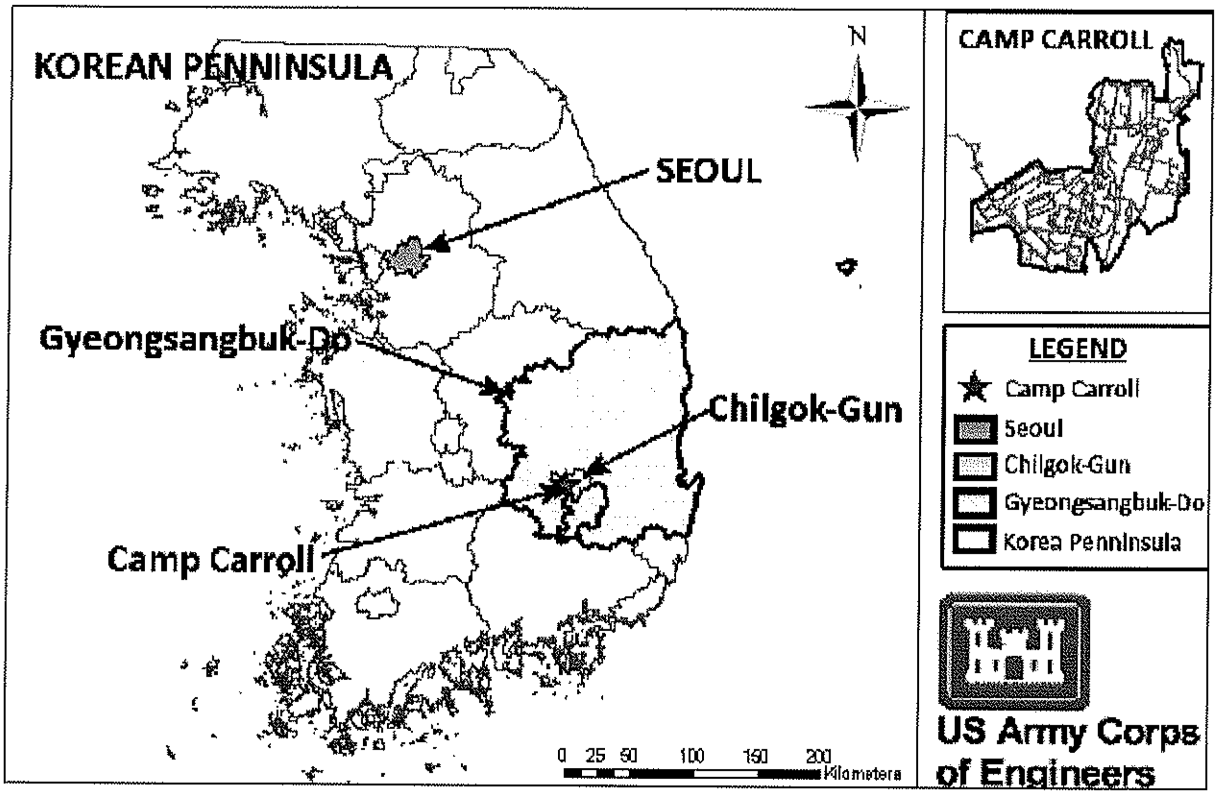
1. INTRODUCTION

This report presents the results of a geophysical survey that was conducted for the Slope site located on Camp Carroll, Republic of Korea (ROK). The purpose of the geophysical survey was to identify and locate foreign objects, especially steel drums that may have been buried in the area. The survey will also delimit the approximate vertical and horizontal coordinates of subsurface anomalies that potentially indicate the presence of foreign objects.

1.1 Site Description and Background

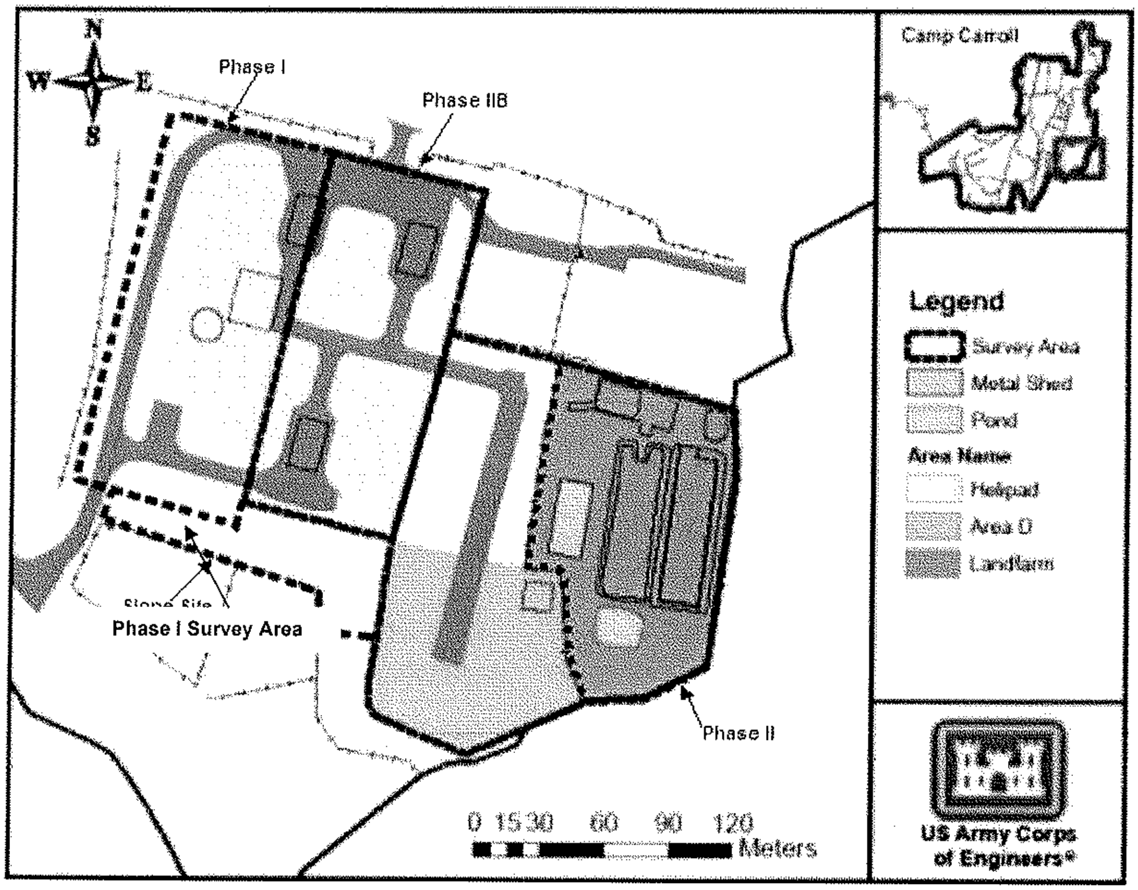
U.S. Army Garrison (USAG) Daegu Camp Carroll (Camp Carroll) is located in Chilgok-Gun, Gyeongsanbuk-Do, adjacent to the village of Waegwan in the south-central portion of the ROK. The general location of the camp is shown on Figure 1-1. Urban areas bound Camp Carroll on the northwest, west and southwest. 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 from north to south approximately 0.5 kilometers west of Camp Carroll.

Figure 1-1. Camp Carroll Location Map



The Slope site is located to the southwest and immediately adjacent to the Helipad, Area D and Landfarm sites at southeastern portion of Camp Carroll (Figure 1-2), where geophysical survey have already been completed during Phase I, II and IIB. The site is unpaved, covered with grass and slopes down about 3 m (10 ft) to the south. The area was recently identified as the location where drums of hazardous material and waste were buried by an eyewitness. The purpose of the survey was to identify and locate buried foreign objects, especially steel drums, should they be present, and delimit the approximate vertical and horizontal coordinates of buried foreign objects.

Figure 1-2. Phase I (Helipad) Site Geophysical Survey Location Map



1.2 Geophysical Survey Methodologies

The geophysical survey for the Phase I area was conducted using three non-intrusive techniques: magnetic gradiometry, ground penetrating radar (GPR), and electrical resistivity imaging (ERI). Three separate techniques were employed for the survey in order to ensure optimum coverage and the ability to identify and locate subsurface anomalies. The following sections provide brief descriptions of each technique, along with some of the strengths and limitations associated with each technique.

1.2.1 Magnetic Gradiometry

Magnetic gradiometry is a more refined technique under the broader category of magnetic geophysical survey. Magnetic surveying in general is a passive method based on the measurement of localized perturbations to the Earth's magnetic field caused by the presence of buried ferrous targets. Magnetic gradiometry determines the vertical gradient of the magnetic field, and are more sensitive to small or weakly magnetic targets than the typical single sensor, total field magnetometer. The limitation with magnetic survey techniques is that they will not identify non-magnetic materials, such as glass, plastics, wood, and non-ferrous metals such as copper and aluminum.

Typically, data is collected in a systematic manner across a field site and then presented as a contoured map in units of nanotesla (nT) or nT per meter (nT/m), which can be interpreted to produce a map of the subsurface. The amplitude and shape of an individual anomaly will reflect the dimensions, orientation and magnetic susceptibility of the buried target.

1.2.2 Ground Penetrating Radar

In GPR surveys, electromagnetic waves of frequencies between 50MHz and 2.5GHz (microwave band of the radio spectrum) are transmitted into the ground. This energy is reflected back to the surface when it encounters significant contrasts in dielectric properties. The amount of energy reflected is dependent on the contrast in electrical properties encountered by the radio waves. A receiver measures the variation in the strength of the reflected signals with time. The resulting profile is called a "scan." Multiple scans generated by traversing the antenna across the ground surface are used to build two-dimensional cross sections (radargrams) of the subsurface.

The advantage of GPR is that it can be used in a variety of media, including rock, soil, ice, fresh water, pavements and structures. Also, because GPR is sensitive to differences in dielectric properties, it can be used to detect non-ferrous objects, changes in material, and voids and cracks. The limitation with GPR is that signal resolution is dependent on the input signal frequency. Higher frequencies provide higher resolution, but higher frequencies provide less penetration depth. Lower frequencies penetrate deeper into the ground but provides less resolution and hence less accuracy. Another potential limitation with GPR is that the difference between dielectric constants of different materials or layers may be too small to classify, and interpretation of data is less straightforward than magnetic techniques.

1.2.3 Electrical Resistivity Imaging

ERI, also called electrical resistivity tomography (ERT) measures ground resistance by introducing an electric current into the subsurface via two grounded electrodes. The current passing through the ground sets up a distribution of electrical potential in the subsurface. The difference in electrical potential is measured using a second set of electrodes. The transmitting and receiving electrode pairs are referred to as dipoles. Using Ohm's law, this voltage can be converted into a resistance reading in units of ohm-meters (ohm-m) for the ground between the two potential electrodes. By varying the unit length of the dipoles as

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well as the distance between them, the horizontal and vertical distribution of electrical properties can be recorded.

To build a vertical cross-sectional image of ground resistance, a string of connected electrodes are deployed along a straight line with an inter-electrode spacing of *a*. Once the resistance measurements have been made, the line is re-surveyed with an inter-electrode spacing of 2*a*, 3*a*, 4*a*, etc. For example, if a = 1 m (the initial spacing between the electrodes is 1 m), the next survey along the same line would be conducted for electrodes spaced at 2 m, followed by a survey with electrodes spaced at 3 m, etc. Each increase in the inter-electrode spacing increases the effective depth of the survey. The vertical cross sections are combined to generate a fence diagram output.

2. GEOPHYSICAL SURVEY PROCEDURE

This section provides a description of the field procedures and instrumentation used in the Phase II area geophysical survey. The Slope site survey area measures approximately 30 m to 50 m from north to south and 140 m east to west. The specifications of the instruments are provided in Appendix A for reference. The results of the survey are presented in Section 3.

2.1 Magnetic Gradiometry Survey

The magnetic gradiometry survey was conducted using a Bartington Instrument Ltd (United Kingdom) model Grad601 gradiometer equipped with a single Grad-01-1000L high stability fluxgate gradient sensor. The data generated was recording using a DL601 Data Logger.

A grid with 1 m intervals was established over the entire survey area. Including endpoints, this resulted in 4,762 intersections points between the north-south and east-west running gridlines as shown on Figure 2-1. Magnetic readings were taken at each of the intersection points.

2.2 GPR Survey

The GPR survey was conducted using a MALÅ GeoScience (Sweden) model ProExTM Professional Explorer GPR. The survey utilized a 2 m interval transects in the east-west direction (36 transects), each transect covering a length of 28 m to 78 m. The GPR survey gridlines are shown on Figure 2-2.

Based on site geology, soil type, subsurface conditions and the anticipated depth of buried materials at 5 m to 6 m below ground surface (bgs), an input frequency of 100 megahertz (MHz) was selected to provide the best resolution.

2.3 ERI Survey

The ERI survey was conducted using an ABEM Instrument AB (Sweden) model Terrameter LS direct current resistivity meter. The survey was conducted along three transects as shown on Figure 2-3.

Figure 2-1. Magnetic Gradiometry Survey Area

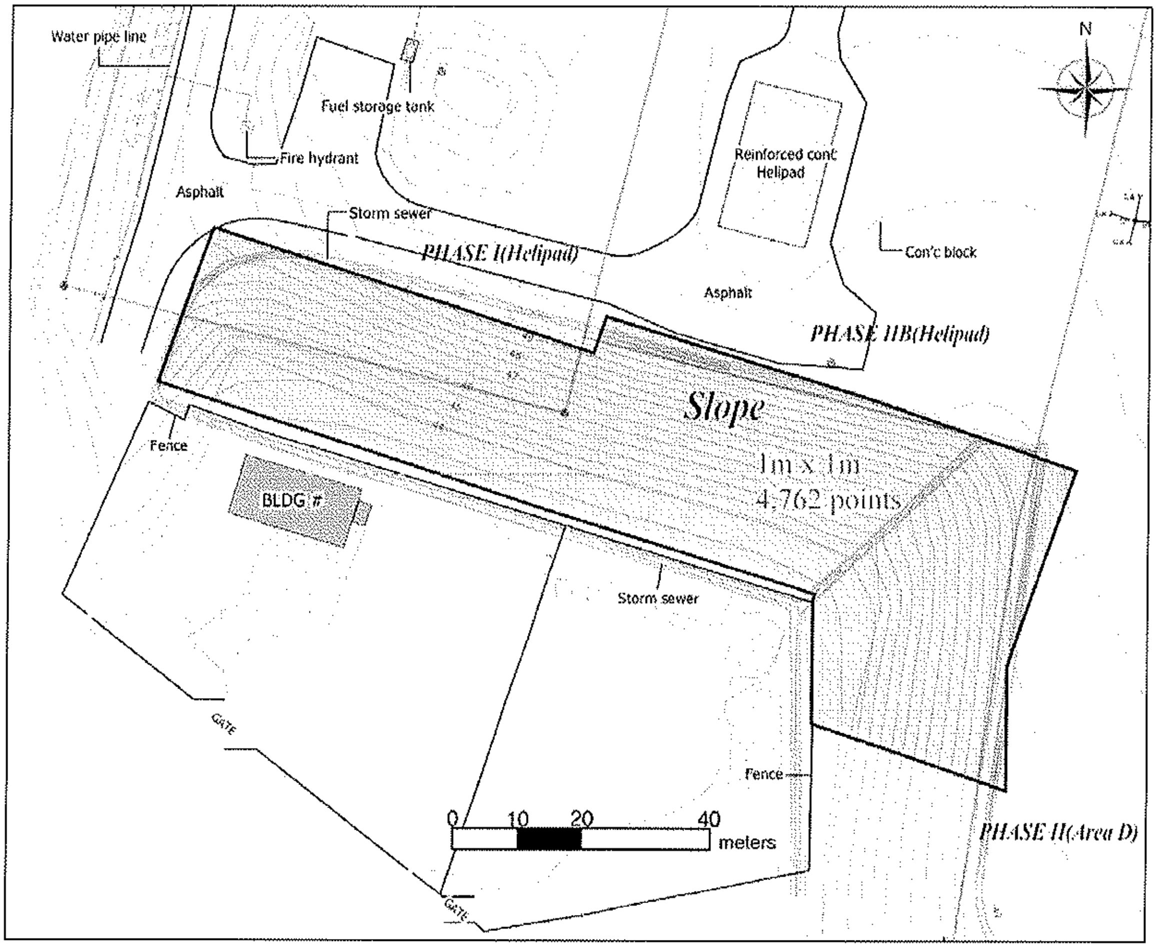


Figure 2-2. GRP (100MHz) Survey Transects

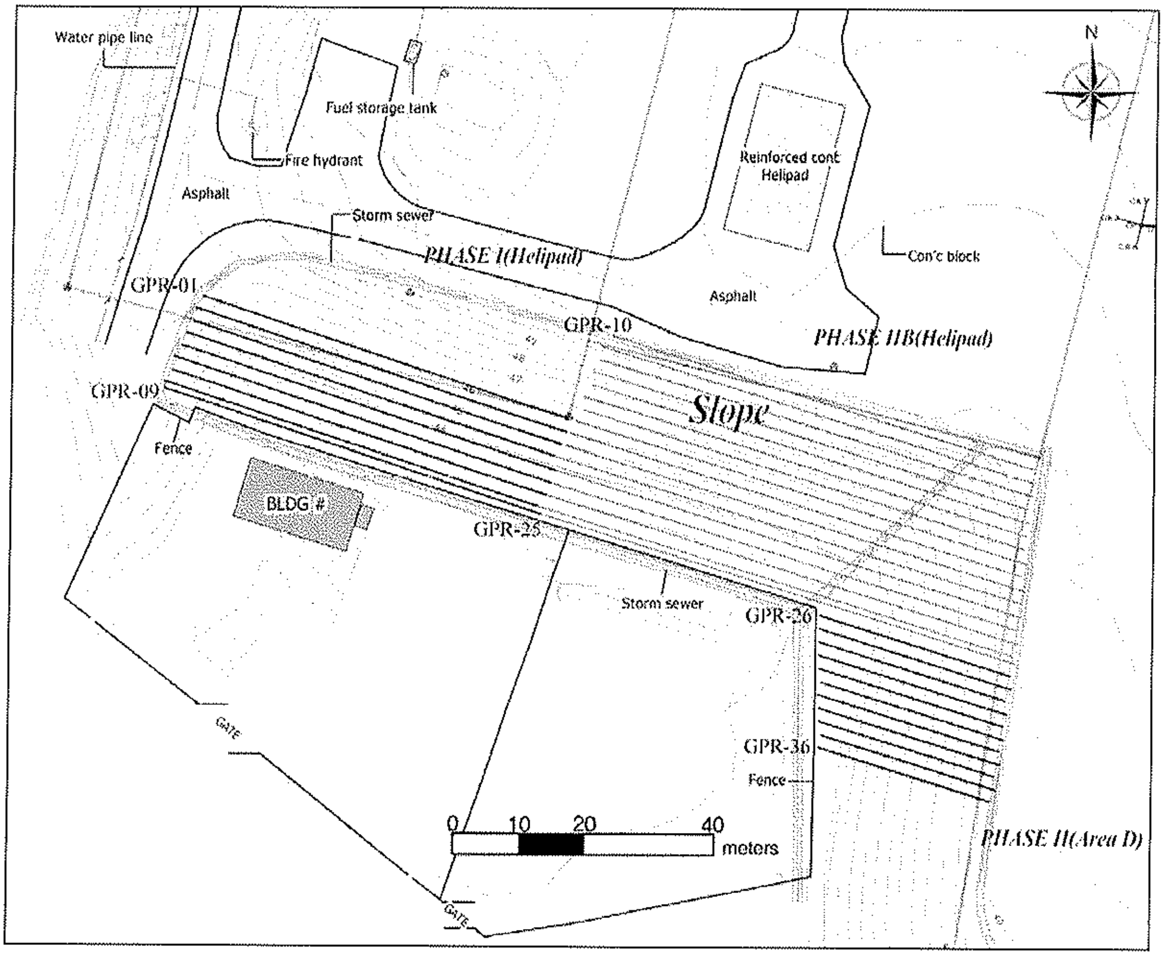
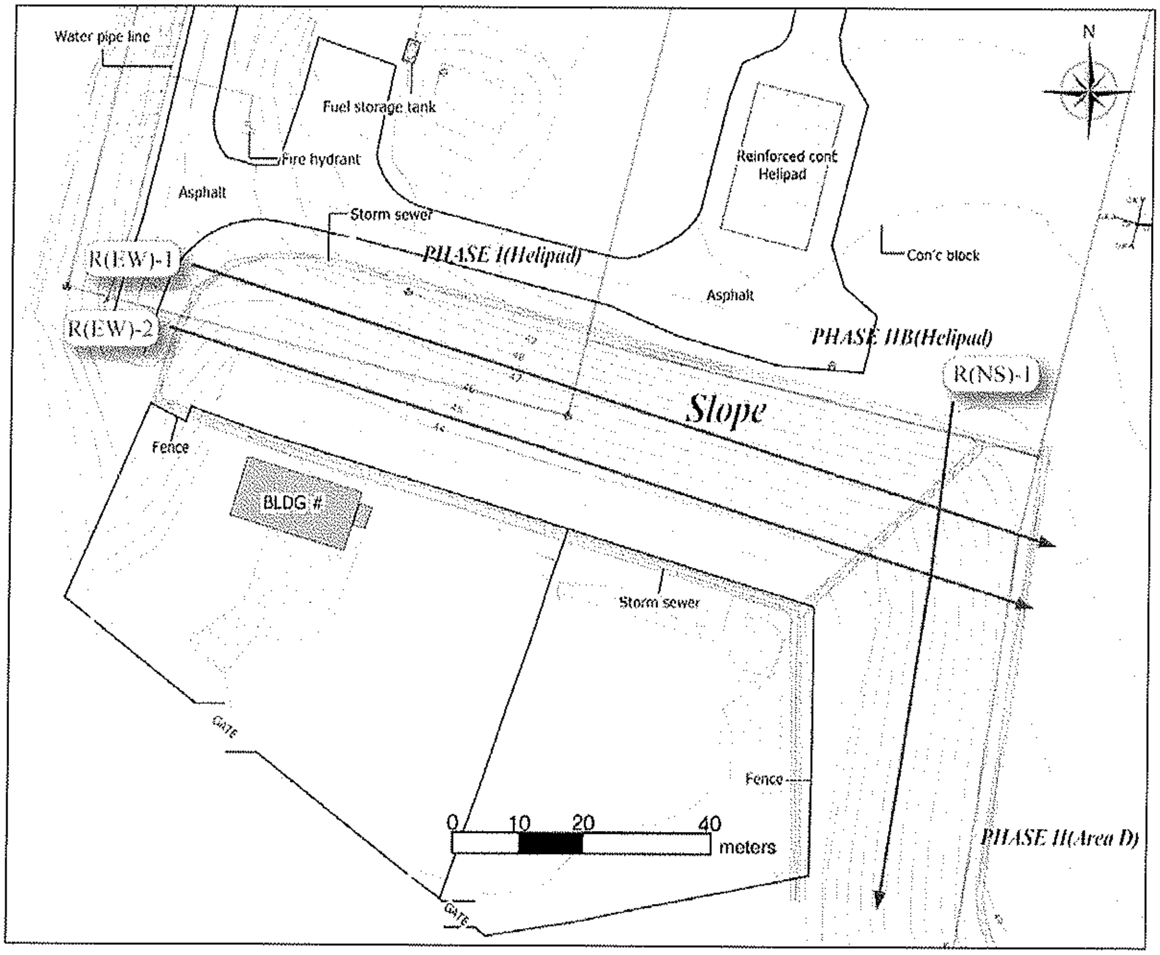


Figure 2-3. ERI Survey Transects



3. GEOPHYSICAL SURVEY RESULTS

This section provides a brief summary of the geophysical survey results and summaries. The 2-dimentional sections from the GPR survey and vertical cross section output from the ERI survey are provided in Appendix B. Photographs documenting field survey activities are provided in Appendix C. Raw data output from the survey instruments will be provided in electronic format. The raw data files are incorporated by reference as part of this report.

3.1 Magnetic Gradiometry Result

The magnetic gradiometry survey result is presented as a single diagram on Figure 3-1. The result is summarized as follows:

- Magnetic field in the area averages in the 400 nT/m to 500 nT/m range.
- The red, blue and green colored areas on Figure 3-1 indicate the possible presence of buried conductive materials.
- The results indicate one anomaly, which is attributed to influenced by a chain link fence and building structures.

3.2 GPR Result

The GPR survey result using a 100 MHz input signal frequency is presented as a series of 2D vertical cross sectional radargrams. The radargrams that indicate subsurface anomalies are shown on Figures 3-2. Complete radargrams are provided in Appendix B. The result is summarized as follows:

- The anomalies indicate the possible presence of foreign objects at a depth of about 4.0 m bgs.
- The 2D radargrams indicate detected six subsurface anomalies. The anomalies indicate relatively small conductive objects and boulders.

