

**SAMPLING and ANALYSIS PLAN ADDENDUM
FORT LEWIS AGREED ORDER**

**Former Small Arms Ranges
Miller Hill Pistol Range and Evergreen
Infiltration Range (AOC 4-2.2 And 4-6.3)**

FINAL

Approved

Washington Department of Ecology

AUGUST 2003

Prepared by:

For:



**US Army Corps
of Engineers®**
Seattle District



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LIST OF ACRONYMS AND ABBREVIATIONS

FLAO	Fort Lewis Agreed Order
AOC	Area of Concern
bgs	Below Ground Surface
COC	Chain-of-custody
COPC	Contaminant(s) of Potential Concern
CSM	Conceptual Site Model
DCQCR	Daily Chemical Quality Control Reports
DMA	Demonstration of Method Applicability
DQI	Data Quality Indicators
DQO	Data Quality Objectives
DTM	Draft Technical Memorandum
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
ER	Engineering Regulation
FTM	Final Technical Memorandum
FWP	Field Work Plan
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTCA	Model Toxics Control Act
PM	Project Manager
PNNL	Pacific Northwest National Laboratory
PW	Fort Lewis Public Works
RL	Reporting Limits
QA	Quality Assurance
QC	Quality Control
RIWP	Remedial Investigation Work Plan
SAP	Sampling and Analysis Plan
SWMU	Solid Waste Management Units
TBD	To Be Determined
TCLP	Toxicity Characteristic Leaching Procedure Analyses
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
VSP	Visual Sampling Plan
XRF	X-Ray Fluorescence

A-1.0 INTRODUCTION

A-1.1 Background

This addendum to the Fort Lewis Agreed Order Remedial Investigation Work Plan addresses site-specific characterization at the former Miller Hill Pistol Range (AOC 4-2.2) and the Evergreen Infiltration Range (AOC 4-6.3). The RIWP provides the framework for site investigation of the former solid waste management units (SWMU) and areas of concern (AOC) identified in the agreed order between Fort Lewis and the Washington State Department of Ecology (Ecology).

This addendum should be considered as incorporated into the Draft RIWP (USACE, 2002). It was prepared in accordance with the Draft RIWP and the guidelines specified by the U. S. Army Corps of Engineers (USACE, 2001) and the Washington State Department of Ecology (Ecology, 2001). This addendum describes the site background, the proposed sampling activities, and the proposed work schedule for the soil-sampling event. A detailed Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP) and Accident Prevention Plan (APP) are presented in Appendix A and B of the Draft RIWP.

USACE will have overall responsibility for field sampling and data collection, with support for specific components provided by subcontractors.

A-1.2 Site Use and History

Fort Lewis is a major military facility located approximately 6 miles south of Tacoma, Washington. The facility consists of approximately 34, 875 hectares of cantonment areas, natural prairies, lakes, wetlands, and forest. Weapons qualifications and field training has occurred at Fort Lewis since around the time the Fort was established.

These sites were not included in the “1996” RFA. However, these sites were added to the FLAO RIWP because existing evidence suggest that these sites are former ranges similar to other sites within AOC 4.

Discontinued use of the former ranges discussed in this SAP has allowed nature to reclaim large portions of these former ranges. Most of these sites are overgrown with trees, grasses, and scrubs. A site map is shown in Figure A-1.

AOC 4-2.2 Former Miller Hill Pistol Range

The former Miller Hill Pistol Range is located near the intersection of Colorado and Jackson Avenues on the Fort Lewis Military Reservation, Pierce County, Washington. This potential range may have been active as early as the 1920s shortly after Fort Lewis was established (1917). A 1929 Fort Lewis map identifies this area as a pistol range. Aerial photography from the 1940s shows indications of clearing and a possible berm. The suspected berm was identified along the roadway during a site visit. However, later

historical maps do not indicate an active range and aerial photography indicated re-vegetation by 1951. There are no records pertaining to use or discontinued use of this range; however, based upon growth of vegetation and historical analyses of aerial photography, indications are that this area was not likely to have been used since the late 1930s if a range did exist in this area.

For pistol ranges, most training is done with fixed or stationary targets at known distances, resulting in the formation of “bullet pockets” on the face of the berm similar to Engineer Bluff and other former Miller Hill ranges. The high-impact energy of these high-speed rounds with the rounds accumulated in the bullet pockets results in significant fragmentation and ricochet. The ammunition associated with pistol training during this era was the 45-caliber cartridge. The primary constituents in the bullet slugs consist of 97% lead and < 2% antimony with trace amounts of antimony, arsenic, copper, tin, and zinc. Potential contaminants of concern are presented in Table A-1.

AOC 4-6.3 Former Evergreen Infiltration Range

The former Evergreen Infiltration Range is located approximately 0.25 miles north of the intersection of Evergreen Ave and 4th Division Drive on the Fort Lewis Military Reservation, Pierce County, Washington. This former range was identified from a 1951 aerial photograph. There are no records pertaining to discontinued use of this range; however, based upon growth of vegetation, observed during site visits, and historical analyses of aerial photography, indications are that activity at this range was decreasing during 1955 and 1957, and the range appears to be in disuse in photographs from 1965. Identified as an infiltration range, the impact berm was set back approximately 300 feet from the firing discharge area. The impact berm is constructed earthen bank 40 feet high. A concrete footing, used to hold the machine gun posts, was constructed approximately 300 feet from front of the base of the berm. Bullet slugs, fragments, and shell casings are evident at the impact berm.

In general, infiltration ranges provided opportunity for conditioning soldiers to move under live fire and under combat type situations. Fixed-position machine guns provided the live fire training (see Figure A-2). The ammunition associated with infiltration range training during this era was the 30-caliber cartridge. The primary constituents in the bullet slugs consist of 97% lead and < 2% antimony with trace amounts of copper. Potential contaminants of concern are lead, antimony, arsenic, copper, tin, and zinc.

Site visits indicate that explosives were also part of training at this range. Nine demolition sites have been identified at this range (see Figures A-7 and A-10). A single crater has been identified at each demolition site, each crater approximately 6 feet in diameter. From remains present at the range, each of the demolition sites were surrounded by a low fence, approximately 1 foot high, of wood and chicken wire with the dimensions of approximately 20 feet by 20 feet (not all the fences remain). Some of the pits have remains of command wires for detonating explosives during training. One of the original signs has survived stating “DEMO PIT NO. 8”. Barbed wired is also present, especially between ED1 and ED2. All of the demolition pits have some vegetation

growing within and around the craters. Several of the demolition craters have trees growing out of them (ED1, ED9, and ED7). Therefore, additional potential contaminants of concern are explosives residues (TNT, 2,4-DNT, 2,6-DNT, RDX, HMX).

A-1.3 Site Geology

Site-specific geology is not available. However, the regional geology for this area is defined by the multiple glacial and nonglacial climatic events. The soils at this site are characteristic of the Steilacoom Gravel, a recessional outwash deposit. An overview of the geology of Fort Lewis is contained in the RIWP.

A-1.4 Site Groundwater

The combination of soil porosity and seasonal precipitation variability combine to result in considerable fluctuation in groundwater elevation. There are no monitoring wells in the immediate area of the site to confirm seasonal groundwater levels of fluctuation. An overview of groundwater conditions at Fort Lewis is contained in the RIWP.

A-2.0 COMMUNICATIONS, DATA MANAGEMENT, AND REPORTING

This section of the SAP describes the important project elements of communications between team members and the flow and management of data that has been collected for the proposed dynamic sampling. The method of reporting project results is also described.

A-2.1 Communication Strategy

Accelerated approaches to sampling and analysis, as required for this project, integrate various characterization tasks and measurements into a single coordinated effort. Accelerated approaches are conducted by a multidisciplinary group of experienced professionals, working as a team in the field to evaluate the data to further refine the CSM and plan the next measurement steps. Project team members and inter-group communication strategies are described below and shown on Figure A-3.

A-2.1.1 Project Team

The project teams consists of representatives from Fort Lewis Public Works (PW); Washington Department of Ecology; the Seattle District USACE; and contractors. The project team provides the overall framework for the sampling and analysis approach by defining project objectives and data quality requirements, and ensuring that both the objectives and data quality requirements are met.

Providing oversight of the project team throughout the process are individuals identified to ensure that project quality assurance/quality control and health and safety issues are addressed. At any time, any individual working on the project may contact the QA/QC Officer or the Health and Safety Officer to discuss project issues or concerns. It is the responsibility of the QA/QC Officer and the Health and Safety Officer to implement corrective actions if project requirements are not being met.

The project team must keep Fort Lewis PW Agreed Order PM (Rich Wilson) informed of how the project is proceeding. The approval of Ecology and the PW PM is required for any major deviations in the work. Project updates will be given to the PW PM and the USACE PM (Bill Graney) by the Field Investigation Lead (Gwyn Puckett) during regularly scheduled meetings and eRoom updates.

A-2.1.2 Core Technical Team

Within the project team is a core technical team made up of individuals who have expertise in geologic and chemical analytical methods appropriate for this site. They provide a continual, integrated, and multidisciplinary presence throughout the process. The members of the core technical team are involved in all steps of the process and are present in the field when data collection related to their areas of expertise is taking place. The optimization of field investigation activities and the quality of the evolving and final CSM depend on the interaction among the members of the core technical team, the project support technical team, and PW, each providing their own special perspective on the site.

The core technical team oversees analysis of the raw data, evaluates the data to further refine the CSM, and recommends to the lead of the core technical team next measurements that best test the crucial features of the CSM. Members of the core technical team should have whole-site-systems understanding of geology and contaminant chemistry. They work together to evaluate the data as they are obtained.

During this project, the core technical team will use field-based site characterization methods that will generate data that will be evaluated and integrated into the CSM in the field. The core technical team will follow a dynamic work plan that allows and requires on-site decision making by the project team. Successive steps are based on that evaluation and integration of field data into the CSM.

Core technical team members include:

- Project Chemist/Field Investigation Lead: Gwyn Puckett (USACE, Seattle District)
- Project Data Coordinator: Rebekah Barker
- XRF Analyst: Joseph Marsh
- Sampling Staff: Glen Terui and TBD

The Project Chemist, with the Support Technical team, is ultimately responsible for all decisions related to the design and implementation of this project, within the framework provided by the approved dynamic work plan. The Project Chemist is tasked with informing the USACE PM and Fort Lewis PW about all decisions that may impact project schedule or budget. Final decisions that impact budget and schedule will be made by the USACE PM and PW.

The Project Chemist and the Project Data Coordinator, supported by the core technical team members and project support technical team, are responsible for ensuring data quality and effective data management and also interpret data and integrate the results into the evolving site model and reports. They have the final authority on site technical decision making concerning field operations. Other core technical team members are in the field for data collection involving their primary area(s) of expertise and are available for telephone consultation when they are not present in the field.

Although data management and QA/QC are specific project support functions, the Project Chemist, supported by other core technical team members is responsible for ensuring the following: (1) that data collection is relevant to the objectives of the project (i.e., necessary to satisfy data quality requirements); (2) that QA/QC procedures for data collection and processing for respective areas of expertise are strictly followed; and (3) that field data reduction and processing do not introduce errors into the data and evolving site model.

The core team will be in daily contact to discuss how the project is proceeding and any changes required by the PW PM. Additionally, daily meetings to discuss project technical issues will be held in the field with core technical team members present or linked by conference call. Representatives of subcontractors or project support team members (below) may also be asked to attend these meetings. Daily chemical quality control reports (DCQCRs) will be generated and faxed to the Project Data leader at the USACE Seattle District office. The DCQCR will include all field data generated on a daily basis, including mobile laboratory data, chain-of-custody forms, and field sampling forms. The report will be scanned and posted on the project eRoom.

A-2.1.3 Project Support Team

The project support team includes technical personnel and equipment operators involved in data collection and sampling and personnel who provide other support functions.

Project support team members include:

- Senior Technical Reviewer / QA/QC Officer: Kira Lynch (USACE, Seattle District)
- Technical Team Leader: Kym Takasaki (USACE, Seattle District)
- Project Geologist/Hydrogeologist: Lisa Scott (USACE, Seattle District)
- Health and Safety Officer (Industrial Hygienist): Kim Calhoun

The project support team will be in daily contact with the Field Investigation Lead, or designated technical task manager, when they are working on site. They may be asked to attend technical team meetings to present results or other technical issues, if needed. The Field Investigation Lead, or designee, as necessary, will contact off-site laboratories.

