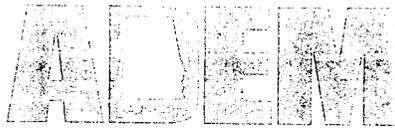


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August 21, 2009

Mr. Scott Bolton
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RE: ADEM Review and Concurrence: *Responses to ADEM and EPA Comments on the Final Baseline Ecological Risk Assessment (BERA) Problem Formulation and Study Design for the Ranges Near Training Area T-24A, dated August 19, 2009*
Fort McClellan, Calhoun County, Alabama
Facility I.D. No. AL4 210 020 562

Dear Mr. Bolton:

The Alabama Department of Environmental Management (ADEM or the Department) has reviewed the Army's *Responses to ADEM and EPA Comments on the Final Baseline Ecological Risk Assessment Problem Formulation and Study Design (BERA PF/SD) for the Ranges Near Training Area T-24A*. The Department concurs with the responses to ADEM's comments.

If you have any questions or concerns regarding this matter, please contact Mrs. Ashley T. Mastin of the Remediation Engineering Section at 334-271-7797 or via email at atmastin@adem.state.al.us.

Sincerely,

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sign for Ranges near T-24 A at FTMC

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ive any questions, please call me

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Final

**Baseline Ecological Risk Assessment
Problem Formulation and Study Design for the
Ranges Near Training Area T-24A**

**Fort McClellan
Calhoun County, Alabama**

Prepared For:

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Shaw Project No. 122336**

February 2009

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1.0 Introduction

A screening-level ecological risk assessment (SLERA) was conducted for the Ranges Near Training Area T-24A (T-24A Ranges) and presented in the report entitled *Draft Remedial Investigation Report, Ranges Near Training Area T-24A* (Shaw Environmental, Inc. [Shaw], 2005a). The results of the SLERA indicated that several constituents in environmental media at the T-24A Ranges have the potential to pose adverse ecological hazards. Therefore, a Baseline Ecological Risk Assessment (BERA) will be completed for the T-24A Ranges in order to reduce the level of uncertainty inherent in the SLERA process and to better define the potential for ecological hazards. Per the U.S. Environmental Protection Agency's (EPA) *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1997), the first step in the BERA process is the "Problem Formulation." The Problem Formulation also constitutes "Step 3" of the EPA's eight-step process (EPA, 1997).

The Problem Formulation for the T-24A Ranges uses the results of the SLERA and on-site reconnaissance to identify the specific ecological values to be protected at the T-24A Ranges, which are then used to establish assessment endpoints. The questions and issues that need to be addressed in the BERA are also defined in this Problem Formulation.

The Problem Formation phase of the BERA addresses and expounds upon a number of issues described in the SLERA, including:

- Refinement of the constituents of potential ecological concern (COPEC) identified in the SLERA;
- Description of the ecotoxicity of the COPECs;
- Description of the fate and transport of the COPECs;
- Description of the ecosystems potentially at risk;
- Development and refinement of the site conceptual model;
- Refinement of the complete exposure pathways; and
- Identification of the assessment endpoints.

Also included in this report is the BERA Study Design. The Study Design for the T-24A Ranges utilizes the information gathered and presented in the Problem Formulation to establish

measurement endpoints and to design studies that are appropriate to test the hypotheses concerning the assessment endpoints. Data quality objectives as well as statistical approaches are also presented in the BERA Study Design.

2.0 Identification of Constituents of Potential Ecological Concern

The SLERA for the T-24A Ranges initially identified a number of COPECs in soil and groundwater at the T-24A Ranges, as well as in surface water and sediments in the South Branch of Cane Creek and its tributaries. COPECs were initially identified by calculating screening-level hazard quotients, which were developed via a three-step process as follows:

- Comparison of maximum detected constituent concentrations to ecological screening values (ESV)
- Identification of essential macro-nutrients
- Comparison to naturally occurring background concentrations.

Constituents that were detected in environmental media at the T-24A Ranges were evaluated against the ESVs by calculating a screening-level hazard quotient (HQ_{screen}) for each constituent in each environmental medium. ESVs are presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000). An HQ_{screen} was calculated by dividing the maximum detected constituent concentration in each environmental medium by its corresponding ESV as follows:

$$HQ_{\text{screen}} = \frac{MDCC}{ESV}$$

where:

- HQ_{screen} = screening-level hazard quotient;
- $MDCC$ = maximum detected constituent concentration; and
- ESV = ecological screening value.

A calculated HQ_{screen} value of one or less indicated that the maximum detected constituent concentration (MDCC) was equal to or less than the chemical's conservative ESV, and was interpreted in the SLERA as a constituent that does not pose a potential for adverse ecological hazard. Conversely, an HQ_{screen} value greater than one indicated that the MDCC was greater than the ESV and that the chemical might pose adverse ecological hazards to one or more receptors and requires further assessment.

In order to better understand the potential hazards posed by chemical constituents at the T-24A Ranges, a mean hazard quotient was also calculated in the SLERA by comparing the arithmetic

mean constituent concentration in each environmental medium to the corresponding ESV. The calculated screening-level hazard quotients for surface soil, surface water, sediment, and groundwater at the T-24A Ranges are presented in Tables 2-1 through 2-4, respectively.

EPA recognizes several constituents in abiotic media that are necessary to maintain normal function in many organisms. These essential macronutrients are iron, magnesium, calcium, potassium, and sodium (EPA, 1989). Most organisms have mechanisms designed to regulate nutrient fluxes within their systems; therefore, these nutrients are generally only toxic at very high concentrations. Although iron is an essential nutrient and is regulated within many organisms, it may become increasingly bioavailable at lower soil pH values, thus increasing its potential to elicit adverse affects. Therefore, iron was not evaluated as an essential nutrient in the SLERA. Essential macronutrients were only considered COPECs if they were present in site samples at concentrations ten times the naturally occurring background concentration.

A comparison of detected constituent concentrations to background constituent concentrations was conducted in order to identify inorganic constituents that may be present in site media at concentrations consistent with background concentrations. In the process of calculating screening level hazard quotients (HQ_{screen}), the background analysis consisted of a comparison of the maximum detected constituent concentrations to the background threshold values (BTV). A study of the natural geochemical composition associated with Fort McClellan (FTMC) (SAIC, 1998) determined the mean concentrations of 24 metals in surface soil, surface water, sediment, and groundwater samples collected from presumably un-impacted areas. Per agreement with EPA Region IV, the background threshold value (BTV) for each metal was calculated as two times the mean background concentration for that metal. The BTV for each metal was used to represent the upper boundary of the range of natural background concentrations expected at FTMC, and was used as the basis for evaluating metal concentrations measured in site samples. Site sample metal concentrations less than or equal to the corresponding BTV represent the natural geochemical composition of media at FTMC, and not contamination associated with site activity. Site sample metal concentrations greater than the corresponding BTV may require further background assessment.

Thus, constituents were initially identified as COPECs in the SLERA if all of the following conditions were met:

- The maximum detected constituent concentration exceeded the ESV;

- The maximum detected constituent concentration was 10 times the BTV if the constituent is a macro-nutrient; and
- The maximum detected constituent concentration exceeded the BTV for inorganics.

If a constituent in a given environmental medium did not meet all of these conditions, then it was not considered a COPEC at the T-24A Ranges and was not considered for further assessment. Identification of a constituent as a COPEC in the SLERA indicated that further assessment of that particular constituent in a given environmental medium was deemed appropriate, and did not imply that a particular constituent posed a definite hazard to ecological receptors.

In order to focus future ecological assessment efforts (if necessary) on the constituents that are the most prevalent at the Ranges Near Training Area T-24A and have the greatest potential to pose ecological hazard, additional lines of evidence were evaluated to refine the initial list of COPECs. These additional lines of evidence were scrutinized to aid in the decision process of whether or not to include a constituent as a COPEC in future ecological assessments at the T-24A Ranges. Some of the additional lines of evidence used in the process of refining the list of COPECs include: 1) frequency of detection, 2) magnitude of the HQ_{screen} value, 3) spatial distribution, 4) comparison to alternative ESVs; 5) statistical and geochemical background evaluation; and 6) association of a chemical with known Army activities. These additional lines-of-evidence were used to further define the COPECs at the T-24A Ranges and are discussed in the following sections.