3.3 ERI Results

The ERI survey result is presented as a Fence diagram on Figure 3-3. The result is summarized as follows:

- The ground resistivity in the area ranges from about 90 ohm-m to 300 ohm-m.
- Locations with low resistivity anomalies (less than 70 ohm-m) are shown in blue and green.
- Two low resistivity anomalies have been tentatively identified as follows:
    - Anomaly A occurs at approximately 10 m to 12 m bgs
    - Anomaly B occurs at approximately 5 m to 12 m bgs

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Figure 3-1. Magnetic Gradiometry Survey Result

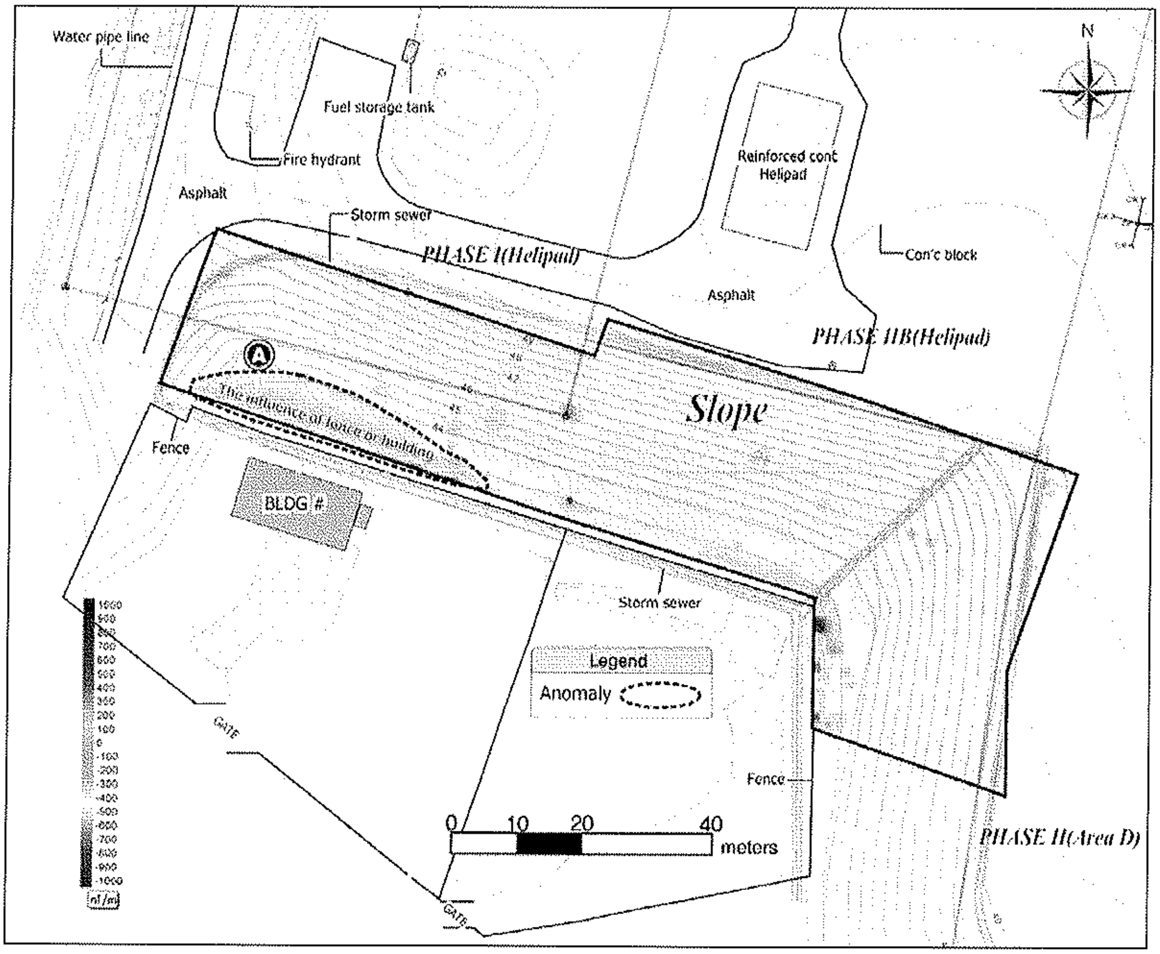

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Figure 3-2. GPR 2D section Results

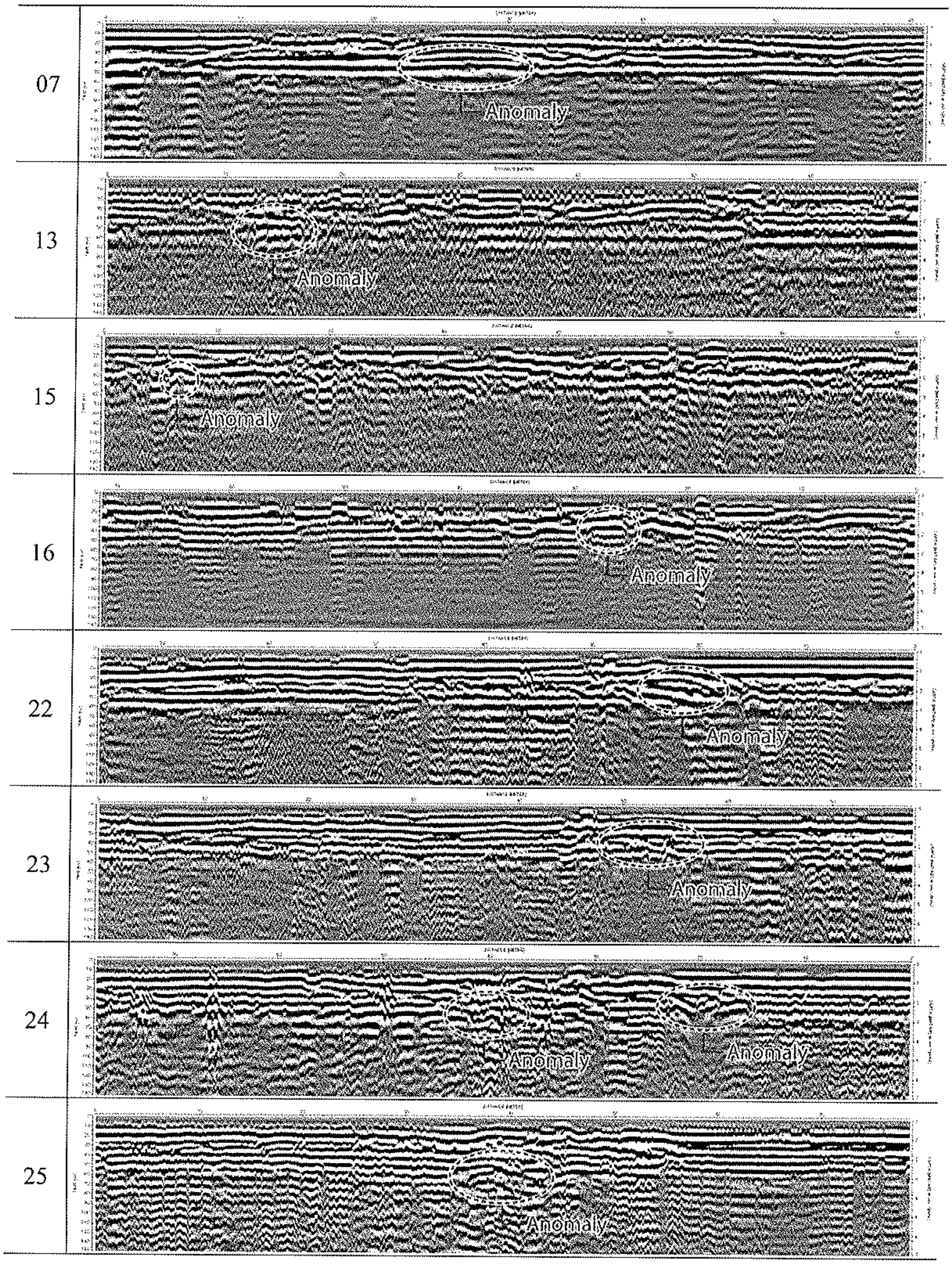
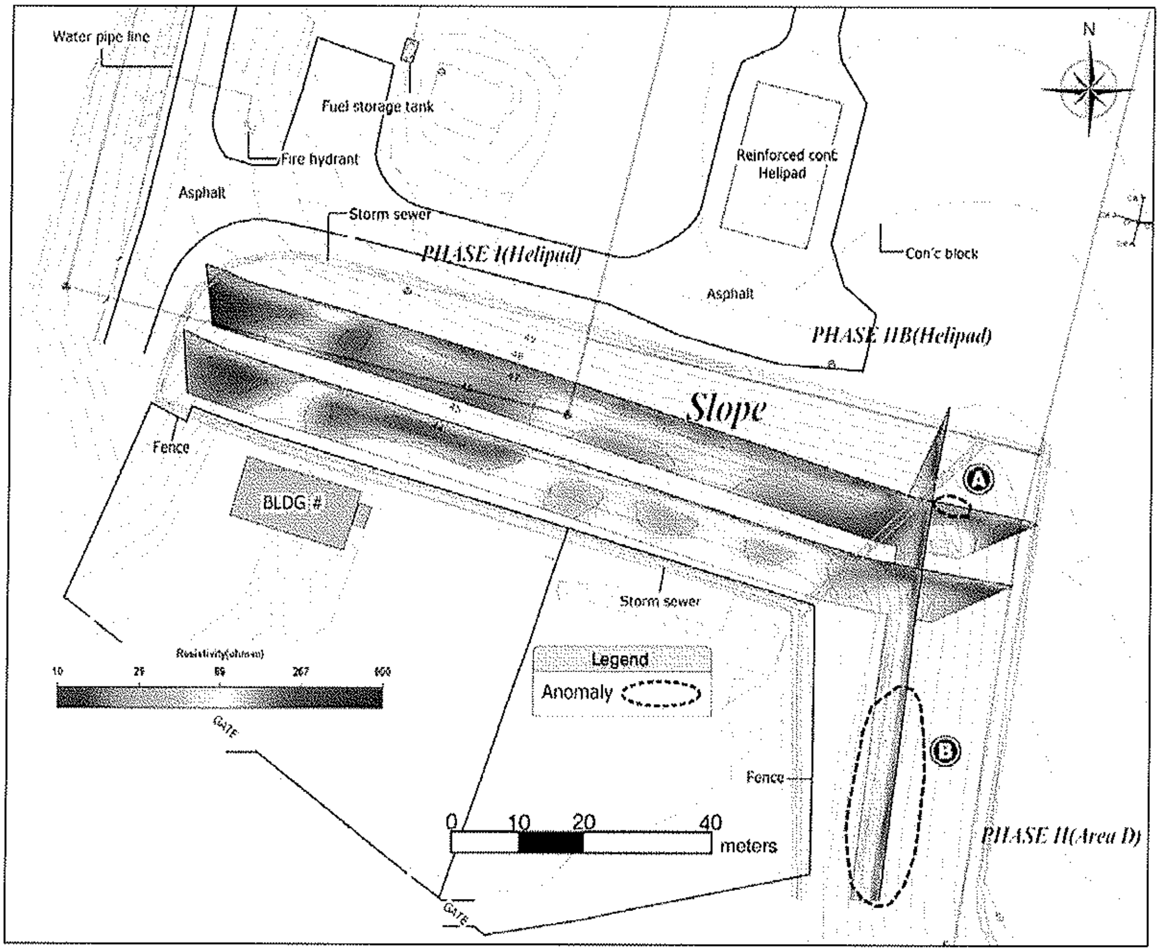


Figure 3-3. ERI Result



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4. CONCLUSIONS

The locations where confirmed subsurface anomalies are indicated by the Magnetic Gradiometry, GPR and ERI surveys are shown on Figures 4-1 through 4-3. A final interpretation of the data and subsurface anomaly zones are shown on Figure 4-4. The conclusions are summarized as follows:

- The Magnetic Gradiometry survey results indicated one subsurface anomaly. The anomaly is attributed to interference from the nearby metal chain link fence and building structure.
- The GPR survey results indicate six subsurface anomalies. The anomalies are attributed to subsurface geologic features such as changes in soil stratum and disturbed soil (soil that has been excavated and backfilled).
- The ERI survey results indicate two subsurface anomalies. The survey results indicate that the anomalies are most likely due to geological structures such as fracture zone in bedrock and ground water level.
- The combined results indicate that the subsurface anomalies that were identified during the geophysical survey can be attributed to existing structures at the site and activities such as excavation and backfilling. The results do not indicate the presence of buried foreign objects such as steel drums.

Figure 4-1. Magnetic Gradiometry Confirmed Subsurface Anomalies

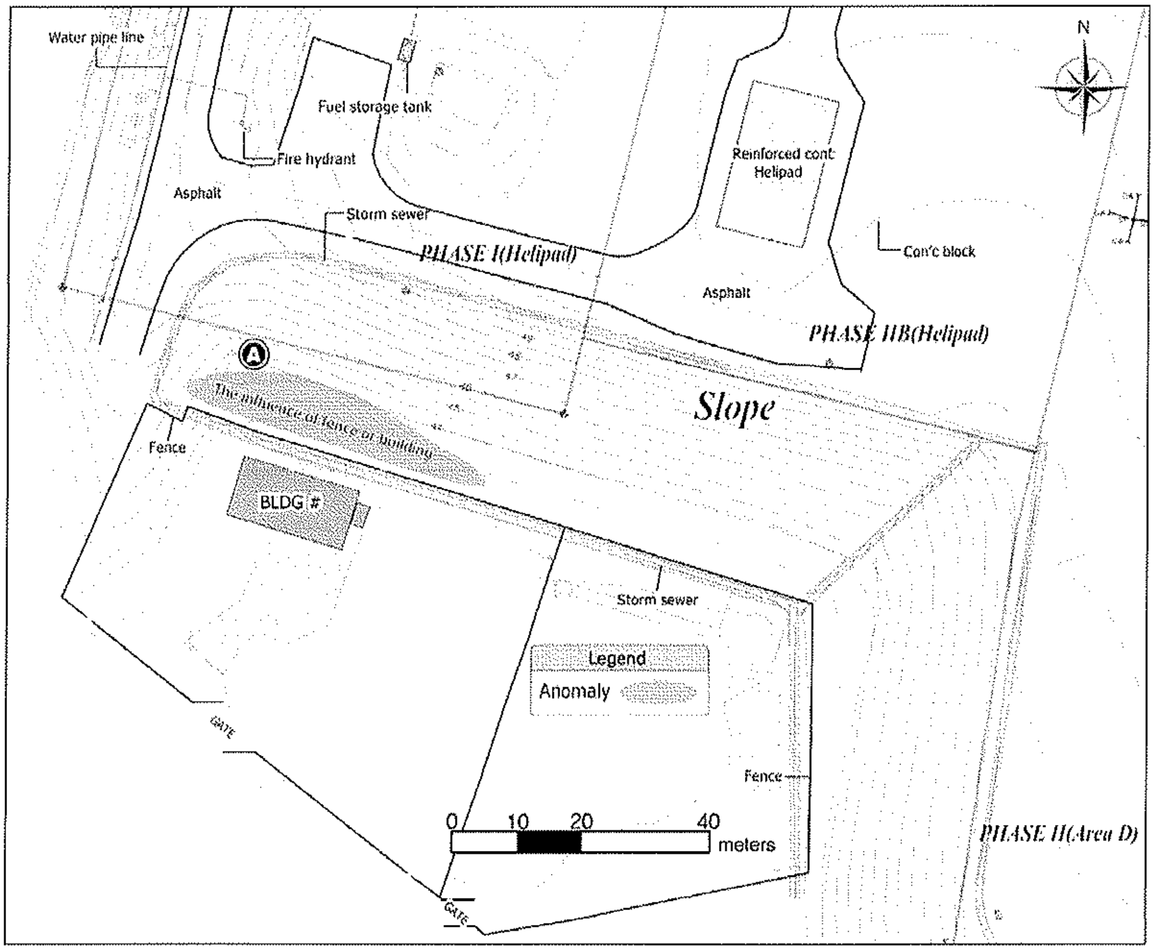


Figure 4-2. GPR Confirmed Subsurface Anomalies

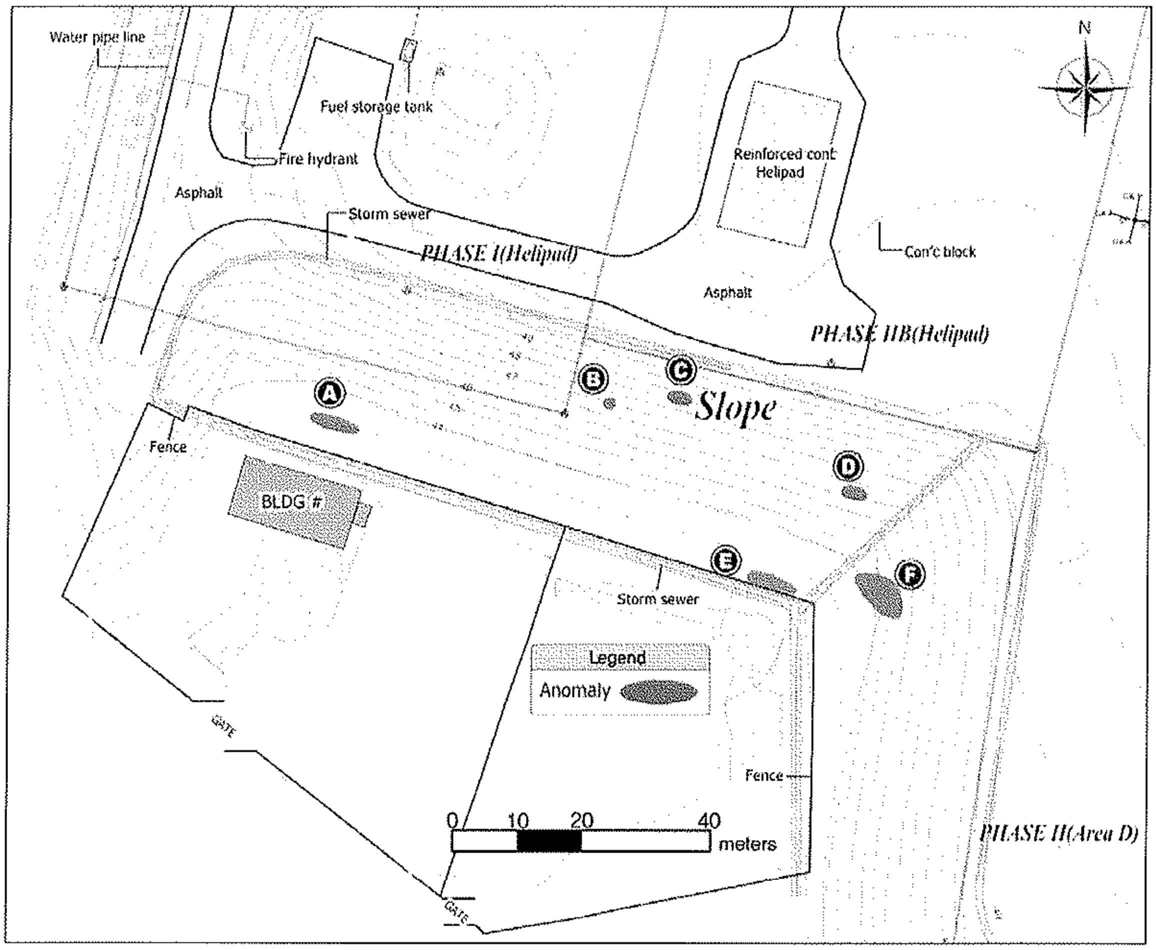


Figure 4-3. ERI Confirmed Subsurface Anomalies

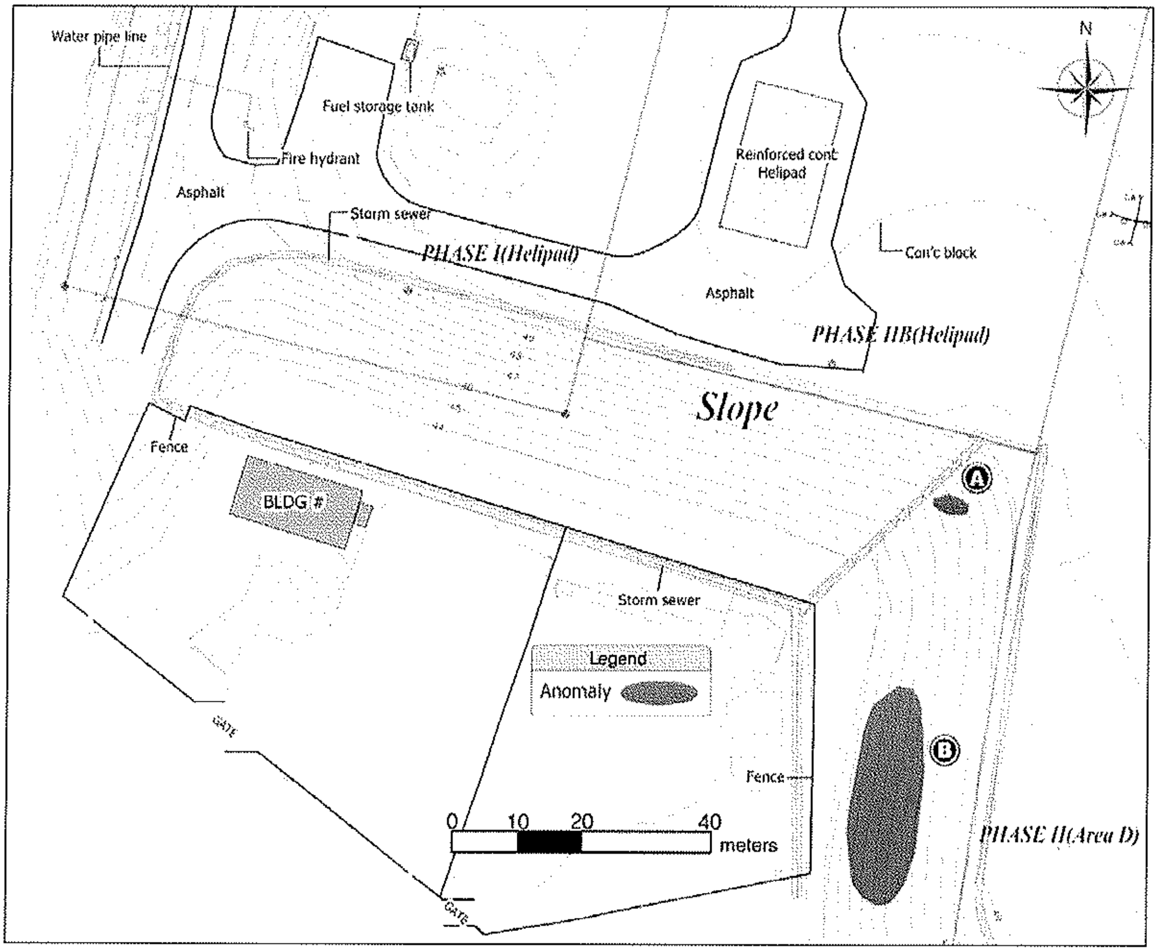
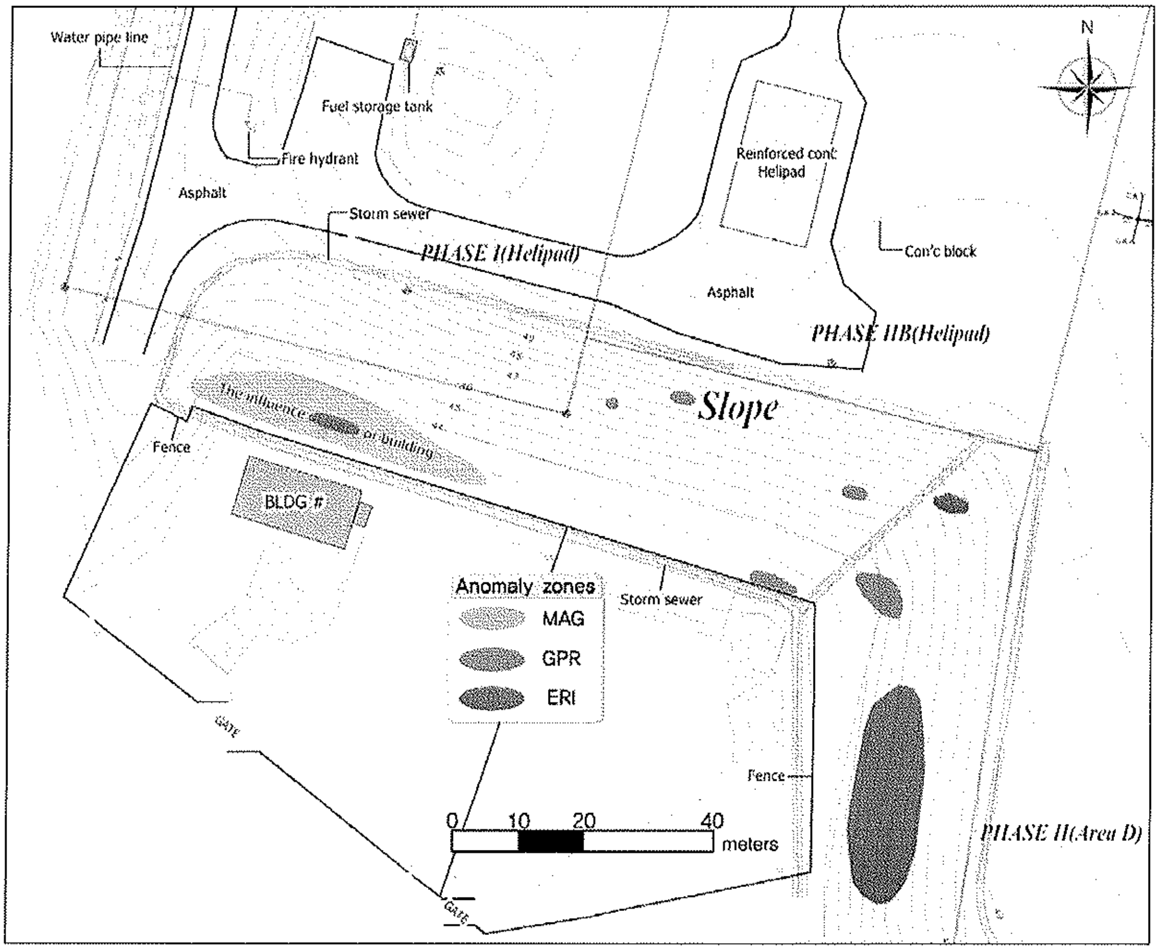