A-2.2 Data Flow

Two primary categories of data will be generated for this project: field data and fixed laboratory data. The procedures to be used for each type of data are described below.

A-2.2.1 Field Data

The core technical team will record field measurements/observations in logbooks and on the appropriate field forms. XRF and off-site fixed laboratory data will be generated on a daily basis and reported in formats that can be interpreted by the core technical team. All field data will be transferred to the Field Investigation Leader. Daily chemical quality control reports will be generated and posted on eRoom. The DCQCR will include all field data generated on a daily basis, chain-of-custody forms, and field sampling forms. Incoming project-related material, including correspondence, authorizations, chain-of-custody forms, or other information, will be marked with the date received and the project name. Postings to eRoom will include updated maps and diagrams of sampling activity and digital photographs of site activities. The Project Data Coordinator will interpret analytical data received from the fixed laboratory. This information will also be posted to eRoom.

Upon completion of the field program, the temporary file will be transferred from the site field office and incorporated into the USACE Seattle District office project file (the Project Data Coordinator will oversee the input of project records). Copies of all field documents may be made and retained by the originator for use in report preparation and later reference. The originals will be filed in the office project file.

On-site field measurements and laboratory data will be input into an electronic database. The data will then be printed out and compared to the original field records to ensure input accuracy. All review documentation will be initialed and dated by the reviewer, then filed with the quality review documentation.

A-2.2.2 Fixed Laboratory Data

Fixed laboratory data will be transferred from the project laboratories to the Project Data Coordinator in hard copy and Excel compatible electronic formats. Data will be loaded into an Excel spreadsheet. Hard copies of the laboratory deliverables will be used to verify the accuracy of electronic data. The original hard copies of laboratory deliverables will then be stored in the office project file.

The laboratories will maintain and follow their own detailed procedures for laboratory record keeping for support of the validity of all analytical work. Each data package submitted to the Project Data Coordinator will contain the laboratory's written certification that the requested analytical method was run and that all QA/QC checks were within established control limits on all samples, with exceptions noted. The Project Data Coordinator will be responsible for ensuring fixed-lab data quality and effective data management and also assist in interpreting data and integrating the results into the evolving site model and reports.

Severn Trent Laboratories (STL) will perform the analyses. The address and contact of the project laboratory is listed below.

STL Seattle
 5755 8th Street East
 Tacoma, WA 98424

Contact: Dawn Werner (253) 922-2310

A-2.2.3 Meetings and Conference Calls

Meetings or conference calls will be scheduled as needed to discuss project status updates, results from demonstration of applicability (correlation data, actions levels), determination of uncertainty limits for decision making, conceptual model data gaps, additional data needs, and discussion of implementation of the appropriate action when data suggests deviations from the conceptual model.

A meeting or conference call will be held with Ecology and PW to discuss the interim results of the Demonstration of Method Applicability (DMA) that will be subsequently documented in an appendix to the final site characterization report. Additional meetings will be scheduled if necessary to discuss results from the site investigation at the former Infiltration Range, the former Pistol Range at Miller Hill, and the former Skeet Range.

A-2.2.4 Daily Updates

Information on project status and available data will be posted daily on the project eRoom website by the core technical team. These postings will include updated maps and diagrams of sampling activity and digital photographs of site activities.

A-2.3 Schedule and Project Completion Reporting

The proposed schedule for the fieldwork is presented in the Table below.

Activity	Time of Completion in Calendar Days
Submit Final Sampling and Analysis Plan Addendum (SAP)	
Ecology Approval of SAP	TBD
Completion of Field Work	65 days after approval of FWP
Receipt of Final Analytical Results	2 days after Laboratory receives samples
Submit Draft Technical Memorandum (DTM)	21 days after completion of field activities and receipt of final Analytical Results
USACE Comments to DTM	14 days after receipt of DTM
Submit Written Responses to DTM	14 days after receipt of comments
USACE Approval of Responses	7 days after receipt of responses

Submit Final Technical Memorandum (FTM)	14 days after approval of responses
Submit Draft FTM to Ecology	7 days after receipt

Review of chemical data quality (precision, accuracy, representativeness, completeness, and comparability) shall be conducted by a qualified chemist to ensure that project goals will be met during the field investigation and acquisition of chemical data and their data quality indicators. A Technical Memorandum will be provided that includes:

- A concise and well written Executive Summary;
- Recommendations for further investigation (including evaluation of the need for groundwater sampling) or remedial action (if necessary);
- A site map showing relevant features, sampling locations, and analytical concentrations;
- A description of field activities, including field notebook, photographs and boring logs;
- Quality assurance review of the sample results;
- Tables summarizing the analytical results compared to applicable State and Federal action levels; and
- Laboratory certificates of analysis.

This technical memorandum will be provided to Ecology. The decision for additional remedial investigations will be determined following review of the technical memorandum. The RI report will include results of any followup investigations needed based on the results of this investigation.

A-3.0 SAMPLING PLAN

A-3.1 Sampling Objectives

Objectives of this sampling event are:

- Confirm the presence of contamination;
- Delineate the vertical and horizontal extent of the lead contamination to 50 ppm;
- Determine the concentration of contaminant of concern;
- Determine if lead can be used as driver to define extent at ranges;
- Collect data for XRF Demonstration of Method Applicability;
- Refine Conceptual Site Model based on field results.

The objectives and sample design associated with this project are in accordance with EPA DQO guidelines. The data gathered will assist in the design and planning of an appropriate, efficient and cost-effective remedy selection. Potential remedial actions include the installment of institutional controls, excavation for disposal, treatment, or

treatment prior to disposal. Data will not be collected specifically to support risk assessments.

A-3.2 Demonstration of Method Applicability

To determine the usability of the XRF for lead soil sampling, a demonstration of method applicability (DMA) will be conducted on the impact berm at the former Evergreen Infiltration Range. Preliminary assessment of the former infiltration range determined that it was the most likely area to have high levels of lead contamination, making it suitable for the DMA.

In order to assure that a reasonable correlation can be substantiated between the proposed field-based sampling method, the fixed lab methods, and the decisions being made, samples representing a full range of lead concentrations will be selected. Sample locations will be chosen from the impact zone, below the impact zone and the toe of the berm (see Figure A-8). The samples for the DMA will be collected during the first two days of sampling (estimated at a minimum of 20 samples; approximately 20 samples can be processed per day).

Comparability of the XRF analysis procedure will be established by comparing results from sample pairs analyzed by both prepared-sample on-site analyses using the XRF analyzer and prepared-sample off-site laboratory analyses using conventional analysis by ICP-AES Method 6010/6020. The correlation of XRF to laboratory data will be expected to have a linear regression correlation coefficient (r) of at least 0.75.

This study will accomplish several goals:

- Initial evaluation of site specific heterogeneities that will support further design of the data collection program
 - Sampling design (how many samples to collect and where to collect them)
 - Refinement of the conceptual site model
- Evaluation of analytical performance on site specific sample matrices
 - Determine whether and how to modify methods to improve performance and/or cost-effectiveness
- Develop initial method performance/QC criteria based on site specific data needs
 - During project implementation, both field and analytical QC results will be judged against these criteria to determine whether procedures are “in control” and meeting the defined project needs
 - Develop list of corrective actions to be taken if QC criteria exceeded

- Decision thresholds (“action levels” to guide decisions about compliant vs. non-compliant soil or areas, and the routing of materials for final disposal)
- Evaluate the inherent bias of the field-based instrument technology such that an adequate safety factor can be built into the overall decision uncertainty limits
- Determine the correlation between the average bag-sample XRF analysis, the cup-sample XRF analysis and the fixed-lab analysis of the soil sample
- Determine the correlation between lead and other metals present.
- Confirm proposed method for soil sample collection (including sample and subsample support and sampling devices) and conducting XRF analysis meets project data quality requirements.

A-3.2.1 Sample Preparation for the DMA

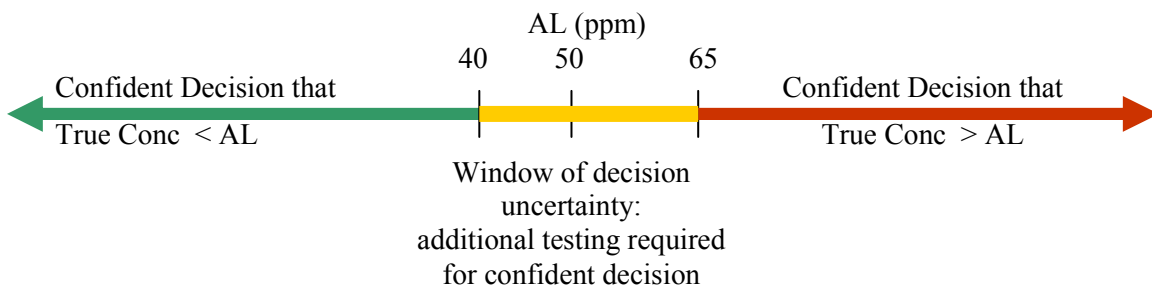
At each sampling location selected, surface samples will be collected from two depth intervals, 0 to 12 inches and 12 to 24 inches, with a hand auger or appropriate equipment. Each sample will be collected as a discrete sample. One or more hand auger samples will be collected at each sample location; the approximate volume collected should fill a gallon-sized zipper locked baggie. Enough soil volume must be collected for all analytical purposes including split samples for ICP metals analysis, TCLP and archived samples. At each sampling location the following procedures will be used:

1. Place the depth interval soil sample into a decontaminated stainless steel bowl.
2. Sieve the soil with a # 10 mesh (2 mm) to remove large particles such as gravel, sticks, and bullet fragments (as required by WAC 173-340-740 (7) (a)).
3. Homogenize the sample in the zipper locked baggie. Conduct 7 XRF bag measurements to determine within-sample variability of the collected volume.
4. Place an aliquot into a XRF sample cup, and conduct measurement with XRF for lead. Submit cup aliquot to fixed lab for metals analysis by ICP 6010/6020. Metals of interest include lead, antimony, arsenic, copper, tin, zinc, and iron.
5. For the DMA, all samples will be submitted for ICP metals analysis.

Rapid turnaround time for fixed lab metals will be required for soil collected during this phase. Results will be evaluated as soon as they become available by the technical team who will make decisions about the frequency of collaborative samples submitted for fixed-lab analysis (see Section A-3.3), method for sample collection and XRF analysis, and selection of subsequent sampling locations and depths to assure that the extent of contamination at the site are identified.

A-3.2.2 Uncertainty Management Issues

Decision uncertainty intervals are set as: (1) the interval where it is judged that the field data results can be confidently trusted to declare areas as “clean” (i.e., no further investigation needed); (2) the interval where field results can be trusted to confidently declare an area “dirty” (i.e., remedial action needed); and (3) the interval where the field results are considered ambiguous (the window of decision uncertainty), and a confident decision of “clean” or “dirty” would require more data to manage the decision uncertainty (see figure below). Table A-2 presents potential uncertainty issues and potential responses. The DMA will be used to calculate the interval of decision uncertainty for XRF measurements.



Source: TIO - Considerations for Developing a Methods Applicability Study, March 2003

A-3.3 Sampling Strategy for Metals

A systematic grid will be used to delineate the vertical and horizontal extent of contamination if present at both sites. Starting at the areas most likely to be contaminated, the impact berms, sample locations will be stepped out laterally until lead XRF values are below the action level determined in the DMA. To determine vertical extent of contamination, samples will be collected in 1-foot intervals starting at ground surface at every location, with maximum depth dependent upon lead criteria. Sample location density will be initially determined using process knowledge of site usage, and conceptual site models, to be modified as real-time data is collected. Initial grid spacing has been set at 10-foot intervals, based upon the reasonable volume of soil that potentially could be excavated for remedial action. The 1-foot depth interval was based upon the reasonable depth of soil that would be removed by a backhoe. Field-portable XRF instrumentation will be used to provide real-time sample analysis of soil lead concentration. Following analysis of the sample results and dependent upon information gaps in the conceptual site model, and uncertainty in definition of contaminant extent, additional samples may be required to further delineate the extent of lead contamination.

At each sampling location selected, surface samples will be collected in one-foot depth intervals with a hand auger or appropriate equipment. One or more hand auger samples will be collected at each sample location; the approximate volume collected should fill a gallon-sized zipper locked baggie. Enough soil volume must be collected for all

analytical purposes including split samples for ICP metals analysis, TCLP and archived samples.

