REMEDIAL INVESTIGATION REPORT ADDENDUM
SITE 287
FORT MONMOUTH, NEW JERSEY

PREPARED FOR:

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

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APPENDICES

HRC	Hydrogen Releasing Compound
HRR	Historical Records Review
HSA	Historical Site Assessment
HVAC	Heating, Ventilation, and Air Conditioning
IH	Industrial Hygiene
IGWSCC	Impact to Ground water Soil Cleanup Criteria
IRP	Installation Restoration Program
kVA	Kilovolt-ampere
LEL	Lowest Effects Level
LOC	Level of Concern
LTM	Long Term Monitoring
m	Meter
MBC	Maximum Background Concentration
MC	Munitions Constituents
MDL	Method Detection Limit
MEC	Munitions and Explosives of Concern
mg/kg	Milligrams per kilogram
mmhos/m	Millimhos per meter
MMRP	Military Munitions Response Program
MODFLOW	Modular finite-difference Flow model
MP	Main Post
MPBC	Main Post Background Concentration
MTBE	Methyl tert-butyl ether
NAD	North American Datum
NFA	No Further Action
NJDEP	New Jersey Department of Environmental Protection
NRDCSCC	Non-Residential Direct Contact Soil Cleanup Criteria
NRIASL	Non-Residential Indoor Air Screening Level
NRS	Non-Residential Standard
NRSGSL	Non-Residential Soil Gas Screening Level
OQA	Office of Quality Assurance
ORC	Oxygen Release Compound
OVA	Organic Vapor Analyzer
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
PID	Photoionization Detector
ppm	Parts per million
PQL	Practical Quantitation Limit
ppt	Parts per thousand
PQL	Practical Quantitation Limit
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RAB	Restoration Advisory Board

EXECUTIVE SUMMARY

Tetra Tech EM, Inc. (Tetra Tech) has been contracted by the U.S. Army Installation, Fort Monmouth Directorate of Public Works (DPW), Fort Monmouth, New Jersey to prepare a Site Investigation Report (SIR) for Site 287 located in the Main Post Area of Fort Monmouth, New Jersey. This report summarizes previous Underground Storage Tank (UST) closure activities and addresses the site investigation activities and ground water monitoring performed at this site to investigate ground water conditions from October 2003 through August 2010. The New Jersey Department of Environmental Protection (NJDEP) case number for ground water contamination at Site 287 is 93-11-29-1745-01.

Site 287 is located in the eastern part of the Main Post Area of Fort Monmouth, in the vicinity of Buildings 202, 205 through 208, and 282 (**Figure 2-1).** One UST closure has been performed in 1993 at Site 287 as part of DPW's UST management program. The ground water monitoring program associated with DPW's UST management program includes one well (287MW01) installed in July 1994.

Ground water samples collected in 1994 were analyzed for VOCs plus 15 TICs, methyl tertiary butyl ether (MTBE), tertiary butyl alcohol (TBA), xylenes, and SVOCs. No contaminant concentrations exceeded the NJDEP Class II-A Ground Water Quality Standard (GWQS).

No additional ground water sampling results for well 287MW01 during the period from December 1994 to October 2003 were available for review.

In 1995, Weston conducted soil sampling, monitoring well installation and sampling and geophysical surveying as part of a Site Investigation (SI) of the Fort Monmouth military installation. Weston established background concentrations for soil and ground water for the Fort Monmouth installation, as reported in the Weston SI Report (1995) (**Appendix C**).

As presented in the Weston 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. 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.

Fort Monmouth DPW has conducted site investigation activities from October 2003 to August 2010, including a ground water sampling program, to define the areal extent of potential pollutants and evaluate potential impacts to ground water in the vicinity of Site 287. .

Monitoring well 287MW01 was sampled during 27 rounds of quarterly ground water sampling, including two low-flow rounds. During the 27 quarterly sampling events, two TAL metals (arsenic and lead) were detected in ground water samples at concentrations greater than their respective NJDEP GWQS; however, based on exceedance frequency only arsenic is identified as contaminant of concern (COC).

1.0 INTRODUCTION

Tetra Tech EM Inc. (Tetra Tech) has been contracted by the U.S. Army Installation, Fort Monmouth Directorate of Public Works (DPW), Fort Monmouth, New Jersey to prepare a Site Investigation Report (SIR) for Site 287 located in the Main Post Area of Fort Monmouth, New Jersey. This report summarizes the previous underground storage tank (UST) closure and addresses the site activities performed at this site to investigate ground water conditions from October 2003 through August 2010. The New Jersey Department of Environmental Protection (NJDEP) case number for ground water contamination at Site 287 is 93-11-29-1745-01.