Figure 4-4. Final Interpretation of Subsurface Anomaly Zone



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APPENDIX A
GEOPHYSICAL SURVEY INSTRUMENT SPECIFICATIONS

Bartington Instrument Ltd model Grad601 gradiometer
MALÅ GeoScience model ProEx^{TM} Professional Explorer GPR
ABEM Instrument AB model Terrameter LS

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APPENDIX B
GPR 2-DIMENSIONAL SECTIONS AND ERI VERTICAL CROSS SECTIONS

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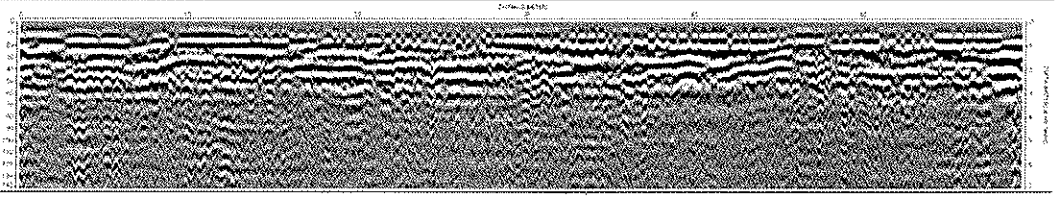
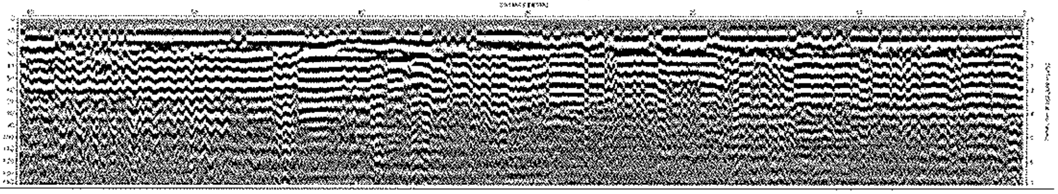
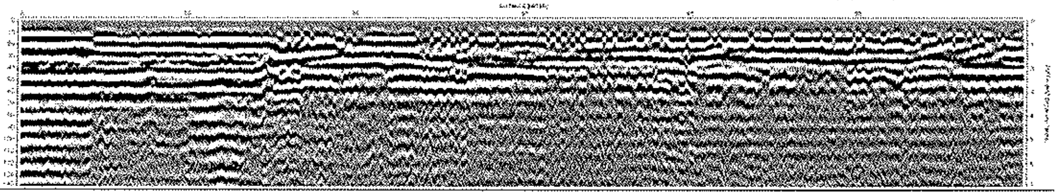
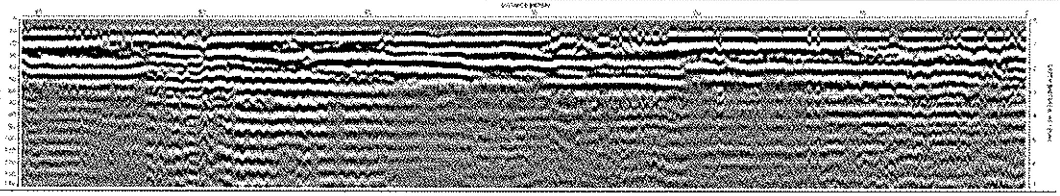
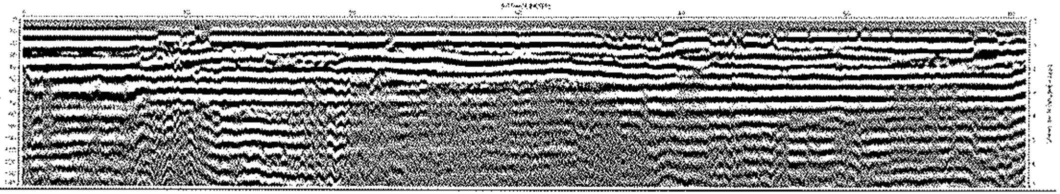
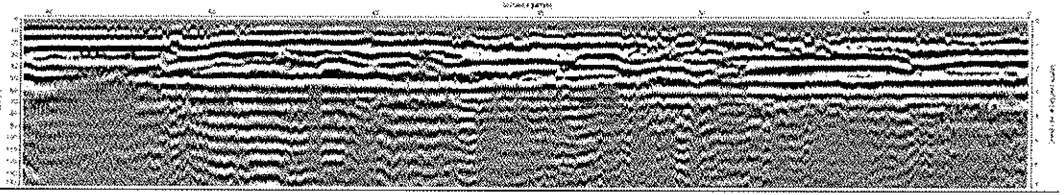
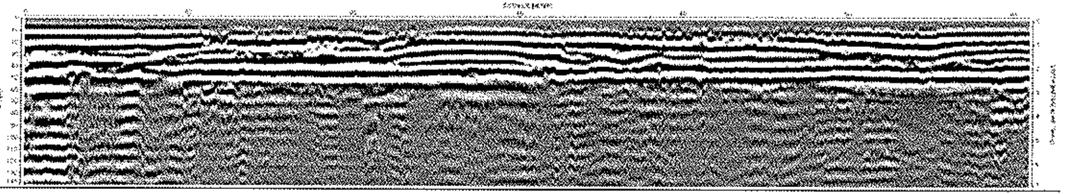
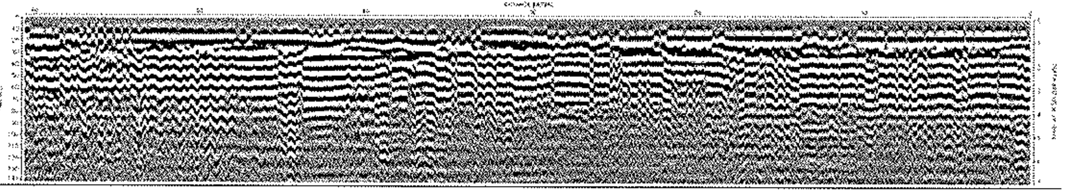
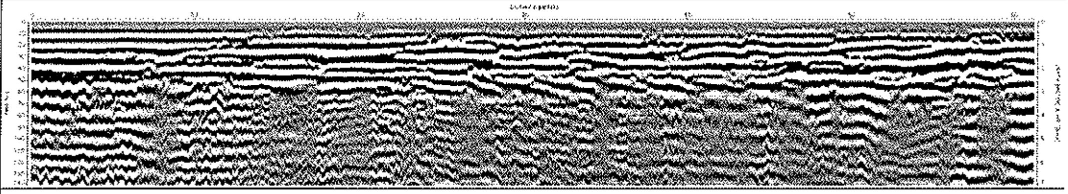
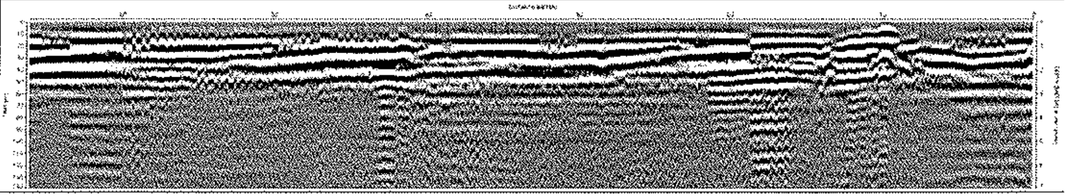
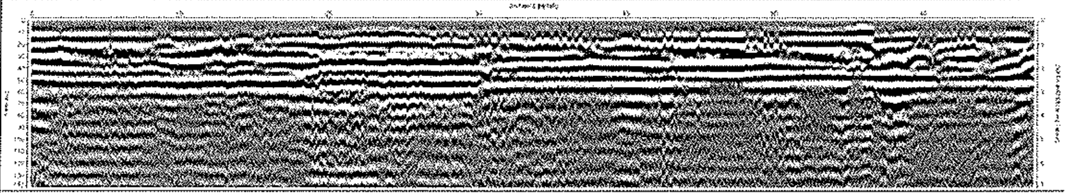
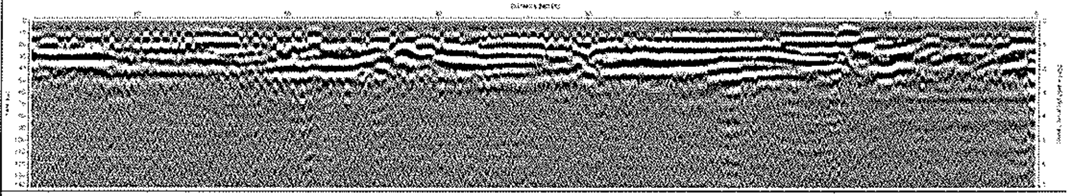
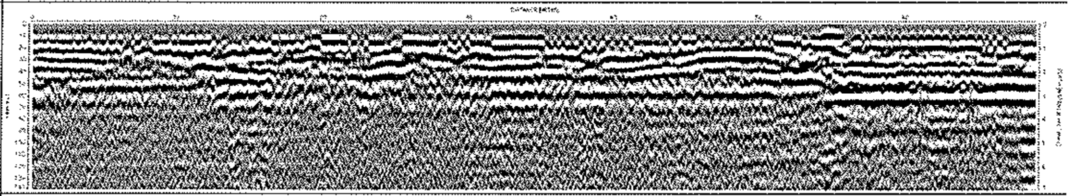
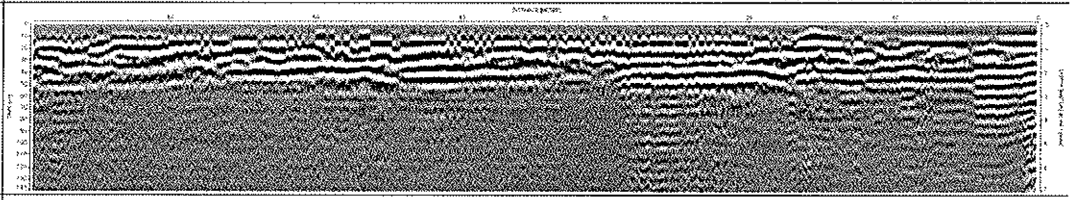
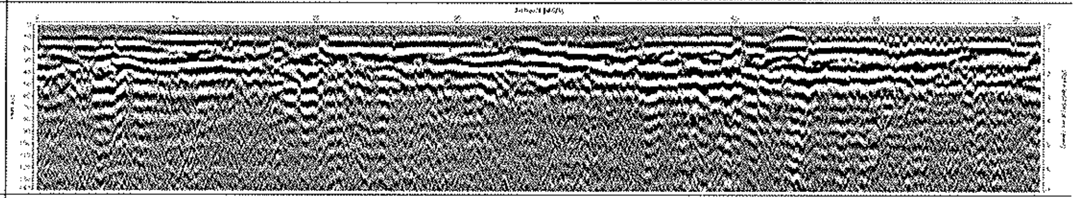
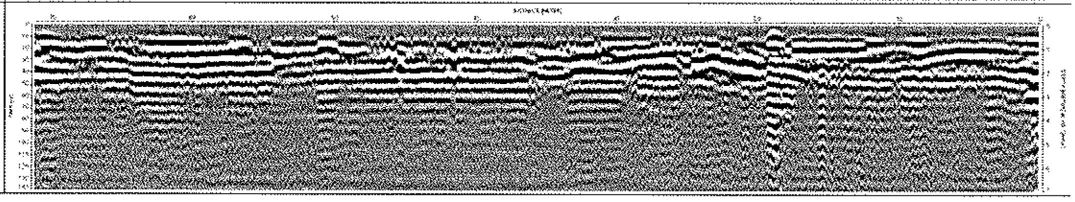
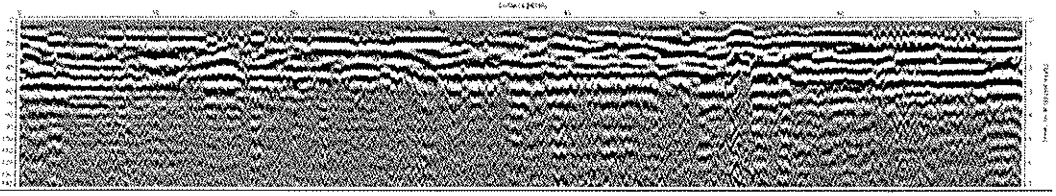
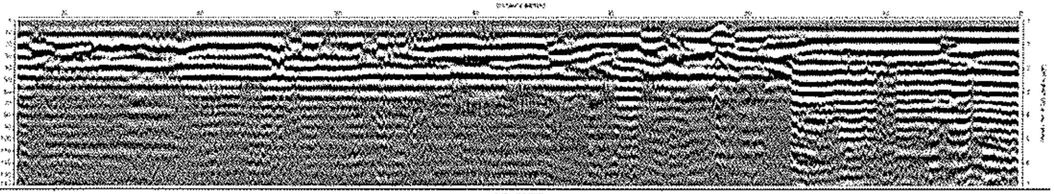
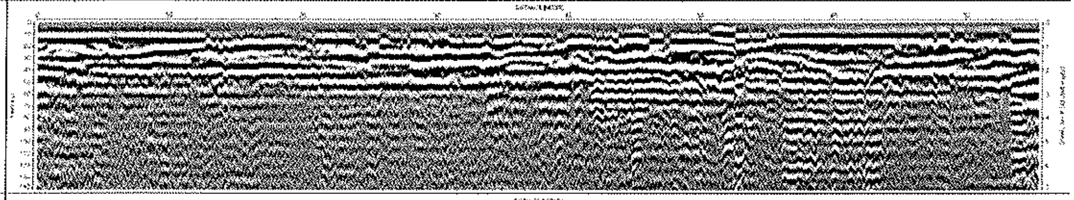
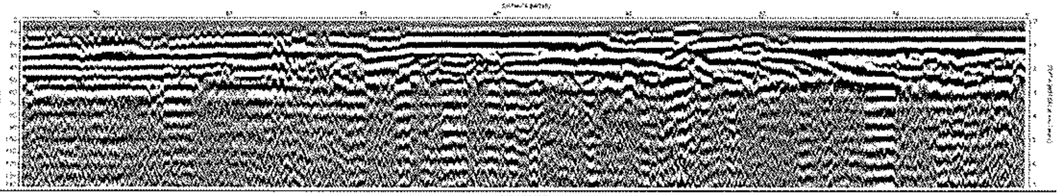
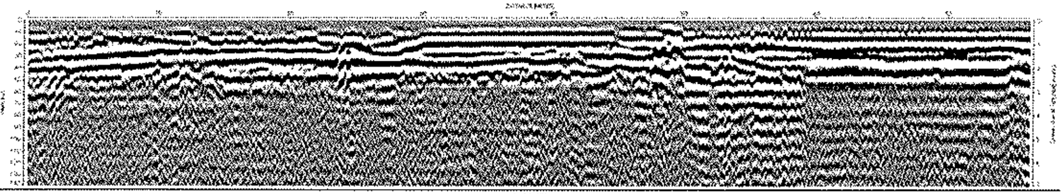
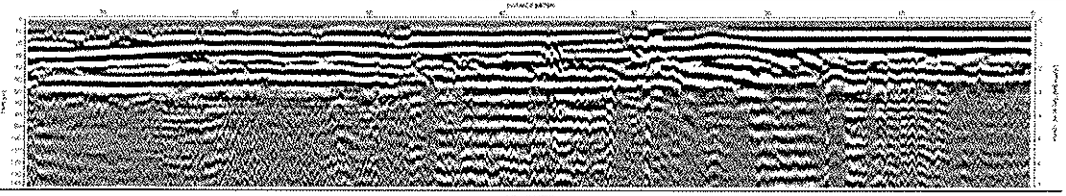
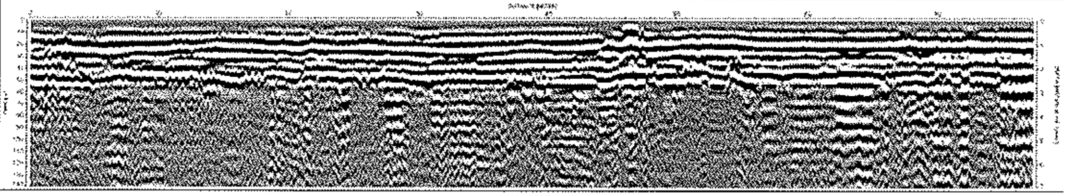
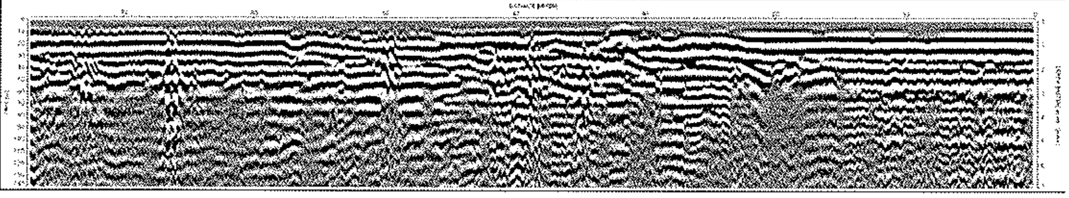
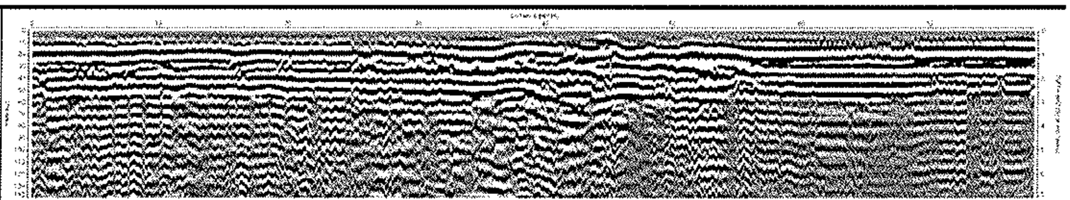
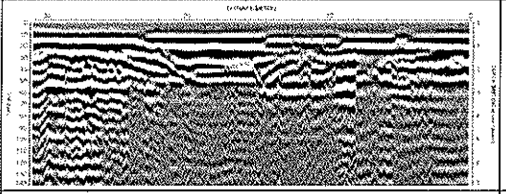
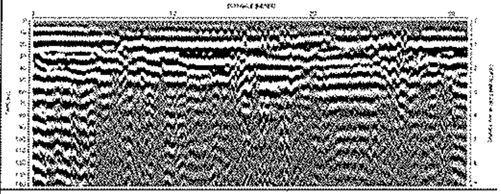
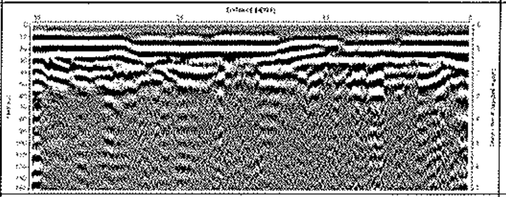
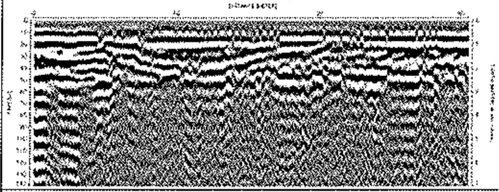
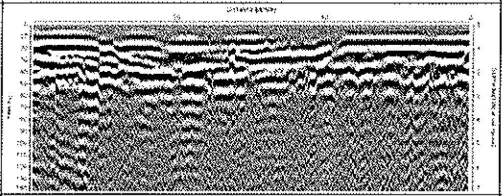
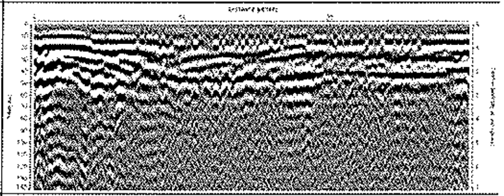
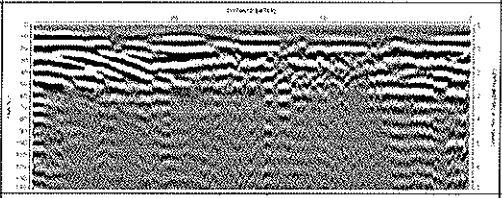
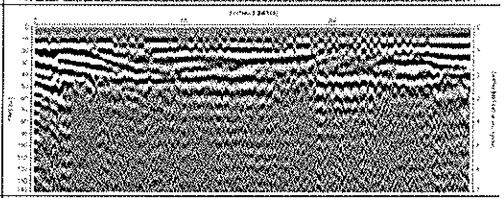
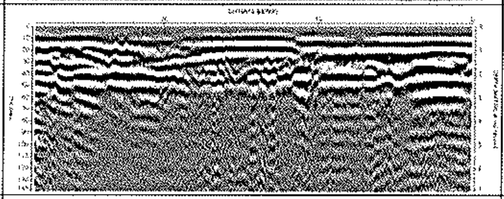
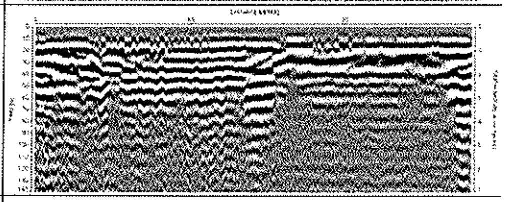
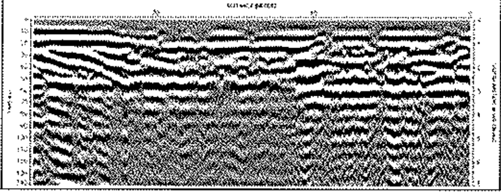
1. 100MHz GPR2D sections of Slope