During the DMA, collaborative samples will be submitted to the fixed laboratory for all samples. The information obtained from the collaborative sample collection in the DMA will be used to determine the frequency and types of collaborative samples for the remainder of the XRF sampling. The number of collaborative samples will be guided by the need to manage decision uncertainty. The frequency of collaborative samples will be determined by the following criteria:

- The interval where field results are considered ambiguous; dependant upon metal concentration results and instrument sensitivity.
- How frequently field results are close to the project's action level; a confident decision of "clean" or "dirty" may require more data.

The results from these analyses will be evaluated to test the hypothesis that lead concentrations will drive decisions regarding this project. Metals to be analyzed by Method 6010/6020 include lead, antimony, arsenic, copper, tin, zinc and iron, contaminants mostly likely to be found at small arms firing ranges.

A-3.3.1 Evergreen Infiltration Range Impact Berm

At the Evergreen Infiltration Range, the impact berm extends upwards of 40 feet, and is approximately 300 feet long. The impact zone, where contamination is believed to be the highest, is easily identified by the lack of vegetation. Figure A-7 and A-8 provide sample locations and the initial field sampling design. The sample grid will be spaced 10 feet apart lengthwise within the impact zone, below the impact zone (to evaluate the extent of the contamination down the slope), and at the toe of the berm to determine any impacts of potential sloughing.

A-3.3.2 Evergreen Infiltration Firing Points

Four samples will be collected at each of the four firing point locations to determine if shells potentially impacted the surrounding soil. Initially, samples from the 0 to 12-inch depth interval will be collected from each side of the concrete pads and measured with XRF. If concentrations of lead are detected above the action level, sampling will continue until the extent of contamination is determined. Figure A-9 presents the sample locations at the firing points.

A-3.3.3 Miller Hill Pistol Range

The potential berm at AOC 4-2.2 is approximately 180 feet long and is covered in heavy vegetation, which may make sampling difficult (see Figure A-5). A secondary soil mound is located to the southeast, closer to Colorado Avenue. This soil mound is approximately 120 feet long and is newer than the primary "berm" to the west, as the mound is rougher and vegetation is younger. Most likely, this soil mound is an artifact from road

construction occurring after the 1965. To determine the presence of contamination, samples will be collected from the “impact” side of the “primary” berm. Sample locations will be placed in 10-foot intervals lengthwise along the berm face. Figure A-6 provides the initial sampling grid at the Miller Hill Pistol Range.

A-3.4 Sampling Methods

From each of the locations, soil will be excavated using a decontaminated hand auger, or appropriate equipment. One or more hand auger samples will be collected at each sample location; the volume collected should fill a gallon-sized zipper locked baggie. Enough soil volume must be collected for all analytical purposes including split samples for ICP metals analysis, TCLP and archived samples. Soil will be sieved through a No. 10 mesh sieve so that larger particles such as gravel, sticks, and bullet fragments will be removed prior to analysis. Written documentation of site activities will include a description of soil samples and the percentage of bullets collected at each sampling site.

A-3.4.1 Sample Collection

The initial sampling depth at each sampling location is 0 to 12 inches. If lead readings are above the XRF action level determined in the DMA in the top 1-foot sample, then each sub-sampling area will be excavated using a decontaminated hand auger or other appropriate instrument, to a depth of 12 to 24 inches. Samples from 1-foot depth intervals will continue until lead concentrations are at or below the action level (see Figure A-4 for the sampling decision tree).

When necessary, and possible, a small backhoe may be used to assist in loosening the soil such that hand tools can be used to collect soil samples. The bucket of the backhoe will be decontaminated between sample points using either steam or flushing the bucket with de-ionized water. The sampling team will use caution to minimize mixing of soil layers in order to reduce cross contamination.

Each sample will be collected as a discrete sample. At each sampling location the following procedures will be used:

1. Sieve soil samples through a No. 10 mesh sieve (as required by WAC 173-340-740 (7)(a)). Examine larger, retained particles and note their description in the laboratory notebook, including a description of soil samples and the percentage of bullets collected at each sampling site. Discard gravel, sticks, vegetation, etc.
2. Place sieved soil into an appropriately labeled one-gallon zipper locked plastic baggie. Homogenize the soil within the bag.
3. Analyze the soil directly through the plastic bag used for homogenization. The XRF analysis time interval will last at least 120 seconds in order to obtain the lowest limits of detection following EPA protocol of 99.7% confidence level for testing times.

4. Seven readings for lead will be taken from various locations on the bag to determine within-sample variability, if the sample is chosen as precision sample. The frequency of such samples will be determined by the DMA based on the ranges of relative standard deviation calculated as described below in Section A-3.4.2 from precision samples in the DMA. Each XRF analysis time interval will last at least 120 seconds.
5. Place an aliquot into a XRF sample cup, and analyze, if sample has been selected for confirmation analysis after initial evaluation of XRF bag analysis. If the sample is selected for collaborative laboratory analysis, submit an aliquot to the analytical laboratory. Collaborative samples will be submitted from the range within the “window of decision uncertainty” determined by the DMA. The frequency of aliquot submittals for fixed-lab analysis will be determined from the results of the DMA.

A-3.4.2 Quality control for onsite XRF Analyses

This sampling effort will adhere to all requirements specified in the generic quality assurance project plan for the Fort Lewis Agreed Order RIWP/SAP (Appendix A). All field and laboratory data will be collected and reported as required by standard operating procedures specified in the generic quality assurance project plan and as described in Section A-3.0 of this document. Quality control samples will be collected as described in Table A-3.

The overall data quality objectives for this work are to determine the nature and extent of soil contamination and to produce data of known and appropriate quality to support the selection of remedial actions for soil at the former ranges. Appropriate procedures and quality control (QC) checks will be used so that known and acceptable levels of accuracy and precision are maintained for each data set. This goal is quantitatively expressed in terms of the Data Quality Indicators (DQIs) for the quality control checks performed. The quantitative requirements for accuracy measurements were established to ensure the data produced is shown to be effective for making defensible project decisions.

Accuracy. Accuracy is the agreement between a measured value and the true or accepted value. While it is not possible to determine absolute accuracy for environmental samples, the analysis of standards and spiked samples provides an indirect assessment of accuracy.

XRF accuracy will be established with a calibration check standard obtained from the XRF instrument manufacturer. A low, medium, and high concentration calibration standard will be used. Calibration verification checks will be conducted at the beginning and end of each day and after every 20 samples. The percent difference (%D) should be less than 20 percent. If this data quality indicator is not met, corrective actions as specified in the XRF User’s Guide would be followed. Samples will not be analyzed until the calibration data are within acceptable range.

Precision. Precision is a measure of mutual agreement among replicate (or between duplicate) or co-located sample measurements of the same analyte. The closer the numerical values of the measurements are to each other, the more precise the measurement. Precision for a single analyte will be expressed as the relative percent difference for results of field and laboratory duplicate samples. Precision requirements for each sample type are presented below.

For FPXRF samples, a precision sample will be measured at a frequency to be determined by the DMA. A precision sample will be a sample that has been analyzed seven times in replicate. If possible, samples near the action level will be selected as the precision sample. Evaluation of precision samples at each of the preparation steps will allow for determination of precision at each of the steps. Following review of this data, the frequency of precision samples will be revised for the remaining sampling activities. The relative standard deviation (RSD) will be calculated for each of the precision samples using the following equation:

$$\text{RSD} = (\text{SD}/\text{Mean}) * 100$$

Where:

SD = standard deviation of the seven replicate results; and
Mean = mean concentration of seven replicate results.

The precision for the sample RSDs will be below 20 percent. If this data quality indicator is not met, the data will be reviewed to determine appropriate corrective actions, if required. Corrective actions will be conducted in accordance with Appendix A of the RIWP.

XRF Field Duplicate Sample. Co-located field duplicate samples will be collected to assess combined sampling, and field variability. The co-located field duplicate will be collected from 0.5 to 3 feet away from the primary sampling point. The relative percent difference (RPD) is calculated for the primary and replicate sample results. Field duplicate samples shall be collected for XRF analysis at a minimum frequency of one per every 10 samples during the DMA. The frequency of XRF field duplicates for the remainder of the project will be determined by the ranges seen in the DMA but will not exceed 10 percent. The RPD criteria for XRF results for field duplicates will be less than 50 percent.

Soil for the field duplicates will be excavated using a decontaminated hand auger, or appropriate equipment. Co-located field duplicate sample locations will be established approximately two feet from the main sample location. One or more hand auger samples will be collected at each sample location; the volume collected must be sufficient to assess the variability within the grid area (to be determined during the DMA). Soil will be sieved through a No. 10 mesh sieve so that larger particles such as gravel, sticks, and bullet fragments will be removed prior to analysis. Written documentation of site

activities will include a description of soil samples and the percentage of bullets collected at each sampling site.

Analytical Laboratory Duplicate Sample. Laboratory duplicate sample analyses are performed by taking aliquots of a well-homogenized sample from the same sample container to assess the precision of the analytical method. The RPD is calculated for the primary and replicate sample results. Laboratory duplicate sample analysis will be performed for soil and water analyses. Laboratory duplicate sample analysis shall be one per every 20 samples or one per analytical batch, whichever is more frequent. The RPD criteria for laboratory duplicates will be less than 35 percent for soils.

Representativeness. Representativeness is a qualitative parameter that expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations (including the impact on the data from an evaluation of duplicate samples, rinsate blanks, and field blanks) at a sampling point, or an environmental condition. The design of and rationale for the sampling program (in terms of the purpose for sampling, selection of sampling locations, the number of samples to be collected, the ambient conditions for sample collection, the frequencies and timing for sampling, and the sampling techniques) ensure that environmental conditions have been sufficiently represented. Discussion of the methods and approaches used to satisfy the representativeness criteria is found throughout the sampling plan.

Care will be taken in the design of the sampling program to ensure sample locations are selected properly, sufficient numbers of samples are collected to accurately reflect conditions at the site, and samples are representative of the sampling locations. A sufficient volume of sample will be collected at each sampling station to minimize bias or errors associated with sample particle size and heterogeneity.

Comparability. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. The comparability goal will be achieved through the use of standard operating procedures to collect and analyze representative samples, and by reporting analytical results in appropriate and consistent units. Each analytical procedure selected from among the acceptable options will be used throughout the work assignment, unless a rationale is provided for an alteration. In essence, comparability will be maintained by consistency in sampling conditions, selection of sampling procedures, sample preservation methods, analytical methods, and data reporting units.

Split samples will be collected from well-homogenized discrete samples and submitted for ICP analysis. A correlation analysis will be performed between XRF and laboratory lead results will be performed to evaluate data comparability. It should be noted that numerical results might not be equivalent since XRF measures total lead in a bulk sample while laboratory analysis detects lead, which is extracted by nitric acid; i.e., one method may exhibit a high or low bias relative to the other. However, a linear regression correlation coefficient (r) greater than 0.75 is anticipated; evaluation of the correlation

data will be conducted prior to using the information for subsequent field decision-making.

Completeness. Completeness is a measure of the number of valid measurements obtained in relation to the total number of measurements planned. The closer the numbers are, the more complete the measurement process. Completeness will be expressed as the percentage of valid-to-planned measurements. An objective of the field-sampling program is to establish the quantity of data needed to support the investigation. This will be achieved by obtaining samples for all types of analyses required at each individual location, a sufficient volume of sample material to complete the analyses, samples that represent all possible contaminant situations under investigation, and quality control samples. Completeness will take into consideration environmental conditions and the potential for change with respect to time and location. Target levels for completeness are 90 percent. These levels are evaluated for individual analytes as well as for locations and matrices.

A-3.5 Field Portable XRF Instrumentation

A detailed XRF instrumentation SOP will be provided as an appendix to the RIWP. The quality of instrumentation and method detection limits will be expected to be equivalent or better than the Niton 300 series. Table A-5 presents method detection and reporting limits for Niton 300 series XRF instrumentation.

A-3.6 Sampling for Explosives Residue

Samples will be collected from the nine demolition sites within the Infiltration Range (see Figures A-7 and A-10). Several of the demolition pits have trees growing out of them, which may make collecting samples difficult. These sites are ED1, ED9, and ED7. Previous studies indicate that explosive residue concentrations are consistently highest in the surface soils, approximately 0 to 4 inches in depth (USACE, 2001). Any explosive residues present will be biased high in the chosen sampling strategy, providing for a conservative estimate of contamination at each of the demolition sites.

