metallic debris (Weston, 1995).

Fort Monmouth DPW conducted exploratory trenching on September 25, 1997. Several test pits were excavated that revealed debris consisting of concrete, asphalt, brick, wood, glass, coal ash and assorted scrap metals. Four monitoring wells were installed by the DPW in December 1997.

The Weston SI report also presented a DPW proposal for a long-term monitoring program at the CW-3A Landfill site that was subsequently implemented by the DPW. This long-term monitoring program was developed utilizing four monitoring wells installed by the DPW in December 1997 at the CW-3A Landfill site.

The DPW conducted remedial investigation activities at the CW-3A Landfill site, including monitoring well installation, subsurface soil sampling, a quarterly groundwater sampling program, and two additional low-flow groundwater sampling rounds. The purpose of these supplemental investigations was to define the areal extent of potential pollutants and evaluate impacts to groundwater in the vicinity of the CW-3A Landfill site. Remedial investigation activities were conducted from December 1997 through January 2001.

Soil sampling was conducted by the DPW on December 17, 1997, during the construction of the four monitoring wells at the CW-3A Landfill site. A total of 12 subsurface soil samples were collected from four borehole locations at depths ranging from 0-6 inches, 18-24 inches and immediately above the groundwater table. In addition, one sample of coal/ash was collected from a test pit at the CW-3A Landfill site. The soil samples were analyzed by the Fort Monmouth Environmental Testing Laboratory (FMETL) for volatile organic compounds (VOCs) plus 15 parameters, semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), Target Analyte List (TAL) metals and cyanide.

A total of four monitoring wells comprise the quarterly groundwater monitoring program conducted by the DPW. As a part of the remedial investigation, a quarterly groundwater sampling program was conducted by the DPW at the CW-3A Landfill site. Groundwater samples were collected during 14 quarterly sampling events and analyzed for VOCs, SVOCs, pesticides, PCBs, ammonia, cyanide and TAL metals.

The soil sample analytical results from the 12 samples and one coal ash sample collected from the CW-3A Landfill site indicate that the five SVOCs were detected in soils at concentrations in excess of their respective RDCSCC criteria. However, based on the low levels of detection of these five SVOCs in soils, there are no COCs for soils at the CW-3A Landfill site. Therefore, NFA is required regarding soils at the CW-3A Landfill site.

Based on the results of the groundwater quality evaluation, no VOCs, SVOCs, pesticides or PCBs were detected above the NJDEP GWQC. The analytical results indicate 17 TAL metals detected in groundwater samples at concentrations exceeding the NJDEP GWQC. However, none of these metals are considered to be COCs in site groundwater due to the process of elimination via categorization of background metals, reduction in concentration or non-detection of samples by low flow sampling, and elimination of isolated and marginal detections. Therefore, no COCs exist at the CW-3A Landfill site, and No Further Action (NFA) is required regarding groundwater at the CW-3A Landfill site.

1.0 INTRODUCTION

VERSAR has been contracted by the U.S. Army Installation, Fort DPW, Fort Monmouth, New Jersey to prepare an RIR for the CW-3A Landfill site based on work conducted by VERSAR in 2001, TVS in 1997-2001 and Weston in 1995. This report addresses the RI activities conducted at the CW-3A Landfill site to investigate soil and groundwater conditions from December 1997 through January 2001.

1.1 Objectives

The objective of this RIR is to determine aquifer chemical and physical characteristics and to determine whether further remedial investigation or remedial action is required within the CW-3A Landfill site. The remedial investigation of the CW-3A Landfill site was conducted in accordance with New Jersey Administrative Code (NJAC) 7:26E - *Technical Requirements for Site Remediation* (July 1999).

The remedial investigation encompassed the following:

- Characterization of surface and subsurface site soils in December 1997.
- Characterization of groundwater quality over time through quarterly groundwater sampling events conducted between December 1997 and January 2001.
- Comparison of the results of the groundwater and soil quality monitoring programs with the NJDEP Ground Water Quality Criteria (GWQC) and Residential Direct Contact Soil Cleanup Criteria (RDCSCC).
- Investigation and evaluation of the designated aquifer uses, the associated aquifer classification, and the appropriate groundwater quality criteria for groundwater resources beneath the CW3A Landfill site. The NJDEP Ground Water Quality Standards (GWQS) specify the quality criteria and designated uses for groundwater and also contain technical and general policies to ensure that the designated uses can be adequately protected.
- Formulation of an NFA proposal regarding soil and groundwater contamination at the CW-3A Landfill site, for consideration by the NJDEP. This proposal is based on the results of field and laboratory investigations and the hydrogeologic conditions at the site. The rationale for the NFA proposal is presented in this RIR.

1.2 Report Organization

The findings of the Weston report entitled, *Site Investigation, Fort Monmouth, New Jersey, Main Post and Charles Wood Areas, Site Investigation Reports* (December 1995), were used as the basis for this remedial investigation program. **Section 2.0** provides background information and a general description of the CW-3A Landfill site located at the Charles Wood Area of Fort

Monmouth (Weston, 1995). **Section 3.0** describes and summarizes the RI field activities conducted at the CW-3A Landfill site, including the groundwater and soil sampling. **Section 4.0** presents the physical characterization of the CW-3A Landfill site including the lithology and groundwater conditions at the CW-3A Landfill site. The chemical characterization of the CW-3A Landfill site is presented in **Section 5.0,** which includes soil and groundwater sampling results. Conclusions and recommendations regarding the CW-3A Landfill site are discussed in **Section 6.0**. References used to prepare this RIR are listed in **Section 7.0**.

2.0 SITE BACKGROUND AND ENVIRONMENTAL SETTING

The following sections describe the background and environmental setting of the area surrounding Fort Monmouth and the CW-3A Landfill site. Included is a description of the CW-3A Landfill site location, background, current conditions and environmental setting.

2.1 Site Location and Description

Fort Monmouth is located in the central-eastern portion of New Jersey in Monmouth County, approximately 45 miles south of New York City and 70 miles northeast of Philadelphia (**Figure 2-1**). In addition to the Main Post, the installation includes two subposts, the Charles Wood Area and the Evans Area. The Main Post encompasses approximately 630 acres and is generally bounded by State Highway 35, Parkers Creek, Lafetra Creek, the New Jersey Transit Railroad and a residential area to the south. The post was established in 1918 during World War I (WWI) as an Army Signal Corps training center. The Main Post currently provides administrative, training and housing support functions, as well as providing many of the community facilities for Fort Monmouth. The Charles Wood Area is located one mile west of the Main Post and is comprised of approximately 511 acres. The Charles Wood Area is used primarily for research and development, testing and personnel housing units. The primary mission of Fort Monmouth is to provide command, administrative and logistical support for Headquarters, U.S. Army Communications and Electronics Command (CECOM). CECOM is a major subordinate command of the U.S. Army Materiel Command (AMC), and is the host tenant at Fort Monmouth.