1	
2	
3	
4	
5	
6	
7	
8	

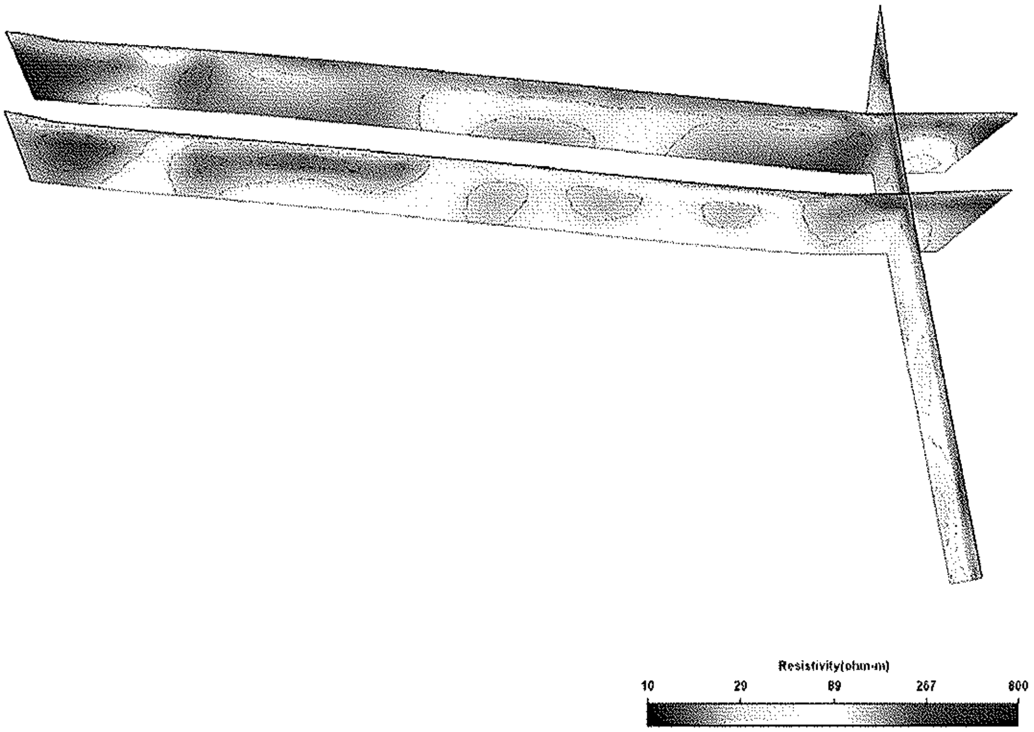
9	
10	
11	
12	
13	
14	
15	
16	

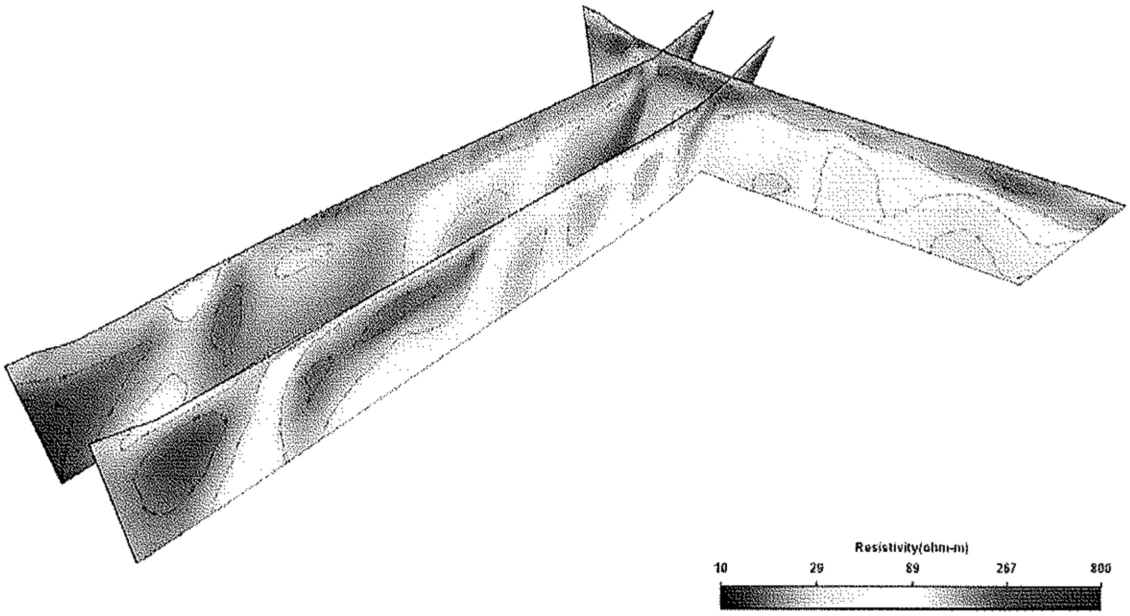
17	
18	
19	
20	
21	
22	
23	
24	

25			
26		27	
28		29	
30		31	
32		33	
34		35	
36			

2.ERI vertical cross sections

Fence Diagram





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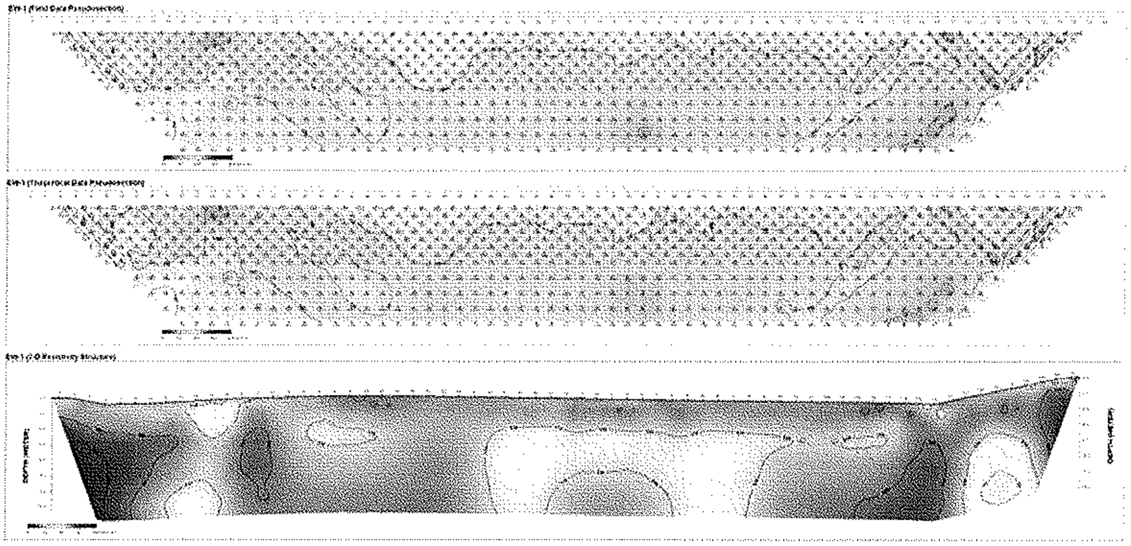

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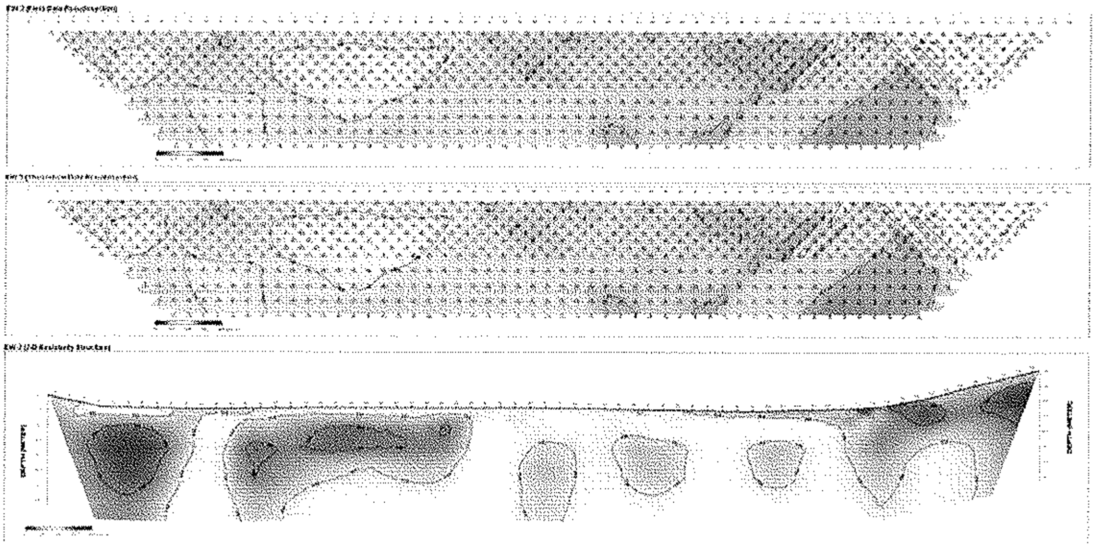

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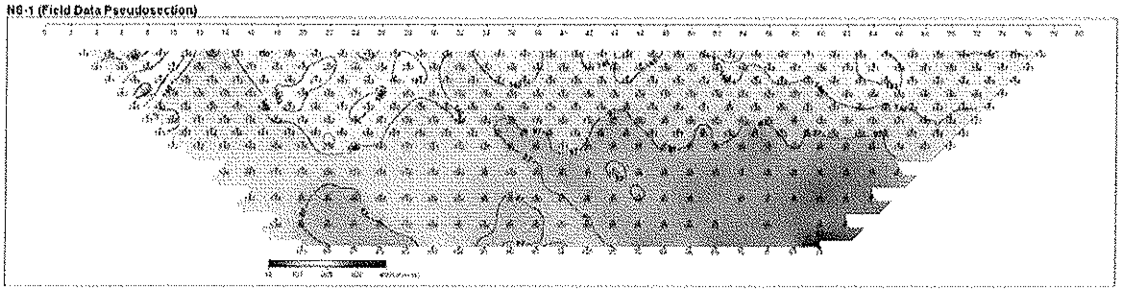
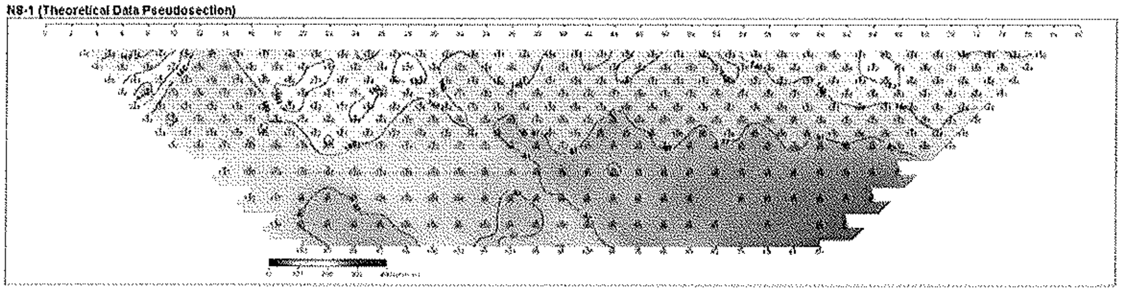
R(NS)-1

NS-1 (Field Data Pseudosection)



NS-1 (Theoretical Data Pseudosection)



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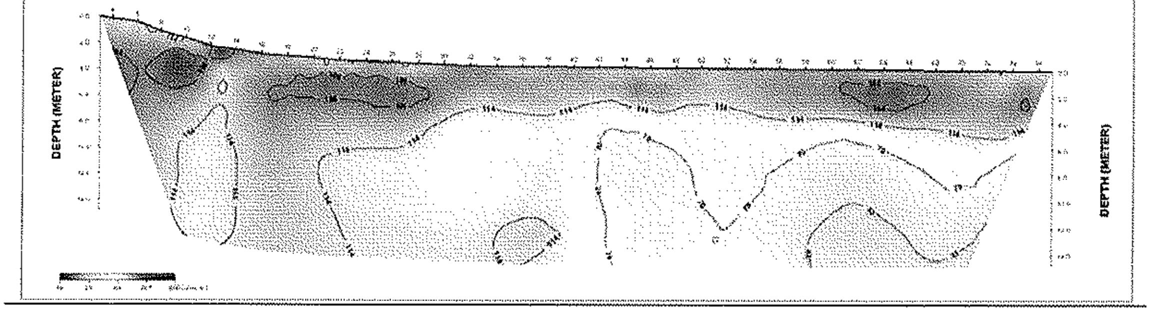

APPENDIX C
FIELDWORK PHOTOGRAPHS

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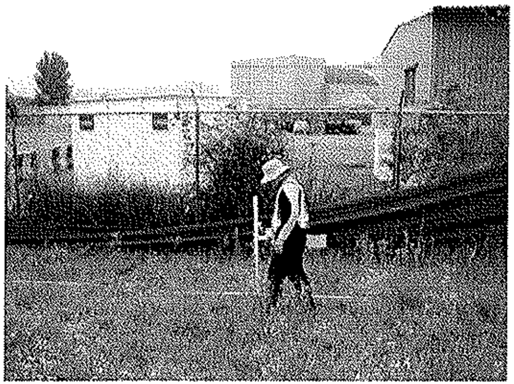

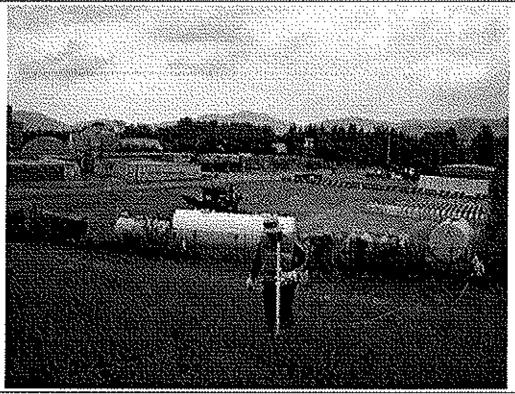

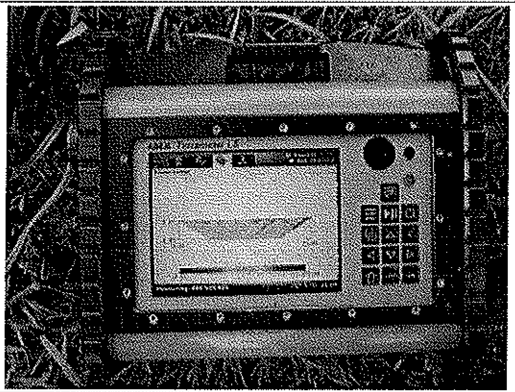

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APPENDIX C
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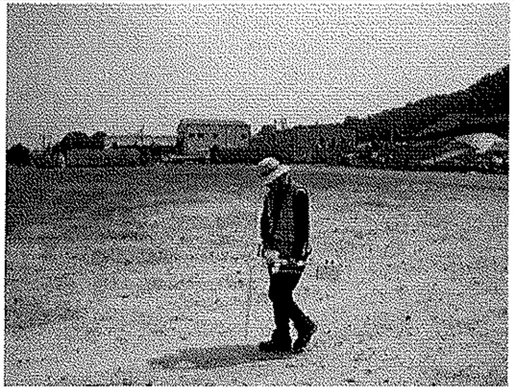
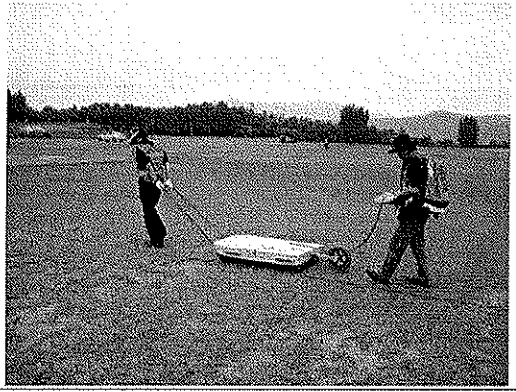
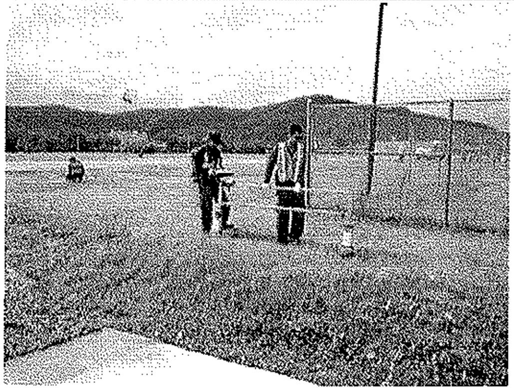
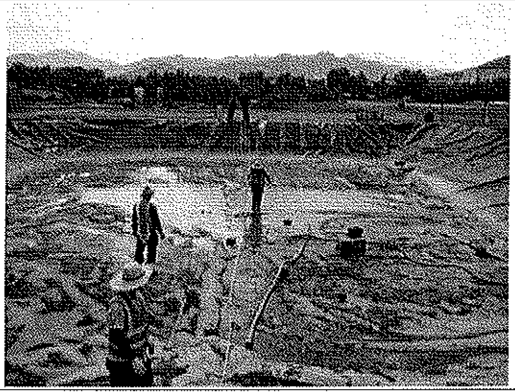
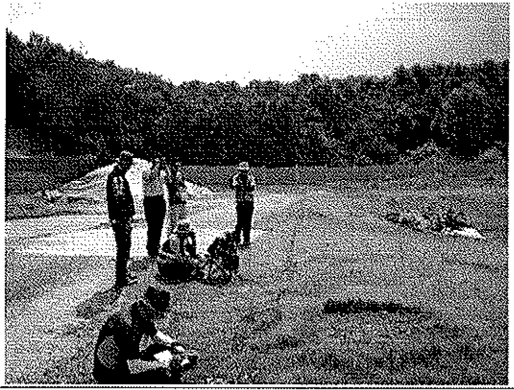
Area D

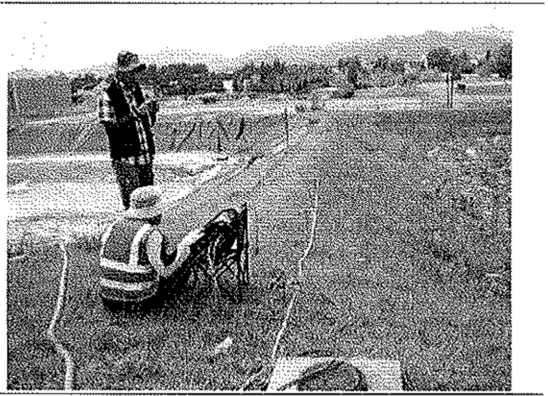






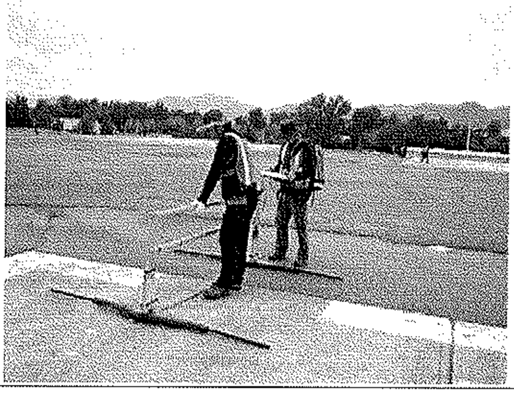

Landfarm

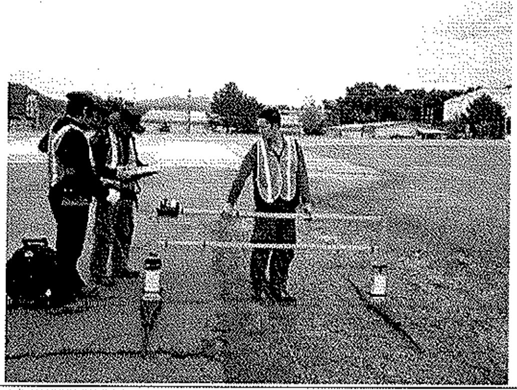


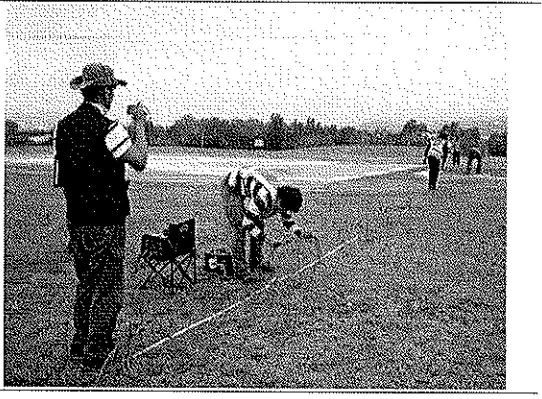




Helipad





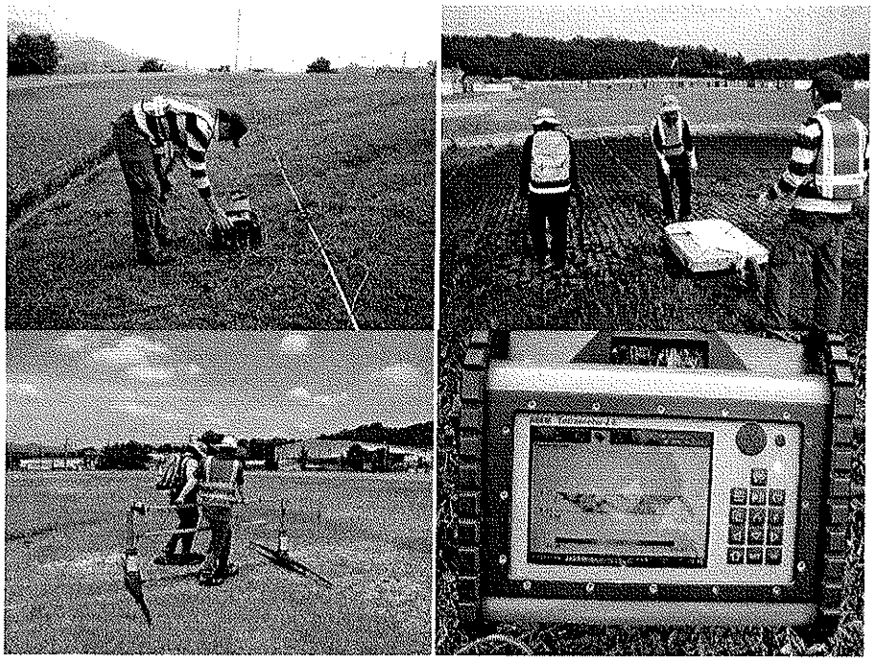


APPENDIX III. SOIL SAMPLING PLAN FOR PHASE 1 AND 2/2B-HELIPAD, LANDFARM AND AREA D- CAMP CARROLL

US Army Corps of Engineers
Far East District®

PHASE I (HELIPAD) SITE SOIL SAMPLING WORK PLAN

Camp Carroll
U.S. Army Garrison Daegu, Republic of Korea



July 8, 2011

Prepared By:

Environmental Section, Geotechnical and Environmental Engineering Branch
Engineering Division, U.S. Army Corps of Engineers, Far East District

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ACRONYMS AND ABBREVIATIONS

2,4-D	2,4-dichlorophenoxyacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
amsl	above mean sea level
bgs	below ground surface
dioxins	polychlorinated dibenzo-p-dioxins
DQO	data quality objective
DSN	Defense Switched Network
EM	Engineering Manual
EPA	U.S. Environmental Protection Agency
FED	U.S. Army Corps of Engineers, Far East District
furans	polychlorinated dibenzofurans
LCS	laboratory control sample
MDL	method detection limit
MEDCOM	U.S. Army Medical Command
PHC	Public Health Command (Provisional)
MS	matrix spike
MSD	matrix spike duplicate
PID	photo-ionization detector
PPE	personal protective equipment
ppm	parts per million
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
USACE	U.S. Army Corps of Engineers
VOA	volatile organic analysis
VSP	Visual Sample Plan
WP	Work Plan
°C	degrees Celsius
°F	degrees Fahrenheit

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1. INTRODUCTION

This soil sampling Work Plan (WP) describes the procedures and equipment that will be used to investigate subsurface anomalies identified by the recently completed geophysical survey at the Phase I (Helipad) site located on U.S. Army Garrison (USAG) Daegu Camp Carroll, Republic of Korea (ROK). A series of environmental investigations is being undertaken to determine whether subsurface soil contamination at the site poses an unacceptable health risk. The soil sampling will be conducted by the U.S. Army Corp of Engineers Far East District (FED) Environmental Section and its contractors.

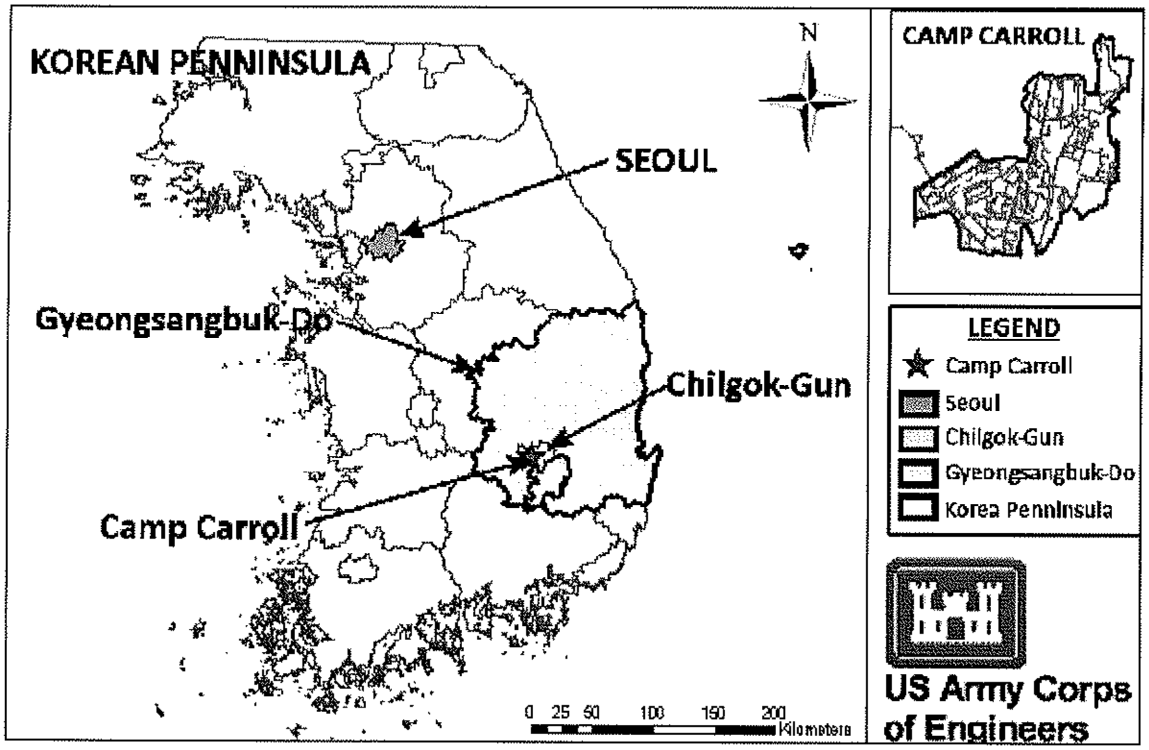
1.1. Project Objectives and Scope

The overall objective of the project is to acquire sufficient environmental data for subsurface soils to perform a human health risk assessment. The scope of the project includes review of available background information and geophysical survey results, identify data gaps, developing sample collection strategy, and the advancement of soil boring to collect subsurface soil samples for laboratory analysis.

