Uploaded to the VFC Website

February 2014

This Document has been provided to you courtesy of Veterans-For-Change!

Feel free to pass to any veteran who might be able to use this information!

For thousands more files like this and hundreds of links to useful information, and hundreds of "Frequently Asked Questions, please go to:

Veterans-For-Change

Veterans-For-Change is a A 501(c)(3) Non-Profit Organizaton
Tax ID #27-3820181
CA Incorporation ID #3340400
CA Dept. of Charities ID #: CT-0190794

If Veterans don't help Veterans, who will?

We appreciate all donations to continue to provide information and services to Veterans and their families.

https://www.paypal.com/cgi-bin/webscr?cmd=_s-xclick&hosted_button_id=WGT2M5UTB9A78

Note: VFC is not liable for source information in this document, it is merely provided as a courtesy to our members & subscribers.

Table of Contents

3601

List of Table

List of Figure

Appendices

1. Introduction

This report describes the findings of an environmental investigation conducted at Building 326 located on Camp Carroll within United States Army Garrison (USAG) Daegu in the Republic of Korea (ROK) [Figure 1-1]. Personnel from the US Army Corps of Engineers (USACE) Far East District's (FED) Geotechnical and Environmental Engineering Branch performed intrusive field sampling in order to determine the vertical and lateral extents of petroleum-related contamination present at the site.

The field work was based on the scope of work in the document titled "*Work Plan for Environmental Site Investigation/Risk Assessment (ESI) at Six Sites of Camp Carroll*" dated January 2009. This ESI report was developed in accordance with industry standards and US Environmental Protection Agency (EPA) guidelines and Engineering Manual (EM) 200-1-3 (USACE, 2005) for sampling and analysis. All field and analytical work was conducted by USACE FED personnel in accordance with health and safety and sampling protocol developed specifically for this investigation (USACE FED, 2009).

1.1. Project objectives

The presence of soil contamination (primarily total petroleum hydrocarbon [TPH] and solvents) at the sites was identified during previous environmental sampling conducted by the USACE FED (USACE FED, 2004). These environmental investigations were prompted by documented fuel releases at the sites. The lateral extent of contamination at the site was not determined during this prior investigation. The overall objective of the current project was to perform an environmental investigation at the site to delineate the current extent and magnitude of contaminants of interest (petroleum-related and solvent contamination) at the site that may affect human health.

The following issues were addressed while performing this ESI:

- **Obtain data of sufficient quality and quantity to describe the physical and chemical properties of site soil and groundwater.** The site characterization work included collection and analysis of deep (greater than three meters below ground surface [bgs]) soil samples, as well as groundwater samples, in order to quantify the levels of residual petroleum and solvent contamination present at the sites.

- **Determine the nature and extent of contamination.** Soil boreholes and groundwater monitoring wells were advanced in areas surrounding Building 326 in an attempt to identify the source of the contamination as well as delineate the vertical and lateral extents of the plume.

1.2. Regulatory Considerations

The release of hazardous substances by DoD activities to the environment has potential implications for health and well-being of DoD personnel (including dependants) on the installation and the public living and working adjacent to the installation. The Department of Defense (DoD) Directive 4715.1E titled "*Environment, Safety, and Occupational Health (ESOH)*" establishes policies for all DOD components world-wide regarding environment, safety, and occupational health (DoD, 2005). DOD 4715.1E states it is DoD policy to protect DoD personnel from accidental death, injury, and occupational illness and to protect the public from

risk of death, injury, illness, or property damage because of DoD activities. Consequently, installations have an obligation to identify potential effects to DoD personnel and the public when a release of hazardous substances is discovered. Once the nature of the contamination is determined DoD Instruction 4715.8 titled "*Environmental Remediation for DoD Activities Overseas*" describes the policy and procedures for remediation of environmental contamination on DoD installations and facilities located outside the US (DoD, 1998). According to this document, remediation of environmental contamination is required when

1. A known imminent and substantial endangerment to human health and safety due to environmental contamination that was caused by DoD operations and that is located on or is emanating from a DoD installation or facility.
2. After consultation with the DoD Environmental Eecutive Agent, the in-thater commander of the DoD Component determines additional remediation of environmental contamination is required to maintain operations or protect human health and safety.
3. International agreements require the United States to fund environmental remediation.

In Korea, DoD Instruction 4715.8 is implemented through US Forces Korea Regulation 200-1 titled "United States Forces Korea Remediation Regulation". Other regulatory guidance for environmental standards in Korea is contained in US Forces Korea Pamphlet 200-1 titled "*Environmental Governing Standards.*"

2. Site Description and History

2.1. Camp Carroll

Camp Carroll is a part of US Army Garrison (USAG)-Daegu, and serves as Headquarters, U.S. Army Material Support Center and functions as a staging ground for U.S. military operations on the Korean Peninsula. The primary mission of the base is to serve as a staging facility and a storage and maintenance depot. USAG-Daegu consists of a series of installations within the greater Daegu metropolitan area, comprising a population of 2.5 million. In addition to Camp Carroll, the installations within USAG-Daegu include: Camp Henry, Camp Walker, and Camp George.

Camp Carroll was constructed in 1959 and is located one hour north of Taegu in the village of Waegwan. It is situated on 546 acres (668,355 pyeong, 2.2 square km), and located in the Nak Tong River Valley, approximately one-quarter mile east of the historic Nak Tong River (Figure 2-1). The terrain is primarily hilly, with surrounding mountains and forested areas bounding the base on the north and east, agricultural fields (mostly rice paddies) bordering the camp on the northeast and the south. Though a small community, Camp Carroll maintains a full service Fitness Center (with indoor and outdoor pools), a small Commissary, PX, Shoppette, Food Court, and All Ranks Club. The total population of Camp Carroll is approximately 2,700. Of that, US military personnel number approximately 1,200, or 44 percent of the base population. Other members of the community include Department of Defense (DoD) civilians, Korean National employees, Korean Augmentation to the US Army (KATUSA) soldiers, and non-command sponsored family members. Camp Carroll is used to house millions of dollars in war reserve stocks, including everything from tanks to tools. Giant garages house repair facilities where wheeled equipment weighing several tons can be disassembled, or a sensitive electronic circuit board can be checked for invisible cracks.

2.2. Building 326

Building 326 is a machine shop that was built in 1964. Used tank and truck engines have been rebuilt and cleaned at this facility. Solvents have been used at the facility and used oil has been generated from cleaning the engines. Several oil-water separators have been located outside the building. Two aboveground fuel storage tanks are located on the west side of the building. Drums containing sodium hydroxide, TCE, Solvent #6850-00-285-8011, hydraulic fluid, calibration fluid, CARC paint, lube oil and grease stored on a concrete pad on the west side of Building 326 near the drainage ditch were observed at the site during a site visit conducted by Woodward-Clyde in 1992. Former employees indicated that solvent wastes may have been disposed of on the ground behind the building, but they could not recall having observed such incidents. In 1992, monitoring well MW-17 was installed to the south side of Building 326 and sampled. In September 2000, a small amount of fuel was observed leaching into an open ditch located west of the building. Subsequent line pressure tests did not indicate a problem with the lines associated with the two aboveground fuel storage tanks at the site. The ground outside Building 326 is covered by concrete. The Camp Carroll DPW environmental office has been concerned about the apparent release of petroleum product from the storage tanks located behind the building." (USACE FED, 2004). Figure 2-2 depicts the location of the project site within Camp Carroll.

3605

2.3. Summary of Previous Investigations

The environmental condition of the project site has been previously evaluated during a Preliminary Site Assessment (PSA) conducted by the FED in 2004. After requests from USAG-Daegu DPW, site visits by FED environmental personnel were conducted in mid-September 2008 to early November 2008 to plan the current investigation, to identify areas of potential environmental concern, and to determine optimal borehole locations.

In 1992, monitoring well MW-17 was installed on the south side of Building 326 and sampled. The VOC compounds TCE and 1,2-DCE were detected in the ground-water sample collected from MW-17. In September 2000, a small amount of fuel was observed leaching into an open storm ditch located west of Building 326. However, subsequent line pressure tests did not indicate a problem with the fuel lines associated with the two aboveground fuel storage tanks which are located on the west side of Building 326. The Camp Carroll DPW environmental office has been concerned in the past about the apparent release of petroleum product from the storage tanks located adjacent to this building.

In 2004, the USACE FED identified fuel and solvent contaminated soil to the southwest of Building 326. Field and laboratory analyses identified high levels of fuel contamination southwest of Building 326 in the subsurface. Fuel contamination is primarily diesel and gasoline, and to a lesser extent JP-8. Total petroleum hydrocarbon concentrations were detected as high as 16,000 mg/kg for diesel-range and 4,400 mg/kg for gasoline-range hydrocarbons. Elevated levels of BTEX were also detected in subsurface soils.

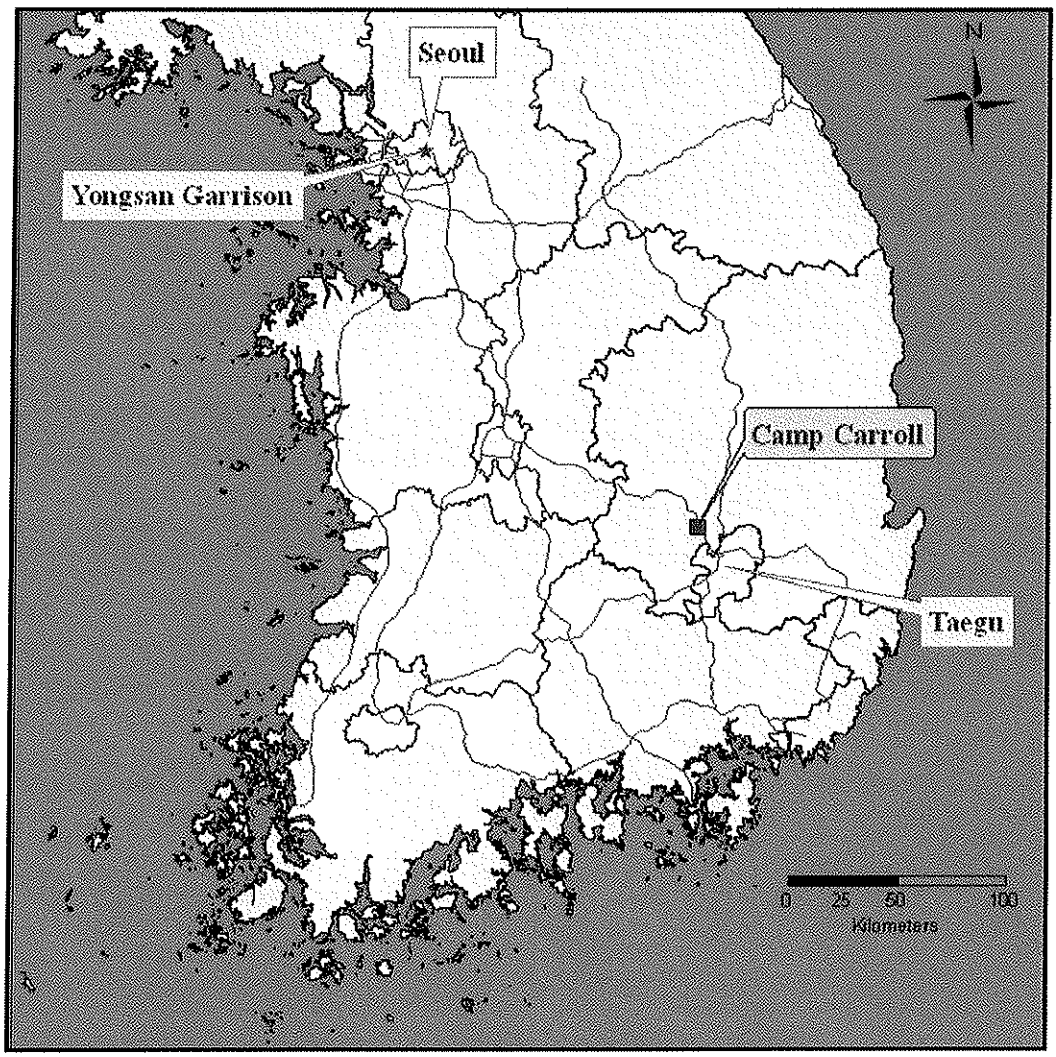
2.4. Identification of Data Needs

The site was previously investigated by the FED in 2004. The previous environmental investigation determined the nature and extent of contamination present at the site. However, there are certain data gaps in the existing information that were identified by this previous investigation. The scope of work developed through correspondence between DPW and USACE FED personnel in January 2008 was based on these identified data needs.

The previous environmental sampling at Building 326 had discovered elevated levels of fuel-related contamination over a significant area which was not completely characterized. The current investigation will drill boreholes to the south, east and west of Building 326 in order to delineate the extent of petroleum contamination. This ESI will also evaluate whether the site poses a threat to human health and the environment. The chemicals of concern at the site are TPH GRO and DRO, BTEX, polycyclic aromatic hydrocarbons (PAHs) and VOCs in soil, and BTEX, PAHs and VOCs in groundwater.

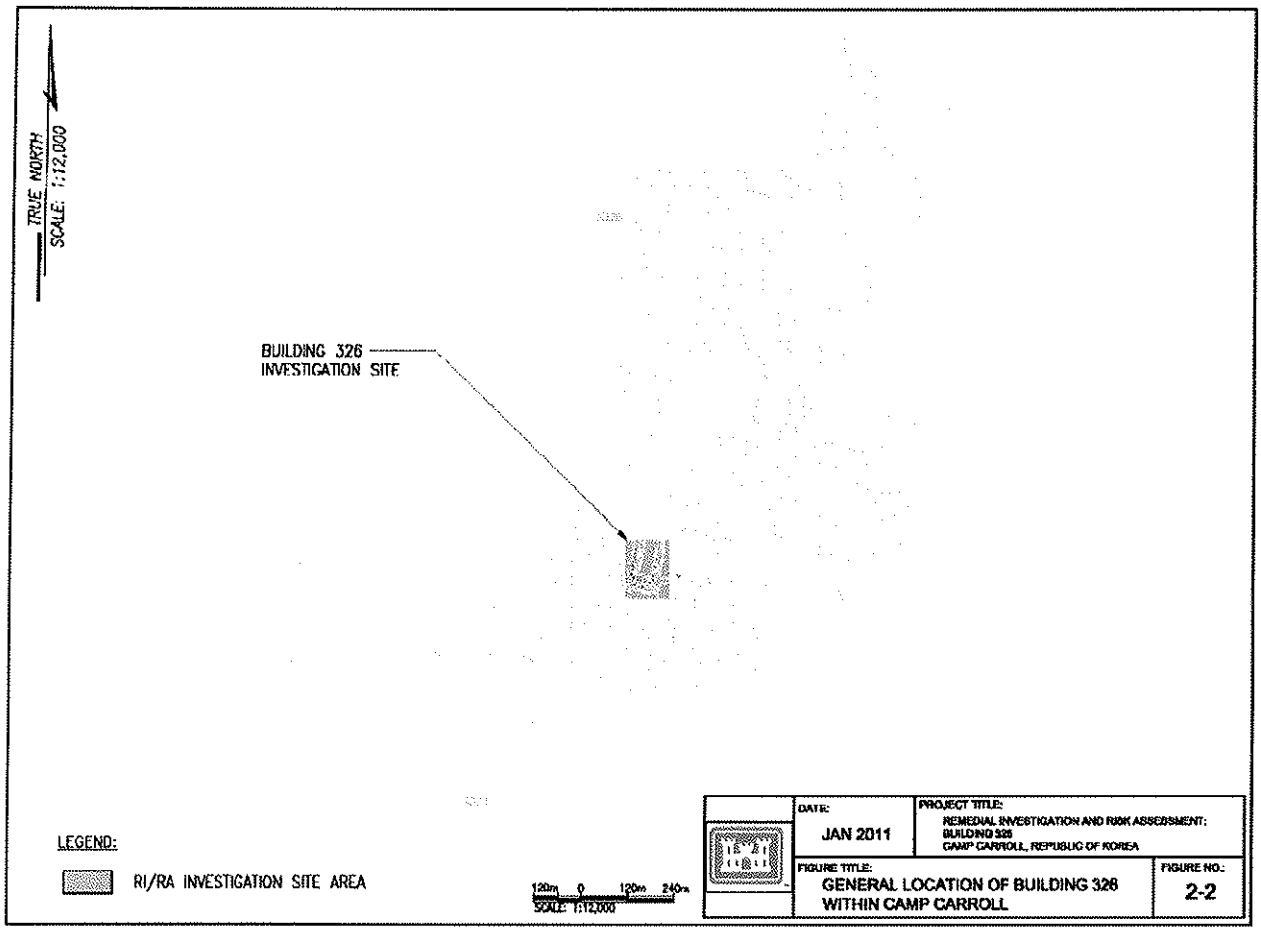
Figure 2-1. Location of Camp Carroll in Republic of Korea.

3606


Seoul
N
Yongsan Garrison
Camp Carroll
Taegu
0 25 50 100
Kilometers

3607

Figure 2-2. Location of Building 326 at Camp Carroll.



3608

3. Field Activity

3.1. Field Activities

The field characterization work was conducted at the site from February to September 2009. Soil sampling was conducted between February and September 2009. Groundwater sampling was conducted in August 2009. The schedule of field work conducted at the site is summarized in **Error! Reference source not found.**.

FED personnel completed all excavation/drilling permits required by USAG-Camp Carroll DPW prior to starting intrusive, sub-surface activities at the site. FED personnel coordinated with the Signal Corps and DPW to obtain all available information about underground communication lines, electric cables, water lines, sewer lines, and fuel pipelines at the ESI site. This phase of work involved reviewing all sub-surface maps and drawings of the investigation area provided by the government, as well as reviewing utility drawings provided by telephone, natural gas, power, and cable companies. Field personnel then evaluated surface features present at the site, such as manholes, utility vaults, and pavement patching, which indicate the potential presence of underground utilities. The approximate locations of underground utilities and the locations of the proposed boreholes were marked on the ground with brightly colored spray paint.

An electromagnetic toner was then waved across each proposed borehole location to check for the presence of nearby sub-surface metallic utilities. The installation personnel in charge of the utilities of concern (fuel, communication, and power) were notified and came to the site to verify that the proposed drilling areas were clear of known sub-surface utilities, prior to the initiation of sub-surface drilling activities.

3.2. Borehole drilling and soil sampling

Discrete sub-surface soil samples were collected via direct-push drilling using a 6.4-cm diameter hollow stem sampler equipped with one-meter long acetate sampling tubes that were driven directly into the ground. Soil boreholes were typically drilled to a couple of meters below the underlying groundwater table, to a maximum depth of 13 meters bgs (but no deeper than the depth at which basement rock was encountered) at the investigation site. Soil samples were recovered from the boring at approximately one meter depth intervals. The first interval sampled for chemical analysis was collected from approximately one to two meters above the estimated depth of the shallow groundwater table at the site. Additional samples were collected at approximately one meter depth intervals down to a maximum depth of 13 meters bgs in the deepest borehole. The specific depth of samples chosen for laboratory analysis was determined by field personnel based on visual observation of the recovered soil cores upon removal from the drill casing. As a general rule, one sample was collected for analysis within the upper one meter of the ground surface and another from near the groundwater capillary fringe. If significant contamination was encountered, an additional one or two soil samples were collected from areas within the soil core that were visibly stained, had an odor, and/or in which an elevated PID reading (greater than 50 parts per million [ppm]) was measured in the corresponding headspace sample. If no staining or odor was encountered in a particular borehole, the sample for analysis was collected from the center of a selected tube interval (every two meters for deeper boreholes). Actual sample depths varied depending upon field observations and/or contamination encountered.

Upon withdrawal from the soil borehole, soil cores were sealed in the acetate sampling tubes with rubber caps. When ready, field personnel exposed the soil core within the tube and selected samples based on the criteria stated above. Soil samples were then transferred into laboratory-provided sampling containers specific to the required analysis. Samples to be analyzed for volatile contaminants were placed into methanol and pure water-preserved 40 milliliter (mL) vials using laboratory-provided, disposable soil plungers to prevent minimal disturbance and exposure to air.

All samples were labeled with the sample identification information described below, transferred into individual re-sealable plastic bags, and then placed into insulated coolers filled with ice for preservation. The samples were chilled and maintained at a temperature of 4 ± 2°C and managed under chain-of-custody protocol and documentation until they were picked up by personnel from the primary or secondary Korean analytical laboratories, SGS Testing Korea (SGS) and NCA Labs Korea (NCA), respectively.

3.2.1. Headspace Analysis

Field sampling included the collection of headspace samples from each sampling area of concern. Soil samples were collected at periodic depths for headspace analysis to provide an indication of the vertical extent of VOC contamination within each soil core. Headspace samples were placed into individual re-sealable plastic bags, agitated, and then exposed to direct sunlight to allow volatile contaminants to vaporize from the soil. After about 15 minutes, the probe tip of a PID was inserted into the plastic bag to take a reading of the concentration of volatile contaminants present in the headspace of the plastic bag. The PID readings were recorded by field personnel in the field notebook and ultimately transferred to the electronic borehole logs (Appendix A).

3.2.2. Soil Sample Identification

The soil sample identification format was recommended by USACE FED personnel to assure that each sample had a unique identification number that was consistent with the borehole/monitoring well identification system used in previous investigations at Camp Carroll. The USACE FED sample identification format provided general information about the borehole type, year of investigation, and sample depth interval. The USACE FED recommended sample identification number had the following general format:

B09-mmm-S1

where,

B signifies that the sample was collected from a soil borehole;
09 is the year in which the soil borehole was drilled (i.e., 2009);
mmm is the sequential soil borehole number (i.e., starting with 202 at the Camp Carroll site);
S1 signifies the range of depth of the sample (S1 signifies 0-1 meter bgs, S2 signifies 1-2 meters bgs, etc.).

The following information was placed on each sample container label:

- Project identification;
- Sample date and time;
- Sample collector's name;
- Sample identification number; and

- Required laboratory analyses.

The primary and quality assurance/quality control (QA/QC) soil samples collected from the ESI site that were submitted for laboratory analysis are summarized in Table 3-2.

3.3. Groundwater Monitoring Well Construction

3.3.1. Monitoring well construction

The well casings and slotted screens were constructed of flush-threaded, 5.04-cm diameter, schedule 40 polyvinyl chloride (PVC) piping. The depth of the wells and the length of the screen intervals varied depending on the site-specific characteristics observed during soil sampling. In general, the tops of the well screens were not placed within one meter of the ground surface and the depth to the bottoms of the wells was set to assure that they extended to at least one meter below the measured water level. Filter pack material of medium-grained sand was packed from the bottom of the well up to a depth of 0.5 meter above the top of the screened section. A bentonite pellet seal was placed above the filter pack to within 0.5 to 1.0 meter of the ground surface. Above the bentonite pellet seal, the remaining 0.5 to 1.0 meter of open annular space was sealed with a concrete grout around a 17.8-cm diameter steel well vault to allow for access to the well casing.

Monitoring wells were installed utilizing the same boreholes used to collect sub-surface soil samples. When a borehole was completed as a monitoring well, the well identification was assigned by placing an "MW" at the end of the identification sequence (as detailed in Section 3.4.2). The boreholes selected to receive monitoring wells were chosen based on their location relative to known groundwater contamination as well as their potential to map the hydraulic gradient at the site. Once drilling had reached the target depth for soil sampling, the 12-cm diameter air percussion hammer was removed from the borehole. A 14-cm diameter hollow out-casing was then driven into the borehole to widen it and any soil trapped in the out-casing was flushed out with water. The depth of the borehole was then measured using a weighted measuring tape to ensure that all slough was removed from the out-casing and that the borehole could accommodate the chosen casing length. The well casing was then assembled and lowered into the borehole through the hollow out-casing. Once the casing was set at the proper depth, filter sand was poured into the annular space between the well casing and the inside of the hollow out-casing to the prescribed depth above the screened section. The out-casing was slowly raised during this operation to allow the sand pack to fill in outward to the borehole walls. Once the sand pack was placed at the proper depth and no further settling of the filter pack sand was evident, the remaining annular space was sealed with bentonite pellets, concrete grout, and finally a flush-mounted 17.8-cm diameter well vault. The construction details of the monitoring wells installed at the ESI site are summarized in Table 3-3 below.

3.3.2. Monitoring Well Development.

After installation, all wells were fully developed. The objectives of well development were to remove sediment that had settled inside the well during construction; remove all water that may have been introduced during drilling and well installation; remove very fine grained sediment in the filter pack and nearby formation so that groundwater samples would not be turbid and well silting does not occur; and improve the flow into the well from the adjacent

formation, thus yielding a representative groundwater sample and an accurate water level measurement.

Well development consisted of surging using a surge block and pumping out the turbid water using a vacuum truck until a noticeable reduction in sediment occurred in the discharged water. This development continued for a minimum of five well volumes of pumped water until the water was visually clear or the site geologist determined that no further development was practical.

3.3.3. Groundwater Sampling.

Groundwater sampling was conducted in accordance with the protocol described in the project WP. After allowing the monitoring wells to settle and the concrete and bentonite to harden for at least one week, the depth to water was measured with a Solinst electronic water level tape and the wells were developed. A surge block was then manually plunged up and down the interior of each monitoring well for a minimum of 15 minutes. The fine-grained material that entered the monitoring well during construction and surging activities was then removed by slowly lowering a dedicated flexible hose (attached to a vacuum truck) to the bottom of each well. In most cases, the liquid and solid contents of the wells were entirely removed. The suction was then turned off and formation water was allowed to enter the well until the water level within the well recovered to at least 50% of its original level within the well. The suction was then reapplied and all water and entrained sediment were removed. This operation was repeated once more, for a total of three times. The rate of water level recovery was monitored after the completion of surging to provide an estimate of the hydraulic conductivity of the aquifer formation (Section 3.10.1).