The CW-3A Landfill site consists of a former historic landfill in the Charles Wood Area (**Figure 2-2**). It is bounded by Pearl Harbor Avenue to the west, an unnamed tributary of Wampum Brook to the north, a wooded area to the east and the Pulse Power Facility (Building No. 2707) to the south. The approximate area of the CW-3A Landfill site is 116,000 ft^2 (2.6 acres). The unnamed tributary of Wampum Brook flows along the northern boundary of the CW-3A Landfill site for a distance of approximately 600 feet. The tributary is choked with thick vegetation and fallen trees with man-made debris scattered along its banks.

2.2 Site Background

The U.S. Army Corps of Engineers (USACE), Baltimore District, initially contracted Weston to perform a field investigation at Fort Monmouth, New Jersey. This investigation was conducted at two separate areas of Fort Monmouth, the Main Post and the Charles Wood areas. Suspected hazardous waste sites were initially identified at Fort Monmouth in a report prepared by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA, 1980). The USATHAMA report identified 37 sites with known or suspected waste materials on the Main Post and the two subposts (Charles Wood and Evans Area). A background investigation was conducted by Weston of the 37 sites and eight additional sites that were identified by Fort Monmouth and the NJDEP. Weston's findings were described in a report titled, *Investigation of Suspected Hazardous Waste Sites at Fort Monmouth, New Jersey* (1993). In this background report, additional investigations (including sampling and other field work) were recommended at 22 of the sites on the Main Post and Charles Wood areas, including the CW-3A Landfill site. NJDEP approved the recommendations on April 20, 1995. Additional investigations were also

recommended at the Evans Area, and such investigations are being completed under the Base Realignment and Closure (BRAC) program.

Background sampling was performed to characterize site conditions identified in the report *The Investigation of Suspected Hazardous Waste Sites at Fort Monmouth, New Jersey* (Weston, 1993). The purpose of the collection of background characterization data was to identify levels of chemicals that are naturally occurring.

The Weston SI report, *Site Investigation, Fort Monmouth, New Jersey, Main Post and Charles Wood Areas, Site Investigation Report* (December 1995), presents the results of field investigation activities that were conducted at 13 sites at the Main Post Area and eight sites at the Charles Wood Area. The results of the investigation of the CW-3A Landfill site are included in the Weston SI report. Initial field investigation activities were conducted between November 1994 and March 1995. The field investigation activities included surface geophysical investigations, surface and subsurface soil sampling, groundwater monitoring well installation and sampling and tidal monitoring. The Weston SI report was used as the basis for the supplemental remedial investigations of the CW-3A Landfill site described in the following sections of this report.

The 1995 Weston SI report indicated that the CW-3A Landfill site was originally planned to be sampled as part of Weston's field investigation activities at the Main Post and Charles Wood areas between November 1994 and March 1995 (**Appendix A**). These activities included surface geophysical investigations, surface and subsurface soil sampling, groundwater monitoring well installation and sampling and tidal monitoring. However, the 1995 Weston SI report noted that the presence of construction debris prevented any sampling from being completed at the CW-3A Landfill site. Consequently, to determine if historic subsurface disposal had occurred at the CW-3A Landfill site, Weston conducted geophysical investigations utilizing MAG, EM measurements, and GPR. These geophysical investigations revealed various "anomalies" indicative of buried ferrous materials at a depth of 2-3 feet bgs. As a result, Weston recommended that exploratory trenching be conducted at the CW-3A Landfill site to verify the presence of subsurface metallic debris (Weston, 1995).

Fort Monmouth DPW conducted exploratory trenching on September 25, 1997. Several test pits were excavated that revealed debris consisting of concrete, asphalt, brick, wood, glass, coal ash and assorted scrap metals. Four monitoring wells were installed by the DPW in December 1997 (**Appendix B**). The Weston SI report also presented a DPW proposal for a long-term monitoring program at the CW-3A Landfill site that was subsequently implemented by the DPW. This long-term monitoring program was developed utilizing four monitoring wells installed by the DPW in December 1997 at the CW-3A Landfill site. The groundwater monitoring program and subsurface soil sampling activities are described in **Section 3.0**.

2.3 Current Conditions

VERSAR conducted a site walk on June 20, 2001, to assess current conditions at the CW-3A Landfill site. The CW-3A Landfill site consisted of a partially wooded lot with tall grass in the center and trees to the north, east and west. A parking area for the Pulse Power Facility is

located to the south of the CW-3A Landfill site. The site photograph is provided in **Appendix C**.

2.4 Environmental Setting

The following is a description of the geological/hydrogeological setting of the area surrounding the CW-3A Landfill site. Included is a description of the regional geology and hydrogeology of the area surrounding Fort Monmouth, as well as descriptions of the local geology and hydrogeology of the CW-3A area. The Charles Wood Area is located one mile from the Main Post and regional geologic/hydrogeologic conditions are similar.

2.4.1 Regional Geology

Monmouth County lies within the New Jersey Section of the Atlantic Coastal Plain physiographic province. The CW-3A Landfill site is located in what may be referred to as the Outer Coastal Plain subprovince, or the Outer Lowlands. The geologic map of New Jersey is provided in **Figure 2-3**.

In general, New Jersey Coastal Plain formations consist of a seaward-dipping wedge of unconsolidated deposits of clay, silt, sand and gravel. These formations typically strike northeast-southwest with a dip ranging from 10-60 feet per mile and were deposited on Precambrian and lower Paleozoic rocks (Zapecza, 1989). These sediments, predominantly derived from deltaic, shallow marine and continental shelf environments, date from Cretaceous through the Quaternary Periods. The mineralogy ranges from quartz to glauconite.

The formations record several major transgressive/regressive cycles and contain units, which are generally thicker to the southeast and reflect a deeper water environment. More than 20 regional geologic units are present within the sediments of the Coastal Plain. Regressive, upward coarsening deposits are usually aquifers (e.g., Englishtown and Kirkwood Formations and the Cohansey Sand), while the transgressive deposits act as confining units (e.g., the Merchantville, Marshalltown and Navesink Formations). The individual thickness for these units varies greatly (e.g., from several feet to several hundred feet). The Coastal Plain deposits thicken to the southeast from the Fall Line (e.g., a boundary zone between older, resistant rocks and younger, softer plain sediments) to greater than 6,500 feet in Cape May County (Brown and Zapecza, 1990).

Based on the regional geologic map (Jablonski, 1968), the Cretaceous age Red Bank and Tinton Sands outcrop at the Main Post area. The Red Bank Sand conformably overlies the Navesink Formation and dips to the southeast at 35 feet per mile. The upper member (Shrewsbury) of the Red Bank Sand is a yellowish-gray to reddish brown clayey, medium-to-coarse-grained sand that contains abundant rock fragments, minor mica and glauconite (Jablonski). The lower member (Sandy Hook) is a dark gray to black, medium-to-fine grained sand with abundant clay, mica and glauconite.

The Tinton Sand conformably overlies the Red Bank Sand and ranges from a clayey medium to very coarse-grained feldspathic-quartz and glauconite-sand to a glauconitic-coarse sand. The

color varies from dark yellowish orange or light brown to moderate brown and from light olive to grayish olive. Glauconite may constitute 60-80 percent of the sand fraction in the upper part of the unit. The upper part of the Tinton is often highly oxidized and iron oxide encrusted (Minard, 1969). Groundwater occurs beneath the site at a depth of approximately 2-12 feet bgs.

