8.0 Data Quality Objectives

Data quality objectives (DQO) are "qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions" (EPA, 2000). The DQO process enables investigators to define performance criteria and limit the likelihood of committing Type I or Type II decision errors. EPA's DQO process is a seven-step process for the development of acceptance criteria. The initial five steps of the process are focused on identifying qualitative criteria, while the sixth and seventh steps define quantitative criteria and a data collection design, respectively. The seven steps are addressed below in Sections 8.1 through 8.7.

8.1 Problem Statement

The SLERA conducted at the BGR ranges (IT, 2002a) identified four inorganic compounds (antimony, copper, lead, and zinc) in surface soil. In addition, barium, copper, lead, manganese, and thallium were identified as COPECs in sediment in Cane Creek. The SLERA also identified surface water COPECs as copper and lead.

The BGR range Problem Formulation and conceptual site model (Chapters 1.0 – 7.0) suggest that exposure pathways for the inorganic constituents identified as COPECs to terrestrial and aquatic receptors do exist and, therefore, require further study. The Problem Formulation process further identified the need for additional information to address questions related to constituent bioavailability, bioaccmulation potential, and site-specific toxicity.

Based on the findings of the SLERA and Problem Formulation, the objectives of the BERA for the BGR ranges include the following:

- Collect site-specific data to address bioavailability and bioaccumulation potentials in lower trophic level organisms that form the basis of the terrestrial and aquatic foodwebs at the BGR ranges.
- Collect site-specific data to address the existence and level of site-specific toxicity to terrestrial and aquatic receptors resulting from exposure to the COPECs.
- Determine the concentrations of the COPECs within the surface soils, surface water, and sediment at the BGR ranges at which the ecological receptors are at risk.
- Provide data of sufficient quality to develop a technically defensible characterization of risk at the BGR ranges for use by risk managers in their acceptance or rejection of

present and future ecological risks posed by the COPECs in surface soil, surface water, and sediment and, if necessary, develop ecologically-based cleanup criteria.

8.2 Decision Identification

The following decisions require site-specific data in order to address the issues identified in the Problem Statement presented in the previous section.

- Determine if the COPECs at the BGR ranges are available for bio-uptake (i.e., bioavailable) in terrestrial or aquatic systems
- Determine what levels of COPECs in soil, sediment, and surface water result in acute or chronic toxicity to terrestrial and aquatic receptors
- Determine if the COPECs bioaccumulate in the tissues of terrestrial invertebrates (e.g., earthworms) or benthic invertebrates, and if so, to what extent
- Determine whether the tissue burdens of COPECs in terrestrial invertebrates or benthic invertebrates have the potential to pose adverse effects to higher trophic level organisms that utilize terrestrial invertebrates as a major food source
- Determine whether benthic communities within Cane Creek are adversely affected by exposure to COPECs in surface water and sediment
- Determine whether the concentrations of COPECs in emergent benthic invertebrates have the potential to pose adverse effects to higher trophic level organisms that utilize emergent benthic invertebrates as a major food source
- Develop constituent-specific cleanup goals for soil, surface water, or sediment if the BERA concludes that there is the potential for unacceptable ecological risk.

8.3 Decision Inputs

This step identifies the information required to support the decisions identified above. The information that will be required include the following:

- Surface soil concentrations of the four soil COPECs (parts per million) within the three different "binding capacity" soils ("low", "medium", and "high")
- Earthworm mortality based on earthworm LC_{50} (lethal concentration killing 50 percent of the test population) data (parts per million) for each of the three different "binding capacity" soils ("low", "medium", and "high")
- Earthworm growth, as measured by earthworm weight at the end of the 28-day test, for each of the three different binding capacity soils ("low," "medium," and "high") and determination of NOAEL and LOAEL values based on weight

- Bio-uptake and accumulation potential based on the ratio of soil COPEC concentrations to earthworm tissue concentrations within each of the three different "binding capacity" soils ("low", "medium", and "high")

- Projected dose estimates of the four soil COPECs in the terrestrial invertivorous shorttail shrew and American woodcock, as well as the omnivorous American robin and white-footed mouse (mg COPEC per unit of body mass per day)

- Estimated levels of concern to the invertivorous shorttail shrew and American woodcock as well as the omnivorous American robin and white-footed mouse based on modeled hazard quotient (HQ) values (estimated total daily dose/literature-based effect value)

- Sediment concentrations of barium, copper, lead, manganese, and thallium

- Surface water concentrations of lead and copper

- *Chironomus riparius* mortality based on exposure to various COPEC concentrations in sediment and derivation of sediment LC_{50} values

- Chironomid growth, as measured by chironomid weight, at the termination of the 10-day test and determination of NOAEL and LOAEL values based on weight

- Bio-uptake and accumulation potential based on the ratio of sediment COPEC concentrations in Cane Creek to *Chironomus sp.* tissue concentrations

- Fathead minnow (*Pimephales promelas*) and water flea (*Ceriodaphnia dubia*) acute and sub-chronic responses to Cane Creek surface water

- Projected dose estimates of the COPECs in the riparian invertivorous little brown bat and marsh wren (mg COPEC per unit of body mass per day)

- Estimated levels of concern to the riparian invertivorous little brown bat and marsh wren based on modeled HQ values (estimated total daily dose/literature-based effect value)

- Benthic invertebrate community structure as determined by rapid bioassessment measurements.

These data will be used to help determine whether COPECs in surface soil, sediment, and surface water at the BGR ranges are, or will, present significant risk to ecological receptors. If ecological risks are predicted using the information presented above, then this information will also be used to determine the concentrations of COPECs in surface soil, sediment, and surface water that are protective of the terrestrial and aquatic receptors at the BGR ranges.

In order to ensure the proposed toxicity tests provide data of sufficient quality and statistical significance, the statistical power calculation presented in Appendix B of Draft Appendix 4-3 of the *Ecological Soil Screening Level Guidance* (USEPA, 2000) was applied. As described in the *Ecological Soil Screening Level Guidance* (USEPA, 2000), the statistical power test was conducted using the following equation:

$$Z_\beta = 0.5\left(\Delta/\sigma\right)\sqrt{N} - Z_\alpha$$

where:

Z_β	=	value of Z needed to detect a difference of Δ with a confidence of α and a power of β between the mean of two distributions each with a standard deviation s;
Δ	=	assumed difference between the exposed and control groups;
σ	=	pooled standard deviation of exposed and control groups;
N	=	number of animals in control plus exposed group combined; and
$Z\alpha$	=	value of Z when the area to the right of Z on the standard normal curve is equal to 100 x (1 – alpha).

The calculated value of Z_β was then compared to a critical value from a table of standard values. If the calculated value of Z_β is larger than the critical value, then the experimental data have the necessary power to detect the specified difference. Based on this calculation, if the toxicity tests have an assumed standard deviation of 15, then ten organisms per test chamber will result in sufficient statistical power to determine a 20 percent difference between on-site media (soil, surface water, and sediment) and reference media results at a 90 percent confidence.

8.4 Study Boundaries

Study boundaries define the spatial scale of the assessment at the BGR ranges. In order to conduct a useful BERA, it is imperative to define the geographic and temporal boundaries of the potential risk and to identify the target populations of interest. The BGR ranges consist of four small arms firing ranges (Ranges 21, 22, 24-upper, and 27 as well as Cane Creek and its tributaries). The BGR SLERA identified the old field terrestrial ecosystem at the BGR ranges and the aquatic habitats associated with Cane Creek as the habitats at greatest potential risk given their quality, level of contamination, and receptors likely to be exposed to the COPECs. The BGR BERA will, therefore, focus on the old field terrestrial and aquatic ecosystems associated with these ranges. The surface soils at these ranges have been classified with regard to their metal binding capacity as "high", "medium", and "low" binding capacity soils. Because the binding capacity of a soil has the potential to significantly affect the COPECs' bioavailability and subsequent toxicity, each of these soil types will be assessed individually in the BERA.

Additionally, based on the historical nature of the contamination at the BGR ranges, and the physical/chemical properties of the COPECs themselves, the concentrations of the COPECs in surface soil and sediment are not likely to change over time due to natural processes. Therefore, temporal variability of COPEC concentrations is not considered an important variable for these relatively static upland and riparian habitats.

The aquatic ecosystem of Cane Creek and its tributaries within the BGR ranges is similar in structure and function. This aquatic ecosystem will be represented by 5 distinct lead concentration ranges in both surface water and sediment.

The target populations for the BERA are the resident aquatic and terrestrial invertebrate communities and the wildlife feeding guilds that may be present within the bounds of the BGR ranges. Given the COPECs relatively low propensity for biomagnification up food chains, the target populations of greatest concern are the lower trophic level organisms (e.g., earthworms and benthic invertebrates) and the wildlife receptors that feed on them.

8.5 Decision Rule

The objective in developing specific decision rules is to construct theoretical "if...then..." statements relative to the ecological habitats, populations and COPECs. These statements can then be used by risk managers in deciding whether to accept or reject the characterized risk and, if necessary, in generating ecological based cleanup goals. The decision rules proposed for the BGR ranges BERA include the following:

- If COPECs in soils from the BGR and IMR ranges cause a 20 percent reduction in earthworm survival or growth, and an earthworm survival or growth rate that is statistically different than those from reference soils at a 90 percent confidence, then there is the potential for unacceptable risks to terrestrial invertebrate receptors at the BGR ranges.