This section describes the objectives and organization of this SIR.

1.1 OBJECTIVES

The objectives of this SIR are to define the chemical and physical characteristics of the aquifer related to the site and to determine potential further investigation activities at Site 287. Site investigation activities were conducted in accordance with NJDEP *Technical Requirements for Site Remediation (TRSR)* (July 2008), NJAC 7:26E, et seq.

As part of the subsequent preparation of this SIR, Tetra Tech performed the following activities:

- Summarized UST removal and closure activities and associated post-excavation sampling and analysis and related site investigation activities.
- Characterized ground water quality at Site 287 based on quarterly ground water sampling events conducted from October 2003 through August 2010.
- Compared the ground water sampling results with NJDEP Ground Water Quality Standard (GWQS) for Site 287.
- Investigated and evaluated the designated aquifer uses, the associated aquifer classification, and the appropriate ground water quality standard for ground water resources beneath Site 287. The NJDEP GWQS specifies the quality criteria and designated uses for ground water, and also contains technical and general policies to ensure that the designated uses can be adequately protected.
- Reviewed information related to the development of a ground water flow and transport model for Site 287 based on the hydrogeologic data, field investigation programs, and technical research to evaluate the migration of potential contaminants of concern (COCs) beneath Site 287.
- Formulated 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 Site 287. The rationale for the NFA proposal is presented in this SIR.

2.0 SITE BACKGROUND AND ENVIRONMENTAL SETTING

The following sections describe the background and environmental setting of the area surrounding Fort Monmouth and Site 287, including a description of the location of Site 287, its background, current conditions and environmental setting.

2.1 SITE LOCATION AND DESCRIPTION

Fort Monmouth is located in the central-eastern portion of New Jersey in Monmouth County, approximately 45 miles south of New York City and 70 miles northeast of Philadelphia (**Figure 2-1**). In addition to the Main Post, the installation includes two subposts, the Charles Wood Area and the Evans Area. The Main Post encompasses approximately 630 acres and is bordered to the north by Parkers Creek, to the northeast by the New Jersey Transit Railroad, to the west by State Highway 35, to the south/southeast by Oceanport Creek, and to the south by residential areas. The post was established in 1918 during World War I as an Army Signal Corps training center. The Main Post currently provides administrative, training, and housing support functions, as well as many of the community facilities for Fort Monmouth. 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.

Site 287 consists of a brick building (currently unoccupied) formerly used as barracks. The site is located in the eastern part of the Main Post Area of Fort Monmouth, in the vicinity of buildings 202, 205 through 208, and 282. Site 287 is located approximately 70 feet southwest of Oceanport Avenue and approximately 210 feet southeast of Hildreth Avenue and is surrounded by Barker Circle (**Figure 2-2**). **Figure 2-3** depicts the utilities layout for Site 287 and **Figure 2-7** depicts the wetlands at the Main Post.

2.2 SITE BACKGROUND

The U.S. Army Corps of Engineers (USACE), Baltimore District, initially contracted Roy F. Weston, Inc. (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) (USATHAMA 1980). The USATHAMA report identified 37 sites with known or suspected waste materials on the Main Post and the two subposts (Charles Wood and Evans Areas). Weston conducted a background investigation of the 37 sites and eight additional sites also 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. The NJDEP approved the recommendations on April 20, 1995.

In the early 1990s, the DPW developed a UST program for managing approximately 506 USTs located throughout the Fort Monmouth installation. This program was created to work toward

Soil Sampling

On November 2, 1993, following the removal of the UST and excavation of potentially contaminated soil, six post-excavation soil samples were collected from the sidewalls of the excavation directly above ground water and analyzed for Total Petroleum Hydrocarbons (TPHC).

TPHC was detected in five of the six post-excavation soil samples at concentrations ranging from 47.4 milligrams per kilogram (mg/kg) in sample SITE E (collected beneath the underground piping run) to 3,130 mg/kg in sample SITE A from the west/southwest side of the excavation. Non-detectable contaminant concentrations were present in sample SITE F. Results of the post-excavation sampling are presented in **Appendix A-8**.