The Kirkwood Formation (part of the Kirkwood-Cohansey system) crops out southeast of the Main Post and dips to the southeast at a slope of 20 feet per mile (Jablonski, 1968). The Kirkwood Formation consists of alternating layers of sand and clay. The upper unit is a light gray to yellowish-brown, fine-grained quartz sand with quartz nodules and small pebbles. The lower unit is brown silt in Monmouth County (Jablonski, 1968).

As presented in the *Site Investigation Report - Main Post and Charles Wood Areas, Fort Monmouth, New Jersey*, prepared by Weston (1995), several natural and anthropogenic factors contribute to the wide range in concentrations of metals in soils, which further impact the concentration of metals in groundwater. Soils derived from the glauconitic sands contain abundant aluminum, calcium, potassium, iron, magnesium and manganese (among others), which are likely to be present at elevated concentrations in the groundwater, particularly when sediments are entrained in the collected groundwater samples.

The boring logs from monitoring wells installed by the DPW in December 1997, indicate that the lithology consists of a thin soil cover (0.4 feet) underlain by alternating layers of reworked sand, silt and broken concrete gravel pieces with interbedded plant/root fragments. Borehole logs also represent a lithology consisting of orange-olive-brown coarse to fine sand with little silt at this site. Groundwater saturation was observed 6-12 feet bgs at each well location during drilling activities. Further discussion of the subsurface conditions is presented in **Section 4.0.** Boring logs and monitoring well construction records are presented in **Appendix B**.

2.4.2 Hydrogeology

Fort Monmouth lies in the Atlantic and Eastern Gulf Coastal Plain groundwater region (Meisler et al., 1988). This groundwater region is underlain by undeformed, unconsolidated to semi-consolidated sedimentary deposits. The chemistry of the water near the surface is variable with low dissolved solids and high iron concentrations. The water chemistry in areas underlain by glauconitic sediments (such as Red Bank, Tinton and Hornerstown Sands) is dominated by calcium, magnesium, manganese, aluminum and iron. The sediments in the area of Fort Monmouth were deposited in fluvial-deltaic to near shore environments.

The water table aquifer in the Main Post Area is identified as part of the "Navesink-Hornerstown Confining Units," or minor aquifers. The minor aquifers include the Navesink formation, Red Bank Sand, Tinton Sand, Hornerstown Sand, Vincentown Formation, Manasquan Formation, Shark River Formation, Piney Point Formation and the basal clay of the Kirkwood Formation. These geologic formations comprise a "Composite Confining Bed" for the Wenonah Mount Laurel Aquifer (Zapecza, 1984).

Wells installed in the Red Bank and Tinton Sands produce 2-25 gallons per minute (gpm) (Jablonski, 1968). Groundwater is typically encountered at the Main Post and in the surrounding

areas at shallow depths below ground surface (2-9 feet bgs). Water in the surficial aquifer generally flows east toward the Atlantic Ocean.

Based on a review of the NJDEP GWQS (NJAC 7:9-6), January 7, 1993, Versar has determined that the site is underlain by a Class III-A aquifer. A formal presentation of this finding was made to the NJDEP on April 17, 2001. The primary designated use for Class III-A groundwater is the release or transmittal of groundwater to adjacent classification areas and surface water, as relevant. Secondary designated uses in Class III-A include any reasonable use. Further discussion of the Class III-A aquifer classification is presented in **Section 2.4.3.**

Shallow groundwater may be locally influenced within the Main Post Area by the following factors:

- Tidal influence (based on proximity to the Atlantic Ocean, rivers, and tributaries)
- Topography
- Nature of the fill material within the Main Post Area
- Presence of clay and silt lenses in the natural overburden deposits
- Local groundwater recharge areas (e.g., streams, lakes)
- Roadways, utility conduits and stormwater culverts

Due to the fluvial nature of the overburden deposits (e.g., sand and clay lenses), shallow groundwater flow direction is best determined on a case-by-case basis. The groundwater flow in the vicinity of the CW-3A Landfill site is assumed to be north towards the unnamed tributary of Wampum Brook.

2.4.3 Aquifer Classification

On review of the NJDEP GWQS (N.J.A.C. 7:9-6), January 7, 1993, the CW-3A Landfill site is found to be underlain by a Class III-A aquifer (**Figure 2-4**). The primary designated use for Class III-A ground water is the release or transmittal of groundwater to adjacent classification areas and surface water, as relevant. Secondary designated uses in Class III-A include any reasonable uses. For an area to be classified as a Class III-A aquifer, the ground water must meet the following characteristics:

- Class III-A ground water includes portions of the saturated zones (that meet the criteria below) of the Woodbury Formation, Merchantville Formation, Marshalltown Formation, Navesink Formation, Hornerstown Formation, aquitard formations of the Potomac-Raritan-Magothy aquifer system and the Kirkwood aquifer system, portions of the glacial moraine and glacial lake deposits, and other geologic units having the characteristics of an aquitard. Class III-A areas have the following characteristics (N.J.A.C. 7:9-6.5):

  - The average thickness of a Class III-A area must be at least 50 feet;

  - Typical hydraulic conductivity of a Class II-A aquifer is approximately 0.1 ft/day or less; and

- The aerial extent defined as Class III-A must be at least 100 acres.

The shallow aquifer at Fort Monmouth meets each of the four criteria listed above. These criteria are discussed below

- As presented in **Figure 2-5**, Fort Monmouth is located within the outcrop area of the "Navesink-Hornerstown Confining Unit." The Navesink and Hornerstown Formations are part of the Composite Confining Unit (Martin, 1998), which also includes the Red Bank Sand, Tinton Sand, Vincentown Formation, Manasquan Formation, Shark River Formation, Piney Point Formation, and the basal clay of the Kirkwood Formation (see **Section 2.4.2**).

  - **Figure 2-6** also illustrates the thickness of the Hornerstown-Navesink Confining Unit, which in the vicinity of Fort Monmouth, is approximately 125 feet.

- Published hydraulic conductivities (Martin, 1998) for the Navesink-Hornerstown Confining Unit, yielding a geometric mean of 0.12 feet per day.

- The area of Fort Monmouth is greater than 100 acres.

2.4.4 Soils

According to the U.S. Department of Agriculture (USDA), Soil Conservation Service, Monmouth County Soil Survey, the majority of the Main Post and Charles Wood areas are covered by urban land (**Figure 2-8**). The soil survey describes urban land as areas where concrete, asphalt, buildings, shopping centers, airports or other impervious surfaces cover 80 percent or more of the surface. In addition, the survey indicated that the natural subsurface soils have largely been replaced with artificial or foreign fill materials (developed land with disturbed soils). The following soil series and classification units are mapped in the Main Post and Charles Wood areas:

- DoB Downer sandy loam (with 2-5 percent slopes);
- FrB Freehold sandy loam (with 2-5 percent slopes);
- FUB Freehold sandy loam/urban land complex (with 0-10 percent slopes);
- HV Humaquepts, frequently flooded;
- KvA Kresson loam (with 0-5 percent slopes);
- PT Pits, Sand and Gravel;
- UA Udorthents, smoothed; and
- UD Udorthents – urban land complex (with 0-3 percent slopes).