Prior to groundwater sampling, the well was purged by removing a minimum of three times the standing volume of static water present in the monitoring well. The pH, temperature, specific conductance, and turbidity of the removed water were monitored during the course of purging after removal of the following approximate volumes of water from a 5.08-cm diameter well: 1, 3, 5, 7, 10, 15, 20, and 25 liters. Purging was considered complete when the well water quality from three successive water quality measurements had stabilized within the following criteria established in D6771-02 of the American Society of Test Methods (ASTM, 2002): pH ±0.2, specific conductance ±3%, temperature ±0.5°C, and turbidity ±3%. The wells were purged and sampled using a peristaltic pump and dedicated tubing for each well sampled. While sampling the well, the water was removed from the well at a rate no greater than one liter per minute.

The recovered groundwater samples were placed in the appropriate sample jars provided by the analytical laboratory. The jars were then properly labeled and placed on ice to ensure that the temperature of the collected samples remained below 4°C prior to arrival at the analytical laboratory. The recovered groundwater samples were then transported to the analytical laboratory as quickly as possible.

The groundwater samples were collected from the site on 31 August 2009. See Table 3-4 for the groundwater sampling summary. The groundwater samples were assigned the name of the associated monitoring well identification established during this or previous investigations, for example:

B09-mmm-MW

where,

B signifies a soil borehole;
09 is the year in which the monitoring well was installed (i.e., 2009);
mmm reflects the approximate number of geotechnical soil borings, environmental boreholes, and monitoring wells that had been installed at the Camp Carroll site by USACE FED and their contractors prior to installation of the monitoring well; and
MW signifies that the groundwater sample was collected from a monitoring well.

3.4. Topographic survey

The location and elevation of the ground surface, the top of casing, and the top of the well cover were surveyed by surveying personnel from the FED in September 2009. The northing and easting coordinates and elevation of each borehole and monitoring well were determined using traditional surveying methods relative to local survey benchmarks that had been established on the installation by FED. The FED surveyors utilized the Universal Transverse Mercator (UTM) World Geodetic System of 1984 (WGS84) datum Zone 52N. The survey data provided by the FED for the ESI site is summarized in Table 3-5.

3.5. Investigation Derived Wastes

Waste material, or investigation-derived wastes (IDW), that were generated during the ESI field work included concrete and asphalt debris, petroleum-contaminated soil, well development/purge water, decontamination water, used disposable sampling equipment, and used personal protective equipment (PPE).

There are no specific Korean regulations applicable to the small quantities of IDW that were generated during the course of this project. The water was placed in 55-gallon drums. The minor amounts of concrete and asphalt debris that was generated in order to expose the underlying soil was bagged. The bags were segregated by their contents and stored on-site until they were transported to BEC's off-site remediation facility located in Yeoju, Gyeonggi-Do for treatment and disposal.

3.5.1. Contaminated Soil

All drilling soil cuttings were bagged on-site in tight knit, woven synthetic bags. Apparent petroleum-contaminated soils in the cuttings were not segregated from uncontaminated soils. Therefore, all soil waste generated during this investigation was considered petroleum-impacted. A waste manifest was used to document the transport of the soil to BEC's treatment facility.

3.5.2. Well Development and Decontamination Water

Water from decontamination activities was pumped into a BEC vacuum truck and transported to the treatment facility. Groundwater generated during well development, purging, and pump test activities was pumped into BEC's larger pump truck, and also transported for disposal at their treatment facility. The results of project groundwater monitoring samples were used to determine disposal options for the well development/purge, bail test, and decontamination water. Results from the soil samples were also considered in determining disposal options for the water. Following receipt and review of the soil and groundwater sample

analytical results, IDW water was disposed of in accordance with applicable regulations at the BEC treatment facility.

3.5.3. Site Restoration

Borehole locations were backfilled with bentonite pellets and the surfaces sealed with concrete, which was finished flush to the existing surface grade. Monitoring wells installed during the project were flush-mounted and pose no impediment to vehicular or foot traffic. Vaults in roads were traffic-rated. All mud and soil cuttings generated in the vicinity of each soil borehole and monitoring well were cleaned up by BEC personnel immediately following the completion of the respective task. Significant site damage did not occur during this investigation, thus the level of site restoration required was minimal.

3.6. Additional Site Characterization

Tests were performed on the aquifer matrix to determine the saturated and air permeability of the impacted aquifer material present at the ESI sites. The saturated permeability measures the ability of the aquifer to transmit water, which is useful for evaluating the effectiveness of remedial technologies that require the extraction of water from the aquifer system as well as the potential for significant lateral migration of groundwater contamination

The hydraulic characteristics of the shallow aquifer in the areas of contamination were determined by performing slug tests on the monitoring wells installed during this study. The hydraulic conductivity, K, of the aquifer was calculated using slug test recovery measurements that were performed on all monitoring wells at the completion of well purging. Hydraulic conductivity is a measure of the aquifer's capacity to transmit water and governs groundwater flow and contaminant transport in the subsurface. Hydraulic conductivity is measured in units of distance per unit of time, typically meters/day. Typical values measured in aquifer systems range from 10^{-6} meters/day (m/day) for clay dominated aquifers to up to 10^{3} m/day for aquifers composed of coarse gravel material.

At the completion of the well purging work, the water in each monitoring well was completely removed using BEC's vacuum truck. The rise in water level in the purged wells (recovery) was recorded manually using a Solinst electronic water level indicator. Measurements were collected until the water level in the monitoring well returned to within approximately five cm of the original water level. The original water level in the well, prior to well development was also measured with a Solinst electronic water level indicator. Two slug tests were performed at the Camp Carroll site at the two wells that were accessible to the vacuum truck and that contained water. The two wells that were slug tested were wells B09-207MW and B09-212MW.

Measurements of water level versus time, along with other relevant aquifer and well characteristics, were then used to determine a value for the hydraulic conductivity of the shallow aquifer. The calculations were performed using Aqtesolv aquifer test analysis software. An isotropic system (i.e., where the hydraulic conductivity in the vertical and horizontal direction is the same) was assumed in the analysis and the analytical solution developed by Bouwer and Rice (1976) for an unconfined aquifer system and the Hvorslev method was used to calculate the hydraulic conductivity.

Slug test data sheets for the Camp Carroll site and graphical analyses can be found in Appendix C, and a presentation of the hydraulic conductivity results can be found in Section 4.4 of

3614

the report. The average K value is 2.78 X 10^{-4}cm/sec at B09-207MW and 1.76 X 10^{-3} cm/sec respectively.

Table 3-1. Project Chronology of ESI at Building 326 of Camp Carroll.

Project Field Work Milestone	Completion Dates
Soil borehole drilling	23-28 February 2009
Soil sampling	23-25 February 2009; 16-19 September 2009
Monitoring well casing installation	3 March 2009
Monitoring well grouting and vault installation	3 March 2009
Monitoring well and soil borehole survey	March 2009
Monitoring well development	3 March 2009
Groundwater sampling	31 August 2009
Groundwater level measurements	1 September 2009

36/6

Table 3-1: Soil Sampling Summary

Borehole ID	Sample ID	Depth (meters bgs)	Sample Type(s)	Analytes	Remarks
B09-202	S6	5-6	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-203	S7	6-7	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-204	S11	10-11	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
	S13	12-13	PS	TPH-DRO, TPH-GRO, TPH-RRO	
B09-205	S7	6-7	PS	TPH-DRO, TPH-GRO, TPH-RRO	
	S11	10-11	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-206	S4	3-4	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-207	S5	4-5	PS	TPH-DRO, TPH-GRO, TPH-RRO	
	S6	5-6	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
	S7	6-7	PS	TPH-DRO, TPH-GRO, TPH-RRO	
	S8	7-8	PS	TPH-DRO, TPH-GRO, TPH-RRO	
	S9	7-8	QC	TPH-DRO, TPH-GRO, TPH-RRO	QC Dup of B09-207-S8
B09-208	S1	0-1	PS	TPH-DRO, TPH-GRO, TPH-RRO	
	S6	5-6	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
	S7	5-6	QC	BTEX, VOCs, PAHs	QC Dup of B09-208-S6
B09-209	S7	6-7	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-210	S9	8-9	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-211	S8	7-8	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-212	S5	4-5	PS	TPH-DRO, TPH-GRO, TPH-RRO	
	S6	5-6	PS	TPH-DRO, TPH-GRO, TPH-RRO	
	S10	9-10	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
	S11	10-11	PS	TPH-DRO, TPH-GRO, TPH-RRO	
B09-213	S10	9-10	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-214	S4	3-4	PS	TPH-DRO, TPH-GRO, TPH-RRO	
	S5	4-5	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
	S6	5-6	PS	TPH-DRO, TPH-GRO, TPH-RRO	
B09-214	S7	6-7	PS, QC	TPH-DRO, TPH-GRO, TPH-RRO	
	S8	6-7	QC	TPH-DRO, TPH-GRO, TPH-RRO	QC Dup of B09-214-S7
B09-215	S5	4-5	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
	S7	6-7	PS	TPH-DRO, TPH-GRO, TPH-RRO	
B09-216	S5	4-5	PS, QC	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
	S6	5 6	PS	TPH DRO, TPH-GRO, TPH-RRO	
	S7	4-5	QC	BTEX, VOCs, PAHs	QC Dup of B09-216-S5
B09-217	S9	8-9	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-218	S6	5-6	PS	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
B09-219	S6	5-6	PS, QC	TPH-DRO, TPH-GRO, TPH-RRO, BTEX, VOCs, PAHs	
	S10	5-6	QC	TPH-DRO, TPH-GRO, TPH-RRO	QC Dup of B09-219-S6

PS: Primary sample. QC: Quality control duplicate of former PS listed, submitted to PS laboratory under different ID. PS and QC samples were analyzed for TPH-DRO/RRO by NCA Labs Korea and VOCs and PAHs by TestAmerica West Sacramento.

3613

Table 3-2: Monitoring Well Construction Details

Monitoring Well	Diameter (cm)	Casing (meters)	Screen (meters)	Cement (meters)	Bentonite (meters)	Sand (meters)	Total Depth (meters)
B09-203-MW	5.08	6.6	8.4	4.5	0.5	10.00	15.0
B09-207-MW	5.08	6.34	8.4	3.7	0.5	10.54	14.8
B09-212-MW	5.08	6.8	8.4	4.3	0.6	10.60	15.5

Vault diameter for all wells is 17.8 cm.
0.15 meter PVC well point extending below the screen on each well..

Table 3-3: Groundwater Sampling Summary

Sample ID	Sample Type(s)	Analytes	Remarks
B09-203MW	**PS**	**BTEX, VOCs, PAHs**	**No water in well**
B09-207MW	**PS**	**BTEX, VOCs, PAHs**	
B09-212MW	**PS**	**BTEX, VOCs, PAHs**	

PS: Primary sample. QC: Quality control duplicate of former PS listed, submitted to PS laboratory under different ID. PS and QC samples were analyzed for VOCs and PAHs by SGS Testing Korea.

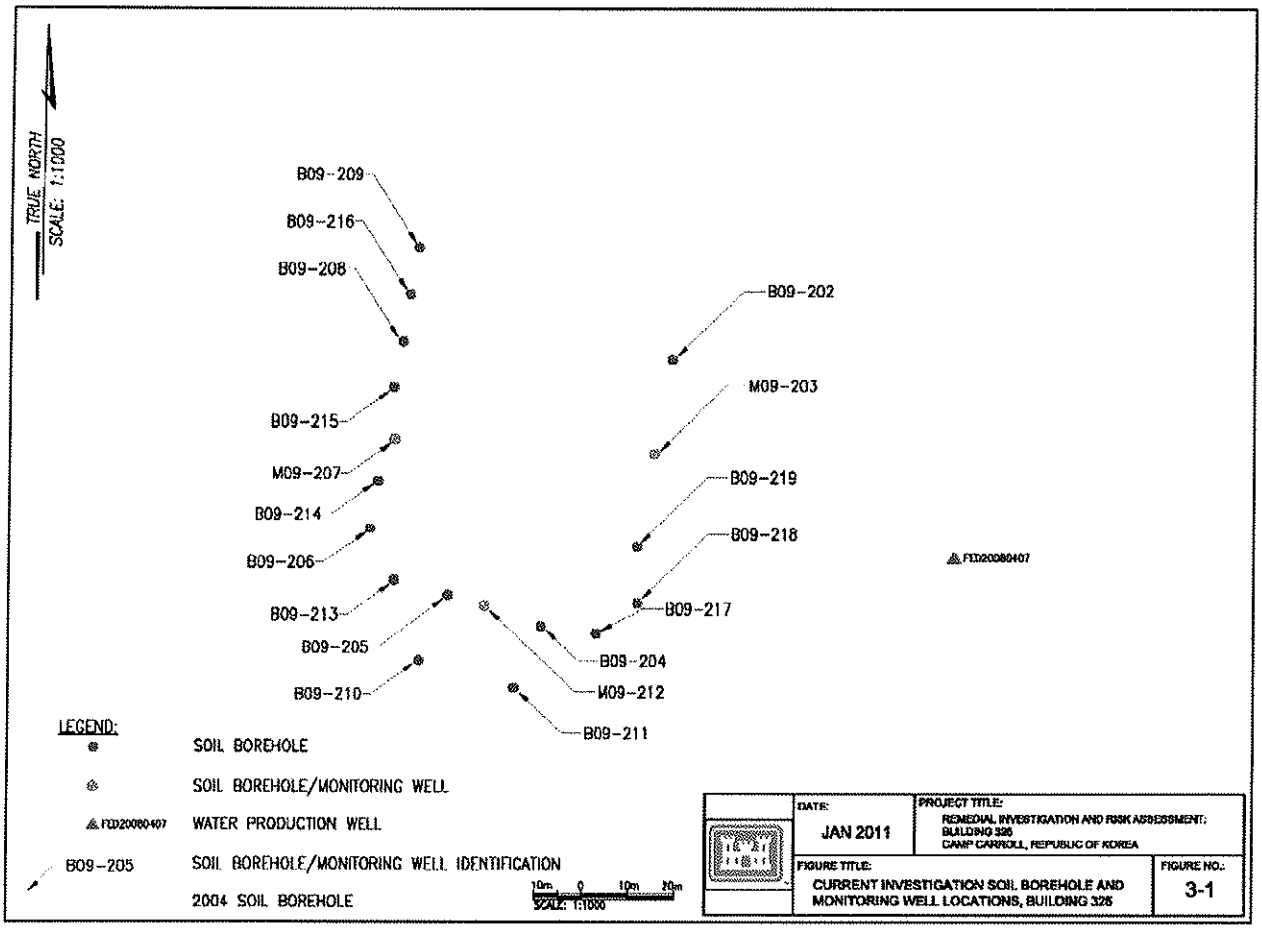
Table 3-4: Borehole and Monitoring Well Survey Data

Borehole / Monitoring Well Number	Northing (WGS84 meters)	Easting (WGS84 meters)	Elevation (meters)	
			Top of Well Casing	Ground Level
Monitoring Wells				
B09-203-MW	3983524.637	447300.540	39.402	39.393
B09-207-MW	3983527.711	447245.582	39.140	39.240
B09-212-MW	3983492.644	447264.643	38.924	39.005
Boreholes				
B09-202	3983544.36	447304.20	-	39.30
B09-204	3983488.38	447276.42	-	38.82
B09-205	3983494.89	447256.86	-	39.10
B09-206	3983508.92	447240.52	-	39.15
B09-208	3983548.16	447247.15	-	39.24
B09-209	3983568.02	447250.41	-	39.32
B09-210	3983481.19	447250.89	-	37.94
B09-211	3983475.47	447270.75	-	37.98
B09-213	3983498.05	447245.56	-	39.09
B09-214	3983518.85	447242.08	-	39.17
B09-215	3983538.57	447245.31	-	39.23
B09-216	3983558.16	447248.55	-	39.26
B09-217	3983486.88	447288.18	-	38.63
B09-218	3983493.21	447297.09	-	38.70
B09-219	3983505.11	447296.90	-	39.22

Coordinate system used is Universal Transverse Mercator (UTM) World Geodetic System of 1984 (WGS84) datum Zone 52N.

36/19

Figure 3-1. Location of Boreholes and Groundwater Monitoring Wells at Building 326 of Camp Carroll.



3680

4. ESI Investigation Results

This section presents the analytical results of the soil and groundwater samples collected at Building 326.

4.1. Summary of Analytical Results: Soil

A total of 18 boreholes were drilled at the Building 326 site during the course of the ESI investigation. Soil samples were collected from all of these boreholes for chemical analysis; subsequently three of these boreholes were converted into permanent groundwater monitoring wells. Laboratory chemical report will be provided a separate compact disk with this document.

4.1.1. Total Petroleum Hydrocarbon

A total of 35 soil samples, collected from various locations and depths at the site, were analyzed for TPH-GRO (C7-C12), TPH-DRO (C10 to C24), and TPH-RRO (C24 to C40). Figure 4-1 depicts the highest concentrations of these various TPH constituents detected in site soils. The lateral extent of soil contamination was estimated to be at least 3,617 m^2 based on an area calculation of the extent of contamination depicted on Figure 4-5. The TPH analytical results for soils are presented in Table 4-1.

TPH-GRO was detected in 27 of the 35 soil samples, ranging from 22 mg/kg to 3,620 mg/kg. TPH-DRO was detected in 25 of the 35 samples, ranging from 13 mg/kg to 6,370 mg/kg. TPH-RRO was detected in eight of the 35 samples, ranging from 13 mg/kg to 108 mg/kg.

4.1.2. Volatile Organic Compounds

A total of 20 soil samples, collected from various locations and depths at the site, were analyzed for volatile organic compounds (VOCs). At least one VOC was detected in all 20 soil samples at concentrations ranging from 0.0019 mg/kg to 120 mg/kg, The detected VOCs included benzene, hexachlorobutadiene, naphthalene, ethylbenzene, styrene, 1,1,1,2-tetrachloroethane, 1,2,4-trichlorobenzene, toluene, trichloroethene, total xylenes, and vinyl chloride. Table 4-2 shows chemical results for VOC analysis for site soils. Figure 4-2 and Figure 4-3 depicts the BTEX and other VOC concentrations measured in site soils.

There were also persistent exceedances of acetone and methylene chloride in ten and 16 of the samples, respectively, which are potentially due to laboratory contamination. Therefore, they were not reported and depicted in figures as contaminants related to the site. Detections of dibromo-fluoro-methane and 2-butanone in 18 and 20 of the soil samples, respectively, were also not considered due to their being suspected laboratory contaminants. The USEPA-CLP (1994) lists the following chemicals as common laboratory contaminants: methylene chloride, acetone, 2-butanone, bis-2 ethylhexyl phthalate n-butyl phthalate, diethyl phthalate n-octyl phthalate, benzyl phthalate, and chloroform.

4.1.3. Polynuclear Aromatic Hydrocarbon Compounds

A total of 20 soil samples, collected from various locations and depths at the site, were analyzed for 19 PAH compounds. The field samples that were believed to contain the highest levels of contamination (based upon headspace measurements) were typically selected for PAH analysis. Table 4-3 lists and Figure 4-4 depicts the PAH concentrations measured in site soils. Seventeen of the 19 PAH compounds were detected in at least one of the samples at concentrations ranging from 0.00041 mg/kg to 3.7 mg/kg.

3691

4.2. Summary of Analytical Results: Groundwater

A total of three monitoring wells were installed at the site during the course of the ESI. Groundwater samples were collected from only two of the three new monitoring wells (B09-207MW and B09-212MW) because the third new monitoring well (B09-203MW) contained no water on the day of sampling. Figure 3-1 depicts the locations of the groundwater monitoring wells installed at the sites during the current ESI. Figure 4-9 depicts the estimated minimum lateral extent of groundwater contamination at Building 326, which is estimated to be approximately 1,618 m^2.

4.2.1. Volatile Organic Compounds

A total of two groundwater samples were analyzed for VOCs. Table 4-5 lists the concentrations and Figures 4-6 and 4-7 depict the locations of VOC concentrations present in the groundwater at the Camp Carroll Building 326 site.

Fourteen VOCs constituents were detected in at least one of the two groundwater samples, ranging from 4.5 µg/L to 130 µg/L. The detected VOCs included benzene, toluene, ethylbenzene, total xylenes, 1-2-dichloroethane, naphthalene, and trichloroethene.

The detections of dibromofluoromethane, 1,2-dichloroethane, 4-bromofluorobenzene, chloroform and methylene chloride are suspected to be laboratory contaminants due to their detection at similar levels in the associated trip blank. The analytes that are suspected to be laboratory contaminants are not shown on the respective figure.

4.2.2. Polynuclear Aromatic Hydrocarbon Compounds

A total of two groundwater samples were analyzed for 20 PAH compounds. Table 4-6 and Figure 4-8 detail the concentrations of the PAH components detected in the groundwater at the sites.

Seven of the 20 PAH components were detected in the two samples at concentrations ranging from 0.22 µg/L to 2,200 µg/L, including 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene

4.3. Shallow Groundwater Aquifer Permeability

Slug tests were performed on 9-12 November 2009 at the sites in order to determine the permeability of the groundwater aquifer. The bail tests were performed at the end of the well development activities by completely removing all of the water present in the well using a vacuum truck and monitoring the subsequent rise in water level as water from the surrounding formation entered the well. The recovery in water levels in two of the groundwater monitoring wells (M09-207 and M09-212 at Building 326) was monitored at the site. The hydraulic conductivities measured at the site are generally low (0.24 to 1.52 m/day using the Bouwer and Rice method and 0.26 to 1.71 m/day using the Hvoslev method). Table 4-8 shows the range in hydraulic conductivity values measured at the sites. The complete BEC Remedial Evaluation report is available in Appendix C.

36 22

Table 4-1: TPH Results [mg/kg] in Soil

Analyte	TPH-GRO (C7-C12)*	TPH-DRO (C10-C24)*	TPH-RRO (C24-C40)*
Borehole ID	(mg/kg)	(mg/kg)	(mg/kg)
B09-202-S6	ND (<11)	ND (<11)	ND (<11)
B09-203-S7	ND (<10.3)	ND (<10.9)	ND (<10.9
B09-204-S11	2,380	6,370	ND (<273)
B09-204-S13	2,870	5,930	ND (<597)
B09-205-S7	2,870	5,730	ND (<454)
B09-205-S11	2,200	5,550	ND (<299)
B09-206-S4	81	ND (<11)	ND (<11)
B09-207-S5	685	190	ND (<14.7)
B09-207-S6	727	78	ND (<14.7)
B09-207-S7	1,340	199	ND (<14.8)
B09-207-S8	1,780	759	ND (<146)
B09-207-S9	1,700	802	ND (<72.8)
B09-208-S1	2,080	680	ND (<56.9)
B09-208-S6	94	13	ND (<10.6)
B09-209-S7	52	ND (<10.1)	ND (<10.1)
B09-210-S9	35	ND (<11.1)	ND (<11.1)
B09-211-S8	ND (<10.7)	17	16
B09-212-S5	22	16	ND (<11.3)
B09-212-S6	1,710	3,090	17
B09-212-S10	3,620	5,470	40.1
B09-212-S11	2,940	4,890	37.6
B09-213-S10	ND (<11)	ND (<11.9)	ND (<11.9)
B09-214-S4	1,950	613	ND (<10.3)
B09-214-S5	894	1,020	ND (<11)
B09-214-S6	2,550	1,420	108
B09-214-S7	2,890	1,830	17
B09-214-S8	941	922	18
B09-215-S5	2,160	19	ND (<11.1)
B09-215-S7	2,630	17	ND (<11)
B09-216-S5	336	104	13
B09-216-S6	356	37	ND (<9.5)
B09-217-S9	ND (<10.8)	ND (<11.6)	ND (<11.6)
B09-218-S6	ND (<10.9)	ND (<11.7)	ND (<11.7)
B09-219-S6	ND (<11.7)	ND (<11.7)	ND (<11.7)
B09-219-S10	ND (<12)	ND (<12)	ND (<12)

mg/kg = milligram per kilogram

326-93

Table 4-2: VOC Results in Soil

Analyte	benzene	toluene	ethyl-benzene	m,p-xylenes	o-xylene	xylenes (total)*
Borehole	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
B09-202-S6	ND	ND	ND	ND	ND	ND
B09-203-S7	ND	ND	ND	ND	ND	ND
B09-204-S11	ND	ND	ND	ND	ND	ND
B09-205-S11	ND	ND	ND	ND	ND	ND
B09-206-S4	ND	ND	ND	ND	ND	ND
B09-207-S6	0.22	4.4	6.7	30	20	50
B09-208-S6	ND	ND	0.025	0.1	0.068	0.168
B09-208-S7	ND	0.097	0.46	1.9	0.84	2.74
B09-209-S7	ND	ND	ND	ND	ND	ND
B09-210-S9	ND	ND	ND	ND	ND	ND
B09-211-S8	ND	ND	0.033	ND	0.068	0.068
B09-212-S10	ND	ND	ND	ND	0.24	0.24
B09-213-S10	ND	ND	0.023	ND	0.05	0.058
B09-214-S5	0.53	ND	5.4	ND	27	27
B09-215-S5	1.1	ND	ND	40	ND	40
B09-216-S5	ND	ND	0.13	ND	0.3	0.3
B09-216-S7	0.0055	ND	0.12	ND	0.4	0.4
B09-217-S9	ND	ND	0.03	ND	0.069	0.069
B09-218-S6	ND	ND	0.024	ND	0.057	0.057
B09-219-S6	ND	ND	0.023	ND	0.059	0.059

mg/kg = milligram per kilogram

3624

Table 4-2: VOC Results in Soil (Continued)