On November 8, 1993, the area surrounding sampling location SITE A, which had the highest concentration of TPHC, was re-sampled; one additional post-excavation sample (Site A-2) was collected from the sidewalls of the excavation directly above ground water and submitted to be analyzed for Volatile Organic Compounds (VOC), Base Neutrals (BN)/Semi-Volatile Organic Compounds (SVOCs) plus 15 Tentatively Identified Compounds (TICs), and lead. The analytical results revealed the following:

- VOCs were not detected in the sample; however, 20 VOC TICs were found at an estimated concentration of approximately 7.86 mg/kg.
- SVOC concentrations ranged from non-detect (ND) to 1.9 mg/kg; and, 20 SVOC TICs were found at an estimated concentration of approximately 86.4 mg/kg.
- Lead was detected at a concentration of 23.5 mg/kg.

In accordance with regulatory requirements, two quality control samples (a field blank and a trip blank) were also collected and analyzed. No contaminants were found in the field blank; however, acetone and methylene chloride were detected in the trip blank, indicating laboratory contamination. Results of the post-excavation sampling are presented in **Appendix A-9**.

On July 6, 1994, one soil sample was collected from the well boring and submitted to Princeton Testing Laboratory for VOC plus 15 TICs analysis. The results revealed the following:

- Methylene chloride (a common laboratory contaminant) was detected at a concentration of 0.0073 mg/kg.
- Acetone (also a common laboratory contaminant) was detected at a concentration of 0.200 mg/kg.
- No other VOCs listed in the standard analytical scan were detected; 15 TICs were detected with low estimated concentrations of approximately 1.07 mg/kg.

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.

2.2.3 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.

2.2.4 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 D**.

2.3 SITE CONDITIONS

On October 21, 2010, Tetra Tech conducted a site visit with Fort Monmouth DPW Environmental Office staff to observe current conditions at Site 287. The site consists of Building 287, which is currently unoccupied. Site photographs taken during the UST closure activities document the former UST location at the rear of the building; copies of the photographs are included in **Appendix A-6**.

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 E**.

2.4.2 Hydrogeology

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

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

Further details of the hydrogeology in the Main Post area is provided in Section 2.6 of the Weston SI Report (see **Appendix C**).

Based on a review of the NJDEP GWQS (NJAC 7:9-6), Tetra Tech has determined that the site is underlain by a Class III-A aquifer (NJDEP 1993). The primary designated use for Class III-A ground water is the release or transmittal of ground water to adjacent classification areas and surface water, as relevant. Secondary designated uses in Class III-A include any reasonable use. Further discussion of the Class III-A aquifer designation is presented in **Section 6.3**.

Shallow ground water may be locally influenced within the Main Post area by the following factors:

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

Because of the fluvial nature of the overburden deposits (i.e., sand and clay lenses), shallow ground water flow direction is best determined on a case-by-case basis. The ground water in the vicinity of Site 287 appears to be flowing in a northerly direction toward Parkers Creek.

3.0 SITE ACTIVITIES

Fort Monmouth DPW has conducted site investigation (SI) activities at Site 287, including a quarterly ground water sampling, as part of a Long-Term Monitoring (LTM) program since the 1993 UST removal and closure revealed potential impacts to ground water in the vicinity of the site. The purpose of the LTM sampling is to define the areal extent of potential pollutants and assess impacts to ground water in the vicinity of the site. Site activities were conducted according to the NJDEP *Field Sampling Procedures Manual (FSPM)* and the applicable Fort Monmouth Standard Operating Procedures (SOPs) for field sampling (**Appendix H**). Initial SI activities were performed from October 1993 to October 1996 (see UST Questionnaire in **Appendix A-1**). This report documents SI activities conducted from October 2003 to August 2010. These activities were managed by the Fort Monmouth DPW and performed by TECOM-Vinnell Services (TVS). The details of SI activities completed at Site 287, including well installation, sample collection activities, ground water depth measurements, and sensitive receptors/well search activities, are described in the following sections.

3.1 WELL INSTALLATION

DPW conducts quarterly ground water monitoring of the one monitoring well (287MW01) at Site 287. As discussed in **Section 2.2**, the well was installed in July 1994 during the UST closure and site investigation for UST No. 0081533-61. Monitoring well construction details are discussed in **Section 2.2** and copies of the well permit, boring logs, and monitoring well construction records are provided in **Appendix B**.

3.2 SAMPLE COLLECTION ACTIVITIES

As part of the SI activities of Site 287, quarterly ground water monitoring was conducted from October 2003 to August 2010. Sampling activities were performed in accordance with the current version of the NJDEP *Field Sampling Procedures Manual* and the *Fort Monmouth Standard Operating Procedures* for field sampling in effect at the time sampling was conducted. Laboratory analyses of the samples collected at Site 287 were conducted by the Fort Monmouth Environmental Testing Laboratory (FMETL), a New Jersey certified laboratory (Certification No. 13461).