1.2. Site Description and Background

USAG Daegu Camp Carroll (Camp Carroll) is located in Chilgok-Gun, Gyeongsanbuk-Do, adjacent to the city of Waegwan in the south-central portion of the ROK (Figure 1-1). Camp Carroll serves as the Headquarters of the U.S. Army Material Support Center and functions as a staging ground for U.S. military operations on the Korean Peninsula.

Figure 1-1. Camp Carroll Location Map



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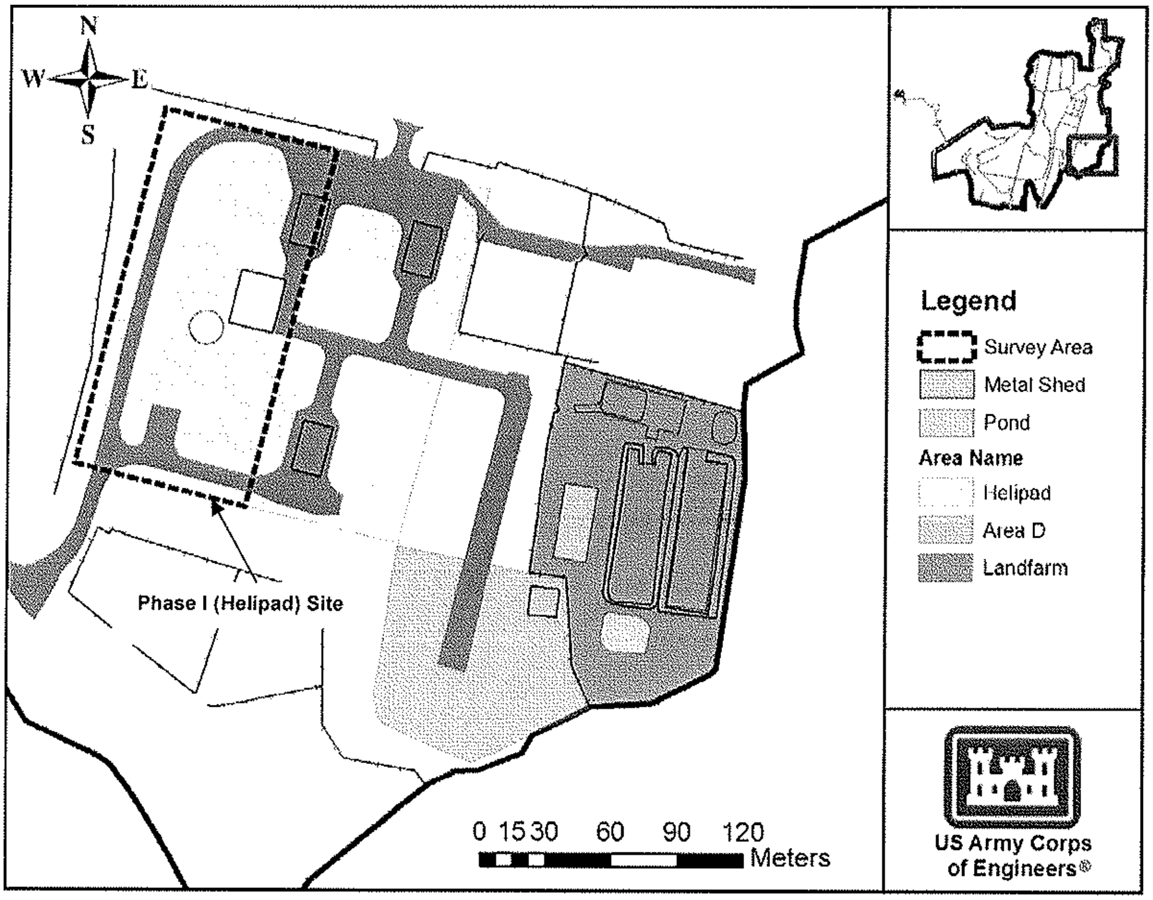
Camp Carroll serves as the Headquarters, U.S. Army Material Support Center and functions as a staging ground for U.S. military operations on the Korean Peninsula. The primary mission of the base is to serve as a staging facility and a storage and maintenance depot. Urban areas bound the installation to the northwest, west and southwest. Hilly, forested areas bound the installation to the north and east. Agricultural fields (mostly rice paddies) border the camp on the northeast and the south, and the Naktong River flows from north to south approximately 0.5 kilometers west of Camp Carroll.

The Helipad site is located in the southeastern portion of Camp Carroll hear the installation's eastern boundary (Figure 1-2). The Phase I portion of the Helipad site is one of three sites located in southeastern portion of Camp Carroll where disposal and burial of hazardous material and waste, some in 55-gallon drums, allegedly occurred in 1978. The buried drums and about 40 to 60 tons of contaminated soil were reportedly excavated and removed during 1979 and 1980. The disposition of the removed materials is not known.

Figure 1-2. Phase I (Helipad) Site Location Map



1.3. Project Site Physical Characteristics

1.3.1. Geology and Soils

The basement rock underlying Camp Carroll is composed of Precambrian granitic gneiss and Mesozoic granite. Siliceous dikes intrude the gneiss without any observed dominant regional trend. In the northern part of Waegwan city, thin beds of quartzite, calcareous-schist, and limestone have been reported.

Based on drilling logs from 11 groundwater monitoring wells located in the southern portion of Camp Carroll, the bedrock in this part of the base is composed largely of granitic gneiss and granodiorite. The upper 100 to 200 feet is weathered, with the degree of weathering decreasing with depth. Calcareous-schist and limestone were reportedly encountered near the bottom of some of the deeper wells. The overburden in the vicinity of these wells varies from 20 to 40 feet in thickness and ranges in composition from silty clays to gravel-rich sandy silts. The soils can be generally described as moist, medium dense, brown, silty to clayey, fine to coarse sand (SM to SC), with approximately 20 percent to 40 percent gravels and cobbles. The soils are predominantly derived from weathered granitic materials.

1.3.2. Climate

The climate of the ROK is defined by its mid-latitudinal location on a peninsula, as well as its configuration as an appendage to the Asian continent. Korea has a humid, East Asian monsoonal climate characterized by short, humid summers and dry, cold winters. The climate is influenced more by the continental climate during winter months and by the ocean during summer months.

Winters are cold and dry with an average daily maximum temperature in the mid 30s degree Fahrenheit. Occasionally, the daytime temperature will climb into the 40 or 50-degree Fahrenheit range. During winter, light northwesterly winds generally prevail. There is little snowfall in the area around Seoul. In spring, average daily high temperatures climb into the low 70s.

The monsoon, a rainy season of three to five weeks duration, begins in late June or early July with temperatures in the middle to upper 80s, relative humidity between 73 and 93 percent, and light southwesterly winds. Fall season starts in mid-September bringing mild and pleasant weather, with a marked drop in rainfall. Fall season on average lasts from mid-September through mid-November, with a gradual transition from summer to winter. The average annual precipitation in Seoul is 49.6 inches, with 72 percent of the annual rainfall occurring during the monsoonal period.

1.3.3. Hydrologic Setting

Based on groundwater elevation measurements obtained from 18 monitoring wells installed in 1992, elevation to the top of the groundwater table ranged from about 51 ft to 123 ft above mean sea level (amsl). One well in the northern portion of the base had a groundwater

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elevation of 191 feet amsl. Overall, groundwater at Camp Carroll flows generally to the south and southwest.

1.4. Previous Investigation and Data Gap Analysis

There have been several environmental investigations conducted in the area, including subsurface soil and groundwater investigations conducted in the nearby Area D and the Landfarm site. No environmental sampling and analysis had been conducted specifically for the Helipad site.

1.4.1. Phase I Geophysical Survey

The Phase I geophysical survey covered an area measuring approximately 180 m from north to south and 80 m east to west. The survey was conducted using three non-intrusive techniques: magnetic gradiometry, ground penetrating radar (GPR), and electrical resistivity imaging (ERI). The survey results were combined and a final interpretation of the data, along with subsurface anomaly zones that have been identified are shown on Figure 1-3. The results of the Phase I geophysical survey are summarized as follows:

- The Magnetic Gradiometry survey results indicate five subsurface anomalies.
- The GPR survey results indicate one subsurface anomaly.
- The ERI survey results indicate four subsurface anomalies.
- The combined results of the three surveys indicate four anomaly zones, identified as Zones A, B, C and D on Figure 1-3 where foreign objects may be present.
- Subsurface anomalies zones may be attributed to loosely packed soils, high water content, or buried foreign objects such as steel drums.
- Zone A has the highest probability to contain buried foreign objects, with higher probabilities indicated by darker shades of red.

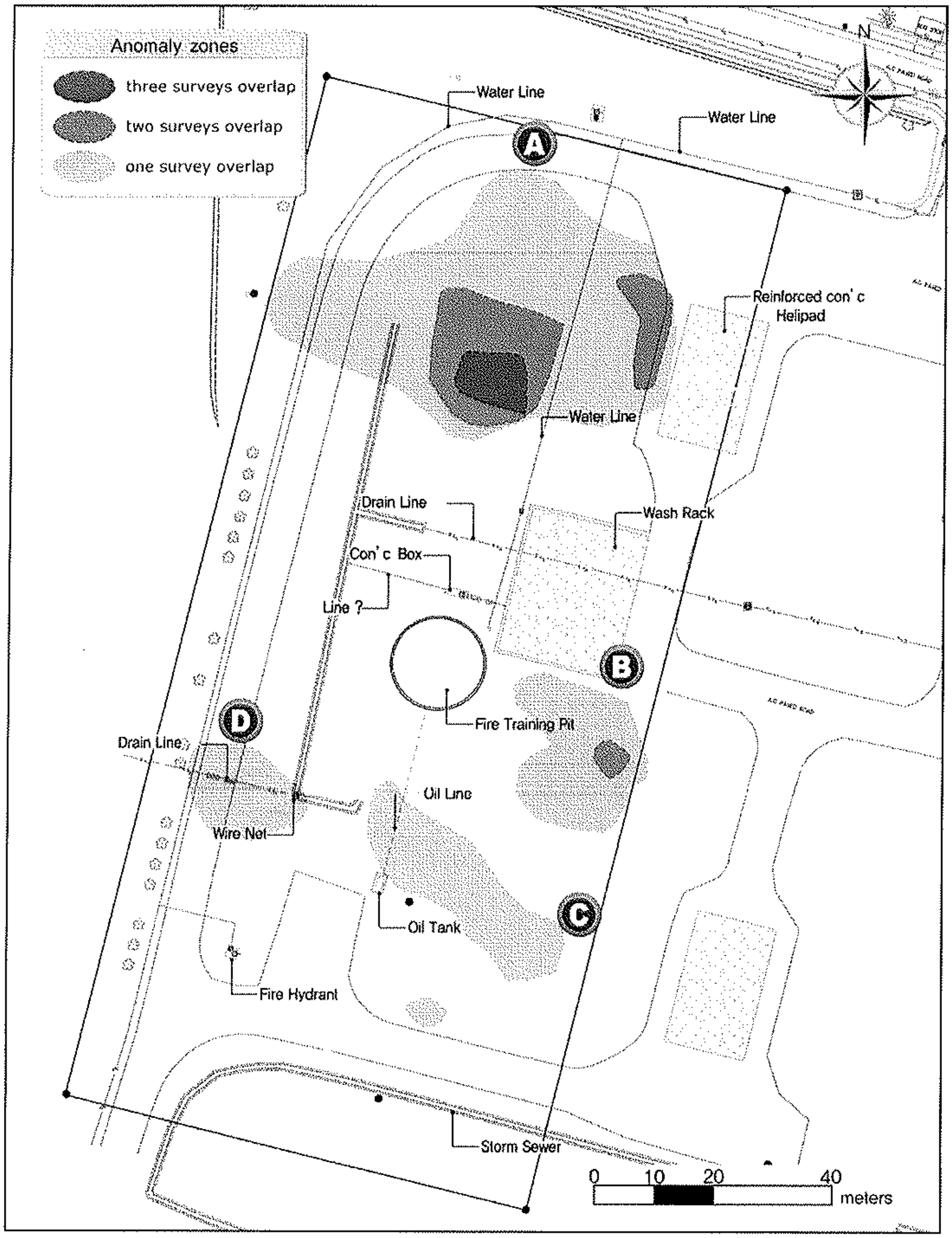
1.5. Chemicals of Potential Concern

The chemicals of potential concern (COPC) were identified by U.S. Army Medical Command (MEDCOM) Public Health Command (PHC) based on materials that were allegedly buried at the site and human health risk assessment requirements. The COPC for this project includes various degreasers and solvents; metals; pesticides and herbicides, including Agent Orange components 2,4-D and 2,4,5-T; and dioxins and furans. For laboratory analyses purposes, the COPC are grouped into the following chemical classes:

- Volatile organic compounds (VOCs)
- Semivolatile organic compounds (SVOCs)
- Metals regulated under the Resource Conservation and Recovery Act (RCRA)
- Organochlorine (OC) pesticides

- Organophosphorus (OP) pesticides
- Chlorinated herbicides
- Dioxins and Furans

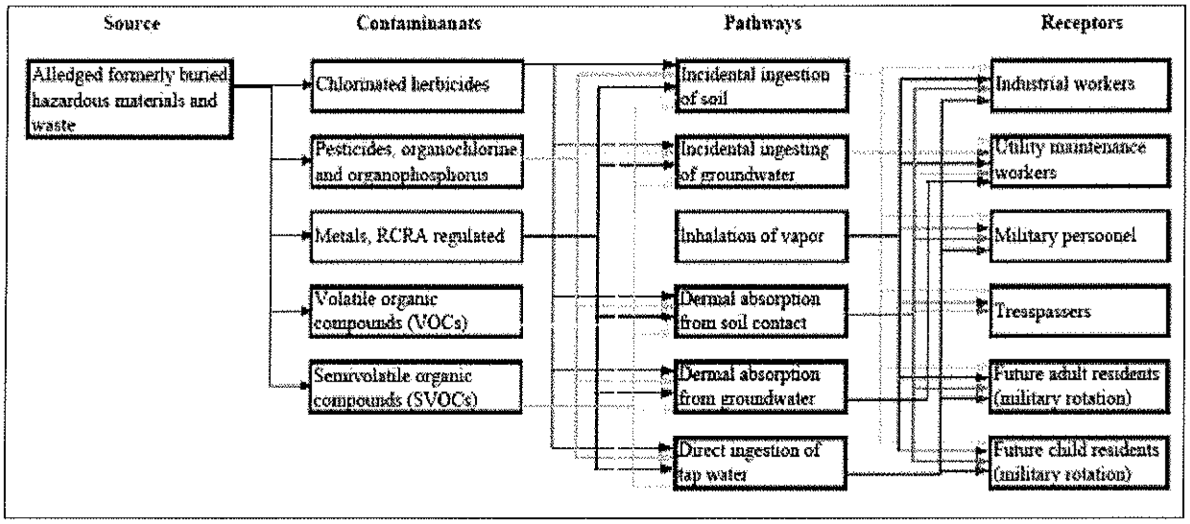
Figure 1-3. Final Interpretation of Subsurface Anomaly Zones



1.6. Conceptual Site Model

A conceptual site model (CSM) was developed based on the COPC identified and an assessment of potential exposure pathways. The CSM also took into consideration current site usage and proposed future use of the site and potential receptors. The CSM is presented in graphical format on Figure 1-4.

Figure 1-4. Helipad Site Conceptual Site Model



1.7. Work Plan Organization

This WP contains the project Sampling and Analysis Plan (SAP), which provides a detailed description of sample collection and laboratory methodologies, as well as the Quality Assurance Project Plan (QAPP). The WP is organized as follows:

- Section 1 - Introduction
- Section 2 - Project Organization
- Section 3 - Sampling and Analysis Plan
- Section 4 - Quality Assurance Project Plan
- Section 5 - References

2. PROJECT ORGANIZATION

The project organizational structure is designed to ensure that everyone involved with the project will receive proper instruction and information, and that appropriate quality assurance and quality control procedures will be followed throughout the project.

2.1. Key Project Personnel

Key personnel and their contact information for this project are provided in Table 2-1.

Table 2-1. Key Project Personnel and Contact Information

Title	Name	Telephone	Email
Project Manager	Mr. [redacted] b6	DSN: [redacted] b6 Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@usace.army.mil b6
Project Engineer	Dr. [redacted] b6	DSN: [redacted] b6 Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@usace.army.mil b6
Chemist/QA Manager	Dr. [redacted] b6	DSN: [redacted] b6 Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@usace.army.mil b6
Field Manager	Dr. [redacted] b6	DSN: [redacted] b6 Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@usace.army.mil b6
PHC Risk Assessor	Mr. [redacted] b6		[redacted]@us.army.mil b6
Subcontract Drilling Team	BEC Co., Ltd. Mr. [redacted] b6	Commercial: [redacted] Mobile: [redacted] b6	[redacted]@esakorea.com b6
Analytical Laboratory	SGS Korea Mr. [redacted] b6	Commercial: [redacted] Mobile: [redacted] b6	[redacted]@sgs.com b6

2.2. Project Schedule

The project has a high priority and all aspects have been compressed and expedited. Soil sample collection is scheduled to begin on or about 12 July 2011. Anticipated project milestones are shown in Table 2-2. Prior to mobilization, all equipment inspected and tested to verify operability. Spare parts and contingency materials will be obtained and inspected to ensure preparedness during the field effort.

Table 2-2. Project Schedule

Project Milestone	Completion Date
1. Prepare project Work Plan	11 July 2011
2. Initiate field investigation	12 July 2011
2.1 Complete field investigation	20 July 2011
3. Complete laboratory analyses	15 August 2011
4. Submit draft soil sampling and risk assessment report	31August 2011
5. Submit final soil sampling and risk assessment report	30 September 2011

Ground transportation will be used for mobilizing personnel and materials to Camp Carroll. The contractors will be responsible for mobilizing the appropriate equipment to the sites. To ensure the success and efficient execution of the project, coordination efforts with stakeholders will be made prior to mobilization to identify and mitigate potential obstacles and determine personnel schedules necessary to best complete the effort. Coordination will be required to mitigate work stoppage due to helicopter landings.

3. SAMPLING AND ANALYSIS PLAN

The soil sampling strategy was developed based on the results of the subsurface geophysical survey and in consultation with PHC Risk Assessor and the ROK governmental representatives.

The number of boreholes and their initial locations were calculated and determined using Visual Sample Plan (VSP), a public domain software developed by Pacific Northwest Laboratory in conjunction with U.S. governmental agencies. It was determined that 40 boreholes will be drilled for soil sampling at the Helipad site. The initial borehole locations were randomly selected for the site. The borehole locations were adjusted to reflect the needs of the PHC risk assessors and following consultation with ROK governmental representatives. The planned borehole locations are shown on Figure 3-1. The final locations of the boreholes may be adjusted by the Field Manager based on site observations as the drilling progresses.

3.1. Site Preparation

The most important consideration for all field activities to be performed is the safety and health of all on-site personnel and the surrounding community. A site-specific Safety and Health Plan (SSHP) has been prepared, which includes the Activity Hazard Analysis and Accident Prevention Plan.

Project personnel will establish a safe perimeter around each work area. Traffic barriers or cones will be used in areas accessible to vehicles to redirect traffic if necessary. Prior to starting work, a safety and health meeting will be conducted by the Site Safety and Health Officer (SSHO).

3.2. Soil Sample Collection Procedure

Subsurface soil samples will be collected using direct-push drilling. Project personnel will be responsible for collecting samples and decontaminating the sampling equipment. To avoid cross contamination of the samples and to protect worker safety and health, the person performing the sample collection will use a new pair of disposable nitrile gloves while collecting each sample.

Up to four samples will be collected from each borehole location. The initial sample intervals will be 0 to 0.5 m below ground surface (bgs), at 0.5 to 2 m bgs, from 2 m to 5 m bgs, and the 2 m increment immediately above the bottom of the borehole (refusal or 10 m, whichever is shallower). In the event groundwater is encountered, the four soil sampling depth zones for subsequent chemical testing will be: 0 to 0.5 m, 0.5 to 2 m, immediately above the groundwater table, and immediately below the groundwater table. The specific collection depths may be adjusted by the Field Manager based on site observations. Maximum drilling depth will be 10 m bgs, even if no groundwater is encountered at a borehole location. Drilling depth may also be limited by depth to bedrock should bedrock be encountered at less than 10 m bgs.

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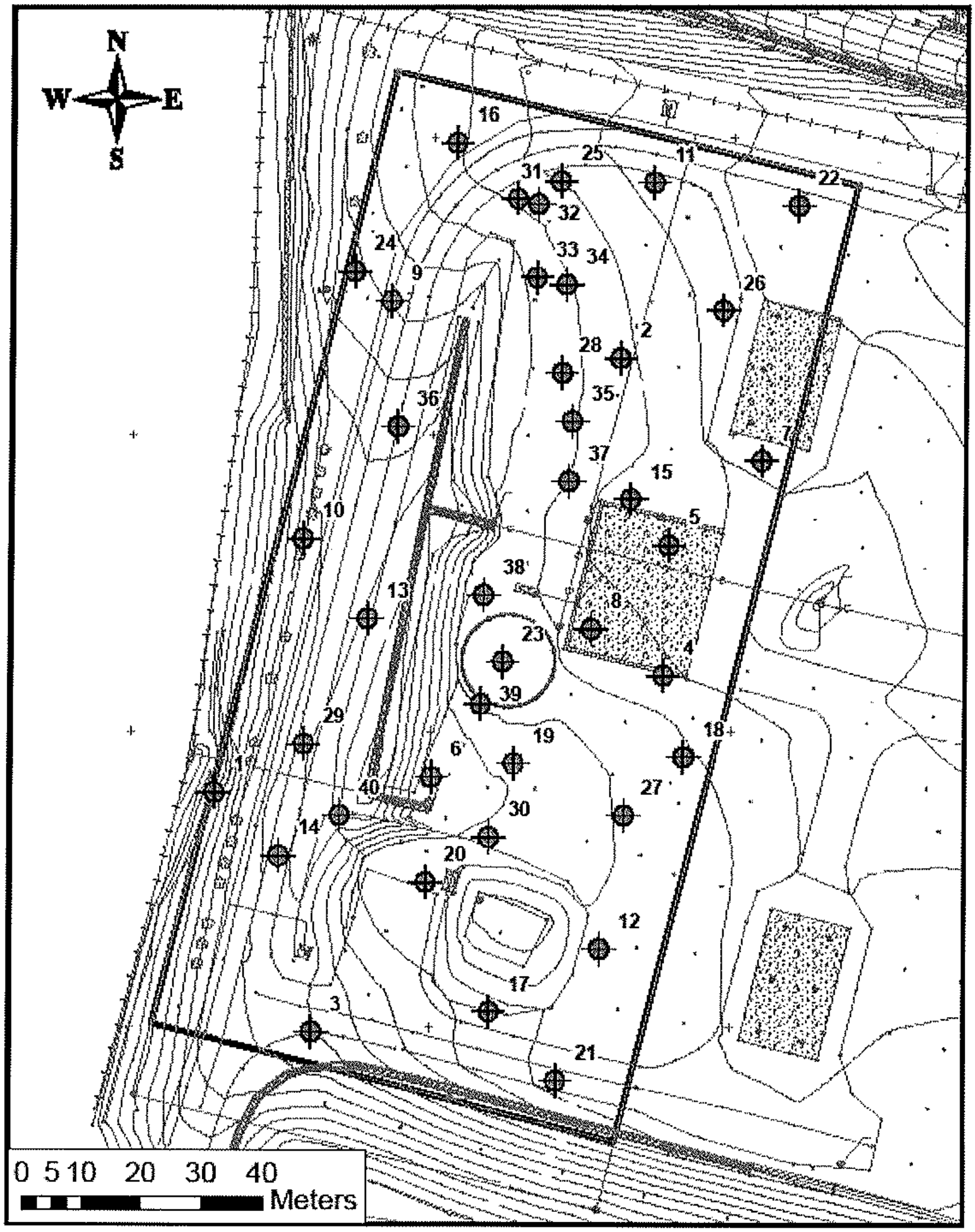
Figure 3-1. Phase I (Helipad) Site Borehole Locations



Upon withdrawal from the boreholes, the soil sample will be transferred into certified clean environmental sample containers. Samples to be analyzed for VOCs will be placed into methanol and reagent grade water-preserved 40 mL volatile organic analysis (VOA) vials using a Terra-Core soil plunger.