- If earthworms exposed to soils from the BGR and IMR ranges demonstrate statistically higher tissue concentrations of COPECs (20 percent difference) than earthworms exposed to "reference" soils, then there is the potential for significant COPEC accumulation in terrestrial invertebrate tissues.

- If calculated doses of COPECs for terrestrial invertivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to terrestrial invertivorous mammals or birds at the BGR ranges.

- If calculated doses of COPECs for terrestrial omnivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to terrestrial invertivorous mammals or birds at the BGR ranges.

- If, based on the collective evaluation of the lines-of-evidence, COPECs are determined to pose unacceptable risks to terrestrial receptors at the BGR ranges, then remedial goals for soil will be developed using the data collected during the BERA.

- If COPECs in Cane Creek surface water cause a 20 percent reduction in survival or reproduction of *Ceriodaphnids* and a survival or reproduction rate for *Ceriodaphnids* that is statistically different at a 90 percent confidence than those for reference waters, then there is the potential for risk to water column receptors at the BGR ranges.

- If COPECs in Cane Creek sediments cause a 20 percent reduction in survival or growth of the benthic invertebrate *Chironomus sp.* and a survival or reproduction rate for *Chironomus sp.* that is statistically different at a 90 percent confidence than those for reference sedimentss, then there is the potential for risk to emergent benthic invertebrates at the BGR ranges.

- If chironomids exposed to sediment from Cane Creek demonstrate statistically higher tissue concentrations of COPECs (20 percent difference) than chironomids exposed to "reference" sediment, then there is the potential for significant COPEC accumulation in benthic invertebrate tissue.

- If the benthic community assemblage in Cane Creek at the BGR ranges is significantly different than the benthic community assemblage in a non-impacted reference stream or literature-based benthic asemblages, then there is the potential for risk to the Cane Creek benthic ecosystem.

- If calculated doses of COPECs for riparian invertivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to riparian invertivorous mammals or birds at the BGR ranges

It is important to consider the role of background concentrations of COPECs when developing specific decision rules. It is possible that naturally-occurring concentrations of certain inorganic constituents in environmental media could result in a determination of unacceptable risk. Therefore, background will be considered within the context of each of the aforementioned decision rules.

8.6 Tolerable Limits on Decision Errors

Chemical and biological data collected as part of the BERA process will be collected in a manner such that they are representative of the abiotic media and biotic communities at the BGR ranges. Since the collected data are only small sub-populations of the entire BGR ranges, they can only be used to predict responses that may actually occur at these ranges under natural conditions. As such, these data must be interpreted with a level of confidence or probability, that will be less

than 100 percent error free. The objective in establishing tolerable probability limits is to generate the proper quantity and quality of data to meet the targeted limit.

The decision error resulting from using soil samples representative of the entire lead concentration range in toxicity testing is acceptable due to the fact that the bioavailability and toxic concentrations of the COPECs are unknown. It is not clear that testing soils in any particular lead concentration range would decrease the decision error. Therefore, the entire lead concentration range will be tested and the resultant decision error will be discussed in the context of the toxicity test results and ecological risk assessment.

8.7 Design Optimization

The objective in design optimization is to develop a "resource-effective" sampling and analysis plan for generating data. The sampling and analysis plans presented in Appendices A and B have been optimized to ensure that the tolerable limits on decision errors will be met.

9.0 Site Investigation Tasks

The BERA for the BGR ranges will focus on characterizing risk associated with the COPECs in surface soil within the old field terrestrial habitats, as well as sediments and surface water within Cane Creek. The site investigation tasks are directly linked to the assessment and measurement endpoints described within Section 7.0.

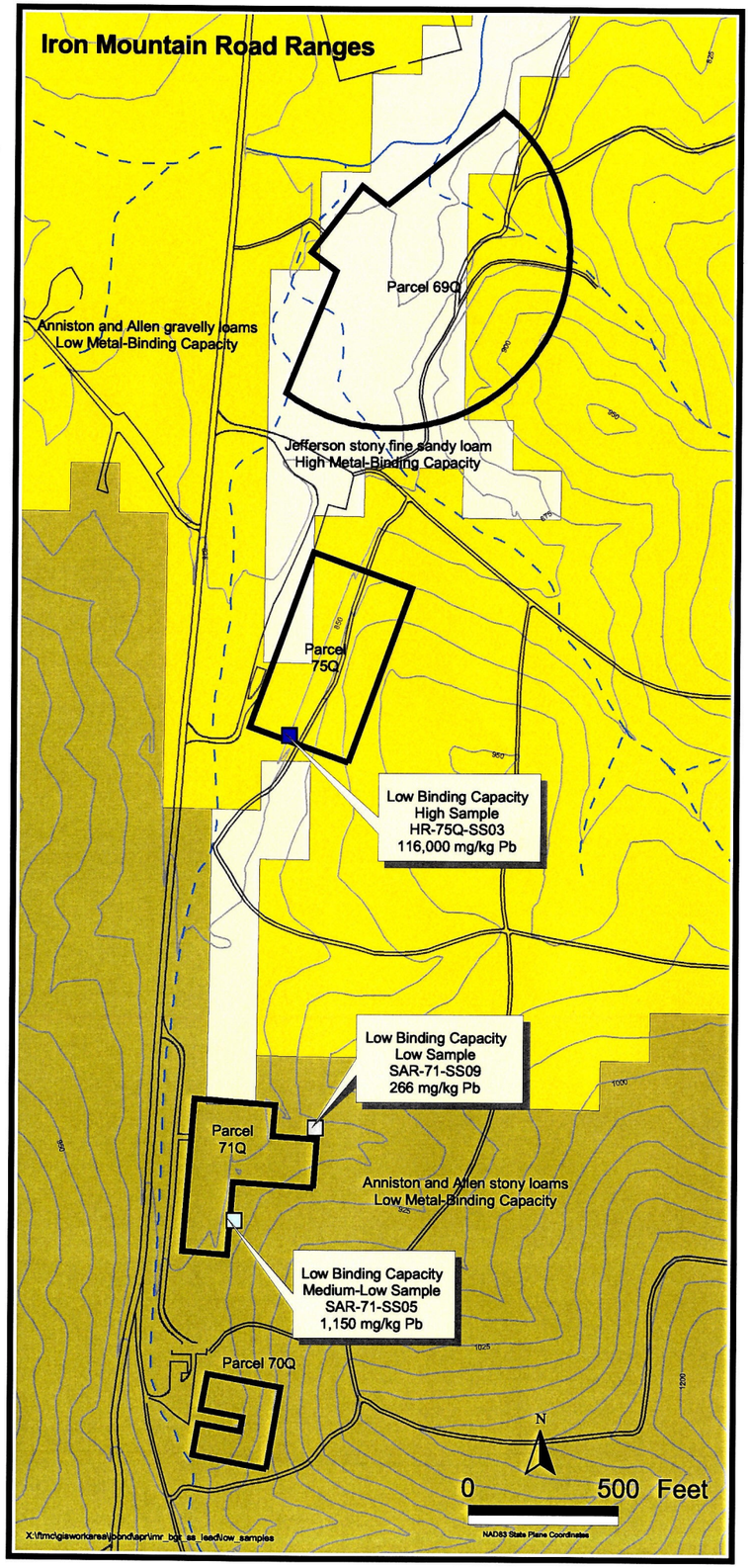
The principal objective of this site investigation is to outline a laboratory and field-based approach to reduce uncertainty associated with the SLERA process and to provide risk managers with information to incorporate into site remedial decisions. It is important to note that the study outlined in this section is designed to provide a number of lines of evidence relative to present and future risks to terrestrial and aquatic receptors.

