U.S. Army
Fort Monmouth, New Jersey

Remedial Investigation Report Addendum

CW-6 Former Pesticide Storage Site Building 2044

Fort Monmouth, New Jersey

December 17, 2010
Revised June 2011

REMEDIAL INVESTIGATION REPORT ADDENDUM
FOR CW-6 FORMER PESTICIDE STORAGE SITE
BUILDING 2044
FORT MONMOUTH, NEW JERSEY

PREPARED FOR:

U.S. ARMY FORT MONMOUTH
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TETRA TECH EM INC. PROJECT NO. 103G1058223.008

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ACRONYMS

AMC	U.S. Army Materiel Command
amsl	Above mean sea level
ATC	ATC Associates, Inc.
bgs	Below ground surface
BRAC	Base Realignment and Closure
Brinkerhoff	Brinkerhoff Environmental Services, Inc.
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CECOM	Communications and Electronic Command
COC	Contaminant of Concern
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
DPW	Directorate of Public Works
FMETL	Fort Monmouth Environmental Testing Laboratory
Fort Monmouth	United States Army Installation, Fort Monmouth
FTMM	Fort Monmouth
GWQS	Ground Water Quality Standards
GWQS	Ground Water Quality Standard
MBC	Maximum Background Concentration
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
MTBE	Methyl tertiary butyl ether
NFA	No Further Action
NJAC	*New Jersey Administrative Code*
NJDEP	New Jersey Department of Environmental Protection
OVA	Organic Vapor Analyzer
PCB	Polychlorinated biphenyl
PQL	Practical Quantitation Limit
PVC	Polyvinyl chloride
QA/QC	Quality assurance/quality control
RI	Remedial Investigation
RIR	Remedial Investigation Report
RIRA	Remedial Investigation Report Addendum
SI	Site Investigation
SOP	Standard Operating Procedure
SVOC	Semi-volatile organic compound
TAL	Target Analyte List
TBA	Tertiary butyl alcohol
Tetra Tech	Tetra Tech EM Inc.
TIC	Tentatively Identified Compound
TPH	Total petroleum hydrocarbons
TVS	TECOM-Vinnell Services
U.S.	United States
USACE	United States Army Corps of Engineers

USATHAMA	United States Army Toxic and Hazardous Materials Agency
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
Versar	Versar, Inc.
VOC	Volatile organic compound
Weston	Roy F. Weston, Inc.
WWI	World War I

EXECUTIVE SUMMARY

Tetra Tech EM Inc. (Tetra Tech) 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 Addendum (RIRA) for the CW-6 Former Pesticide Storage site (Site) located in the Charles Wood area in the vicinity of former Building 2044. This RIRA addresses the remedial investigation activities at the Site from May 2001 to July 2010.

The Site consists of a small complex of buildings in the south-central section of the Charles Wood area historically was used to store and mix pesticides and herbicides. During an inspection of three underground storage tanks (UST) associated with the Site, the DPW concluded that historical discharges were associated with three USTs removed in December 1993. During excavation of the USTs, several corrosion holes were observed in one fuel oil UST, and evidence of potentially contaminated soils was observed surrounding the tank. No holes or punctures were identified in the gasoline and diesel USTs.

Soil and ground water samples were collected in regard to closure of the USTs. No exceedances of applicable comparison criteria were found in the soil samples. No further action for soil was granted by NJDEP on January 10, 2003.

In response to the observation of holes in the former fuel oil UST, three shallow overburden monitoring wells were installed in 1994. Benzene, methylene chloride, arsenic, and lead were detected in the ground water at concentrations exceeding their respective NJDEP Ground Water Cleanup Standards (GWQS). Based on the ground water analytical results, additional ground water monitoring for VOCs and arsenic was recommended in the UST Closure Report.

The soil samples collected in 2010 indicate SVOCs were detected at concentrations less than their respective NJDEP soil cleanup criteria. One pesticide was detected at concentrations greater than its NJDEP cleanup criterion used at the time. Comparison of the soil data presented in the Weston report against current NJDEP cleanup criteria revealed exceedances of two additional pesticides, alpha-chlordane and gamma chlordane, in one surface soil sample. PCBs were not detected in site soils. One metal, chromium, was detected in concentrations exceeding the previous NJDEP soil cleanup criterion; however the chromium concentration does not exceed the current NJDEP residential direct contact soil cleanup criterion.

The ground water samples collected in 1995 indicated one VOC, benzene, was detected at concentrations greater than the NJDEP GWQS. SVOCs were detected at concentrations less than their respective NJDEP GWQS.

Fort Monmouth DPW conducted Remedial Investigation (RI) activities at the Site, including a quarterly ground water sampling program. This RI objective was to assess the ground water quality at the Site and to verify that no contaminants of concern (COC) were present at concentrations greater than benchmarks within the ground water at the Site.

Four monitoring wells were involved in the quarterly ground water monitoring program conducted by the DPW at the Site, three associated with the UST closure, the fourth installed as part of an SI.

A remedial investigation report (RIR) was prepared by Versar, Inc., in January 2005 for the first 18 rounds of quarterly ground water sampling at the Site. The ground water samples were collected and analyzed for VOCs, SVOCs, pesticides, PCBs, and TAL metals. No COCs were identified as part of the initial RI.

This RIRA was prepared to evaluate the most recent 38 rounds of quarterly ground water sampling (sampling rounds #19 through #56).

The analytical results for the ground water samples collected at the Site from May 2001 to July 2010 indicate no presence of COCs at concentrations greater than benchmarks within the ground water at the Site.

The Monmouth County and site-specific Maximum Background Concentrations (MBC) for certain constituents were determined as part of the 1995 SI using literature values and on-site background data. Each round of sampling was compared with appropriate GWQS at the time the samples were collected. If an analytical result exceeded the GWQS, it was then compared against the MBC (the higher of the Monmouth County or site-specific background concentration for organics, and the 95% confidence limit for inorganics).

One pesticide (4,4'-dichlorodiphenyldichloroethane [DDD]) was detected at concentrations greater than the comparison criteria in one well during one event (Round #19). This is considered an isolated and marginal exceedance, and thus 4,4'-DDD is not considered a COC. Six metals (antimony, arsenic, cadmium, lead, selenium, and thallium) were detected in ground water samples at concentrations exceeding the respective comparison criteria. Arsenic, cadmium, lead, and selenium were determined to be background constituents in Monmouth County and the Charles Wood area ground water. Thallium was detected at a concentration greater than comparison criteria during only one round of ground water sampling; this is considered an isolated event.

Three metals (antimony, arsenic, and lead) were further considered as potential COCs; however, migration rates of these metals are too slow in the ground water at the Site to pose potentially significant impacts from migration. Moreover, the sensitive receptor survey indicates no domestic or irrigation wells close enough to the Site to be adversely impacted by migration of COCs.

