U.S. Army
Fort Monmouth, New Jersey

Remedial Investigation Report Addendum

Building 296

Fort Monmouth, New Jersey

January 4, 2011
Revised June 2011

REMEDIAL INVESTIGATION REPORT ADDENDUM
FOR BUILDING 296
FORT MONMOUTH, NEW JERSEY

PREPARED FOR:

U.S. ARMY FORT MONMOUTH
DIRECTORATE OF PUBLIC WORKS
BUILDING 167
FORT MONMOUTH, NJ 07703

PREPARED BY:

TETRA TECH

1000 THE AMERICAN ROAD
MORRIS PLAINS, NJ 07950

January 4, 2011
Revised June 2011

TETRA TECH EM INC. PROJECT NO. 103G1058223.013

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EXECUTIVE SUMMARY

Tetra Tech, Inc. (Tetra Tech) has been contracted by the U.S. Army Garrison, Fort Monmouth Directorate of Public Works (DPW) to prepare a Remedial Investigation Report Addendum (RIRA) to document ground water conditions at Building 296 located in the Main Post area of Fort Monmouth, New Jersey. This report addresses the remedial investigation activities performed at this site to investigate ground water conditions from May 2001 to September 2010.

Building 296 is located in the Main Post-West area of the Fort Monmouth Army Base. A total of 12 underground storage tanks (UST) (New Jersey Department of Environmental Protection [NJDEP] Registration Nos. 81533-213 through 223 and 081533-69) were closed at Building 296 between November 2 and November 16, 1993. Versar, Inc. (Versar) prepared 11 UST closure reports in May 2001; NJDEP declared No Further Action (NFA) was necessary for the 11 USTs on January 10, 2003. In February 1996, Smith Environmental Technologies Corporation (Smith) prepared a UST closure report for NDJEP for UST 081533-69, which received an NFA declaration from the NJDEP on **XXXX**.

After observing visibly stained soil on site in November 1993, DPW installed seven monitoring wells in July 1994 (wells 296-MW01, 296-MW02, 296-MW03, 296-MW04, 296-MW06, 296-MW07, and 296-MW08) to monitor ground water in the vicinity of Building 296. The ground water monitoring program associated with the DPW's UST management program includes the seven monitoring wells located at Building 296.

During the 38 quarterly sampling events, one VOC and nine metals were detected in ground water samples at concentrations exceeding their respective NJDEP Ground Water Quality Standard (GWQS). The most recent eight quarters of sampling, from October 2008 to September 2010 were used to define the current ground water quality beneath Building 296 and to determine any contaminants of concern (COC). During the most recent eight sampling quarters, benzene, antimony, arsenic, cadmium, lead, selenium, and thallium were identified as potential COCs for Building 296.

Therefore, based on analytical results for Building 296, further remedial investigation activities at Building 296 are not required. Tetra Tech recommends continued ground water monitoring, in agreement with the fiscal year 2010 Fort Monmouth Base Realignment and Closure (BRAC) Installation Action Plan (BIAP). No Further Action (NFA) is recommended with respect to ground water at Building 296.

1.0 INTRODUCTION

Tetra Tech EM Inc. (Tetra Tech) has been contracted by the U.S. Army Garrison, Fort Monmouth Directorate of Public Works (DPW) to prepare a Remedial Investigation Report Addendum (RIRA) to document ground water conditions at Building 296 located in the Main Post area of Fort Monmouth, New Jersey. This report addresses the remedial investigation activities performed at this site to investigate ground water conditions between May 2001 and September 2010.

This section describes the objectives and organization of this RIRA.

1.1 OBJECTIVES

The objectives of this RIRA are to define aquifer chemical and physical characteristics and to determine the requirement for any potential further remedial activities for Building 296. The remedial investigation (RI) was conducted in accordance with New Jersey Department of Environmental Protection's (NJDEP) New Jersey Administrative Code (NJAC) 7:26E, *Technical Requirements for Site Remediation* (NJDEP 2009) that was current at the time sampling was conducted.

The remedial investigation and subsequent preparation of the RIRA included:

- Characterization of ground water quality at Building 296 area through quarterly ground water sampling events conducted from May 2001 to September 2010
- Comparison of the ground water sample results and monitoring program with the NJDEP Ground Water Quality Standard (GWQS)
- Formulation of a No Further Action (NFA) proposal for consideration by the NJDEP based on the results of field and laboratory investigations and the hydrogeologic conditions at Building 296. The rationale for the NFA proposal is presented in this RIRA.

1.2 REPORT ORGANIZATION

This report is organized to minimize repetition. **Section 2.0** provides background information and a general description of Building 296 area located in the Main Post area of Fort Monmouth. **Section 3.0** describes and summarizes the site activities conducted at Building 296 including ground water sampling from monitoring wells, and aquifer testing. **Section 4.0** presents the physical characterization of Building 296 including lithology and ground water conditions. **Section 5.0** presents the chemical characterization of Building 296 and includes ground water sampling results and the determination of potential contaminants of concern (COC). Conclusions and recommendations for Building 296 are presented in **Section 6.0**. References used to prepare this report are listed following Section 6.0.

2.0 SITE BACKGROUND AND ENVIRONMENTAL SETTING

The following sections describe Building 296 background information and the environmental setting of the area surrounding Fort Monmouth and Building 296. Specifically, this section describes the site and its location, summarizes site background information, presents current site conditions, and portrays the environmental setting of Building 296 at the Fort Monmouth installation.

2.1 SITE LOCATION AND DESCRIPTION

Fort Monmouth is located in the eastern-central 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 bordered to the north by Parkers Creek, to the northeast by New Jersey Transit Railroad, to the east by State Highway 35, to the south/southeast by Oceanport Creek, and to the south by residential areas. The Main Post was established in 1918 during World War I as an U.S. 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 primary mission of Fort Monmouth is to provide command, administrative, and logistical support for U.S. Army Headquarters' Communications and Electronics Command (CECOM). CECOM is a major subordinate command of the U.S. Army Material Command (AMC) and is the host tenant at Fort Monmouth.