Statistical and geochemical background evaluations comprise tiers two and three of the three-tiered background evaluation. If maximum constituent concentrations were greater than the BTV, then the second tier of the background comparison was employed. Tier two of the background comparison consists of statistical comparisons of the site data to background data using the hot measurement test and the Wilcoxon Rank Sum (WRS) Test. If the site data failed either the hot measurement test or the WRS Test, then the site data were subjected to a geochemical evaluation to determine whether concentrations of inorganic compounds are naturally occurring or are elevated due to contamination (Tier 3) (Shaw, 2005b). The three-tier background screening protocol is described in detail in the *Draft Remedial Investigation Report, Ranges Near Training Area T-24A* (Shaw, 2005a).

2.1 COPECs in Surface Soil

The following constituents exceeded their respective ESVs and BTVs in surface soil at the T-24A Ranges, and are not essential macro-nutrients (Table 2-1):

- aluminum
- antimony
- barium
- beryllium
- cadmium
- chromium
- cobalt
- copper
- iron
- lead
- mercury
- nickel
- selenium
- zinc
- phenanthrene
- chloroform
- trichlorofluoromethane
- xylene.

In order to ensure that the identification and refinement of soil COPECs considered the most recent and most conservative screening values available, the USEPA's Ecological Soil Screening Levels (Eco-SSL) were considered in the COPEC refinement process. Table 2-5 presents a summary of the surface soil data for the T-24A ranges along with the ESVs used to identify the initial list of COPECs and the Eco-SSLs used in the COPEC refinement process. Eco-SSLs are discussed below with respect to the refinement of each surface soil COPEC, where applicable.

Antimony, copper, lead, and zinc were detected in numerous surface soil samples from the T-24A Ranges at concentrations that exceeded ESVs, Eco-SSLs, and naturally occurring levels. Based on the frequency of detection at elevated concentrations, these four metals have been identified as COPECs in surface soil at the T-24A Ranges.

Per EPA (2003a) guidance, aluminum toxicity is associated with soluble aluminum only. Numeric screening values for aluminum are considered inappropriate due to the uncertainty in the solubility of aluminum in any given soil type under different environmental conditions. Alternatively, potential ecological risks associated with exposure to aluminum are associated with soil pH. Aluminum is identified as a COPEC only if the soil pH is less than 5.5 (EPA,

2003a). Since the pH of soils at the T-24A Ranges is greater than 5.5, aluminum is not considered a COPEC in surface or depositional soil at the T-24A Ranges.

Eleven surface soil samples out of 110 total surface soil samples exhibited barium concentrations greater than the ESV. The calculated HQ_{screen} value for barium was 2.27. If the EPA (2005a) recommended Eco-SSLs for barium are used for comparison (Table 2-5), one sample exceeded the Eco-SSL that is protective of soil invertebrates (330 milligrams per kilogram [mg/kg]) and all of the detected barium concentrations in surface soil were less than the Eco-SSL that is protective of mammalian receptors (2,000 mg/kg). Geochemical evaluation indicated that all of the detected concentrations of barium were consistent with naturally occurring background concentrations of barium. Based on the relatively low HQ_{screen} value for barium, the fact that none of the detected concentrations of barium exceeded the Eco-SSL derived for the protection of mammalian receptors, and the fact that geochemical evaluation indicated the detected concentrations of barium were consistent with naturally occurring background concentrations of barium, barium was not identified as a COPEC in surface soil at the T-24A Ranges.

Five surface soil samples out of 106 total surface soil samples (excluding "B"-flagged data) exhibited beryllium concentrations greater than the ESV. The calculated HQ_{screen} value for beryllium was 2.14. If the EPA (2005b) recommended Eco-SSLs for beryllium are used for comparison (Table 2-5), all of the detected concentrations of beryllium were less than the Eco-SSLs for the protection of terrestrial invertebrates (40 mg/kg) and mammalian receptors (21 mg/kg). Geochemical evaluation indicated that all of the detected concentrations of beryllium were consistent with naturally occurring background concentrations of beryllium. Therefore, beryllium was not considered a COPEC in surface soil at the T-24A Ranges.

Cadmium was detected in one surface soil sample out of 110 samples collected at the T-24A Ranges. The calculated HQ_{screen} value for cadmium was 1.06. The single detected concentration of cadmium in soil (1.7 mg/kg) was greater than the Eco-SSLs (EPA, 2005e) for the protection of avian and mammalian wildlife (0.77 mg/kg and 0.36 mg/kg, respectively), but less than the Eco-SSLs for the protection of terrestrial plants and invertebrates (32 mg/kg and 140 mg/kg, respectively) (Table 2-5). The home ranges for avian and mammalian wildlife receptors are likely much greater than the area exhibiting elevated cadmium concentrations in soil at the T-24A ranges. Therefore, the over-all exposure point concentration of cadmium in soil for avian and mammalian receptors at the T-24A ranges would likely be much less than the single detected concentration of cadmium and also less than the Eco-SSLs for avian and mammalian wildlife receptors. Geochemical evaluation indicated that all of the detected concentrations of cadmium

were consistent with naturally occurring background concentrations of cadmium. Based on the infrequency of detection, the low level of the HQ_{screen} value, and the fact that geochemical evaluation indicated the detected concentrations of cadmium were consistent with naturally occurring background concentrations of cadmium, cadmium was not identified as a COPEC in surface soil at the T-24A Ranges.

One surface soil sample out of 110 samples exhibited a chromium concentration in excess of the ESV and BTV. The concentration of chromium in the same soil sample exceeded the Eco-SSLs (EPA, 2008) for the protection of avian and mammalian wildlife (Table 2-5). The home ranges for avian and mammalian wildlife receptors are likely much greater than the area exhibiting elevated chromium concentrations in soil at the T-24A ranges. Therefore, the over-all exposure point concentration of chromium in soil for avian and mammalian receptors would likely be much less than the single elevated concentration of chromium and also less than the Eco-SSLs for avian and mammalian wildlife receptors. Geochemical evaluation indicated that all of the detected concentrations of chromium were consistent with naturally occurring background concentrations of chromium. Based on the infrequency of detection at elevated concentrations and the fact that geochemical evaluation indicated the detected concentrations of chromium were consistent with naturally occurring background concentrations of chromium, chromium was not identified as a COPEC in surface soil at the T-24A Ranges.

Six surface soil samples out of 107 samples (excluding "B"-flagged data) exhibited cobalt concentrations in exceedence of the ESV. The calculated HQ_{screen} value for cobalt was 2.09. Fifteen surface soil samples had cobalt concentrations that exceeded the Eco-SSL for the protection of plants (EPA, 2005f). None of the detected concentrations of cobalt exceeded the Eco-SSLs for the protection of avian or mammalian wildlife (Table 2-5). It is important to note that the Eco-SSL for cobalt for the protection of plants (13 mg/kg) is less than the background screening value for cobalt in soil (15.2 mg/kg), which indicates the plant Eco-SSL is overly conservative for this site and not directly applicable to conditions at the T-24A ranges. Geochemical evaluation indicated that all of the detected concentrations of cobalt were consistent with naturally occurring background concentrations of cobalt. Due to the low frequency of detected concentrations of cobalt in exceedence of the ESV, the relatively low magnitude of the HQ_{screen} value, and the fact that geochemical evaluation indicated that all of the detected cobalt concentrations were consistent with naturally occurring background concentrations of cobalt, cobalt was not identified as a COPEC in surface soil at the T-24A Ranges.

Iron was detected at a maximum concentration that was 2.4 times the BTV for iron. Although the maximum detected concentration of iron exceeds the BTV, iron is not present at concentrations that grossly exceed the naturally occurring levels; therefore, it is likely that the concentrations of this macro-nutrient found at the T-24A Ranges are easily regulated by most organisms. Iron is generally non-toxic to plants at pH levels between 5 and 8. Toxicity of iron is associated with soluble iron only; therefore, numeric screening values for iron are considered inappropriate due to the uncertainty in the solubility of iron in any given soil type under different environmental conditions. Iron is identified as a COPEC only if the soil pH is less than 5 (EPA, 2003b). Since the pH of soils at the T-24A Ranges is greater than 5, iron is not considered a COPEC in surface or depositional soil at the T-24A Ranges.

Mercury was detected in 3 surface soil samples out of 105 total samples (excluding “B”-flagged data) at concentrations that exceeded the ESV and naturally occurring levels. The HQ_{screen} value for mercury was calculated to be 2.9. Based on the infrequency of detection at elevated concentrations and the relatively low magnitude of the HQ_{screen} value, mercury was not identified as a COPEC in surface soil at the T-24A Ranges.