Therefore, no further action (NFA) is requested concerning ground water at the Site.

1.0 INTRODUCTION

Tetra Tech EM Inc. (Tetra Tech) 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 Addendum (RIRA) for the CW-6 Former Pesticide Storage site (Site) located in the Charles Wood area in the vicinity of former Building 2044. This RIRA addresses the remedial investigation activities at the site from May 2001 to July 2010.

1.1 OBJECTIVES

The objective of this Remedial Investigation (RI) is to assess the ground water quality at the Site and verify that no contaminants of concern (COC) are present at concentrations greater than benchmarks within ground water at the Site. The remedial investigation was conducted in accordance with *New Jersey Administrative Code* (NJAC) 7:26E - *Technical Requirements for Site Remediation* (April 2010) and the *Site Remediation Reform Act*, N.J.S.A. 58:10C-1 et seq (May 2009).

This report is an addendum to the Versar, Inc. (Versar) report, *Remedial Investigation Report, CW-6 Former Pesticide Storage Building, Fort Monmouth, New Jersey* (Versar 2005), which described the remedial investigation conducted from April 1997 to February 2001.

The remedial investigation and subsequent preparation of the Remedial Investigation Report (RIR) and this RIRA encompassed the following:

- Characterization of ground water quality over time through quarterly ground water sampling events conducted from April 1997 to July 2010.
- Investigation and evaluation of the designated aquifer uses, the associated aquifer classification, and the appropriate Ground water Quality Standards for ground water resources beneath the Site. The New Jersey Department of Environmental Protection (NJDEP) Ground Water Quality Standards (GWQS) specify the quality criteria and designated uses for ground water, and present technical and general policies to ensure that the designated uses can be adequately protected.
- Comparison of the results of the ground water monitoring program with the NJDEP Ground Water Quality Standards (GWQS).
- Formulation of a No Further Action (NFA) proposal for consideration by the NJDEP based on the results of field and laboratory investigations and evaluation of the hydrogeologic conditions at the Site.

1.2 REPORT ORGANIZATION

This report is organized to minimize repetition. The findings of the Roy F. Weston, Inc. (Weston) report entitled, *Site Investigation, Fort Monmouth, New Jersey, Main Post and Charles Wood Areas, Site Investigation Reports* (Weston 1995), were used as the basis for the RI program. **Section 2.0** provides background information and a general description of the Site

located at the Charles Wood area of Fort Monmouth (largely derived from Weston [1995]). **Section 3.0** describes and summarizes the RI field activities at the Site from May 2001 to July 2010. **Section 4.0** presents the physical characterization of the Site, including the lithology and ground water conditions. **Section 5.0** presents a chemical characterization of the Site, including ground water sampling results and identification of COCs. **Section 6.0** offers conclusions and a recommendation for NFA for ground water at the Site. References cited in the report are provided following **Section 6.0.**

2.0 SITE BACKGROUND AND ENVIRONMENTAL SETTING

The following sections describe the site background and environmental setting of the area surrounding Fort Monmouth and the Site.

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**). 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 approximately 511-acre Charles Wood area is located 1 mile west of the Main Post. 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 Site consists of a small complex of buildings in the south-central section of the Charles Wood area (**Figure 2-2**). The complex consists of Building T-2070 and Building T-2071 in the vicinity of the former Building T-2044. The approximate area of the site is 25,000 square feet (0.6 acre). The Site was historically used to store and mix pesticides and herbicides. The aforementioned buildings are currently used to store golf course maintenance and landscaping equipment such as tractors and mowers. No storage or mixing of pesticides or herbicides currently occurs at the Site; an outside contractor has been hired to apply pesticides or herbicides.

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. Weston conducted a background investigation of the 37 sites and eight additional sites that had been 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* (Weston 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 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.

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 and Evans areas). This program was created to work toward replacing the use of heating oil as a major energy source and to convert to natural gas. DPW's approach involved installing new gas lines and new boilers that could be gas-fed, and removing the non-regulated (residential) USTs. Since 1990, approximately 97 percent of the aforementioned USTs at Fort Monmouth have been removed.

As part of the DPW's UST management program, a UST closure report (dated May 2000) has been submitted to the NJDEP regarding USTs in the immediate vicinity of Building 2044. The Site was assigned Case Number 93-6-28-1009 by the NJDEP. This report is presented in **Appendix A** and is discussed below. Ground water monitoring was recommended as part of the UST closure investigation.

Four monitoring wells (CW6-MW01, CW6-MW02, CW6-MW03 and CW6-MW34) are involved in the quarterly ground water monitoring program conducted by the DPW at the Site. Three monitoring wells (CW6-MW01 CW6-MW02 and CW6-MW03) were installed in the west and northeast section of the Site by Tyree in June, July, and December 1994, respectively, as part of the UST closure investigation. The wells were constructed with 4-inch-diameter 20 Slot polyvinyl chloride (PVC) to a depth of 15 feet below ground surface (bgs). Three additional monitoring wells (CW6-MW34, CW6-MW35, and CW6-MW36) were installed by J.C. Anderson in January 1995. The wells were constructed using 4-inch diameter 10 Slot polyvinyl chloride (PVC) to a depth of 14.5 feet below ground surface (bgs). A well construction summary is provided in **Table 2-1**. Well boring logs and monitoring well records are provided in **Appendix B**. Of these wells, two are no longer sampled (CW6-MW35 and CW6-MW36). Locations of the monitoring wells at the Site are depicted on **Figure 2-3**.

The Weston report, *Site Investigation, Fort Monmouth, New Jersey, Main Post and Charles Wood Areas, Site Investigation Report* (Weston 1995), presents the results of field investigation activities conducted at 13 sites at the Main Post area and eight sites at the Charles Wood area. The results of the investigation of the Site are included in the Weston Site Investigation (SI) report and summarized below. Initial field investigation activities conducted from November 1994 to March 1995 included subsurface soil sampling, ground water monitoring well installation, and ground water sampling. The Weston SI report (**Appendix C**) was used as the basis for the supplemental RIs of the Site described in the following sections of this report.

According to the Weston SI report, DPW recommended implementation of a long-term monitoring program at the Site. This remedial investigation was undertaken to assess the ground water quality at the Site and to verify no presence of COCs at concentrations exceeding benchmarks within the Site ground water. The initial RIR prepared by Versar (**Appendix D**) addressed RI activities at the site from April 1997 to February 2001. This RIRA details RI activities from May 2001 to July 2010.

2.2.1 2000 UST Closure and Site Investigation Report

According to the *Underground Storage Tank Closure and Site Investigation Report, Building 2044, Charles Wood, NJDEP UST Registration Nos. 192486-24, 32, 33; NJDEP Closure Approval Nos. C-93-3186, C-93-3885, C-93-3886*, prepared by ATC Associates, Inc., (ATC) for the DPW (ATC 2000) (**Appendix A**), three USTs were located adjacent to Building 2044 (**Figure 2-4**). UST No. 192486-24 was a steel, 1,000-gallon No. 2 fuel oil tank; UST No. 192486-32 was a fiberglass-coated steel 550-gallon diesel tank; and UST No. 192486-33 was a fiberglass-coated steel 550-gallon gasoline tank.