Analyte	acetone	dibromo-fluoro-methane	1,2-dichloroethand-d4	tert-butyl-benzene	2-butanone (MEK)	n-butyl-benzene	sec-butyl-benzene	chloro-methane
Borehole	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
B09-202-S6	1.5	0.111	0.118	ND	3.9	ND	ND	ND
B09-203-S7	1.9	0.112	0.122	ND	4.5	ND	ND	ND
B09-204-S11	2.7	0	0	ND	4.4	5.2	1.9	ND
B09-205-S11	2.1	0	0	0.082	3.6	4.7	2.1	ND
B09-206-S4	1.9	0.108	0.107	ND	4.9	ND	ND	ND
B09-207-S6	2.2	0.101	0.105	ND	5.2	ND	0.470	ND
B09-208-S6	2.2	0.091	0.095	ND	4.8	ND	0.015	ND
B09-208-S7	1.9	0.093	0.100	ND	4.9	ND	0.130	ND
B09-209-S7	2.3	0.112	0.124	ND	5.1	ND	ND	ND
B09-210-S9	1.6	0.094	0.095	ND	4.0	ND	ND	ND
B09-211-S8	ND	0.080	0.086	ND	1.6	ND	ND	ND
B09-212-S10	ND	0.080	0.089	ND	4.3	3.7	1.9	ND
B09-213-S10	ND	0.062	0.068	ND	1.0	ND	ND	0.0034
B09-214-S5	ND	0.075	0.089	ND	4.1	ND	0.480	ND
B09-215-S5	ND	0.084	0.095	ND	4.0	ND	0.770	ND
B09-216-S5	ND	0.076	0.082	ND	1.9	ND	0.250	ND
B09-216-S7	ND	0.076	0.081	ND	1.8	ND	0.170	ND
B09-217-S9	ND	0.073	0.078	ND	1.1	ND	ND	ND
B09-218-S6	ND	0.081	0.084	ND	0.9	ND	ND	ND
B09-219-S6	ND	0.080	0.086	ND	1.0	ND	ND	ND

3825

Table 4-2: VOC Results in Soil (Continued)

Analyte	1,4-dichloro-benzene	hexachloro-butadiene	2-hexanone	isopropyl-benzene	p-isopropyl-toluene	4-methyl-2-pentanone (MIBK)	methylene-chloride	naph-thalene	n-propyl-benzene	styrene
Borehole	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
B09-202-S6	ND	ND	ND	ND	ND	ND	0.120	ND	ND	ND
B09-203-S7	ND	ND	ND	ND	ND	ND	0.140	0.013	ND	ND
B09-204-S11	ND	ND	ND	0.850	2.1	ND	ND	6.2	1.3	ND
B09-205-S11	ND	ND	ND	0.690	ND	ND	ND	5.5	0.530	ND
B09-206-S4	ND	ND	0.016	ND	ND	ND	0.110	0.031	ND	ND
B09-207-S6	ND	ND	ND	2.4	0.230	ND	ND	1.8	12	ND
B09-208-S6	ND	ND	ND	0.030	0.0061	ND	0.150	0.049	0.170	ND
B09-208-S7	ND	ND	ND	0.330	0.099	ND	ND	0.220	1.9	ND
B09-209-S7	ND	ND	ND	ND	ND	ND	0.130	0.014	ND	ND
B09-210-S9	ND	ND	ND	ND	ND	ND	0.130	0.016	ND	ND
B09-211-S8	ND	ND	ND	ND	ND	ND	0.260	ND	ND	ND
B09-212-S10	ND	ND	ND	0.530	1.4	ND	0.220	ND	2.2	0.330
B09-213-S10	ND	ND	ND	ND	ND	ND	0.170	ND	0.004	ND
B09-214-S5	ND	ND	ND	1.4	0.590	ND	0.330	ND	1.6	5.9
B09-215-S5	ND	8.1	ND	ND	3.6	0.200	0.340	ND	ND	1.9
B09-216-S5	ND	ND	ND	0.280	0.170	ND	0.200	ND	0.045	1.7
B09-216-S7	ND	ND	ND	0.250	0.110	ND	0.200	ND	0.033	1.5
B09-217-S9	0.0027	ND	ND	ND	ND	ND	0.170	ND	0.0082	ND
B09-218-S6	ND	ND	ND	ND	ND	ND	0.170	ND	0.0033	ND
B09-219-S6	ND	ND	ND	ND	ND	ND	0.180	ND	ND	ND

3626

Table 4-2: VOC Detected Results in Soil (Continued)

Analyte	1,1,1,2-tetrachloro-ethane	1,2,3-trichloro-benzene	1,2,4-trichloro-benzene	1,1,1-trichloro-ethane	trichloro-ethene	trichloro-fluoro-methane (Freon 11)	1,2,4-trimethyl-benzene	1,3,5-trimethyl-benzene	vinyl chloride
Borehole	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
B09-202-S6	ND	ND	ND	ND	0.021	ND	ND	ND	ND
B09-203-S7	ND	ND	ND	ND	0.021	ND	ND	ND	ND
B09-204-S11	ND	ND	ND	ND	0.280	ND	1.2	5.0	ND
B09-205-S11	ND	ND	ND	ND	0.310	ND	7.6	ND	ND
B09-206-S4	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-207-S6	ND	ND	ND	ND	ND	ND	26	20	ND
B09-208-S6	ND	ND	ND	ND	ND	ND	1.3	0.450	ND
B09-208-S7	ND	ND	ND	ND	0.020	ND	13	4.4	ND
B09-209-S7	ND	ND	ND	ND	0.023	ND	ND	ND	ND
B09-210-S9	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-211-S8	ND	0.027	ND	ND	ND	ND	ND	ND	ND
B09-212-S10	ND	ND	ND	ND	ND	ND	ND	4.4	4.4
B09-213-S10	ND	0.034	ND	ND	ND	0.0066	ND	ND	ND
B09-214-S5	ND	1.9	ND	ND	ND	ND	ND	34	13
B09-215-S5	23	ND	7.1	ND	ND	ND	ND	ND	120
B09-216-S5	0.002	0.024	ND	ND	ND	ND	ND	5.9	4.4
B09-216-S7	0.0032	0.038	ND	ND	ND	ND	ND	4.4	3.7
B09-217-S9	0.0019	0.025	0.021	0.017	ND	ND	ND	ND	ND
B09-218-S6	ND	0.022	0.016	0.012	ND	ND	ND	ND	ND
B09-219-S6	ND	0.023	ND	0.011	ND	0.0069	ND	ND	ND

mg/kg = milligram per kilogram

3627

Table 4-3: PAH Results in Soil

Analyte	acenaph-thylene	acenaph-thene	anthracene	benzo(a) anthracene	benzo(b) fluoro-anthene	benzo(k) fluoranthene	benzo(ghi)-perylene
Borehole	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
B09-202-S6	ND	ND	ND	ND	0.0021	0.002	ND
B09-203-S7	ND	ND	ND	ND	0.001	0.0031	ND
B09-204-S11	0.260	0.830	0.062	ND	ND	ND	ND
B09-205-S11	0.150	0.230	0.046	ND	ND	ND	ND
B09-206-S4	ND	ND	ND	ND	0.0012	0.0011	ND
B09-207-S6	0.007	0.027	0.016	ND	ND	ND	ND
B09-208-S6	0.00041	0.0025	0.0046	0.001	0.002	0.0019	0.0013
B09-208-S7	0.00055	0.0019	0.0047	0.0012	0.0013	0.0023	0.0016
B09-209-S7	ND	ND	ND	ND	0.0013	0.0012	ND
B09-210-S9	ND	ND	ND	ND	ND	ND	ND
B09-211-S8	ND	ND	ND	ND	ND	ND	ND
B09-212-S10	0.250	0.330	0.095	ND	ND	ND	ND
B09-213-S10	ND	ND	ND	ND	ND	ND	ND
B09-214-S5	0.056	0.058	ND	ND	ND	ND	ND
B09-215-S5	0.0059	0.018	0.0081	0.002	0.0027	ND	0.0036
B09-216-S5	0.0076	0.011	0.0087	0.0014	0.0012	ND	0.0016
B09-216-S7	0.0072	0.010	0.0086	0.0011	0.0012	ND	0.0016
B09-217-S9	ND	ND	ND	ND	ND	ND	ND
B09-218-S6	ND	ND	ND	ND	ND	ND	ND
B09-219-S6	ND	ND	ND	ND	ND	ND	ND

3628

Table 4-3: PAH Detected Results [mg/kg] in Soil (Continued)

Analyte	benzo(a) pyrenee	chrysene	dibenzo(a,h) anthracene	fluoro-anthene	fluorene	indeno (1,2,3-cd) pyrene	naphthalene	phen-anthrene	pyrene
Borehole	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
B09-202-S6	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-203-S7	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-204-S11	ND	ND	ND	ND	0.830	ND	3.7	0.940	0.030
B09-205-S11	ND	0.0064	ND	ND	0.510	ND	2.5	0.660	0.022
B09-206-S4	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-207-S6	ND	ND	ND	0.0086	0.140	ND	0.360	0.130	0.017
B09-208-S6	ND	0.0012	ND	0.0042	0.030	ND	0.0017	0.046	0.0084
B09-208-S7	ND	0.0015	ND	0.0049	0.033	ND	0.0018	0.047	0.0098
B09-209-S7	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-210-S9	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-211-S8	ND	ND	ND	ND	ND	ND	ND	0.00041	ND
B09-212-S10	ND	ND	ND	ND	0.900	ND	2.6	1.1	0.041
B09-213-S10	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-214-S5	ND	ND	ND	ND	0.180	ND	0.870	0.230	ND
B09-215-S5	ND	0.003	ND	0.011	0.170	ND	0.390	0.150	0.025
B09-216-S5	0.00092	0.0018	ND	0.0049	0.093	ND	0.008	0.081	0.012
B09-216-S7	0.00074	0.0019	ND	0.0047	0.087	ND	0.0086	0.080	0.011
B09-217-S9	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-218-S6	ND	ND	ND	ND	ND	ND	ND	ND	ND
B09-219-S6	ND	ND	ND	ND	ND	ND	ND	ND	ND

mg/kg = milligram per kilogram

3609

3630

Table 4-4: VOC Results [µg/L] in Groundwater

Analyte	benzene	toluene	ethylbenzene	m,p-xylenes	o-xylene	xylenes (total)*
Monitoring Well	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
B09-207MW	5,200	170	270	860	97	957
B09-212MW	1.8	ND	ND	6.7	ND	6.7
Trip Blank	ND	1.5	ND	ND	ND	ND

N/A = not available; ND (<) = non-detect (above the indicated laboratory reporting limit); µg/L = microgram per liter

363

Table 4-5: VOC Concentrations in Groundwater, continued

Analyte	dibromo-fluoro-methane	1,2-dichloro-ethane-d4	Toluene	4-bromofluoro-benzene	n-butyl-benzene	sec-butyl-benzene	cis-1,2-dichloro-ethene
Monitoring Well	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
B09-207MW	100	100	97	95	20	ND	ND
B09-212MW	102	102	95	101	18	9.7	4.7
Analyte	**isopropylbenzene**	**p-isopropyl-toulene**	**naphthalene**	**n-propyl-benzene**	**trichloroethene**	**1,2,4-trimethyl-benzene**	**1,3,5-trimethyl-benzene**
Monitoring Well	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**
B09-207MW	26	ND	130	74	ND	630	170
B09-212MW	7.5	7.4	84	4.5	9.7	73	59

N/A = not available; ND (<) = non-detect (above the indicated laboratory reporting limit); µg/L = microgram per liter

Table 4-5: PAH Results [µg/L] in Groundwater

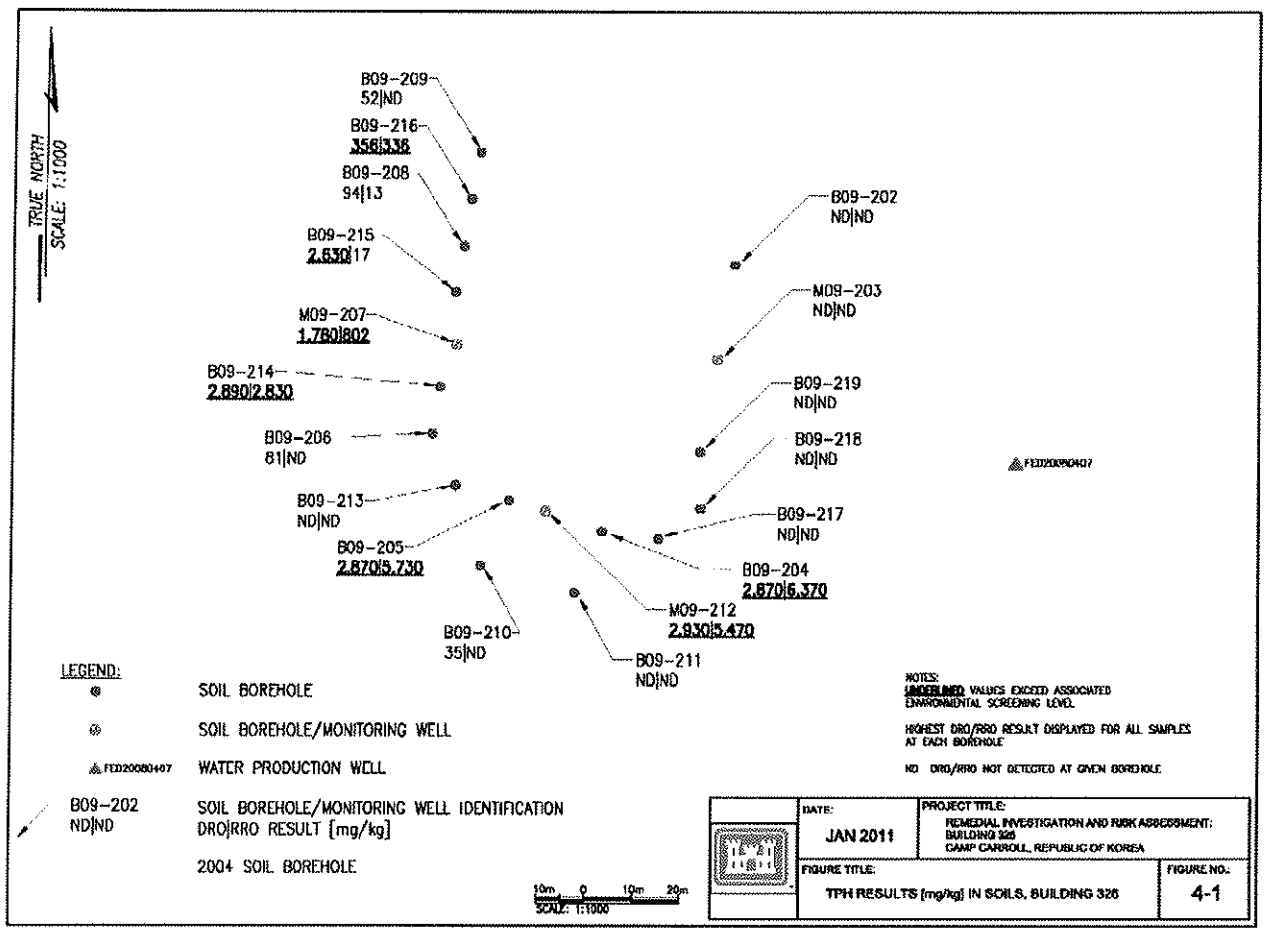
Analyte	2-methyl-naphthalene	acenaph-thene	acenaph-thylene	anthracene
Monitoring Well	(µg/L)	(µg/L)	(µg/L)	(µg/L)
B09-207MW	2,200	50	58	24
B09-212MW	72	1.7	1.9	0.65
Analyte	**fluorene**	**naphthalene**	**phenanthrene**	**pyrene**
Monitoring Well	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**
B09-207MW	200	1,200	210	ND
B09-212MW	9.6	54	6.7	0.22

Table 4-6: Summary of Hydraulic Conductivity Results

Number of Monitoring Wells Tested	Hydraulic Conductivity Range (m/day) Bouwer & Rice - Hvoslev Method
2	0.24 – 1.71