Nickel was only detected in one surface soil sample (R24A-187-GP54) out of 104 samples (excluding “B”-flagged data) at a concentration that slightly exceeded the ESV. The calculated HQ_{screen} value for nickel was 1.3. The maximum detected concentration of nickel (37.7 mg/kg) is less than the Eco-SSLs for the protection of plants, terrestrial invertebrates, avian wildlife, and mammalian wildlife (38 mg/kg, 280 mg/kg, 210 mg/kg, and 130 mg/kg, respectively) (EPA, 2007a) (Table 2-5). Based on the infrequency of detection, low HQ_{screen} value, and the fact that the maximum detected concentration is less than all of the Eco-SSLs, nickel was not identified as a COPEC in surface soil at the T-24A Ranges.

Eighteen surface soil samples out of 92 samples (excluding “B”-flagged data) exhibited selenium concentrations in exceedence of the ESV. The calculated HQ_{screen} value for selenium was 2.96. A number of surface soil samples also exhibited selenium concentrations that exceeded one or more of the Eco-SSLs (EPA, 2007d) for selenium (Table 2-5). Geochemical evaluation indicated that all of the detected concentrations of selenium were consistent with naturally occurring background concentrations of selenium. The elevated concentrations of selenium did not show any pattern that would be considered consistent with Army activities at the T-24A ranges and appear to be randomly scattered across the study area. This lack of a distinct pattern of “contamination” and the relatively low levels of detection could indicate that the detected concentrations of selenium may be associated with naturally-occurring background levels of

selenium and not associated with “contamination” due to Army activities. Due to the relatively low magnitude of the HQ_{screen} value and the fact that geochemical evaluation indicated that all of the detected selenium concentrations were consistent with naturally occurring background concentrations of selenium, selenium was not identified as a COPEC in surface soil at the T-24A Ranges.

Phenanthrene was initially identified as a COPEC in surface soil; however, it was only detected in one surface soil sample out of 81 samples analyzed for SVOCs at a concentration that exceeded the ESV. The HQ_{screen} value for phenanthrene was calculated to be 1.9. The maximum detected concentration of phenanthrene (0.19 mg/kg) is less than the background concentration for phenanthrene in soils adjacent to asphalt (1.08 mg/kg) (IT, 2000). The single detection of phenanthrene is also less than the Eco-SSLs for the protection of terrestrial invertebrates (29 mg/kg) and mammalian wildlife receptors (100 mg/kg). Based on the infrequency of detection at elevated concentrations, the low magnitude of the HQ_{screen} value, the fact that the maximum detected concentration is less than the background concentration for phenanthrene in soils adjacent to asphalt, and the fact that the detected concentration of phenanthrene is less than the Eco-SSLs, phenanthrene was not identified as a COPEC in surface soil at the T-24A Ranges.

Xylene and trichlorofluoromethane were detected in one surface soil sample (R24A-187-MW25) out of 44 samples analyzed for VOCs at concentrations that exceeded their ESVs. The HQ_{screen} values for xylene and trichlorofluoromethane were calculated to be 1.4 and 2.0, respectively. Based on the low frequency of detection at elevated concentrations and the low magnitude of the HQ_{screen} values, xylene and trichlorofluoromethane were not identified as COPECs in surface soil at the T-24A Ranges.

Chloroform was detected in 2 surface soil samples (R24A-187-MW25 and R24A-187-GP31) out of 44 samples analyzed for VOCs at concentrations that exceeded the ESV. The HQ_{screen} value for chloroform was calculated to be 320. Although the calculated HQ_{screen} values for chloroform are high, chloroform was not detected frequently in soil samples and was not detected in any other environmental medium at the T-24A Ranges. Furthermore, chloroform is highly volatile and any chloroform that might be present at the soil surface would likely volatilize rapidly and would not be available for ecological exposures. Due to the low frequency of detection and the small likelihood of ecological exposures, chloroform was not identified as a COPEC in surface soil at the T-24A Ranges.

The constituents in surface soil at the T-24A Ranges that were identified as COPECs through examination of additional lines of evidence were the following:

- antimony
- copper
- lead
- zinc.

2.2 COPECs in Surface Water

The following constituents exceeded their respective ESVs and BTVs in surface water at the T-24A Ranges, and are not essential macro-nutrients:

- aluminum
- barium
- beryllium
- chromium
- copper
- lead
- vanadium
- zinc
- bis(2-ethylhexyl)phthalate.

All surface water samples were analyzed for total recoverable constituent concentrations and no adjustments for bioavailability were made to the ESVs for COPEC identification.

In order to ensure that the identification and refinement of surface water COPECs considered the most recent and most conservative screening values available, the state of Alabama ambient water quality criteria (AWQC) for freshwater were considered in the COPEC refinement process. Table 2-6 presents a summary of the surface water data for the T-24A ranges along with the ESVs used to identify the initial list of COPECs and the Alabama AWQC used in the COPEC refinement process. AWQC that are hardness-dependent were calculated using the average hardness of surface water samples collected from the T-24A ranges (30.6 mg/L). Alabama AWQC are discussed below with respect to the refinement of each surface water COPEC, where applicable.

One surface water sample exhibited aluminum at a concentration greater than the BTV for aluminum in surface water. Geochemical evaluation indicated that all of the detected concentrations of aluminum in surface water were consistent with naturally occurring background concentrations of aluminum in surface water. Aluminum is the most abundant metal

in the earth's crust. Because only a single sample exhibited an aluminum concentration greater than the BTV and geochemical evaluation indicated all of the aluminum was consistent with naturally occurring levels, aluminum was not identified as a COPEC in surface water at the T-24A Ranges.

The maximum detected concentration of arsenic in surface water at the T-24A ranges was less than the ESV and chronic AWQC for arsenic; therefore, arsenic was not identified as a COPEC in surface water at the T-24A ranges.

Two surface water samples exhibited barium concentrations greater than the BTV for barium in surface water. Geochemical evaluation indicated that all of the detected concentrations of barium in surface water were consistent with naturally occurring background concentrations of barium in surface water. Barium is not bioaccumulative in aquatic organisms and is unlikely to pose a hazard to populations of ecological receptors. The HQ_{screen} value for barium in surface water was calculated to be 126. Although the HQ_{screen} value is high, barium was only detected in two surface water samples at concentrations that exceeded the BTV. Based on the relative infrequency of detection at elevated concentrations and the fact that geochemical evaluation indicated all of the detected barium concentrations in surface water were consistent with background concentrations of barium, barium was not identified as a COPEC in surface water at the T-24A Ranges.

Beryllium was detected in one surface water sample out of 11 samples collected. Geochemical evaluation indicated that the single detected concentration of beryllium in surface water was consistent with naturally occurring background concentrations of beryllium in surface water. The HQ_{screen} value for beryllium in surface water was calculated to be 4.2. Because beryllium was infrequently detected at an elevated concentration, the HQ_{screen} value is relatively low, and geochemical evaluation indicated beryllium concentrations were consistent with naturally occurring concentrations, beryllium was not identified as a COPEC in surface water at the T-24A Ranges.

Chromium was detected in two out of 11 surface water samples at concentrations that exceeded the ESV. The calculated HQ_{screen} value for chromium is 3.7. This HQ_{screen} value was calculated using the ESV which is based on hexavalent chromium toxicity. If the National Recommended Water Quality Criterion (EPA, 2002) for trivalent chromium is used for comparison, all of the detected concentrations of chromium are below the recommended criterion. One surface water sample exhibited chromium at a concentration that exceeded the Alabama chronic AWQC.

Additionally, geochemical evaluation indicated that all of the detected concentrations of chromium in surface water were consistent with naturally occurring background concentrations of chromium in surface water. Therefore, chromium was not identified as a COPEC in surface water at the T-24A Ranges.

Statistical comparisons determined that the single detected concentration of cobalt in surface water from the T-24A ranges was consistent with background levels. Cobalt was detected in one out of 11 surface water samples at the T-24A ranges. Additionally, the single detected concentration of cobalt was less than the USEPA Region 3 BTAG freshwater screening benchmark value for cobalt (23 µg/L). Based on the fact that cobalt was infrequently detected, statistical comparison to background indicated the detected concentration was consistent with naturally occurring levels, and the detected concentration was less than the alternative screening value, cobalt was not identified as a COPEC in surface water at the T-24A ranges.