2.2 SITE BACKGROUND

In the early 1990s, the DPW developed an underground storage tank (UST) program for managing approximately 506 USTs located throughout the Fort Monmouth installation (Main Post and Charles Wood Areas). This program was undertaken to replace the use of heating oil as a major energy source with natural gas. DPW's approach involved installing new gas lines and new gas-fed boilers and removing the non-regulated (residential) USTs. Since 1990, approximately 97 percent of the USTs at Fort Monmouth have been removed. As part of DPW's UST management program, 12 UST closure reports have been submitted to the NJDEP for the USTs at Building 296 (**Figures 2-2 and 2-3**). Utilities servicing Building 296 are depicted on **Figure 2-4.** Wetlands at the Main Post are depicted on **Figure 2-5**.

This section summarizes background information for the Building 296 UST removal activities presented in reports written for the site.

2.2.1 November 1993 UST Closure and Site Investigation Report for Building 296 (Smith 1996)

According to the February 1996 UST Closure and Site Investigation Report, Building 296, Main Post Area, prepared by Smith Environmental Technologies Corporation (Smith) for the DPW (**Appendix A**), one 550-gallon No. 2 steel UST was closed by removal on November 16, 1993.

Approximately 8 cubic yards of potentially contaminated soils were removed from the excavation. Post-excavation samples were collected and analyzed for Total Petroleum Hydrocarbons TPHC. All sample analytical results were less than the NJDEP Residential Direct Contact Soil Cleanup Criteria (RDCSCC) for TPHC. An NFA recommendation was given for the site with regard to the closure and site assessment.

2.2.2 Site Investigation Report for Main Post and Charles Wood Areas (Weston 1995)

In the Site Investigation Report (SIR) - Main Post and Charles Wood Areas, Fort Monmouth, New Jersey, dated December 1995, Roy F. Weston, Inc. (Weston) summarized findings of q 1993 site inspection (SI). The report indicated that the historic fill area near the vicinity of Building 296 was used after 1919 as an Army Signal School Training Area (**Appendix B**). Diesel and gasoline generators, situated approximately 150 meters from Parkers Creek, were used to support field exercises. Weston suspected that numerous fuel spills that occurred in the area of the generator had potentially impacted the area. A riot control agent was also used in this area for troop protective mask training. During the 1993 site inspection, a suspected debris disposal area used for building rubble was discovered in the area north of Building 289 (Weston 1995).

As part of the SI of the Fort Monmouth military installation, Weston conducted soil sampling, monitoring well installation, and sampling and geophysical surveying. In addition to sampling soil and ground water at sites throughout the Main Post and Charles Wood areas of Fort Monmouth, Weston established background concentrations for soil and ground water for the installation. These background concentrations have been used by the DPW for comparing sample results for native constituents of soil and ground water (see **Section 5.2**) (Weston 1995).

As presented in the Weston SIR, several natural and anthropogenic factors contribute to the wide range in concentrations of metals in soils, which further impact the concentration of metals in ground water. 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 ground water, particularly when sediments are entrained in the collected ground water samples (Weston 1995).

DPW proposed using a low-flow sampling methodology to assess the impact of entrained sediments on the dissolved-phase metals concentrations at Fort Monmouth, and NJDEP accepted the proposal. 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 (Weston 1995).

2.2.3 Remedial Investigation Report for Building 296 (Versar 2001)

According to Versar, Inc.'s (Versar) UST Closure and Site Investigation Report, Building 296, Main Post West Area, Fort Monmouth, New Jersey, dated May 2001 (**Appendix C**), eleven 1,000 to 2,000-gallon USTs located immediately south of Building 296 were removed in November 1993. Nine of the USTs contained gasoline and two of the USTs contained diesel fuel. Between November 1993 and January 1994, approximately 16 cubic yards of visually stained soils and approximately 487 feet of piping were removed adjacent to the closed USTs and were disposed off site. During UST closure, numerous holes were observed in the USTs and a total of 81 post-excavation soil samples were collected from the excavation areas. The post-excavation soil samples were analyzed for TPHC, volatile organic compounds (VOC) plus 15 Tentatively Identified Compounds (TICs) and lead (Versar 2001).

Based on visibly stained soil observed on site in November 1993, DPW installed seven monitoring wells in July 1994 (wells 296-MW01, 296-MW02, 296-MW03, 296-MW04, 296-MW06, 296-MW07, and 296-MW08) to monitor ground water in the vicinity of Building 296. The wells extended through the landfill materials to native material. The wells were constructed with 4-inch diameter 20-Slot PVC to maximum finished depth ranging from 10 to 12.5 ft. Ground water was encountered during well construction at depths ranging from 1.5 feet (below ground surface (bgs to 3.5 ft bgs). The locations of these monitoring wells are depicted in **Figure 2-6**. The monitoring well records for these wells are provided in **Appendix D**. The seven wells at Building 296 were sampled quarterly and analyzed for VOCs plus 15 TICs, SVOCs plus 15 TICs, pesticides, polychlorinated biphenyls (PCB) and total analyte list (TAL) metals (Versar 2001).

The May 2001 Closure and Site Investigation Report presents soil sample results for samples collected between November 1993 and January 1994, and ground water sample results for samples collected between November 1994 and August 2000. None of the target analytes were detected in the post-excavation soil samples at concentrations exceeding applicable NJDEP RDCSCC. The ground water sample analytical results indicated that benzene and 14 metals were detected at concentrations exceeding their respective NJDEP GWQS (Versar 2001).