On June 28, 1993, a discharge was reported to the NJDEP, and Case Number 93-6-28-1009 was assigned.

In December 1993, the three USTs were drained of all contents, removed, and disposed of off-site. During excavation of the USTs, several corrosion holes were observed in UST No. 192486-24, and evidence of potentially contaminated soils was observed surrounding the tank. No holes or punctures were identified in UST Nos. 192486-32 and 192486-33. Approximately 8 cubic yards of potentially contaminated soil was removed from the excavation area following the removal of UST No. 192486-24. The potentially contaminated soil was disposed of off-site. No potentially contaminated soils were identified around the other two USTs.

Based on an inspection of the USTs and field screening of the subsurface soils, the DPW concluded that historical discharges were associated with the USTs. Field screening was performed by a NJDEP-certified subsurface evaluator using an organic vapor analyzer (OVA) and visual observations.

Collection of post-excavation soil and ground water samples in regard to the closures of UST Nos. 192486-24, 192486-32, and 192486-33 are described as follows.

Soil Sampling

Post-excavation soil samples were collected on March 18, 1994 from the former UST excavations at Building 2044. Four post-excavation soil samples were collected from the excavations associated with each UST. The soil samples collected from the former UST No. 192486-24 (No. 2 fuel oil) excavation were analyzed for total petroleum hydrocarbons (TPH), with one sample also analyzed for volatile organic compounds (VOC). The soil samples collected from the former UST No. 192486-32 (diesel) excavation were analyzed for TPH. The soil samples collected from the former UST No. 192486-33 (gasoline) excavation were analyzed for TPH, VOCs, and lead.

The post-excavation soil sample results were compared to the NJDEP soil cleanup criteria. The soil samples contained TPH concentrations less than the NJDEP residential direct contact total organic contaminants soil cleanup criterion of 10,000 milligrams per kilogram (mg/kg). Additional analyses for VOCs and lead indicated no detections of compounds greater than their respective NJDEP cleanup criteria. NFA for soil was granted by NJDEP on January 10, 2003 (**Appendix E**).

An Order of Magnitude Compliance Review of the soil results obtained as part of the UST closure was conducted as part of this RIRA, in accordance with the NJDEP Order of Magnitude Guidance Document. The available soil data were compared with newly adopted remediation standards that are an order of magnitude or more lower than the previous soil cleanup criteria. No contaminant was identified as a concern based on the order of magnitude analysis.

Ground water Sampling

In response to the observation of holes in the former UST No. 192486-24, three shallow overburden monitoring wells (CW6MW01, CW6MW02, and CW6MW03) were installed on June 30 and July 1, 1994. The three monitoring wells were installed around Building 2044 (CW6MW01 is 10 feet northwest, CW6MW02 is 25 feet northeast, and CW6MW03 is 100 feet northwest of former Building 2044). These wells were screened from a depth of 2 to 15 feet bgs with 4-inch-diameter 10-slot PVC. Ground water in the former Building 2044 area is located at approximately 3 feet bgs. Well boring logs and monitoring well records are provided in **Appendix B**. The locations of the monitoring wells at the Site are shown on **Figure 2-3**.

On November 10 and 30, 1994, all three monitoring wells were sampled for VOCs plus 15 tentatively identified compounds (TIC), methyl tertiary butyl ether (MTBE), tertiary butyl alcohol (TBA), and lead. On January 9, 1997, all three monitoring wells were sampled for benzene, toluene, ethylbenzene, and xylenes (BTEX) and arsenic. The following ground water concentrations exceeded the NJDEP Class II-A GWQS:

- In the ground water samples collected from well CW6MW01 on November 10 and 30, 1994, ***benzene*** was detected greater than the GWQS (1 microgram per liter [µg/L]) at concentrations of 4 and 12 µg/L.
- In ground water samples collected from all three wells on November 10, 1994, and from well CW6MW03 on November 30, 1994, ***methylene chloride*** (a common laboratory contaminant) was detected at concentrations greater than the GWQS (2 µg/L in 1997; currently 3 µg/L) at concentrations ranging from 4 to7 µg/L.
- In the ground water sample collected from well CW6MW01 on January 9, 1997, ***arsenic*** was detected at concentrations greater than the GWQS (8 µg/L in 1997; currently 3 µg/L) at a concentration of 12 µg/L.
- In the ground water sample collected from well CW6MW01 on November 10, 1994, ***lead*** was detected at concentrations greater than the GWQS (10 µg/L in 1997; currently 5 µg/L) at a concentration of 9.3 µg/L.

Ground water sampling results for wells CW6MW01, CW6MW02, and CW6MW03, as presented in the 2000 ATC report, are included in **Appendix A**.

Based on the ground water analytical results, additional ground water monitoring for VOCs and arsenic was recommended in the UST Closure Report.

2.2.3 1995 Site Investigation Report

As part of a 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 Fort Monmouth installation, as reported in the Weston SI Report (1995) (**Appendix C**). These background concentrations have been used by the DPW for comparing sampling results for native constituents of soil and ground water (see **Section 5.1**).

As presented in the Weston SI Report, several natural and anthropogenic factors contribute to the wide range in concentrations of metals in soils—with further impacts to concentrations 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 collected ground water 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 Fort Monmouth. Using a low-flow sampling methodology to reduce the presence of entrained sediment has generally resulted in substantial reductions in the dissolved phase concentrations of metals indicated in ground water analytical data from Fort Monmouth sites (metals include arsenic, antimony, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, silver, thallium, and vanadium). Large decreases in the concentrations of metals characteristic of glauconitic sand also were observed. These metals included aluminum, barium, calcium, copper, iron, magnesium, manganese, nickel, potassium, sodium, and zinc.

The Weston report presents the results of field investigations at 13 sites within the Main Post area and eight sites within the Charles Wood area. The results of the investigation of the Site are included in the Weston SI report. Initial field investigation activities from November 1994 to March 1995 included subsurface soil sampling, ground water monitoring well installation, and ground water sampling. The Weston SI report was used as the basis for the supplemental RIs of the Site described in the following sections of this report.

The soil samples collected by Weston in November 1994, and January and May 1995, were analyzed for VOCs, semivolatile organic compounds (SVOC), pesticides, polychlorinated biphenyls (PCB), and target analyte list (TAL) metals. According to Weston SI, VOCs were not detected in site soils. SVOCs were detected at concentrations less than NJDEP soil cleanup criteria. One pesticide, dieldrin, was detected at concentrations greater than both the 1995 and current NJDEP cleanup criteria in SB-34. Two pesticides that did not have NJDEP comparison criteria in 1995, alpha-Chlordane and gamma-Chlordane (0.870 mg/kg and 0.800 mg/kg, respectively), had concentrations exceeding the current NJDEP criteria of 0.2 mg/kg each. PCBs were not detected in site soils. Of the 18 metals detected, one metal (cadmium) was detected at concentrations exceeding the 1995 NJDEP soil cleanup criteria, but not exceeding current NJDEP residential direct contact soil cleanup criteria.