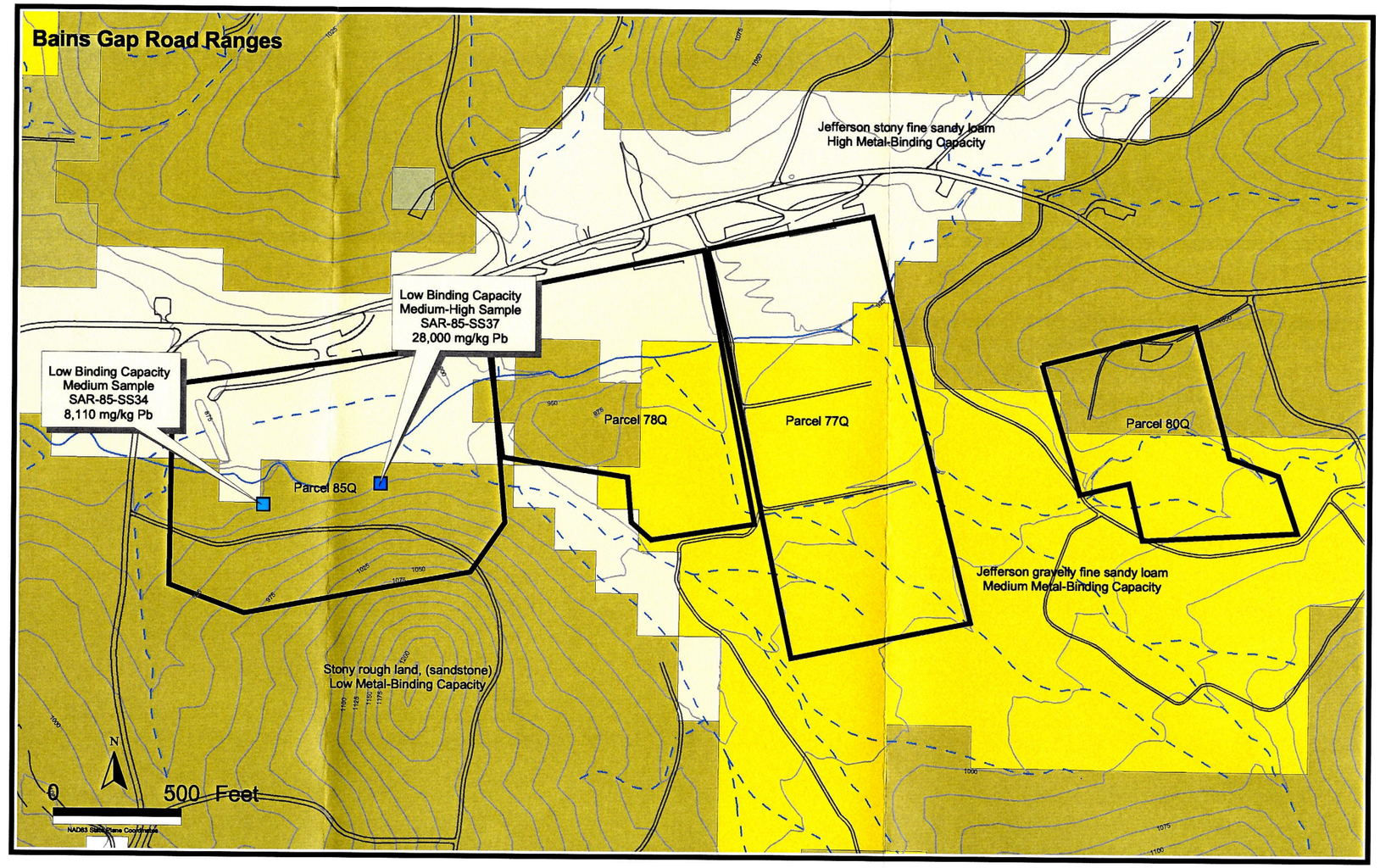
9.1 Terrestrial Receptor Study Design

The tasks involved in the study design for terrestrial ecosystems at the BGR ranges are described in the following sections.

9.1.1 Soil Collection for Chemical Analysis

It is important to note that surface soils collected from IMR and BGR ranges are being used jointly in order to characterize toxicity and bioavailability of the COPECs under differing soil conditions. The old field soils of IMR and BGR ranges represent a spectrum of three major soil types relative to binding capacities. Since binding capacities will dictate the bioavailability of COPECs to terrestrial receptors, toxicity and bioaccumulation will be measured for each of the three soil types. Soils representing high and low binding capacities will be collected from the IMR ranges, while the medium binding capacity soils will be collected from the BGR ranges (Figures 9-1, 9-2, and 9-3). Results of earthworm toxicity and bioaccumulation measurements will therefore be used for both the IMR and BGR range BERAs for assessing risks to terrestrial receptors. Surface soil (0 to 0.5 feet below ground surface) will be collected from five locations in each of these three soil types. Figures 9-1, 9-2, and 9-3 present the sample locations for a five-point concentration gradient within each of the three metal-binding capacity soil types. Table 9-1 summarizes information about these sample locations. These fifteen locations will represent the total lead gradient found within the three soil types at the IMR and BGR ranges. Locations for soil sampling will be identified using *in situ* x-ray fluorescence technology. These surface soil samples will be analyzed for a full suite of inorganic and organic analytes. Additionally, one soil sample will be collected from each of the five different soil mapping units





Legend

- Study Area
- Roads
- Streams (dashed where intermittent)
- Topographic Contours (25-foot interval)

Target Concentration Range

- Low Sample
- Medium-Low Sample
- Medium Sample
- Medium-High Sample
- High Sample

Soil Mapping Units

- Anniston and Allen gravelly loams
- Anniston and Allen stony loams
- Jefferson gravelly fine sandy loam
- Jefferson stony fine sandy loam
- Stony rough land, (sandstone)
- mine or quarry (D)

Figure 9-1

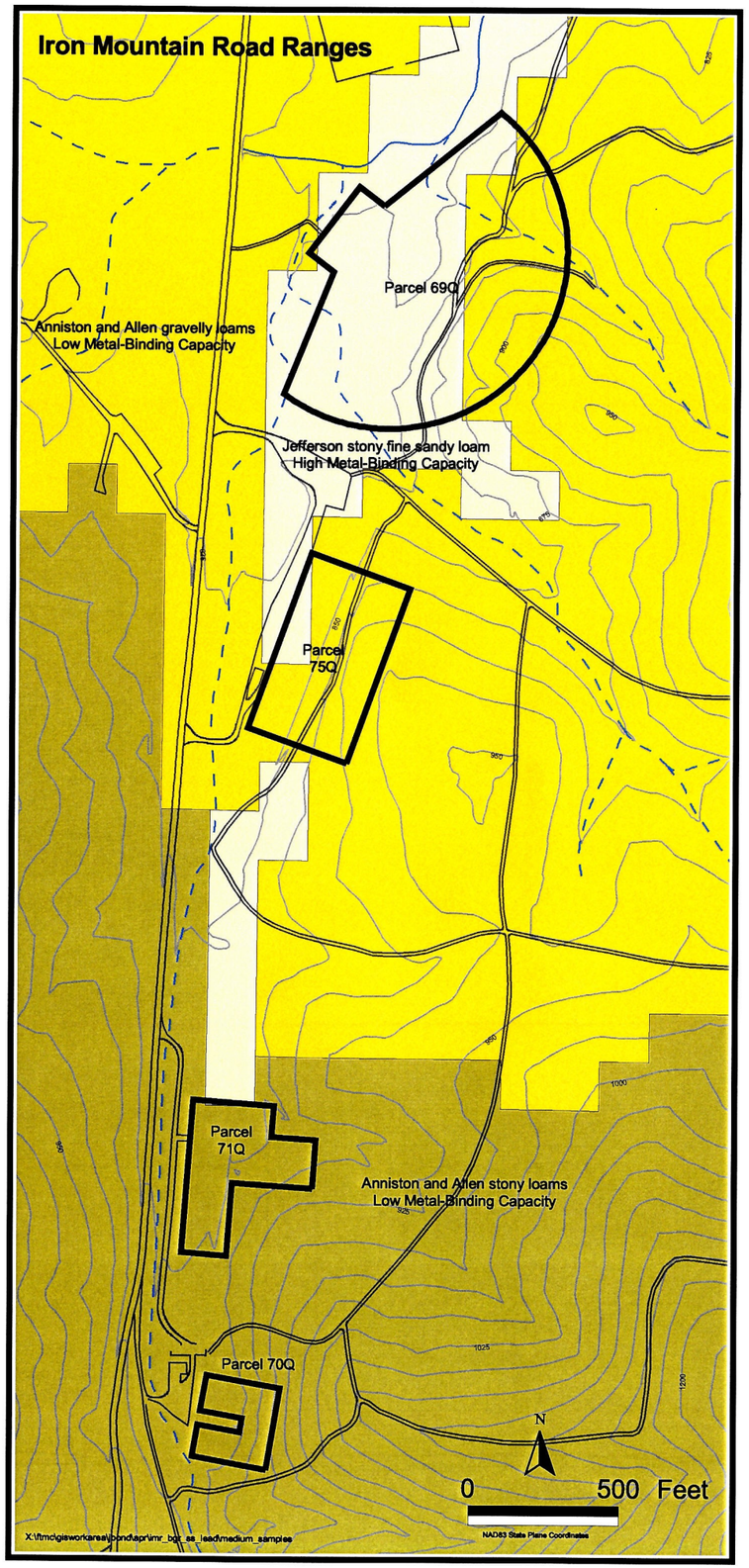
Low Metal-Binding Capacity Surface Soil Sample Locations