In order to provide sufficient sample volume for the requisite laboratory analyses, 12 oz of soil and three 40 mL VOA will be required for each sample. Each sample will also be collected in duplicate, with one set provided to the ROK government for their analysis. Additional sample volume will be required for quality assurance and quality control (QA/QC). A description of QA/QC sampling requirements is provided in Section 4.

3.3. Sample Management

All samples will be labeled with unique sample identification numbers and placed into individual resealable plastic bags, then into insulated coolers filled with ice for preservation. The samples will be chilled and maintained at a temperature of 4 degrees Celsius (°C) ± 2 °C and managed under chain-of-custody (COC) protocol and documentation until shipment to the analytical laboratories. COC forms will not be provided with the samples going to the ROK government.

Field notes will be maintained by FED personnel recording the location, sample media, number, date and time for each sample collected as well as any appropriate observations. The field notes will be recorded in a bound notebook using an indelible marker. Digital color photographs will be taken to document the field investigation, with select photographs to be included in the report.

3.3.1. Sample Identification Sequence

Soil sample identification number will have the following general sequence:

CCH-SBnn-Sm-xx.x

where,

CCH: Camp Carol Helipad
SB: borehole
nn: sequential borehole number
S: soil sample
m: sequential sample number in a borehole
xx.x: depth to the top of the sample interval, expressed in meters

Alternative sample identification number may be used at the discretion of the Field Manager. Samples provided to the ROK government will have the same identification number to facilitate comparison of analytical results.

3.4. Investigation Derived Waste

Investigation derived waste (IDW) may include concrete debris, drill cuttings, decontamination water and used personal protective equipment (PPE). IDW will be collect into 55-gal drums that meet the specifications for hazardous waste. The drums will be labeled a drum identification number, project name, drum content (associated borehole number), date(s) generated, contractor name, FED Point of Contact (POC) and telephone number using paint or permanent marker. The drums will be stored on-site or at a location designated by the Camp Carroll Environmental Office while awaiting laboratory analyses results. The IDW will be managed and disposed based on the results of laboratory analyses.

3.5. Site Restoration

Boring locations will be backfilled with clean soil cuttings or bentonite pellets and the surfaces restored to match existing surface covering. Significant site damage is not anticipated during this investigation, thus site restoration should be minimal.

3.6. Borehole Survey

The location and elevation of boreholes will be surveyed using Global Positioning System (GPS) to centimeter-level accuracy after completion of sample collection and site restoration. The location of relevant site features will also be surveyed. The survey coordinates will be reported using the Universal Transverse Mercator (UTM) World Geodetic System (WGS84).

3.7. Laboratory Analyses

Soil samples collected will be analyzed for the COPC using U.S. Environmental Protection Agency (EPA) methods published in SW-846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods." The specific analytical methods that will be used for the COPC chemical classes are shown in Table 3-1. A complete listing of analytical parameters is provided in Section 4.

3.7.1. Sample Containers, Preservation Techniques, and Holding Times

Each soil sample will require a volume of about 12 oz, which will be collected using one 4 oz and one 8 oz glass jars, and one 40 mL VOA vile. Sample holding times (time between sample collection and analysis) have not been established for soil matrixes. Current EPA guidelines and industry standard is to use holding times in SW-846 for aqueous samples. The holding times are shown in Table 3-1.

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Table 3-1. Analytical Methods and Sample Holding Times

Analytical Parameter	Analytical Method (EPA SW-846)	Sample Holding Time (days)	
		Until Extraction	After Extraction
VOCs	8260	-	14
SVOCs	8270	14	40
RCRA metals (total)	6010/7471 (Hg)	-	6 months; Hg 28 days
OC pesticides	8081	14	40
OP pesticides	8141	14	40
Chlorinated herbicides	8151	14	40
Dioxins and Furans	8290	30	45

Hg - mercury

4. QUALITY ASSURANCE PROJECT PLAN

This section presents the Quality Assurance Project Plan (QAPP) for the Helipad site soil sampling and laboratory analysis activities. The purpose of the QAPP is to ensure that all field and laboratory activities are conducted in a manner consistent with regulatory requirements, official guidelines and industry standards to provide data representative of conditions present at the site. The QAPP addresses the following:

- Method selection and target analyte lists
- Laboratory and field QA acceptance criteria
- Field and laboratory documentation and data management
- Data validation requirements
- Data evaluation procedures
- Performance and system audits
- Preventative maintenance
- Corrective actions
- QA/QC reporting

4.1. Data Quality Objectives

The overall sampling and analysis strategy was developed using the EPA's data quality objectives (DQO) process (EPA, 1994). DQO are qualitative and quantitative statements that specify the quality of data required to support decisions concerning the project site. The DQO process begins by identifying the type of decisions that will be made regarding a site, evaluation of available information, developing a conceptual site model, and specifying project objectives. The next step is the identification of data needs and data quality needs, followed by design of the sample collection program.

The objective of the soil sampling and analysis program is to provide data with sufficient quality to perform a human health risk assessment. The usability of the data collected will depend on its quality. A large number of factors along the sample collection and analysis process have the potential to impact the overall quality of the data generated. Adhering to proper sample collection techniques, observing and documenting COC procedures and using certified laboratories and approved analytical methods will ensure that the quality of data generated will meet project objectives.

4.2. Sample Collection and Handling Procedures

Copies of this project WP outlining appropriate field procedures will be provided to field personnel, one copy of the WP will also be maintained in the field by the FED site personnel during sample collection activities. Prior to sampling, the Project Manager or the QA Manager will inspect all supplies and consumables to insure that they are acceptable for use.

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Sampling and sample handling procedures are designed to ensure that samples are consistently collected, labeled, preserved, and transported in a manner that maintains their integrity for their intended purposes. Copies of this WP and appropriate field procedures will be carried by field personnel during field data collection.

4.2.1. Sample Logs, Labeling, and Chain-of-Custody

Bound, paginated, and waterproof field notebooks will be maintained by the Field Manager to provide daily records of significant events, observations, and measurements during field tasks. Each sample container sent to the laboratory must have its own sample identification label, as described in Section 3.

Samples will be managed under COC protocol, which is under direct observation by project personnel or under lock and key. COC documentation will be maintained for samples during all phases of sample collection, transport, and receipt and internal transfer within the laboratory.

4.2.2. Sample Handling and Shipping

Upon collection, samples will be properly labeled, packaged and transported to the laboratory as soon as possible. Soil samples will be hand delivered to SGS Testing Korea. COC forms will be placed inside resealable plastic bags and accompany the sample shipment to the laboratories.

4.3. Field Instrument Calibration and Maintenance

Field equipment that may be used during field activities for documentation purposes may include: PID, Handheld GPS unit, and Digital Camera. Preventive maintenance of field equipment will be performed in accordance with the requirements of the specified manufacturer. Equipment will be periodically cleaned, checked for operability, and repaired as necessary. Equipment will be properly stored when not in use.

Field equipment will be calibrated prior to and during use as specified by the manufacturer. All calibration activities will be noted in the field logbooks. Field personnel are responsible for ensuring that the instruction manuals are on-site with the equipment and that the equipment is tested, calibrated, and in good working condition prior to use. Field equipment preventive maintenance frequencies will be determined based on manufacturer recommendations and the anticipated use of the equipment.

4.4. Field Consumables and Supplies

All field consumables will be inspected by the field manager prior to use and discarded if the integrity has been altered and there is any possibility of the use of the consumable will sacrifice the integrity of the sampling effort.

4.5. Equipment Decontamination

The proper decontamination of all non-dedicated sampling equipment that come into contact with sample media is crucial to obtaining data that meets the quality objectives of the project. The decontamination procedures were also developed to ensure worker safety and health, and to prevent the spread of contamination off-site. All sample collection equipment will be decontaminated by project personnel before their initial use and between uses. Individuals who are conducting sample collection or handling the sample media directly will wear disposable nitrile gloves and put on a new pair of gloves for each sample. Personnel who may otherwise handle sampling equipment may wear nitrile outer gloves that can be decontaminated as necessary.

4.5.1. Sampling Equipment Decontamination

After a sample has been collected, the sample collector will remove the nitrile gloves without touching the outside of the gloves during removal and place the gloves in a trash bag. All sampling equipment that comes into contact with environmental media will be decontaminated as follows:

- Gross contamination will be scraped off or wiped off with paper towels.
- The equipment will be washed in a solution containing Alconox or equivalent detergent and potable water and scrubbed with a brush or scouring pad.
- The equipment will be rinsed in at least one bucket containing potable tap water.
- A final rinse will be performed using deionized or distilled water.
- Rinse and detergent water will be replaced as necessary.
- After decontamination, the sampling equipment will be placed in a clean area or on clean plastic sheeting.

If a piece of sampling equipment will not be used immediately after decontamination, the equipment will be covered with plastic sheeting or placed in clean plastic bags.

4.5.2. Heavy Equipment Decontamination

Heavy equipment parts that come into contact with contaminated environmental media during their operation (e.g., drill rig probe) will be decontaminated between sample locations. The following steps will be used to decontaminate heavy equipment:

- Personnel performing the decontamination will wear PPE required by the SSHP.
- Gross contamination will be scraped off.
- Equipment will be steam cleaned or scrubbed using an industrial detergent such as Alconox.
- Additional washing with Alconox or equivalent detergent solution and rinsing with potable water may be conducted at the discretion of the FED Site Inspector.

- After decontamination, drilling equipment will be placed on the drill rig. If equipment is not used immediately, it will be stored in a clean area.

4.6. Field and Laboratory QA/QC

The field and laboratory QA/QC programs are designed to ensure data generated throughout the sampling and analysis program meets the DQO for the project and problems that arise are addressed in a timely manner. Quality assurance is a management or oversight function; it deals with setting policy and running an administrative system of management controls that cover planning, implementation, and review of data collection activities and the use of data in decision making. Quality control is a technical function that includes all the scientific precautions, such as calibrations and duplications that are needed to acquire data of known and adequate quality. Field and laboratory QC samples will be collected and analyzed in accordance with USACE and industry standard methods and practices.

4.6.1. Field QA/QC

The field QA program includes the use of appropriately trained and experienced drillers and sample collection personnel, formal and standardized sample collection procedures, documentation of all field activities, second-party review of field logs and notes, and collection of field QC samples.

Field QC samples include blind duplicates, equipment rinsate blanks and trip blanks. Detailed description of field QC samples is provided in the following sections. Blind duplicates are usually collected at a rate of 10% of primary project samples. However, because of the large number of primary samples (approximately 160), blind duplicates will be collected at a rate of about 5% of primary samples (estimate 8 total). Other field QC samples will be collected at the frequency shown in Table 4-1.

Table 4-1. Minimum Field QC Sample Frequency

QC Sample	Collection Frequency
Blind duplicates	Approximately 5% of primary project samples
Equipment rinsate blanks	1 for each 3 days of sample collection (2 to 3 total)
Trip blanks	1 for each shipment of VOC analysis samples, maximum 3

4.6.1.1 Blind Duplicate Samples

Blind duplicate are samples collected from the same location and time, and submitted to the laboratory as separate samples with different sample identification numbers. Blind duplicates are used to document the overall precision of the sampling and analysis program. Duplicate samples will be analyzed for the same parameters as the primary project samples.

4.6.1.2 Equipment Rinsate Blanks

Equipment rinsate blanks are used for non-dedicated or non-disposable sampling equipment (e.g., direct push sampling probe) to assess the adequacy of decontamination procedures. An equipment rinsate blank is collected by pouring analyte-free water over sampling equipment and collecting the rinsate. It is collected after equipment decontamination has been completed and before the next sample is collected.

Equipment rinsate blanks will be collected once ever three days of sample collection (1st, 4th 7th day etc. of sampling). The samples will be analyzed for VOCs or total metal (the other chemical classes have poor water solubility and less likely to be indicative). The analytical procedure will be selected based on the chemicals most likely to be present, or have the highest concentrations in the primary sample collected immediate prior to the rinsate blank.

4.6.1.3 Trip Blanks

Trip blanks are laboratory prepared reagent-free water samples that accompany sample containers throughout the sampling process. The trip blanks will accompany sample container shipments from the analytical laboratories, taken out into the field and managed in the same manner as project samples, and returned to the laboratory along with project sample shipment. Trip blanks are used to document contamination attributable to shipping and field handling procedures. Trip blanks will accompany every sample shipment that contains VOC analysis samples. Trip blanks will be analyzed for VOCs.

4.6.2. Laboratory QA/QC

The laboratory QA program includes using laboratories accredited by the National Environmental Laboratory Accreditation Program (NELAP) for sample analysis; the use of EPA published analytical methods; submitting split samples to a separate QA laboratory; and the preparation and analysis of internal laboratory QC samples.

4.6.2.1 Quality Assurance Laboratory

Field split samples will be collected at a rate of 5% of primary project samples and submitted to a separate laboratory. The QA samples may, but is not required to be collected at the same time as blind field duplicate samples. The Field Manager will mate the determination. The QA laboratory for this project is the PHC laboratory located in Aberdeen Proving Grounds, Maryland. The QA sample analysis results will be compared with results from the primary laboratory to assess overall performance of the primary laboratory.

4.6.3. Laboratory QC Samples

Internal laboratory QC samples will be prepared and analyzed SGS Korea concurrently with project samples. Laboratory QC samples include:

- Method blanks (MB) and reagent blanks

- Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples
- Surrogates (applicable to organic analyses only)
- Blank spike (BS) or laboratory control sample (LCS)

4.6.3.1 Method Blank

A method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.6.3.2 Matrix Spike/Matrix Spike Duplicate

A MS sample is an aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A MS sample is used to document the bias of a method in a given sample matrix. MSD samples are internal laboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. MSD is used to document the precision and bias of a method in a given sample matrix.

MS/MSD analysis will be performed at a rate of about one MS/MSD sample for every 20 project samples, or one for every analytical batch. An extra aliquot of sample will be collected for MS/MSD analyses. Samples for MS/MSD analysis will be designated on the COC form by the Field Manager. The laboratory is not required to use the designated samples for MS/MSD analyses if the samples are batched with other samples, and sufficient volume of other samples is available to perform MS/MSD analyses at the required frequency.

4.6.3.3 Surrogate Spike

A surrogate is an organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. Surrogate spike samples are used to evaluate the capability of the analytical methods to detect the target analytes in each sample and to assess bias and variability that were due to matrix effects and gross laboratory processing errors

4.6.3.4 Laboratory Control Sample

A LCS is a well-characterized sample matrix spiked with compound(s) representative of the target analytes that documents laboratory performance. LCS is used to assess the accuracy of the analytical process independent of project sample matrix and to identify potential background interference or contamination of the analytical system. LCSs will be analyzed and reported for each analytical batch.

4.6.4. Equipment Calibration and Preventive Maintenance

Laboratory equipment will be maintained in accordance with the approved laboratory QA program and as specified by the analytical method employed for sample analyses. The laboratory equipment will be calibrated following the procedures and frequency specified by the analytical methods used. The laboratories are required to document calibration procedures and preventive maintenance in accordance with industry standard guidance and their established QA/QC program. A control system indicating the date of required maintenance, the person maintaining the equipment, and the next maintenance date will be used by laboratory personnel for laboratory equipment requiring routine maintenance. Most of the major instruments found in laboratories are covered by service agreements. Information pertaining to historical maintenance will be recorded in individual logs for each instrument.

4.6.5. Reporting Limits Objectives

The method detection limits (MDL) and laboratory reporting limits for the analytical procedures are provided in Tables 4-2 through 4-8. MDL is the minimum concentration of a substance that can theoretically be measured and reported with 99% confidence that the analyte concentration is greater than zero. The laboratory report limit (or reporting limit) is the concentration that can be measured and reported based on individual laboratory's historic performance record and is the concentration that is actually reported in laboratory data sheets. The detection limits listed may not be achievable in individual samples for any of the following reasons:

4.6.5.5 Data Validation and Usability Assessment

The project chemist will perform data validation by validating the sample and QA/QC results. Data validation is a systematic process for reviewing a body of data against a pre-established set of quality control "acceptance" criteria to determine whether it is within the criteria windows to determine the quality of the data. The validation will be conducted in accordance with EPA Level III data validation protocols.

4.7. Corrective Action

The ultimate responsibility for maintaining quality throughout the investigation rests with the Project Manager. The day-to-day responsibility for ensuring the quality of field and laboratory activities rests with the FED Principle Investigator. All incidences of nonconformance with the established QC parameters will be identified and corrected.

No additional work that is dependent on a nonconforming activity that potentially affects data quality will be performed until the identified nonconformance is corrected. Documentation describing the nonconformity will be submitted to the FED Project Manager. The documentation will include corrective measures to prevent the nonconformity from recurring.

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Table 4-2. VOC Analysis Method Detection Limits and Reporting Limits

NO	Chemical	MDL(ug/kg)	Report Limit(ug/kg)
1	Acetone	5.47	50
2	Benzene	1.22	5
3	Bromobenzene	1.15	5
4	Bromochloromethane	1.14	5
5	Bromodichloromethane	1.11	5
6	Bromoform	0.728	5
7	Bromomethane	1	1
8	2-Butanone	4.22	12.5
9	n-Butylbenzene	1.21	5
10	sec-Butylbenzene	1.31	5
11	tert-Butylbenzene	1.21	5
12	Carbon disulfide	1.26	5
13	Carbon tetrachloride	1.13	5
14	Chlorobenzene	1.16	5
15	Chloroethane	1.67	5
16	Chloroform	1.11	5
17	Chloromethane	0.826	5
18	2-Chlorotoluene	1.18	5
19	4-Chlorotoluene	1.14	5
20	Dibromochloromethane	0.906	5
21	1,2-Dibromo-3-chloropropane	4.58	25
22	Dibromomethane	1.02	5
23	1,2-Dibromoethane (EDB)	1	5
24	1,2-Dichlorobenzene	0.974	5
25	1,3-Dichlorobenzene	1.05	5
26	1,4-Dichlorobenzene	1	5
27	trans-1,4-Dichloro-2-butene	4.8	25
28	1,1-Dichloroethane	1.18	5
29	1,1-Dichloroethene	1.44	5
30	1,2-Dichloroethane	1.1	5
31	cis-1,2-Dichloroethene	1.17	5
32	trans-1,2-dichloroethene	1.23	5
33	1,2-Dichloropropane	0.996	5
34	1,3-Dichloropropane	1.21	5
35	2,2-Dichloropropane	1.24	5
36	1,1-Dichloropropene	1.21	5

Table 4-2. VOC Analysis Method Detection Limits and Reporting Limits

37	cis-1,3-Dichloropropene	1.04	5
38	trans-1,3-Dichloropropene	1.12	5
39	Dichlorodifluoromethane	0.945	5
40	Diisopropyl ether (DIPE)	1.04	5
41	Ethylbenzene	1.22	5
42	Hexachlorobutadiene	1.1	5
43	2-Hexanone	3.17	12.5
44	Iodomethane	1.43	5
45	Isopropylbenzene	1.29	5
46	4-Isopropyltoluene	1.21	5
47	Methylene chloride	1.31	5
48	4-Methyl-2-pentanone	2.53	12.5
49	Methyl-tert-butyl ether (MTBE)	0.949	5
50	Naphthalene	0.816	5
51	n-Propyl benzene	1.28	5
52	Styrene	1.07	5
53	1,1,1,2-Tetrachloroethane	0.954	5
54	1,1,2,2-Tetrachloroethane	0.839	5
55	Tetrachloroethene	1.2	5
56	Toluene	1.14	5
57	1,2,3-Trichlorobenzene	0.952	5
58	1,2,4-Trichlorobenzene	0.918	5
59	Trichloroethene	1.19	5
60	1,1,1-Trichloroethane	1.16	5
61	1,1,2-Trichloroethane	1.14	5
62	Trichlorofluoromethane	1.18	5
63	1,2,3-Trichloropropane	0.848	5
64	1,2,4-Trimethylbenzene	1.18	5
65	1,3,5-Trimethylbenzene	1.21	5
66	Vinyl chloride	0.818	5
67	m/p-Xylene	2.57	10
68	o-Xylene	1.22	5

Table 4-3. SVOC Analysis Method Detection Limits and Reporting Limits

No.	Chemical	MDL (μg/kg)	Report Limit (μg/kg)
1	Acenaphthene	14.2	313
2	Acenaphthylene	13.2	313
3	Anthracene	13.9	313
4	Benzo[a]anthracene	17.2	313
5	Benzo[a]pyrene	17.7	313
6	Benzo[b]fluoranthene	18	313
7	Benzo[g,h,i]perylene	11.2	313
8	Benzo[k]fluoranthene	11.1	313
9	Benzoic Acid	45.9	313
10	Bis(2-chloroethoxy)methane	14.1	313
11	Bis(2-chloroethyl)ether	6.62	313
12	Bis(2-chloroisopropyl)ether	9.94	313
13	Bis(2-ethylhexyl)phthalate	15	313
14	4-bromophenyl phenyl ether	12.2	313
15	Butylbenzylphthalate	11.7	313
16	4-Chloroaniline	25	313
17	4-Chloro-3-methylphenol	15.6	313
18	2-Chloronaphthalene	10	313
19	2-Chlorophenol	16.6	313
20	4-Chlorophenyl phenyl ether	13.7	313
21	Chrysene	13	313
22	Di-n-Butylphthalate	14.8	313
23	Di-n-octylphthalate	17.3	313
24	Dibenzo[a,h]anthracene	14.1	313
25	Dibenzofuran	11.1	313
26	1,2-Dichlorobenzene	15.6	313
27	1,3-Dichlorobenzene	21.1	313
28	1,4-Dichlorobenzene	7.08	313

Table 4-3. SVOC Analysis Method Detection Limits and Reporting Limits

No.	Chemical	MDL (µg/kg)	Report Limit (µg/kg)
29	3,3'-Dichlorobenzidine	15	313
30	2,4-Dichlorophenol	18.1	313
31	Diethylphthalate	16.9	313
32	2,4-Dimethylphenol	22.9	313
33	Dimethylphthalate	12	313
34	2,4-Dinitrotoluene	15.8	313
35	2,6-Dinitrotoluene	22.4	313
36	Diphenylamine	14.1	313
37	Fluoranthene	10.5	313
38	Fluorene	16.6	313
39	Hexachlorobenzene	29.6	313
40	Hexachlorobutadiene	18.7	313
41	Hexachlorocyclopentadiene	94.7	313
42	Hexachloroethane	18	313
43	Indeno(1,2,3-c,d)pyrene	9.7	313
44	Isophorone	14.2	313
45	2-Methylnaphthalene	9.94	313
46	2-Methylphenol	17.3	313
47	3-, 4-Methylphenol	20.3	313
48	N-Nitrosodi-n-propylamine	89.6	313
49	Naphthalene	9.7	313
50	2-Nitroaniline	20.6	313
51	3-Nitroaniline	14.1	313
52	4-Nitroaniline	18	313
53	Nitrobenzene	18	313
54	2-Nitrophenol	15	313
55	Pentachlorophenol	25	313
56	Phenanthrene	9.7	313

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Table 4-3. SVOC Analysis Method Detection Limits and Reporting Limits

No.	Chemical	MDL (µg/kg)	Report Limit (µg/kg)
57	Phenol	13	313
58	Pyrene	13.2	313
59	1,2,4-Trichlorobenzene	10.9	313
60	2,4,5-Trichlorophenol	20.9	313
61	2,4,6-Trichlorophenol	21.2	313

Table 4-4. Metals Analysis Method Detection Limits and Reporting Limits

No.	Chemical	MDL(mg/kg)	Report Limit(mg/kg)
1	Arsenic	0.365	4.0
2	Barium	0.388	3.5
3	Cadmium	0.0764	0.5
4	Chromium	0.797	0.5
5	Lead	0.099	0.4
6	Mercury (µg/kg)	0.0101	0.02
7	Selenium	0.24	5.0
8	Silver	0.112	0.5

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Table 4-5. Organochlorine Pesticide Analysis Method Detection Limits and Reporting Limits