Copper and lead were detected in two and three surface water samples, respectively, at concentrations that exceeded their respective ESVs and Alabama chronic AWQC. The HQ_{screen} values for copper and lead were calculated to be 16.4 and 326, respectively. Geochemical evaluation indicated that all of the detected concentrations of copper and lead in surface water were consistent with naturally occurring background concentrations of copper and lead in surface water. However, since both copper and lead were identified as COPECs in surface soil at the T-24A Ranges and both metals are known components of munitions, both copper and lead were identified as COPECs in surface water in at least a limited area at the T-24A Ranges.

Statistical comparisons determined that the detected concentrations of mercury in surface water from the T-24A ranges were consistent with background levels. Mercury was detected in three out of 11 surface water samples with estimated concentrations (“J” flagged results) that exceeded the ESV and Alabama chronic AWQC. All of the detected concentrations of mercury were less than the National Recommended Water Quality Criteria for mercury (0.77 µg/L). Based on the fact that statistical comparisons to background indicated the detected concentrations of mercury in surface water were consistent with naturally occurring levels, and the detected concentrations were less than the alternative screening value, mercury was not identified as a COPEC in surface water at the T-24A ranges.

Nickel was detected in three surface water samples out of a total of 11 samples. All of the detected concentrations of nickel were less than the ESV. One surface water sample exhibited a nickel concentration that slightly exceeded the Alabama chronic AWQC for nickel (19 µg/L). It

is important to note that the Alabama chronic AWQC for nickel is less than the background screening value for nickel in surface water (22.5 µg/L), which indicates the chronic AWQC is overly conservative for this site and not directly applicable to conditions at the T-24A ranges. Additionally, statistical comparison of the detected concentrations of nickel in surface water from the T-24A ranges to background concentrations of nickel indicated that the detected concentrations of nickel were consistent with naturally occurring background concentrations. Therefore, nickel was not identified as a COPEC in surface water at the T-24A ranges.

One surface water sample out of 11 samples exhibited a vanadium concentration greater than the ESV and one surface water sample out of 6 samples (excluding “B”-flagged data) exhibited a zinc concentration greater than the ESV. Geochemical evaluation indicated that all of the detected concentrations of vanadium and zinc in surface water were consistent with naturally occurring background concentrations of vanadium and zinc in surface water. The HQ_{screen} value for vanadium was calculated to be 3.5. Based on the infrequency of detection at elevated concentrations, the relatively low HQ_{screen} value, and the fact that geochemical evaluation indicated vanadium in surface water was naturally occurring, vanadium was not identified as a COPEC in surface water at the T-24A Ranges. Zinc was only detected in one surface water sample at an elevated concentration compared to its ESV, and two surface water samples had zinc concentrations that exceeded its chronic AWQC. However, zinc was identified as a COPEC in surface water because zinc was identified as a COPEC in surface soil at the T-24A Ranges and the elevated concentrations of zinc in surface water were co-located with the elevated concentrations of copper and lead in surface water.

Bis(2-ethylhexyl)phthalate (BEHP) was detected in two surface water samples out of 11 samples at concentrations that exceeded the ESV. The HQ_{screen} value was calculated to be 53.3. Although the magnitude of the HQ_{screen} value was relatively high, the fact that BEHP was only detected in two samples does not suggest that a source of BEHP is present at the T-24A Ranges. Furthermore, BEHP is commonly used as a plasticizer in a wide variety of materials, and is also a common laboratory contaminant (National Library of Medicine [NLM], 1996; Agency for Toxic Substances and Disease Registry [ATSDR], 1993). Because of their many uses, phthalates are widespread in the environment and have been identified at low levels in the air, water, and soil. BEHP is also very insoluble in water and is unlikely to be found in the dissolved form (bioavailable form) in surface water. The detected concentrations of BEHP are likely the result of re-suspended sediment caused by physical disturbance of the sediment during sampling or laboratory-derived contamination. Therefore, the detected BEHP is likely an artifact of the sampling technique and not truly present in surface water. Because the ESV of 0.004 milligrams

per liter (mg/L) is an order of magnitude below the reporting limit typically achieved by laboratory analytical techniques (0.01 mg/L in this investigation), even very low detections of BEHP would result in HQ values greater than 1. An alternative screening value for BEHP developed using the Tier II methodologies proposed in the USEPA's Great Lakes Water Quality Initiative (USEPA, 1995) and presented as an Ecotox Threshold Value in an Eco Update (USEPA, 1996) is 0.032 mg/L. Both of the detected concentrations of BEHP in surface water at the T-24A Ranges were less than this alternative screening value. BEHP is not a bioaccumulative chemical, and is unlikely to pose a hazard to populations of ecological receptors even if the detections in the surface water are accurate. Therefore, although it was retained as a COPEC in the SLERA, due to the factors presented above, BEHP is not carried forward as a COPEC in surface water at the T-24A Ranges.

The constituents in surface water at the T-24A Ranges that were identified as COPECs through examination of additional lines of evidence were the following:

- copper
- lead
- zinc.

2.3 COPECs in Sediment

Sediment samples from the T-24A Ranges exhibited maximum concentrations of the following constituents that exceeded ESVs and BTVs, and were not essential macro-nutrients:

- aluminum
- barium
- beryllium
- copper
- iron
- lead
- mercury
- nickel
- thallium
- zinc
- di-n-butylphthalate
- chloromethane
- benzo(a)anthracene
- chrysene
- fluoranthene
- pyrene.

Aluminum was detected in five sediment samples at concentrations that exceeded the BTV. There is no ESV for aluminum in sediment. Geochemical evaluation indicated that all of the detected concentrations of aluminum in sediment were consistent with naturally occurring background concentrations of aluminum in sediment. Aluminum is the most abundant metal in the earth's crust. Because the maximum detected aluminum concentrations only slightly exceeded the BTV and geochemical evaluation indicated that all of the detected aluminum in sediment was naturally occurring, aluminum was not identified as a COPEC in sediment.

Three sediment samples exhibited barium and beryllium concentrations greater than their respective BTVs. There are no ESVs for barium or beryllium in sediment. Geochemical evaluation indicated that all of the detected concentrations of barium and beryllium in sediment were consistent with naturally occurring background concentrations of barium and beryllium in sediment. Because the maximum detected barium and beryllium concentrations only slightly exceeded their BTVs and geochemical evaluation indicated that all of the detected barium and beryllium in sediment was naturally occurring, neither barium nor beryllium were identified as COPECs in sediment.

Copper was detected in four sediment samples at concentrations that exceeded the ESV. The HQ_{screen} value for copper in sediment was calculated to be 1.9. Geochemical evaluation indicated that all of the detected concentrations of copper in sediment were consistent with naturally occurring background concentrations of copper in sediment. Based on the relatively low HQ_{screen} value and the fact that geochemical evaluation indicated that the detected concentrations of copper were consistent with naturally occurring background, copper was not identified as a COPEC in sediment.

Two sediment samples exhibited iron concentrations greater than the BTV for iron. The HQ_{screen} value for iron in sediment was calculated to be 3.7. Geochemical evaluation indicated that all of the detected concentrations of iron in sediment were consistent with naturally occurring background concentrations of iron in sediment. Iron is often considered a macro-nutrient which is easily regulated by most organisms and only toxic at very high levels. Since iron was detected relatively infrequently at elevated concentrations compared to the BTV, is often considered a macro-nutrient that is easily regulated, and geochemical evaluation indicated that the detected iron was consistent with naturally occurring levels, iron was not identified as a COPEC in sediment.

Lead was detected in four sediment samples at concentrations that exceeded the ESV. The HQ_{screen} value for lead in sediment was calculated to be 5.2. Geochemical evaluation indicated that all of the detected concentrations of lead in sediment were consistent with naturally occurring background concentrations of lead in sediment. However, because lead is a known component of munitions and is present in several sample locations at elevated concentrations, lead was identified as a COPEC in sediment.

Mercury was detected in one sediment sample at a concentration that exceeded the ESV. The HQ_{screen} value for mercury in sediment was calculated to be 1.6. Geochemical evaluation indicated that the single detection of mercury in sediment was consistent with naturally occurring background concentrations of mercury in sediment. Some commonly used screening values for mercury in sediment are 0.18 mg/kg (MacDonald, et al., 2000), 0.15 mg/kg (USEPA, 1996), and 0.2 mg/kg (Persaud, et al., 1993). All of these screening values are very close to the maximum detected concentration of mercury in sediment. Based on the infrequency of detection, low HQ_{screen} value, the fact that numerous alternative screening values are very close to the maximum detected value, and the fact that geochemical evaluation indicated that the detected mercury was consistent with background levels, mercury was not identified as a COPEC in sediment.