The Downer series soils are well-drained soils that are found on uplands and terraces. The soils are formed in acid, silty coastal plain sediments. The Freehold soils are also well drained and are formed in acid, loamy, coastal plain sediments that, by volume, are 1-10 percent glauconite and are found on uplands. The Humaquepts soils are somewhat poorly- to very poorly- drained soils that are formed in stratified, sandy, or loamy sediments of fluvial origins. The Humaquepts soils are located on the floodplain and are subject to flooding several times each year. The Kresson

loam is a nearly level to gently sloping soil and is somewhat poorly drained. The soil is found on low divides and in depressions. The Udorthents soils have been altered by excavation or filling activities. In filled areas, these soils consist of loamy material that is more than 20 inches thick. The filled areas include floodplain, tidal marshes and areas with moderately, well drained to very poorly drained soils. Some Udorthent soils contain concrete, asphalt, metal and glass. The soils in the vicinity of the CW-3A Landfill site are classified as FUB – Freehold sandy loam/urban land complex (with 0-10 percent slopes).

2.4.5 Topography and Surface Drainage

Over the last 80 years, the natural topography of Fort Monmouth has been altered by excavation and filling activities conducted by the military. The CW-3A Landfill site is located on the floodplain of Wampum Brook. The USGS topographic map (**Figure 2-1**) shows that the land surface of the CW-3A Landfill Site is relatively flat at an elevation of 30-60 feet above mean sea level (amsl).

Surface water bodies in the vicinity of the Charles Wood Area include two unnamed tributaries of Wampum Brook. Wampum Brook is joined by several unnamed tributaries east of Charles Wood, prior to becoming Wampum Lake. Wampum Lake discharges into Mill Creek, which flows toward the Main Post Area.

The U.S Fish and Wildlife Service (FWS) National Wetland Inventory Long Branch quadrangle maps indicate the presence of several wetlands at the Main Post and Charles Wood areas. However, in the vicinity of the CW-3A Landfill site, the golf course lake is classified as palustrine open water/unknown bottom, and several areas along the unnamed tributaries of Wampum Brook are classified as palustrine forested wetland, broad-leaved deciduous. Based on the topography at the CW-3A Landfill site, surface water runoff is expected to flow north toward the unnamed tributary of Wampum Brook.

3.0 SITE ACTIVITIES

The DPW conducted remedial investigation activities at the CW-3A Landfill site, including monitoring well installation, subsurface soil sampling, a quarterly groundwater sampling program, and two additional low-flow groundwater sampling rounds. The purpose of these supplemental investigations was to define the areal extent of potential pollutants and evaluate impacts to groundwater in the vicinity of the CW-3A Landfill site. Remedial investigation activities were conducted from December 1997 through January 2001. These activities were managed by the DPW, conducted by TVS and reported by VERSAR. The details of remedial investigation activities that occurred at the CW-3A Landfill site are described in the following sections.

3.1 Soil Sampling Activities

Soil sampling was conducted by the DPW on December 17, 1997, during the construction of the four monitoring wells at the CW-3A Landfill site. A total of 12 subsurface soil samples were collected from four borehole locations (CW3A-MW1, CW3A-MW2, CW3A-MW3 and CW3A-MW4) at depths ranging from 0-6 inches, 18-24 inches and immediately above the groundwater table (encountered from 7-15 feet bgs). **Figure 3-1** shows the locations of the soil samples (monitoring well boreholes) at the CW-3A Landfill site. In addition, one sample of coal/ash was collected from a test pit at the CW-3A Landfill site. The soil samples were analyzed by the FMETL for VOCs plus 15 parameters, SVOCs, pesticides, PCBs, TAL metals and cyanide. A summary of the soil samples activities, including sample IDs, collection/analysis date, analytical parameters and analysis method is provided in **Table 3-1**. The results of these analyses are discussed in **Section 5.1**

Sampling equipment was thoroughly decontaminated before and after each use, in accordance with the *Fort Monmouth Standard Operating Procedures* (1997). The soil samples were collected using split spoons and immediately placed in laboratory-supplied bottleware. The sample containers were labeled, sealed, packed in ice and transported to the FMETL under proper chain-of-custody procedures. Copies of the chain-of-custody for the laboratory analyses of soil samples can be found in **Appendix D**.

3.2 Well Installation

A total of four monitoring wells (CW3A-MW1 through CW3A-MW4) comprise the quarterly groundwater monitoring program conducted by the DPW. These monitoring wells were installed at the CW-3A Landfill site by Lutz Environmental, Inc. for the DPW in December 1997. The wells were constructed with 4-inch diameter 20 Slot PVC ranging to depths of 13.5-20 feet bgs. The monitoring well construction details are presented in **Table 2-1.** The monitoring well locations are shown in **Figure 3-1**. Monitoring well boring logs and records are provided in **Appendix B**.

3.3 Groundwater Sampling Activities

As a part of the remedial investigation, a quarterly groundwater sampling program was conducted by the DPW at the CW-3A Landfill site from December 1997 through January 2001.

Sampling activities were conducted in accordance with the *Fort Monmouth Standard Sampling Operating Procedure* (1997). Laboratory analyses of the samples collected at the CW-3A Landfill site were conducted at the FMETL, a New Jersey certified laboratory (Certification No. 13461).

Groundwater samples were collected during 14 quarterly sampling events and analyzed for VOCs, SVOCs, pesticides, PCBs, ammonia, cyanide and TAL metals. A total of 110 groundwater samples were collected as a part of the groundwater sampling program, including 14 duplicate samples, 13 field blanks and 14 trip blanks for quality assurance/quality control (QA/QC) purposes. The groundwater samples were collected from the four 4-inch diameter monitoring wells (CW3A-MW1 through CW3A-MW4) installed at the CW-3A Landfill site in December 1997.

The analytical parameters were modified during the course of the groundwater monitoring program. The first two rounds included analytical testing for ammonia and cyanide. During the four rounds of groundwater sampling conducted from March 16, 1998 to February 23, 1999 (rounds #3 through #6), a total of 16 samples (out of the total 110 groundwater samples) were collected and analyzed for only VOCs. Rounds #7 through #14 conducted from June 1999 through January 2001 included analytical testing for VOCs, SVOCs, pesticides, PCBs and TAL metals.