2.2.4 Remedial Investigation Report for M-18 Landfill (Versar 2003)

According to Versar's Remedial Investigation Report for the M-18 Landfill Site (including Building 296), Main Post West Area, Fort Monmouth, New Jersey, dated October 2003 (**Appendix E**), quarterly ground water monitoring was conducted from June 1997 to February 2001 at the M-18 Landfill, including Building 296. The ground water monitoring program consisted of 16 quarterly rounds and two low-flow rounds of sampling (Versar 2003).

Benzene, arsenic, cadmium, chromium, and lead were identified as contaminants of concern (COC) in ground water at the M-18 Landfill site including Building 296. Ground water modeling and a sensitive receptor survey were conducted to determine whether ground water from the M-18 Landfill site could impact surface water, off-site domestic wells, and adjacent aquifers. The ground water modeling illustrates that the impact of the metals in ground water is minimal because of the low hydraulic conductivity of the geologic formations, sorption of the

metals to the soil (retardation), and the correspondingly low potential for contaminant migration. The benzene detected at two monitoring well locations is shown to biodegrade to concentrations less than the NJDEP Class II-A GWQS in approximately 5 years, with minimal potential for migration into Parkers Creek. The sensitive receptor survey indicates that there are no domestic or irrigation wells in proximity to the M-18 Landfill site and adverse impacts to human health, public welfare, or the environment are unlikely (Versar 2003).

No further ground water monitoring and remedial investigation activities at the M-18 Landfill site including Building 296 were recommended. An NFA determination was requested with respect to ground water at the site (Versar 2003).

2.2.5 NJDEP Comments on RI Reports (NJDEP 2007)

In a letter dated August 14, 2007, NJDEP listed several comments regarding the RI Reports for M-18 Landfill site and associated Building 296. The comments that may apply to Building 296 stated in the letter are as follows:

Soil – UST Removal

- Based on the information provided in the RI report (Versar 2003), no further investigation of soil is required for Building 296.

Ground Water

- Because existing wells may not have been sampled since 2001, an additional round of sampling of all wells is required for remedial decision making. Samples should be analyzed for target compound list (TCL) VOCs, methyl tertiary butyl ether (MTBE), tert-butyl alcohol (TBA), TCL semivolatile organic compounds (SVOC), and TAL metals.
- NJDEP required the U.S. Army to submit a map depicting the former locations of all USTs and the existing M-18 monitoring wells. The Army was required to justify the locations of monitoring wells in relation to the USTs, demonstrate that ground water contamination was delineated, and document whether gasoline stored was leaded or unleaded.
- NJDEP required that paper copies of all sampling documentation (such as ground water field parameters and low-flow sampling sheets) be submitted in summary tables in reports.

2.2.6 Public Notification

In accordance with the Notification and Public Outreach Rule of the NJDEP TRSR (N.J.A.C. 7:26E-1.4), Fort Monmouth established a Restoration Advisory Board (RAB) in 2006 with representatives from the local municipalities vested in a variety of interests and viewpoints. The RAB acts as a focal point to exchange information between Fort Monmouth and the local communities regarding environmental and restoration activities and meets on a quarterly basis to review and comment on on-going environmental work. The meetings are open to the public and

are advertised in local newspapers. All environmental projects subject to the NJDEP TRSR are presented at the RAB.

Although the Public Notification requirements were amended in 2009 with the implementation of signs or periodic letters to inform the public of on-going environmental work, on June 17, 2010, Fort Monmouth requested that the NJDEP grant approval of an alternate notification and public outreach plan using the existing RAB and document repository of Fort Monmouth environmental reports, which is accessible to the public. The NJDEP response indicated that the alternative plan provided adequate public notice and complied with the intent of 7:26E-1.4; NJDEP approved the request on June 24, 2010.

Copies of public notification documents are presented in **Appendix F**.

2.2.7 Baseline Ecological Evaluation (BEE)

Shaw Environmental, Inc. was contracted by the Army to conduct a BEE for Fort Monmouth's Main Post and Charles Wood Areas. Sampling of multiple media was conducted in 2010, the results of which are not available for discussion herein. The final BEE will be submitted to the NJDEP under separate cover in June 2011.

2.3 CURRENT CONDITIONS

On October 22, 2010, Tetra Tech conducted a site drive-through to assess current conditions at Building 296. The site currently consists of Building 296, which is used by DPW as office space and equipment storage, a parking area used for storage of construction and army vehicles, and grassy areas along Riverside Drive.

2.4 ENVIRONMENTAL SETTING

The description of the geological/hydrogeological setting of the area surrounding Building 296 is presented in the 2003 RIR (**Appendix E**). This section describes the regional and local geology, hydrogeology, and topography and surface drainage in the area surrounding Fort Monmouth and the Main Post and Charles Wood areas of the installation.

2.4.1 Regional and Local Geology

Monmouth County lies within the New Jersey Section of the Atlantic Coastal Plain physiographic province. The M-18 Landfill site, which includes Building 296, is located in what may be referred to as the Outer Coastal Plain subprovince, or the Outer Lowlands.

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 to 60 feet per mile and were deposited on Precambrian and lower Paleozoic rocks. 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 that 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 (i.e., from several feet to several hundred feet). The Coastal Plain deposits thicken to the southeast from the Fall Line (i.e., a boundary zone between older, resistant rocks and younger, softer plain sediments) to greater than 6,500 feet in Cape May County.

Based on the regional geologic map, 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. 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 to 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. Ground water occurs beneath the site at a depth of approximately 2 to 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. 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 a brown silt in Monmouth County.

As presented in Weston's 1995 SI Report, several natural and anthropogenic factors contribute to the wide range in concentrations of metals in soils, which further impact the concentration of metals in ground water. 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 ground water, particularly when sediments are entrained in the collected ground water samples (Weston 1995).