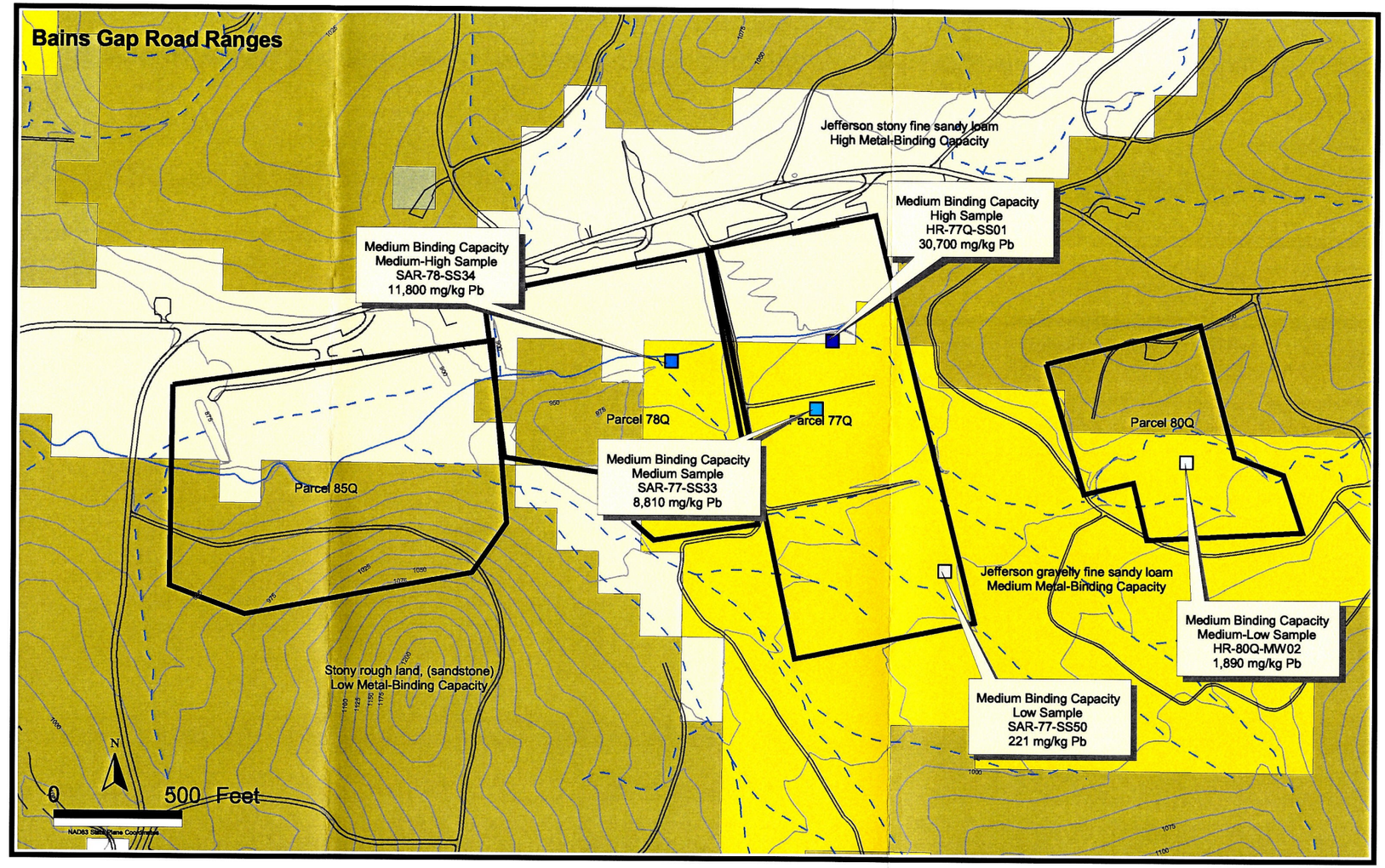
Iron Mountain Road and Bains Gap Road Ranges, Fort McClellan, Alabama

Shaw™ Shaw Environmental, Inc.

U.S. Army Corps of Engineers Mobile District

Contract No. DACA21-96-D-0018





Legend

- Study Area
- Roads
- Streams (dashed where intermittent)
- Topographic Contours (25-foot interval)

Target Concentration Range

- Low Sample
- Medium-Low Sample
- Medium Sample
- Medium-High Sample
- High Sample

Soil Mapping Units

- Anniston and Allen gravelly loams
- Anniston and Allen stony loams
- Jefferson gravelly fine sandy loam
- Jefferson stony fine sandy loam
- Stony rough land, (sandstone)
- mine or quarry (D)

Figure 9-2

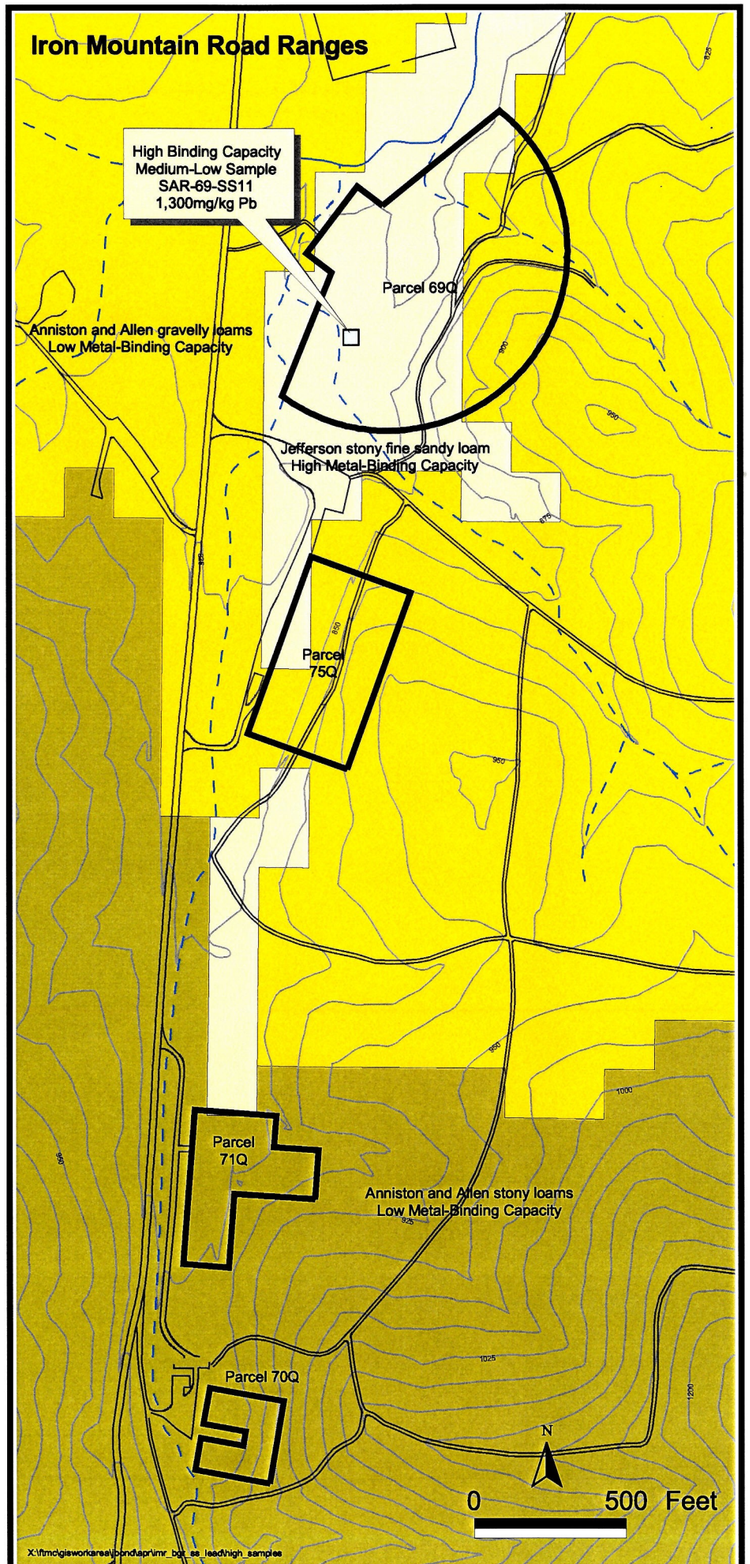
Medium Metal-Binding Capacity Surface Soil Sample Locations