As presented in the Weston SI Report (1995), several natural and anthropogenic factors contribute to the wide range in concentrations of metals in soils, which further impact the concentration of metals in groundwater. Soils derived from the glauconitic sands contain abundant aluminum, calcium, potassium, iron, magnesium and manganese (among others), which are likely to be present at elevated concentrations in the groundwater, particularly when sediments are entrained in the collected groundwater samples. A low-flow sampling methodology was proposed for use by the DPW and accepted by the NJDEP to assess the impact of entrained sediments on the dissolved phase metals concentrations at the CW-3A Landfill site. Using a low-flow sampling methodology to reduce the presence of entrained sediment has generally yielded substantial reductions in the dissolved phase concentrations of metals, such as arsenic, antimony, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, silver, thallium and vanadium at Fort Monmouth sites. Significant decreases in the concentrations of metals characteristic of glauconitic sand also were observed. These included aluminum, barium, calcium, copper, iron, magnesium, manganese, nickel, potassium, sodium and zinc.

In consideration of the potential benefits of the low-flow sampling procedure, two additional rounds of low-flow sampling were conducted on August 24, 2000 (Low-Flow #1) and October 4, 2000 (Low Flow #2). A total of 12 samples (out of the total 110 groundwater samples) were collected and analyzed only for TAL metals, to determine whether elevated metal concentrations observed in the groundwater samples are due to sediments rather than groundwater. The samples were analyzed by the FMETL for TAL metals utilizing United States Environmental Protection Agency (USEPA) Methods 3120B and 3112B (**Table 3-2**). The results of these analyses are discussed in greater detail in **Section 5.1**.

Sampling equipment was thoroughly decontaminated before and after each use, in accordance with the *Fort Monmouth Standard Sampling Operating Procedure* (1997). Following collection, the groundwater samples were immediately placed in laboratory-supplied bottleware. The sample containers were labeled, sealed, packed in ice and transported to the FMETL under proper chain-of-custody procedures. Copies of the chain-of-custody for the laboratory analyses of groundwater can be found in can be found in **Appendix E.** A summary of the groundwater sampling activities, including rounds, sample IDs, collection/analysis date, analytical parameters and analysis method is provided in **Table 3-2**. The results of these analyses are discussed in **Section 5.1**.

3.4 Groundwater Depth Measurements

During each of the 16 groundwater monitoring rounds, measurements of the depth-to-water in each of the monitoring wells were recorded with an accuracy of 0.01 feet. These depth-to-water measurements, recorded from December 1997 through January 2001, are presented in **Table 3-3**. The groundwater elevation at each well was calculated as the difference between the surveyed elevation of the top of the well casing and the measured depth-to-water. The groundwater elevations are discussed in **Section 4.2**.

4.0 SITE PHYSICAL CHARACTERISTICS

The following sections represent the findings of the CW-3A Landfill site geologic and hydrogeologic characterization program. These sections include a detailed discussion of the physical properties of the unconsolidated soil, bedrock and groundwater underlying the study area. Groundwater elevation and water quality data collected by the DPW from December 1997 through January 2001 are also discussed in this report. The soil and groundwater sampling and associated laboratory analytical data comprise the long-term monitoring program that was instituted by the DPW after the Weston SI activities.

4.1 Lithology

The lithology encountered at the CW-3A Landfill site consists primarily of fill material, fine sand, silt and clay. A geologic cross section (A-A') was prepared for three monitoring wells. The cross section location map is included as **Figure 4-1**. The location of cross section A-A' is presented in map is included as **Figure 4-2**. The data used to create the cross section is presented in **Table 4-1**.

Cross section A-A' (**Figure 4-2**) depicts the profiles for monitoring wells CW3A-MW1, CW3A-MW2, CW3A-MW3 and CW3A-MW4. Wells CW3A-MW1, CW3A-MW2, CW3A-MW3 and CW3A-MW4 are projected onto the cross section line A-A' (**Figure 4-1**). The fill encountered in monitoring well borings at the CW-3A Landfill site consisted of lumber fragments, black-stained gravel fine to coarse with organics within the top five feet of the boring, ranging in depth from 2-5.5 feet bgs. Native material was encountered below the fill in all monitoring wells consisting of brown to black fine sand, silt and clay with organic material and ranged in depth from 6-20 feet bgs. The observation of sub-rounded quartz gravel led to the interpretation that the native material is representative of the Tinton Sand. Groundwater was encountered during well installation at depths ranging from 7-15 feet bgs grading toward an unnamed tributary of Wampum Brook.

As stated in **Section 2.4.2**, the wide range of concentrations of metals in soils further impact the concentration of metals in groundwater. Soils derived from glauconitic sands contain abundant aluminum, calcium, potassium, iron, magnesium and manganese (among others), which are likely to be present at elevated concentrations in the groundwater, particularly when sediments are entrant during the collection of groundwater samples.

4.2 Groundwater Flow

In accordance with NJAC 7:26E-3.13(d)2iv, 16 groundwater contour maps (**Figure 4-3a** through **4-3p**) were generated based on groundwater depth measurements collected at the CW-3A Landfill site between December 1997 and January 2001. As presented in **Table 3-3**, groundwater elevations were calculated as the difference of the surveyed top of casing measurements and groundwater depth measurements. In the most of the CW-3A Landfill site, groundwater flows northwest towards an unnamed tributary of Wampum Brook. The groundwater depth measurements also imply groundwater flow to the north and northwest in the northern part of the CW-3A Landfill site. There were no significant changes in groundwater elevation between the 16 rounds of water level measurements (see **Table 3-3**).

5.0 SITE CHEMICAL CHARACTERIZATION

This section includes a discussion of the chemical analytical characterization of the CW-3A Landfill site based on samples collected and analyzed from the site, including one round of soil sampling, 14 quarterly rounds of groundwater monitoring well samples and two rounds of low-flow groundwater sampling. DPW personnel were responsible for the collection of samples during this remedial investigation. Sample analyses were conducted by the FMETL, a New Jersey certified laboratory (Certification No. 13461).

5.1 Soil and Coal Ash Sampling Results

This section presents a summary of the laboratory analyses conducted for the one round of soil sampling (a total of 12 soil samples and one coal ash sample) on December 17, 1997 from the four groundwater monitoring well boreholes (CW3A-MW1, CW3A-MW2, CW3A-MW3 and CW3A-MW4). The coal ash sample was collected on December 17, 1997 from a test pit dug within the CW-3A Landfill site. The samples were collected from depths ranging from 0-6 inches bgs, 18-24 inches bgs and immediately above the water table (encountered at 7-15 feet bgs). The samples were analyzed by the FMETL. Four samples were analyzed for VOCs, SVOCs, TAL metals and cyanide. Four samples were analyzed for SVOCs, pesticides, PCBs, TAL metals and cyanide. Four samples were analyzed for VOCs. One sample (coal ash) was analyzed for VOCs, SVOCs, TAL metals and cyanide.

There were no detections of VOCs or cyanide in the 12 soil samples and one coal ash sample. The detections of SVOCs, pesticides and PCBs and TAL metals are discussed below in **Sections 5.1.1**, **5.1.2**, and **5.1.3**, respectively. The laboratory analytical results for soil sampling are summarized in **Table 5-1**. The results were compared to the NJDEP Residential Direct Contact Soil Cleanup Criteria (RDCSCC). Analytes detected above the respective NJDEP cleanup criteria in **Table 5-1** are highlighted and bold typeface. Analytes for soil samples that exceeded the RDCSCC are shown in **Figure 5-1**. The laboratory chain-of-custody forms for soil samples are provided in **Appendix D.**

5.1.1 Semi-Volatile Organic Compounds

A total of 17 SVOCs were detected in soil samples. Five SVOCs were detected at concentrations exceeding their respective NJDEP RDCSCC, and the remaining 12 SVOCs were detected at concentrations below their respective NJDEP RDCSCC. There were no SVOCs detected in the coal ash sample.