Four monitoring wells were used to collect ground water samples as part of the Weston SI at the Site. Three monitoring wells (CW6-MW01, CW6-MW02, and CW6-MW03) had been installed as part of the UST closure investigation (see **Section 2.2.2).** One monitoring well (CW6-MW34) was installed in the southeast section of the site in January 1995 as part of the SI. CW6-MW34 was constructed using 4-inch-diameter 10 Slot PVC to a depth of 14.5 feet bgs. Two additional monitoring wells (CW6-MW35 and CW6-MW36) were installed in 1995 at locations considered part of a neighboring site, CW-9. Well boring logs and monitoring well records are provided in **Appendix B**. The locations of the four monitoring wells at the Site are shown on **Figure 2-3**.

The ground water samples collected by Weston in 1995 from monitoring wells CW6-MW01 and CW6-MW34 were analyzed for VOCs, SVOCs, pesticides, and PCBs. Weston reported that one VOC, benzene, was detected at concentrations greater than the NJDEP GWQS, and attributed its presence to the previously removed USTs. SVOCs and pesticides were detected at concentrations less than respective NJDEP GWQS. No PCBs were detected in the ground water samples.

Weston concluded that the ground water sampling results for the Site indicated a concentration of benzene slightly greater than the NJDEP GWQS. According to the Weston SI report, the DPW recommended implementation of a long-term monitoring program at the Site. The remedial investigation was undertaken to assess ground water quality at the Site, and to verify no presence of COCs at concentrations greater than benchmarks within ground water at the Site.

2.2.4 2005 Remedial Investigation Report

According to the *Remedial Investigation Report for CW-6 Former Pesticide Storage Building*, prepared by Versar for the DPW, dated January 2005 (**Appendix D**), the analytical results for the ground water samples collected from monitoring wells CW6-MW01, CW6-MW02, CW6-MW03, and CW6-MW34 from April 1997 to February 2001 (18 rounds) indicated no presence of COCs greater than benchmark concentrations within the Site ground water. The Class II-A criteria were used for comparison with site-specific data obtained from the various ground water sampling rounds because the GWQS (NJAC 7:9C-1.5) specifies that the Ground water Quality Standards to be used for Class III-A aquifers are the most stringent criteria associated with vertically or horizontally adjacent ground waters that are not Class III-A.

One SVOC, bis(2-ethylhexyl)phthalate, was detected at concentrations greater than the current NJDEP GWQS in CW6-MW02 during one sampling round in 1997; the concentration was less than comparison criterion at the time the RIR was prepared. One pesticide (heptachlor epoxide) was detected at concentrations slightly greater than the NJDEP GWQS during one round (fourth quarter 1999) in one monitoring well (CW6-MW01); this is considered an isolated and marginal exceedance, and therefore heptachlor epoxide is not considered a COC. Eleven metals (aluminum, antimony, arsenic, beryllium, chromium, iron, lead, manganese, nickel, silver and sodium) were detected in ground water samples at concentrations exceeding their respective NJDEP GWQS. Of these, only one metal, lead, was further considered as a potential COC. According to the RIR, the low concentrations and slow migration rate of lead in ground water at the Site posed little potential for significant COC impact by migration.

The RIR concluded that the lead distribution in ground water did not suggest an association with any source and was more indicative of natural background conditions or a regional source, and therefore, the lead was not considered a COC. NFA was requested concerning ground water at the Site.

2.2.5 Baseline Ecological Evaluation

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.

2.2.6 Aerial Photograph Evaluation

Aerial photographs of the Charles Wood area from 1947 to 1974 appear in **Appendix F**. A summary of each aerial photograph is provided as follows:

Figure 11: September 19, 1947: The land use for the subject property in 1947 reveals the golf course and the officer housing areas. Gibbs Hall (Building 2000) and Building 2001 are clearly visible, and the golf course appears to be in use. The northeastern portion of the Charles Wood area includes numerous buildings that have since been dismantled. The 2044/CW-6 pesticide storage area does not appear to be utilized at this time. The western side of Charles Wood shows numerous buildings that have since been dismantled. The CW-3A landfill area seems to be active and is labeled as a disturbed area.

Figure 12: May 2, 1957: The land use for the subject property in 1957 focuses primarily on the 2044/CW-6 pesticide storage area and is labeled as "Site 3." The northwestern portion of CW-6 seems to be somewhat active; visible portions of vegetation are cleared; striations and a ground scar are also noted. The eastern section of CW-6 is occupied by lush vegetation.

Figure 13: May 13, 1963: The land use for the subject property in 1963 reveals striations and ground scarring within the eastern portion of CW-6, while the northwestern section now seems inactive and covered with vegetation. The CW-3A landfill is active, and ground scarring is labeled within the area. The buildings in the northeastern portion of the Charles Wood area appear to have been recently dismantled. In addition, many buildings inside the northwestern portion of the area have been replaced with housing quarters.

Figure 14: March 13, 1974: The land use for the subject area in 1974 shows slight changes in comparison to the 1963 aerial photograph. CW-6 seems to be completely covered with vegetation, and several small buildings have been erected on the eastern portion of the Site. A probable ground scar is noted on the southern portion of the Site. CW-3A seems to be active with ground scarring marked throughout the entire area.

2.2.7 Public Notification

In accordance with the Notification and Public Outreach Rule of the NJDEP Technical Requirements for Site Remediation (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 who represent 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 utilizing 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.

Public notification documentation is presented in **Appendix G.**

2.3 SITE CONDITIONS

Tetra Tech conducted a site walk on October 21, 2010, to assess current conditions at the Site. The Site included two buildings (T-2070 and T-2071) within the golf course, which is located in the south-central portion of the Charles Wood area.

General utilities servicing the Site are depicted on **Figure 2-5**. Wetlands present on site are depicted on **Figure 2-6**.

2.4 ENVIRONMENTAL SETTING

A description of the geological/hydrogeological setting of the area surrounding the Site is presented in the 2005 RIR (**Appendix D**). 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 Charles Wood area.

2.4.1 Regional and Local Geology

A detailed description of the regional and local geology is provided in Section 2.4.1 of the 2005 RIR (**Appendix D**).

As presented in the 1995 SI, several natural and anthropogenic factors contribute to the wide range in concentrations of metals in soils, which further impacts concentrations 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.