A Basewide Glauconitic Investigation Report was completed by DPW in March 2011 and a Background Metals Evaluation was prepared by Brinkerhoff for DPW in May 2011. Both documents indicate the potential for soil particles present in ground water samples which are potentially affecting the metals analysis results in ground water samples collected from the overall FTMM site. Additional ground water sampling including the comparison of filtered and unfiltered samples results has been proposed to determine the potential affect of soil particles on metals analysis results. Results and conclusions from these future sampling events will be provided to NJDEP under separate cover.

The Basewide Glauconitic Investigation Report and the Background Metals Evaluation Report are provided in **Appendix G**.

2.4.2 Hydrogeology

A description of the hydrology of the site is provided in **Section 2.4.2** of the 2003 RIR (**Appendix E**).

A, was prepared by Brinkerhoff Environmental Services, Inc. (Brinkerhoff) prepared the MODFLOW Ground water Modeling Report, dated June 10, 2010, included as **Appendix H**. Brinkerhoff developed and refined site-wide ground water models for both the Main Post and the Charles Wood areas.

As part of the ground water modeling project, Brinkerhoff performed a Preliminary Tidal Evaluation of select monitoring wells throughout the Main Post of Fort Monmouth. The study locations were mutually selected by Brinkerhoff and representatives of Fort Monmouth. These locations were chosen to represent an overall profile for the Main Post area. On September 29, 2009, wireless downhole data loggers were placed into each of the 25 predetermined ground water monitoring wells targeted for the study of the Main Post area. Data was collected for approximately 30 days (Brinkerhoff 2010).

Monitoring wells 296-MW01 and 296-MW06 were included in this evaluation within Building 296. Building 296 is south of Parkers Creek between the M-8 and M-18 Landfills. Tidal influence was not found to be evident in the area, although 296MW06 exhibited short-term tidal impact under extremely high water conditions. Additionally, ground water elevation data indicate exaggerated ground water fluctuations congruent with heavy rainfall amounts recorded during the period of the evaluation, indicating high susceptibility to surface water infiltration. Areas with ground water elevations less than 5 feet above mean sea level (amsl) are considered to be within the primary zone of potential tidal influence. Ground water elevations from 296-MW01 and 296-MW06 for Building 296 used in the evaluation ranged from 3.75 to 7.5 feet amsl; therefore, there is potential for tidal influence (Brinkerhoff 2010).

According to the modeling report, the suggested ground water flow directions indicated by the ground water flow model are generally consistent with that seen in previous ground water investigations and are also favorable when compared to ground water contour maps prepared using field depth-to-water measurements collected on January 28, 2010. The ground water contour map for the January 2010 measurements at Building 296 area created as part of the ground water modeling report is included in **Appendix H** of this report. The ground water contour map suggests that ground water at the site flows radially from the northwest to the northeast (Brinkerhoff 2010).

In general, ground water flows from areas of relatively high topographic elevations toward lower topographic elevations where site surface water features are present. The MODFLOW simulation shows that the central portion of the Main Post is a relative high (ground water divide) because this portion of Fort Monmouth is almost completely surrounded by low-

elevation surface water. The Main Post area can be characterized as having a small hydraulic gradient. When combined with the low hydraulic conductivity of the aquifer materials, this translates into very slow ground water migration. Particle markers, which represent typical travel paths and speeds for water molecules in the system, indicate extremely long travel times. In several areas of the Main Post, representative markers did not reach the nearest surface water sink within the 200-year travel time shown. As a result of the slow ground water velocity, recharge to the aquifer from rainfall, although very limited, has the effect of adding a downward component to the ground water flow.

The physical conditions of the site would likely contribute to ground water contaminant plumes with a dominant elongation in a downgradient direction. Vertical contaminant migration would typically be heavily impeded by the fine-grained aquifer materials present at depth.

2.4.3 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 land surface at the Main Post is relatively flat and ranges in elevation from approximately 4 feet amsl in the east at Oceanport Creek to 32 feet amsl at the western end of the post, near Highway 35. The eastern half of the post is generally 10 feet amsl in elevation.

Surface water runoff from the western part of the Main Post flows into Lafetra Creek to the north or into Mill Creek to the south. Both Mill Creek and Lafetra Creek originate off post. Mill Creek is channeled and flows along the southern boundary of the Main Post, turning north just past the Auto Craft Shop. Lafetra Creek forms the northern boundary of the Main Post and joins Mill Creek to form Parkers Creek. Parkers Creek flows east along the northern boundary and joins Oceanport Creek east of the post. Most of Parkers Creek, Lafetra Creek, and Mill Creek are tidally influenced.

The U.S. Fish and Wildlife Service (FWS) National Wetland Inventory Long Branch quadrangle maps indicate the presence of wetlands at the Main Post. Parkers Creek and Oceanport Creek are classified as estuarine intertidal aquatic beds. The area of Parkers Creek and part of Oceanport Creek/Husky Brook are classified as estuarine intertidal emergent wetlands. Lafetra Creek and Mill Creek are classified as riverine lower perennial open water/unknown bottom.

Building 296 is located just south of Parkers Creek, which empties to the east into the Shrewsbury River. The land surface of the site is relatively flat at an elevation of less than 20 feet amsl. Surface water runoff likely flows north from Building 296 into Parkers Creek.

3.0 SITE ACTIVITIES

Fort Monmouth DPW has conducted remedial investigation activities at Building 296, including a quarterly ground water sampling program, based on the findings of the Weston SI andUST closure and site investigations conducted for Buildings 296 (Weston 1995; Versar 2001). The purpose of these supplemental investigations was to define the areal extent of potential pollutants and evaluate potential impacts to ground water and surface water in the vicinity of Building 296. While the Weston report did not identify direct evidence of a source area or significant impacts to soil, ground water or surface water, DPW was concerned with the historical uses of the site. Remedial investigation activities at Building 296 continued from May 2001 to September 2010. These activities were managed by the Fort Monmouth DPW and performed by TECOM-Vinnell Services (TVS) and Versar.