Nickel was detected in one sample at a concentration that exceeded the ESV. The HQ_{screen} value for nickel in sediment was calculated to be 1.7. Geochemical evaluation indicated that all of the detected concentrations of nickel in sediment were consistent with naturally occurring background concentrations of nickel in sediment. Based on the infrequency of detection at elevated concentrations, the low magnitude of the HQ_{screen} value, and the fact that geochemical evaluation indicated that nickel in sediment was naturally occurring, nickel was not identified as a COPEC in sediment.

Thallium was detected in one sediment sample, although the detected concentration is an estimated value (“J” flagged). There is no ESV for thallium in sediment. Although the estimated concentration of thallium is greater than the BTV, the infrequency of detection results in thallium not being identified as a COPEC in sediment.

Zinc was detected in one sediment sample at a concentration that exceeded the ESV. The HQ_{screen} value for zinc in sediment was calculated to be 1.5. Geochemical evaluation indicated that all of the detected concentrations of zinc in sediment were consistent with naturally occurring background concentrations of zinc in sediment. Based on the infrequency of detection at elevated concentrations, the low magnitude of the HQ_{screen} value, and the fact that geochemical

evaluation indicated that zinc in sediment was naturally occurring, zinc was not identified as a COPEC in sediment.

Benzo(a)anthracene, chrysene, fluoranthene, and pyrene were all detected in one or two samples at concentrations that exceeded their respective ESVs. The HQ_{screen} values for these polynuclear aromatic hydrocarbons (PAHs) ranged from 2.97 to 6.06. Although these PAHs were relatively infrequently detected, the maximum detected concentrations may indicate isolated areas of contamination; therefore, these PAHs were identified as COPECs in sediment.

Di-n-butylphthalate was detected in two samples out of 11 at concentrations that exceeded the ESV. The HQ_{screen} values for di-n-butylphthalate was calculated to be 2.88. An alternative screening value of 11 mg/kg is presented as an Ecotox Threshold Value by USEPA (1996) in an Eco Update. Both of the detected concentrations of di-n-butylphthalate are less than this alternative screening value. Based on the infrequency of detection and the fact that all of the detected concentrations are less than the alternative screening value, di-n-butylphthalate was not identified as a COPEC in sediment at the T-24A Ranges.

Chloromethane was detected in one sediment sample at a concentration that exceeded the ESV. The HQ_{screen} value for chloromethane in sediment was calculated to be 42. The ESV for chloromethane has been rescinded by EPA Region 5 due to the lack of supporting data. The ESV for chloromethane is four orders of magnitude less than the ESVs for most other volatile organic compounds (VOC). If the ESV for chloromethane was similar to the ESVs for the other VOCs, then it is likely the maximum detected concentration of chloromethane in sediment would be less than the screening level. For this reason, chloromethane was not identified as a COPEC in sediment.

The constituents in sediment at the T-24A Ranges that were identified as COPECs through examination of additional lines of evidence were the following:

- lead
- benzo(a)anthracene
- chrysene
- fluoranthene
- pyrene
- total PAHs.

2.4 COPECs in Groundwater

Groundwater samples from the T-24A Ranges exhibited maximum concentrations of the following constituents that exceeded surface water ESVs and BTVs, and were not essential macro-nutrients (Table 2-4):

- aluminum
- barium
- chromium
- iron
- manganese
- mercury
- bis(2-ethylhexyl)phthalate
- benzene
- carbon tetrachloride.

It is important to note that ecological receptors do not have a direct exposure pathway to groundwater. Ecological receptors can only be exposed to constituents in groundwater if groundwater is expressed at the ground surface as seeps or is discharged to lakes or streams via springs. Exposure of ecological receptors to groundwater could then occur via surface water pathways. The study area of the T-24A ranges forms the headwaters of the South Branch of Cane Creek. As such, there are a number of areas of potential seepage and wetland areas at the T-24A ranges which are highly dependent upon the amount of precipitation received in the local watershed. Therefore, during periods of significant precipitation, there may be the potential for ecological receptors to be exposed to constituents in groundwater if groundwater is expressed at the surface as a seep or wetland area. Contaminants that may have entered groundwater in the past are likely to have been mostly, if not entirely, transported to surface water bodies by now, and if ongoing groundwater contamination of surface water bodies were a concern, surface water samples would indicate the presence of groundwater contaminants.

In order to ensure that the identification and refinement of groundwater COPECs considered the most recent and conservative screening values available, the state of Alabama ambient water quality criteria (AWQC) for freshwater were considered in the COPEC refinement process. Table 2-7 presents a summary of the groundwater data for the T-24A ranges along with the ESVs used to identify the initial list of COPECs and the Alabama AWQC used in the COPEC refinement process. AWQC that are hardness-dependent were calculated using the average hardness of surface water samples collected from the T-24A ranges (30.6 mg/L). Alabama AWQC are discussed below with respect to the refinement of each groundwater COPEC, where applicable.

All of the detected concentrations of arsenic were less than the ESV and chronic Alabama AWQC; therefore, arsenic was not identified as a COPEC in groundwater at the T-24A ranges.

Aluminum was detected in one groundwater sample out of 37 samples at a concentration that exceeded the BTV. Geochemical evaluation indicated that all of the detected concentrations of aluminum in groundwater were consistent with naturally occurring background concentrations of aluminum in groundwater. Based on the low frequency of detection at elevated concentrations and the fact that geochemistry evaluation indicated that the detected aluminum is naturally occurring, aluminum was not identified as a COPEC in groundwater.

Barium was detected in three groundwater samples out of 37 total samples that exceeded the BTV. The HQ_{screen} value for barium was calculated to be 805. Geochemical evaluation indicated that the detected concentrations of barium in groundwater were consistent with naturally-occurring background concentrations of barium in groundwater, with one caveat. The barium, calcium, potassium, and sodium concentrations in samples from well R24A-187-MW14 are elevated due to grout contamination. Grout contamination is an artifact of well construction and only affects the local environment of the well bore and is not indicative of the overall groundwater condition. If the results for well R24A-187-MW14 are removed from the evaluation, the HQ_{screen} value is 35.9. Based on the infrequency of detection at concentrations exceeding the BTV, and the fact that barium was not identified as a COPEC in any other medium at the T-24A Ranges, and the fact that geochemical evaluation indicated all of the detected barium in groundwater was naturally-occurring, barium was not identified as a COPEC in groundwater at the T-24A ranges.

Chromium was detected in one groundwater sample out of 38 samples at a concentration that exceeded the ESV. The HQ_{screen} value for chromium was calculated to be 1.1. All of the detected concentrations of chromium were less than the chronic Alabama AWQC. Geochemical evaluation indicated that all of the detected concentrations of chromium in groundwater were consistent with naturally occurring background concentrations of chromium in groundwater. Based on the infrequency of detection at elevated concentrations, the low magnitude of the HQ_{screen} value, the fact that all of the detected concentrations were less than the chronic AWQC, and the fact that geochemical evaluation indicated that the detected chromium was naturally occurring, chromium was not identified as a COPEC in groundwater.

All of the detected concentrations of copper were less than the ESV. Seven groundwater samples out of 35 samples exhibited estimated (“J” flagged data) copper concentrations that exceeded the Alabama chronic AWQC. The HQ_{screen} value calculated using the AWQC was 1.9. Geochemical evaluation indicated that all of the detected copper concentrations in groundwater samples were consistent with naturally occurring background concentrations of copper in groundwater. Based on the fact that none of the detected concentrations of copper exceeded the ESV, the relatively low HQ_{screen} value, and the fact that geochemical analysis indicated that all of the detected concentrations of copper were consistent with naturally occurring levels of copper in groundwater, copper was not identified as a COPEC in groundwater at the T-24A ranges.

Iron was detected in five groundwater samples at concentrations greater than the BTV. The HQ_{screen} value for iron was calculated to be 11.7. Geochemical evaluation indicated that all of the detected concentrations of iron in groundwater were consistent with naturally occurring background concentrations of iron in groundwater. Iron is often considered a macro-nutrient which is easily regulated by most organisms and only toxic at very high levels. Because the maximum detected concentrations of iron in groundwater are not grossly elevated compared to the BTV and geochemical evaluation indicated all of the detected iron in groundwater is naturally occurring, and iron is often considered an essential macro-nutrient, iron was not considered a COPEC in groundwater.