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 groundwater samples which are potentially affecting the metals analysis results in groundwater samples collected from the overall FTMM site. Additional groundwater 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 H.**

2.4.2 Hydrogeology

A detailed description of the hydrology of the site is provided in Section 2.4.2 of the 2005 RIR (**Appendix D**).

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

According to the modeling report, the suggested ground water flow directions indicated by the ground water flow model are generally consistent with those reported in previous ground water investigations, and are also favorable when compared to ground water contour maps prepared using field depth to water measurements obtained in December 2009. In general, ground water flow is from areas of relatively high topographic elevations toward lower topographic elevations where site surface water features are present.

The ground water contour map for the December 2009 measurements at the CW-6 area created as part of the ground water modeling report is presented as **Figure 2-7**. The ground water contour map suggests that ground water at the site flows toward the southeast.

When applied to the understanding of contaminated areas, the net result of these physical conditions, according to the *Ground Water Modeling Summary Report,* would likely be ground water contaminant plumes with a dominant elongation in a downgradient direction. Vertical contaminant migration would typically be retarded by the fine-grained aquifer materials present at depth.

2.4.3 Aquifer Classification

A detailed description of the aquifer classification for the site is provided in Section 2.4.3 of the 2005 RIR (**Appendix D**). According to the RIR, the Site is found to be underlain by a Class III-A aquifer.

2.4.4 Soils

A detailed description of the soils in the vicinity of the site is provided in Section 2.4.4 of the 2005 RIR (**Appendix D**). According to the RIR, the soils in the vicinity of the Site are classified as Sn – Shrewsbury sandy loam—poorly drained soils on upland flats.

2.4.5 Topography and Surface Drainage

A detailed description of the topography and surface draining in the vicinity of the Site is provided in Section 2.4.5 of the 2005 RIR (**Appendix D**). According to the RIR, the land surface of the site is relatively flat at an elevation of approximately 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. In the vicinity of the 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.

3.0 SITE ACTIVITIES

Fort Monmouth DPW conducted RI activities at the Site, including a quarterly ground water sampling program. The purpose of this RI was to assess the ground water quality at the Site and verify that no COCs are present at concentrations greater than benchmarks within the Site ground water. Site activities were conducted according to applicable Fort Monmouth Site Operating Procedures (SOP) (**Appendix J**). Ground water RI activities were conducted from April 1997 through July 2010. These activities were managed by the Fort Monmouth DPW and performed by TECOM-Vinnell Services (TVS). The 2005 RIR (**Appendix D**) documented the results of the RI from April 1997 until February 2001. This RIRA details the results of the RI from May 2001 until July 2010. The details of RI activities at the Site are described in the following sections.

3.1 WELL INSTALLATION

Four monitoring wells (CW6-MW01, CW6-MW02, CW6-MW03, and CW6-MW34) were involved with the quarterly ground water monitoring program conducted by the DPW at the Site. As discussed in **Section 2.2**, three of the four wells (CW6-MW01 CW6-MW02, and CW6-MW03) were installed in 1994, during the UST closure and site investigations for UST Nos. 192486-24, 192486-32, and 192486-33. The remaining well, CW6-MW34, was installed by the DPW in January 1995. Monitoring wells CW6-MW35 and CW6-MW36 were also installed in 1994 as part of the SI for nearby site CW-9 but were not sampled as part of the quarterly ground water monitoring program for the Site. Monitoring well construction details are discussed in **Section 2.2**. Monitoring well construction details are summarized in **Table 2-1**. Well boring logs and monitoring well records are provided in **Appendix B**. Monitoring wells inspection checklists are provided in **Appendix O**.

3.2 SUPPLEMENTAL SOIL COLLECTION ACTIVITIES

On March 18, 1994, as documented in the UST Closure Report (ATC 2000), post-excavation soil samples were collected from the former UST excavations and submitted to the laboratory for TPH analysis only. VOCs and lead analyses were not completed for the post-excavation soil samples collected from the gasoline UST (UST No. 192486-33) excavation; therefore, additional soil sampling was conducted in 2010.

On August 27, 2010, soil samples were collected from four soil borings in the vicinity of former UST No. 192486-33 (2044SB-1, 2044SB-2, 2044SB-3, and 2044SB-4) within 6 inches of the ground water table (field-determined to be approximately 5.5-6 feet below grade); these samples were submitted to the Fort Monmouth Environmental Laboratory for analyses for VOCs plus 10 TICs, MTBE, TBA, and lead. The supplemental soil summary report is provided as **Appendix N.**

3.3 GROUND WATER SAMPLE COLLECTION ACTIVITIES

As a part of the remedial investigation, a quarterly ground water sampling program was conducted by the DPW from April 1997 through July 2010 at the Site. Sampling activities were

performed in accordance with the *Fort Monmouth Standard Sampling Operating Procedures* (1997). Laboratory analyses of the samples collected at the site were conducted at the Fort Monmouth Environmental Testing Laboratory (FMETL), a New Jersey-certified laboratory (Certification No. 13461). 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*."

Ground water sample collection activities from April 1997 until February 2001 (i.e., sampling rounds #1 through #18) are documented in Section 3.1 of the 2005 RIR (**Appendix D**). Discussion in this section is limited to samples collected from May 2001 until July 2010.

Monitoring wells CW6-MW01, CW6-MW02, CW6-MW03, and CW6-MW34 were sampled during 38 rounds of quarterly ground water sampling (i.e., sampling rounds #19 through #56). A total of 244 ground water samples, including 38 duplicate samples, 38 field blanks, and 16 trip blanks for quality assurance/quality control (QA/QC), were collected from the four monitoring wells at the Site. The quarterly ground water samples were analyzed as follows:

- During the quarterly sampling rounds #19 through #33, ground water samples were analyzed for VOCs plus 15 TICs using United States Environmental Protection Agency (USEPA) Method 624, for SVOCs plus 25 TICs using USEPA Method 625, for pesticides and PCBs using USEPA Method 608, for mercury using Standard Method 3112B, and for other TAL metals using Standard Method 3120B.
- During the quarterly sampling rounds #34 through #52, ground water samples were analyzed for mercury using Standard Method 3112B, and for other TAL metals using Standard Method 3120B.
- During the quarterly sampling round #53, ground water samples were analyzed for arsenic using Standard Method 3113B, for mercury using Standard Method 3112B, for thallium using USEPA Method 279.2, and for other TAL metals using Standard Method 3120B.
- During the quarterly sampling round #54, ground water samples were analyzed for arsenic using Standard Method 3113B, for mercury using Standard Method 3112B, for thallium using USEPA Method 279.3, and other for TAL metals using Standard Method 3120B.
- During the quarterly sampling rounds #55 and #56, ground water samples were analyzed for VOCs plus 15 TICs using USEPA Method 624, for SVOCs plus 25 TICs using USEPA Method 625, for arsenic using Standard Method 3113B, for mercury using Standard Method 3112B, for thallium using USEPA Method 279.3, and for other TAL metals using Standard Method 3120B.