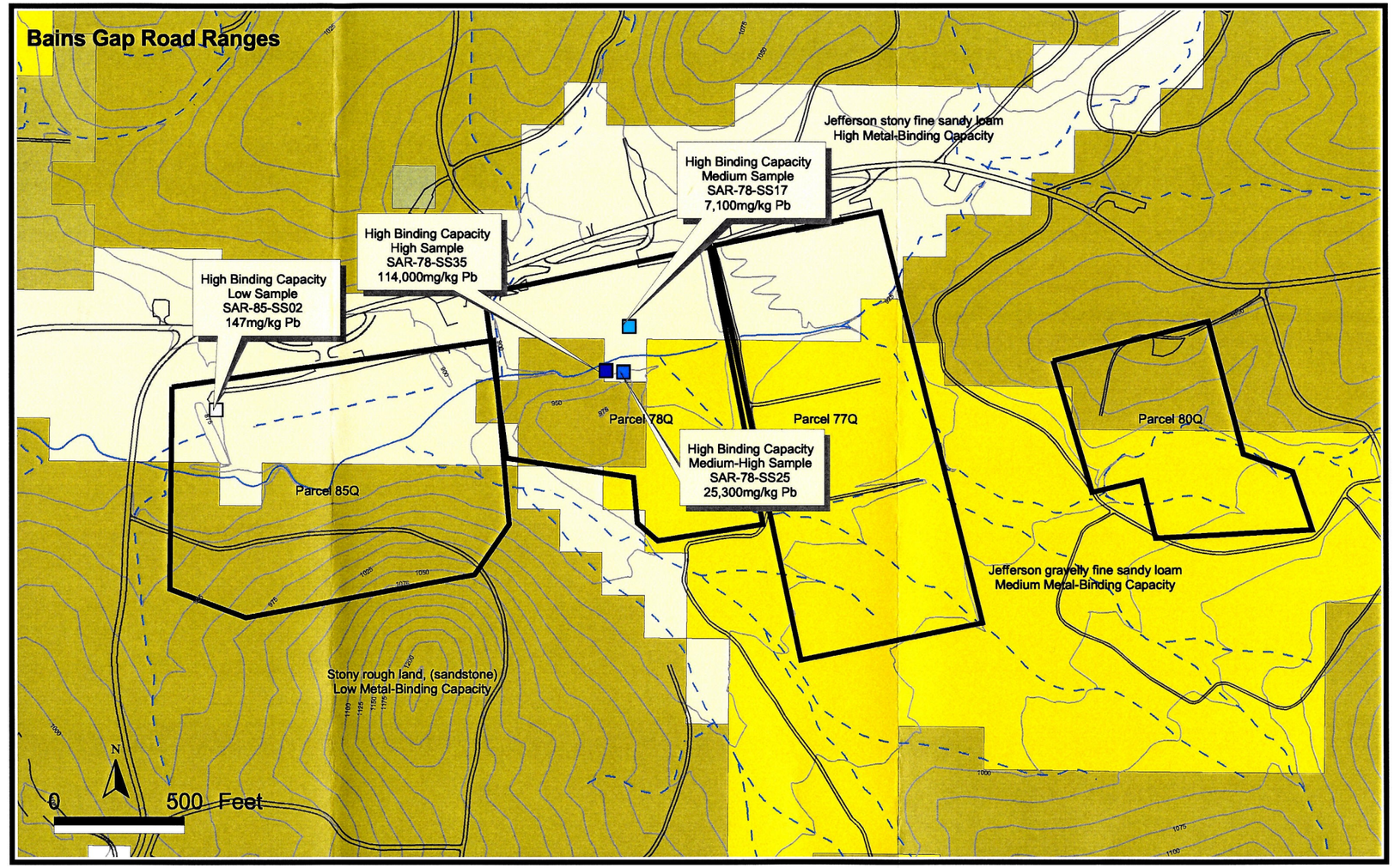
Iron Mountain Road and Bains Gap Road Ranges, Fort McClellan, Alabama

Shaw™ Shaw Environmental, Inc.

U.S. Army Corps of Engineers Mobile District

Contract No. DACA21-96-D-0018





Legend

- Study Area
- Roads
- Streams (dashed where intermittent)
- Topographic Contours (25-foot interval)

Target Concentration Range

- Low Sample
- Medium-Low Sample
- Medium Sample
- Medium-High Sample
- High Sample

Soil Mapping Units

- Anniston and Allen gravelly loams
- Anniston and Allen stony loams
- Jefferson gravelly fine sandy loam
- Jefferson stony fine sandy loam
- Stony rough land, (sandstone)
- mine or quarry (D)

Figure 9-3

High Metal-Binding Capacity Surface Soil Sample Locations

Iron Mountain Road and Bains Gap Road Ranges, Fort McClellan, Alabama

Shaw™ Shaw Environmental, Inc.

U.S. Army Corps of Engineers Mobile District

Contract No. DACA21-96-D-0018

Table 9-1
Surface Soil and Sample Location Summary
Soil Collection for Chemical Analysis

Type	Pb Level	Sample ID	Site ID	Pb Conc
Low MBC	High	HR75Q-SS03	IMR-R19	116000
	Med-High	SAR-85-SS37	BGR-R27	28000
	Med	SAR-85-SS34	BGR-R27	8110
	Med-Low	SAR-71-SS05	IMR-R13	1150
	Low	SAR-71-SS09	IMR-R13	266
Med MBC	High	HR-77Q-SS01	BGR-R21	30700
	Med-High	SAR-78-SS34	BGR-R22	11800
	Med	SAR-77-SS33	BGR-R21	8810
	Med-Low	HR-80Q-MW02	BGR-R24U	1890
	Low	SAR-77-SS50	BGR-R21	221
High MBC	High	SAR-78-SS35	BGR-R22	114000
	Med-High	SAR-78-SS25	BGR-R22	25300
	Med	SAR-78-SS17	BGR-R22	7100
	Med-Low	SAR-69-SS11	IMR-Skeet	1300
	Low	SAR-85-SS02	BGR-R27	147
		Total No. Samples = 15		

MBC - metal-binding capacity

IMR - Iron Mountain Road Ranges - Skeet Range, Range 19, Range 13, and Range 12

BGR - Bains Gap Road Ranges - Range 21, Range 22, Range 27, and Range 24 Upper

Pb Conc - measured lead concentration in mg/kg

different soil mapping units in an area that is unimpacted by FTMC activities. These five soil samples will represent the reference soils.

Analytical data from these surface soil samples will be used in conjunction with the earthworm toxicity test results to derive lowest-observed-adverse-effect-levels (LOAEL) and no-observed-adverse-effect-levels (NOAEL) for earthworms. These soil data will also be used in the food web models to calculate total COPEC doses for the terrestrial invertivorous and omnivorous birds and mammals. Additionally, these soil data will be used in conjunction with the measured tissue concentrations of COPECs in the earthworms to estimate soil-to-earthworm bioaccumulation factors.

Details of the collection methods, decontamination procedures, quality assurance/quality control, and other sampling procedures are presented in the installation-wide sampling and analysis plan (IT, 2002b) and are summarized in Appendix A of this report. As presented in the installation-wide sampling and analysis plan and Appendix A, visible bullets and bullet fragments will be manually removed from the samples prior to transferring the sample to the sample containers. Samples for chemical analysis and toxicity testing will not be sieved.

9.1.2 Soil Collection for Earthworm Toxicity Tests

Assessment of the terrestrial invertebrate community associated with IMR and BGR range surface soils will be based on quantitative laboratory testing using the detritivorous earthworm. The earthworm's bioturbative feeding habits, its ability to bioaccumulate the identified COPECs, and its critical position in terrestrial food webs make it an ideal surrogate to represent the terrestrial invertebrate community.

Earthworm toxicity testing will use surface soil from the same locations identified in the previous section. As is the case with the soil samples for chemical analysis, soil samples for earthworm toxicity testing will be collected from fifteen locations representing five lead concentrations within the three different soil types.

Quantification of possible adverse effects to terrestrial invertebrates and the potential for constituent transfer up the food chain to higher trophic level feeding guilds will be accomplished with the use of earthworm toxicity tests and tissue burden analysis. As a soil-boring detritivore, the common earthworm *(Eisenia fetida)* is an excellent sentinel not only to assess surface soil toxicity, but also to approximate food chain bioaccumulation potential. The earthworm survival test recommended by the EPA (1996) will be employed to assess the potential for risk to

members of this critical ecological trophic level. Earthworms have been shown to be acutely sensitive to soil-bound metal toxicity, and they represent a key prey item for mammalian and avian omnivores and invertivores. Additionally, earthworm growth will be measured throughout the duration of the test to assess nonlethal effects on the earthworm.

Appendix A provides details relative to the EPA-recommended earthworm test. In brief, the 28-day static earthworm test will consist of exposing 10 worms per chamber to 100 percent undiluted soil from the BGR and IMR ranges, soil from a reference location, and laboratory control soil. Observations of mortality will be recorded at 7, 14, 21, and 28 days after the initiation of the test. Mortality will be assessed by emptying the test chamber onto an inert surface and testing each worm's reaction to a gentle mechanical stimulus. Missing worms will be considered dead. Dead worms will be removed from the test chamber and all live worms will be carefully re-introduced into the test soils. At the end of the 28-day exposure period all live worms will be removed from each test chamber, rinsed of soil and weighed. After weighing, all living worms will be preserved in separate containers for COPEC whole-body burden analysis.

Supplemental feeding of earthworms during toxicity and bioaccumulation test will occur if the mortality rate of earthworms exposed to reference site soil is 20 percent or greater, or if the total mean weight of the earthworms in the reference soil declines by 30 percent or more, per EPA guidance (EPA, 1996).

Since surface soil lead concentration gradients will be used as exposure gradients, as described in the sampling and analysis plan (Appendix A), data from earthworm tests will consist of 7-day, 14-day, 21-day, and 28-day NOAELs and LOAELs. In addition, whole-body tissue burdens for each of the COPECs will be determined. The maximum, mean, and minimum COPEC concentrations in exposed earthworms will be used in the food web models to calculate HQ values for terrestrial omnivorous and invertivorous birds and mammals. By providing three HQ values (maximum, mean, and minimum), a line of evidence will be established regarding biotransfer to higher trophic levels.

Details of the collection methods, decontamination procedures, quality assurance/quality control, and other sampling procedures are presented in the installation-wide sampling and analysis plan (IT, 2002b) and are summarized in Appendix A of this report.