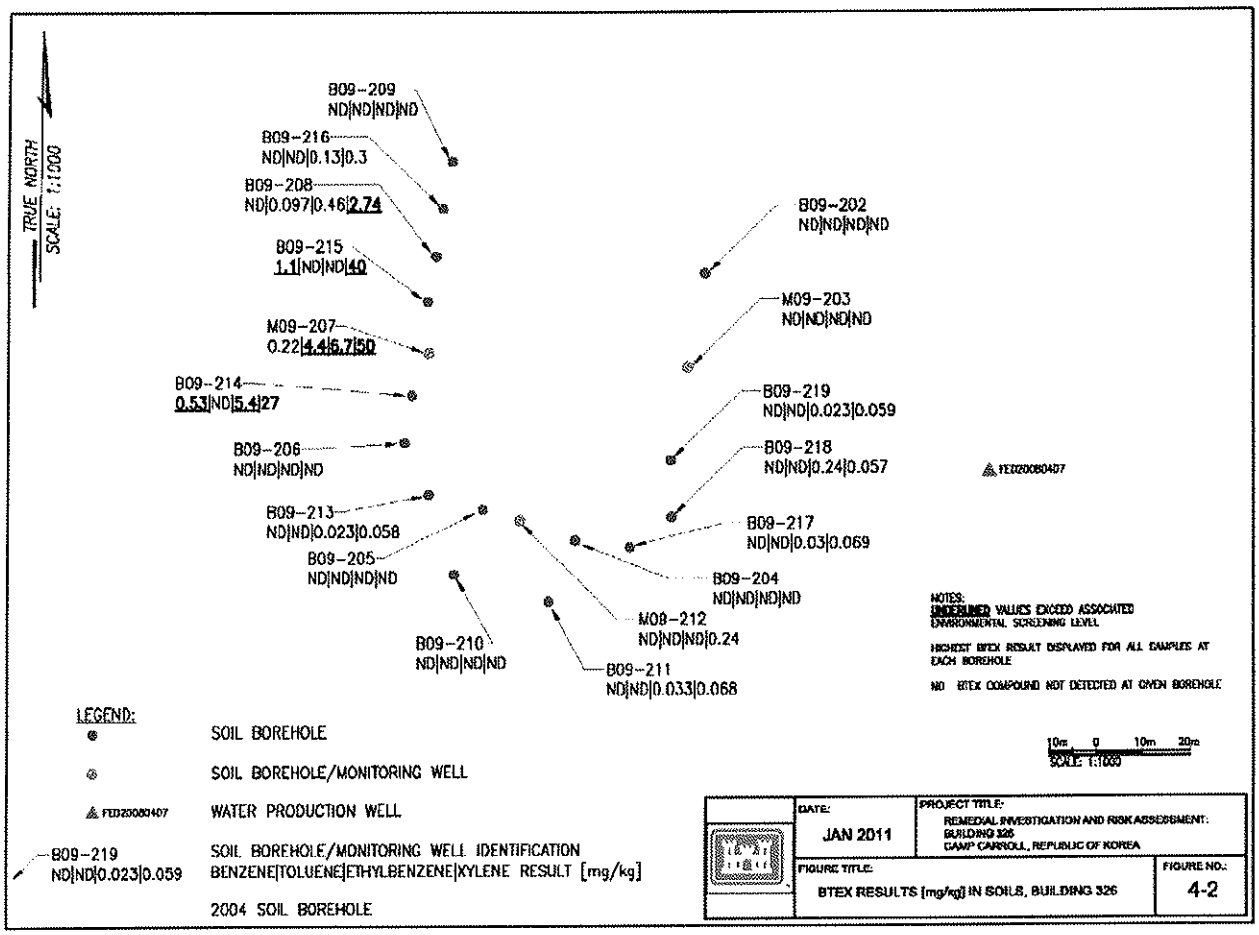
3633

Figure 0-1: TPH Results [mg/kg] in Soils, Building 326



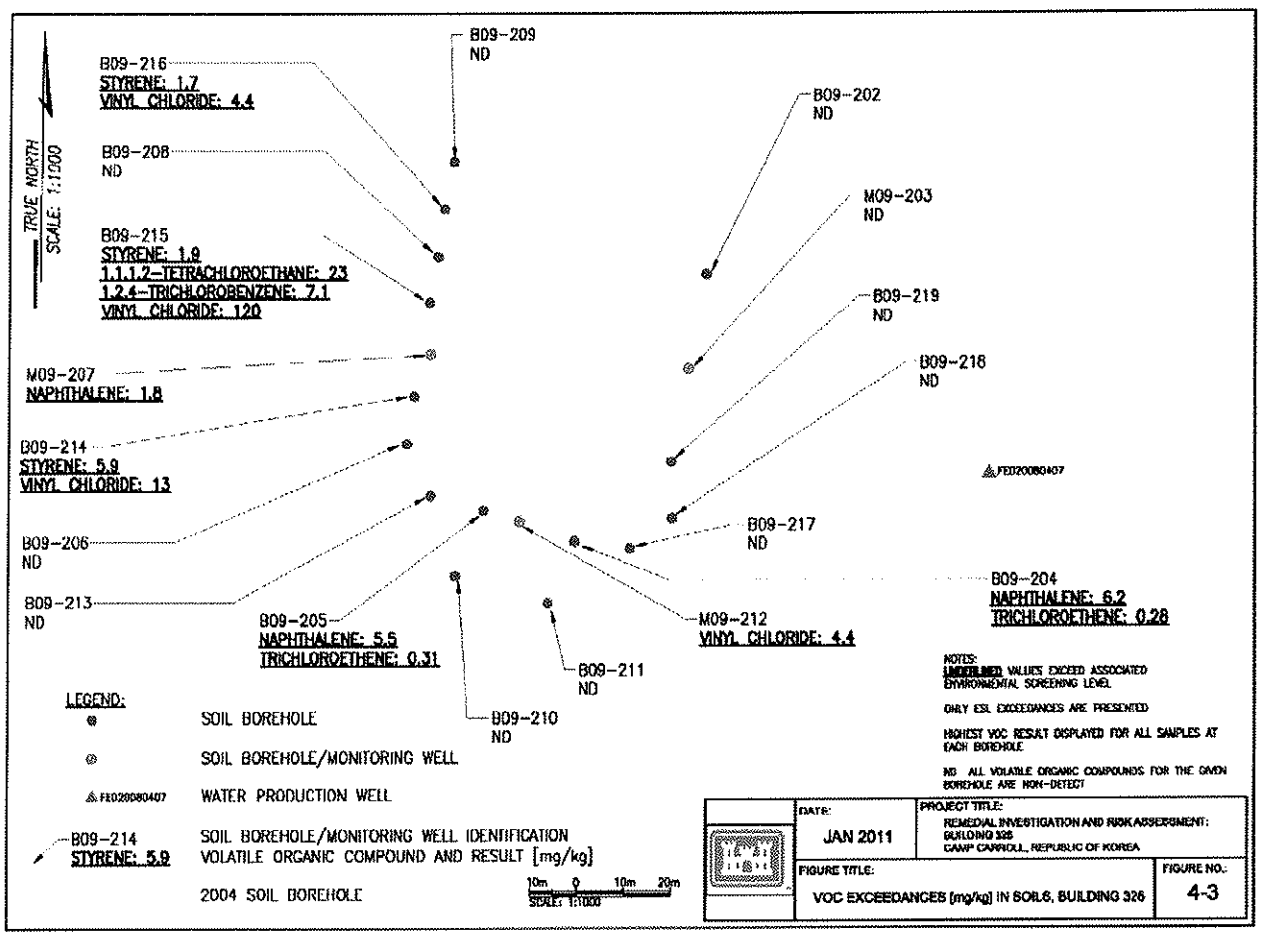
3634

Figure 0-2: BTEX Results [mg/kg] in Soils, Building 326



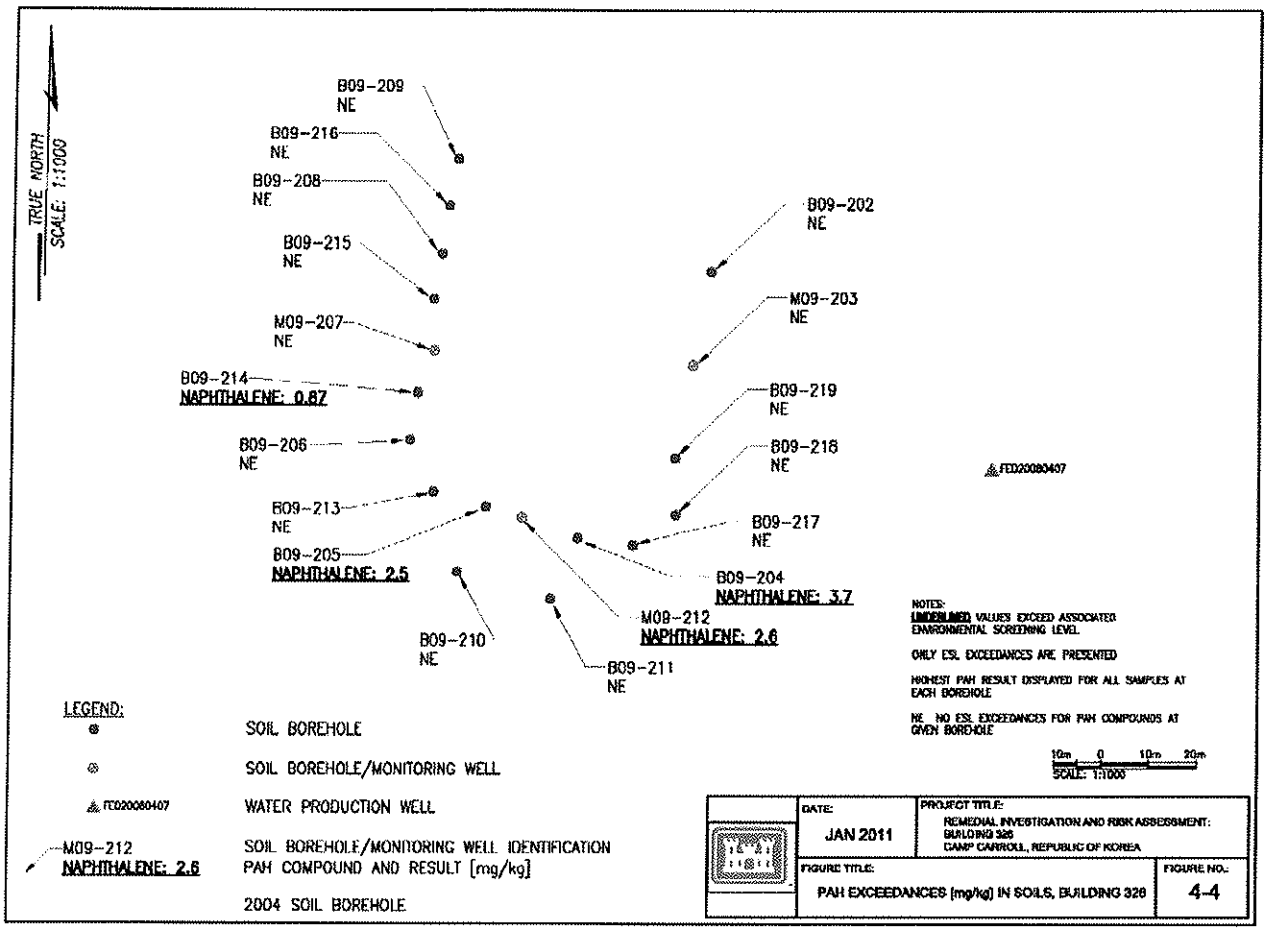
3635

Figure 0-3: VOC [mg/kg] in Soils, Building 326



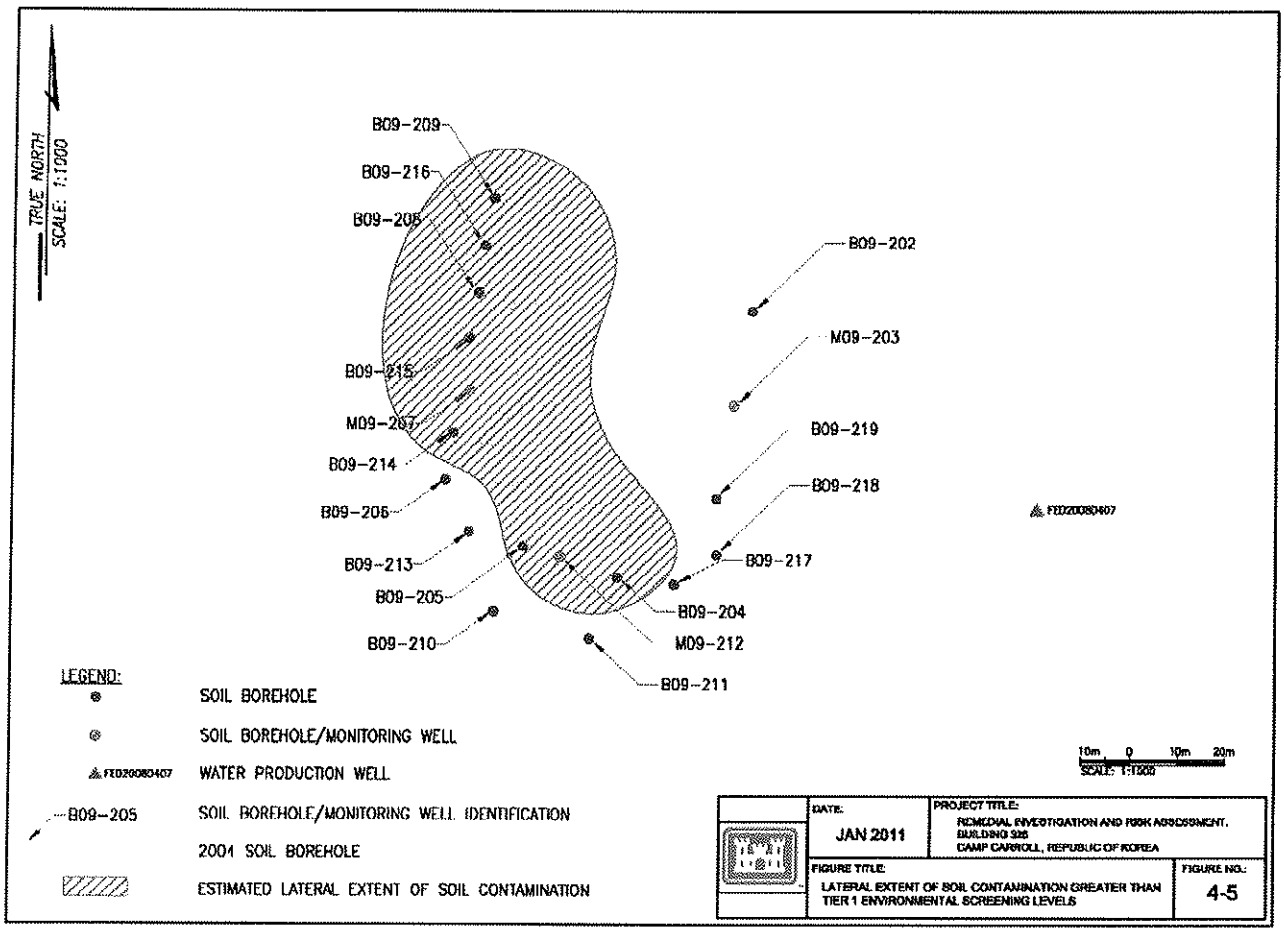
3636

Figure 0-4: PAH [mg/kg] in Soils, Building 326



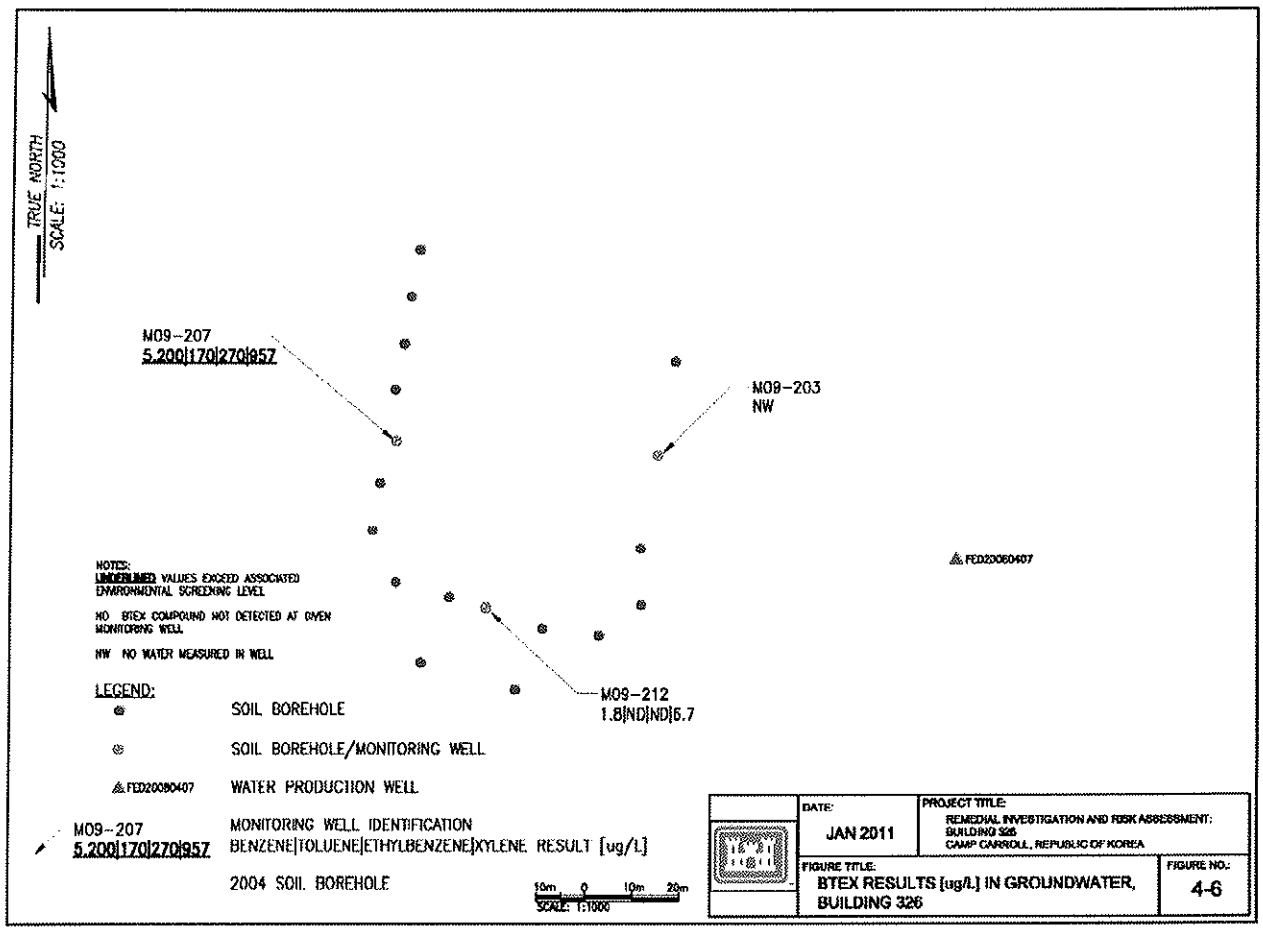
3637

Figure 0-5: Minimum Lateral Extent of GRO/DRO Soil Contamination at Building 326



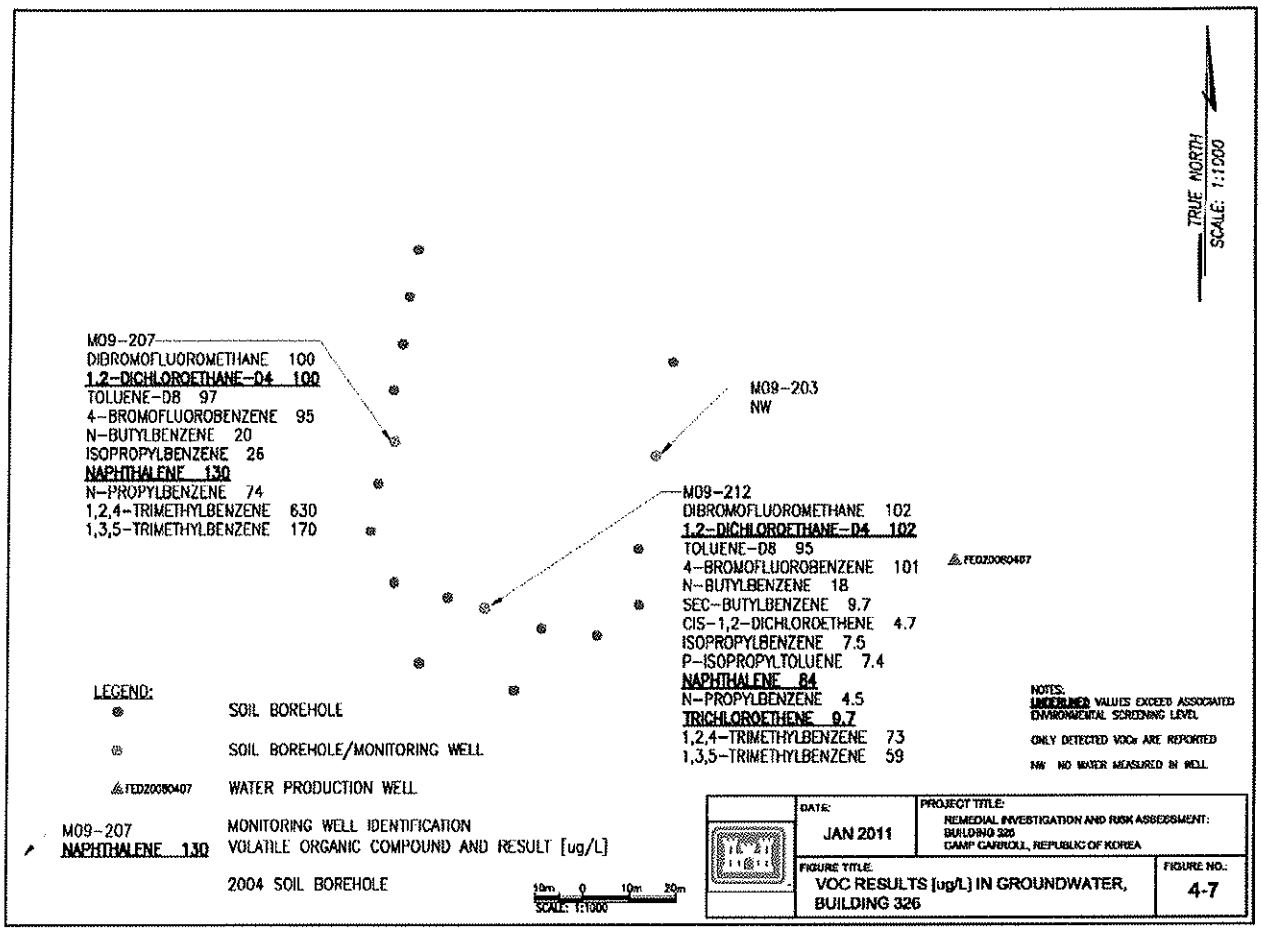
3638

Figure 0-6: BTEX Results [µg/L] in Groundwater, Building 326



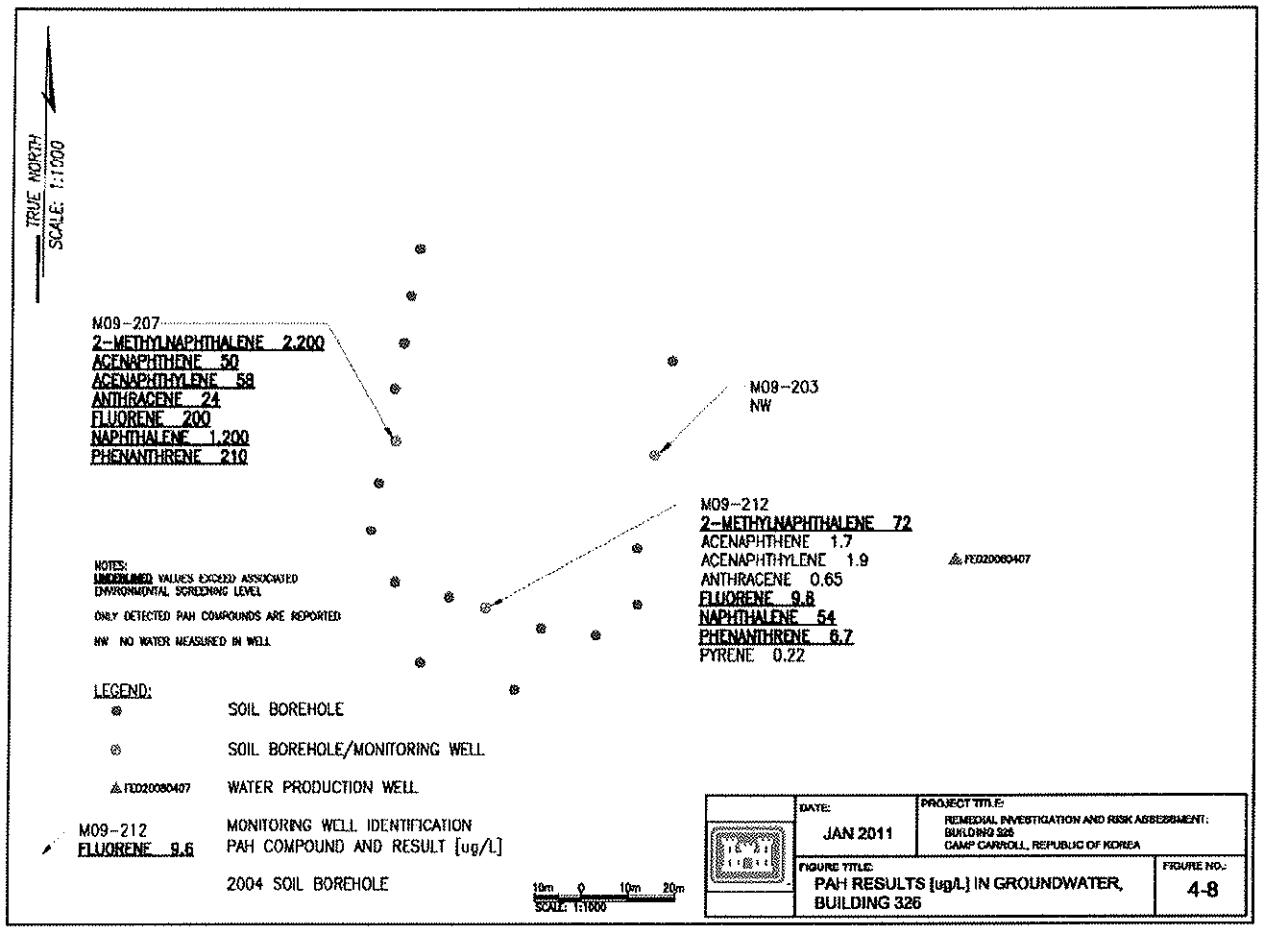
3639

Figure 0-7: VOC Results [µg/L] in Groundwater, Building 326



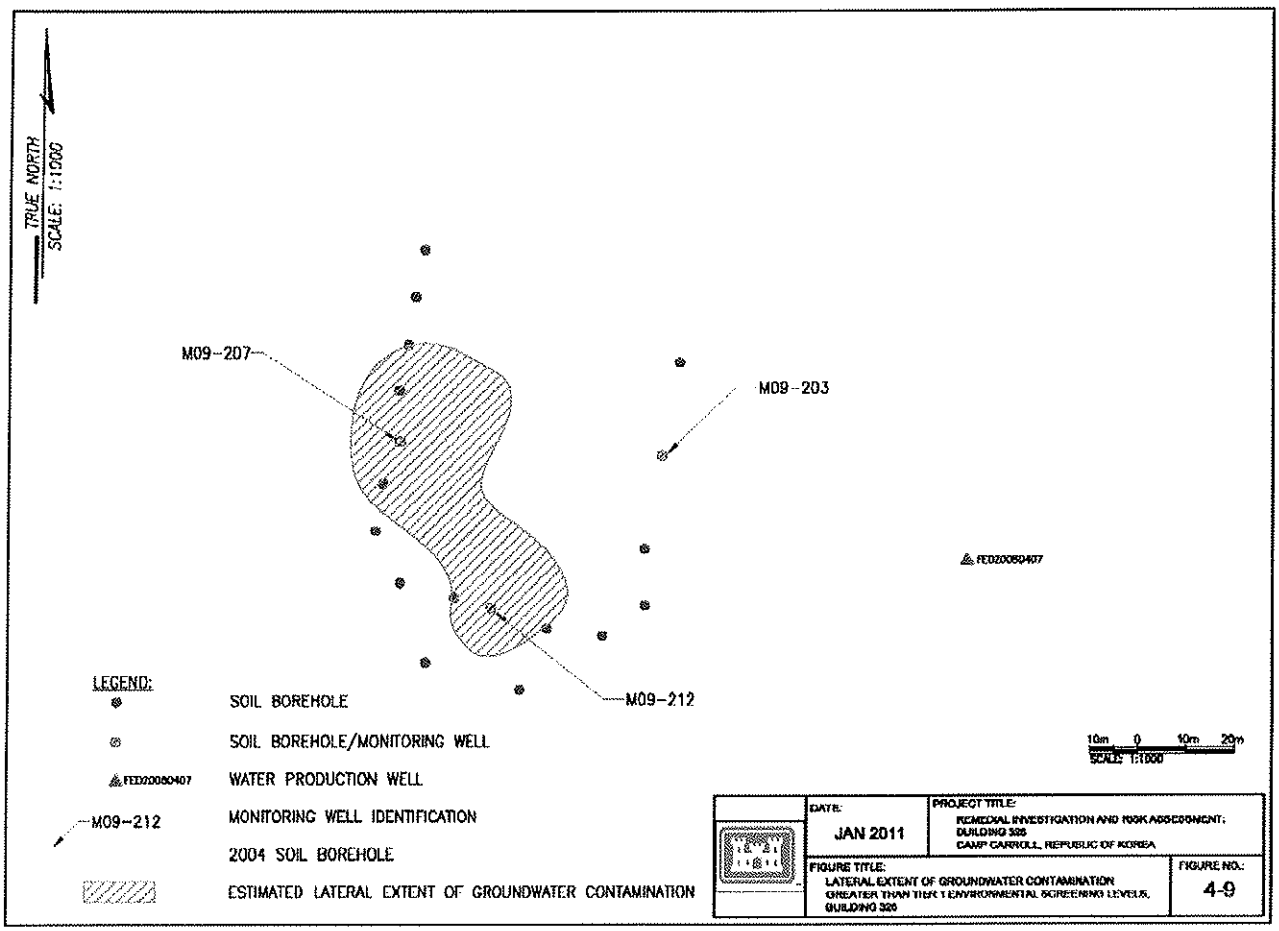
3640

Figure 0-8: PAH Results [µg/L] in Groundwater, Building 326



3641

Figure 0-9: Minimum Lateral Extent of Groundwater Contamination



3642

5. References

American Society of Test Methods, 2002. D6771-02 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations.

Beautiful Environmental Construction (BEC), 2010. *Draft Final Report for Task Order No.0014, Camp Carroll Remedial Evaluation at Five Sites.* Prepared for: US Army Corps of Engineers, Far East District, Geotechnical and Environmental Engineering Branch, Unit #15546, APO AP 96205-5546, Contract # W912UM-07-D-0001, Prepared by BEC. April 2010.

Bouwer, H. and R.C. Rice, 1976. *A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research.* Vol. 12, No. 3, pp. 423-428.

Department of Defense (DoD), 2009. DoD Quality Systems Manual for Environmental Laboratories, Version 4.1. Based on NELAC Voted Revision, June 5, 2003.

DoD, 2005. Department of Defense Directive 4715.1E. Environment, Safety, and Occupational Health (ESOH), 19 March 2005.

DoD, 1998. Department of Defense Instruction 4715.8, Environmental Remediation for DoD Activities Overseas, 2 February 1998.

GlobalSecurity.org, 2010. *Military, Camp Carroll/Taegu Storage Area.* GlobalSecurity.org, Site maintained by John Pike, last updated August 2010. http://www.globalsecurity.org/military/facility/camp-carroll.htm

USACHPPM, 2002. *Geohydrologic study No. 38-EH-3316-01 Ground-Water contamination investigation Camp Walker, Republic of Korea.* United States Army Center for Health Promotion and Preventive Medicine, Report submitted in 2002.

United States Army Corp of Engineers (USACE), 2005. *Guidance for Evaluating Performance-Based Chemical Data, Manual EM 200-1-10,* US Army Corps of Engineers Manual dated June 30, 2005.

USACE, 1997. *Engineer Manual EM 200-1-6, Chemical Quality Assurance for Hazardous, Toxic and Radioactive Waste (HTRW) Projects.* US Army Corps of Engineers Manual dated October 10, 1997.

USACE FED, 2009. *Work Plan for Environmental Site Investigation/Risk Assessment at Six Sites of Camp Carroll: Bachelor's Enlisted Quarters (BEQ) Hill, Area 41, Area D, Land Farm Building 565 and Building 326. Prepared for: Environmental Division, DPW, Camp Carroll, USA Garrison Daegu IMKO-ADP-PWE (Mr. Kim Chom-Tong), UNIT#15748, APO AP 96260-5748, Prepared by: Geotechnical and Environmental*

Engineering Branch (Dr. U-Yong Chon), US Army Corps of Engineers, Far East District, January 6, 2009.

United States Forces Korea Regulation 200-1, *United States Forces Korea Remediation Regulation*, 2 October 2007

United States Forces Korea Pamphlet 200-1, *Environmental Governing Standards*, 25 March 2005

US EPA, 1996. *Test Methods for Evaluating Solid Waste, SW-846.* 3rd ed. Final Update III. Washington. GPO. November.