As recommended by *Distribution and Fate of Energetics on DoD Test and Training Ranges: Interim Report 1* (USACE, 2001) a set of seven surface samples will be collected in a wheel pattern from the crater at each site, composited, and analyzed to determine if explosive residues are present. The top 6 inches of soil will be excavated using a decontaminated hand trowel and placed in a decontaminated stainless steel bowl, homogenized and placed into a labeled 8 oz clear wide mouth glass jar. Samples will be submitted to a fixed laboratory for analysis by EPA Method 8330. A second set of composite samples will be collected from the 6 to 12 inch depth interval in the same manner and submitted for analysis. If residue is present, further samples may be required to determine extent of contamination. Two duplicates, and one MS/MSD will be collected with this sample delivery group. All soils samples will be collected using stainless steel trowels, which were carefully wiped with a clean paper towel, washed with acetone and air dried between samples.

A-3.7 Archived Samples

Soil samples collected from both ranges will be archived either in storage at the Seattle District or at Fort Lewis Public Works. Samples will be archived in the labeled sample bag or jar, with Chain-of-custody documentation, for further analysis if deemed necessary. Any subsequent analyses performed on the archived samples must be performed within the maximum holding time appropriate to the analytical method (See Table A-10).

A-3.8 Evaluation to Determine Additional Sampling Locations

The initial sampling strategy will be evaluated once real time data from XRF results have been obtained to determine if increased sampling density is required. Software programs such as Spatial Analysis and Decision Assistance (SADA) provides a number of tools for the visualization of data, geospatial analysis, statistical analysis, sampling design and decision analysis (TIEM 2003). Secondary sampling design applications assists in determining additional sample locations, such as placing new sample locations in areas where there is the greatest uncertainty about exceeding the action level, delineating the boundaries of the area of concern.

A-3.9 Groundwater Sampling

Previous groundwater sampling at Miller Hill and Engineer Bluff does not indicate impact to groundwater. Groundwater samples were collected from one location at Miller Hill and nine locations at Engineer Bluff. Groundwater was noted at depths ranging from roughly 20 to 32 feet below ground surface at Engineer Bluff and 40 feet below ground surface at Miller Hill. Total and dissolved fractions were collected at each sample location; both total and dissolved lead concentrations were below the screening criteria.

Based on results of previous monitoring, groundwater sampling at AOC 4-2.2 and 4-6.3 is not warranted at this time. However, once soil results have been collected, potential impact to groundwater will be evaluated including use of the 3-phase model.

A-3.10 Toxicity Characteristic Leaching Procedure Analyses

Following the completion all characterization data evaluation, a subset of samples will be selected that are representative of those soils that may potentially be disposed. These samples will be submitted for TCLP (EPA method 1311/6010) to evaluate waste disposal cost impacts (a potential for remedy selection). A minimum of five samples per range will be collected (see Table A-13). No remedial action or offsite disposal will take place under this remedial investigation.

A-3.11 Decontamination Procedures and Investigative-Derived Waste Plan

Decontamination of sampling equipment will be conducted in accordance with Appendix A Attachment A-1 of the RIWP.

Investigative-derived waste will be handled in accordance with the procedures outlined in Appendix A Attachment A-7 of the RIWP. It is anticipated that only PPE and decon water will be generated.

A-3.12 Sample Documentation and Handling Procedures

A-3.12.1 Field Notebooks

Sample custody and documentation are vital aspects of the site investigation. The field documentation system provides the means to identify, track, and monitor each individual sample from the point of collection through final data reporting. All field documentation will be completed using indelible ink. Errors will be scratched out with a single line, initialized and dated.

A bound book with consecutively numbered pages will be maintained by the sampling team to provide a daily record of significant events, observations, and measurements taken during the field investigation. The field logbooks are intended to provide sufficient data and observations to enable the field team to reconstruct events that occur during the project. The field logbooks will contain the following as a minimum:

1. Date and military time of sample collection.
2. Weather conditions, including temperature.
3. The location number and name.
4. Location of sampling point.
5. Sample identification number.
6. Type of sample.
7. Any field measurement taken
8. Field observations.
9. References, such as maps or photographs of the sampling site.
10. Any procedural steps taken that deviate from those outlined in this addendum.

3.12.2 Sample Labeling and Nomenclature

Sample labels will clearly indicate the sample number, date, sampler's initials, parameters to be analyzed, preservative added, and any pertinent comments. Sample nomenclature will consist of the sample location code (i.e., MH, EB, EF, ED), sample type (S for soil sample), and depth interval (if appropriate). Depth intervals will be numbered sequentially, 1 (0 to 12 inches), 2 (12 to 24 inches), 3 (24 to 36 inches), and so forth. For example, the first sample collected from the 0 to 12 inch depth interval at the impact berm at the Evergreen infiltration range will be labeled EB1-S1.

<i>Site Name</i>	<i>AOC No.</i>	<i>Sample Location Code</i>
Miller Hill Pistol Range (MH)	A4-2.2	MH1, MH2, MH3....
Evergreen Infiltration Range (E) - Impact Berm (B)	A4-6.3	EB1, EB2, EB3....
- 4 Firing Points (F)		EF1 through EF4 Sides of pads will be labeled

- 9 Demolition Sites (D)		A through D ED1 through ED9
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A-3.12.3 Chain-of-custody Records

Chain-of-custody procedures are employed to maintain and document sample possession. A sample is considered under a person’s custody if it is in that person’s physical possession, within visual sight of that person after taking physical possession, secured by that person so that the sample cannot be tampered with, or secured by that person in an area that is restricted to unauthorized personnel.

Chain-of-custody records completed by the sampler will accompany all shipments of samples. Each cooler will have a chain-of-custody form listing the samples in the cooler. It is possible that more than one chain-of-custody form will be needed per cooler to list all the samples contained in the cooler. The purpose of these forms is to document the transfer of a group of samples traveling together; when the group of samples changes, a new custody record is initiated. The original chain-of-custody record always travels with the samples; the initiator of the record keeps a copy. The following procedures will be followed when using chain-of-custody record sheets.

1. The originator will fill in all requested information from the sample labels.
2. The person receiving custody will check the sample label and tag information against the chain-of-custody form. The person receiving custody will also check sample condition and note anything unusual under “Remarks” on the chain-of-custody form.
3. The originator will sign the “Relinquished by” box and keep a copy of the chain-of-custody form.
4. After delivery by the commercial carrier, the person receiving custody will sign in the “Received by” box adjacent to the “Relinquished by” box (may also be filled in by recipient as “Federal Express” or other carrier name). All signatures and entries will be dated.
5. When custody is transferred to the analytical laboratory, blank signature spaces may be left and the last “Received by” signature box used. Another approach is to run a line through the unused signature boxes.
6. In all cases, it must be readily seen that the same person receiving custody has relinquished it to the next custodian.
7. If samples are left unattended or a person refuses to sign, this will be documented and explained on the chain-of-custody form.

A-3.12.4 Chain-of-custody Documentation for XRF Samples

Chain-of-custody records will be completed by the sampler and accompany all XRF samples to be archived (see Section A-3.7). COCs for the XRF samples may be in the

form of spreadsheets. Otherwise, the XRF COCs will follow the same guidelines described in Section A-3.12.3.

A-3.12.5 Sampling Handling

Sample packaging and shipping procedures are based on EPA specifications, USDOT regulations, and USACE ER 1110-1-263. All samples will be shipped as “Environmental Samples” and not as hazardous material. Ice will be placed in each cooler to maintain a temperature of 4°C to meet sample preservation requirements. All samples will be delivered to the laboratory within 24 hours of collection. Tables A-6 to A-11 identify sample containers, method detection limits, QC limits, and preservation requirements.

The following are general packaging procedures:

1. Sample labels with adhesive backing will be securely attached to each sample container.
2. Labeled sample containers will then be sealed into plastic bubble-wrap bags or Ziploc-type bags prior to being loaded into the sample coolers.
3. Insulated plastic or metal-clad plastic coolers will be used as shipping containers. The drain plugs shall be taped shut (using strapping tape) on the inside and outside. Several plastic bubble-wrap sheets shall be placed on the interior bottom and sides of the coolers for shock absorption. One to three inches of Styrofoam pellet packing material may also be placed in the bottom of the coolers for additional shock absorption at the discretion of the Sampling Team Site Manager. New, clean, heavy-duty plastic garbage-type bags will be used as protective liners inside all coolers. Bagged sample containers will be placed within the liner.
4. Styrofoam pellets may also be placed between sample containers to protect the containers from breakage during shipment and handling.
5. All samples requiring refrigeration will be chilled to 4°C with the addition of four bags (gallon-size Ziploc type – double bagged) of cubed ice or block ice spalls.
6. The paperwork intended for the laboratory will be placed inside a plastic bag. The bag will be sealed and taped to the inside of the cooler lid. The original chain-of-custody form will be included in the paperwork sent to the laboratory. If samples are sent by air transport, the air bill will be completed before the samples are handed over to the carrier.
7. Two signed custody seals will be placed over the lid of the cooler, one on the right front and one on the upper left, and covered with clear plastic tape.
8. The cooler will be securely taped shut with strapping tape wrapped completely around the cooler at least once in a minimum of two locations.
9. “Up Arrow” symbols will be placed on all four sides of cooler.
10. The completed shipping label will be attached to the top of the cooler. The cooler will then be delivered to the overnight courier.

The project and QA laboratories will be notified, two weeks prior to sample collection and again two days prior to arrival of samples, of the approximate number of samples, matrix, and requested analyses. A key to field identification numbers will be provided to the QA laboratory only.

A-3.13 Field Quality Control Samples

One rinse blank per day will be required for this project since the equipment used to collect samples during this field sampling investigation shall not be dedicated. Field duplicates will also be collected at a frequency of 1 per 10 samples for explosives and for XRF lead analysis for the DMA (see Table A-3). The frequency of collection of XRF field duplicates for the remainder of the project will be determined by the DMA.

A-4.0 QUALITY ASSURANCE PROJECT PLAN

The purpose of the Quality Assurance Project Plan (QAPP) is to define, in specific terms, the quality assurance (QA) and quality control (QC) objectives, organization, and functional activities associated with the sampling and analysis of soil samples obtained during this investigation. Details of the QA/QC requirements are presented in the Draft RIWP.

All analyses for soil samples will be performed in general accordance with the methods specified in the Shell document (USACE, 1998). Laboratory Standard Operating Procedures (SOPs) are maintained in the project files.

Tables A-5, A-6, and A-7 present the methods of analysis and reporting limits to be used for this project. Reporting limits (RLs) typically achieved by the laboratory for the methods are defined in the Draft RIWP; however, matrix interferences may result in higher sample quantitation limits. In general, RLs will reflect the lowest levels of analyte that can be accurately and reproducibly detected by the analytical method employed. The RL can vary from sample to sample depending on sample size, matrix interferences, moisture content, and other sample-specific conditions. Reporting limits usually correspond to the lowest calibration standard.

Tables A-8 and A-9 present the QC criteria to be used by the project laboratory for soil samples. In general, these criteria meet the data quality objectives presented in the RIWP.

All analytical data generated by the laboratory shall be extensively reviewed prior to report release to assure the validity of the reported data. Each step of this review process involves evaluation of data quality based on both the results of the QC data and the professional judgment of those conducting the review.

If a problem is detected during the field program and/or a routine audit, an investigation will be conducted immediately to evaluate the problem and to determine the most appropriate corrective action, if necessary. Similar action will also be conducted for

off-site laboratory analysis, if necessary. Corrective actions will be conducted in accordance with Appendix A of the RIWP.

A-5.0 ACTIVITY HAZARD ANALYSIS

All work described in this Sampling and Analysis Plan will be performed according to the RIWP Appendix B: Accident Prevention Program (APP). This APP will be made available to all personnel involved with the sampling.

A-6.0 REFERENCES

- Air Force Center for Environmental Excellence. 2000. Technical Protocol for Determining the Remedial Requirements for Soils at Small Arms Firing Ranges. Technology Transfer Division (AFCEE/ERT). Prepared by Parsons Engineering.
- U.S. Army Corps of Engineers (USACE). 2000. *Draft Remedial Investigation Work Plan Agreed Order, DPW, Fort Lewis, WA*. February 2000.
- _____. 2000a. *Draft Site Investigation, Firing Range 61, Engineer Bluff, Fort Lewis, WA*. July 2000.
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- U.S. Army. 2000. *Munitions Items Disposition Action System (MIDAS)*, web site: <http://www.dac.army.mil/TD/MIDAS>. September 2000.
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- The Institute for Environmental Modeling (TIEM). 2003. Spatial Analysis and Decision Assistance (SADA). <http://www.tiem.utk.edu>. University of Tennessee, Knoxville, TN.
- Environmental Protection Agency (EPA). 1998. *QA/G-9, Guidance for Data Quality Assessment*. Quality Assurance Division, Office of Research and Development, Washington DC. EPA QA/G-9. January 1998.