Benzo(a)anthracene was detected above the RDCSCC of 0.9 mg/kg in one soil sample (0-2') collected from one monitoring well boring location (CW3A-MW3) at a concentration of 8.2 mg/kg.

Benzo(a)pyrene was detected above the RDCSCC of 0.66 mg/kg in one soil sample (0-2') collected from one monitoring well boring location (CW3A-MW3) at a concentration of 6.2 mg/kg.

Benzo(b)flouranthene was detected above the RDCSCC of 0.9 mg/kg in one soil sample (0-2') collected from one monitoring well boring location (CW3A-MW3) at a concentration of 3.3 mg/kg.

Benzo(k)flouranthene was detected above the RDCSCC of 0.9 mg/kg in one soil sample (0-2') collected from one monitoring well boring location (CW3A-MW3) at a concentration of 4.3 mg/kg.

Indeno(1,2,3-cd)pyrene was detected above the RDCSCC of 0.9 mg/kg in one soil sample (0-2') collected from one monitoring well boring location (CW3A-MW3) at a concentration of 2.8 mg/kg.

5.1.2 Pesticides and PCBs

No pesticides or PCBs were detected above their respective RDCSCC at the site.

5.1.3 TAL Metals

A total of 21 TAL metals were detected in site soil samples. Three metals were detected at concentrations above their respective NJDEP RDCSCC, and the remaining 18 TAL metals were detected at concentrations below their respective NJDEP RDCSCC.

Barium was detected above the RDCSCC of 700 mg/kg in one soil sample (6-8') collected from one monitoring well boring location (CW3A-MW2) at a concentration of 729.8 mg/kg.

Cadmium was detected above the RDCSCC of 1.0 mg/kg in two soil samples and the coal ash sample. Concentrations ranged from 2.021 mg/kg at monitoring well boring location CW3A-MW3 (4-6') to 5.646 mg/kg in the coal ash sample.

Zinc was detected above the RDCSCC of 1,500 mg/kg in the coal/ash sample at a concentration of 1,842 mg/kg.

5.2 Groundwater Sampling Results

A total of 110 groundwater samples were collected to evaluate potential chemical impacts to groundwater from the CW-3A Landfill site. This section presents a discussion of the results of laboratory analyses collected for the 14 quarterly rounds of groundwater sampling and two additional low-flow rounds that were collected from December 1997 through January 2001 from the four monitoring wells at the CW-3A Landfill site. The four monitoring wells (CW3A-MW1, CW3A-MW2, CW3A-MW3 and CW3A-MW4) were installed on December 17, 1997. The groundwater samples were collected by the DPW and analyzed for VOCs, SVOCs, pesticides, PCBs, ammonia, cyanide and TAL metals. The two additional rounds of sampling (low-flow #1 and low-flow #2) were conducted on August 24, 2000 and October 4, 2000, using a low-flow groundwater sampling technique for TAL metals. As stated above, a low flow sampling methodology was proposed for use by the DPW and accepted by the NJDEP to assess the impact of suspended sediments on the dissolved phase metals concentrations at the CW-3A Landfill site.

As discussed in **Section 2.4.2**, Fort Monmouth is underlain by a Class III-A aquifer. The appropriate groundwater quality criteria for Class III-A are the criteria for the most stringent classification for vertically or horizontally adjacent ground waters that are not Class III-A (NJAC 7:9-6.7e). The NJDEP criteria used for comparison of groundwater analytical results were the higher of the Practical Quantitation Limits (PQLs) and the NJDEP GWQC for Class II-A aquifers (NJAC 7:9-6, Table 1).

Four VOCs were detected in site groundwater at concentrations below the NJDEP criteria. Seven SVOCs were detected in site groundwater at concentrations below the NJDEP criteria. There were no pesticides, PCBs or cyanide detected in site groundwater. A total of 23 TAL metals were detected in site groundwater. Seventeen TAL metals were detected at concentrations exceeding their respective NJDEP criteria, and the remaining six TAL metals were detected below their respective NJDEP criteria. Analytes detected in groundwater samples at concentrations above the NJDEP criteria are bold and highlighted in **Table 5-2**.

5.2.1 Volatile Organic Compounds

No VOCs were detected above their respective GWQC at the site.

5.2.2 Semi-Volatile Organic Compounds

No SVOCs were detected above their respective GWQC at the site.

5.2.3 Pesticides and PCBs

No pesticides or PCBs were detected at the site.

5.2.4 TAL Metals

During 12 groundwater sampling rounds and two low-flow sampling rounds, a total of 17 TAL metals were detected above their respective NJDEP GWQC in at least one sample at the CW-3A Landfill site. In four of the quarterly groundwater sampling rounds, TAL metals were not analyzed.

Aluminum was detected at concentrations exceeding the GWQC of 200 ug/L during 11 separate rounds of sampling collected at four separate monitoring well locations. Concentrations ranged from 214 ug/L in CW3A-MW1 (sampling round #11) to 367,000 ug/L in CW3A-MW3 (sampling round #9).

Antimony was detected at concentrations exceeding the GWQC of 20 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 27.1 ug/L (sampling round #9).

Arsenic was detected at concentrations exceeding the GWQC of 8.0 ug/L during seven separate rounds of sampling collected at four separate monitoring well locations. Concentrations ranged

from 8.12 ug/L in CW3A-MW2 (sampling round #7) to 587 ug/L in CW3A-MW3 (sampling round #9).

Barium was detected at concentrations exceeding the GWQC of 2,000 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 2,250 ug/L (sampling round #9).

Beryllium was detected at concentrations exceeding the GWQC of 20 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 26.1 ug/L (sampling round #9).

Cadmium was detected at concentrations exceeding the GWQC of 4.0 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 266 ug/L (sampling round #9).

Chromium was detected at concentrations exceeding the GWQC of 100 ug/L during three separate rounds of sampling collected at two separate monitoring well locations. Concentrations ranged from 108.5 ug/L in CW3A-MW1 (sampling round #2) to 6,190 ug/L in CW3A-MW3 (sampling round #9).

Copper was detected at concentrations exceeding the GWQC of 1,000 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 14,400 ug/L (sampling round #9).

Iron was detected at concentrations exceeding the GWQC of 300 ug/L during 12 separate rounds of sampling collected at four separate monitoring well locations. Concentrations ranged from 426 ug/L in CW3A-MW1 (sampling round #12) to 1,020,000 ug/L in CW3A-MW3 (sampling round #9).