Wikipedia, 2010. *Camp Carroll.* Wikipedia Foundation, Inc., last modified on November 2010. http://en.wikipedia.org/wiki/Camp_Carroll

36 of 14

Appendix A

Borehole and Monitoring Well Logs

3645

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-202**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**
LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] b6
DATE STARTED: **23 Feb 09** FINISHED: **23 Feb 09** DRILLER: [redacted] b6
DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **7.0 m**
OVERBURDEN THICKNESS: DEPTH DRILLED: **7.0 m** WATER DEPTH:
COORDINATES: N: **3,983,544.4** E: **447,304.2** GROUND ELEV.: **39.30 m** DATUM: **MSL**
GROUND COVER: **Grass** CONTAMINATION:
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					SW SC	**WELL GRADE SAND**: dark yellowish orange; moist; subangular medium Sand (max.1mm); no plasticity; fill material(SW); no odor.	%Recovery = 80 PID = 0ppm Petro Flag = 0ppm FC = S2	
38	S2					CH SW	**CLAEY SAND**: dark yellowish orange; moist; angular fine to corase gravel (max.1.5cm); (max.1mm); low plasticity; fill material(SC); no odor.	FC = F3 FC = F3	
2	S3					CH	**FAT CLAY**: dark yellowish orange; moist; (max.0.43mm); medium plasticity; very stiff; fill material(CH); no odor. **WELL GRADE SAND**: dark brown; wet; (max.2mm); no plasticity; fill material(SW); no odor.	%Recovery = 100 PID = 0.2ppm Petro Flag = 0ppm FC = S2 FC = F3	
36	S4						**FAT CLAY**: dark yellowish orange; moist; (max.0.43mm); high plasticity; stiff; alluvial; no odor.	%Recovery = 70 PID = 0ppm Petro Flag = 1.4ppm %Recovery = 90 PID = 0ppm Petro Flag = 0ppm	
4	S5					SM	**SILTY SAND**: yellowish brown; moist; (max.1mm); no plasticity; medium dense; residual; no odor.	%Recovery = 100 PID = 1ppm Petro Flag = 0ppm	
34	S6							%Recovery = 100 PID = 1.1ppm Petro Flag = 0ppm	
6	S7							%Recovery = 90 PID = 0.5ppm Petro Flag = 0ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_555 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3646

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-203MW**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**
LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] 66
DATE STARTED: **23 Feb 09** FINISHED: **23 Feb 09** DRILLER: [redacted] 66
DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **8.0 m**
OVERBURDEN THICKNESS: DEPTH DRILLED: **8.0 m** WATER DEPTH:
COORDINATES: N: **3,983,524.6** E: **447,300.5** GROUND ELEV.: **39.39 m** DATUM: **MSL**
GROUND COVER: **Grass** CONTAMINATION:
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					CH SW SC	**FAT CLAY WITH SAND**: dark brown; moist; no plasticity; soft; fill material(CH); no odor. **WELL GRADE SAND**: dark yellowish orange; moist; no plasticity; dense; fill material(SW); no odor.	%Recovery = 100 PID = 1.3ppm Petro Flag = 79ppm FC = F3	
38 — 2	S2					CH	**CLAEY SAND**; dark yellowish orange; moist; no plasticity; loose; fill material(SC); no odor. **FAT CLAY**; dark gray; moist; high plasticity; stiff; alluvial; medium sewage 1.2 to 1.5m.	%Recovery = 80 PID = 0.7ppm Petro Flag = 7.2ppm	
	S3							%Recovery = 60 PID = 1.8ppm Petro Flag = 12.1ppm	
36 — 4	S4					SC	**CLAEY SAND**; yellowish brown; moist; low plasticity; very dense; residual; no odor.	%Recovery = 90 PID = 3.1ppm Petro Flag = 0ppm	
	S5							%Recovery = 70 PID = 2ppm Petro Flag = 3.3ppm	
34 — 6	S6					CH SC	**FAT CLAY WITH SAND**; dark yellowish brown; moist; low plasticity; soft; residual; no odor. **CLAEY SAND**; yellowish brown; moist; low plasticity; very loose; residual; no odor.	%Recovery = 60 PID = 2.4ppm Petro Flag = 0ppm	
	S7							%Recovery = 50 PID = 4ppm Petro Flag = 8.4ppm	
32 — 8	S8							%Recovery = 80 PID = 2.5ppm Petro Flag = 14.4ppm	

ENVIRO-EXPLORATION LOG 08-033_37E 3326_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3647

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-204**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**
LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] b6
DATE STARTED: **24 Feb 09** FINISHED: **24 Feb 09** DRILLER: [redacted] b6
DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **12.2 m**
OVERBURDEN THICKNESS: _____ DEPTH DRILLED: **12.2 m** WATER DEPTH: _____
COORDINATES: N: **3,983,488.4** E: **447,276.4** GROUND ELEV.: **38.82 m** DATUM: **MSL**
GROUND COVER: **Asphalt** CONTAMINATION: **Yes**
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other _____

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0 / 38	S1					AC	Asphalt concrete cement.	%Recovery = 70 PID = 0.8ppm Petro Flag = 52.5ppm FC = F4	
	S2					CH	**SANDY FAT CLAY**: dark yellowish orange; moist; subangular fine gravel (max.0.7cm); subangular; high plasticity; soft; fill material(CH); no odor.	%Recovery = 100 PID = 1ppm Petro Flag = 51.6ppm	
2 / 36	S3					ML	**SILT**: dark yellowish orange; moist; subangular; low plasticity; medium soft; residual.	%Recovery = 60 PID = 1.1ppm Petro Flag = 31.9ppm	
	S4							%Recovery = 100 PID = 2.1ppm Petro Flag = 36.4ppm	
4 / 34	S5					ML	**SANDY SILT**: bright brown; moist; subangular; no plasticity; stiff; residual; strong fuel 4.4 to 8.0m.	%Recovery = 100 PID = 127ppm Petro Flag = 789.6ppm	
	S6							%Recovery = 70 PID = 142ppm Petro Flag = 2156ppm	
6 / 32	S7							%Recovery = 80 PID = 180ppm Petro Flag = 4550ppm	
	S8							%Recovery = 60 PID = 200ppm Petro Flag = 4625ppm	
8 / 30	S9					CH	**FAT CLAY**: brown; moist; subangular; low plasticity; medium stiff; residual; strong fuel 8.0 to 9.1m.	%Recovery = 100 PID = 271ppm Petro Flag = 4509ppm	
	S10					SW	**WELL GRADE SAND**: grayish green; moist; subangular; high plasticity; medium; residual; strong fuel 9.1 to 12.2m.	%Recovery = 100 PID = 281ppm Petro Flag = 13426ppm	
10 / 28	S11							%Recovery = 100 PID = 339ppm Petro Flag = 8050ppm	
	S12							%Recovery = 100 PID = 336ppm Petro Flag = 9856ppm	
12	S13							%Recovery = 100 PID = 360ppm Petro Flag = 6150ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.GPJ JSACE SKOREA.GDT 10/22/10

3698

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-205**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**
LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] 66 06
DATE STARTED: **24 Feb 09** FINISHED: **24 Feb 09** DRILLER: [redacted]
DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **13.0 m**
OVERBURDEN THICKNESS: DEPTH DRILLED: **13.0 m** WATER DEPTH:
COORDINATES: N: **3,983,494.9** E: **447,256.9** GROUND ELEV.: **39.10 m** DATUM: **MSL**
GROUND COVER: **Asphalt** CONTAMINATION: **Yes**
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0 / 39	S1					AC / CH	Asphalt concrete cement. **SANDY FAT CLAY**: dark yellowish orange; moist; about10% subangular corase gravel (max.2.5cm); about25% subangular fine to medium Sand (max.2mm); about65% Fines; medium plasticity; medium stiff; fill material(CH); slight fuel odor 3.0 to 3.3m.	%Recovery = 70 PID = 2.6ppm Petro Flag = 49.5ppm FC = F4	
38	S2							%Recovery = 80 PID = 2.5ppm Petro Flag = 36.4ppm	
2	S3							%Recovery = 90 PID = 2.3ppm Petro Flag = 35.1ppm	
36	S4					ML	**SANDY SILT**: dark yellowish orange; moist; low plasticity; medium stiff; residual; moderate fuel 3.3 to 4.0m.	%Recovery = 100 PID = 219ppm Petro Flag = 3080ppm	
4	S5							%Recovery = 100 PID = 165ppm Petro Flag = 3452.1ppm	
34	S6					CH / SM	**FAT CLAY**: dark yellowish orange; moist; medium plasticity; medium soft; residual; strong fuel 4.0 to 5.2m. **SILTY SAND**: bright brown; moist; no plasticity; dense; residual; strong fuel 5.2 to 8.0m.	%Recovery = 100 PID = 260ppm Petro Flag = 4362ppm	
6	S7							%Recovery = 90 PID = 325ppm Petro Flag = 5300ppm	
32	S8							%Recovery = 90 PID = 284ppm Petro Flag = 7200ppm	
8	S9					ML	**SANDY SILT**: dark gray; moist; no plasticity; stiff; residual; strong fuel 8.0 to 13.0m.	%Recovery = 100 PID = 244ppm Petro Flag = 4862ppm	
30	S10							%Recovery = 80 PID = 281ppm Petro Flag = 3100ppm	
10	S11							%Recovery = 70 PID = 390ppm Petro Flag = 6300ppm	
28	S12							%Recovery = 50 PID = 364ppm Petro Flag = 9000ppm	
12	S13							%Recovery = 20 PID = 121ppm Petro Flag = 540ppm	

ENVIRO-EXPLORATION LOG 08-033_37E 3326_565 CP CARROLL.GPJ JSACE SKOREA.GDT 10/22/10

3649

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-206**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted]

DATE STARTED: **24 Feb 09** FINISHED: **24 Feb 09** DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **7.8 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **7.8 m** WATER DEPTH:

COORDINATES: N: **3,983,508.9** E: **447,240.5** GROUND ELEV.: **39.15 m** DATUM: **MSL**

GROUND COVER: **Asphalt** CONTAMINATION:

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					AC	Asphalt concrete cement.	%Recovery = 70 PID = 5.4ppm Petro Flag = 12ppm FC = S1	
						GP	**POOLY GRADED GRAVEL WITH SAND**: dark brown; moist; subangular fine to coarse gravel (max.3cm); no plasticity; medium; fill material(GP); no.	FC = F4	
38	S2					CH	**FAT CLAY WITH SAND**: yellowish brown; moist; high plasticity; medium; residual; no.	FC = F4	
2	S3					ML	**SANDY SILT**: yellowish brown; moist; low plasticity; stiff; residual; no.	%Recovery = 70 PID = 3.8ppm Petro Flag = 10ppm	
36	S4							%Recovery = 100 PID = 4.7ppm Petro Flag = 3.6ppm	
4	S5					SM	**SILTY SAND**: yellowish brown; moist; no plasticity; dense; residual; no.	%Recovery = 100 PID = 5.4ppm Petro Flag = 2.6ppm	
34	S6							%Recovery = 100 PID = 4.7ppm Petro Flag = 5.2ppm	
6	S7							%Recovery = 100 PID = 3.8ppm Petro Flag = 0ppm	
32	S8							%Recovery = 80 PID = 3.5ppm Petro Flag = 6.5ppm	
								%Recovery = 100 PID = 3.2ppm Petro Flag = 1ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARRO_LGP_ USACE SKOREA.GDT 10/22/10

3650

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-207MW**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**
LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted]
DATE STARTED: **25 Feb 09** FINISHED: **25 Feb 09** DRILLER: [redacted]
DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **7.8 m**
OVERBURDEN THICKNESS: DEPTH DRILLED: **7.8 m** WATER DEPTH:
COORDINATES: N: **3,983,527.7** E: **447,245.6** GROUND ELEV.: **39.24 m** DATUM: **MSL**
GROUND COVER: **Asphalt** CONTAMINATION: **Yes**
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					AC	Asphalt concrete cement.	%Recovery = 90 PID = 96ppm Petro Flag = 224ppm FC = S1	
						GP CH	**POORLY GRADED GRAVEL**: dark gray; high moist; about85% subangular fine to coarse gravel (max.4cm); about10%; about5% Fines; no plasticity; medium; fill material(GP); no.	FC = F4 FC = F4	
38	S2					ML ML	**SANDY FAT CLAY**: dark yellowish brown; moist; about0%; about30%; about70% Fines; high plasticity; medium; fill material(CH); no.	%Recovery = 40 PID = 82.3ppm Petro Flag = 77.7ppm FC = F4	
2	S3						**SILT WITH SAND**: yellowish brown; moist; no plasticity; stiff; residual; no.		
							SANDY SILT: yellowish brown; moist; no plasticity; stiff; residual; moderate fuel 1.0 to 6.7m.		
36	S4							%Recovery = 70 PID = 629ppm Petro Flag = 399.6ppm	
4	S5							%Recovery = 100 PID = 1124ppm Petro Flag = 233.1ppm	
34	S6							%Recovery = 90 PID = 937ppm Petro Flag = 0ppm	
6	S7							%Recovery = 100 PID = 1126ppm Petro Flag = 399.6ppm	
						SM	**SILTY SAND**: yellowish brown; moist; no plasticity; dense; residual; strong fuel 6.7 to 7.8m.		
32	S8							%Recovery = 60 PID = 1052ppm Petro Flag = 350ppm	
								%Recovery = 75 PID = 919ppm Petro Flag = 1750ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3651

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-208**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted]

DATE STARTED: **25 Feb 09** FINISHED: **25 Feb 09** DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **6.0 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **6.0 m** WATER DEPTH:

COORDINATES: N: **3,983,548.2** E: **447,247.2** GROUND ELEV.: **39.24 m** DATUM: **MSL**

GROUND COVER: **Concrete** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					GC CH	**CLAYEY GRAVEL**; brown; moist; subangular medium gravel (max.3cm); subangular fine to medium Sand (max.2mm); low plasticity; medium; fill material(GC); no.	%Recovery = 70 PID = 358ppm Petro Flag = 663ppm	
38	S2					SW-SM	**FAT CLAY**; dark yellowish orange; moist; low plasticity; medium; fill material(CH); no. **WELL GRADED SAND WITH SILT**; yellowish brown; moist; no plasticity; loose; residual; weak fuel 0.9 to 1.0m.	FC = F3 FC = F3 FC = F2 %Recovery = 80 PID = 16.6ppm Petro Flag = 0ppm	
2	S3					SW-SM	**WELL GRADED SAND WITH SILT**; yellowish brown; moist; no plasticity; loose; residual; moderate fuel 2.15 to 4.5m.	%Recovery = 100 PID = 43.8ppm Petro Flag = 6ppm	
36	S4							%Recovery = 100 PID = 49.4ppm Petro Flag = 0ppm	
4	S5					SW	**WELL GRADED SAND**; brown; moist; no plasticity; loose; residual; strong fuel 4.5 to 5.7m.	%Recovery = 100 PID = 121ppm Petro Flag = 0ppm	
34	S6							%Recovery = 90 PID = 420ppm Petro Flag = 0ppm	
6						SW	**WELL GRADED SAND**; brown; moist; no plasticity; loose; residual; strong fuel 5.7 to 6.0m.		

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

36 52

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-209**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] b6 b6

DATE STARTED: **25 Feb 09** FINISHED: **25 Feb 09** DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **7.5 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **7.5 m** WATER DEPTH:

COORDINATES: N: **3,983,568.0** E: **447,250.4** GROUND ELEV.: **39.32 m** DATUM: **MSL**

GROUND COVER: **Asphalt** CONTAMINATION:

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0						AC			
	S1					GP-GC	**POORLY GRADED GRAVEL WITH CLAY AND SAND**: brown; moist; subangular fine to medium gravel (max.2cm); medium plasticity; medium; fill material(GP-GC); no.	%Recovery = 80 PID = 4ppm Petro Flag = 13ppm FC = F1	
						CH	**SANDY FAT CLAY**: dark yellowish orange; moist; medium plasticity; medium; fill material(CH); no.	FC = F4	
38	S2					SM	**SILTY SAND**: yellowish brown; moist; no plasticity; loose; residual; no.	FC = F3 %Recovery = 100 PID = 4ppm Petro Flag = 0ppm	
2	S3							%Recovery = 100 PID = 4.9ppm Petro Flag = 0ppm	
36	S4							%Recovery = 100 PID = 3.7ppm Petro Flag = 0ppm	
4	S5							%Recovery = 90 PID = 4.4ppm Petro Flag = 0ppm	
34	S6					SW-SM	**WELL GRADED SAND WITH SILT**: yellowish brown; moist; no plasticity; loose; residual; no.	%Recovery = 90 PID = 4.5ppm Petro Flag = 3ppm	
6	S7							%Recovery = 90 PID = 4.8ppm Petro Flag = 2ppm	
32	S8					SM	**SILTY SAND**: yellowish brown; moist; no plasticity; loose; residual; no.	%Recovery = 100 PID = 3.9ppm Petro Flag = 0ppm	
						GP	**POORLY GRADED GRAVEL WITH SAND**: yellowish brown; moist; subangular medium gravel (max.2cm); no plasticity; medium; residual; no; contain quartzite.		

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3653

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-210**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] b6 b6

DATE STARTED: **25 Feb 09** FINISHED: **25 Feb 09** DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **10.0 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **10.0 m** WATER DEPTH:

COORDINATES: N: **3,983,481.2** E: **447,250.9** GROUND ELEV.: **37.94 m** DATUM: **MSL**

GROUND COVER: **Concrete** CONTAMINATION:

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					GP	**POORLY GRADED GRAVEL**; dark gray; dry; no plasticity; medium; fill material(GP); no.	%Recovery = 70 PID = 3.4ppm Petro Flag = 22.1ppm FC = NFS FC = F4 FC = F3	
						ML SM	**SILT WITH SAND**; dark yellowish orange; moist; low plasticity; soft; residual; no. **SILTY SAND**; yellowish brown; moist; low plasticity; soft; residual; no.		
36 2	S2							%Recovery = 80 PID = 3.8ppm Petro Flag = 16ppm	
	S3							%Recovery = 90 PID = 3.1ppm Petro Flag = 16.5ppm	
34 4	S4							%Recovery = 100 PID = 3.9ppm Petro Flag = 0ppm	
	S5							%Recovery = 100 PID = 3.4ppm Petro Flag = 0ppm	
	S6							%Recovery = 90 PID = 3.3ppm Petro Flag = 0ppm	
32 6	S7							%Recovery = 90 PID = 3.1ppm Petro Flag = 0ppm	
	S8							%Recovery = 100 PID = 3.1ppm Petro Flag = 0ppm	
30 8	S9							%Recovery = 90 PID = 3.7ppm Petro Flag = 0ppm	
	S10					ML ML GW	**SILT**; yellowish brown; moist; low plasticity; soft; residual; no. **SILT**; yellowish brown; moist; low plasticity; soft; residual; no. **WELL GRADED GRAVEL WITH SAND**; brown; moist; no plasticity; medium; residual; no; contain quartzite.	%Recovery = 90 PID = 1.9ppm Petro Flag = 0ppm	
28 10									

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROL_.GPJ USACE SKOREA.GDT 10/22/10

3654

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-211**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**
LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] DG
DATE STARTED: **25 Feb 09** FINISHED: **26 Feb 09** DRILLER: [redacted] DG
DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **10.0 m**
OVERBURDEN THICKNESS: DEPTH DRILLED: **10.0 m** WATER DEPTH:
COORDINATES: N: **3,983,475.5** E: **447,270.7** GROUND ELEV.: **37.98 m** DATUM: **MSL**
GROUND COVER: **Concrete** CONTAMINATION:
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0									
	S1					CH	**SANDY FAT CLAY WITH GRAVEL**: brown; moist; about20% subangular fine to medium gravel (max.1.5cm); about20%; about60% Fines; low plasticity; stiff; fill material(CH); no.	%Recovery = 80 PID = 2.7ppm Petro Flag = 33.6ppm	
	S2					SC	**CLAYEY SAND**: dark gray; moist; low plasticity; medium; fill material(SC); medium sewage 0.9 to 2.0m.	FC = F4 FC = F3 %Recovery = 70 PID = 1.5ppm Petro Flag = 24.2ppm	
36 — 2	S3					CH	**FAT CLAY**: moderate red; moist; high plasticity; medium; residual; no.	%Recovery = 50 PID = 2.2ppm Petro Flag = 40.8ppm	
	S4					ML	**SILT**: dark yellowish orange; moist; no plasticity; soft; residual; no.	%Recovery = 70 PID = 2ppm Petro Flag = 22ppm	
34 — 4	S5							%Recovery = 80 PID = 2ppm Petro Flag = 12ppm	
	S6					SM	**SILTY SAND**: yellowish brown; moist; no plasticity; medium; residual; no.	%Recovery = 90 PID = 1.8ppm Petro Flag = 12.1ppm	
32 — 6	S7					SM	**SILTY SAND**: yellowish brown; moist; no plasticity; very dense; residual; no.	%Recovery = 90 PID = 2.1ppm Petro Flag = 13ppm	
	S8							%Recovery = 95 PID = 3ppm Petro Flag = 0ppm	
30 — 8	S9							%Recovery = 100 PID = 2.3ppm Petro Flag = 13.2ppm	
	S10							%Recovery = 80 PID = 2.9ppm Petro Flag = 0ppm	
28 — 10									

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3655

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-212MW**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted]

DATE STARTED: **26 Feb 09** FINISHED: **26 Feb 09** DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **10.4 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **10.4 m** WATER DEPTH:

COORDINATES: N: **3,983,492.6** E: **447,264.6** GROUND ELEV.: **39.01 m** DATUM: **MSL**

GROUND COVER: **Asphalt** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0 / 38	S1					AC / CH / CH	**FAT CALY WITH SAND**: dark yellowish orange; moist; about0%; about20% subangular; about80% Fines; fill material(CH); no.	%Recovery = 90 PID = 2.6ppm Petro Flag = 3.6ppm FC = F4	
2	S2					CH / CH	**FAT CLAY**: brown; moist; about0%; about5% subangular; about95% Fines; fill material(CH); no. **FAT CALY WIH GRAVEL**: dark yellowish orange; moist; about15% subangular medium gravel (max.2cm); about5% subangular; about80% Fines; fill material(CH); no.	FC = F3 %Recovery = 100 PID = 3.3ppm Petro Flag = 5.4ppm FC = F4	
36	S3					ML	**FAT CLAy**: dark yellowish orange; moist; subangular; residual; no. **SILT**: dark yellowish orange; moist; subangular; residual; no.	FC = F3 %Recovery = 90 PID = 3.6ppm Petro Flag = 11.2ppm	
4	S4							%Recovery = 100 PID = 6ppm Petro Flag = 8.8ppm	
34	S5					SM	**SILTY SAND**: yellowish brown; moist; subangular; residual; no.	%Recovery = 90 PID = 86ppm Petro Flag = 359.8ppm	
6	S6							%Recovery = 90 PID = 166ppm Petro Flag = 4064ppm	
32	S7							%Recovery = 90 PID = 211ppm Petro Flag = 9202ppm	
8	S8							%Recovery = 90 PID = 213ppm Petro Flag = 8685.6ppm	
30	S9							%Recovery = 90 PID = 222ppm Petro Flag = 8164.8ppm	
10	S10							%Recovery = 100 PID = 242ppm Petro Flag = 9616.2ppm	
	S11							%Recovery = 100 PID = 205ppm Petro Flag = 5456.7ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.CPJ USACE SKOREA.GDT 10/22/10

3656

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-213**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] 66

DATE STARTED: **26 Feb 09** FINISHED: **26 Feb 09** DRILLER: [redacted] 66

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **10.0 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **10.0 m** WATER DEPTH:

COORDINATES: N: **3,983,498.1** E: **447,245.6** GROUND ELEV.: **39.09 m** DATUM: **MSL**

GROUND COVER: **Asphalt** CONTAMINATION:

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0						AC			
	S1					GW	**WELL GRADED GRAVEL WITH SAND**: dark gray; moist; about70% subangular medium to coarse gravel (max.3cm); about25% subangular fine to coarse Sand (max.4.8mm); about5% Fines; no plasticity; soft; fill material(GW); no.	%Recovery = 80 PID = 3.5ppm Petro Flag = 46.8ppm FC = S1 FC = F4	
38	S2					CH	**FAT CLAY WITH SAND**: brown; moist; about0%; about20% subangular fine to coarse Sand (max.4.8mm); about80% Fines; high plasticity; medium; fill material(CH); no; contain MICA.	%Recovery = 60 PID = 4.9ppm Petro Flag = 0ppm FC = F4	
2	S3					ML	**SILT**: moderate red; moist; about0%; about10% subangular medium Sand (max.2mm); about90% Fines; no plasticity; medium; residual; no.	%Recovery = 60 PID = 5ppm Petro Flag = 4.5ppm	
36	S4							%Recovery = 80 PID = 4ppm Petro Flag = 5.5ppm	
4	S5					SM	**SILTY SAND**: yellowish brown; moist; about0%; about70% subangular fine to medium Sand (max.2mm); about30% Fines; no plasticity; loose; residual; no.	%Recovery = 90 PID = 4.1ppm Petro Flag = 0ppm	
34	S6							%Recovery = 100 PID = 4.1ppm Petro Flag = 0ppm	
6	S7							%Recovery = 80 PID = 4.8ppm Petro Flag = 0ppm	
32	S8							%Recovery = 90 PID = 4.2ppm Petro Flag = 0ppm	
8	S9							%Recovery = 90 PID = 4.5ppm Petro Flag = 0ppm	
30	S10							%Recovery = 80 PID = 5.1ppm Petro Flag = 0ppm	
10									

ENVIRO-EXPLORATION LOG 08-033_37E 3326_56E CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3657

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-214**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] 66

DATE STARTED: **26 Feb 09** FINISHED: **26 Feb 09** DRILLER: [redacted] 66

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **7.0 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **7.0 m** WATER DEPTH:

COORDINATES: N: **3,983,518.8** E: **447,242.1** GROUND ELEV.: **39.17 m** DATUM: **MSL**

GROUND COVER: **Concrete** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					GP	**POORLY GRADED GRAVEL WITH SAND**: dark gray; moist; about80% subgangular medium gravel (max.2cm); about20% subangular medium to coarse Sand (max.4.8mm); about0% Fines; no plasticity; medium; fill material(GP); no.	%Recovery = 50 PID = 26.7ppm Petro Flag = 419.9ppm FC = NFS FC = F4 FC = F4	
38	S2					CH	**FAT CLAY WITH SAND**: dark yellowish orange; moist; about0%; about30% subangular fine to coarse Sand (max.4.8mm); about70% Fines; no plasticity; soft; fill material(CH); no.	%Recovery = 40 PID = 19.7ppm Petro Flag = 164.8ppm	
2	S3					ML	**SILT WITH SAND**: yellowish brown; moist; about0%; about20% subangular fine to medium Sand (max.2mm); about80% Fines; no plasticity; soft; residual; no.	%Recovery = 70 PID = 420ppm Petro Flag = 187.2ppm	
36	S4					SM	**SILTY SAND**: yellowish brown; moist; about0%; about60% subangular fine to medium Sand (max.2mm); about40% Fines; no plasticity; dense; residual; moderate fuel 2.3 to 7.0m.	%Recovery = 100 PID = 1006ppm Petro Flag = 50ppm	
4	S5							%Recovery = 90 PID = 1062ppm Petro Flag = 1598.4ppm	
34	S6							%Recovery = 100 PID = 951ppm Petro Flag = 462.5ppm	
6	S7							%Recovery = 90 PID = 849ppm Petro Flag = 1336.3ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

365F

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-215**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] 66 66

DATE STARTED: **26 Feb 09** FINISHED: **26 Feb 09** DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **6.5 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **6.5 m** WATER DEPTH:

COORDINATES: N: **3,983,538.6** E: **447,245.3** GROUND ELEV.: **39.23 m** DATUM: **MSL**

GROUND COVER: **Concrete** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					GP	**POORLY GRADED GRAVEL**: dark gray; moist; about90% subangular medium to coarse gravel (max.3cm); about10%; about0% Fines; no plasticity; loose; fill material(GP); no.	%Recovery = 60 PID = 55.2ppm Petro Flag = 0ppm FC = NFS	
38						CH	**FAT CLAY WITH SAND**: moderate red; moist; about0%; about15%; about85% Fines; high plasticity; medium; fill material(F4); no; contain MICA.	FC = F4 FC = F3	
2	S2					SM	**SILTY SAND**: yellowish brown; moist; about0%; about60%; about40% Fines; no plasticity; medium; residual; weak fuel 0.8 to 2.3m.	%Recovery = 90 PID = 8.5ppm Petro Flag = 0ppm	
	S3					SM	**SILTY SAND**: dark yellowish orange; moist; about0%; about80%; about20% Fines; no plasticity; medium; residual; moderate fuel 2.3 to 6.5m.	%Recovery = 90 PID = 296ppm Petro Flag = 0ppm	
36	S4							%Recovery = 100 PID = 773ppm Petro Flag = 0ppm	
4	S5							%Recovery = 100 PID = 1138ppm Petro Flag = 0ppm	
34	S6							%Recovery = 100 PID = 720ppm Petro Flag = 0ppm	
6	S7							%Recovery = 100 PID = 604ppm Petro Flag = 0ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B325_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