Gilbert, Richard O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand-Reinhold. New York, N.Y. 320 pp.

ITRC. 2003. *Characterization and Remediation of Soils at Closed Small Arms Firing Ranges*. Interstate Technology and Regulatory Council. January 2003.

Washington Department of Ecology (Ecology). 1994. *Natural Background Soil Metals Concentrations in Washington State*, Toxics Cleanup Program. Publication 94-15.

Washington Department of Ecology (Ecology). 1995. *Guidance on Sampling and Data Analysis Methods*. Toxics Cleanup Program. Publication 94-49.

Environmental Protection Agency Technology Innovation Office (TIO) 2003. *Considerations for Developing a Methods Applicability Study Small Arms Firing Range Bluffton South Carolina*, March 2003.

Figures

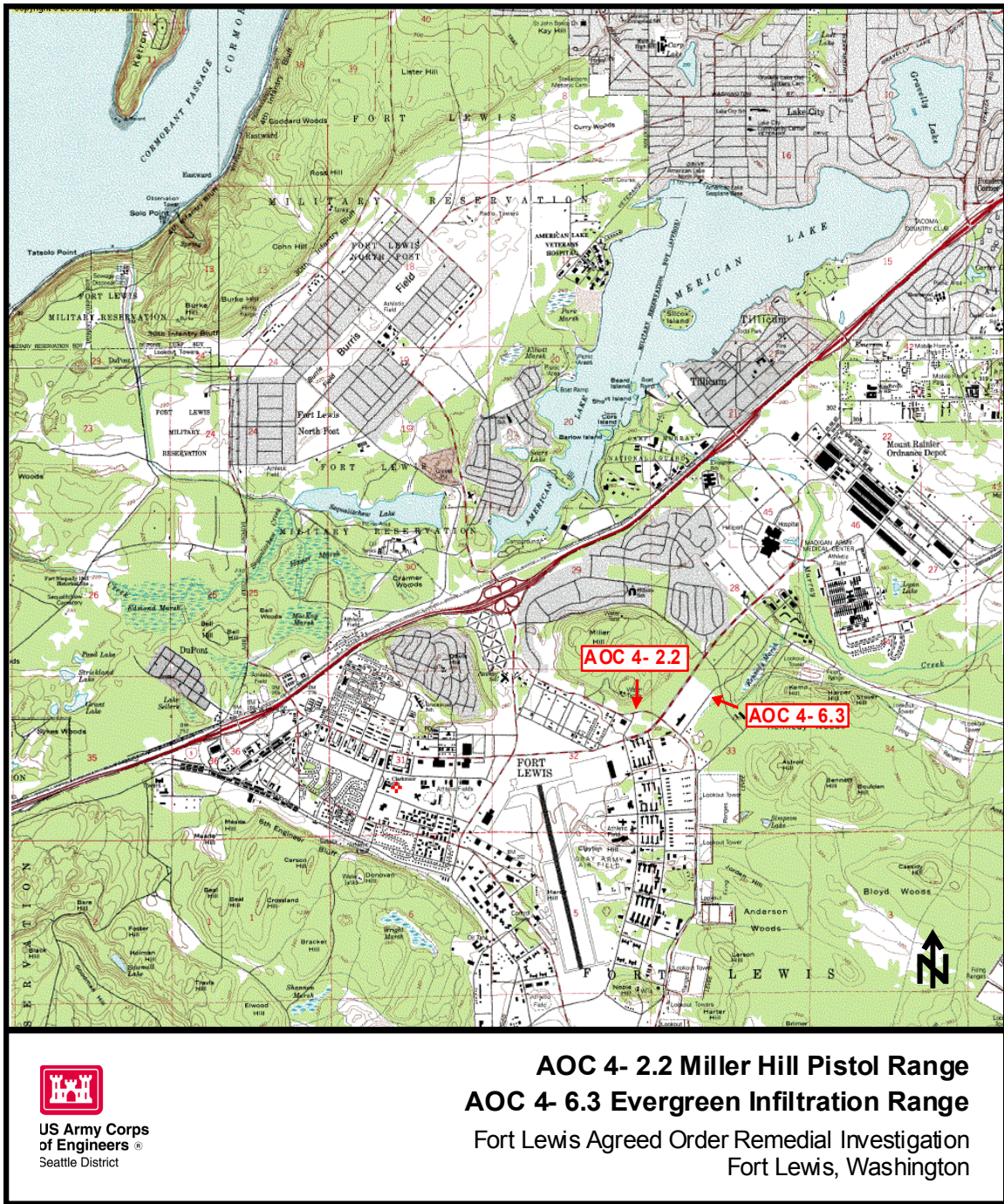


Figure A-1. Site Locations

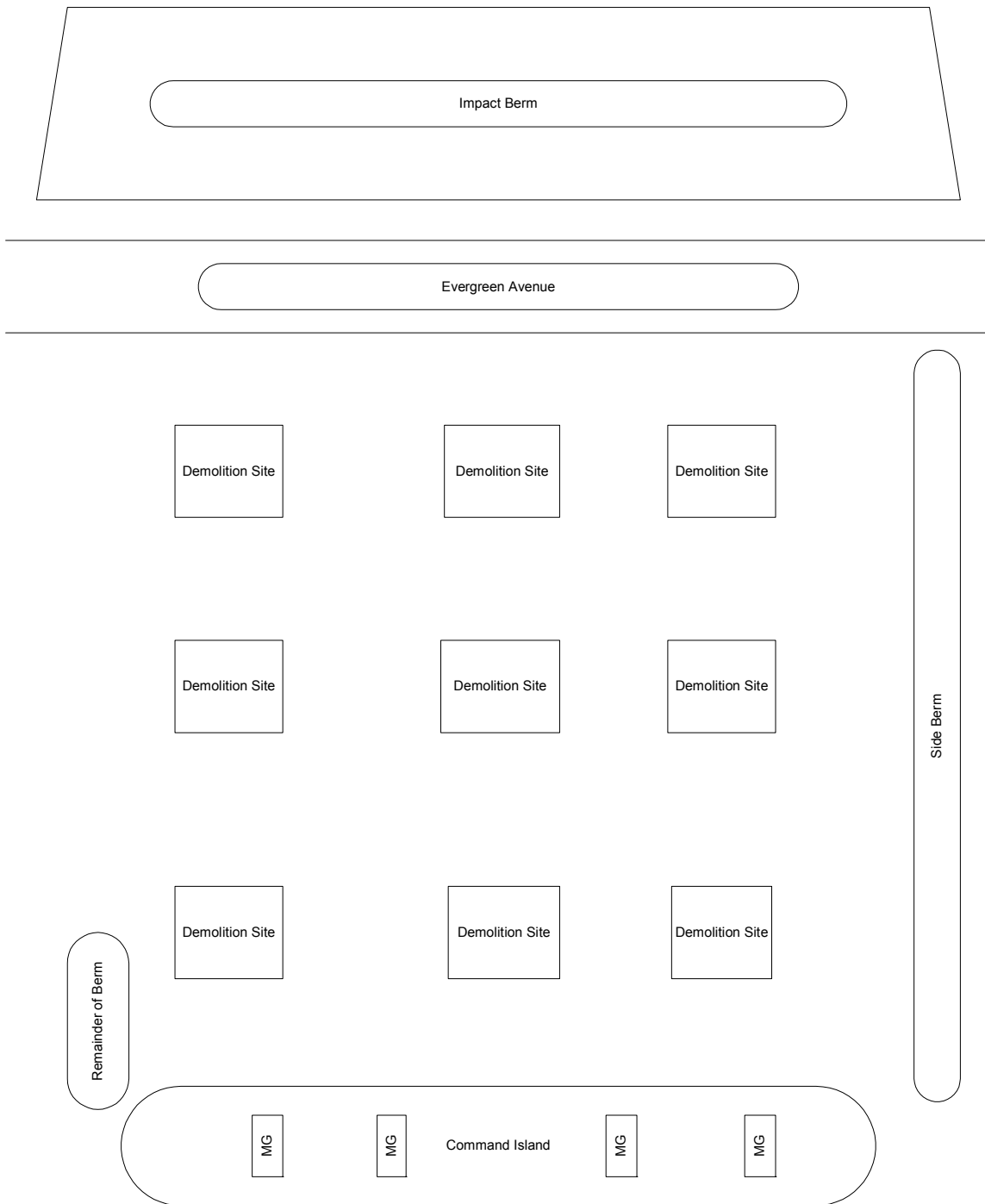


Figure A-2. Illustration of the Infiltration Range (Not Drawn to Scale)