9.1.3 Soil Sampling for Particulate Bullet Fragment Determination

In order to address the potential for ingestion of bullet fragments by birds for use as grit in their crops, surface soil samples will be collected and lead fragments enumerated using the methodology described by Peddicord and LaKind (2000). Samples will be collected from the same locations as the soil samples collected for earthworm toxicity testing and chemical analysis (5 soil samples from each of the 3 soil types) as summarized on Table 9-1 and as shown on Figures 9-1, 9-2, and 9-3.

Soil samples for bullet fragment enumeration will be collected from a one foot-by-one foot square area to a depth of one inch using a steel, wooden, or plastic sampling template and stainless-steel sampling trowel. At each location, the sample area will be prepared by carefully removing any vegetative matter and large loose rock, leaving the soil surface and any visible bullet fragments as undisturbed as possible. The sample template will be mounted and tamped into the ground using a small hammer until the template is flush with the ground surface. The soil area inside the template will be removed making several shallow cuts using a stainless-steel sampling trowel. Removed soil will be composited into a large, 2-gallon ziplock storage bag. If plant/root systems are encountered as part of the sample, they will be removed from the sample area and transferred into the ziplock bag using the trowel. Working inside the bag using his gloved hand and a soils knife, the sample technician will then separate the soil from the root structures as much as possible, collecting the soil in the bag and discarding the plant/roots. The technician will use the sides of the template and ruler to gage the depth of the sample periodically during removal, advancing the sample depth to no greater than 1-inch across the area.

Once collected, soil bag will be sealed and the sample location will be identified on the exterior surface of the bag using a marker. The soil bag will be placed in a secondary, outer ziplock bag, the sample label will be completed and affixed to the outer bag and secured with clear, plastic tape by the technician. Collected samples will be placed under custody in a designated cooler, physical preservation (ice) is not required. Samples for bullet fragment enumeration analysis will be sent from the field to the Shaw geotechnical laboratory at the Environmental Technology Development Center, in Oak Ridge, Tennessee.

At Shaw, the sample will be analyzed using the Peddicord and LaKind method for particulate bullet fragments. The soil sample will be prepared by weighing, drying, and sieving. Sieve sizes will correspond to the grit sizes found in the gizzards of the bobwhite quail, *Colinus virginianus* 0.8 to 2.2 mm) and the wild turkey *Meleagris gallopavo* (2.8 to 4.2 mm) (Best and Gionfriddo,

1991). These two species were selected to represent the various bird species that could utilize the ranges as feeding grounds and thus utilize grit particles found at these ranges. After sieving, the different size fractions retained on each sieve screen and the pan bottom will be initially weighed. Each fraction will undergo washing with water to remove material less dense than lead, drying, and reweighing. Next, the volume of each fraction will be determined by water displacement. The mass assumptions for lead particulate and proportionality formula cited in Peddicord and LaKind will be used to calculate and report the number of lead and non-lead grit-sized particles in each sample which represents one square foot.

9.2 Aquatic Study Design

The two major freshwater stream habitats to be addressed in this quantitative BERA are the sediments and the overlying surface water column in Cane Creek. Both are critical to the viability of the overall stream ecosystem, and they differ significantly relative to organism assemblages and contaminant binding capacities.

The aquatic study design is designed to address exposure and potential effects to receptors within and around Cane Creek as it flows through the BGR ranges. Elevated levels of COPECs may or may not pose a risk to aquatic receptors depending upon their availability for uptake (bioavailability) from the water column or underlying sediments. The study is therefore designed to assess bioavailability of the COPECs as well as the potential for acute or chronic toxicity and biomagnification up the food chain.

9.2.1 Surface Water

The surface water assessment will focus on characterization of risks to water column invertebrates as well as vertebrates. Surface water samples will be collected from five locations within Cane Creek representing five different lead concentration ranges detected in previous investigations. Lead will be used as the indicator of COPEC concentrations because it has been detected in surface water at all of the BGR ranges and has been used as an indicator of contamination resulting from small arms range activity. Figures 9-4 and 9-5 present the proposed locations for the surface water samples that will be collected to represent the range of COPEC concentrations in surface water at the BGR ranges. These surface water samples will be used in the toxicity tests described in the following sections. Additionally, surface water samples will be collected from a stream with similar physical characteristics as Cane Creek but outside the influence of the BGR ranges. These surface water samples will be used as the reference surface water. All surface water samples will be analyzed for a full suite of inorganic and organic analytes.

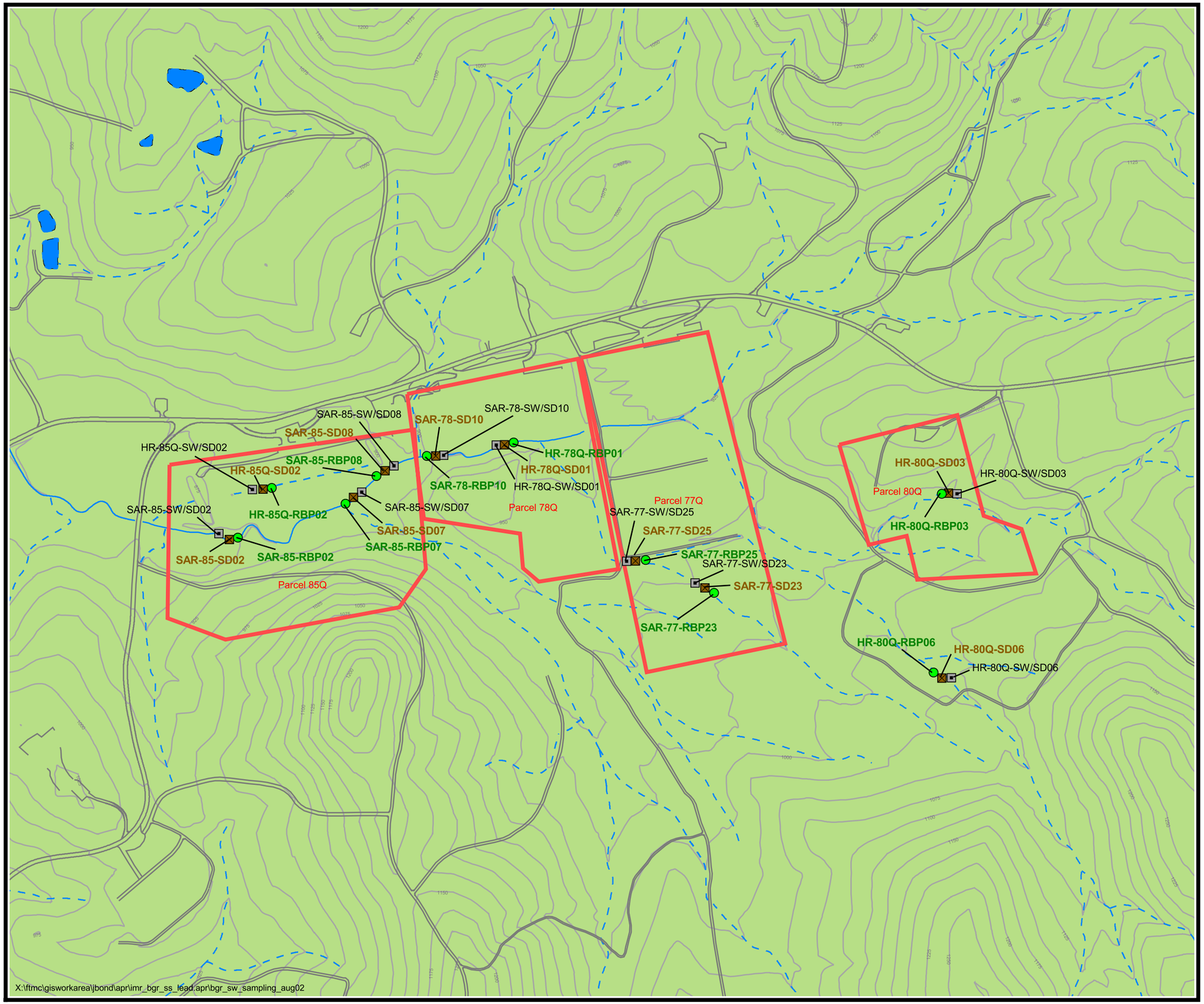


Figure 9-4

Proposed Surface Water Sample Locations

Bains Gap Road Ranges, Parcels 77Q, 78Q, 80Q, and 85Q

Legend

- Existing Surface Water/ Sediment Sample Location
- Proposed Surface Water Sample Location
- Roads
- Streams (dashed where intermittent)
- Topographic Contours (25-foot interval)
- Study Area
- Surface Water Feature (may be ephemeral)

500 0 500 Feet

NAD83 State Plane Coordinates

N

Shaw Environmental, Inc.