Remedial investigation activities that occurred at Building 296 area, including well installation, sample collection activities, ground water depth measurements, and the offsite receptor evaluation, are described in the following sections.

3.1 WELL INSTALLATION

The quarterly ground water monitoring program conducted by the DPW included seven previously installed monitoring wells (296-MW01, 296-MW02, 296-MW03, 296-MW04, 296-MW06, 296-MW07, and 296-MW08). DWP installed these seven wells in 1994 during the site investigations related to USTs at the M-18 Landfill site. **Figure 2-6** depicts monitoring well locations at Building 296. The construction details for these wells are discussed above in **Sections 2.2.3**. Boring logs and monitoring well records for the seven wells at Building 296 provided in **Appendix D**.

3.2 SAMPLE COLLECTION ACTIVITIES

As part of the remedial investigation for Building 296, quarterly ground water monitoring was conducted between May 2001 and September 2010. Sampling activities were performed in accordance with the NJDEP Field Sampling Procedures Manual current at the time of sample collection (NJDEP 2009).

Seven monitoring wells (296-MW01, 296-MW02, 296-MW03, 296-MW04, 296-MW06, 296-MW07, and 296-MW07) were sampled during 36 quarterly sampling rounds and 2 rounds of low-flow sampling from May 2001 to September 2010. Fort Monmouth Environmental Testing Laboratory (FMETL), a New Jersey certified laboratory (Certification No. 13461), conducted laboratory analyses of the samples collected from Building 296.

During the 36 rounds of quarterly ground water sampling and two low-flow ground water sampling, a total of 266 ground water samples, including 38 duplicate samples, 38 field blanks and 38 trip blanks for quality assurance and quality control (QA/QC) purposes, was collected from the seven monitoring wells at Building 296. The quarterly ground water samples were analyzed as follows:

- During quarterly sampling rounds 1 through 15, VOCs plus 15 TICs were analyzed using U.S. Environmental Protection Agency (EPA) Method 624, SVOCs plus 25 TICs were analyzed using EPA Method 625, pesticides and PCBs were analyzed using EPA Method 608, and TAL metals were analyzed using EPA Methods 3112B and 3120B.
- During quarterly sampling rounds 16 through 36, VOCs plus 15 TICs were analyzed using EPA Method 624 and TAL metals were analyzed using EPA Methods 3112B and 3120B.
- During quarterly sampling rounds 37 and 38 (low-flow sampling), ground water samples were analyzed only for TAL metals using EPA Methods 3112B, 3113B, 3120B, and 279.3.

A summary of the ground water sampling activities, including rounds, well IDs, sample IDs, sampling locations, collection/analysis date, analytical parameters, analysis method, copies of the ground water sampling chain-of-custody forms and laboratory data sheets are presented in **Appendix I**. The results of the quarterly ground water monitoring program for Building 296 are discussed in **Section 5.0**.

Sampling equipment was thoroughly decontaminated before and after each use in accordance with the current version of the NJDEP *Field Sampling Procedures Manual* and the *Fort Monmouth Standard Sampling Operating Procedures* for field sampling in effect at the time sampling was conducted. The waste types generated by the remedial activities included three-gallon polyethylene pails, polyethylene tubing, Teflon® bailers, mason string, and personal protective equipment (PPE). The pails were recycled, and the other materials were disposed of in accordance with the *Fort Monmouth Solid Waste Management Plan.*

Because of the potential benefits of the low-flow sampling (**Section 5.1.5**), two rounds of low-flow sampling were conducted in May 2010 and September 2010. A total of 14 samples, including two duplicate samples and 14 field blank samples for QA/QC purposes, was collected and analyzed for VOCs and TAL metals. Samples were analyzed by FMETL for TAL metals using EPA Methods 279.3, 3112B, 3113B, and 3120B; and for VOCs plus 15 TICs using EPA Method 624.

Sampling equipment was thoroughly decontaminated before and after each use in accordance with the *NJDEP Field Sampling Procedures Manual* in effect at the time sampling was conducted. Following collection, ground water samples were immediately placed in laboratory-supplied bottleware. The samples were labeled, sealed, packed in ice, and transported to the FMETL under proper chain-of-custody procedures.

During each of the monitoring well sampling rounds, aquifer chemical characteristics including pH, temperature, conductivity, and dissolved oxygen (DO) were recorded prior to sampling. All analytical data for these sites were validated for any laboratory issues and the data validation packages for the last quarterly sampling events are provided in **Appendix J**.

3.3 GROUND WATER DEPTH MEASUREMENTS

During each of the ground water monitoring rounds conducted at Building 296 (including the 36 quarterly monitoring rounds and two low-flow rounds), depth-to-water measurements were recorded with an accuracy of 0.01 foot. Depth-to-ground water measurements, recorded from May 2001 to September 2010, are presented in **Table 3-1**. The ground water elevation at each well was calculated by subtracting the measured depth to ground water from the elevation of the top of the well casing.

3.4 SENSITIVE RECEPTOR SURVEY

A visual and documentary search of sensitive populations was performed by the U.S. Army Fort Monmouth (FTMM), Directorate of Public Works (DPW) and their subcontractor to identify any potentially sensitive populations within 200 feet of the FTMM boundary. The identification of said populations is in accordance with New Jersey Department of Environmental Protection (NJDEP) statutory requirement. An Offsite Receptor Report (dated October 13, 2010) was prepared for the Main Post of Fort Monmouth by Environmental Data Resources, Inc. (EDR) of Southport, Connecticut. A copy of the Offsite Receptor Report, identifying sensitive receptors in the area, is provided in **Appendix K**. In the following written summary, the sensitive populations and their locations have been identified. Their locations are plotted on the Offsite Receptor Survey map, **Figure 3-1**.

Although sensitive populations have been identified within 200 feet of the Fort Monmouth boundary, all of the environmentally impacted locations are a significant distance from the fence line and in all cases exceed the 200-foot buffer established by NJDEP.