Lead was detected at concentrations exceeding the GWQC of 10 ug/L during five separate rounds of sampling collected at three separate monitoring well locations. Concentrations ranged from 16 ug/L in CW3A-MW1 (sampling round #2) to 1,010 ug/L in CW3A-MW3 (sampling round #9).

Manganese was detected at concentrations exceeding the GWQC of 50 ug/L during 12 separate rounds of sampling collected at four separate monitoring well locations. Concentrations ranged from 61.8 ug/L in CW3A-MW1 (sampling round #1) to 9,680 ug/L in CW3A-MW3 (sampling round #9).

Mercury was detected at concentrations exceeding the GWQC of 2.0 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 5.1 ug/L (sampling round #9).

Nickel was detected at concentrations exceeding the GWQC of 100 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 1,050 ug/L (sampling round #9).

Selenium was detected at concentrations exceeding the GWQC of 50 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 73.8 ug/L (sampling round #9).

Silver was detected at concentrations exceeding the GWQC of 20 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 118 ug/L (sampling round #9).

Sodium was detected at concentrations exceeding the GWQC of 50,000 ug/L during nine separate rounds of sampling collected at three separate monitoring well locations. Concentrations ranged from 52,100 ug/L in CW3A-MW3 (sampling round #13) to 132,000 ug/L in CW3A-MW1 (sampling round #8).

Zinc was detected at concentrations exceeding the GWQC of 5,000 ug/L during one separate round of sampling collected at one separate monitoring well location (CW3A-MW3) at a concentration of 33,900 ug/L (sampling round #9).

5.2.5 Wet Chemistry

The wet chemistry analyses were performed by the FMETL during the first two quarterly sampling rounds (#1 and #2) conducted during in the remedial investigation at the CW-3A Landfill site. The wet chemical analyses included ammonia and cyanide. Cyanide was not detected at the CW-3A Landfill site.

Ammonia was detected above the NJDEP criteria of 0.10 mg/L during two separate rounds of groundwater sampling collected at four separate monitoring well locations. Concentrations ranged from 0.21 mg/L in CW3A-MW1 (sampling round #1) to 6.81 mg/L in CW3A-MW1 and CW3A-MW4 (sampling round #2).

5.3 Contaminants of Concern

Based on the soil and groundwater sample results discussed above, there are no contaminants of concern (COCs) in both soil and groundwater at the CW-3A Landfill site. The analysis that led to this result is discussed below.

5.3.1 Contaminants of Concern Analysis for Soils

There were no VOCs, pesticides or PCBs detected in the soil samples or in the coal ash sample at concentrations in excess of their respective RDCSCC criteria.

Five SVOCs were detected in one soil sample CW3A-MW3 (0.0-2.0'), at concentrations above the RDCSCC. Due to the low levels of detection of these SVOC analytes at concentrations above their respective RDCSCC, they are not considered to be COCs in soil at the CW-3A Landfill site.

Three metals were detected in soil samples collected from the CW-3A Landfill site at concentrations in excess of their respective RDCSCC criteria. Of these 3 metals, two metals are native constituents of soils at the Charles Wood Area and are not considered to be COCs. Cadmium was detected above the RDCSCC in two borehole locations (CW3A-MW2 and CW3A-MW3). Due to the low levels of detection of cadmium in soil from these two locations, cadmium is not considered to be a COC in soil at the CW-3A Landfill site.

5.3.2 Contaminants of Concern Analysis for Groundwater

There were no VOCs, SVOCs, pesticides, PCBs or cyanide detected in the groundwater samples collected from the CW-3A Landfill site at concentrations exceeding their respective NJDEP GWQC.

Ammonia was detected above the NJDEP criteria of 0.010 mg/L in two sampling rounds collected at each of the four monitoring wells at concentrations ranging from 0.21 mg/L to 6.81 mg/L. Since the ammonia concentrations are within an order of magnitude of the NJDEP GWQC, ammonia is not considered to be a COC in groundwater at the CW-3A Landfill site.

There were 17 TAL metals that were detected in the CW-3A Landfill site groundwater at concentrations exceeding their respective NJDEP GWQC. **Table 5-3** summarizes the process used to identify COCs in groundwater at the CW-3A Landfill site. These specific exceedences and the identification of each constituent as a potential COC are discussed below. None of these 17 TAL metals were found to be COCs in the groundwater at the CW-3A Landfill site.

The 17 different metals that were detected in site groundwater at concentrations exceeding the NJDEP GWQC are distinguished into background and non-native metals. The indigenous metals are compared to the Maximum Background Concentrations (MBC) for the Charles Wood Area (Weston 1995), and presented in **Tables 5-1** and **5-3.** The non-native metals are discussed in relation to the NJDEP GWQC only.

Of the 17 TAL metals detected that exceeded the NJDEP cleanup criteria, eight metals (aluminum, barium, copper, iron, manganese, nickel, sodium and zinc) are common background constituents in Monmouth County and the Charles Wood Area soils. The water chemistry in areas underlain by glauconitic sediments (such as Red Bank, Tinton and Hornerstown Sands) is dominated by calcium, magnesium, manganese, aluminum and iron. Elevated concentrations of these metals are routinely observed in groundwater samples collected at Fort Monmouth. The groundwater analytical results for aluminum, iron and manganese were compared to their respective MBCs of 121,000 ug/L, 431,000 ug/L and 331 ug/L. The groundwater analytical results for (aluminum, barium, copper, iron, manganese, nickel, sodium and zinc) were compared with the low flow sampling results to their respective MBCs. In consideration of these facts, these eight background metals are not considered to be COCs in groundwater in the CW-3A Landfill site.

There were nine non-native metals detected in site groundwater at the CW-3A Landfill site that exceeded the NJDEP GWQC (antimony, arsenic, beryllium, cadmium, chromium, lead, mercury,

selenium and silver). The groundwater analytical results are compared with the low-flow sampling results and to their respective GWQC.

The two separate rounds of low-flow sampling (August 24, 2000 and October 4, 2000) were collected during the quarterly groundwater sampling program, using the low-flow groundwater sampling technique as discussed in **Section 3.2.1**. This technique was used to determine if the detected metal concentrations observed in the groundwater samples are a function of entrained sediments suspended in the groundwater during the course of well purging and sampling activities, or an accurate representation of dissolved phase aquifer/groundwater conditions. In the two low-flow sampling rounds, there were no detections or lower concentrations of these nine uncharacteristic metals (antimony, arsenic, beryllium, cadmium, chromium, lead, mercury, selenium and silver) above the NJDEP GWQC. Therefore, these nine non-native metals were determined not to be COCs in groundwater at the CW-3A Landfill site.

5.4 Quality Assurance/Quality Control

To verify the reliability of the analytical results, VERSAR reviewed the holding times for each sample and the results of the analysis of 17 method blanks for VOCs, 12 method blanks for SVOCs, nine method blanks for pesticides and PCBs, 12 method blanks for TAL metals, 14 trip blanks, 13 field blanks and 14 field duplicate samples. Samples were analyzed by the FMETL within the prescribed holding time requirements for each analytical method.