36 59

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-216**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] b6

DATE STARTED: **27 Feb 09** FINISHED: **27 Feb 09** DRILLER: [redacted] b6

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **5.5 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **5.5 m** WATER DEPTH:

COORDINATES: N: **3,983,558.2** E: **447,248.6** GROUND ELEV.: **39.26 m** DATUM: **MSL**

GROUND COVER: **Concrete** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0									
	S1					GP-GC / CH	**POORLY GRADED GRAVEL WITH CLAY AND SAND**; dark gray; moist; subangular medium gravel (max.2cm); subangular fine to coarse Sand (max.4.8mm); medium plasticity; loose; fill material(GP-GC); no.	%Recovery = 85 PID = 3.5ppm Petro Flag = 9.9ppm FC = F1 FC = F4 FC = S2	
38	S2					SW	**FAT CLAY WITH SAND**; dark yellowish orange; moist; high plasticity; stiff; residual; no; contain MICA. **WELL GRADED SAND**; grayish green; moist; no plasticity; medium; residual; weak fuel 0.8 to 2.4m.	%Recovery = 100 PID = 4.9ppm Petro Flag = 0ppm	
2	S3					SW-SM	**WELL GRADED SAND WITH SILT**; grayish green; moist; no plasticity; medium; residual; weak fuel 2.4 to 3.7m.	%Recovery = 100 PID = 4.3ppm Petro Flag = 8.4ppm	
36	S4							%Recovery = 90 PID = 60.2ppm Petro Flag = 76.5ppm	
4	S5					SW	**WELL GRADED SAND**; grayish green; moist; no plasticity; dense; residual; strong fuel 3.7 to 4.0m.	%Recovery = 100 PID = 293ppm Petro Flag = 0ppm	
34	S6							%Recovery = 100 PID = 232ppm Petro Flag = 90ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.CPJ JSACE SKOREA.GDT 10/22/10

3663

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-217**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**
LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] 66
DATE STARTED: **28 Feb 09** FINISHED: **28 Feb 09** DRILLER: [redacted] 66
DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **10.0 m**
OVERBURDEN THICKNESS: DEPTH DRILLED: **10.0 m** WATER DEPTH:
COORDINATES: N: **3,983,486.9** E: **447,288.2** GROUND ELEV.: **38.63 m** DATUM: **MSL**
GROUND COVER: **Asphalt** CONTAMINATION:
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0						AC			
38	S1					SW-SC	**WELL GRADED SAND WITH CLAY**: dark gray; dry; subangular fine to medium gravel (max.1cm); no plasticity; dense; fill material(SW-SC); no.	%Recovery = 80 PID = 1ppm Petro Flag = 15ppm FC = F2	
						CH			
	S2					ML	**FAT CLAY WITH SAND**: moderate red; moist; high plasticity; medium; fill material(CH); no.	FC = F4 FC = F4	
2							**SILT WITH SAND**: dark yellowish orange; moist; low plasticity; medium; residual; no.	%Recovery = 80 PID = 2.3ppm	
36	S3					CH	**FAT CLAY WITH SAND**: brown; moist; high plasticity; medium; residual; no.	Petro Flag = 21.6ppm FC = F4	
	S4							%Recovery = 100 PID = 2.4ppm Petro Flag = 23.4ppm	
4	S5							%Recovery = 90 PID = 2.7ppm Petro Flag = 23ppm	
34								%Recovery = 80 PID = 2.4ppm Petro Flag = 0ppm	
	S6					SM	**SILTY SAND**: yellowish brown; moist; low plasticity; medium; residual; no.	%Recovery = 90 PID = 2.8ppm Petro Flag = 8.8ppm	
6	S7							%Recovery = 90 PID = 2.1ppm Petro Flag = 8.4ppm	
32	S8							%Recovery = 90 PID = 2.1ppm Petro Flag = 10.8ppm	
8	S9							%Recovery = 90 PID = 3ppm Petro Flag = 0ppm	
30	S10							%Recovery = 90 PID = 2.9ppm Petro Flag = 0ppm	
10									

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3661

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-218**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] b6

DATE STARTED: **28 Feb 09** FINISHED: **28 Feb 09** DRILLER: [redacted] b6

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **7.0 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **7.0 m** WATER DEPTH:

COORDINATES: N: **3,983,493.2** E: **447,297.1** GROUND ELEV.: **38.70 m** DATUM: **MSL**

GROUND COVER: **Asphalt** CONTAMINATION:

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0 / 38	S1					AC / GP / CH	**POORLY GRADED GRAVEL WITH SAND**: brown; moist; subangular medium gravel (max.2cm); no plasticity; medium; fill material(GP); no.	%Recovery = 60 PID = 3ppm Petro Flag = 0ppm FC = S1 FC = F4	
	S2					CH	**FAT CLAY WITH SAND**: moderate red; moist; high plasticity; medium; fill material(CH); no.	%Recovery = 100 PID = 3.2ppm Petro Flag = 5.5ppm	
2 / 36	S3							%Recovery = 80 PID = 3.8ppm Petro Flag = 88.8ppm	
	S4					SC	**CLAYEY SAND**: yellowish brown; moist; low plasticity; stiff; residual; no.	%Recovery = 90 PID = 3.8ppm Petro Flag = 15.4ppm	
4 / 34	S5					SM / CH	**QUARTZ DIKE**	%Recovery = 90 PID = 3.6ppm Petro Flag = 4ppm	
	S6					SW-SM / ML	**FAT CLAY WITH SAND**: dark yellowish orange; moist; high plasticity; stiff; residual; no. **WELL GRADED SAND WITH SILT**: dark brown; moist; no plasticity; dense; residual; no. **SILT**: yellowish brown; moist; low plasticity; stiff; residual; no.	%Recovery = 80 PID = 4.6ppm Petro Flag = 0ppm	
6 / 32	S7					SM	**SILTY SAND**: yellowish gray; moist; low plasticity; dense; residual; no.	%Recovery = 90 PID = 4.2ppm Petro Flag = 0ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 C> CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3662

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B09-219**

Far East District

PROJECT: **RIRA at B326 and B565 Areas**

LOCATION: **Camp carroll** G&EE NO.: **08-033E and 037E** INSPECTOR: [redacted] bb

DATE STARTED: **28 Feb 09** FINISHED: **28 Feb 09** DRILLER: [redacted] bb

DRILLING METHOD/EQUIPMENT: **GeoProbe 6600**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **3 cm** TOTAL DEPTH: **8.5 m**

OVERBURDEN THICKNESS: _____ DEPTH DRILLED: **8.5 m** WATER DEPTH: _____

COORDINATES: N: **3,983,505.1** E: **447,296.9** GROUND ELEV.: **39.22 m** DATUM: **MSL**

GROUND COVER: **Grass** CONTAMINATION: _____

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☐ Auger Hole ☐ other _____

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1					CH	**FAT CLAY WITH SAND**: dark brown; moist; subangular fine to medium Sand (max.2mm); medium plasticity; medium; fill material(CH); no.	%Recovery = 80 PID = 4.3ppm Petro Flag = 73.2ppm FC = F4	
38	S2					SC	**CLAYEY SAND**: dark gray; moist; subangular fine to medium Sand (max.2mm); low plasticity; medium; fill material(SC); medium sewage 1.5 to 1.7m.	%Recovery = 70 PID = 6.1ppm Petro Flag = 49.2ppm FC = F3	
2	S3					CH	**FAT CLAY**: yellowish brown; moist; subangular medium Sand (max.2mm); high plasticity; stiff; alluvial; no.	FC = F3	
36	S4					ML	**SANDY SILT**: yellowish brown; moist; subangular medium Sand (max.2mm); low plasticity; stiff; residual; no.	%Recovery = 50 PID = 5.2ppm Petro Flag = 44ppm	
4	S5							%Recovery = 70 PID = 5.3ppm Petro Flag = 32.4ppm	
34	S6							%Recovery = 90 PID = 4.8ppm Petro Flag = 28ppm	
6	S7							%Recovery = 90 PID = 5.8ppm Petro Flag = 11ppm	
32	S8							%Recovery = 90 PID = 4.8ppm Petro Flag = 20.4ppm	
8	S9							%Recovery = 90 PID = 5.8ppm Petro Flag = 12.1ppm	
								%Recovery = 100 PID = 4.3ppm Petro Flag = 0ppm	

ENVIRO-EXPLORATION LOG 08-033_37E B326_565 CP CARROLL.GPJ USACE SKOREA.GDT 10/22/10

3663

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B04-200**

Far East District

PROJECT: **Site Assessment of HM/POL Site**

LOCATION: **Camp Carroll** G&E NO.: **03-079E** INSPECTOR: [redacted] 66 66

DATE STARTED: **21 May 04** FINISHED: **21 May 04** DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **Hollow Stem Auger w/CME-75**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **18 cm** TOTAL DEPTH: **8.4 m**

OVERBURDEN THICKNESS: _____ DEPTH DRILLED: **8.4 m** WATER DEPTH: **No water; AD**

COORDINATES: N: **3,983,545.3** E: **447,254.4** GROUND ELEV.: **39.00 m** DATUM: **MSL**

GROUND COVER: **Concrete Paved Area** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☒ Auger Hole ☐ other _____

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0									
						SC	CLAYEY SAND: reddish brown; moist; low to medium plasticity; soft to medium stiff; no fuel odor.		
39 — 1	S1			2 4 5 6	9			%Recovery = 83 Petro Flag = 117ppm	
						SM	SILTY SAND: brown to light brown; moist; loose to medium dense; heavy fuel odor 1.8 to 8.4 m.		
37 — 2	S2			3 4 6 8	10		...1.8~2.4m bgs: Moderate to Heavy fuel odor.	%Recovery = 100 Petro Flag = 413ppm	
36 — 3	S3			4 6 8 9	14			%Recovery = 90 Petro Flag = 387ppm	
35 — 4	S4			5 8 10 13	18			%Recovery = 92 Petro Flag = 197ppm	
34 — 5	S5			6 9 13 17	22		...3.0~3.4m bgs. Heavy fuel odor.	%Recovery = 100 Petro Flag = 704ppm	
33 — 6	S6			10 23 36 53	59			%Recovery = 100 Petro Flag = 1100ppm	
32 — 7	S7			13 18 23 27	41			%Recovery = 100 Petro Flag = 2161ppm	
31 — 8									

ENVIRO-EXPLORATION LOG 03-079E_FEED_4SITES1.GPJ USACE.SKOREA.GDT 28/10/04

3664

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B04-201**

Far East District

PROJECT: **Site Assessment of HM/POL Site**

LOCATION: **Camp Carroll** G&E NO.: **03-079E** INSPECTOR: [redacted]

DATE STARTED: **20 May 04** FINISHED: **20 May 04** DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **Hollow Stem Auger w/CME-75**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **18 cm** TOTAL DEPTH: **8.4 m**

OVERBURDEN THICKNESS: _____ DEPTH DRILLED: **8.4 m** WATER DEPTH: **No water; AD**

COORDINATES: N: **3,983,537.3** E: **447,256.4** GROUND ELEV.: **39.05 m** DATUM: **MSL**

GROUND COVER: **Concrete Paved Area** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☒ Auger Hole ☐ other _____

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
39–0									
						SC	...0~0.6m bgs: Fill material, Angular rock fragment with silty sand.		
							CLAYEY SAND: reddish brown; moist; medium plasticity; soft to medium stiff; heavy fuel odor 0.6 to 1.8 m; ...Heavy fuel odor with unidentified chemical odor.		
	S1			2 4 4 6	8			%Recovery = 92 Petro Flag = 7842ppm	
38–1									
	S2			3 4 5 8	9	SM	SILTY SAND: light brown to brown; moist; loose to dense; heavy fuel odor 1.8 to 8.4 m.	%Recovery = 100 Petro Flag = 4456ppm	
37–2									
	S3			4 6 8 9	14		...1.8~8.4m bgs: Heavy fuel and chemical odor noted from entire sample depth.	%Recovery = 100 Petro Flag = 293ppm	
36–3									
	S4			4 5 7 10	12			%Recovery = 100 Petro Flag = 333ppm	
35–4									
	S5			4 7 9 15	16			%Recovery = 92 Petro Flag = 544ppm	
34–5									
	S6			7 9 12 16	21			%Recovery = 97 Petro Flag = 3722ppm	
33–6									
	S7			8 13 17 23	30			%Recovery = 97 Petro Flag = 7015ppm	
32–7									
31–8									

3665

ENVIRO-EXPLORATION LOG 03-079E FIELD_4SITES1.GPJ USACE SKOREA.GDT 28/10/04

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B04-202**

Far East District

PROJECT: **Site Assessment of HM/POL Site**

LOCATION: **Camp Carroll** G&E NO.: **03-079E** INSPECTOR: [redacted] b6

DATE STARTED: **20 May 04** FINISHED: **20 May 04** DRILLER: [redacted] b6

DRILLING METHOD/EQUIPMENT: **Hollow Stem Auger w/CME-75**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **18 cm** TOTAL DEPTH: **8.4 m**

OVERBURDEN THICKNESS: _____ DEPTH DRILLED: **8.4 m** WATER DEPTH: **No water; AD**

COORDINATES: N: **3,983,531.3** E: **447,250.4** GROUND ELEV.: **38.97 m** DATUM: **MSL**

GROUND COVER: **Concrete Paved Area** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☒ Auger Hole ☐ other _____

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0						SC	CLAYEY SAND: brown; moist; medium plasticity; soft to medium stiff; slight chemical odor 0.6 to 0.8 m.		
38 — 1	S1			1 3 3 5	6	SM	SILTY SAND: light brown to brown; moist; loose to dense; heavy fuel odor 0.8 to 8.4 m.	%Recovery = 100 Petro Flag = 148ppm	
37 — 2	S2			3 7 7 10	14		...1.2~3.0m bgs: Moderate fuel odor with chemical odor.	%Recovery = 75 Petro Flag = 203ppm	
36 — 3	S3			4 7 8 8	15			%Recovery = 97 Petro Flag = 691ppm	
35 — 4	S4			5 8 11 5	19			%Recovery = 100 Petro Flag = 520ppm	
34 — 5	S5			9 13 18 23	31			%Recovery = 85 Petro Flag = 390ppm	
33 — 6							...3.0~8.4m bgs: Strong fuel and chemical odor.		
	S6			12 19 22 30	41			%Recovery = 87 Petro Flag = 1131ppm	
32 — 7									
	S7			15 22 27 33	49			%Recovery = 100 Petro Flag = 6625ppm	
31 — 8									

3666

ENVIRO-EXPLORATION LOG 03-079E_FIELD_4SITES1.GPJ USACE SKOREA.GDT 28/10/04

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B04-203**

Far East District

PROJECT: **Site Assessment of HM/POL Site**

LOCATION: **Camp Carroll** | G&E NO.: **03-079E** | INSPECTOR: [redacted] 66 06

DATE STARTED: **19 May 04** | FINISHED: **19 May 04** | DRILLER: [redacted]

DRILLING METHOD/EQUIPMENT: **Hollow Stem Auger w/CME-75**

DRILLING AGENCY: **Far East District** | HOLE DIAMETER: **18 cm** | TOTAL DEPTH: **8.4 m**

OVERBURDEN THICKNESS: | DEPTH DRILLED: **8.4 m** | WATER DEPTH: **No water; AD**

COORDINATES: N: **3,983,522.8** E: **447,253.4** | GROUND ELEV.: **39.05 m** | DATUM: **MSL**

GROUND COVER: **Concrete Paved Area** | CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☒ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
39 — 0						SC	CLAYEY SAND: reddish brown; moist; medium plasticity; soft to medium stiff; heavy fuel odor 0.6 to 2.4 m.		
	S1			3 4 4 6	8			%Recovery = 75 Petro Flag = 252ppm	
38 — 1									
	S2			3 4 8 10	12			%Recovery = 100 Petro Flag = 542ppm	
37 — 2						SM	SILTY SAND: light brown to greenish gray; moist; loose to dense; heavy fuel odor 3.0 to 8.4 m.		
	S3			5 6 7 9	13			%Recovery = 92 Petro Flag = 824ppm	
36 — 3									
	S4			8 11 17 18	28			%Recovery = 87 Petro Flag = 645ppm	
35 — 4									
	S5			10 12 11 12	23		...3.0–8.4m bgs: Heavy fuel odor mixed with unknown chemical odor.	%Recovery = 100 Petro Flag = 2586ppm	
34 — 5									
	S6			12 19 18 22	37			%Recovery = 87 Petro Flag = 6026ppm	
33 — 6									
	S7			11 18 22 22	40			%Recovery = 87 Petro Flag = 10859ppm	
32 — 7									
31 — 8									

3667

ENVIRO-EXPLORATION LOG 03-079E_FIELD_4SITES1.GPJ USACE SKOREA.GDT 28/10/04

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B04-204**

Far East District

PROJECT: **Site Assessment of HM/POL Site**

LOCATION: **Camp Carroll** G&E NO.: **03-079E** INSPECTOR: [redacted] b6 b6

DATE STARTED: **20 May 04** FINISHED: **20 May 04** DRILLER:

DRILLING METHOD/EQUIPMENT: **Hollow Stem Auger w/CME-75**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **18 cm** TOTAL DEPTH: **8.4 m**

OVERBURDEN THICKNESS: DEPTH DRILLED: **8.4 m** WATER DEPTH: **No water; AD**

COORDINATES: N: **3,983,515.9** E: **447,247.5** GROUND ELEV.: **38.94 m** DATUM: **MSL**

GROUND COVER: **Concrete Paved Area** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☒ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0						SC	CLAYEY SAND: brown; moist; low plasticity; soft; very weak chemical odor 0.6 to 1.8 m		
38 – 1	S1			2 2 4 4	6			%Recovery = 100 Petro Flag = 196ppm	
						SM	SILTY SAND: light brown to brown; moist; loose to very dense; heavy fuel odor 1.2 to 8.4 m.		
37 – 2	S2			3 4 5 8	9			%Recovery = 100 Petro Flag = 138ppm	
36 – 3	S3			5 6 10 11	16		...1.2~3.0m bgs: Very Weak to Slight fuel odor with unidentified chemical odor.	%Recovery = 87 Petro Flag = 4383ppm	
35 – 4	S4			11 17 23 32	40			%Recovery = 75 Petro Flag = 6063ppm	
34 – 5	S5			10 15 18 27	33			%Recovery = 92 Petro Flag = 6189ppm	
33 – 6							...3.0~8.4m bgs: Heavy fuel and chemical odor.		
32 – 7	C6			14 27 33 42	60			%Recovery = 100 Petro Flag = 7470ppm	
31 – 8	S7			21 39 50	89			%Recovery = 42 Petro Flag = 9732ppm	

3665

ENVIRO-EXPLORATION LOG 03-079E_FIELD_4SITES1.GPJ USACE SKOREA.GDT 28/10/04

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B04-205**

Far East District

PROJECT: **Site Assessment of HM/POL Site**

LOCATION: **Camp Carroll** G&E NO.: **03-079E** INSPECTOR: [redacted] 66

DATE STARTED: **18 May 04** FINISHED: **19 May 04** DRILLER: [redacted] 66

DRILLING METHOD/EQUIPMENT: **Hollow Stem Auger w/CME-75**

DRILLING AGENCY: **Far East District** HOLE DIAMETER: **18 cm** TOTAL DEPTH: **8.4 m**

OVERBURDEN THICKNESS: _____ DEPTH DRILLED: **8.4 m** WATER DEPTH: **No water; AD**

COORDINATES: N: **3,983,507.8** E: **447,251.0** GROUND ELEV.: **38.98 m** DATUM: **MSL**

GROUND COVER: **Asphalt Paved Area** CONTAMINATION: **Yes**

TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☒ Auger Hole ☐ other _____

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0	S1			12 18 10	28	SC	...0~0.6m bgs: Fill material, Angular rock fragment with silty sand. CLAYEY SAND: brown to reddish brown; moist; low to medium plasticity; soft to medium stiff; no fuel odor.	%Recovery = 40	
38 — 1	S2			4 4 4 6	8			%Recovery = 72 Petro Flag = 180ppm	
	S3			2 3 5 7	8			%Recovery = 95	
37 — 2	S4			3 4 6 5	10			%Recovery = 100 Petro Flag = 149ppm	
	S5			3 4 9 10	13			%Recovery = 100	
36 — 3	S6			2 5 6 9	11	SM	SILTY SAND: light brown to greenish gray; moist; loose to dense; heavy fuel odor 3.0 to 8.4 m.	%Recovery = 80 Petro Flag = 4590ppm	
	S7			4 6 8 11	14		...3.0~4.8m bgs: Very Weak to Slight fuel odor.	%Recovery = 90	
35 — 4	S8			4 9 10 13	19			%Recovery = 75 Petro Flag = 5670ppm	
34 — 5	S9			8 11 13 15	24			%Recovery = 100	
	S10			8 11 15 10	26		...4.8~6.0m bgs: Slight to Moderate fuel odor.	%Recovery = 100 Petro Flag = 5358ppm	
33 — 6	S11			8 16 18 20	34			%Recovery = 83	
	S12			9 13 21	34			%Recovery = 100 Petro Flag = 6434ppm	
32 — 7	S13			9 20 25 34	45		...6.0~8.4m bgs: Moderate to Heavy fuel odor.	%Recovery = 100	
31 — 8	S14			10 22 28 30	50			%Recovery = 100 Petro Flag = 6826ppm	

3869

ENVIRO-EXPLORATION LOG 03-079E_FIELD_4SITES1.3PJ USACE SKOREA.GDT 28/10/04

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B04-206**

Far East District

66
66

PROJECT: **Site Assessment of HM/POL Site**
LOCATION: **Camp Carroll** G&E NO.: **03-079E** INSPECTOR: [redacted]
DATE STARTED: **19 May 04** FINISHED: **19 May 04** DRILLER: [redacted]
DRILLING METHOD/EQUIPMENT: **Hollow Stem Auger w/CME-75**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **18 cm** TOTAL DEPTH: **8.4 m**
OVERBURDEN THICKNESS: DEPTH DRILLED: **8.4 m** WATER DEPTH: **No water; AD**
COORDINATES: N: **3,983,502.5** E: **447,265.1** GROUND ELEV.: **38.93 m** DATUM: **MSL**
GROUND COVER: **Asphalt Paved Area** CONTAMINATION: **Yes**
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☒ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0						SC	...0~0.6m bgs: Fill material, Angular rock fragment with silty sand.		
							CLAYEY SAND: brown to reddish brown; moist; medium plasticity; soft to medium stiff, very weak fuel odor 0.6 to 1.8 m.		
38 1	S1			2 1 1 1	2			%Recovery = 17 Petro Flag = 726ppm	
37 2	S2			2 4 4 6	8	SM	SILTY SAND: light brown to brown; moist; loose to dense; heavy fuel odor 1.8 to 8.4 m.	%Recovery = 100 Petro Flag = 817ppm	
36 3	S3			2 5 6 8	11		...2.4~3.6m bgs: Very Weak to Slight fuel odor.	%Recovery = 100 Petro Flag = 5610ppm	
35 4									
	S4			2 4 5 6	9		...3.6~4.8m bgs: Moderate to Heavy fuel odor.	%Recovery = 100 Petro Flag = 9376ppm	
34 5									
	S5			3 5 7 9	12			%Recovery = 100 Petro Flag = 7957ppm	
33 6									
	S6			5 6 9 12	15		...4.8~8.4m bgs: Heavy fuel odor.	%Recovery = 100 Petro Flag = 11145ppm	
32 7									
	S7			9 13 22 26	35			%Recovery = 100 Petro Flag = 8954ppm	
31 8									

3670

ENVIRO-EXPLORATION LOG 03-079E_FIELD_4SITES1.GPJ USACE SKOREA.GDT 28/10/04

US Army Corps Of Engineers

EXPLORATION LOG

HOLE NO. **B04-207**

Far East District

PROJECT: **Site Assessment of HM/POL Site**
LOCATION: **Camp Carroll** G&E NO.: **03-079E** INSPECTOR: [redacted]
DATE STARTED: **21 May 04** FINISHED: **21 May 04** DRILLER: [redacted]
DRILLING METHOD/EQUIPMENT: **Hollow Stem Auger w/CME-75**
DRILLING AGENCY: **Far East District** HOLE DIAMETER: **18 cm** TOTAL DEPTH: **8.4 m**
OVERBURDEN THICKNESS: DEPTH DRILLED: **8.4 m** WATER DEPTH: **No water; AD**
COORDINATES: N: **3,983,500.4** E: **447,278.6** GROUND ELEV.: **38.81 m** DATUM: **MSL**
GROUND COVER: **Asphalt Paved Area** CONTAMINATION: **Yes**
TYPE OF HOLE: ☐ Piezometer ☐ Monitoring Well ☐ Test Pit ☒ Auger Hole ☐ other