In addition to the sensitive receptors, the DPW identified off-site wells within 2,000 feet of the Fort Monmouth perimeter. No production wells were identified within 2,000 feet of the Fort Monmouth boundary. The majority of off-site wells are monitoring wells associated with various remedial activities. A ground water model developed for Fort Monmouth shows an overall pattern of ground water flow east from the Main Post with a localized northeasterly component. Fort Monmouth is bordered by surface water bodies to the east and northeast. Any domestic and/or irrigation wells to the east or northeast of the Main Post would not be impacted by the military base.

Surface water bodies interact with ground water at Fort Monmouth. The interaction takes place in three basic ways: (1) streams gain water from inflow of ground water through the streambed, (2) streams lose water to ground water by outflow through the streambed, or (3) streams do both -- gaining in some reaches and losing in others. When ground water discharges into a surface water body, the altitude of the ground water table in the vicinity of the creek must be higher than the altitude of the stream water surface. Conversely, for surface water to seep to ground water, the altitude of the water table in the vicinity of the stream must be lower than the altitude of the stream water surface. The surface water bodies at Fort Monmouth (Oceanport and Parkers Creeks) may be gaining or losing depending upon the tidal cycle. Throughout the entire tidal cycle however, ground water flows into the creeks, albeit at low flow rates.

4.0 4.0 SITE PHYSICAL CHARACTERISTICS

The following sections represent the findings of the site geologic and hydrogeologic characterization program for Building 296. DPW collected the ground water elevation data from April 2001 to September 2010. Specifically, this section summarizes lithology and ground water flow direction data collected for the area surrounding Building 296.

4.1 LITHOLOGY

The lithology encountered at Building 296 consists primarily of fill material, fine sand, silt, and clay. Two geologic cross-sections (A-A' and B-B') were prepared for 7 monitoring wells in the study area. Geologic cross-section A-A' depicts the profiles for monitoring wells 296-MW04, 296-MW03, 296-MW06, 296-MW08, 296-MW02, and 296-MW01. These wells (with the exception of monitoring well 296-MW04) consistently encountered fill (Layer 1), which consisted of brown sand, gravel, and clay at the top of the boring, with the maximum depth of the fill ranging from 2 to 9 feet bgs. Native soil (Layer 2) was encountered below the fill in each monitoring well, which consisted of brown to black fine sand, silt, and clay with organic material, with a maximum depth of 14 to 18 feet. A small zone of black and brown clayey silt with organic material (Layer 3) was observed in monitoring well 296-MW04. This zone is most likely indicative of recent sediment deposition along the banks of Parkers Creek.

Geologic cross-section B-B' depicts the profiles for monitoring wells 296-MW07 and 296-MW06. These wells encountered fill (Layer 1) consisting of brown sand, gravel, and clay at the top of the boring, ranging in depth from 9 feet bgs to the bottom of the borings. Native soil (Layer 2), consisting of green glauconitic clay and sand, was only encountered in monitoring well 296-MW06 below the fill at a depth of 9 feet bgs. These profiles are included in Versar's 2003 RIR (Versar 2003).

4.2 GROUND WATER FLOW DIRECTION

Ground water contour maps were generated based on ground water depth measurements from the first three quarterly ground water sampling rounds in 2010 (Figures 4-1 through 4-3). Ground water was encountered in both the fill and native soils in each monitoring well at depths ranging from 2.54 to 8.68 feet bgs with a slight gradient toward Parkers Creek. The ground water underlying the site appears to be consistently flowing radially from the northwest to the northeast. This flow direction is due to the site's proximity to the bend in Parkers Creek. No significant variations in ground water flow conditions were observed in these ground water contour maps. The ground water elevation data are presented in **Table 3-2**.

5.0 SITE CHEMICAL CHARACTERIZATION

This section includes a discussion of the chemical characterization of Building 296 based the 36 rounds of monitoring well sampling and 2 rounds of low-flow ground water sampling conducted at the site. DPW personnel were responsible for the collection of samples during this remedial investigation and sample analyses were performed by the FMETL, a New Jersey certified laboratory (Certification No. 13461).

Specifically, this section discusses ground water action levels, ground water sampling results, and Mann-Whitney U-test results for the samples collected from the Building 296 monitoring wells.

5.1 GROUND WATER ACTION LEVELS

Ground water analytical data was compared to NJDEP criteria and COCs were identified based on those results. Ground water data was compared to the NJDEP GWQS or the Practical Quantitation Limits (PQL), whichever was higher.

According to the 2008 SI Report prepared by Shaw, several natural and anthropogenic factors can influence chemical concentrations (specifically metals) in soil and ground water samples collected at Fort Monmouth. The primary natural influence at Fort Monmouth is parent material: glauconitic quartzose sands of the Tinton and Red Bank sands and their fluvially and tidally reworked equivalents. The mineral glauconite found in these sands is a potassium-, sodium-, calcium-, iron-, aluminum-, magnesium-rich hydrosilicate. These glauconitic soils therefore contain abundant iron, aluminum, calcium, magnesium, manganese, sodium, and potassium (Shaw 2008).

Ground water quality is often affected by the composition of the aquifer; in this case, the Tinton and Red Banks sands. Coastal Plain aquifers are susceptible to saltwater encroachment. Aquifers underlying Fort Monmouth can also be identified by saltwater intrusion, affecting ground water chemistry. High concentrations of sodium are likely a result of saltwater intrusion (Shaw 2008).

As a result of these natural influences, aluminum, calcium, iron, manganese, magnesium, potassium, and sodium likely to be present at elevated concentrations are not considered COCs in soil and ground water at Fort Monmouth. Therefore, these metals were not included in the ground water results summary in **Table 5-1**.