Method Blanks

Laboratory method blanks accompanied each batch of samples for the CW-3A Landfill site. These method blanks consist of laboratory grade water that is processed identically to the samples and analyzed with the sample batch. A total of 17 method blanks for VOCs, 12 method blanks for SVOCs, nine method blanks for pesticides and PCBs and 12 method blanks for TAL metals were analyzed with the CW-3A Landfill site samples.

Two SVOCs were detected in at least one method blank sample. These SVOCs were benzyl alcohol and di-n-butylphthalate. Neither of these SVOCs were detected at a concentration exceeding their respective NJDEP criteria. Their presence in only a few samples is not indicative of a widespread laboratory contamination problem.

Several metals were detected in at least one method blank sample, including aluminum, antimony, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. All of the metals were detected in only a few samples at very low concentrations. Their presence in only a few samples is not indicative of a widespread laboratory contamination problem.

Trip Blanks

Fourteen trip blanks were included as part of the CW-3A Landfill site sampling program to document that volatile organics were not introduced into the samples during the handling process. The trip blanks were prepared by the FMETL and consisted of sample bottles filled with laboratory deionized water. The trip blanks remained with the sample bottles in coolers and were returned to the laboratory for analysis with the groundwater samples.

Two VOCs were detected in at least one trip blank. Chloroform was detected in four of the 14 trip blanks, with no detections exceeding the NJDEP criteria Methylene chloride was detected in one of the trip blanks at a concentration exceeded its NJDEP criteria. However, methylene chloride is a common laboratory contaminant. The detections of chloroform indicate that the sample handling procedures, including the sample glassware, may have introduced contamination into the sampling and analysis process.

Field Blanks

One field blank sample was obtained during the sampling activities each day to document the equipment decontamination procedures. A total of 13 field samples (e.g., field blanks) were collected during the CW-3A Landfill site sampling events. The field blanks were collected by rinsing deionized water, supplied by the laboratory, over the sampling equipment used for daily activities. The water was collected in clean laboratory-supplied sample jars and submitted for analysis along with the CW-3A Landfill site groundwater samples.

The results of the field blank analyses showed that two VOCs were detected in at least one field blank. Chloroform was detected in four of the 13 field blanks, all at concentrations below the NJDEP criteria. Methylene chloride was detected in one field blank at a concentration exceeding its NJDEP criteria. As noted for the trip blanks, methylene chloride is a common laboratory contaminant, and the detections of chloroform indicate that the sample handling procedures, including the sample glassware, may have introduced contamination into the sampling and analysis process. In addition, the same VOCs found in the field blanks were also found in the trip blanks, suggesting that the sampling and decontamination procedures did not introduce additional contamination.

Two SVOCs, bis(2-ethylhexyl) phthalate and di-n-butylphthalate, were each detected in at least one of the field blank samples. Both analytes were detected at low concentrations that are below their respective NJDEP criteria. In addition, di-n-butylphthalate was also identified in the method blanks; therefore, its presence in the field blank samples does not suggest that the sampling and decontamination procedures introduced additional contamination.

As noted for the method blanks, several metals were detected in at least one field blank sample, including aluminum, antimony, barium, calcium, chromium, copper, iron, magnesium, manganese, nickel, potassium, sodium and zinc. All of the metals were detected in only a few samples at very low concentrations. Because these metals were also detected in the method blank samples, the sampling and decontamination procedures do not appear to have been the source of sample contamination. However, any subsequent evaluation of the metals analytical results must account for the possibility of laboratory contamination resulting in false positives for the environmental samples.

Duplicate Samples

Fourteen field duplicate samples were also collected during the CW-3A Landfill site sampling events to verify the consistency of the entire sampling and analytical procedure. The results for all of the duplicate samples were close to those obtained for the original samples. The relative percent differences (RPDs), which are the differences between the two samples being compared divided by their average, indicate the relative levels of precision maintained by the laboratory

throughout its analytical procedures. The RPDs for the soils duplicate samples was 41.4%. The RPDs for the duplicate samples VOCs ranged from 1.1% to 10.2%, and their average RPD was 7.2%. The RPDs for the duplicate samples SVOCs ranged from 14.4% to 50.5%, and their average RPD was 32.5%. These RPDs are very near the established limit of 30% for laboratory duplicate samples and indicate that a high level of precision was maintained throughout the sampling and analytical procedures.

The RPDs for the duplicate samples metals analyses ranged from 0.0% to 194.0%, however, the average RPDs for all of the metals results is 41.9%. This indicates that, overall, good precision was maintained, but that the metals results were much more varied than those for the VOCs or SVOCs. The apparent metals contamination noted in the method and field blanks may have impacted the precision of the metals analysis.

The QC sample results indicate good precision for all of the analyses. However, the presence of metals in the method blanks and field blanks indicate that contamination may have been introduced by the sampling and analysis procedures. Therefore, any subsequent evaluation of the metals analytical results must account for the possibility of laboratory contamination resulting in false positives for the environmental samples.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Geologic publications show that the CW-3A Landfill site is located within an aquitard (the Navesink-Hornerstown Confining Unit). The low hydraulic conductivity of the aquitard and the thickness of the aquitard at the site conform to the requirements of a Class III-A aquifer, as specified in the NJDEP GWQS (NJAC 7:9-6, January 7, 1993).

The soil sample analytical results from the 12 samples and one coal ash sample collected in December 1997 from the CW-3A Landfill site indicate that the five SVOCs were detected in soils at concentrations in excess of their respective RDCSCC criteria. However, based on the low levels of detection of these five SVOCs in soils, there are no COCs for soils at the CW-3A Landfill site. Therefore, NFA is required regarding soils at the CW-3A Landfill site.

The analytical results for the groundwater samples collected at the CW-3A Landfill site between December 1997 and January 2001 indicate that no COCs exist within the CW-3A Landfill site groundwater. The Class II-A criteria were used for comparison with site-specific data obtained from the various groundwater sampling rounds because the GWQS (NJAC 7:9-6.7e) state that the groundwater quality criteria to be used for Class III-A aquifers are the most stringent criteria associated with vertically or horizontally adjacent groundwaters that are not Class III-A.

Based on the results of the groundwater quality evaluation, no VOCs, SVOCs, pesticides or PCBs were detected above the NJDEP GWQC. The analytical results indicate 17 TAL metals detected in groundwater samples at concentrations exceeding the NJDEP GWQC. However, none of these metals are considered to be COCs in site groundwater due to the process of elimination via categorization of background metals, reduction in concentration or non-detection of samples by low flow sampling, and elimination of isolated and marginal detections. Therefore, no COCs exist at the CW-3A Landfill site, and NFA is required regarding groundwater at the CW-3A Landfill site.

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TABLES

FIGURES

APPENDICES

APPENDIX A

Roy F. Weston, Inc. Site Investigation Report, December 1995
Excerpts from Section 4.3 – Background Sampling and Debris Site CW-3A

APPENDIX B

Soil Boring Logs and Monitoring Well Construction Records

APPENDIX C

Current Conditions Site Photograph

APPENDIX D

Soil Laboratory Data Sheets

APPENDIX E

Groundwater Laboratory Data Sheets