U.S. Army Corps of Engineers Mobile District

Contract No. DACA21-96-D-0018

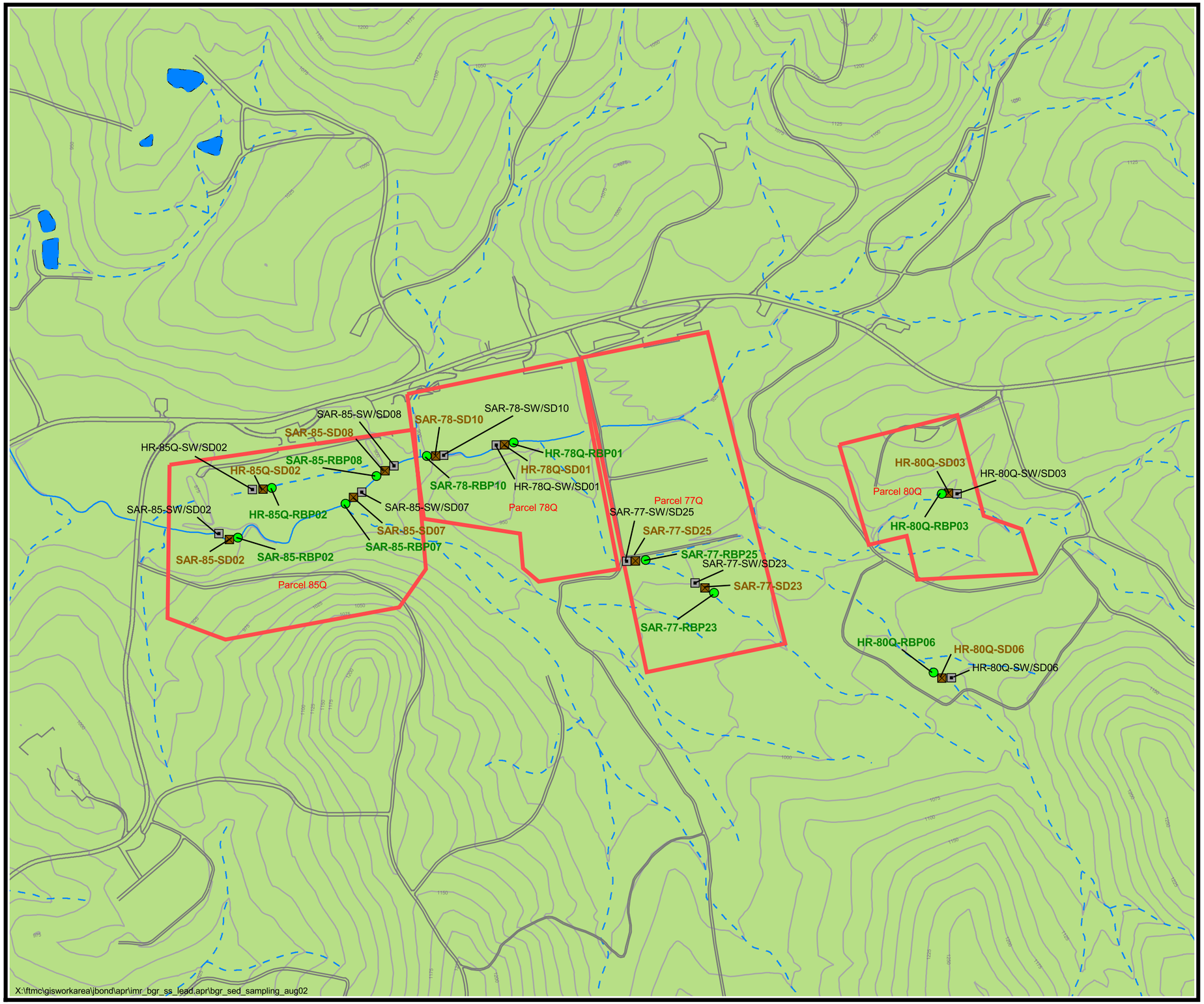


Figure 9-5

Proposed Sediment and Rapid Bioassessment Survey Sample Locations

Bains Gap Road Ranges, Parcels 77Q, 78Q, 80Q, and 85Q

Legend

- Existing Surface Water/ Sediment Sample Location
- Proposed Sediment Sample Location
- Proposed Rapid Bioassessment Survey Location
- Roads
- Streams (dashed where intermittent)
- Topographic Contours (25-foot interval)
- Study Area
- Surface Water Feature (may be ephemeral)

500 0 500 Feet

NAD83 State Plane Coordinates

N

Shaw Environmental, Inc.

U.S. Army Corps of Engineers Mobile District

Contract No. DACA21-96-D-0018

Details of the collection methods, decontamination procedures, quality assurance/quality control, and other sampling procedures are presented in the installation-wide sampling and analysis plan (IT, 2002b) and are summarized in Appendix B of this report.

9.2.1.1 Aquatic Water-Column Invertebrates

In order to evaluate potential COPEC toxicity to aquatic water-column invertebrates, the standard 7-day *Ceriodaphnia dubia* test will be conducted using surface water samples collected from Cane Creek representative of the five different COPEC concentration ranges. Appendix B references the test protocol for *Ceriodaphnia dubia* survival and reproduction tests. In brief, ten young daphnid neonates will be exposed within each of 10 replicate chambers, with a dilution series of 100 percent, 50 percent, 25 percent, 12.5 percent and 6.25 percent of Cane Creek surface water. Test chamber dilutions will be made by mixing site-collected water with a diluent comprised of off-site reference waters. Bioassay technicians will not only note survival, but also reproduction by counting the number of neonates released into the surrounding test waters. Stress, which can be caused by elevated contaminant concentrations, will frequently be exhibited by retention of neonates within the mother's brood pouch. All survival and reproduction results will be compared statistically to survival and reproduction results from daphnids exposed to 100 percent off-site reference waters. NOAEL and LOAEL concentrations will be calculated for survival and reproduction of this species for waters collected from each of the five surface water sampling locations (Figures 9-4 and 9-5).

9.2.1.2 Finfish

Assessment of the aquatic vertebrate community will utilize the fathead minnow (*Pimephales promelas*) as a representative species for finfish potentially inhabiting Cane Creek. The fathead minnow is an outstanding surrogate because it has been used in numerous aquatic toxicity studies and thus, has a robust database for COPEC toxicity. Field observations suggest that the Cane Creek's size and lack of depth accommodates only small minnow-type fish populations. The 7-day fathead minnow survival and growth test will be conducted using surface water samples collected from Cane Creek representative of the five different COPEC concentration ranges. The 7-day fathead minnow test described in Appendix B will test whether stream waters could be acutely toxic or inhibit growth within these surrogate organisms. Newly hatched fry less than 24 hours old will be exposed to five dilutions of stream water (100 percent, 50 percent, 25 percent, 12.5 percent and 6.25 percent) with four replicates per dilution and 15 fry per replicate. Growth will be measured by weight gain following the 7-day exposure period. In addition to an LC_{50} value, chronic NOAEL and LOAEL values will be computed for each of the five surface water

sampling locations (Figures 9-4 and 9-5). These data will not only provide investigators with information on the relative acute and/or chronic toxicity of the on-site waters, but will also assist in the derivation of ecologically-based clean-up criteria for surface water if remedial action is warranted.

9.2.2 Sediment

The sediment assessment will focus on characterization of risks to benthic invertebrates as well as the upper trophic level organisms that may feed on them. In many ways, sediments represent a more definite assessment of potential risks to aquatic systems because the receptors are generally less mobile and the COPECs can accumulate within depositional zones. Sediment samples will be collected from five locations within Cane Creek representing five different lead concentration ranges detected in previous investigations. Lead will be used as the indicator of COPEC concentrations because it has been detected in sediment at all of the BGR ranges and has been used as an indicator of contamination resulting from small arms range activity. Figures 9-4 and 9-5 present the proposed locations for sediment samples that will be collected to represent the range of COPEC concentrations in sediment at the BGR ranges. These sediment samples will be used in the toxicity and bioaccumulation tests described in the following sections. Additionally, sediment samples will be collected from a stream with similar substrate characteristics as Cane Creek but outside the influence of the BGR ranges. These sediment samples will be used as reference sediment. All sediment samples will be analyzed for a full suite of inorganic and organic analytes. The COPEC concentrations in sediment samples from Cane Creek will also be utilized in the food web models that will be used to calculate the total dose of COPECs potentially received by riparian invertivorous mammals and birds.

Details of the collection methods, decontamination procedures, quality assurance/quality control, and other sampling procedures are presented in the installation-wide sampling and analysis plan (IT, 2002b) and are summarized in Appendix B of this report.

9.2.2.1 Benthic Invertebrates

In order to evaluate potential toxicity to benthic invertebrates, the standard 10-day *Chironomus riparius* survival, growth, and emergence test will be conducted using sediment samples collected from Cane Creek representative of the five different COPEC concentration ranges. Appendix B references the test protocol for *Chironomus riparius* survival and growth tests. *C. riparius* was selected as the benthic invertebrate test species rather than *C. tentans* because *C. riparius* is more sensitive to metal toxicity. Tests of 10 days in duration will permit observance of sub-lethal responses such as growth. Four replicates for each of the five sediment locations,

reference stations and laboratory controls, will be used for measurements of lethality and growth. All test organisms will be laboratory reared and less than 24 hours old at test initiation. At the termination of the test, all living chironomids will be preserved in separate containers for COPEC whole-body burden analysis.