All other analytical results for environmental samples collected at Fort Monmouth as part of the remedial investigation were evaluated with respect to applicable NJDEP-comparison criteria and the MBCs. If concentrations exceeded the NJDEP regulations, the sample concentrations were then compared to the Maximum Background Concentration (MBC). Those compounds with concentrations that exceeded the regulatory standard and established background levels were

classified as COCs. Laboratory data for all analytes, including the metals listed above, are provided in **Appendix I**.

5.2 GROUND WATER SAMPLING RESULTS

This section presents the results of laboratory analyses performed for the 36 rounds of ground water sampling and two additional low-flow sampling collected From May 2001 to September 2010 from the seven monitoring 296-MW01, 296-MW02, 296-MW03, 296-MW04, 296-MW06, 296-MW07, 296-MW08) at Building 296. From May 2001 to November 2004 (rounds 1 through 15) ground water samples were collected and analyzed for VOCs plus 15 TICs, SVOCs plus 15 TICs, pesticides, PCBs, and TAL metals.

On November 10, 2004, DPW requested that NJDEP reduce the ground water sampling analyses requested for several sites. The request for Building 296 was to sample quarterly and analyze only for VOCs and TAL metals. NJDEP subsequently approved the request on November 12, 2004. From February 2005 to September 2010 (rounds 16 through 38), ground water samples were collected and analyzed for VOCs and TAL metals only.

DPW proposed low-flow sampling to assess the impact of suspended sediments on the dissolved-phase metals concentrations at the site, and NJDEP accepted the request. Two rounds of low-flow sampling (Low-flow #3 and Low-flow #4) were conducted on May 21, 2010 and September 13, 2010 (respectively), using a low-flow ground water sampling technique for VOCs and TAL metals.

Fort Monmouth is underlain by a Class III-A aquifer. The ground water quality criteria for Class III-A is considered to be the criteria for the most stringent classification for vertically or horizontally adjacent ground waters that are not Class III-A (N.J.A.C. 7:9-6.7e) (NJDEP 2009). The NJDEP criteria used for comparison of ground water analytical results were the higher of the PQLs and the NJDEP GWQS for Class II-A aquifers (N.J.A.C. 7:9-6,Table 1) (NJDEP 2009).

During the 15 quarterly sampling events prior to the NJDEP approval letter for the reduction of ground water sampling analyses, no PCBs were detected in ground water at the site. A total of six VOCs were detected, but only one VOC concentration (benzene) was detected exceeding the NJDEP GWQS in at least one sample collected. A total of 15 SVOCs were detected in site ground water at concentrations less than their respective NJDEP GWQS. A total of seven pesticides were detected in site ground water that did not exceed their respective NJDEP GWQS. A total 10 metals were detected in site ground water at concentrations exceeding their respective NJDEP GWQS.

Following approval from NJDEP to reduce the analytical program, a total of 11 metals were detected in site ground water at concentrations exceeding their respective NJDEP GWQS during the last 23 rounds of sampling. Eight VOCs were detected in site ground water but only one VOC concentration (benzene) exceeded its respective NJDEP GWQS.

This section discusses the detection of the compounds and analytes in ground water samples collected from Building 296 from the four analytical categories: VOCs, SVOCs, pesticides and

PCBs, and TAL metals. These four sections will concentrate on the most recent eight quarters of sampling, from October 2008 to September 2010. Nine metals and one VOC were detected in site ground water exceeding their respective NJDEP GWQS in the last eight quarters. These eight quarters define the most current conditions of ground water beneath Building 296. The results are presented in **Table 5-1**.

5.2.1 VOCs

Benzene was detected at concentrations exceeding the GWQS of 1.0 ug/L in three of the last eight rounds of sampling collected at one monitoring well location, inlcuding the two low-flow sampling events. Concentrations ranged from 1.74 ug/L to 27.45 ug/L in 296-MW06.

5.2.2 Tentatively Identified Compounds (TICs)

No TICs were detected greater than the appropriate NJDEP GWQW at the site (500 µg/L for SVOCs and an individual compound can exceed 100 µg/L).

5.2.3 SVOCs

No SVOCs were detected at concentrations exceeding the appropriate GWQS at the site.

5.2.4 Pesticides and PCBs

No pesticides or PCBs were detected at concentrations exceeding the appropriate GWQS at the site.

5.2.5 Metals

Antimony was detected at concentrations exceeding the NJDEP criteria of 6 micrograms per liter (µg/L) in five of the last eight rounds of sampling conducted from the seven monitoring well locations. Concentrations ranged from 6.05 µg/L in 296-MW03 to 40.1 µg /L in 296-MW04.

Arsenic was detected at concentrations exceeding the NJDEP criteria of 3 µg/L in the last eight rounds of sampling conducted at the seven monitoring well locations. Concentrations ranged from 3.01 µg/L in 296MW07 to 75.08 µg/L in 296-MW02.

Beryllium was detected at a concentration exceeding the NJDEP criteria of 1 µg/L once in the last eight rounds of sampling collected from one monitoring well location at a concentration of 9.99 µg/L in 296-MW02.

Cadmium was detected at concentrations exceeding the NJDEP criteria of 4 µg /L in three separate rounds during the last eight quarters of sampling collected from three monitoring well locations. Concentrations ranged from 4.02 µg/L in 296-MW08 to 184 µg /L in 296-MW02.

Chromium was detected at a concentration exceeding the NJDEP criteria of 70 µg/L once during the last eight rounds of sampling collected from one monitoring well location. Chromium was detected at a concentration of 840 µg/L in 296-MW02.

Copper was detected at a concentration exceeding the NJDEP criteria of 1,300 µg/L once during the last eight rounds of sampling collected from one monitoring well location. Copper was detected at a concentration of 5,440 µg/L in 296-MW02.