ELEVATION / DEPTH (meters)	SAMPLE TYPE / NUMBER	GRAPHIC LOG	CONTAMINATED	BLOW COUNT	SPT N-VALUE	USCS / STRATA	DESCRIPTION OF MATERIALS	FIELD DATA	LAB DATA
0						SC	CLAYEY SAND: reddish brown; moist; low to medium plasticity; very soft to medium stiff; no fuel odor.		
38 – 1	S1			1 1 2 2	3		...0.6~1.2m bgs: Clayey Sand with Gravel.	%Recovery = 50 Petro Flag = 608ppm	
37 – 2	S2			1 3 6 6	9			%Recovery = 100 Petro Flag = 141ppm	
36 – 3	S3			3 4 5 6	9	SM	SILTY SAND: light brown; moist; loose to dense; heavy fuel odor 3.0 to 8.4 m; ...3.0~3.6m bgs: Slight fuel odor.	%Recovery = 100 Petro Flag = 258ppm	
35 – 4	S4			4 7 12 15	19		...4.2~4.8m bgs: Moderate~Heavy fuel odor.	%Recovery = 87 Petro Flag = 3530ppm	
34 – 5	S5			6 8 11 14	19		...5.4~8.4m bgs: Heavy fuel odor.	%Recovery = 97 Petro Flag = 4413ppm	
33 – 6	S6			10 17 19 20	36			%Recovery = 88 Petro Flag = 4625ppm	
32 – 7	S7			13 18 23 27	41			%Recovery = 100 Petro Flag = 7475ppm	
31 – 8									

ENVIRO-EXPLORATION LOG 03-079E_FIELD_4SITES1.GPJ USACE SKOREA.GDT 28/10/04

367

Camp Carroll Building 326 Monitoring Well Log

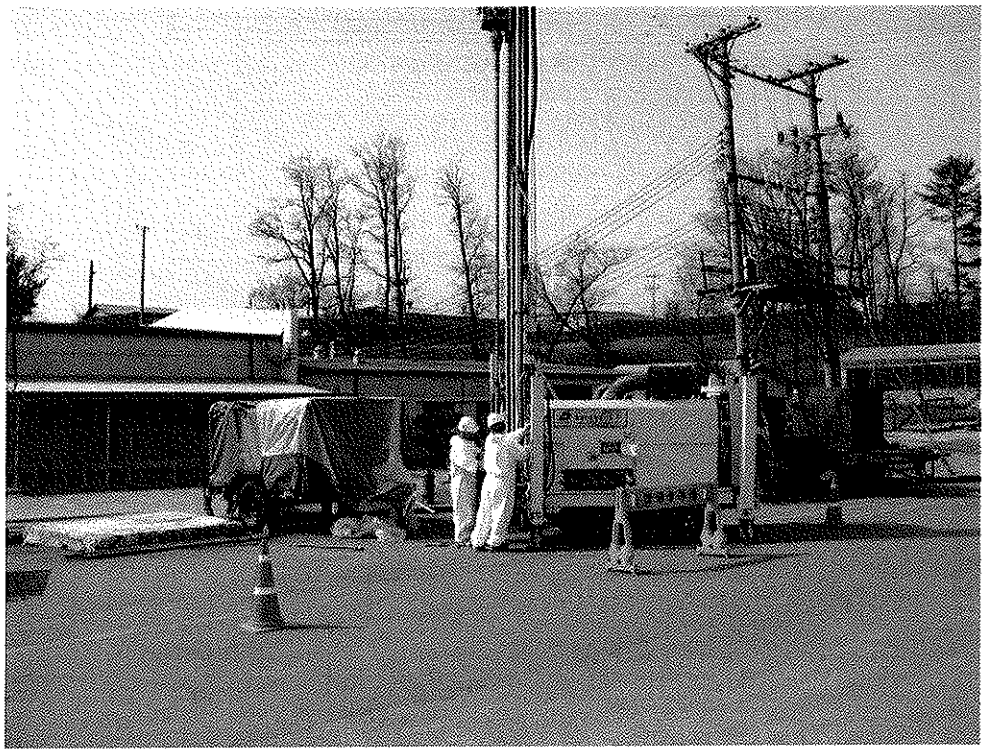
Well ID	B09-203-MW	B09-207-MW	B09-212-MW
Drilling Start	2/28 1310 HRS	2/27 1030 HRS	2/27 1335 HRS
Drilling Complete	2/28 1400 HRS	2/27 1135 HRS	2/27 1435 HRS
Install Date	3/2/2009	3/2/2009	3/2/2009
Drilling Equipment	BEC Direct Push Rig	BEC Direct Push Rig	BEC Direct Push Rig
Driller	Mr. [redacted] b6	Mr. [redacted] b6	Mr. [redacted] b6
Well Diameter	6 inch hammer down to 15 m bgs	6 inch hammer down to 15 m bgs	6 inch hammer down to 15 m bgs
	No casing work	No casing work	No casing work
	2 inch well screen/riser used	2 inch well screen/riser used	2 inch well screen/riser used
Well Depth	15 meter	14.8 meter	15.5 meter
Cement Grout	?? Pack of 40 kg mortar	?? pack of 40 kg mortar	?? Pack of 40 kg mortar
Top	Above groundsurface	Above ground surface	Above groundsurface
Bottom	4.5 m bgs	3.7 m bgs	4.3 m bgs
Bentonite Seal	0.5 m thick / 0.5 bucket of 55 gallon bentonite	0.5 m thick / 0.5 bucket of 55 gallon bentonite	0.6 m thick / 0.5 bucket of 55 gallon bentonite
Top	4.5 m bgs	3.7 m bgs	4.3 m bgs
Bottom	5 m bgs	4.2 m bgs	4.9 m bgs
Sand Filter Pack	10 m thick / 7 Pack of 20 kg sand	10.54 m thick / 9 pack of 20 kg sand	10.6 m thick / 9 Pack of 20 kg sand
Top	5 m bgs	4.2 m bgs	4.9 m bgs
Bottom	15 m bgs	14.74 m bgs	15.5 m bgs
Riser	6.8 m length (~ 22.5 ft)	6.8 m length (~ 22.5 ft)	6.8 m length (~ 22.5 ft)
Top	-0.26 m bgs	-0.52 m bgs	-0.22 m bgs
Bottom	6.6 m bgs	6.34 m bgs	6.6 m bgs
Screen	8.4 m length (~ 27.5 ft)	8.4 m length (~ 27.5 ft)	8.4 m length (~ 27.5 ft)
Top	6.6 m bgs	6.34 m bgs	6.6 m bgs
Bottom	15 m bgs	14.74 m bgs	15 m bgs

Groundwater Depth

3672

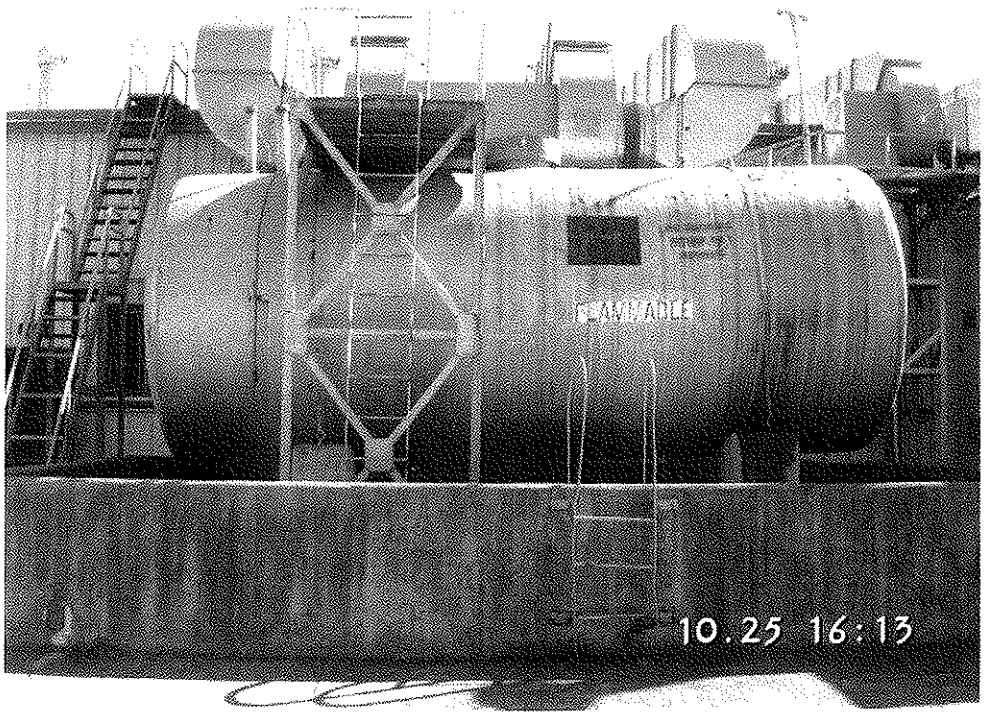
Appendix B

RI/RA Investigation Photographs



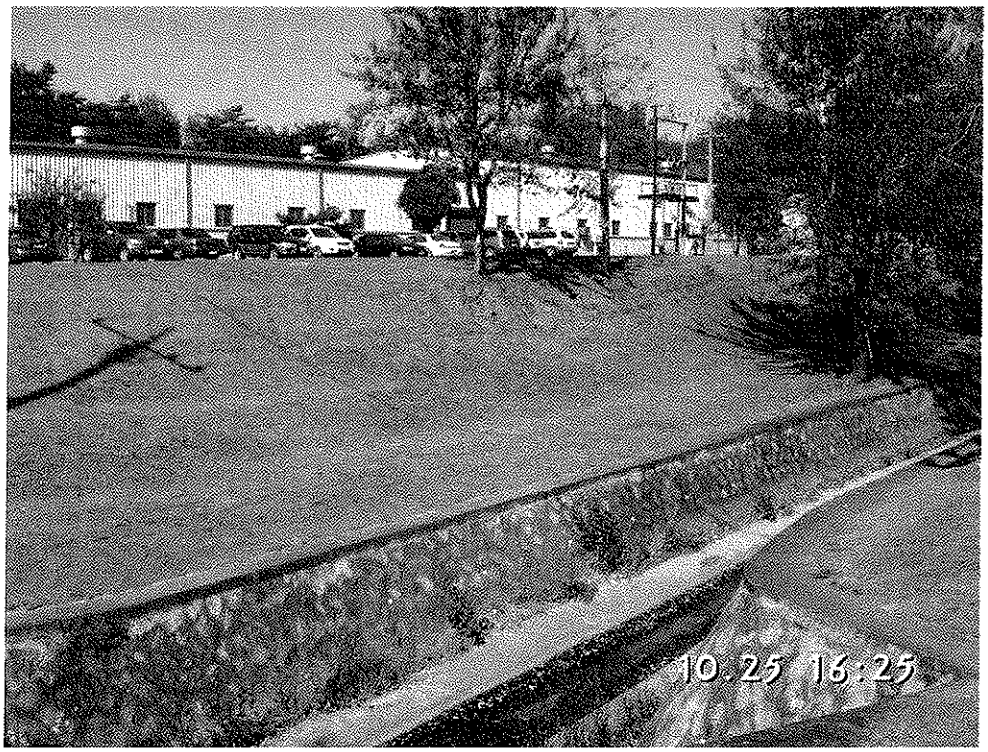
Photograph 1 – Drilling activities in the driveway in front of Building 326

Photograph 2 – Drilling activities in the driveway in front of Building 326



Photograph 3 – 10,000 gallon JP-8 AST adjacent to Building 326

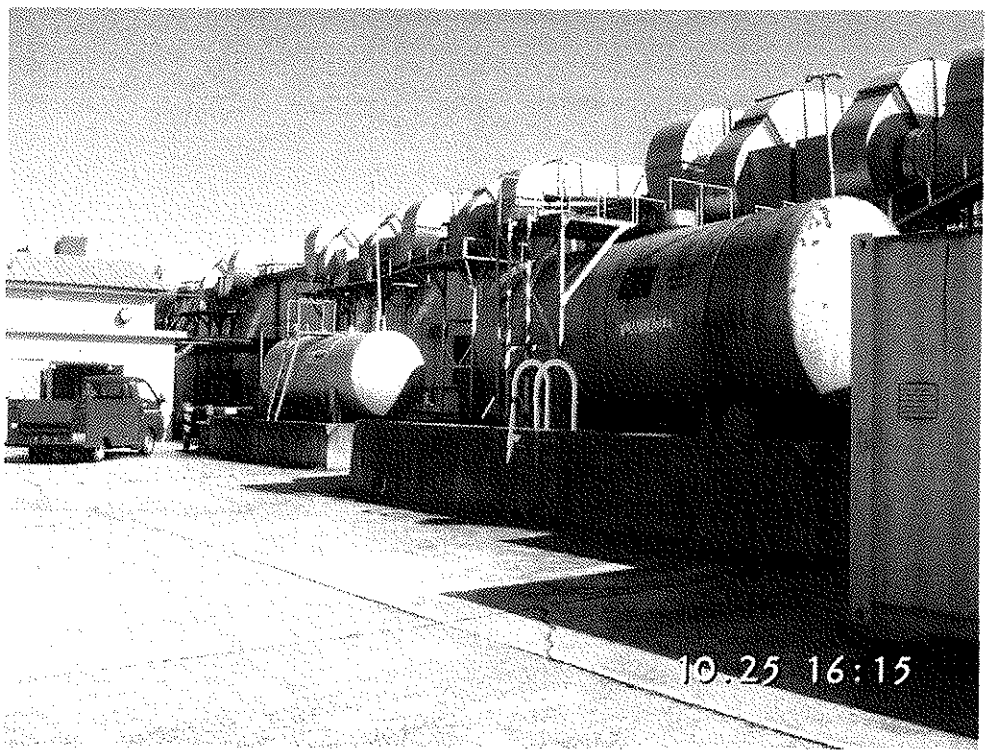
Photograph 4 – Newly installed monitoring well near AST adjacent to Building 326



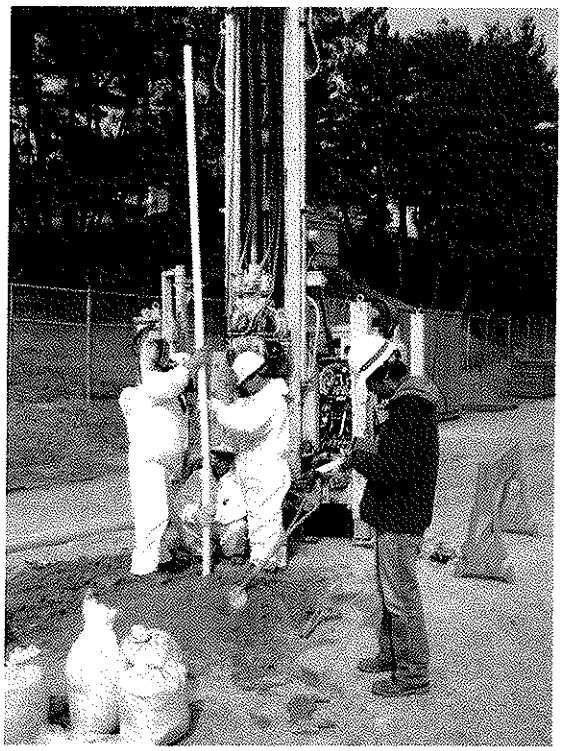
Photograph 5 – Concrete-lined stream running through Camp Carroll, Building 326 in the background

Photograph 6 – Drainage culvert near Building 326 where sheen was observed in storm runoff water

Photograph 7 – Building 326



Photograph 8 – View of west side of Building 326 and the associated ASTs



Photograph 9 – Monitoring well installation at Building 326 Investigation Area

Photograph 10 – Newly installed monitoring well near Building 326

Appendix C

BEC Report – Hydraulic Conductivity (Slug)

US Army Corps of Engineers

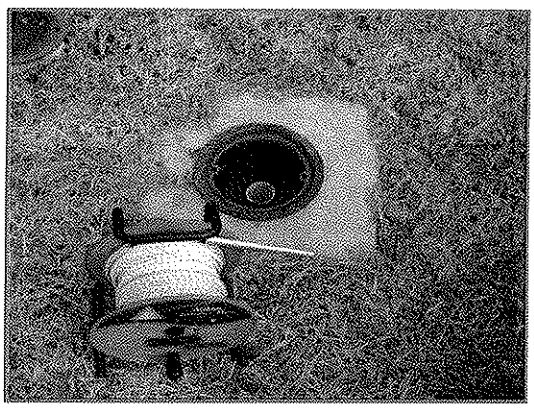
Far East District

Draft Final Report

FOR

TASK ORDER NO.0014
CAMP CARROLL FEASIBILITY STUDY AT Building 326

APRIL 2010



Prepared for:

US Army Corps of Engineers, Far East District
Geotechnical and Environmental Engineering Branch
Unit #15546, APO AP 96205-5546

Contract # W912UM-07-D-0001
Task Order # 0014

Prepared by:

BEC

3680

Table of Contents

Section

3681

1. INTRODUCTION

1.1 Project Background

BEC has prepared this fianl report for the FED under contract NO. W912UM-07-D-0001, Task Order No.0014. This report summarizes the result to analyze for slug, pumping and air permeability test at Camp Carroll.

1.2 Project Progress

Field tests were performed in the camp Carroll during the period of 9 November, 2009 ~ 13 November, 2009(1st) and 22 February, 2010 ~ 25 February, 2010(2^{nd}). The project site is Building 326 at Camp Carroll. Only slug test was conducted at this site.

2. ANALYSIS MATHOD

2.1 Slug test

The slug test method involves the instantaneous injection or withdrawal of a volume or slug of water or solid cylinder of known volume. This is accomplished by displacing a known volume of water from a well and measuring the artificial fluctuation of the groundwater level. The primary advantages of using slug tests to estimate hydraulic conductivities are numerous. First, estimates can be made in-situ, thereby avoiding errors incurred in laboratory testing of disturbed soil samples. Second, tests can be performed quickly at relatively low costs because pumping and observation wells are not required. Lastly, the hydraulic conductivity of small discrete portions of an aquifer can be estimated (e.g., sand layers in a clay)(EPA,1994).

The most commonly used method for determining hydraulic conductivity in groundwater investigation is the Bouwer and Rice slug test shown schematic groundwater level drawdown zone through withdrawal of dummy(Hanmm et al, 2001).

Bouwer and Rice's expression for hydraulic conductivity (K) is:

$$K = \frac{r_c^2 \ln(R_e/R)}{2L_e} \frac{l}{T} \ln \frac{H_t}{H_0}$$

3682

Where:

K = hydraulic conductivity [ft/sec]

R_e = filter pack (borehole) radius [ft]

R = screen radius [ft]

r_c = casing radius [ft]

L_e = length of open screen (or borehole)[ft]

H_0 = drawdown at t = 0

H_t = drawdown at $t \geq H_0$

The simplest interpretation of piezometer recovery is that of Hvorslev(1951). The analysis assumes a homogenous, isotropic medium in which soil and water are incompressible(EPA,1994).

$$K = \frac{r2\ ln(L/R)}{2L\ T_0} \qquad for\ L/R > 8$$

Where:

K = hydraulic conductivity [ft/sec]

r = casing radius [ft]

L = length of open screen (or borehole)[ft]

R = filter pack (borehole) radius [ft]

T_0 = Basic Time Lag [sec]; value of t on semi-logarithmic plot of H-h/H-H0 vs. t, where H-h/H-H = 0.37 0

H = initial water level prior to removal of slug

H_0 = water level at t = 0

h = recorded water level at t > 0

3683

3. ANALYSIS RESULT

3.1 Information of Monitoring Wells

Next is the information is performed wells each area in camp Carroll. The test is performed by in 9 Nov.~12 Nov and chosen one well that test is possible. The depth, natural groundwater level, radius, order of wells was checked before the test. Water level measured for time after injected the dummy using diver. If water level has been stable, withdrew the dummy so water level measured. Sometimes, rise up with diver when the dummy is withdrew that get tangled fixed each line of the dummy and diver in well. Also, water level after injected the dummy rose up more than natural groundwater level. It should pay attention to analysis of test results(Table 2).

Table 2. Information of slug test is performed wells

Site	Well No.	Time	Dummy	Well information			Remark
				D[1] (m)	WR[2] (mm)	NG[3] (m)	
B326	M09-207	1103	injection	14.86	51	10.360	Pet. Oder (8.78~10.36m)
		1133	withdrawal				
	M09-212	1037	injection	15.10	51	8.610	Pet. Oder (8.61~8.63m) / Diver up
		1052	withdrawal				
		1027	withdrawal				

1) well depth, 2) well radius, 3) natural groundwater level(blg)

3.2 Description for the slug test at Site

Generally, groundwater level showed a fluctuation by injection and withdrawal of dummy. Groundwater level data of withdrawal is less than a noise the groundwater level data of injection. Groundwater level had been stable within minutes beyond the stress (dummy). Some data of wells are distinct with other trend of wells. When the slug test analyzed the range of groundwater was assumed in the aquifer

The diagrams are plots of injection and withdrawal that slug test was performed each in the sites. Each plots of injection and withdrawal is the head (H/H0) against the elapsed time. The Plots is drew the fitting line above interval which is consistent on head (H/H0). The analysis for slug test needs the initial drawdown data of water level. Sometimes, the initial drawdown of water level have the noise of data to be different with general trend so the initial drawdown is selected by an analyst is based the hydrogeology. The slop(Δs) to need analysis can obtain from fitting line is drew on drawdown of water level.

3.2.1 B326

The ground outside B326 is covered by concrete. The Slug test conducted B09-207 and B09-212 in the B326 site. B09-203 is not groundwater in the well. The Groundwater level(blg) of

MW(monitoring wells) was checked from 8.61m to 10.36m and the depth of MW is from 14.86m to 15.10m.

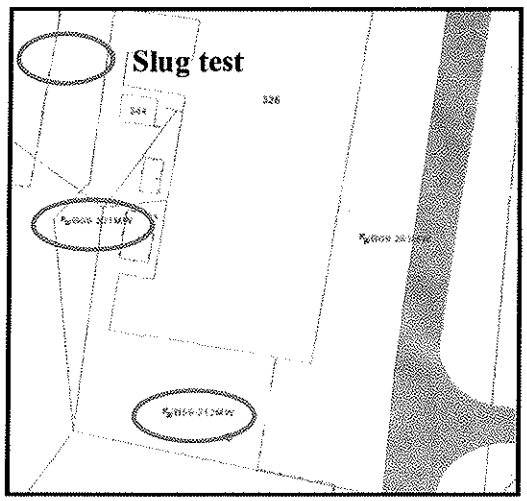


Figure 3 Location of Monitoring well conducted the slug test in the B326.

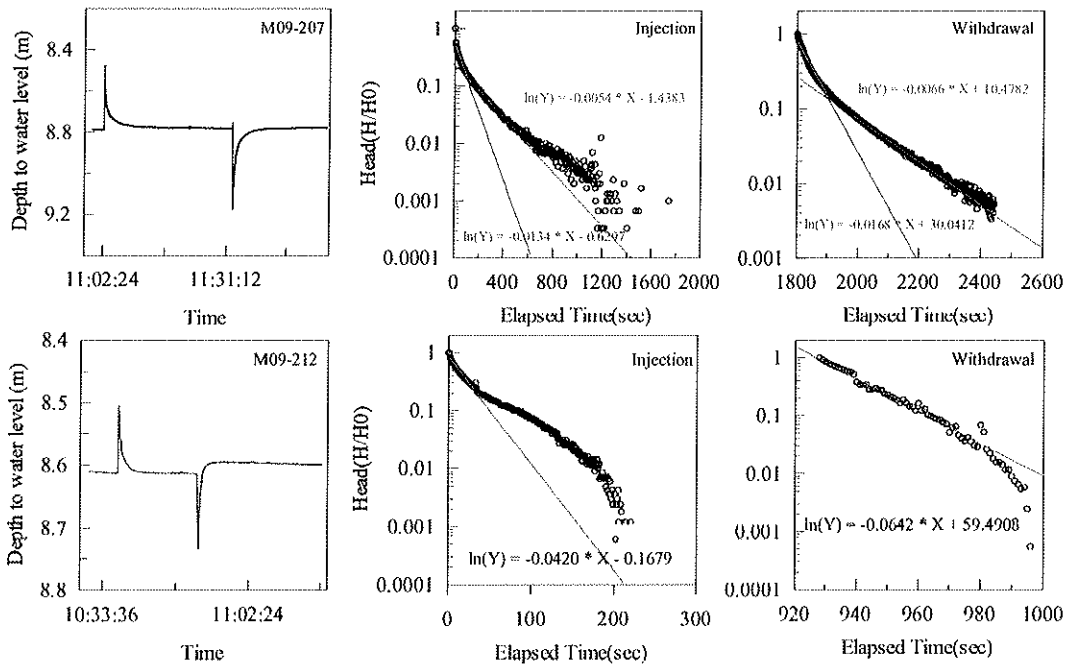


Figure 4 Curve-fitting results against elapsed time at constant slug tests in the B326.

3685

3.3 Result

3.3.1 Slug test

The hydraulic conductivity(K) is calculated by the Hvorslev and the Bouwer & Rice methods.

Calculated results of the injection are greater than the withdrawal. In theory, hydraulic conductivity(K) have to be calculated the same value irrespective of injection and withdrawal of the slug. This is estimated a condition of the test apparatus or to be the skin effect around test wells(Lee et al., 1999, Ham et al.,2001). Also, calculated results using Horvslev method is a little differences with the Bouwer&Rice method. A correlation coefficient is 0.99 calculated results using between Horvslev method and the Bouwer&Rice method and it is nearly consistent.