Although collected sediments will not be "cut" with reference or laboratory grade sediments to generate a concentration series, the five sediment collection sites will represent a gradient of lead concentrations. This field-collected concentration gradient will allow investigators to generate a sediment concentration-based NOAEL and LOAEL in comparison to off-site reference sediments. Additionally, the various sediment concentrations and corresponding chironomid tissue concentrations of COPECs will provide data for the calculation of sediment-to-biota bioaccumulation factors.

In addition to laboratory-based sediment toxicity testing direct in-field measurements of benthic invertebrate community structure using RBP will be conducted. Direct measurement of biological condition is considered the most effective means of evaluating cumulative impacts of non-point source contamination patterns such as those that may exist within the BGR ranges. The presence or absence of habitat degradation assists in evaluating the present level of risk to existing receptors. When combined with laboratory toxicity testing, direct field measurements reduce uncertainty and strengthen the line-of-evidence relative to potential risk levels.

For Cane Creek and associated tributaries in and around the BGR ranges, benthic macroinvertebrate surveys will be conducted within riffle and pool zones of Cane Creek as it flows through the BGR ranges. It is important to note the need to carefully compare benthic communities in the areas of concern with comparable communities present in reference areas or literature-based community assemblages. For example, due to natural erosional processes and the presence of gravelly/rocky bottoms throughout much of Cane Creek, a diverse and well-established in-faunal community may not be present. A similar reference area will be located in order to properly compare the benthic assemblage in Cane Creek to a similar stream un-impacted by small arms range activities. Great care will therefore be taken in establishing off-site reference locations to ensure that the sediment grain size, TOC and stream bank makeup are comparable.

The advantages of employing benthic macroinvertebrates as a measure of risk to stream communities include the following (EPA, 1997):

- Macroinvertebrate assemblages are good indicators of localized conditions. Because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life, they are particularly well-suited for assessing site-specific impacts (upstream-downstream studies).

- Macroinvertebrates integrate the effects of short-term environmental variations. Most species have a complex life cycle of approximately one year or more. Sensitive life stages will respond quickly to stress; the overall community will respond more slowly.

- Degraded conditions can often be detected by an experienced biologist with only a cursory examination of the benthic assemblage. Macroinvertebrates are relatively easy to identify to family; many "intolerant" taxa can be identified to lower taxonomic levels with ease.

- Benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects.

- Sampling is relatively easy, requires few people and inexpensive gear, and has no detrimental effect on the resident biota.

- Benthic macroinvertebrates serve as a primary food source for many recreationally and commercially important fish.

- Benthic macroinvertebrates are abundant in most streams. Many small streams (i.e., Cane Creek), may support a diverse macroinvertebrate fauna, but only support a limited fish fauna.

Observations that will be made during the RBP benthic invertebrate survey will include substrate type, surrounding land use, evidence of erosion and pollutant sources, vegetative stream canopy, and other relevant data. In addition to benthic sampling, which will consist of one kick net sample and one course particulate organic matter (CPOM) sample, *in situ* water quality parameters (temperature, conductivity, dissolved oxygen, pH) will be measured with the use of a Horiba U-10, or similar, water quality instrument. Measurements will be taken at mid-stream at approximately mid-depth. Water quality parameters will be obtained prior to any sampling activities in the stream.

Two macroinvertebrate samples will be collected at each sampling station; the riffle/run sample will be collected with a kick net and the CPOM sample will be collected by hand. All macroinvertebrate samples will be transported to Shaw Environmental and Infrastructure (Shaw

E&I) Technology Development Laboratory (formerly IT Corporation) located in Knoxville, Tennessee.

The kick net sample provides data as to the abundance of the scraper and filtering functional feeding groups and is generally collected in a riffle and a run area of the stream. The riffle and run sample will be composited in the field for processing as one sample per location. The kick net consists of a 0.9 mm mesh bag attached to a rectangular 8- by 18-inch frame mounted on a handle. The use of the sampler is described as follows:

1. The sampler is positioned securely on the substrate with the opening of the net facing upstream.

2. An area of one square-meter immediately upstream of the sampler is disturbed by overturning and scraping rocks and large stones by shifting the feet to dislodge clinging or attached organisms. Any rocks or other large items that have been swept into the net are examined to ensure that organism removal is complete.

3. The remaining sediment is agitated with the feet to dislodge epibenthic and burrowing organisms.

All organisms and debris such as sticks and leaves will be removed from the kick net bag and placed into a container with 95 percent ethanol to preserve the organisms.

One CPOM sample will be collected at each location from depositional areas of little or no current velocity in the stream. The CPOM sample, which provides data as to the abundance of the shredder feeding group, will be collected by hand including a composite variety of leaves, twigs, bark and other fragments. The collected material and organisms will be placed into a sample container with 95 percent ethanol.

Organisms will be identified in the laboratory to Family level or to the lowest practical taxon. Identification of organisms will be made using published keys such as those developed by Merritt and Cummins (1984), Peckarsky, et al. (1990), and Pennak (1989 and 1978). Each family of organisms identified at each location will be placed into separate vials containing ethanol as a preservative in order to assemble a reference collection for the project.

Eight metrics will be calculated from the benthic macroinvertebrate data obtained at each sampling station in accordance with the procedures outlined in EPA's Rapid Bioassessment Protocol II (EPA, 1999c). Each metric result will be given a score based on percent

comparability to a reference station. Scores will be totaled, and a Biological Condition Category will be assigned based on percent comparability with the reference station score. The following metrics will be calculated:

Metric 1: Taxa Richness. Taxa richness will be calculated by counting the number of taxa present in the sample. In general, taxa richness increase with increasing water quality.

Metric 2: Modified Family Biotic Index. This index, developed by Hilsenhoff (1988), summarizes the tolerances of the benthic arthropod community to organic pollutants with a single value. Tolerance values used in the calculation of the Family Biotic Index (FBI) were obtained from Hilsenhoff (1988) and Bode (1988). The FBI is calculated by multiplying the number of organisms in each taxon by the tolerance value for that taxon, summing the products, and dividing by the total number of organisms in the sample for which an index will be calculated. Values for the FBI range from 0.00 to 10.00 with higher values corresponding to greater levels of organic pollution as shown in the following:

Family Biotic Index	Water Quality	Degree of Organic Pollution
3.5	Excellent	Organic pollution unlikely
3.51-4.5	Very good	Possible slight organic pollution
4.51-5.5	Good	Some organic pollution probable
5.51-6.5	Fair	Fairly substantial pollution likely
6.51-7.5	Fairly poor	Substantial pollution likely
7.51-8.5	Poor	Very substantial pollution likely
8.51-10	Very poor	Severe organic pollution likely

Metric 3: Ratio of Scraper and Filtering Collector Functional Feeding Groups. The relative abundance of scrapers and filtering collectors in the riffle/run habitat is an indicator of the food sources available. Functional feeding group designations for the taxa identified will be obtained from Merritt and Cummins (1984) and Barbour, et al., (1999). This metric is calculated by dividing the relative abundance of scrapers by the relative abundance of filter feeding organisms.

Metric 4: Ratio of EPT and Chironomidae Abundances. The ratio of Ephemeroptera, Plecoptera and Trichoptera (EPT) and chironomidae abundance will be calculated by dividing the relative abundance of EPT taxa by the relative abundance of chironomidae. The ratio of EPT

to chironomidae will indicate if there is an even distribution between the pollution sensitive EPT taxa and more pollution tolerant chironomidae.

Metric 5: Percent Contribution of Dominant Taxon. The percent contribution of the dominant taxon will be calculated by dividing the abundance of the taxon which is numerically dominant by the total number of organisms in the sample. A low percent contribution of the dominant family indicates a balanced community. Factors influencing this percentage include environmental stress, habitat quality, and life histories of the organisms collected in the sample.

Metric 6: EPT Index. This result of the EPT index is determined by counting the number of distinct taxa within the groups Ephemeroptera, Plecoptera, and Trichoptera. The EPT index usually increases with increasing water quality as EPT taxa are generally considered pollution sensitive.

Metric 7: Community Similarity Index. This index evaluates the benthic populations at specific locations relative to populations present at a "reference" location. For this metric, the upstream and/or downstream stations (where pesticide related effects are not expected) will be used as the reference stations for each of the IRP sits. The community loss (CL) index is calculated by subtracting the number of taxa common to both locations (B) from the number of taxa present at the reference location R divided by the number of taxa present at the potential impact location (I), as follows:

$$CL = \frac{R - B}{I}$$

Metric 8: Ratio of Shredder Functional Feeding Group and Total Number of Individuals Collected. The ratio of the relative abundance of shredders to the abundance of all other functional feeding groups will be calculated by dividing the relative abundance of shredders by the total number of organisms in the sample. The abundance of shredders in comparison to other functional feeding groups can be influenced by climate, seasonality, and vegetation within the riparian zone, as well as levels of toxicants adsorbed to CPOM while in the riparian zone, or adsorption of toxicants to the CPOM while it is in the water.