Monitoring well 287MW01 was sampled during 27 rounds of quarterly ground water sampling. A total of 82 ground water samples, including 11 duplicate samples, 23 field blanks, and 21 trip blanks for quality assurance/quality control (QA/QC), were collected from the well at Site 287. The quarterly ground water samples were analyzed as follows:

- For the first 16 quarters (2004 through 2007), the sample analyses consisted of VOCs plus 15 TICs, Acid Base Neutrals (ABN)/SVOCs plus 15 TICs, TPHC, and lead.
- For the next eight quarters (2008 through 2009), the sample analyses consisted of VOCs plus 15 TICs, ABN/SVOCs plus 15 TICs, and lead.

3.4 SENSITIVE RECEPTORS/WELL SEARCH

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 J**. 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 the identified populations are within 200 feet of the FTMM 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 has 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. Any domestic and/or irrigation wells to the east or northeast of the Main Post would not be impacted by base.

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, they lose water to ground water by outflow through the streambed or they do both, gaining in some reaches and losing in other reaches. 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 FTMM (Oceanport and Parkers Creeks) may be gaining or losing depending upon the tidal cycle. Throughout the entire tidal cycle however, net results is that ground water inflows into the creeks, albeit at low flow rates.

A copy of the offsite receptor evaluation report and survey (Tetra Tech 2010) is provided in **Appendix J.**

and at a shallow depth below the Charles Wood Area. The Hornerstown and Red Bank Formations overlay the larger Wenonah-Mount Laurel aquifer (Brinkerhoff 2010).

As discussed above, 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 F**. The following is a description of the ground water flow conditions summary from the *Ground water Modeling Summary Report* (Brinkerhoff 2010):

> 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 in December of 2009.
>
> When 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 which 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, in contrast to the Main Post area, with travel times in excess of 200 years. Due to the faster ground water velocities, varying the recharge to the aquifer from rainfall has a limited effect on ground water flow direction.

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

5.1.2 Tentatively Identified Compounds (TICs)

During the reporting period, all wells sampled had VOC TICs detected for at least a sampling event. However, none of the individual compound or total TICs concentration exceed their respective GWQS, 100 µg/L for individual TIC or 500 µg/L for total TIC.

5.1.3 SVOCs

Benzo[a]anthracene was detected at concentrations exceeding the GWQS of 0.1 µg/L during the second low-flow sampling round (June 2010); a concentration of 0.207 µg/L was detected.

5.1.4 TPHC

No TPHCs were detected greater than the appropriate GWQS at the site.

5.1.5 Metals

During the quarterly sampling events, the following five metals were detected in ground water samples at concentrations greater than their respective NJDEP GWQS (NOTE: Full TAL metal analysis was only performed during the last three sampling quarters as part of the base-wide metals ground water investigation).

Antimony was detected at concentrations exceeding the GWQS of 6.0 µg/L during the last three rounds of sampling; concentrations ranged from 8.89 µg/L to 14.0 µg/L.

Arsenic was detected at concentrations exceeding the GWQS of 3.0 µg/L during the last three rounds of sampling; concentrations ranged from 8.04 µg/L to 8.79 µg/L.

Iron was detected at concentrations exceeding the GWQS of 300 µg/L during the last three rounds of sampling; concentrations ranged from 1,090 µg/L to 3,250 µg/L.

Lead was detected at a concentration exceeding the GWQS of 5.0 µg/L during sampling round #2 conducted in May 1994; lead was detected at a concentration of 10.9 µg/L.

Manganese was detected at concentrations exceeding the GWQS of 50 µg/L during the last three rounds of sampling; concentrations ranged from 57.8 µg/L to 173 µg/L.

5.2 CONTAMINANTS OF CONCERN

In order to determine the potential COCs in ground water at Site 287, the first step was to identify exceedances of the NJDEP criteria (GWQS) in the monitoring well samples collected at Site 287. These exceedances are presented in **Section 5.1** above and in **Table 5-1**. Arsenic was the only ground water constituent identified as a potential COC at Site 287.