Table 3-1 is a summary of the ground water sampling activities, including rounds, well IDs, sample IDs, sample locations, collection/analysis dates, analytical parameters, and analytical methods. On November 16, 2004, Fort Monmouth was granted permission via email to reduce the sampling parameters at the site from VOCs, SVOCs, pesticides, PCBs, and metals to

sampling only for metals (**Appendix E**). Copies of the ground water sampling chain-of-custody forms and laboratory data sheets are presented in **Appendix K**. Data validation reports of ground water sampling results are presented in **Appendix L** for the fourth quarter of 2009 and second quarter of 2010. The results of the quarterly ground water monitoring program for the Site are discussed in **Section 5.1** and are presented in **Tables 5-1 through 5-12**.

Low-flow sampling methodology was used by the DPW to assess the impact of entrained sediments on the dissolved phase metals concentrations at Fort Monmouth. In consideration of the potential benefits of the low-flow sampling procedure, two rounds of low-flow sampling were conducted on April 9, 2010 (Low Flow #3; Round #55), and July 22, 2010 (Round #56). Samples were collected and analyzed for VOCs, SVOCs, and TAL metals to determine whether elevated metal concentrations observed in the ground water samples at the Site are due to entrained soil particles (e.g., high turbidity), rather than dissolved phased ground water constituents. The results of the low-flow sampling rounds for the Site are discussed in **Section 5.1** and presented in **Tables 5-3, 5-6, 5-9, and 5-12**.

Sampling equipment was thoroughly decontaminated before and after each use, in accordance with the *Fort Monmouth Standard Sampling Operating Procedures* (1997) (**Appendix J**). Following collection, ground water 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.

During each of the monitoring well sampling rounds, aquifer chemical characteristics including pH, temperature, conductivity, and dissolved oxygen were recorded prior to sampling. These chemical characteristics are included in the laboratory data packages.

3.4 GROUND WATER DEPTH MEASUREMENTS

During each of the ground water monitoring rounds, measurements of the depth-to-water in each of the monitoring wells were recorded within an accuracy of 0.01 feet. These depth-to-water measurements, recorded from May 2001 through July 2010, are presented in **Table 3-2** and shown on **Figure 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. Ground water elevations are discussed in **Section 4.2**.

As approved by the NJDEP (**Appendix E**), ground water depth measurements are obtained quarterly by the DPW on a site-wide basis. This approach allows evaluation of ground water flow using monitoring wells associated with multiple sites, as opposed to using just the available wells on one site.

3.5 SENSITIVE RECEPTORS/WELL SEARCH

A visual and documentary search of sensitive populations was performed by FTMM, the DPW, and their subcontractor to identify potentially sensitive populations within 200 feet of the FTMM boundary. The identification of said populations is in accordance with NJDEP statutory

requirements. The Receptor Evaluation Report and NJDEP Sensitive Receptor Survey Form is provided in **Appendix M** and the Sensitive Receptor Survey figure as **Figure 3-2**.

Although the identified populations are within 200 feet of the FTMM boundary, all of the environmentally impacted locations are an appreciable distance from the fence line and in all cases exceed the 200-foot buffer established by NJDEP. In addition, Brinkerhoff also reviewed Site specific utility maps to identify any preferential pathways which could affect site contamination plumes.

In addition to the sensitive receptors, the DPW included all identified off-site wells within 2,000 feet of the FTMM perimeter. No production wells were identified within 2,000 feet of the FTMM boundary. The majority of off-site wells are monitoring wells associated with various remedial activities. A ground water model has been developed for FTMM, with the overall ground water flow pattern for the Main Post being easterly with a localized northeasterly component. FTMM is bounded by surface water bodies to the east and northeast. Domestic and/or irrigation wells to the east or northeast of the Main Post would not be impacted by activities on FTMM property.

Surface water bodies interact with ground water at FTMM. The interaction takes place in three basic ways: streams gain water from inflow of ground water through the streambed; streams lose water to ground water by outflow through the streambed, or both, gaining in some reaches and losing in other reaches. When ground water discharges into a surface water body, the elevation of the ground water table in the vicinity of the surface water body must be higher than the elevation of the stream water surface. Conversely, for surface water to seep to ground water, the elevation of the water table in the vicinity of the stream must be lower than the elevation of the stream water surface. The surface water bodies at FTMM (Oceanport and Parkers Creeks) may be gaining or losing depending upon the tidal cycle. Throughout the entire tidal cycle however, net results are that ground water inflows into the creeks, albeit at low flow rates.

A copy of the well search summary is provided as Appendix II of the ground water modeling summary report (**Appendix I**).

4.0 SITE PHYSICAL CHARACTERISTICS

The following sections represent the findings of the site geologic and hydrogeologic characterization program for the Site. These sections include a summary discussion of the physical properties of the unconsolidated soil and ground water underlying the study area. Ground water elevations obtained by the DPW from May 2001 to July 2010 are presented in this section.

4.1 LITHOLOGY

The lithology encountered at the Site consists of fine to coarse sand, silt, and clay. A geologic cross section (A-A') prepared for the four monitoring wells is included in the 2005 RIR (**Appendix D**). Ground water was encountered at a depth of 4 feet bgs during drilling activities.

As stated in **Section 2.4.1**, the wide range of concentrations of metals in soils further impacts concentrations of metals in ground water. 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 ground water, particularly if sediments enter during collection of ground water samples.

4.2 GROUND WATER CHARACTERISTICS

The following sections discuss ground water flow direction and hydrogeologic properties.

4.2.1 Flow Direction

A ground water contour plot (**Figure 2-7**) was generated based on the 2010 ground water modeling effort performed by Brinkerhoff (**Appendix I**). The ground water underlying the Site appears to be flowing towards the southeast. Changes in ground water elevation were noted in the 38 rounds of water level measurements (**Figure 3-1**).

Ground water contour maps were generated based on ground water depth measurements from the first and third quarterly ground water sampling rounds in 2010 (**Figures 4-1 and 4-2**). The groundwater contour reporting forms are provided in **Appendix P.** The ground water underlying the Site appears to be flowing towards the southeast. Changes in ground water elevation were noted in the 16 rounds of water level measurements (**Table 3-2**).

4.2.2 Hydrogeologic Properties

As discussed in **Section 2.4.2**, Brinkerhoff developed and refined site-wide ground water models for both the Main Post and the Charles Wood area in 2010. The ground water flow model simulation was performed under steady state conditions using the WHS Solver for Visual MODFLOW, a proprietary solver developed by Waterloo Hydrogeologic Inc., of Ontario, Canada. The *Ground Water Modeling Summary Report* is included as **Appendix I**. The following is a description of the ground water flow conditions summary for the Charles Wood area from the *Ground Water Modeling Summary Report*.