Both of the detected concentrations of lead in groundwater were less than the background screening value for lead in groundwater. Although the 2 detected concentrations of lead out of 35 samples were greater than the Alabama chronic AWQC for lead, it is important to note that the chronic AWQC for lead (0.7 $\mu\text{g/L}$) is less than the background screening value for lead in groundwater (8.0 $\mu\text{g/L}$), which indicates the chronic AWQC is overly conservative for this site and not directly applicable to conditions at the T-24A ranges. Based on the infrequency of detection, the fact that all of the detected concentrations of lead were less than the background screening value for lead, and the fact that geochemical analysis indicated that all of the detected concentrations of lead in groundwater were consistent with naturally occurring concentrations of lead in groundwater, lead was not identified as a COPEC in groundwater at the T-24A ranges.

Manganese was detected in 13 groundwater samples at concentrations that exceeded the BTV. Geochemical evaluation indicated that all of the detected concentrations of manganese in groundwater were consistent with naturally occurring background concentrations of manganese in groundwater. Although manganese was detected fairly frequently at concentrations that exceeded the BTV, the detected concentrations did not grossly exceed the BTV. Since

geochemical evaluation indicated that the detected concentrations of manganese were naturally occurring and manganese was not identified as a COPEC in surface soil or surface water, manganese was not identified as a COPEC in groundwater.

Mercury was detected in one groundwater sample out of 38 samples at a concentration that exceeded the ESV and the Alabama chronic AWQC. Geochemical evaluation indicated that all of the detected concentrations of mercury in groundwater were consistent with naturally occurring background concentrations of mercury in groundwater. Based on the infrequency of detection, the fact that mercury was not identified as a COPEC in surface soil or surface water, and the fact that geochemical evaluation indicated that all of the detected mercury in groundwater was naturally occurring, mercury was not identified as a COPEC in groundwater.

All of the detected concentrations of nickel in groundwater were less than the ESV. Two groundwater samples out of 36 total samples exhibited nickel concentrations that exceeded the Alabama chronic AWQC for nickel. It is important to note that the chronic AWQC for nickel (0.019 µg/L) is less than the background screening value for nickel in groundwater (22.5 µg/L), which indicates the chronic AWQC is overly conservative for this site and not directly applicable to conditions at the T-24A ranges. Geochemical evaluation indicated that all of the detected nickel concentrations in groundwater samples were consistent with naturally occurring background concentrations of nickel in groundwater. Based on the fact that all of the detected nickel concentrations in groundwater were less than the ESV, the detected nickel was infrequently greater than the AWQC, and geochemical evaluation indicated all of the detected nickel was consistent with naturally occurring background concentrations of nickel in groundwater, nickel was not identified as a COPEC in groundwater at the T-24A ranges.

Selenium was detected in one groundwater sample out of 36 samples at a concentration that exceeded the ESV and Alabama chronic AWQC. The HQ_{screen} value was calculated to be 1.01. Statistical analysis indicated the detected selenium was consistent with naturally occurring background concentrations of selenium in groundwater. Due to the infrequency of detection at “elevated” concentrations, the low HQ_{screen} value, and the fact that statistical analysis indicated the detected selenium was consistent with naturally occurring background concentrations of selenium, selenium was not identified as a COPEC in groundwater at the T-24A ranges.

Zinc was detected in one groundwater sample out of 35 samples at a concentration that exceeded the ESV and Alabama chronic AWQC. The Alabama chronic AWQC for zinc (44 µg/L), is less than the background screening value for zinc in groundwater (220 µg/L), which indicates the

chronic AWQC is overly conservative for this site and not directly applicable to conditions at the T-24A ranges. The HQ_{screen} value was calculated to be 5.04. Statistical analysis indicated the detected zinc was consistent with naturally occurring background concentrations of zinc in groundwater. Due to the infrequency of detection at “elevated” concentrations, and the fact that statistical analysis indicated the detected zinc was consistent with naturally occurring background concentrations of zinc, zinc was not identified as a COPEC in groundwater at the T-24A ranges.

BEHP was detected in two groundwater samples out of 37 samples at concentrations that exceeded the ESV. The HQ_{screen} value was calculated to be 14.3. BEHP is commonly used as a plasticizer in a wide variety of materials, and is also a common laboratory contaminant (NLM, 1996; ATSDR, 1993). Because of their many uses, phthalates are widespread in the environment and have been identified at low levels in the air, water, and soil. BEHP is also very insoluble in water and is unlikely to be found in the dissolved form (bioavailable form) in groundwater. The detected concentrations of BEHP are likely the result of re-suspended sediment caused by the sampling technique and may not truly be present in groundwater. Because the screening value of 0.0003 mg/L is two orders of magnitude below the reporting limit typically achieved by laboratory analytical techniques (0.01 mg/L in this investigation), even very low detections of BEHP would result in HQ values greater than 1. An alternative screening value for BEHP developed using the Tier II methodologies proposed in the USEPA’s Great Lakes Water Quality Initiative (USEPA, 1995) and presented as an Ecotox Threshold Value in an Eco Update (USEPA, 1996) is 0.032 mg/L. Both of the detected concentrations of BEHP in groundwater at the T-24A Ranges were less than this alternative screening value. BEHP is not a bioaccumulative chemical, and is unlikely to pose a hazard to populations of ecological receptors even if the detections in the groundwater are accurate. Therefore, based on the low frequency of detection and the factors presented above, BEHP was not identified as a COPEC in groundwater at the T-24A Ranges.

Benzene and carbon tetrachloride were detected in one groundwater sample out of 61 samples at concentrations that exceeded their respective ESVs. The HQ_{screen} values for benzene and carbon tetrachloride were calculated to be 18.3 and 1.1, respectively. Neither benzene nor carbon tetrachloride was detected in surface soil or surface water. Based on the infrequency of detection, the relatively low HQ_{screen} values, and the fact that neither benzene nor carbon tetrachloride was detected in any other environmental medium, benzene and carbon tetrachloride were not identified as COPECs in groundwater.

A thorough examination of additional lines of evidence resulted in no COPECs being identified in groundwater at the T-24A Ranges.

2.5 Summary of COPECs

In order to focus on the constituents that are most prevalent at the T-24A Ranges and have the greatest potential to pose adverse ecological effects to local ecological communities and populations, the initial list of COPECs was scrutinized using additional lines of evidence. These additional lines of evidence included frequency of detection, magnitude of the HQ_{screen} value, comparison to alternative screening values, comparison to naturally occurring background levels, association with Army activities, bioaccumulation, and toxicity potential. Based on these additional lines of evidence, the COPECs that have been identified at the T-24A Ranges are summarized below and presented in Table 2-8:

- **Surface Soil** – Antimony, copper, lead, and zinc
- **Surface Water** – Copper, lead, and zinc
- **Sediment** – Lead, benzo(a)anthracene, chrysene, fluoranthene, pyrene, and total PAHs
- **Groundwater** – None.

3.0 Ecotoxicity

The ecotoxicological properties of the COPECs identified at the T-24A Ranges dictate which receptors have the greatest potential ecological hazard and the pathways by which those receptors have the greatest potential for exposure. Factors such as the propensity to bioaccumulate or biomagnify, as well as their acute and/or chronic toxicity to immature or adult receptors are important factors in the consideration of a constituent's ecotoxicity and also in the development of assessment and measurement endpoints. Current ecological risk assessment methodologies generally address chronic exposures and effects since they generally provide for more ecological protection than methods for assessing acute exposures and effects. Some ecological risk assessment test methodologies (i.e., acute surface water toxicity tests) directly assess acute exposures, and the results are extrapolated to assess chronic exposures. However, a thorough ecological risk assessment addresses both acute and chronic toxicity.

In order for a constituent to exhibit toxicity or to bioaccumulate, it first must be bioavailable. In general, there are three microbial processes affecting the bioavailability of metals (Connell and Miller, 1984). The first is biodegradation of organic matter into lower molecular weight compounds, which are more capable of complexing metal ions than higher molecular weight organic molecules. The second is alterations to physicochemical properties of metals by microbial metabolic activities (i.e., oxidation-reduction potential and pH conditions). Finally, the process of bacterial methylation, specifically of lead and mercury, may greatly enhance the bioavailability of certain inorganic compounds.

The actual uptake of bioavailable metals by terrestrial and aquatic organisms is through three main routes: 1) uptake across respiratory surfaces (lungs or gills), 2) adsorption from soil, sediment or water onto body surfaces, and 3) ingestion of food, water or incidental particles. Given the state of science relative to bio-uptake dynamics, the ingestion route is the most quantifiable uptake route at this time. Metal uptake from dietary sources, in comparison to direct adsorption, is also considered the primary uptake route in small terrestrial and aquatic receptors.