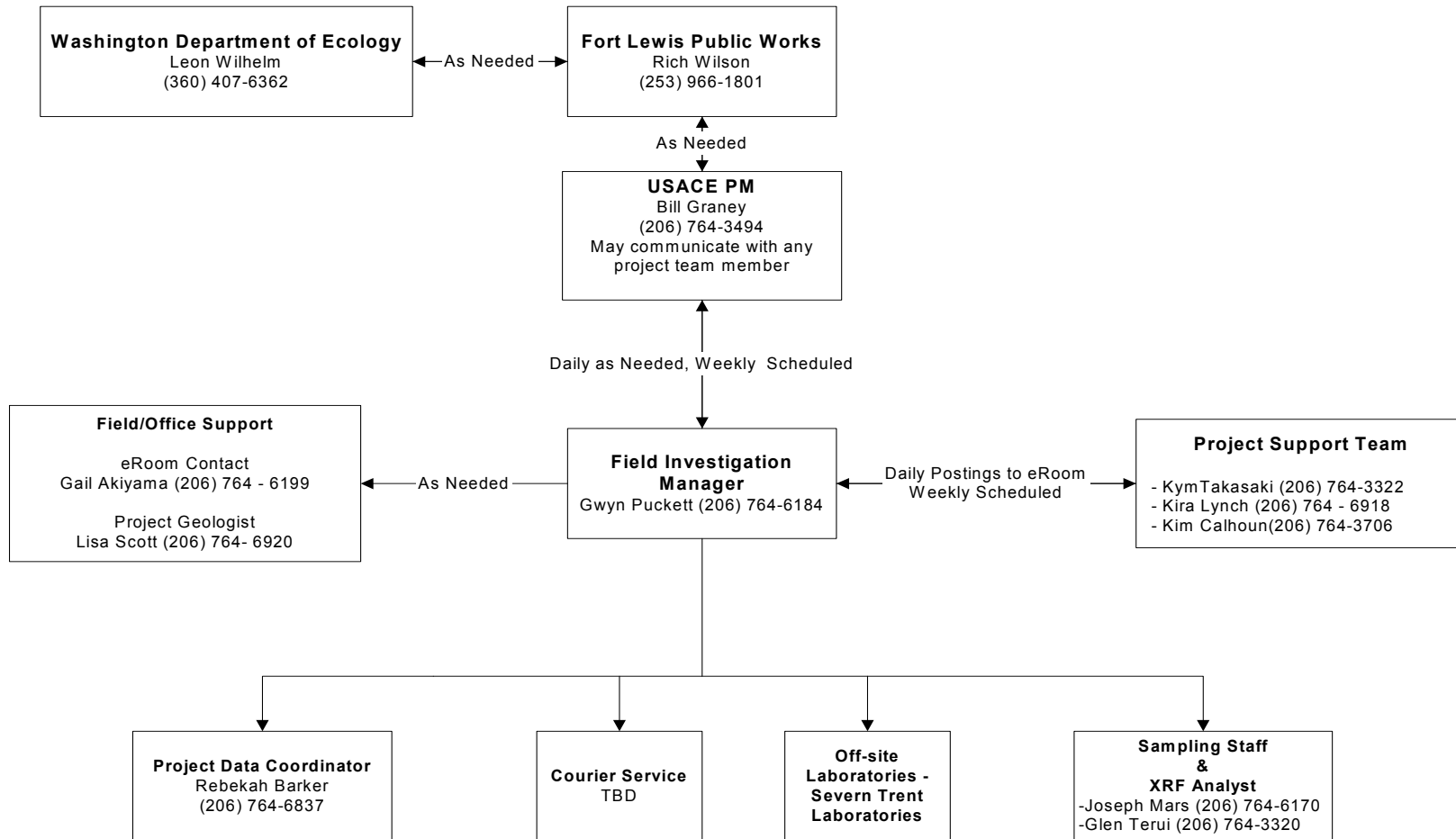


Figure A-3. Communication Strategy

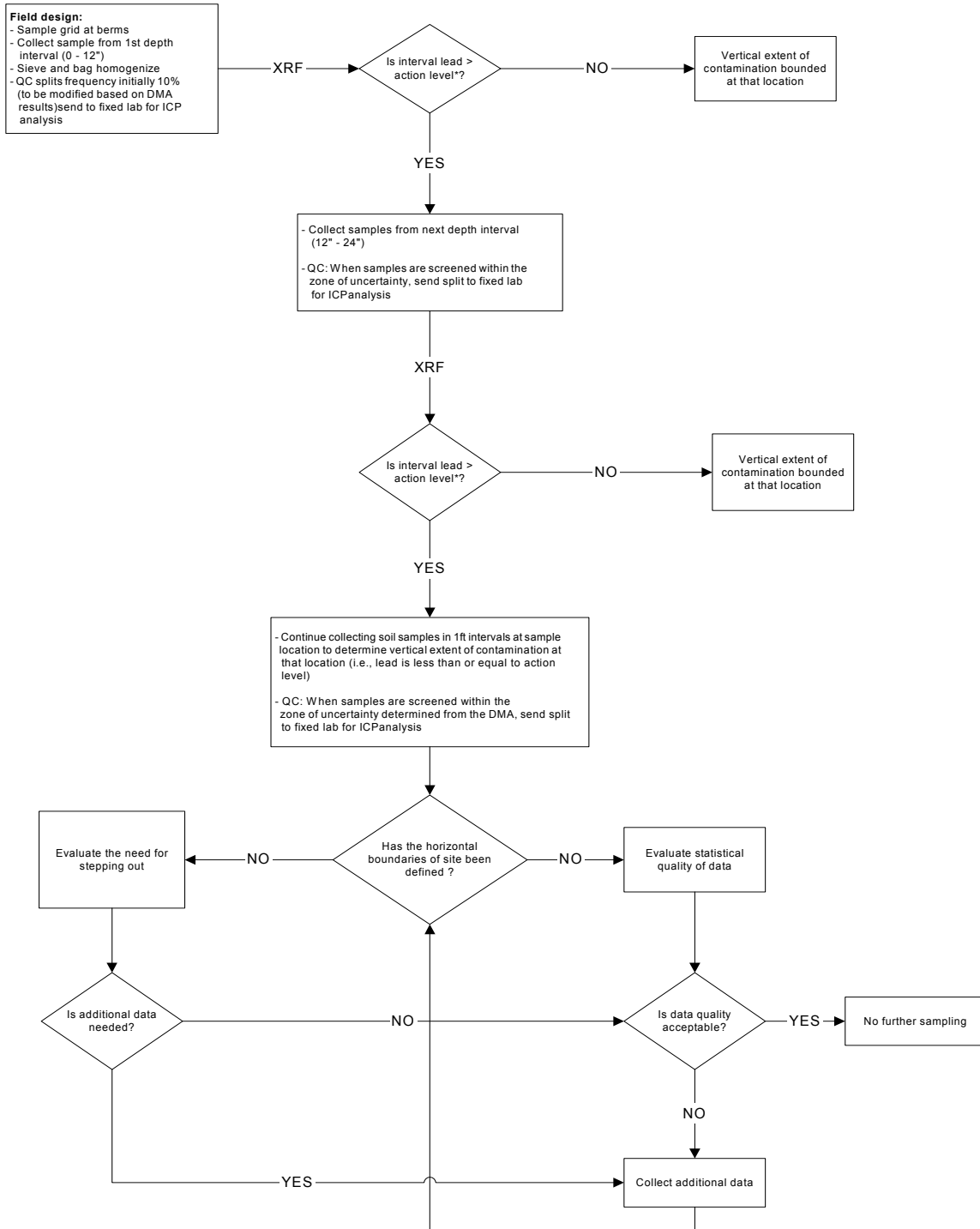
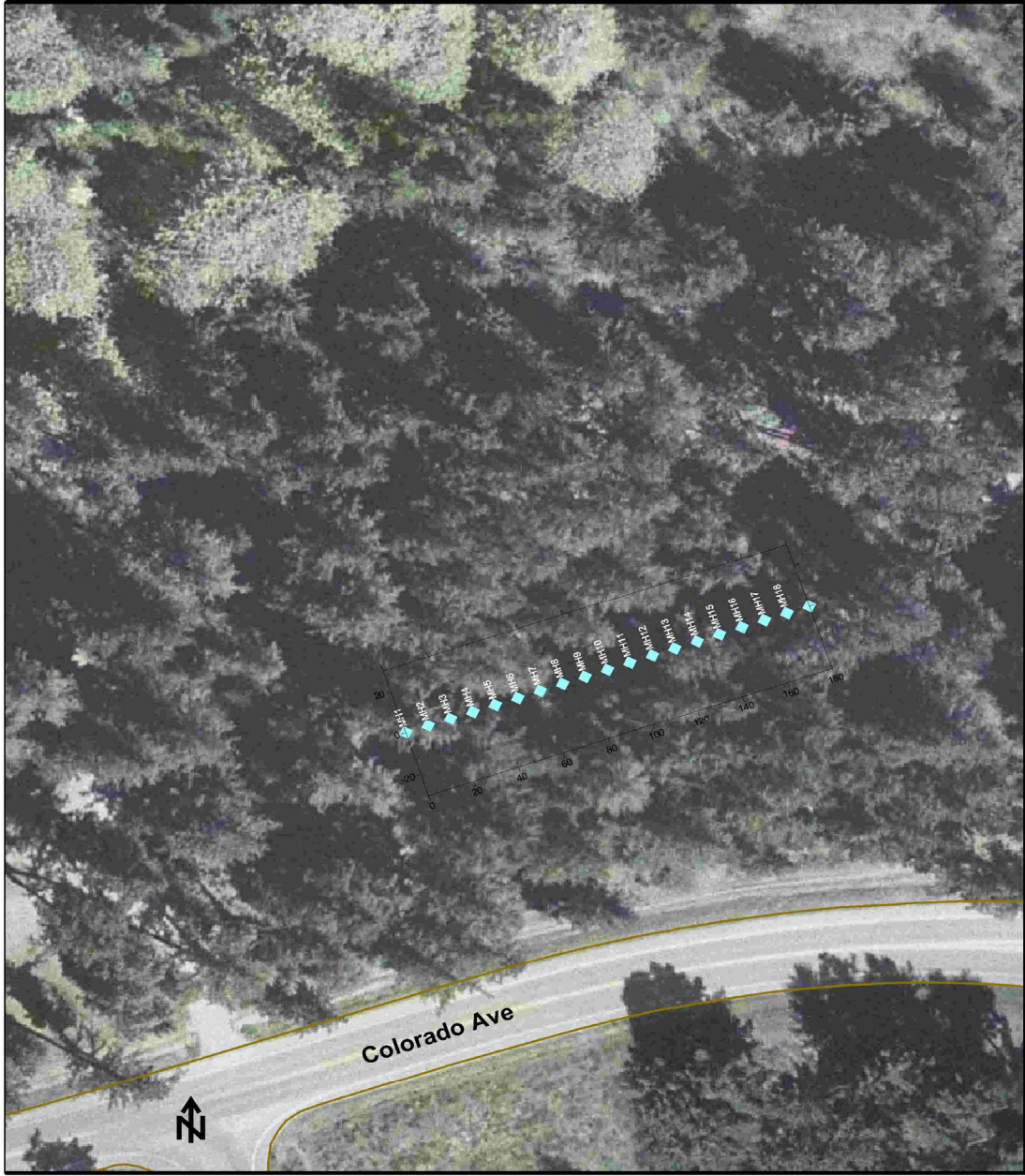


Figure A-4. Decision Tree for Field XRF Analysis

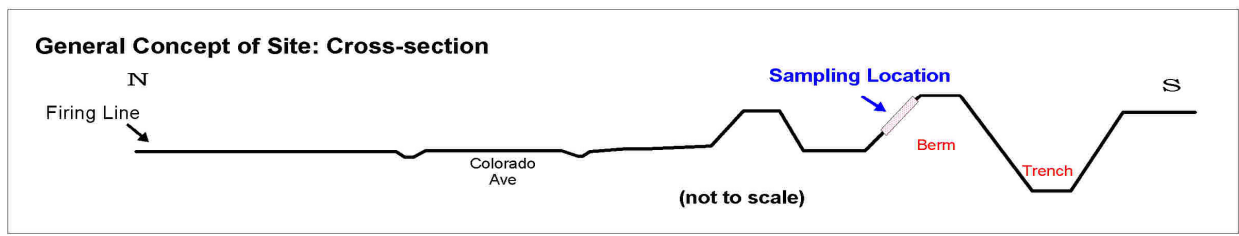
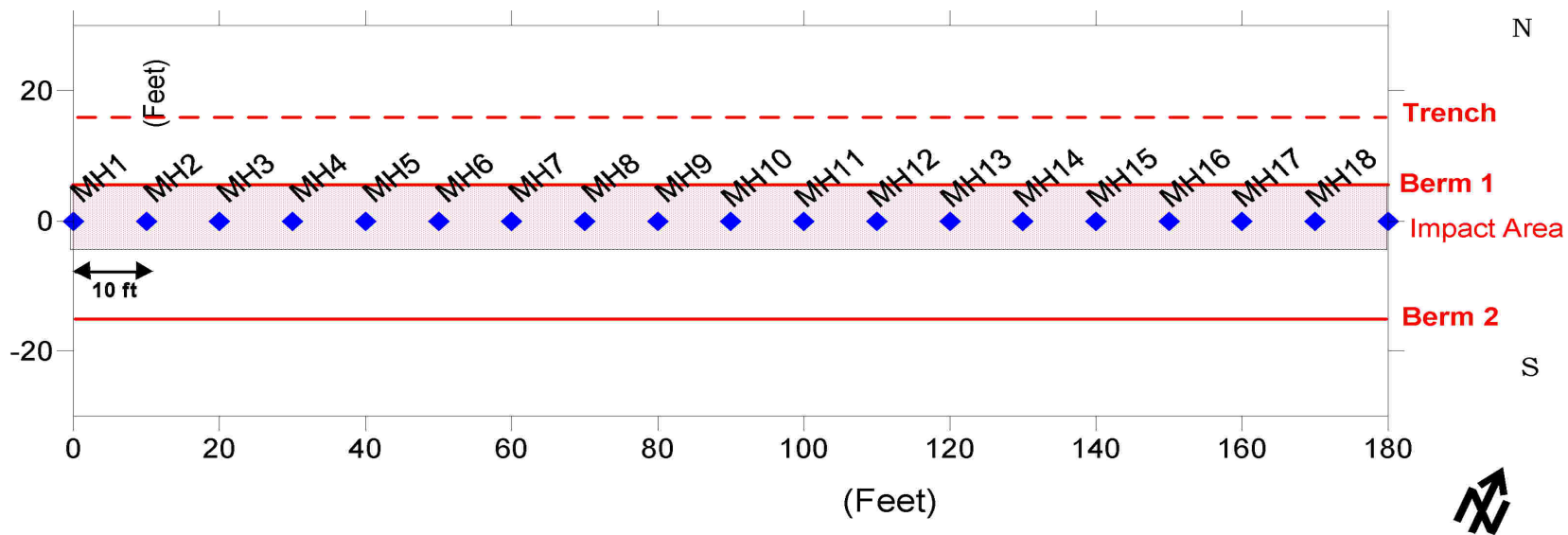
* The initial action level of 50 ppm will be modified for XRF during the DMA



AOC 4-2.2
Miller Hill Former Pistol Range
Sample Locations - Aerial Photograph 2002