No.	Chemical	MDL (µg/kg)	Report Limit (µg/kg)
1	4,4'-DDD	0.2150	7.81
2	4,4'-DDE	0.2920	7.81
3	4,4'-DDT	0.2710	7.81
4	Aldrin	0.3240	7.81
5	alpha-BHC	0.2920	7.81
6	alpha-Chlordane	0.2960	7.81
7	beta-BHC	0.2550	7.81
8	Chlordane	3.9400	31.3
9	delta-BHC	0.2730	7.81
10	Dieldrin	0.3060	7.81
11	Endosulfan I	0.3000	7.81
12	Endosulfan II	0.3120	7.81
13	Endosulfan sulfate	0.3470	7.81
14	Endrin	0.2220	7.81
15	Endrin aldehyde	0.3400	7.81
16	Endrin ketone	0.3710	7.81
17	gamma-BHC (Lindane)	0.2890	7.81
18	gamma-Chlordane	0.2970	7.81
19	Heptachlor	0.3610	7.81
20	Heptachlor epoxide	0.3000	7.81
21	Methoxychlor	0.3270	7.81
22	Toxaphene	3.7400	31.3

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Table 4-6. Organophosphorus Pesticide Analysis Method Detection Limits and Reporting Limits

No.	Chemical	MDL (µg/kg)	Report Limit (µg/kg)
1	Azinphos methyl	17.0	66
2	Bolstar (Sulprofos)	17.0	66
3	Chlorpyrifos	17.0	66
4	Coumaphos	17.0	66
5	Demeton, O and S	33.0	130
6	Diazinon	17.0	66
7	Dichlorvos	17.0	66
8	Dimethoate	17.0	66
9	Disulfoton	17.0	66
10	EPN	17.0	66
11	Ethoprop	17.0	66
12	Fensulfothion	17.0	66
13	Fenthion	17.0	66
14	Malathion	17.0	66
15	Merphos	17.0	170
16	Mevinphos	17.0	66
17	Monocrotophos	66.0	170
18	Naled	17.0	66
19	Parathion-ethyl	17.0	66
20	Parathion-methyl	17.0	66
21	Phorate	17.0	66
22	Ronnel	17.0	66
23	Sulfotep	17.0	66
24	Tepp	66.0	66
25	Stirophos (Tetrachlorovinphos)	17.0	66
26	Tokuthion (Protothiofos)	17.0	66
27	Trichloronate	17.0	66

Table 4-7. Chlorinated Herbicide Analysis Method Detection Limits and Reporting Limits

No.	Chemical	MDL (µg/kg)	Report Limit (µg/kg)
1	2,4-D	7.12	15.6
2	2,4-DB	6.97	15.6
3	2,4,5-TP (Silvex)	4.31	15.6
4	2,4,5-T	4.41	15.6
5	Dicamba	4.8	15.6

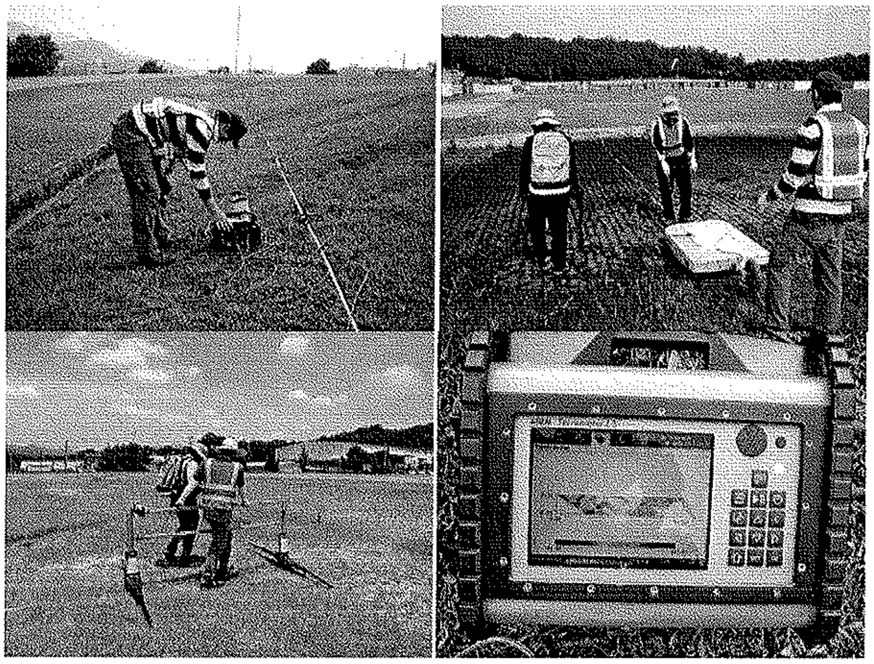
Table 4-8. Dioxin and Furan Analysis Method Detection Limits and Reporting Limits

No.	Chemical	MDL (µg/kg)	Report Limit (µg/kg)
1	2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.180	0.5
2	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.299	2.5
3	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.336	2.5
4	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.264	2.5
5	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	0.405	2.5
6	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.603	2.5
7	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	2.877	5.0
8	2,3,7,8-Tetrachlorodibenzofuran (TCDF)	0.091	0.5
9	1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	0.328	2.5
10	2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	0.241	2.5
11	1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.131	2.5
12	1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	0.215	2.5
13	1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	0.250	2.5
14	2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	0.768	2.5
15	1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF	0.267	2.5
16	1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	0.611	2.5
17	1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	0.642	5.0

US Army Corps of Engineers
Far East District®

PHASE II/IIb SOIL SAMPLING WORK PLAN

Camp Carroll
U.S. Army Garrison Daegu, Republic of Korea



July 28, 2011

Prepared By:

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ACRONYMS AND ABBREVIATIONS

2,4-D	2,4-dichlorophenoxyacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
amsl	above mean sea level
bgs	below ground surface
dioxins	polychlorinated dibenzo-p-dioxins
DQO	data quality objective
DSN	Defense Switched Network
EM	Engineering Manual
EPA	U.S. Environmental Protection Agency
FED	U.S. Army Corps of Engineers, Far East District
furans	polychlorinated dibenzofurans
LCS	laboratory control sample
MDL	method detection limit
MEDCOM	U.S. Army Medical Command
PHC	Public Health Command (Provisional)
MS	matrix spike
MSD	matrix spike duplicate
PID	photo-ionization detector
PPE	personal protective equipment
ppm	parts per million
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
USACE	U.S. Army Corps of Engineers
VOA	volatile organic analysis
VSP	Visual Sample Plan
WP	Work Plan
°C	degrees Celsius
°F	degrees Fahrenheit

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1. INTRODUCTION

This soil sampling Work Plan (WP) describes the procedures and equipment that will be used to investigate subsurface anomalies identified by the recently completed geophysical survey at the Phase II area located on U.S. Army Garrison (USAG) Daegu Camp Carroll, Republic of Korea (ROK). A series of environmental investigations is being undertaken to determine whether subsurface soil contamination at the area poses an unacceptable health risk. The soil sampling will be conducted by the U.S. Army Corp of Engineers Far East District (FED) Environmental Section and its contractors. The risk assessment will be performed by U.S. Army Public Health Command.

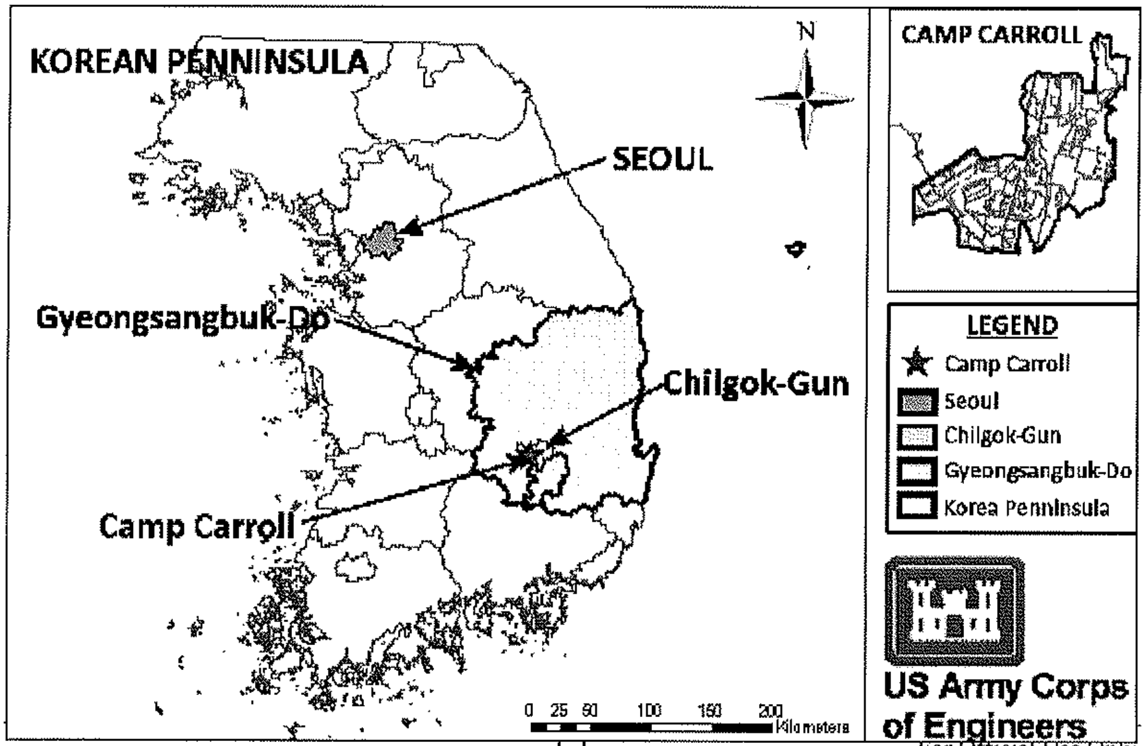
1.1. Project Objectives and Scope

The overall objective of the project is to acquire sufficient environmental data for subsurface soils to perform a human health risk assessment. The scope of the project includes review of available background information and geophysical survey results, identify data gaps, developing sample collection strategy, and the advancement of soil boring to collect subsurface soil samples for laboratory analysis.

1.2. Site Description and Background

USAG Daegu Camp Carroll (Camp Carroll) is located in Chilgok-Gun, Gyeongsanbuk-Do, adjacent to the city of Waegwan in the south-central portion of the ROK (Figure 1-1). Camp Carroll serves as the Headquarters of the U.S. Army Material Support Center and functions as a staging ground for U.S. military operations on the Korean Peninsula.

Figure 1-1. Camp Carroll Location Map



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 the installation to the northwest, west and southwest. Hilly, forested areas bound the installation to the north and east. Agricultural fields (mostly rice paddies) border the camp on the northeast and the south, and the Naktong River flows from north to south approximately 0.5 kilometers west of Camp Carroll.

The Phase II/IIb area is located in the southeastern portion of Camp Carroll hear the installation's eastern boundary (Figure 1-2). The Phase II/IIb investigation site encompasses an area located in southeastern portion of Camp Carroll where disposal and burial of hazardous material and waste, some in 55-gallon drums, allegedly occurred in 1978. The buried drums and about 40 to 60 tons of contaminated soil were reportedly excavated and removed during 1979 and 1980. The disposition of the removed materials is not known.

Figure 1-2. Phase II Site Location Map

1.3. Project Site Physical Characteristics

1.3.1. Geology and Soils

The basement rock underlying Camp Carroll is composed of Precambrian granitic gneiss and Mesozoic granite. Siliceous dikes intrude the gneiss without any observed dominant regional trend. In the northern part of Waegwan city, thin beds of quartzite, calcareous-schist, and limestone have been reported.

Based on drilling logs from 11 groundwater monitoring wells located in the southern portion of Camp Carroll, the bedrock in this part of the base is composed largely of granitic gneiss and granodiorite. The upper 100 to 200 feet is weathered, with the degree of weathering decreasing with depth. Calcareous-schist and limestone were reportedly encountered near the bottom of some of the deeper wells. The overburden in the vicinity of these wells varies from 20 to 40 feet in thickness and ranges in composition from silty clays to gravel-rich sandy silts. The soils can be generally described as moist, medium dense, brown, silty to clayey, fine to coarse sand (SM to SC), with approximately 20 percent to 40 percent gravels and cobbles. The soils are predominantly derived from weathered granitic materials.

1.3.2. Climate

The climate of the ROK is defined by its mid-latitudinal location on a peninsula, as well as its configuration as an appendage to the Asian continent. Korea has a humid, East Asian monsoonal climate characterized by short, humid summers and dry, cold winters. The climate is influenced more by the continental climate during winter months and by the ocean during summer months.

Winters are cold and dry with an average daily maximum temperature in the mid 30s degree Fahrenheit. Occasionally, the daytime temperature will climb into the 40 or 50-degree

Fahrenheit range. During winter, light northwesterly winds generally prevail. There is little snowfall in the area around Seoul. In spring, average daily high temperatures climb into the low 70s.

The monsoon, a rainy season of three to five weeks duration, begins in late June or early July with temperatures in the middle to upper 80s, relative humidity between 73 and 93 percent, and light southwesterly winds. Fall season starts in mid-September bringing mild and pleasant weather, with a marked drop in rainfall. Fall season on average lasts from mid-September through mid-November, with a gradual transition from summer to winter. The average annual precipitation in Seoul is 49.6 inches, with 72 percent of the annual rainfall occurring during the monsoonal period.

1.3.3. Hydrologic Setting

Based on groundwater elevation measurements obtained from 18 monitoring wells installed in 1992, elevation to the top of the groundwater table ranged from about 51 ft to 123 ft above mean sea level (amsl). One well in the northern portion of the base had a groundwater elevation of 191 feet amsl. Overall, groundwater at Camp Carroll flows generally to the south and southwest.

1.4. Previous Investigation and Data Gap Analysis

There have been several environmental investigations conducted in the area, including subsurface soil and groundwater investigations conducted in the nearby Area D and the Landfarm site. No environmental sampling and analysis had been conducted specifically for the Helipad site.

1.4.1. Phase II Geophysical Survey

The Phase II geophysical survey covered an area measuring approximately 180 m from north to south and 80 m east to west. The survey was conducted using three non-intrusive techniques: magnetic gradiometry, ground penetrating radar (GPR), and electrical resistivity imaging (ERI). The survey results were combined and a final interpretation of the data, along with subsurface anomaly zones that have been identified are shown on Figure 1-3. The results of the Phase II geophysical survey are summarized as follows:

- The Magnetic Gradiometry survey results indicate five subsurface anomalies.
- The GPR survey results indicate one subsurface anomaly.
- The ERI survey results indicate four subsurface anomalies.
- The combined results of the three surveys indicate four anomaly zones, identified as Zones A, B, C and D on Figure 1-3 where foreign objects may be present.
- Subsurface anomalies zones may be attributed to loosely packed soils, high water content, or buried foreign objects such as steel drums.

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- Zone A has the highest probability to contain buried foreign objects, with higher probabilities indicated by darker shades of red.

1.5. Chemicals of Potential Concern

The chemicals of potential concern (COPC) were identified by U.S. Army Medical Command (MEDCOM) Public Health Command (PHC) based on materials that were allegedly buried at the site and human health risk assessment requirements. The COPC for this project includes various degreasers and solvents; metals; pesticides and herbicides, including Agent Orange components 2,4-D and 2,4,5-T; and dioxins and furans. For laboratory analyses purposes, the COPC are grouped into the following chemical classes:

- Volatile organic compounds (VOCs)
- Semivolatile organic compounds (SVOCs)
- Metals regulated under the Resource Conservation and Recovery Act (RCRA)
- Organochlorine (OC) pesticides
- Organophosphorus (OP) pesticides
- Chlorinated herbicides
- Dioxins and Furans

1.6. Conceptual Site Model

A conceptual site model (CSM) was developed based on the COPC identified and an assessment of potential exposure pathways. The CSM also took into consideration current site usage and proposed future use of the site and potential receptors. The CSM is presented in graphical format on Figure 1-4.

1.7. Work Plan Organization

This WP contains the project Sampling and Analysis Plan (SAP), which provides a detailed description of sample collection and laboratory methodologies, as well as the Quality Assurance Project Plan (QAPP). The WP is organized as follows:

- Section 1 - Introduction
- Section 2 - Project Organization
- Section 3 - Sampling and Analysis Plan
- Section 4 - Quality Assurance Project Plan
- Section 5 - References

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Figure 1-3. Final Interpretation of Subsurface Anomaly Zones

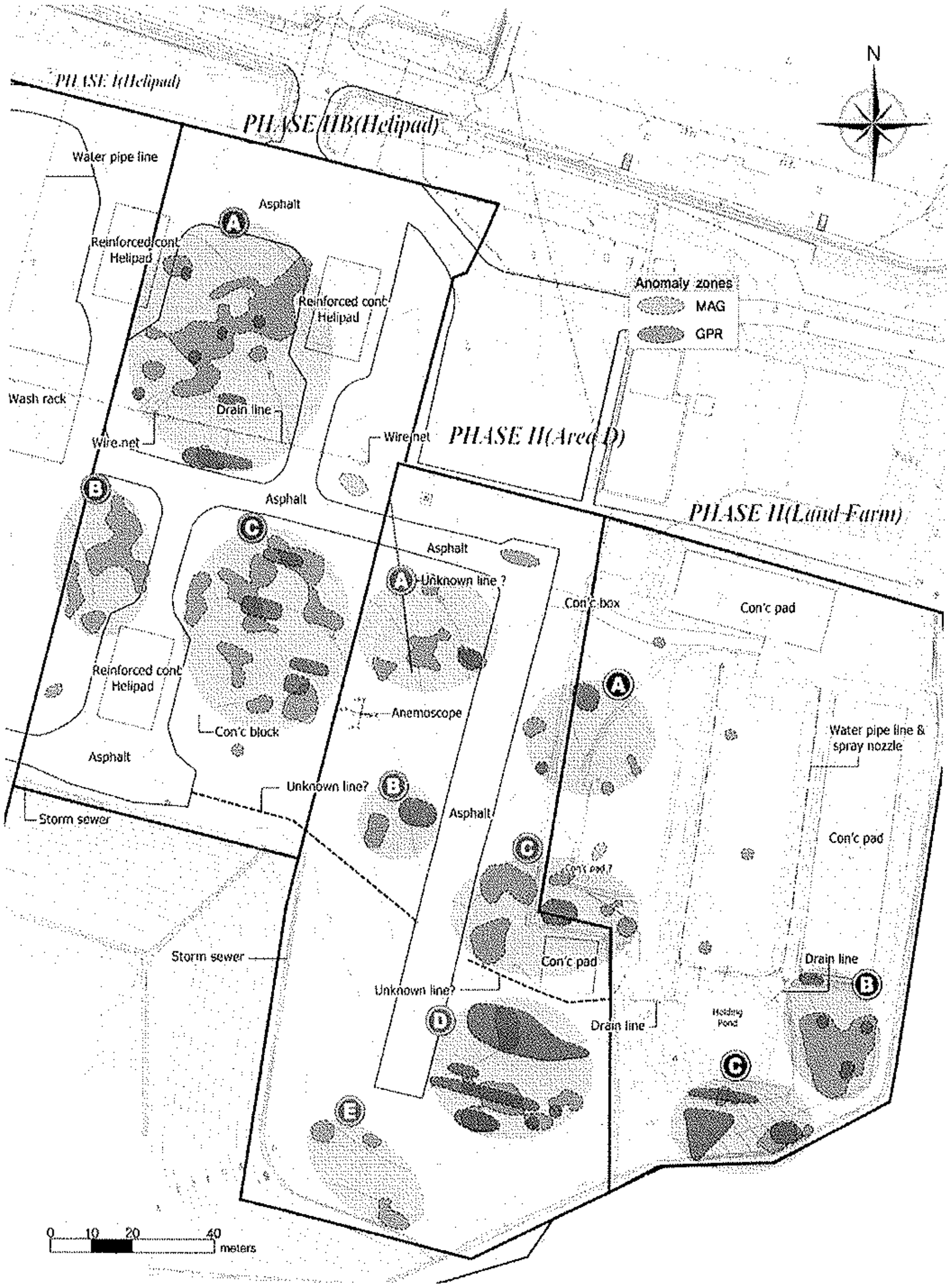
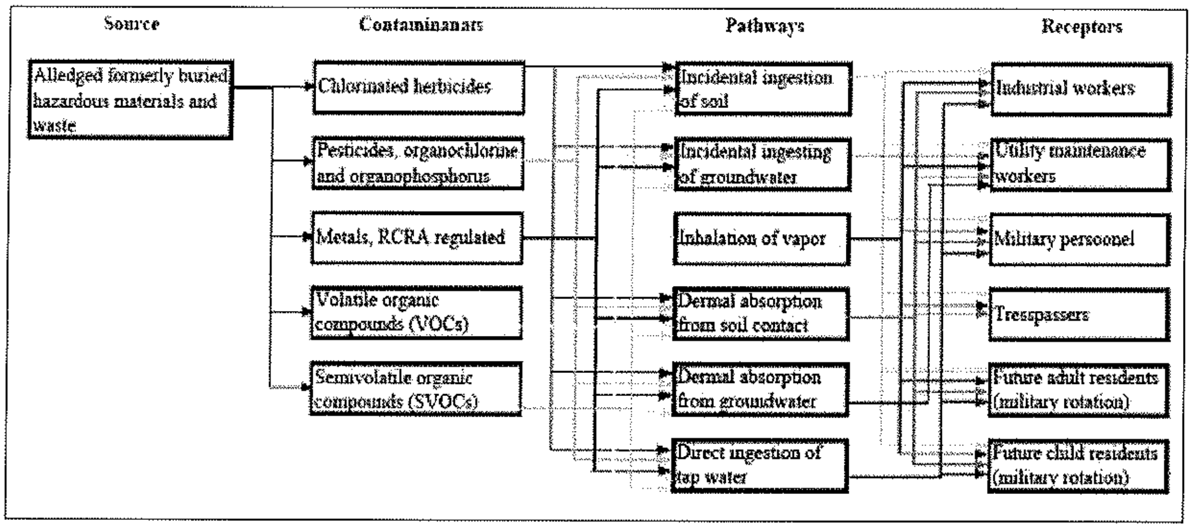


Figure 1-4. Phase II Site Conceptual Site Model



2. PROJECT ORGANIZATION

The project organizational structure is designed to ensure that everyone involved with the project will receive proper instruction and information, and that appropriate quality assurance and quality control procedures will be followed throughout the project.

2.1. Key Project Personnel

Key personnel and their contact information for this project are provided in Table 2-1.

Table 2-1. Key Project Personnel and Contact Information

Title	Name	Telephone	Email
Project Manager	Mr. [redacted] b6	DSN: [redacted] b6 b6 Commercial: [redacted] Mobile: [redacted] b6	[redacted]@usace.army.mil b6
Project Engineer	Dr. [redacted] b6	DSN: [redacted] b6 Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@usace.army.mil b6
Chemist/QA Manager	Dr. [redacted] b6	DSN: [redacted] b6 Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@usace.army.mil b6
Field Manager	Dr. [redacted] b6	DSN: [redacted] b6 Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@usace.army.mil b6
PHC Risk Assessor	Mr. [redacted] b6		[redacted]@us.army.mil b6

Subcontract Drilling Team	BEC Co., Ltd. Mr. [redacted] b6	Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@esakorea.com b6
Analytical Laboratory	SGS Korea Mr. [redacted] b6	Commercial: [redacted] b6 Mobile: [redacted] b6	[redacted]@sgs.com b6

2.2. Project Schedule

The project has a high priority and all aspects have been compressed and expedited. Soil sample collection is scheduled to begin on or about 1 August. Anticipated project milestones are shown in Table 2-2. Prior to mobilization, all equipment inspected and tested to verify operability. Spare parts and contingency materials will be obtained and inspected to ensure preparedness during the field effort.

Table 2-2. Project Schedule

Project Milestone	Completion Date
1. Prepare project Work Plan	27 July 2011
2. Initiate field investigation	1 August 2011
2.1 Complete field investigation	20 July 2011
3. Complete laboratory analyses	15 August 2011
4. Submit draft soil sampling and risk assessment report	31August 2011
5. Submit final soil sampling and risk assessment report	30 September 2011

Ground transportation will be used for mobilizing personnel and materials to Camp Carroll. The contractors will be responsible for mobilizing the appropriate equipment to the sites. To ensure the success and efficient execution of the project, coordination efforts with stakeholders will be made prior to mobilization to identify and mitigate potential obstacles and determine personnel schedules necessary to best complete the effort. Coordination will be required to mitigate work stoppage due to helicopter landings.

3. SAMPLING AND ANALYSIS PLAN

The soil sampling strategy was developed based on the results of the subsurface geophysical survey and in consultation with PHC Risk Assessor and the ROK governmental representatives.

The borehole locations were adjusted to reflect the needs of the PHC risk assessors and following consultation with ROK governmental representatives. The planned borehole locations are shown on Figure 3-1. The final locations of the boreholes may be adjusted by the Field Manager based on site conditions and observations as the drilling progresses.

3.1. Site Preparation

The most important consideration for all field activities to be performed is the safety and health of all on-site personnel and the surrounding community. A site-specific Safety and Health Plan (SSHP) has been prepared, which includes the Activity Hazard Analysis and Accident Prevention Plan.