Several factors were used to eliminate or identify analytes as COCs. These factors included the magnitude and frequency of the exceedances, comparisons to low-flow sampling results (for

Three separate rounds of sampling (March 22, 2010, June 22, 2010, and September 14, 2010) were performed during the quarterly ground water sampling program using the low-flow ground water sampling technique as discussed in **Section 3**. 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. These comparisons provided the following results:

- Arsenic concentrations exceeded the GWQS in samples collected during all of the low-flow sampling rounds. Based on these results, arsenic is considered to be a potential COC at Site 287.
- No concentrations of lead exceeding the GWQS were detected during any of the three low-flow sampling rounds. Lead was detected greater than the GWQS of 5.0 µg/L in only one sample collected during the 27 sampling rounds (10.9 µg/L in well 287MW01, collected in May 2004); in addition, the concentration is well less than one order of magnitude greater than the GWQS. Based on these results, lead is not considered to be a COC at Site 287.

Based on the magnitude of the exceedances, the frequency of occurrences, and the wide-ranging results, one metal (arsenic) is identified as a COC at Site 287. Arsenic is further discussed with regard to contaminant migration potential in **Section 6.0** of this SIR. No other COCs were identified in ground water at Site 287. The concentrations of arsenic in ground water at Site 287 are summarized on **Figure 5-1** and in **Table 5-1**.

The method detection limit (MDL) for each analysis is included in the laboratory data packages. These method detection limits were used in the ground water model as discussed in **Section 6.1**.

5.3 RESULTS OF MANN-WHITNEY U TESTS

Fort Monmouth DPW performed Mann-Whitney U tests for the last eight quarterly sampling rounds. The tests concluded that the concentrations of antimony, arsenic, and selenium do not present a decreasing trend over time, with a confidence of greater than 90 percent, as specified in Appendix C of the NJDEP Technical Requirements for Site Remediation (N.J.A.C. 7:26E). A copy of the Mann-Whitney U tests is included in the **Appendix M**.

5.4 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Quality assurance and quality control (QA/QC) samples were collected in accordance with the version of the NJDEP *Field Sampling Procedures Manual* and the applicable Fort Monmouth SOPs in effect at the time sampling was conducted. A total of 33 duplicates, 41 field blanks, and 17 trip blanks were collected. No evidence of any QA/QC issues were identified based on the QA/QC sampling results.

6.0 CONTAMINANT MIGRATION AND GROUND WATER USE DESIGNATION

The purpose of developing a ground water model for the Main Post (including Site 287) was to predict the migration of identified COCs, including arsenic, in site ground water. For the model area, initial concentrations of arsenic were assigned based on ground water quality sample results (**Section 5.1**), and migration trends and changes in arsenic concentrations over time were predicted. The time required to achieve compliance with the NJDEP criteria was then estimated.

This section discusses the development of the ground water model, sensitive receptor survey results, aquifer classification, and contaminant migration.

6.1 GROUND WATER MODEL DEVELOPMENT

As discussed in Section **2.4.2**, Brinkerhoff prepared the *MODFLOW Ground Water Modeling Report*, dated June 10, 2010, which is included as **Appendix F**. Brinkerhoff developed and refined site-wide ground water models for both the Main Post and the Charles Wood Area.

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.

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 also appear to be consistent when compared to ground water contour maps prepared using field depth-to-water measurements. The ground water contour map for the January 2010 measurements at the Site 287 area created as part of the ground water modeling report is presented as **Figure 4-1**. The ground water contour map suggests that ground water at the site flows toward the north.

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 relatively 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.

Ground water modeling and a sensitive receptor survey were conducted to determine whether ground water from Site 287 could impact surface water, off-site domestic wells, and the subsurface ground water aquifers. The ground water modeling indicates that the impact of arsenic migration in ground water at Site 287 will be minimal due to low hydraulic conductivity and sorption of the arsenic to the soil (retardation). The results of the ground water modeling and sensitive receptor survey are summarized below:

- Because of the low concentrations of the identified COC (arsenic) at Site 287, and the very slow migration rates for this metal in the ground water, there is little potential for significant impact by migration (seepage) into Parkers Creek or Oceanport Creek.
- The closest aquifer, the Wenonah-Mount Laurel Aquifer, is located approximately 125 feet bgs. The results of the ground water modeling indicate that this aquifer is too deep to be affected by the COC present near the ground surface at Site 287, and that the vertical exchange of ground water between the aquifers (leakage) is minimal.
- The sensitive receptor survey indicates that the closest downstream domestic well is (at least) approximately 550 feet from Site 287, across Oceanport Creek, which is too far to be impacted by COC migration. The potential migration of the COC from Site 287 to this well in any reasonable time period is not possible.

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