Although ecological receptors can readily absorb metals from food/water ingestion, their ability to regulate elevated concentrations of metals dictates their tolerance and is a critical factor in survival. Once the upper limit, or threshold, of metal sequestration and excretion is reached, sub-lethal effects such as inhibited reproduction and growth potentials may be exhibited, followed by lethality. Temporary metal storage is generally by binding to proteins, such as

metallothioneins, polysaccharides, and amino acids (Connell and Miller, 1984). Storage within liver and kidney tissues as well as bone, feathers, and fur also provide a useful means for sequestering metals such as lead.

Considerable inter- and intra-species differences exist in bioaccumulation potential of individual metals. In addition, according to Phillips (1980), different chemical forms of any one metal may be absorbed and excreted at widely differing rates. Many studies support the premise that inorganic metals do not have a high propensity to biomagnify up through food chains.

The following sections highlight key toxicological properties of the COPECs that have been identified at the T-24A Ranges (antimony, copper, lead, mercury, zinc, benzo(a)anthracene, chrysene, di-n-butyl phthalate, fluoranthene, and pyrene).

3.1 Antimony

Antimony binds to soil and particulates (especially those containing iron, manganese, or aluminum) and is oxidized by bacteria in soil. Exposure routes for mammals include ingestion and inhalation. Antimony does not tend to biomagnify in terrestrial food chains (Ainsworth, 1988), and is not significantly metabolized and excreted in the urine and feces. Antimony at elevated levels has the potential to cause reproductive, pulmonary, and hepatic effects in mammals (EPA, 1999a).

Plants. Antimony is considered a non-essential element and is easily taken up by plants if available in the soil in soluble forms (Kabata-Pendias and Pendias, 1992). A screening level of 5.0 mg/kg has been proposed by Kabata-Pendias and Pendias (1992) based on a report of unspecified phytotoxic responses by plants grown in soil amended with antimony.

Terrestrial Invertebrates. EPA (2005c) has developed an ecological soil screening level (Eco-SSL) for antimony of 78 mg/kg. The eco-SSL for antimony is the geometric mean of three EC₂₀ values reported in the literature. Kuperman et al. (2002) reported an EC₂₀ value using enchytraeids (*Enchytraeus crypticus*) of 194 mg/kg; Phillips et al. (2002) reported an EC₂₀ value using springtails (*Folsomia candida*) of 81 mg/kg; and Simini et al. (2002) reported an EC₂₀ value using earthworms (*Eisenia fetida*) of 30 mg/kg.

Mammals. Female mice exposed to 5.0 mg/L antimony (as antimony potassium tartrate) in their drinking water showed a reduction in their lifespan. This dose was equivalent to a lowest-observed-adverse-effects-level (LOAEL) of 1.25 mg/kg/ per day [mg/kg/day]), which can be

converted to a no-observed-adverse-effects-level (NOAEL) of 0.125 mg/kg/day (Integrated Risk Information Service, 2007).

Laboratory data on antimony toxicity (as antimony potassium tartrate) in laboratory mice through drinking water ingestion were used to estimate a chronic NOAEL value of 0.125 mg/kg/day (Schroeder et al., 1968). Lifespan and longevity were the endpoints tested.

EPA (2005c) has derived an Eco-SSL for mammalian wildlife species of 0.27 mg/kg antimony in soil. This mammalian Eco-SSL is the lowest calculated value based on reproduction, growth, and survival of ground insectivores (shrew).

USEPA Region 4 has adopted the Netherlands' Maximum Permissible Concentration (Crommentuijn, et al., 1997) of 3.5 mg/kg as their recommended ecological soil screening value, and this value has also been adopted as the ESV for antimony in soil at FTMC.

Birds. No information was found regarding the potential toxicity of antimony to birds.

Aquatic Life. The available data for antimony indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 9.0 and 1.6 mg/L, respectively, and would occur at lower concentrations among species that are more sensitive than those tested. Toxicity to algae can occur at concentrations as low as 0.61 mg/L.

Effects from antimony exposure on benthic community composition have been detected at levels between 3.2 and 150 mg/kg (Long and Morgan, 1990). Data on antimony suggest an effects range-low (ER-L) of 2 mg/kg and an effects range-median (ER-M) of 25 mg/kg.

3.2 Copper

Copper is ubiquitously distributed in nature in the free state and in sulfides, arsenides, chlorides, and carbonates. Several copper-containing proteins have been identified in biological systems as oxygen binding hemocyanin, cytochrome oxidase, tyrosinase, and lactase. Copper has also been identified with the development of metalloproteins employed in the sequestering and cellular detoxification of metals. Most organisms are able to regulate copper levels within their systems. Copper may accumulate in the tissues of certain organisms but it does not tend to accumulate or magnify in higher trophic levels.

Copper has been known to sorb rapidly to sediment. The rate of sorption is of course dependent upon factors such as the sediment grain size, organic fraction, pH, competing cations, and the presence of ligands. In industrialized freshwater environments around the world total copper levels within sediments can range from 7 to 2,350 parts per million (ppm) (Moore and Ramamoorthy, 1984).

Plants. Copper is an essential nutrient for the growth of plants. Background concentrations of copper in grasses and clovers collected in the United States averaged 9.6 mg/kg and 16.2 mg/kg (dry weight) (Kabata-Pendias and Pendias, 1992). Copper is one of the least mobile heavy metals in soil, and its availability to plants is highly dependent on the molecular weight of soluble copper complexes (Kabata-Pendias and Pendias, 1992).

According to Rhodes et al. (1989), copper concentrations in plant tissues do not serve as conclusive evidence of copper toxicity in species of plants such as tomatoes, because some species are able to tolerate higher concentrations of copper than others. The pH of soil may also influence the availability and toxicity of copper in soils to plants. In a study with tomato plants, Rhodes et al. (1989) found a reduction in plant growth when plants were grown in soils containing greater than 150 mg/kg of copper at a pH of less than 6.5. At pH values greater than 6.5, soil copper concentrations of greater than 330 mg/kg were required to reduce plant growth.

Concentrations of copper in leaf tissue that are excessive or toxic to various plant species range from 20 to 100 mg/kg (dry weight) (Kabata-Pendias and Pendias, 1992). A soil concentration of 100 mg/kg has been proposed by Efrogmson et al., (1997) as a benchmark screening value for copper phytotoxicity in soil. General symptoms of copper toxicity in plants include the presence of dark green leaves followed by induced iron chlorosis; thick, short, or barbed wire roots; and depressed tillering (Kabata-Pendias and Pendias, 1992).

Terrestrial Invertebrates. Beyer et al. (1982) and others have reported that copper concentrations in earthworms have been observed to be correlated with copper concentrations in soil. Further studies by Beyer (1990) indicate that copper can be more toxic to bioturbative earthworms than most metals. Research by Phillips (1980) suggests that copper and other metal accumulation within terrestrial invertebrates may vary significantly depending on soil conditions and other physical/chemical properties, and bioconcentration factors can approach 10,000. EPA (2007b) has derived a soil screening level (SSL) for copper of 80 mg/kg. This invertebrate SSL was based on reproductive and growth data from studies conducted with natural soils under conditions of high or very high bioavailability. The tests were conducted with highly soluble

salts and neither aging nor weathering, which would lower bioavailability, was included in the experimental designs.

Mammals. Copper is an essential trace element to animals as well as plants (Callahan et al., 1979), but becomes toxic at concentrations only slightly higher than essential levels (EPA, 1985). Copper is an essential element for hemoglobin synthesis and oxidative enzymes in animals, and is absorbed by mammals following ingestion, inhalation, and dermal exposure. Once absorbed, copper is distributed to the liver, and is not metabolized (Marceau et al., 1970). No evidence of bioaccumulation was obtained in a study of pollutant concentrations in the muscles and livers of 10 species of herbivorous, omnivorous, and carnivorous animals in Donana National Park in Spain (Hernandez et al., 1985). Copper concentrations in small mammals collected from various uncontaminated sites ranged from 8.3 to 13.4 mg/kg (whole-body concentrations) (Talmage and Walton, 1991). Highest concentrations of copper tend to be in hair, followed in decreasing concentration by liver, kidney, and whole body (Hunter and Johnson, 1982). Among the small mammals collected, Hunter and Johnson (1982) found shrews (*Sorex araneus*) to contain the highest concentrations of copper. Mice were found to contain the lowest copper concentrations. Increased fetal mortality was observed in fetuses of mice fed more than 104 mg/kg-day of copper as copper sulfate (Lecyk, 1980). Increased mortality rates in mink offspring have been observed at levels above 3.21 mg/kg-day (Aulerich et al., 1982).