Table 8 Hydraulic conductivity (K) estimated from the slug tests using the Horvslev and Bouwer & Rice method

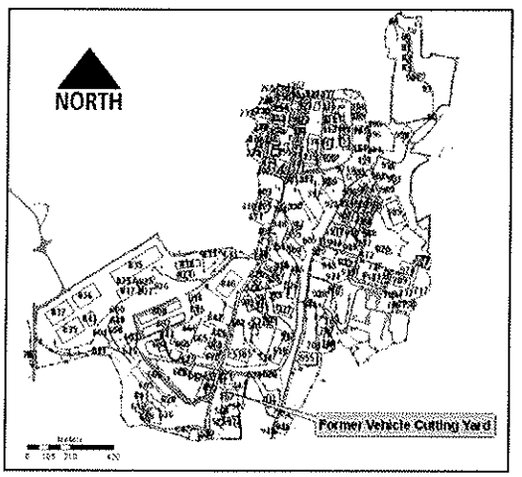
Site	Well	Dummy	K(m/sec) (Horvslev)	K(m/sec) (B& R)	K(m/day) (Horvslev)	K(m/day) (B&R)	Average K (cm/sec) Horvslev	Average K (cm/sec) B&R
B326	B09-207MW	injection	2.7E-06	2.5E-06	0.23221	0.21585	2.99E-04	2.78E-04
		withdrawal	3.3E-06	3.1E-06	0.28408	0.26407		
	B09-212MW	injection	1.6E-05	1.4E-05	1.35379	1.20075	1.98E-03	1.76E-03
		withdrawal	2.4E-05	2.1E-05	2.06682	1.83318		

3656

US Army Corps of Engineers
Far East District

Report for

Environmental Site Investigation at Former Vehicle Cutting Yard (Building 563 and 565) of Camp Carroll, Korea



Submitted to:
Environmental Division of Directorate of Public Works
United States Army Garrison Daegu
Unit # 15746, APO AP 96218-5746

Prepared by:
Environmental Section
Geotechnical and Environmental Engineering Branch
US Army Corps of Engineers District, Far East
Unit #15546, APO AP 96205-5546

AUGUST 2011

3687

Executive Summary

This environmental site investigation (ESI) was conducted at the former vehicle cutting yard (VCY: Buildings 563 and 565) at Camp Carroll within United States Army Garrison Daegu (USAG)-Daegu. Field activities occurred during the period from February 2009 to November 2009. Building 563 is currently being used as a military antenna site and building 565 as an outdoor storage by Directorate of Public Works (DPW) of Camp Carroll. The presence of volatile organic compounds (VOCs) has been identified during the previous environmental investigation conducted by the FED in 2004 and 2005. The investigation was completed to allow the installation meet its obligations under DoD Directive 4715.1E to protect DoD personnel and the public from hazardous environmental substances and provide information to support the evaluation process in DoD Instruction 4718.5 for determining the need for remediation of environmental contamination.

The ESI at the site was conducted to delineate and identify the lateral and vertical extent of soil contamination and the lateral extent of groundwater contamination. Seven borings were completed across the site and 18 soil samples were collected. All soil samples submitted to the analytical laboratory were analyzed for total petroleum hydrocarbon (TPH) (gasoline range organics (GRO), diesel range organics (DRO) and residual range organics (RRO), volatile organic compounds (VOCs), and polynuclear aromatic hydrocarbon (PAH). Two groundwater monitoring wells were installed during this investigation. Groundwater samples were collected from the two new wells and one existing wells. These groundwater samples were analyzed for VOCs.

The overall levels of TPH contamination measured in soils at the VCY site of Camp Carroll range from non-detected (ND) above the practical quantitation limit (PQL) to 129.3 mg/kg. VOCs detected in soil samples (with maximum concentrations) are 1,1-trichloroethylene (11 μg/kg), methylene chloride (180μg/kg), ethylbenzene (31 μg/kg), toluene (140 μg/kg), and xylenes (85 μg/kg).

In groundwater samples, tetrachloroethlyene (9.5 μg/L), chloroform (1 μg/L) and toluene (16 μg/L) were detected in all three water samples. Trichloroethylene (1.1 μg/L) and cis-1,2 dichloroethylene (5.6 μg/L) were detected in two samples. Acetone (2.1 μg/L) was detected in a single sample.

Table of Contents

3689

List of Tables

List of Figures

3690

List of Appendices

I : Soil Borehole Logs
II : Monitoring Well Construction Logs
III : Field Experiment Result- Slug Test

Abbreviations

ASTM: American Society for Testing and Materials
AMSL: Above Mean Sea Level
BEC: Beautiful Environmental Construction (BEC)
Bgs: Below Ground Surface
BTEX: Benzene, Toluene, Ethylbenzene and Xylenes
CD: Compact disk
COPC: Chemicals of Potential Concern
CSM: Conceptual Site Model
DPW: Directorate of Public Works
EHE: environmental hazard evaluation
EM-Engineering Manual
EPA: Environmental Protection Agency
ESA: Environmental Site Assessment
ESI: Environmental Site Investigation
FED: Far East District
HTRW: Hazardous, Toxic, and Radioactive Waste
IDIQ: Indefinite Delivery and Indefinite Quantity
IDW: Investigation-derived wastes
LCS: Laboratory Control Sample
LNAPL: Light Non-Aqueous Phase Liquid
MS: Matrix Spike
ND: Not detected
NELAC: National Environmental Laboratory Accreditation Conference
O/M: Operation and Maintenance
OC-pesticide: organo-chlorinated pesticides
PAH: Poly Aromatic Hydrocarbons
PCB: polychlorinated biphenyl
PCE: Tetrachloroethylene
PID: Photo Ionization
PQL: Practical quantitation limit

PSA: Preliminary Site Assessment
QA: Quality Assurance

QC: Quality Control
ROK: Republic of Korea
SI: Site Investigation
SSHP: Site Safety and Health Plan
SVE: Soil Vapor Extraction
TCE: trichloroethylene
TPH: total petroleum hydrocarbon
TPH-D: diesel range TPH
TPH-G: gasoline range TPH
TPH-O: oil range TPH
USACE: US Army Corps of Engineers
USAG-Daegu: US Army Garrison Daegu
USFK: US Forces Korea
UTM: Universal Transverse Mercator
VOCs: volatile organic compounds
WGS: World Geodetic System
WP: Work Plan

3692

1. Introduction

This report describes the work conducted and findings obtained from the Environmental site investigation (ESI) conducted in the vicinity of Vehicle Cutting Yard (VCY; Buildings 563 and 565) of Camp Carroll.

This ESI project was conducted by US Army Corps of Engineers, Far East District (FED), with support from FED's Environmental Indefinite Delivery/Indefinite Quantity (IDIQ) contractor Beautiful Environmental Construction (BEC). This report was developed in accordance with industry standards and US Environmental Protection Agency (EPA) guidelines for sampling and analysis. All field and analytical work was performed according to the Work Plan (WP) and Site Safety and Health Plan (SSHP) developed by FED.

1.1. Project Authority.

FED has been authorized by the US Army Garrison Daegu (USAG-Daegu) Directorate of Public Works (DPW), US Forces Korea (USFK) to perform work on 23 June 2008 on 20 April 2009 at the former vehicle cutting yard (VCY) through MIPR 8GDBPENV06 and MIPR 9GDATENV05, respectively.

1.2. Project objectives

The overall objective of this ESI was to delineate and identify the current extent and level of contamination. As a result the scope of work for the project included conducting further site assessment to characterize the lateral and vertical extent of soil and groundwater contamination at the site, to determine the concentration levels of chemicals of interest that may affect human health. The chemicals are gasoline, diesel and residual ranges (GRO, DRO and RRO respectively) of total petroleum hydrocarbons (TPH), polynuclear aromatic hydrocarbons (PAHs), and the volatile organic compounds (VOCs) in the site environmental media. The following specific objectives were addressed during this ESI for the VCY of Camp Carroll:

1) Assessment of the presence of the COPCs in the site subsurface environmental media. The site characterization work included the collection of soil and groundwater samples to analyze the concentration s of COPC.
2) Assessment of the presence of volatile organic compounds (VOCs) in subsurface soils and groundwater, and collect soil-gas from the monitoring wells and analyze for VOCs.

1.3 Regulatory Considerations

The release of hazardous substances by DoD activities to the environment has potential implications for health and well-being of DoD personnel (including dependants) on the installation and the public living and working adjacent to the installation. The Department of Defense (DoD) Directive 4715.1E titled "*Environment, Safety, and Occupational Health (ESOH)*" establishes policies for all DOD components world-wide regarding environment, safety, and occupational health (DoD, 2005). DOD 4715.1E states it is DoD policy to protect DoD personnel from accidental death, injury, and occupational illness and to protect the public from risk of death, injury, illness, or property damage because of DoD activities. Consequently,

3693

installations have an obligation to identify potential effects to DoD personnel and the public when a release of hazardous substances is discovered. Once the nature of the contamination is determined DoD Instruction 4715.8 titled "*Environmental Remediation for DoD Activities Overseas*" describes the policy and procedures for remediation of environmental contamination on DoD installations and facilities located outside the US (DoD, 1998). According to this document, remediation of environmental contamination is required when

1. A known imminent and substantial endangerment to human health and safety due to environmental contamination that was caused by DoD operations and that is located on or is emanating from a DoD installation or facility.
2. After consultation with the DoD Environmental Eecutive Agent, the in-thater commander of the DoD Component determines additional remediation of environmental contamination is required to maintain operations or protect human health and safety.
3. International agreements require the United States to fund environmental remediation.

In Korea, DoD Instruction 4715.8 is implemented through US Forces Korea Regulation 200-1 titled "United States Forces Korea Remediation Regulation". Other regulatory guidance for environmental standards in Korea is contained in US Forces Korea Pamphlet 200-1 titled "*Environmental Governing Standards.*"

2. Site Description and History

2.1. Camp Carroll

Camp Carroll is a U.S. Army Installation located adjacent to the village of Waegwan in the south-central portion of Korea (Figure 2-1). Camp Carroll serves as the Headquarters, U.S. Army Material Support Center and functions as a staging ground for U.S. military operations on the Korean Peninsula. The primary mission of the base is to serve as a staging facility and a storage and maintenance depot. Urban areas bound Camp Carroll on the northwest, west and southwest. Hilly, forested areas bound the base on the north and east. Agricultural fields (mostly rice paddies) border the camp on the northeast and the south. The Naktong River flows north-south approximately 0.5 kilometers west of Camp Carroll. The VCY site is located in the southern central portion of the camp, east of Nebraska Avenue and south of New York Avenue. Figure 2-2 presents the VCY site location at Camp Carroll and the area concern for this project.

2.2. Former Vehicle Cutting Yard (VCY; Bldg 563 and 565)

The VCY was built as a general-purpose warehouse in 1965. It was used in support of a Defense Reutilization and Marketing Office (DRMO) metal crushing and cutting operation. The activities were reportedly run by a DRMO contractor who cut and crushed vehicles. The yard on the east side of the building was used either to store vehicles awaiting cutting/crushing, to cut/crush vehicles, or to store materials awaiting final disposition by DRMO. The yard consisted of bare ground (compacted gravel and soil). The building and yard were used for approximately 20 years to support the DRMO activity. The open area of the yard is approximately 2,000 square meters. The Camp Carroll DPW environmental office is concerned that solvents or petroleum products may have leaked directly onto the ground surface during operation of the facility.

2.3. Summary of Previous Investigations

The project site has been previously evaluated for their environmental conditions during the environmental site investigation by FED as follow:

- Environmental Site Assessment (ESA) by FED in December 2004
- Groundwater sampling and analysis by FED in June 2005

In 2004, FED reported the result of ESA around Bldg565 that VOCs are the only chemicals detected by analyses of the site soils. Six petroleum-related compounds and one solvent related compound were detected in site soil samples. One solvent-related compound, tetrachloroethlyene (PCE), was detected in a site soil sample at a concentration greater than the EPA guidance level for protection of ground water.

In a follow-up groundwater study by FED in 2005, four solvent-related compounds and one fuel-related compound were detected in groundwater samples. The solvent-related compound PCE was detected at an up-gradient well location at a concentrate that exceeds the USFK drinking water standards. It is not definitive if PCE is migrating from the subsurface soil at the site to the groundwater because there are other off-site potential source area(s) that might be contributing to PCE-contaminated groundwater at the site. Other compounds which were detected in the groundwater but did not exceed regulated levels included chloroform, 1,1-

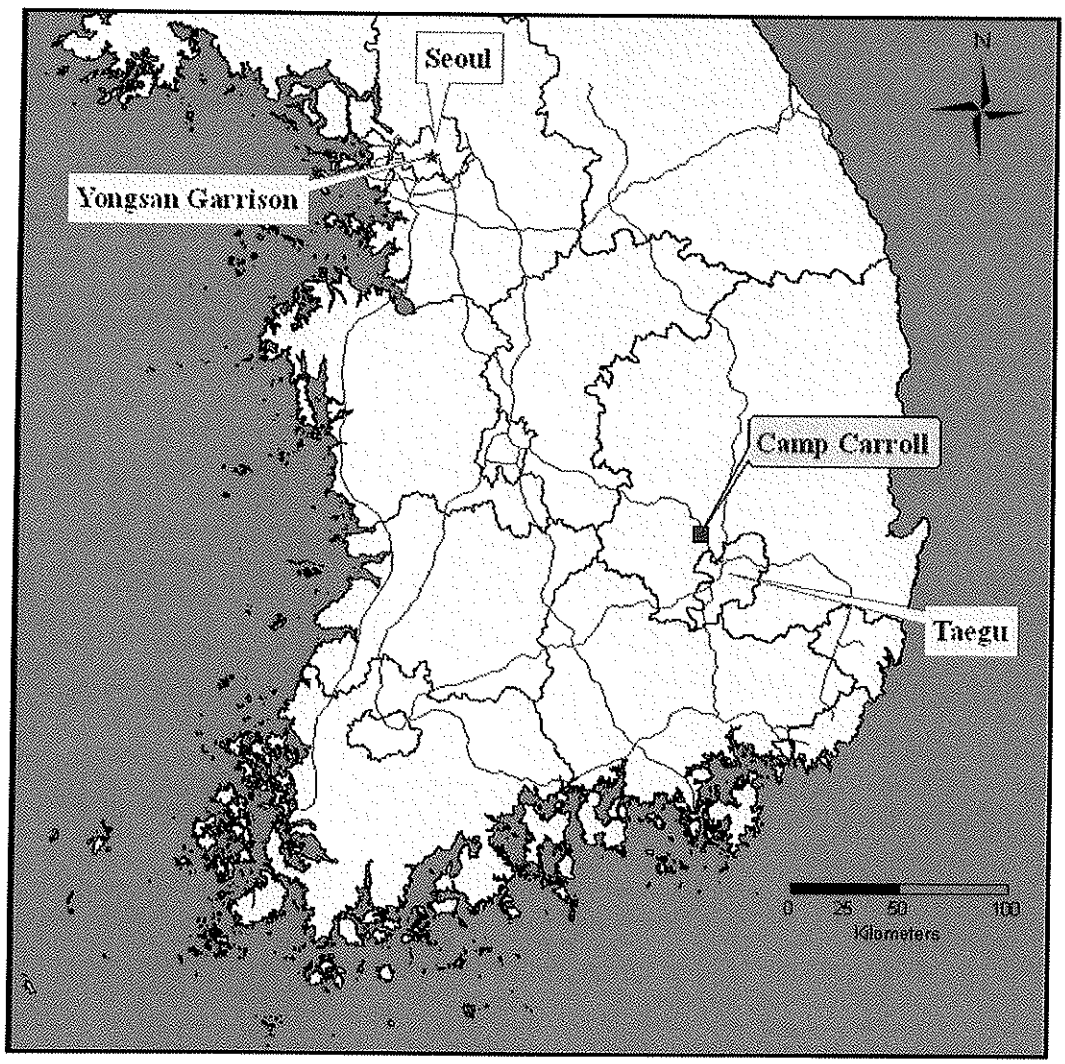
3695

Dichloroethylene (1,1-DCE), and cis-1,2-Dichloroethylene (cis-1,2-DCE). Figure 2-3 summarizes the previous investigation results at the VCY area (Bldg 565 area).

Recommendations from the previous ESAs included the following:

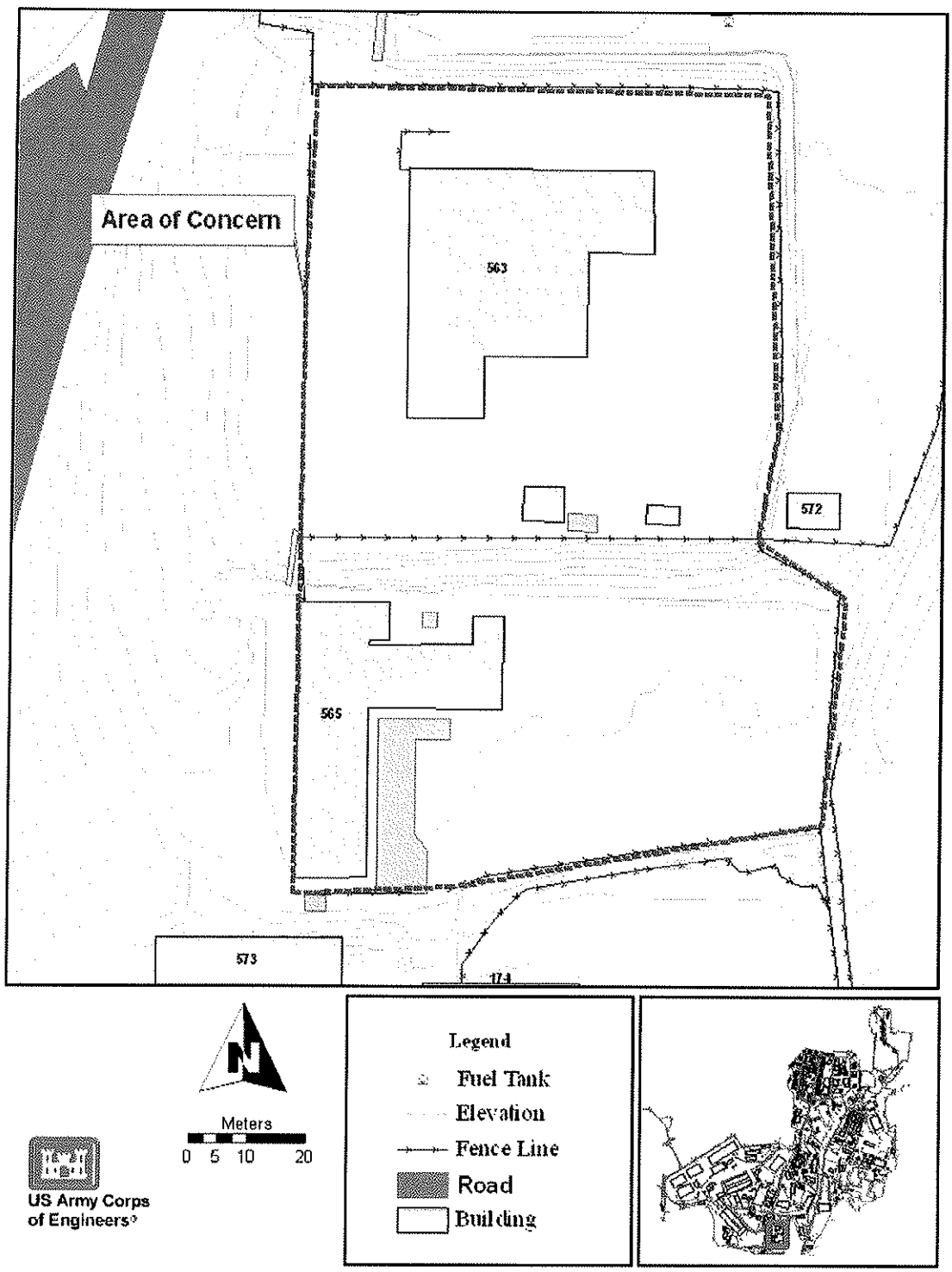
- Construct groundwater monitoring wells in the vicinity of the VCY (Bldg 563 and 565)
- Determine source area of PCE contamination in the northern limit of the site.
- Potential risk of exposure to human health with the PCE contaminated ground-water is likely minimal due to as the fact that no installation drinking water wells exist down gradient of the site. Therefore, ground-water remediation at the site is unnecessary.
- Potential for off-site migration of PCE contaminated groundwater might exist and needs to be evaluated.

Figure 2-1. Location of Camp Carroll in Republic of Korea.



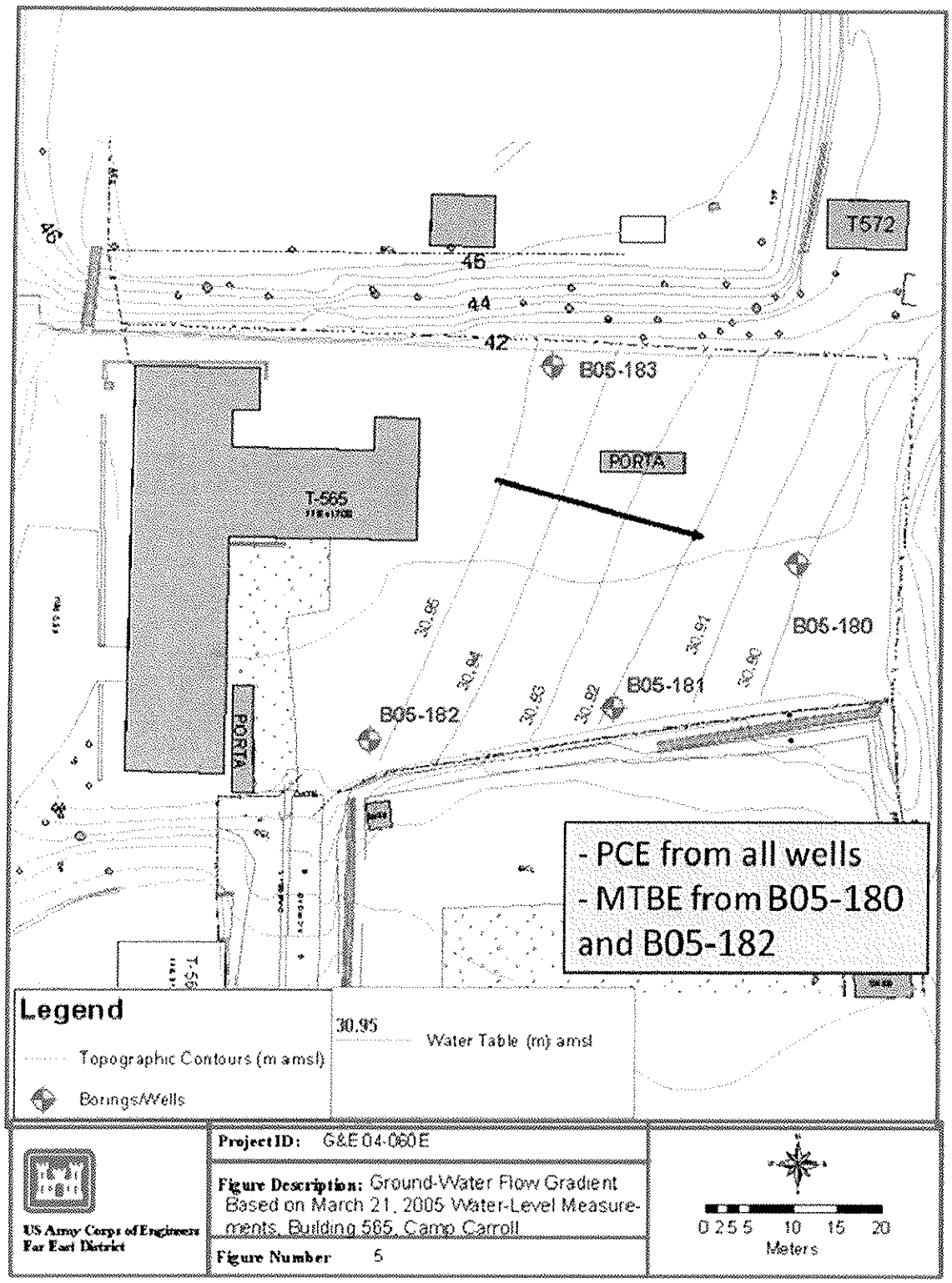
3697

Figure 2-2. Location of the VCY Site at Camp Carroll.



3698

Figure 2-3. Summary of the Previous Investigation Results at the VCY Site.



3699

3. Field Activity

3.1. Field Activities

Field procedures for this ESI followed the description in the project Work Plan. A total of seven soil borings were drilled and of those two boreholes were converted to groundwater monitoring wells. Soil and groundwater sample collection and analyses were conducted in accordance with industry standard practice and in strict accordance with the requirements of the project specific SSHP. The resultant data was used to help determine the spatial extent of contamination and whether significant subsurface contamination with the chemicals of concern at the site is present in soil and groundwater of the project site. The analytical results were used to conduct a human health risk assessment with a comparison to the Environmental Action Levels. The project chronology is summarized in Table 3-1.

3.2. Borehole Drilling and Soil Sampling

Borehole locations were chosen prior to actual field work to provide areal coverage within the area of concern (Figure 2-2). During performance of the field work, some proposed borehole locations were moved and cancelled to avoid underground and aboveground utilities and for drill rig accessibility. Especially the project site is currently occupied by a military signal which receives various information thru antennas. The number of subsurface soil collection intervals was determined by target depth, apparent contamination, depth to groundwater, and depth to bedrock. Soil samples submitted for laboratory analyses were chosen based on field observations and photo ionization detector (PID) reading to determine the level of concentrations of the chemicals of concern.

Borehole drilling for soil samples was conducted using a direct push soil probing machine (GeoProbe). The GeoProbe minimizes cuttings and creates a smaller diameter borehole that is easily grouted/filled after all subsurface soil samples are collected. Using a GeoProbe, continuous soil cores were collected from the surface to the target depth. Subsurface soil sample cores were collected by advancing an open barrel sampler with a plastic sample liner (3.7 cm inner diameter) through the sample interval equivalent to the barrel length or less (normally about 0.9 m). After the barrel sampler was pushed through the desired depth interval, the sampler was extracted from the hole and the plastic liner, containing the soil sample, was removed from the barrel sampler. The discrete soil sample required for chemical analyses (e.g., TPH) was collected from the desired depth by retrieving it from the appropriate interval of the plastic liner. Figure 3-1 presents the soil boring location, and Appendix I presents the soil bore logs.

A portion of each recovered soil sample was placed into a sealable plastic bag and the headspace was analyzed for VOCs with a PID. All soil samples were subsequently placed in zip-lock bags and kept in an ice-cooler for preservation until field screening tests were performed if required except VOCs sample. Soil sample for VOCs analysis was collected using a Terra Core kit with fixed 5-g volume, and immediately put in methanol preservative 40 ml jar. Information on the sample container labels included project number, installation name, analysis required, sample identification number, depth, name of sample collector, and date and time of collection.