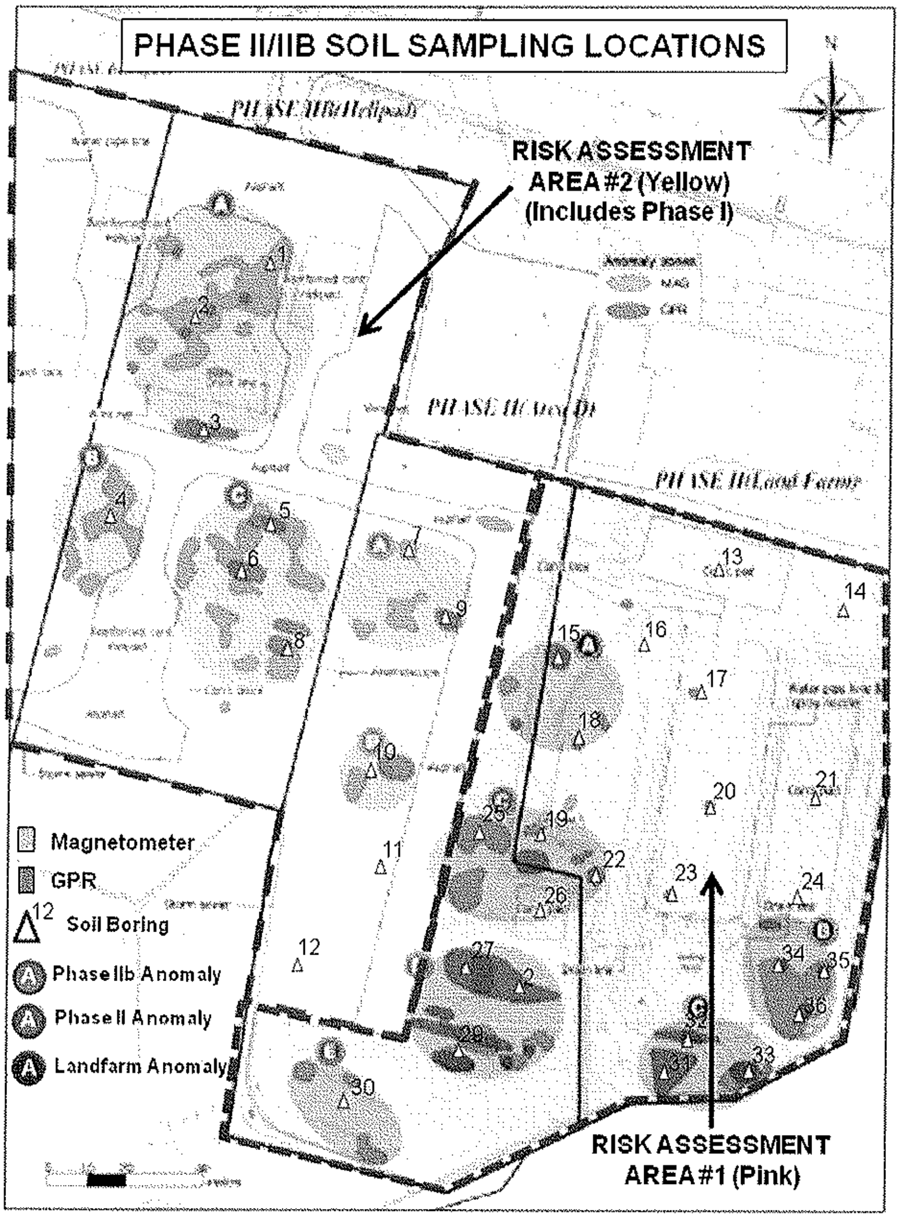
Project personnel will establish a safe perimeter around each work area. Traffic barriers or cones will be used in areas accessible to vehicles to redirect traffic if necessary. Prior to starting work, a safety and health meeting will be conducted by the Site Safety and Health Officer (SSHO).

3.2. Soil Sample Collection Procedure

Subsurface soil samples will be collected using direct-push drilling. Project personnel will be responsible for collecting samples and decontaminating the sampling equipment. To avoid cross contamination of the samples and to protect worker safety and health, the person performing the sample collection will use a new pair of disposable nitrile gloves while collecting each sample.

Up to three samples will be collected from each borehole location. The initial sample intervals will be 0 to 0.5 m below ground surface (bgs), at 0.5 to 2 m bgs, from 2 m to 5 m bgs, and the 2 m increment immediately above the bottom of the borehole (refusal or 10 m, whichever is shallower). In the event groundwater is encountered, the four soil sampling depth zones for subsequent chemical testing will be: 0 to 0.5 m, 0.5 to 2 m, immediately above the groundwater table, and immediately below the groundwater table. The specific collection depths may be adjusted by the Field Manager based on site observations. Maximum drilling depth will be 10 m bgs, even if no groundwater is encountered at a borehole location. Drilling depth may also be limited by depth to bedrock should bedrock be encountered at less than 10 m bgs.

Figure 3-1. Phase II Site Conceptual Site Model



Upon withdrawal from the boreholes, the soil sample will be transferred into certified clean environmental sample containers. Samples to be analyzed for VOCs will be placed into methanol and reagent grade water-preserved 40 mL volatile organic analysis (VOA) vials using a Terra-Core soil plunger.

In order to provide sufficient sample volume for the requisite laboratory analyses, 12 oz of soil and three 40 mL VOA will be required for each sample. Each sample will also be collected in duplicate, with one set provided to the ROK government for their analysis. Additional sample volume will be required for quality assurance and quality control (QA/QC). A description of QA/QC sampling requirements is provided in Section 4.

3.3. Sample Management

All samples will be labeled with unique sample identification numbers and placed into individual laboratory sample jars, then into insulated coolers filled with ice for preservation. The samples will be chilled and maintained at a temperature of 4 degrees Celsius (°C) ± 2 °C and managed under chain-of-custody (COC) protocol and documentation until shipment to the analytical laboratories. COC forms will not be provided with the samples going to the ROK government.

Field notes will be maintained by FED personnel recording the location, sample media, number, date and time for each sample collected as well as any appropriate observations. The field notes will be recorded in a bound notebook using an indelible marker. Digital color photographs will be taken to document the field investigation, with select photographs to be included in the report.

3.3.1. Sample Identification Sequence

Soil sample identification number will have the following general sequence:

B-yy-xxx-Sm

where,

B: Boring
yy: last 2 digits of current year
xxx: sequential borehole number
S: soil sample
m: sequential sample number in a borehole

Alternative sample identification number may be used at the discretion of the Field Manager. Samples provided to the ROK government will have the same identification number to facilitate comparison of analytical results.

3.4. Investigation Derived Waste

Investigation derived waste (IDW) may include concrete debris, drill cuttings, decontamination water and used personal protective equipment (PPE). IDW will be collect into 55-gal drums that meet the specifications for hazardous waste. The drums will be labeled a drum identification number, project name, drum content (associated borehole number), date(s) generated, contractor name, FED Point of Contact (POC) and telephone number using paint or permanent marker. The drums will be stored on-site or at a location designated by the Camp Carroll Environmental Office while awaiting laboratory analyses results. The IDW will be managed and disposed based on the results of laboratory analyses.

3.5. Site Restoration

Boring locations will be backfilled with clean soil cuttings or bentonite pellets and the surfaces restored to match existing surface covering. Significant site damage is not anticipated during this investigation, thus site restoration should be minimal.

3.6. Borehole Survey

The location and elevation of boreholes will be surveyed using Global Positioning System (GPS) to centimeter-level accuracy after completion of sample collection and site restoration. The location of relevant site features will also be surveyed. The survey coordinates will be reported using the Universal Transverse Mercator (UTM) World Geodetic System (WGS84).

3.7. Laboratory Analyses

Soil samples collected will be analyzed for the COPC using U.S. Environmental Protection Agency (EPA) methods published in SW-846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods." The specific analytical methods that will be used for the COPC chemical classes are shown in Table 3-1. A complete listing of analytical parameters is provided in Section 4.

3.7.1. Sample Containers, Preservation Techniques, and Holding Times

Each soil sample will require a volume of about 12 oz, which will be collected using one 4 oz and one 8 oz glass jars, and one 40 mL VOA vile. Sample holding times (time between sample collection and analysis) have not been established for soil matrixes. Current EPA guidelines and industry standard is to use holding times in SW-846 for aqueous samples. The holding times are shown in Table 3-1.

Table 3-1. Analytical Methods and Sample Holding Times

Analytical Parameter	Analytical Method (EPA SW-846)	Sample Holding Time (days)	
		Until Extraction	After Extraction
VOCs	8260	-	14
SVOCs	8270	14	40

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RCRA metals (total)	6010/7471 (Hg)	-	6 months; Hg 28 days
OC pesticides	8081	14	40
OP pesticides	8141	14	40
Chlorinated herbicides	8151	14	40
Dioxins and Furans	8290	30	45

Hg - mercury

4. QUALITY ASSURANCE PROJECT PLAN

This section presents the Quality Assurance Project Plan (QAPP) for the Phase II soil sampling and laboratory analysis activities. The purpose of the QAPP is to ensure that all field and laboratory activities are conducted in a manner consistent with regulatory requirements, official guidelines and industry standards to provide data representative of conditions present at the site. The QAPP addresses the following:

- Method selection and target analyte lists
- Laboratory and field QA acceptance criteria
- Field and laboratory documentation and data management
- Data validation requirements
- Data evaluation procedures
- Performance and system audits
- Preventative maintenance
- Corrective actions
- QA/QC reporting

4.1. Data Quality Objectives

The overall sampling and analysis strategy was developed using the EPA's data quality objectives (DQO) process (EPA, 1994). DQO are qualitative and quantitative statements that specify the quality of data required to support decisions concerning the project site. The DQO process begins by identifying the type of decisions that will be made regarding a site, evaluation of available information, developing a conceptual site model, and specifying project objectives. The next step is the identification of data needs and data quality needs, followed by design of the sample collection program.

The objective of the soil sampling and analysis program is to provide data with sufficient quality to perform a human health risk assessment. The usability of the data collected will depend on its quality. A large number of factors along the sample collection and analysis process have the potential to impact the overall quality of the data generated. Adhering to proper sample collection techniques, observing and documenting COC procedures and using certified laboratories and approved analytical methods will ensure that the quality of data generated will meet project objectives.

4.2. Sample Collection and Handling Procedures

Copies of this project WP outlining appropriate field procedures will be provided to field personnel, one copy of the WP will also be maintained in the field by the FED site personnel during sample collection activities. Prior to sampling, the Project Manager or the QA Manager will inspect all supplies and consumables to insure that they are acceptable for use.

Sampling and sample handling procedures are designed to ensure that samples are consistently collected, labeled, preserved, and transported in a manner that maintains their integrity for their intended purposes. Copies of this WP and appropriate field procedures will be carried by field personnel during field data collection.

4.2.1. Sample Logs, Labeling, and Chain-of-Custody

Bound, paginated, and waterproof field notebooks will be maintained by the Field Manager to provide daily records of significant events, observations, and measurements during field tasks. Each sample container sent to the laboratory must have its own sample identification label, as described in Section 3.

Samples will be managed under COC protocol, which is under direct observation by project personnel or under lock and key. COC documentation will be maintained for samples during all phases of sample collection, transport, and receipt and internal transfer within the laboratory.

4.2.2. Sample Handling and Shipping

Upon collection, samples will be properly labeled, packaged and transported to the laboratory as soon as possible. Soil samples will be hand delivered to SGS Testing Korea. COC forms will be placed inside resealable plastic bags and accompany the sample shipment to the laboratories.

4.3. Field Instrument Calibration and Maintenance

Field equipment that may be used during field activities for documentation purposes may include: PID, Handheld GPS unit, and Digital Camera. Preventive maintenance of field equipment will be performed in accordance with the requirements of the specified manufacturer. Equipment will be periodically cleaned, checked for operability, and repaired as necessary. Equipment will be properly stored when not in use.

Field equipment will be calibrated prior to and during use as specified by the manufacturer. All calibration activities will be noted in the field logbooks. Field personnel are responsible for ensuring that the instruction manuals are on-site with the equipment and that the equipment is tested, calibrated, and in good working condition prior to use. Field equipment preventive maintenance frequencies will be determined based on manufacturer recommendations and the anticipated use of the equipment.

4.4. Field Consumables and Supplies

All field consumables will be inspected by the field manager prior to use and discarded if the integrity has been altered and there is any possibility of the use of the consumable will sacrifice the integrity of the sampling effort.

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4.5. Equipment Decontamination

The proper decontamination of all non-dedicated sampling equipment that come into contact with sample media is crucial to obtaining data that meets the quality objectives of the project. The decontamination procedures were also developed to ensure worker safety and health, and to prevent the spread of contamination off-site. All sample collection equipment will be decontaminated by project personnel before their initial use and between uses. Individuals who are conducting sample collection or handling the sample media directly will wear disposable nitrile gloves and put on a new pair of gloves for each sample. Personnel who may otherwise handle sampling equipment may wear nitrile outer gloves that can be decontaminated as necessary.

4.5.1. Sampling Equipment Decontamination

After a sample has been collected, the sample collector will remove the nitrile gloves without touching the outside of the gloves during removal and place the gloves in a trash bag. All sampling equipment that comes into contact with environmental media will be decontaminated as follows:

- Gross contamination will be scraped off or wiped off with paper towels.
- The equipment will be washed in a solution containing Alconox or equivalent detergent and potable water and scrubbed with a brush or scouring pad.
- The equipment will be rinsed in at least one bucket containing potable tap water.
- A final rinse will be performed using deionized or distilled water.
- Rinse and detergent water will be replaced as necessary.
- After decontamination, the sampling equipment will be placed in a clean area or on clean plastic sheeting.

If a piece of sampling equipment will not be used immediately after decontamination, the equipment will be covered with plastic sheeting or placed in clean plastic bags.

4.5.2. Heavy Equipment Decontamination

Heavy equipment parts that come into contact with contaminated environmental media during their operation (e.g., drill rig probe) will be decontaminated between sample locations. The following steps will be used to decontaminate heavy equipment:

- Personnel performing the decontamination will wear PPE required by the SSHP.
- Gross contamination will be scraped off.
- Equipment will be steam cleaned or scrubbed using an industrial detergent such as Alconox.
- Additional washing with Alconox or equivalent detergent solution and rinsing with potable water may be conducted at the discretion of the FED Site Inspector.

- After decontamination, drilling equipment will be placed on the drill rig. If equipment is not used immediately, it will be stored in a clean area.

4.6. Field and Laboratory QA/QC

The field and laboratory QA/QC programs are designed to ensure data generated throughout the sampling and analysis program meets the DQO for the project and problems that arise are addressed in a timely manner. Quality assurance is a management or oversight function; it deals with setting policy and running an administrative system of management controls that cover planning, implementation, and review of data collection activities and the use of data in decision making. Quality control is a technical function that includes all the scientific precautions, such as calibrations and duplications that are needed to acquire data of known and adequate quality. Field and laboratory QC samples will be collected and analyzed in accordance with USACE and industry standard methods and practices.

4.6.1. Field QA/QC

The field QA program includes the use of appropriately trained and experienced drillers and sample collection personnel, formal and standardized sample collection procedures, documentation of all field activities, second-party review of field logs and notes, and collection of field QC samples.

Field QC samples include blind duplicates, equipment rinsate blanks and trip blanks. Detailed description of field QC samples is provided in the following sections. Blind duplicates are usually collected at a rate of 10% of primary project samples. However, because of the large number of primary samples (approximately 160), blind duplicates will be collected at a rate of about 5% of primary samples (estimate 8 total). Other field QC samples will be collected at the frequency shown in Table 4-1.

Table 4-1. Minimum Field QC Sample Frequency

QC Sample	Collection Frequency
Blind duplicates	Approximately 5% of primary project samples
Equipment rinsate blanks	1 for each 3 days of sample collection (2 to 3 total)
Trip blanks	1 for each shipment of VOC analysis samples, maximum 3

4.6.1.1 Blind Duplicate Samples

Blind duplicate are samples collected from the same location and time, and submitted to the laboratory as separate samples with different sample identification numbers. Blind duplicates are used to document the overall precision of the sampling and analysis program. Duplicate samples will be analyzed for the same parameters as the primary project samples.

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4.6.1.2 Equipment Rinsate Blanks

Equipment rinsate blanks are used for non-dedicated or non-disposable sampling equipment (e.g., direct push sampling probe) to assess the adequacy of decontamination procedures. An equipment rinsate blank is collected by pouring analyte-free water over sampling equipment and collecting the rinsate. It is collected after equipment decontamination has been completed and before the next sample is collected.

Equipment rinsate blanks will be collected once ever three days of sample collection (1st, 4th 7th day etc. of sampling). The samples will be analyzed for VOCs or total metal (the other chemical classes have poor water solubility and less likely to be indicative). The analytical procedure will be selected based on the chemicals most likely to be present, or have the highest concentrations in the primary sample collected immediate prior to the rinsate blank.

4.6.1.3 Trip Blanks

Trip blanks are laboratory prepared reagent-free water samples that accompany sample containers throughout the sampling process. The trip blanks will accompany sample container shipments from the analytical laboratories, taken out into the field and managed in the same manner as project samples, and returned to the laboratory along with project sample shipment. Trip blanks are used to document contamination attributable to shipping and field handling procedures. Trip blanks will accompany every sample shipment that contains VOC analysis samples. Trip blanks will be analyzed for VOCs.

4.6.2. Laboratory QA/QC

The laboratory QA program includes using laboratories accredited by the National Environmental Laboratory Accreditation Program (NELAP) for sample analysis; the use of EPA published analytical methods; submitting split samples to a separate QA laboratory; and the preparation and analysis of internal laboratory QC samples.

4.6.2.1 Quality Assurance Laboratory

Field split samples will be collected at a rate of 5% of primary project samples and submitted to a separate laboratory. The QA samples may, but is not required to be collected at the same time as blind field duplicate samples. The Field Manager will mate the determination. The QA laboratory for this project is the PHC laboratory located in Aberdeen Proving Grounds, Maryland. The QA sample analysis results will be compared with results from the primary laboratory to assess overall performance of the primary laboratory.

4.6.3. Laboratory QC Samples

Internal laboratory QC samples will be prepared and analyzed SGS Korea concurrently with project samples. Laboratory QC samples include:

- Method blanks (MB) and reagent blanks

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- Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples
- Surrogates (applicable to organic analyses only)
- Blank spike (BS) or laboratory control sample (LCS)

4.6.3.1 Method Blank

A method blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.6.3.2 Matrix Spike/Matrix Spike Duplicate

A MS sample is an aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A MS sample is used to document the bias of a method in a given sample matrix. MSD samples are internal laboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. MSD is used to document the precision and bias of a method in a given sample matrix.

MS/MSD analysis will be performed at a rate of about one MS/MSD sample for every 20 project samples, or one for every analytical batch. An extra aliquot of sample will be collected for MS/MSD analyses. Samples for MS/MSD analysis will be designated on the COC form by the Field Manager. The laboratory is not required to use the designated samples for MS/MSD analyses if the samples are batched with other samples, and sufficient volume of other samples is available to perform MS/MSD analyses at the required frequency.

4.6.3.3 Surrogate Spike

A surrogate is an organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. Surrogate spike samples are used to evaluate the capability of the analytical methods to detect the target analytes in each sample and to assess bias and variability that were due to matrix effects and gross laboratory processing errors

4.6.3.4 Laboratory Control Sample

A LCS is a well-characterized sample matrix spiked with compound(s) representative of the target analytes that documents laboratory performance. LCS is used to assess the accuracy of the analytical process independent of project sample matrix and to identify potential background interference or contamination of the analytical system. LCSs will be analyzed and reported for each analytical batch.

4.6.4. Equipment Calibration and Preventive Maintenance

Laboratory equipment will be maintained in accordance with the approved laboratory QA program and as specified by the analytical method employed for sample analyses. The laboratory equipment will be calibrated following the procedures and frequency specified by the analytical methods used. The laboratories are required to document calibration procedures and preventive maintenance in accordance with industry standard guidance and their established QA/QC program. A control system indicating the date of required maintenance, the person maintaining the equipment, and the next maintenance date will be used by laboratory personnel for laboratory equipment requiring routine maintenance. Most of the major instruments found in laboratories are covered by service agreements. Information pertaining to historical maintenance will be recorded in individual logs for each instrument.

4.6.5. Reporting Limits Objectives

The method detection limits (MDL) and laboratory reporting limits for the analytical procedures are provided in Tables 4-2 through 4-8. MDL is the minimum concentration of a substance that can theoretically be measured and reported with 99% confidence that the analyte concentration is greater than zero. The laboratory report limit (or reporting limit) is the concentration that can be measured and reported based on individual laboratory's historic performance record and is the concentration that is actually reported in laboratory data sheets. The detection limits listed may not be achievable in individual samples for any of the following reasons:

4.6.5.5 Data Validation and Usability Assessment

The project chemist will perform data validation by validating the sample and QA/QC results. Data validation is a systematic process for reviewing a body of data against a pre-established set of quality control "acceptance" criteria to determine whether it is within the criteria windows to determine the quality of the data. The validation will be conducted in accordance with EPA Level III data validation protocols.

4.7. Corrective Action

The ultimate responsibility for maintaining quality throughout the investigation rests with the Project Manager. The day-to-day responsibility for ensuring the quality of field and laboratory activities rests with the FED Principle Investigator. All incidences of nonconformance with the established QC parameters will be identified and corrected.

No additional work that is dependent on a nonconforming activity that potentially affects data quality will be performed until the identified nonconformance is corrected. Documentation describing the nonconformity will be submitted to the FED Project Manager. The documentation will include corrective measures to prevent the nonconformity from recurring.

Table 4-2. VOC Analysis Method Detection Limits and Reporting Limits

NO	Chemical	MDL(ug/kg)	Report Limit(ug/kg)
1	Acetone	5.47	50
2	Benzene	1.22	5
3	Bromobenzene	1.15	5
4	Bromochloromethane	1.14	5
5	Bromodichloromethane	1.11	5
6	Bromoform	0.728	5
7	Bromomethane	1	1
8	2-Butanone	4.22	12.5
9	n-Butylbenzene	1.21	5
10	sec-Butylbenzene	1.31	5
11	tert-Butylbenzene	1.21	5
12	Carbon disulfide	1.26	5
13	Carbon tetrachloride	1.13	5
14	Chlorobenzene	1.16	5
15	Chloroethane	1.67	5
16	Chloroform	1.11	5
17	Chloromethane	0.826	5
18	2-Chlorotoluene	1.18	5
19	4-Chlorotoluene	1.14	5
20	Dibromochloromethane	0.906	5
21	1,2-Dibromo-3-chloropropane	4.58	25
22	Dibromomethane	1.02	5
23	1,2-Dibromoethane (EDB)	1	5
24	1,2-Dichlorobenzene	0.974	5
25	1,3-Dichlorobenzene	1.05	5
26	1,4-Dichlorobenzene	1	5
27	trans-1,4-Dichloro-2-butene	4.8	25
28	1,1-Dichloroethane	1.18	5
29	1,1-Dichloroethene	1.44	5
30	1,2-Dichloroethane	1.1	5
31	cis-1,2-Dichloroethene	1.17	5
32	trans-1,2-dichloroethene	1.23	5
33	1,2-Dichloropropane	0.996	5
34	1,3-Dichloropropane	1.21	5
35	2,2-Dichloropropane	1.24	5
36	1,1-Dichloropropene	1.21	5

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Table 4-2. VOC Analysis Method Detection Limits and Reporting Limits

37	cis-1,3-Dichloropropene	1.04	5
38	trans-1,3-Dichloropropene	1.12	5
39	Dichlorodifluoromethane	0.945	5
40	Diisopropyl ether (DIPE)	1.04	5
41	Ethylbenzene	1.22	5
42	Hexachlorobutadiene	1.1	5
43	2-Hexanone	3.17	12.5
44	Iodomethane	1.43	5
45	Isopropylbenzene	1.29	5
46	4-Isopropyltoluene	1.21	5
47	Methylene chloride	1.31	5
48	4-Methyl-2-pentanone	2.53	12.5
49	Methyl-tert-butyl ether (MTBE)	0.949	5
50	Naphthalene	0.816	5
51	n-Propyl benzene	1.28	5
52	Styrene	1.07	5
53	1,1,1,2-Tetrachloroethane	0.954	5
54	1,1,2,2-Tetrachloroethane	0.839	5
55	Tetrachloroethene	1.2	5
56	Toluene	1.14	5
57	1,2,3-Trichlorobenzene	0.952	5
58	1,2,4-Trichlorobenzene	0.918	5
59	Trichloroethene	1.19	5
60	1,1,1-Trichloroethane	1.16	5
61	1,1,2-Trichloroethane	1.14	5
62	Trichlorofluoromethane	1.18	5
63	1,2,3-Trichloropropane	0.848	5
64	1,2,4-Trimethylbenzene	1.18	5
65	1,3,5-Trimethylbenzene	1.21	5
66	Vinyl chloride	0.818	5
67	m/p-Xylene	2.57	10
68	o-Xylene	1.22	5