The suggested ground water flow directions indicated by the ground water flow model are generally consistent with those reported in previous ground water investigations, and are also favorable when compared to ground water contour maps prepared using field depth to water measurements obtained in December 2009.

Compared to the Main Post area, the Charles Wood area is characterized as having a moderate hydraulic gradient and corresponding ground water migration velocities. Ground water flow tends to be predominantly horizontal toward the streams that traverse the parcel.

Particle markers, which represent typical travel paths and speeds for water molecules in the system, tended to reach the nearest surface water sink within 10 to 20 years at the Charles Wood area, in contrast to the Main Post area, with travel times exceeding 200 years. Due to the faster ground water velocities, variations in the recharge to the aquifer from rainfall had a limited effect on ground water flow direction.

As applied to efforts at understanding contaminated areas, the net result of these physical conditions would likely be ground water contaminant plumes with a dominant elongation in a downgradient (horizontal) direction. Vertical contaminant migration would typically be retarded by the fine-grained aquifer materials present at depth.

5.0 SITE CHEMICAL CHARACTERIZATION

This section includes a discussion of the chemical analytical characterization of the site based on the various samples collected and analyzed from the site from May 2001 to July 2010, including 38 rounds of ground water monitoring well samples. DPW personnel were responsible for collecting samples during this site investigation. Sample analyses were performed by the FMETL, a New Jersey-certified laboratory (Certification No. 13461).

5.1 GROUND WATER SAMPLE RESULTS

This section presents a discussion of laboratory analytical results from the 38 rounds of quarterly ground water sampling during May 2001 through July 2010 from four monitoring wells (CW6-MW01, CW6-MW02, CW6-MW03 and CW6-MW34). From May 2001 until November 2004, the ground water samples were collected and analyzed for VOCs plus 15 TICs, for SVOCs plus 25 TICs, for pesticides, for PCBs and for TAL metals. From January 2005 until April 2010, the ground water samples were collected and analyzed only for TAL metals. In July 2010, the ground water samples were collected and analyzed for VOCs plus 15 TICs, for SVOCs plus 25 TICs, and for TAL metals. **Table 3-1** is a summary of the ground water sampling activities—including rounds, well IDs, sample IDs, sample locations, collection/analysis dates, analytical parameters, and analytical methods. As discussed in **Section 3.3**, the last two quarterly rounds of ground water sampling, on April 9, 2010 and July 22, 2010, were conducted using a low-flow sampling technique.

As discussed in **Section 2.4.3**, Fort Monmouth is underlain by a Class III-A aquifer. N.J.A.C. 7:9C-1.5 specifies that the Ground water Quality Standards to be used for Class III-A aquifers should be the most stringent criteria associated with vertically or horizontally adjacent ground waters that are not Class III-A. The NJDEP criteria used for comparisons with ground water analytical results were the higher of the Practical Quantitation Limits (PQL) and the NJDEP GWQS for Class II-A aquifers (N.J.A.C. 7:9C, Appendix Table 1).

Monmouth County and site-specific Maximum Background Concentrations (MBC) for certain constituents were determined as part of the 1995 SI using literature values and on-site background data (**Appendix C**). As part of the response to NJDEP comments on the 1995 SI, 95% confidence limits were established for inorganics in background soil and ground water (**Appendix E**). The analytical results were compared with the appropriate GWQS at the time the samples were collected. If an analytical result exceeded a GWQS, it was then compared with the MBC (the higher of the Monmouth County or site-specific background concentration for organics, or the 95% confidence limit for inorganics).

Analytes detected in ground water samples at concentrations greater than GWQS are in bold and are highlighted in **Tables 5-1 through 5-12**. The laboratory data sheets are provided in **Appendix K**. **Figure 5-1** depicts the contaminant distribution for ground water for the Site.

This section discusses detections of analytes within the four analytical categories of VOCs, SVOCs, pesticides and PCBs, and TAL metals.

5.1.1 Volatile Organic Compounds

Ground water samples were analyzed for VOCs from May 2001 until November 2004, then again in July 2010. Three VOCs (acetone, 2-butanone, and MTBE) were detected in ground water samples at concentrations less than the GWQS.

5.1.2 Tentatively Identified Compounds (TICs)

During the reporting period, all wells sampled had no VOC TICs detected at concentrations exceeding the GWQS for both individual TIC compound (100 µg/L) or total TICs compounds (500 µg/L) in groundwater samples.

5.1.3 Semivolatile Organic Compounds

Ground water samples were analyzed for SVOCs from May 2001 until November 2004, then again in July 2010. Four SVOCs (bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, 2,4-dichlorophenol, and caprolactam) were detected in ground water samples at concentrations less than the GWQS. No SVOCs TICs concentrations exceeded the individual or total TICs GWQS.

5.1.4 Pesticides and PCBs

Ground water samples were analyzed for pesticides and PCBs from May 2001 until November 2004. No PCBs were detected in the ground water samples. Eight pesticides (4,4'-DDD, 4,4'-dichlorodiphenyldichloroethene (DDE), 4,4'-dichlorodiphenyltrichloroethane (DDT), alpha-chlordane, gamma-chlordane, Endosulfan sulfate, Endosulfan I, and heptachlor epoxide) were detected in the ground water samples. Except for 4,4'-DDD, all pesticides were detected at concentrations less than the GWQS.

4,4'-DDD was detected at a concentration exceeding the GWQS of 0.1 µg/L during one round of sampling at one monitoring well location (CW6-MW01). It was present at a concentration of 0.199 µg/L (sampling round #19).

5.1.5 TAL Metals

Within the 38 ground water sampling rounds, at least six TAL metals were detected at concentrations greater than their respective comparison criterion in at least one sample at the Site.

Antimony was detected at concentrations exceeding the GWQS (maximum of 6 µg/L) during four rounds of sampling at two monitoring well locations. Concentrations exceeding GWQS ranged from 6.13 µg/L in CW6-MW03 (sampling round #40) to 17.9 µg/L in CW6-MW03 (sampling round #50).

Arsenic was detected at concentrations exceeding the GWQS (maximum of 27.6 µg/L) during 11 rounds of sampling at all four monitoring well locations. Concentrations exceeding GWQS ranged from 32.9 µg/L in CW6-MW02 (sampling round #34) to 144 µg/L in CW6-MW02 (sampling round #35).

Cadmium was detected at concentrations exceeding the GWQS (maximum of 4 µg/L) during two rounds of sampling at CW6-MW02 at concentrations of 7.24 µg/L (sampling round #33) and 4.04 µg/L (sampling round #27).

Lead was detected at concentrations exceeding the GWQS (maximum of 10 µg/L from 2001 until November 2005; 5.5 µg/L after November 2005) during 16 rounds of sampling at three monitoring well locations. Concentrations exceeding GWQS ranged from 6.58 µg/L in CW6-MW01 (sampling round #44) to 63.2 µg/L in CW6-MW02 (sampling round #27).