Lead was detected at a concentration exceeding the NJDEP criteria of 100 µg/L in five separate rounds during the last eight quarters of sampling conducted at four separate monitoring well locations. Concentrations ranged from 5.51 µg/L in 296-MW03 to 1,060 µg/L in 296-MW02.

Nickel was detected at a concentration exceeding the NJDEP criteria of 100 µg/L once during the last eight rounds of sampling conducted at one monitoring well location. Nickel was detected at a concentration of 514 µg/L in 296-MW02.

Selenium was detected at concentrations exceeding the NJDEP criteria 40 µg/L during five separate rounds of sampling conducted at six monitoring well locations. Concentrations ranged from 42.7 µg/L in 296-MW02 to 163 µg/L in 296-MW06.

Thallium was detected at a concentration exceeding the NJDEP criteria of 2 µg/L once during the last eight rounds of sampling collected from one monitoring well location. Thallium was detected at a concentration of 2.41 µg/L in 296-MW07.

5.3 CONTAMINANTS OF CONCERN

No SVOCs, pesticides, or PCBs were detected in the ground water samples collected from the Building 296 at concentrations exceeding the NJDEP GWQS criteria. One VOC (benzene) and nine metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, and selenium) were detected in the ground water samples collected at Building 296 in concentrations exceeding the NJDEP GWQS. These specific exceedances and the identification of each constituent as a potential contaminant of concern (COC) are discussed below and are presented in **Table 5-2**. The ground water contaminant distribution map is presented in **Figure 5-1**

Benzene was detected in the ground water samples collected at Building 296 in concentrations exceeding the NJDEP GWQS. Benzene exceedances occurred in only one monitoring well (296-MW06). Based on the magnitude of the exceedances, the frequency of occurrences, and the wide-ranging results, benzene is considered a potential COC for Building 296.

Two separate rounds of sampling (May 2010 and September 2010) were performed during the quarterly ground water sampling program using the low-flow ground water sampling technique. This technique was used to determine whether the detected metal concentrations observed in the ground water samples are a function of entrained sediments suspended in the ground water during the course of well purging and sampling activities, or an accurate representation of dissolved-phase aquifer/ground water conditions.

The different metals detected in ground water at the site with concentrations that exceeded the New Jersey GWQS are categorized as either background or non-native metals. The indigenous metals were compared to the Main Post Maximum Background Concentrations (MBC) identified in the Weston SI report (1995) and the U.S. Army's response letter to the NJDEP comments on the Weston SI report dated February 24, 1997. Based on the water chemistry of the area, the ground water analytical results for these metals were compared to their respective MBCs for Monmouth County or site-specific MBCs for the Main Post (whichever is lower, as shown in Table 2 of the U.S. Army's February 24, 2997 letter included as **Appendix L** to this report).

The concentrations of beryllium, chromium, copper, nickel, and thallium during the two low-flow sampling events were non-detect or less than the NJDEP criteria. Additionally, these five metals were detected exceeding the NJDEP standard only once in the last eight quarters from one monitoring well location. Because of the infrequency and magnitude of exceedances in ground water, these metals are not considered a COC.

The use of the low-flow sampling approach did not eliminate the detection of the five uncharacteristic metals (antimony, arsenic, cadmium, lead, and selenium), which persisted at concentrations exceeding the NJDEP cleanup criteria during the two low-flow sampling rounds mentioned above.

Based on the magnitude of the exceedances, the frequency of occurrences, and the wide-ranging results, one VOC (benzene) and five metals (antimony, arsenic, cadmium, lead, and selenium) are identified as potential COCs in ground water at Building 296. No other potential COC were identified at Building 296.

5.4 MANN-WHITNEY U-TEST

Fort Mommouth conducted the Mann-Whitney U-Test using fourth quarter 2008 to third quarter 2010 ground water data to determine whether metal concentrations in the ground water at Building 296 are decreasing over time. According to the Mann-Whitney U-test, if U is less than 1, the null hypothesis is rejected and contaminant concentrations are decreasing over time. If U is more than 1, the null hypothesis is accepted and concentrations can be concluded with 90 percent or greater confidence to be decreasing over time.

The test was conducted at monitoring well 296-MW03 for antimony, arsenic, cadmium, lead, and selenium. The results indicated that for all five metals tested, the concentrations were not decreasing over time. The "U" value is greater than 1 for all metals. Therefore, the null hypothesis is accepted, and it cannot be concluded with 90 percent or greater confidence that the metal concentrations are decreasing over time. The results of the Mann-Whitney U-tests are presented in **Table 5-3**.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Geologic publications indicate that Building 296 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 Ground Water Quality Standards (NJAC 7:9-6, January 7, 1993) (NJDEP 2009).

The analytical results for the ground water samples collected from May 2001 to September 2010 indicate that benzene, arsenic, cadmium, copper, lead, and selenium exceed the GWQS at Building 296. However, the Class II-A criteria were used for comparison with site-specific data obtained from the various sampling rounds, as dictated by NJDEP GWQS (NJAC 7:9-6.7e) (NJDEP 2009).

The Wenonah Mount Laurel aquifer (vertical component), which is approximately 125 feet bgs, is too deep to be affected by the COCs present near the ground surface. In addition, the sensitive receptor survey indicates that no domestic or irrigation wells are close enough to the Building 296 to be adversely impacted by COC horizontal migration. In addition, there is minimal potential for COC migration into Parkers Creek because of the low concentrations of COCs at the site and the slow migration rates for the COCs in the ground water.

Based on analytical results for the Building 296, further remedial investigation activities at Building 296 are not required. Tetra Tech recommends continued ground water monitoring, in agreement with the fiscal year 2010 Fort Monmouth Base Realignment and Closure (BRAC) Installation Action Plan (BIAP). No Further Action (NFA) is recommended with respect to ground water at the site.

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TABLES

FIGURES

APPENDIX

Appendix A

Appendix B

Appendix C

Appendix D

Appendix E

Appendix F

Appendix G

Appendix H