◆ Sampling Locations for Lead

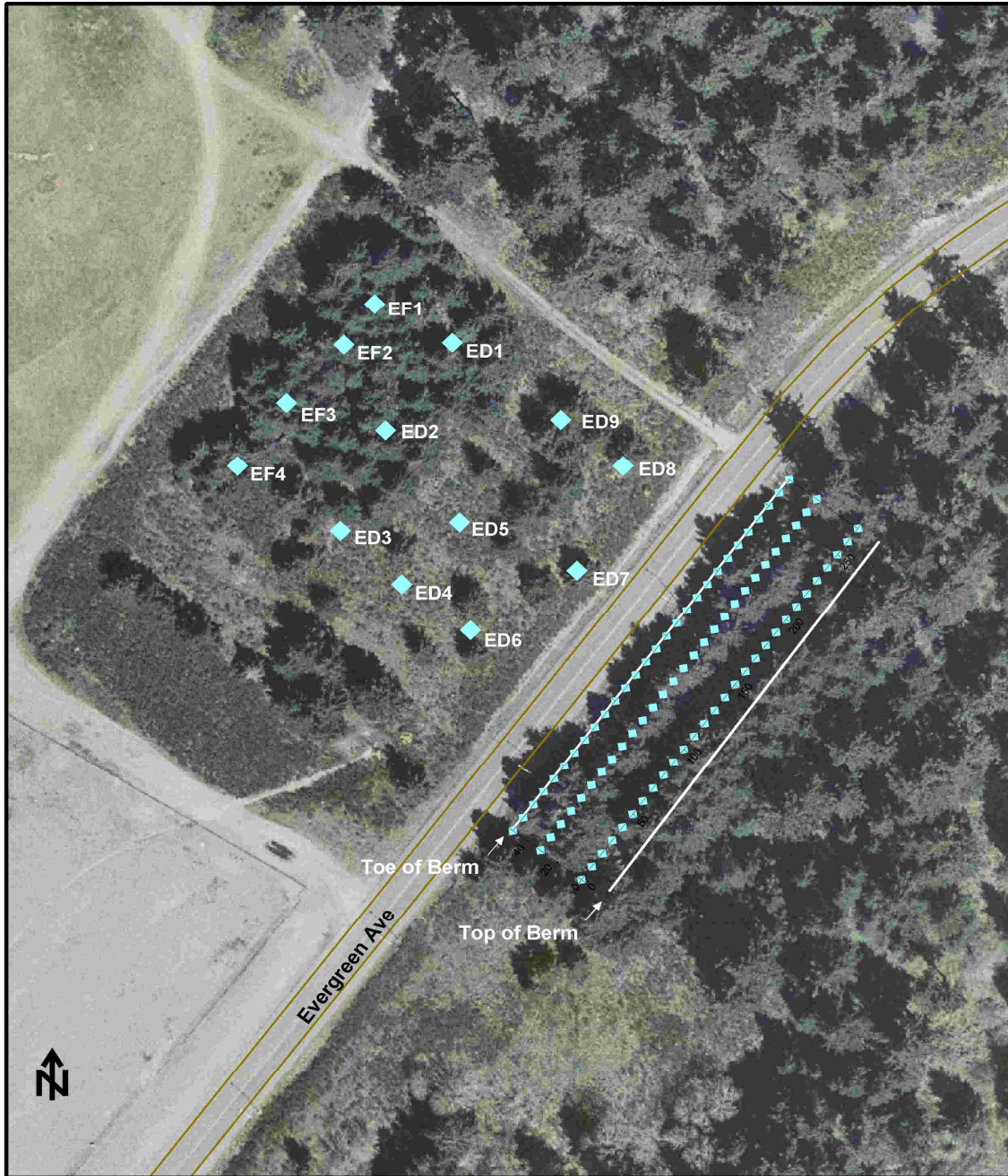
Figure A-5. Sample Locations at Miller Hill Pistol Range (AOC 4-2.2)



AOC 4- 2.2
Miller Hill Former Pistol Range
Sample Locations

- Berm
- - - Trench
- ◆ Sampling Locations for Lead
- Impact Zone

Figure A-6. Sampling Grid For Impact Berm at the Miller Hill Pistol Range (AOC 4-2.2)

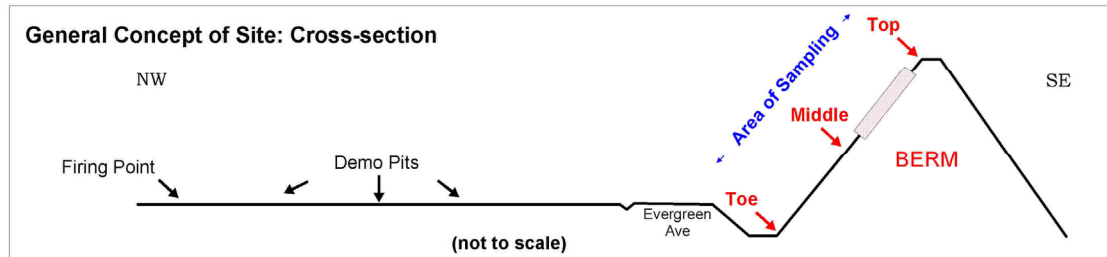
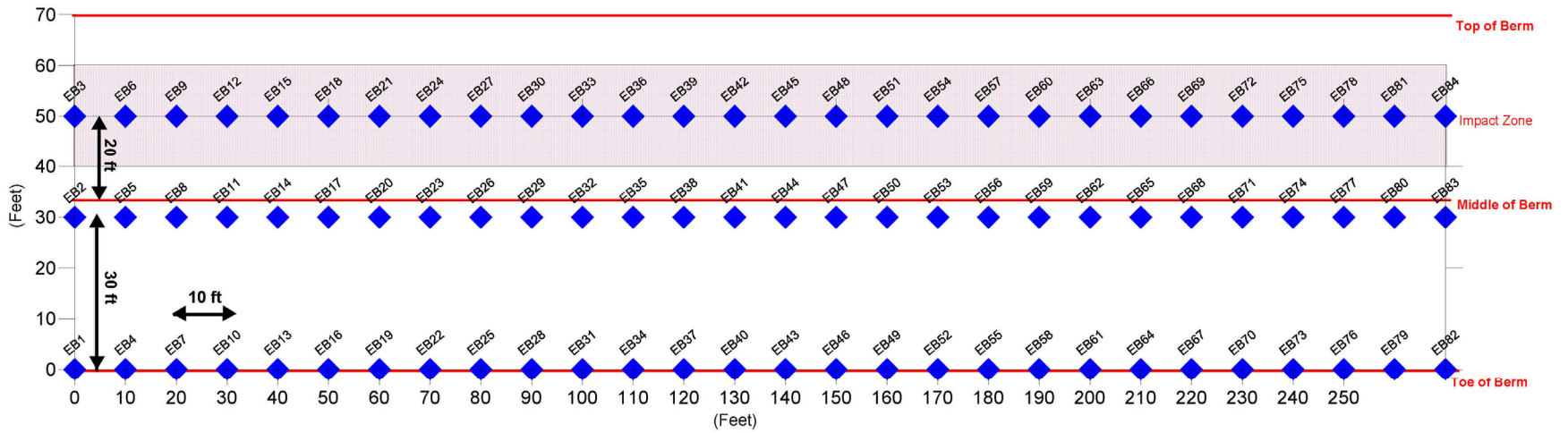


**AOC 4-6.3
Evergreen Former Infiltration Range
Aerial Photograph 2002
Sample Locations**

- Approx. Location of Berm (GPS coordinates)
- ◆ Sampling Locations for Lead
- ◆ Sampling Locations for Explosives
- EF (Firing Sites)
- ED (Demolition Sites)

Note: These locations are based on GPS, and locations need to be field verify. Errors appears to be occurring at Demo locations.

Figure A-7. Sampling Locations at Evergreen Infiltration Range (AOC 4-6.3)



AOC 4- 6.3
Evergreen Former Infiltration Range
Sample Locations on Northwest Facing Slope of Berm

- Berm Location Lines
- ◆ Sampling Locations for Lead
- Impact Zone

Figure A-8. Sampling Grid For Impact Berm at the Evergreen Infiltration Range (AOC 4-6.3)

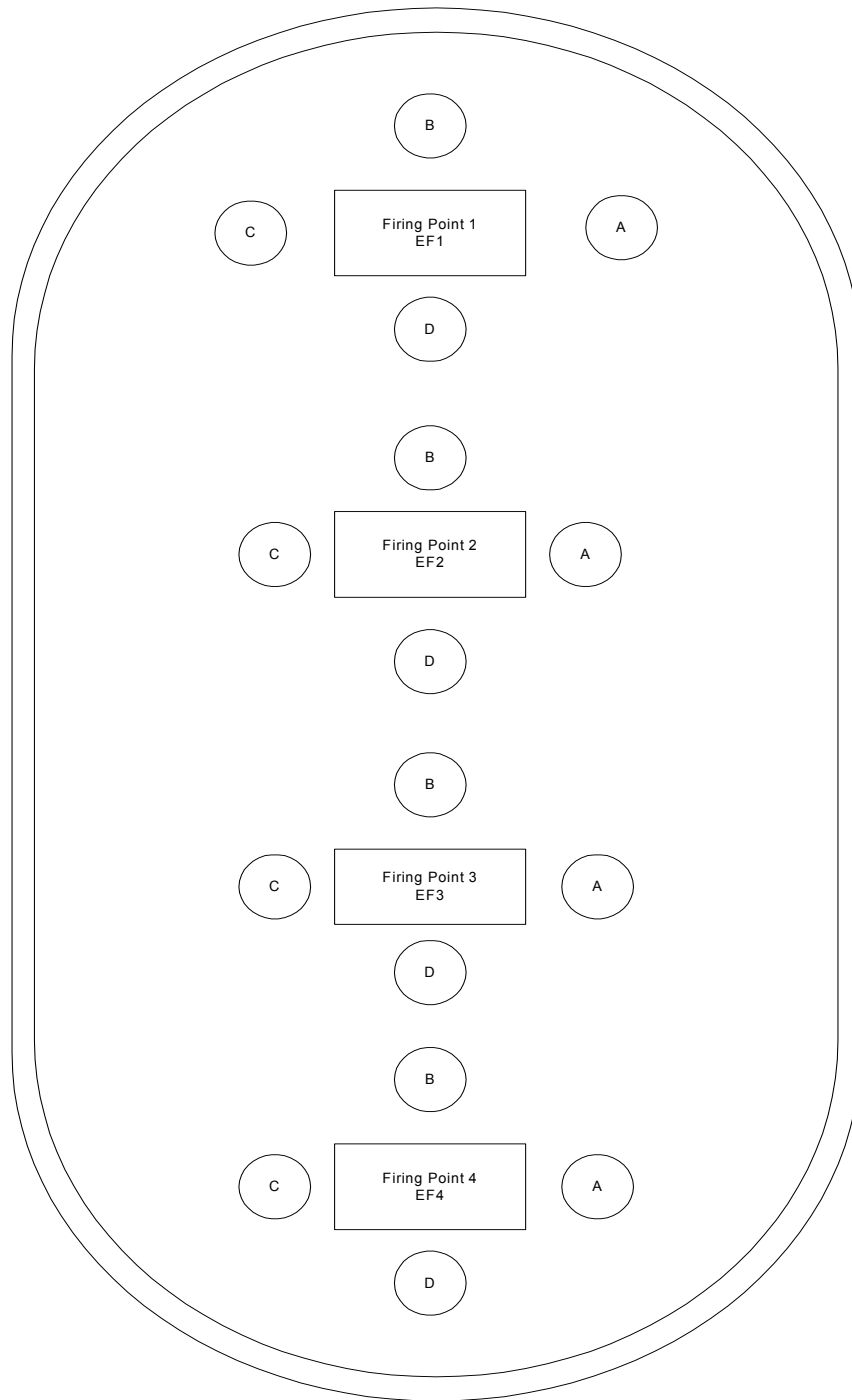


Figure A-9. Sampling Locations for the Firing Points in the Command Island at Evergreen Infiltration Range (drawing not to scale)