Selenium was detected at concentrations exceeding the GWQS (maximum of 40 µg/L) during two rounds of sampling at three monitoring well locations. Concentrations exceeding the GWQS ranged from 48 µg/L in CW6-MW34 (sampling round #50) to 95.9 µg/L in CW6-MW03 (sampling round #50).

Thallium was detected at concentrations exceeding the GWQS (maximum of 2 µg/L) during one round of sampling at two monitoring well locations. Concentrations exceeding the GWQS ranged from 2.07 µg/L in CW6-MW01 (sampling round #43) to 2.29 µg/L in CW6-MW34 (sampling round #43).

5.2 CONTAMINANTS OF CONCERN

No VOCs or SVOCs were detected in ground water at concentrations greater than the NJDEP GWQS. No PCBs were detected in the ground water samples. One pesticide which detected in ground water samples at concentrations greater than comparison criterion is not considered a COC. Six TAL metals were detected at concentrations greater than their respective GWQS. **Tables 5-1 through 5-12** are summaries of each analyte's exceedences of GWQS.

As presented in the Weston SI Report (1995), several natural and man-made factors contribute to the wide range in concentrations of metals in soils, which further impact concentrations 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. A low-flow sampling methodology was used by the DPW to assess the impact of suspended sediments on the dissolved phase metals concentrations at the site. The two separate rounds of low-flow sampling were performed during the quarterly ground water sampling program, using the low-flow ground water sampling technique as discussed in **Section 3.2.1**. This technique was used to determine if the detected metal concentrations observed in the ground water samples resulted from contaminated sediments suspended in the ground water during the course of well purging and sampling activities, or were an accurate representation of aquifer/ground water conditions. Using a low-flow sampling methodology

resulted in substantial reductions in dissolved phase concentrations of metals indicated in ground water analytical data.

Of the six TAL metals detected with concentrations exceededing the GWQS (antimony, arsenic, cadmium, lead, selenium, and thallium); four TAL metals (arsenic, cadmium, lead, and selenium) were determined to be background constituents in Monmouth County and the Charles Wood area ground water (Weston 1995). The ground water analytical results for arsenic, cadmium, lead, and selenium from low-flow sampling were compared to their respective 95% confidence limit MBCs. Based on this review, cadmium and selenium are not considered COCs in site ground water.

Arsenic was detected at concentrations greater than the GWQS in 11 rounds of sampling at all four monitoring well locations. Lead was detected at concentrations greater than the GWQS in 16 rounds of sampling at three of the monitoring wells. Ground water concentrations of both metals varied greatly. During some sampling events, their concentrations exceeded comparison criteria, while during other rounds, these metals were not detected. During the two rounds of low-flow ground water sampling at the Site, samples collected using the low-flow sampling approach showed reduced concentrations or non-detections of arsenic and lead.

Two metals, antimony and thallium, that were not present in the background ground water collected during the SI and not identified in the literature search as metals common to Monmouth County, exceeded comparison criteria. This conclusion resulted from comparing their ground water analytical results from low-flow sampling to their NJDEP GWQS.

Antimony was detected at concentrations greater than the NJDEP GWQS in four rounds of sampling at two monitoring well locations. Use of the low-flow sampling approach did not eliminate detections of antimony, which persisted at concentrations exceeding the NJDEP GWQS during the second of the two low-flow sampling rounds.

Thallium was detected at concentrations greater than the NJDEP GWQS at two monitoring well locations in one round of ground water sampling. The exceedences appear to have been isolated events, and therefore thallium is not considered a COC.

Due to the low concentrations of antimony, arsenic, and lead in ground water at the Site and the extremely slow migration rates of these analytes in the site ground water, they pose little potential for significant impact by migration. The Wenonah Mount Laurel aquifer, which is approximately 125 feet bgs, is too deep to be affected by presence of these metals near ground surface. In addition, the sensitive receptor survey (**Appendix M**) indicated no domestic or irrigation wells close enough to the Site to be adversely impacted by COC migration. Therefore, antimony, arsenic, and lead are not considered COCs.

5.3 SUPPLEMENTAL SOIL SAMPLING RESULTS

On August 27, 2010, soil samples were collected for analyses for VOCs plus 10 TICs and lead that had not been completed during the post-excavation soil sampling associated with the UST excavation on March 18, 1994. Soil samples were collected from four soil borings in the vicinity

of former UST No. 192486-33 (2044SB-1, 2044SB-2, 2044SB-3, and 2044SB-4) within 6 inches of the ground water table (field-determined to be approximately 5.5-6 feet below grade); these samples were submitted to the Fort Monmouth Environmental Laboratory for VOCs plus 10 TICs, MTBE, TBA, and lead analyses (**Figure 5-2**). The results of the supplemental soil sampling are included in **Appendix N.**

No VOCs were detected in the soil samples. Lead was detected in the soil samples but at concentrations less than NJDEP's Impact to Ground Water Soil Remediation Standards, Residential Direct Contact Soil Remediation Standards, and Non-Residential Direct Contact Soil Remediation Standards.

Based on the analytical results for the soil samples collected on August 27, 2010 (in compliance with all applicable NJDEP soil remediation standards), no additional investigation is warranted for gasoline UST No. 192486-33 and its associated NJDEP Case Number 93-6-28-1009.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Geologic publications show that the 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 7:9C, July 22, 2010).

Analytical results for the ground water samples collected at the Site from May 2001 to July 2010 indicate no presence of COCs at concentrations greater than benchmarks within the Site ground water. The Class II-A criteria were used for comparison with site-specific data obtained from the various ground water sampling rounds because the GWQS (NJAC 7:9C-1.5) specifies that the Ground water Quality Standards to be used for Class III-A aquifers should be the most stringent criteria associated with vertically or horizontally adjacent ground waters that are not Class III-A.

One pesticide (4,4'-DDD) was detected at concentrations greater than the comparison criteria during one quarterly round. This is considered an isolated and marginal exceedance, and therefore 4,4-DDD is not considered a COC. Six metals (antimony, arsenic, cadmium, lead, selenium, and thallium) were detected in ground water samples at concentrations exceeding their comparison criteria. Arsenic, cadmium, lead, and selenium were determined to be background constituents in Monmouth County and the Charles Wood area ground water. Thallium was detected at a concentration greater than comparison criteria during only one round of ground water sampling; this is considered an isolated event.

Three metals (antimony, arsenic, and lead) were further considered as potential COCs; however, due to the extremely slow migration rates of these metals in the site ground water, they pose little potential for significant impact by migration. The Wenonah Mount Laurel aquifer, which is approximately 125 feet bgs, is too deep to be affected by presence of these metals near ground surface. In addition, the sensitive receptor survey (**Appendix M**) indicates no domestic or irrigation wells close enough to the Site to be adversely impacted by COC migration.

NFA is requested concerning ground water at the Site.

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