Firing Points

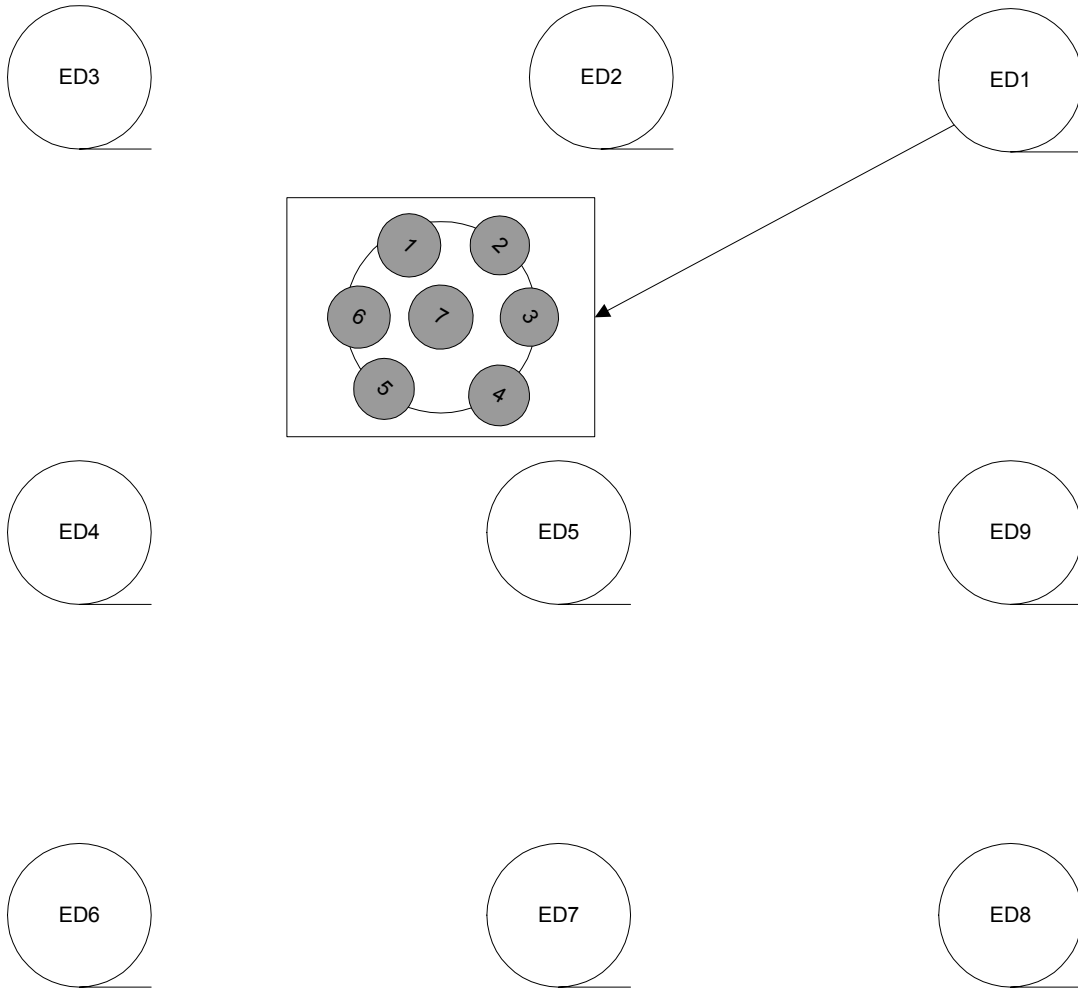


Figure A-10. Sampling Locations for Nine Demolition Sites at Evergreen Infiltration Range (drawing not to scale). The insert for ED1 is representative of the composited samples to be collected from each of the demolition sites.

Tables

TABLE A-1. CONTAMINANTS POTENTIALLY FOUND AT SMALL ARMS FIRING RANGES

Constituent	Comment
Lead metal	Primary bulk constituent of a projectile
Lead Styphnate/Lead Azide	Detonating compounds
Antimony	Increases hardness
Arsenic	Present in lead shot. A small amount is necessary in the production of small shot since it increases the surface tension of dropped lead, thereby improving lead shot roundness.
Copper bullet core alloy	Increases hardness
Tin	Increases hardness
Copper	Jacket alloy metal
Zinc	Jacket alloy metal
Iron	Iron tips on penetrator rounds

Source: ITRC – Characterization and Remediation of soils at Closed Small Arms Firing Ranges, January 2003

TABLE A-2. UNCERTAINTY MANAGEMENT ISSUES AND POTENTIAL RESPONSES

Problem	How to Identify	Resolution
Matrix heterogeneity	Compare the results of samples collected at known distances from each other (co-located duplicates)	After determining the scale over which it is important to understand the impact of heterogeneity, increase the sampling density in those areas where incorrect decisions would be risky from a protectiveness or economic aspect
Inadequate sample preparation/homogenization	Compare the precision of replicate sample prep + 7 XRF analyses on bag to the analysis performed on a single cup sample	Improve the consistency of sample preparation procedures, or select a procedure more appropriate to the matrix. Increasing sample size or the use of compositing might also need to be considered.
High analytical variability	Analytical QC sample results are outside required performance criteria or interferences are suggested by analysts observations	Apply additional sample cleanup steps or use an alternative peak to perform the analyte quantitations. For example, use an alternative spectral line for quantitation of arsenic when lead concentrations are high.
Detection limits are elevated due to the presence of interferences.	Non-detections are above the action level for the site resulting in the calculation of artificial risk	Same as above and selection of an alternative method that is more analyte specific. For example, use of a selective ion monitoring method for poly nuclear aromatics versus the standard SW-846 method 8270 for semivolatile organics
Detection frequencies are insufficient or the distribution of results so erratic that the maximum value has to be used for comparison to the action level	If detection frequencies are less than 50 percent and data distributions cannot be established as either normal or lognormal use of a UCL for determination of attainment may not be possible.	Block or stratify the data into different populations that could be more amenable to statistical analysis. Collect more data based on a geostatistical design to focus on where the highest uncertainty is predicted
Results are very close to the action level making decision making difficult	Based on the project limits of uncertainty the results fall in the category of too close to call	Decide that the result should be considered dirty, take a conservative approach, collect additional confirmation results and make a decision based on the average

TABLE A-3. QUALITY CONTROL SUMMARY TABLE FOR XRF AND LABORATORY ANALYSIS

QC Sample	Frequency	Acceptance Range	Purpose
PXRF			
Calibration Check sample	Beginning/end of day, 1 for every 20 samples	%D < 20%	Evaluate accuracy of FPXRF instrument
Precision sample	Every Sample for DMA. Frequency for the remainder of project will be determined during DMA.	%RSD <20%	Evaluate precision of FPXRF analysis at each step
Blank	1 for every 20 samples	< Reporting Limit	Determine presence of contamination on FPXRF equipment
Lab duplicate	1 for every 20 samples at every stage of prep	RPD <20%	Evaluate precision of FPXRF prep at each step
Field duplicate	1 for every 10 samples	RPD < 50%	Evaluate overall precision of sampling effort
Laboratory			
Matrix Spike	1 for every 20 samples	75%<R<125%	Evaluate accuracy of FPXRF instrument
Equipment Blank	1 per day	< Reporting Limit	Determine presence of contamination on field equipment
Lab duplicate	1 for every 20 samples	RPD <20%	Evaluate precision of laboratory analysis
Field duplicate	1 for every 10 samples	RPD < 50%	Evaluate overall precision of sampling effort

TABLE A-4. CLASSES OF EXPLOSIVES

Classes of Explosives		Standard Method
Nitroaromatics	TNT, DNT, TNB, DNB, NB, & Tetryl	EPA 8330
Cyclic nitramines	RDX & HMX	
Nitro esters	PETN, nitroglycerin, & nitrocellulose	

TABLE A-5. DETECTION/REPORTING LIMITS FOR XRF

Analyte	Matrix	Method Detection Limit (ppm) in Matrix	
		120 SECOND TESTING TIME	
		Sand	Standard Reference Materials (STM)
Lead	Soil	35	45

TABLE A-6. REPORTING LIMITS FOR METALS EPA 6010/6020

Parameter/Method	Analyte	MTCA Method A/B (in mg/kg)	Soil	
			RL	Unit
ICP Screen for Metals SW6010/6020		(in mg/kg)		
	Antimony	32	3.0	mg/kg
	Arsenic	20/0.67	1.0	mg/kg
	Copper	2960	2.0	mg/kg
	Iron	NA	20.0	mg/kg
	Lead	250	2.0	mg/kg
	Zinc	24000	2.0	mg/kg
	Tin	NA	10.0	mg/kg

TABLE A-7. REPORTING LIMITS FOR EXPLOSIVE RESIDUES

Parameter/Method	Analyte	MTCA Method A/B (mg/kg)	Soil	
			RL	Unit
Explosive Residues EPA 8330	1,3,5- TNB	21400	0.25	mg/kg
	1,3- DNB	8	0.25	mg/kg
	2,4,6- TNT	NA	0.25	mg/kg
	2,4-DNT	1600	0.25	mg/kg
	2,6-DNT	80	0.26	mg/kg
	HMX	NA	2.2	mg/kg
	m-Nitrotoluene	800	0.25	mg/kg
	Nitrobenzene	40	0.26	mg/kg
	o-Nitrotoluene	800	0.25	mg/kg
	p-Nitrotoluene	800	0.25	mg/kg
	RDX	9.09	1.0	mg/kg
	Tetryl	NA	0.05	mg/kg
	2,4/2,6 Dinitrotoluenes	1.47	0.05	mg/kg

TABLE A-8. METHOD QC LIMITS EPA METHOD 6000 SERIES

Metals	Blank Spike Recovery %
Pb, As, Cu, Sb, Zn, Fe, Sn	80-120

Metals	Matrix Spike Recovery %
Pb, As, Cu, Sb, Zn, Fe, Sn	75-125

Metals	Duplicate RPD
Pb, As, Cu, Sb, Zn, Fe, Sn	< = 25 %

TABLE A-9. METHOD QC LIMITS EPA METHOD 8330

Explosives	Blank Spike Recovery %
TNT, 2 4- DNT, RDX HMX, etc.	60-120
Explosives	Matrix Spike Recovery %
TNT, 2 4- DNT, RDX HMX, etc.	50-140
Explosives	Duplicate RPD
TNT, 2 4- DNT, RDX HMX, etc.	< = 20 %

TABLE A-10. SAMPLE REQUIREMENTS

ANALYTICAL METHOD	MATRIX	CONTAINER, PRESERVATION	MAXIMUM HOLDING TIME
Explosive Residues	Soil	1 8-oz. Clear wide mouth glass jar with Teflon lid. Cool to 4°C	40 days
TCLP – metals	Soil	1 8-oz. Clear wide mouth glass jar with Teflon lid. Cool to 4°C	180 days
XRF field-portable Analyses	Soil	Zipper-locking bag. Samples will be minimally prepared and bag analyzed.	180 days
EPA 6010/6020 – Total Metals – As, Cu, Pb, Tn, Zn, Sb, Fe (Split Samples)	Soil	1 8-oz. Clear wide mouth glass jar with Teflon lid. Cool to 4°C	180 days

TABLE A-11. SOIL SAMPLES FOR METALS ¹

<i>Area Matrix</i>		<i>Initial Sample Points</i>	<i>Depth (in)</i>	<i>Estimated Number of Samples</i>		
				<i>XRF</i>	<i>Confirmation Splits ²</i>	<i>Field Duplicates</i>
<i>Demonstration of Method Applicability</i>						
Berm	Soil	10	0-12	20	20	2
			12-24	20	20	2
<i>Former Miller Hill Pistol Range AOC 4-2.2</i>						
Berm	Soil	18	0-12	18	2	2
			12-24	18	2	2
			24-36	18	2	2
<i>Former Evergreen Infiltration Range AOC 4-6.3</i>						
Berm	Soil	84	0-12	64	7	7
			12-24	64	7	7
			24-36	84	8	8
Firing Points	Soil	16	0-12	16	2	2
			12-24	16	2	2
			24-36	16	2	2

¹These numbers are presented for contracting purposes only.

²The initial frequency for confirmation split samples is 100% during the DMA. The frequency of confirmation splits for the remainder of the samples will be determined from the DMA.

TABLE A-12. SOIL SAMPLES FOR EXPLOSIVES RESIDUE

<i>Site</i>	<i>Area Matrix</i>	<i>Depth (in)</i>	<i>Number of Samples</i>	<i>QC Samples</i>
Former Evergreen Demolition Sites	Soil	0-4	9	1 duplicate, and 1 MS/MSD
		6-12	9	1 duplicate

TABLE A-13. TCLP SAMPLES

<i>Site</i>	<i>Matrix</i>	<i>Contaminants</i>	<i>No. Samples</i>
Former Evergreen Infiltration Range	Soil	Lead and Arsenic	5
Former Miller Hill Pistol Range	Soil	Lead and Arsenic	5