Laboratory toxicity data for mink exposed to copper sulfate in their diet were used to estimate a NOAEL value of 11.7 mg/kg/day (Aulerich et al., 1982). Reproduction was the endpoint studied. Symptoms of acute copper poisoning in mammals include vomiting, hypotension, melena, coma, jaundice, and death (Klaassen et al., 1991). Selenium can act as an antidote for copper poisoning.

Birds. Laboratory toxicity data for one-day old chicks exposed to copper oxide in their diets were used to estimate a NOAEL value of 47 mg/kg/day (Mehring et al., 1960). Growth and mortality were the endpoints studied.

Aquatic Life. Invertebrates inhabiting “polluted” freshwaters worldwide have been known to have tissue residues of copper ranging from 5 to 200 ppm (Moore and Ramamoorthy, 1984). Field studies have shown that there is virtually no accumulation of this metal through the food chain (Fuller and Averett, 1975). Studies by Kosalwat and Knight (1987) indicated that copper present in the substrate or sediment was significantly less toxic to chironomid species than overlying water column levels. The substrate copper concentration at which chironomid larval

growth was reduced 50 percent (EC_{50}) was 1,602 mg/kg. These researchers found that deformities in larval mouth parts were observed in elevated concentrations, and adult emergence was inhibited when the sediment concentration exceeded 1,800 mg/kg. Carins et al. (1984) reported copper toxicity in sediment for several chironomus midges and cladocerans with LC_{50} values ranging from 681 to 2,296 mg/kg.

Moore and Ramamoorthy (1984) reported that copper can be highly toxic to many aquatic plants and algae. Inhibition of growth can occur at levels as low as 0.1 mg/L. In some algal species, copper may inhibit electron transport during photosynthesis. In general, since low pH increases the proportion of free ions in solution, acidic waters may exhibit greater copper toxicity. However, Stokes (1975) reported the observance of algal adaptation to copper-tainted waters with certain species able to tolerate and flourish within highly copper-contaminated waters.

Moore and Ramamoorthy (1984) reported LC_{50} in fresh water fish ranging from 0.017 to 1.0 mg/L. Copper is similar to other metals in that its toxicity to fin fish is often greater within fresh water environments versus marine environments because of the lack of complexing agents within fresh water.

3.3 Lead

Global production of lead from both smelter and mining operations has been high throughout the past century. Lead is commonly used in storage batteries as well as in ammunition, solder, and casting materials. In addition, tetraethyl lead was a principal additive to gasoline as an anti-knock agent and was commonly used as an additive in paints. In short, lead is one of the most ubiquitous pollutants in the civilized world.

Lead is strongly sorbed in sediments, and the rate is strongly correlated with grain size and organic content. In the absence of soluble complexing species, lead is almost totally adsorbed to clay particles at pH values greater than 6 (Moore and Ramamoorthy, 1984).

Plants. Although lead is not an essential nutrient for plant growth, it is detected in plant tissues due to the prevalence of lead in the environment. The bioavailability to plants of lead in soil is limited. Bioavailability may be enhanced by a reduction in soil pH, a reduction in the content of organic matter and inorganic colloids in soil, a reduction in iron oxide and phosphorous content, and increased amounts of lead in soil (National Research Council of Canada [NRCC], 1973). Plants can absorb lead from soil and air. Aerial deposition of lead can also contribute significantly to the concentration of lead in above-ground plant parts. Lead is believed to be the

metal of least bioavailability and the most highly accumulated metal in root tissue (Kabata-Pendias and Pendias, 1992). Lead tends not to accumulate into plants from soil unless concentrations are very high (i.e., percentage levels). The tips of some trees, such as pine and fir, can accumulate lead from contaminated soil when contamination levels are high. Such conditions often occur at mining sites (NLM, 1996). Lead inhibits plant growth, reduces photosynthesis, and reduces mitosis and water absorption

Mean background concentrations of lead in grasses and clovers have been reported to range from 2.1 to 2.5 mg/kg (dry weight) (Kabata-Pendias and Pendias, 1992). Adverse effects of lead on terrestrial plants occur only at total concentrations of several hundred mg/kg of soil (Eisler, 1988). This is explained by the fact that, in most cases, lead is tightly bound to soils, and substantial amounts must accumulate before it can affect the growth of higher plants (Bogges, 1977).

The Eco-SSL for plants, as derived by EPA (2005d), is 110 mg/kg. The plant Eco-SSL is the geometric mean of the maximum acceptable toxicant concentration (MATC) for four test species (loblolly pine, red maple, Berseem clover, and ryegrass) under three different test conditions.

Terrestrial Invertebrates. Lead has been shown to accumulate in the tissues of lower trophic level organisms, including terrestrial invertebrates, but is not effectively transferred to higher trophic level organisms through the food web. Centipedes (*Lithobius variegatus*) that ate woodlice hepatopancreas did not assimilate lead even though the food contained concentrations that were many times greater than normally encountered. However, survival and reproduction were reduced in woodlice (*Porcellio scaber*) fed soil litter treated with 12,800 mg/kg lead (Beyer and Anderson, 1985). This concentration of lead is similar to the amount of lead reportedly associated with reductions in natural populations of decomposers, such as fungi, earthworms, and arthropods.

EPA (2005d) has derived an Eco-SSL based on soil invertebrate toxicity of 1,700 mg/kg lead in soil. The Eco-SSL for terrestrial invertebrates is the geometric mean of the MATC values for one test species (*Folsomia candida*) under three different test conditions.

Mammals. As with plants, lead is not considered an essential nutrient for mammalian life. Ingestion is the major route of exposure for wildlife. Lead tends to accumulate in bone, hair, and teeth. Biomagnification of lead is negligible (Eisler, 1988). Jenkins (1981) also reported that soil conditions of low alkalinity and low pH can enhance the potential for bioconcentration of

lead in mammals, birds, mosses, lichens, lower animals, and higher plants. Reduced survival was reported at acute oral doses as low as 5 mg/kg body weight in rats, at a chronic dose of 0.3 mg/kg body weight in dogs, and at a dietary level of 1.7 mg/kg body weight in horses (Eisler, 1988). Laboratory data from studies of rats fed lead acetate in their diets were used to estimate a NOAEL value of 8.0 mg/kg-day (Azar et al., 1973). Reproduction was the endpoint for this study. Symptoms of lead poisoning in mammals are diverse and depend on the form of lead ingested, the concentration, and the species and its age. These symptoms may include reproductive impairment, decreased body weight, vomiting, uncoordinated body movements, visual impairment, reduced life span, renal disorders, and abnormal social behavior (Eisler, 1988).

In laboratory studies, breeding mice exposed to low doses of lead in drinking water (25 ppm) resulted in loss of the strain in two generations with many abnormalities (Schroeder and Mitchener, 1971). Exposure of rats in this same experiment resulted in many early deaths and runts. Blood δ -aminolevulinic acid dehydratase activity associated with exposure to lead was reduced in white-footed mice living near a metal smelter (Beyer et al., 1985). Amounts of whole-body lead content and feeding habits of roadside rodents have been correlated with highest body burdens in insectivores such as shrews, intermediate in herbivores, and lowest in granivores (Boggess, 1977; Getz et al., 1977).

EPA (2005d) has derived an Eco-SSL for lead in soil of 56 mg/kg for the protection of mammalian species. This mammalian Eco-SSL for lead is based on the NOAEL for reproduction, growth and survival in a number of mammalian species.

Birds. Most of the information on the effects of lead to terrestrial vertebrates is concerned with acute poisoning of waterfowl by lead shot. Apparent symptoms include loss of appetite and mobility, avoidance of other birds, lethargy, weakness, emaciation, tremors, dropped wings, green feces, impaired locomotion, loss of balance and depth perception, nervous system damage, inhibition of heme synthesis, damage to kidneys and liver, and death (Eisler, 1988; Mudge, 1983). Anemia, kidney disease, testicular and liver lesions, and neurological disorders have been associated with high brain lead concentrations in mourning doves (*Zenaida macroura*) (Kendall, 1992). Hatchlings of chickens, Japanese quail, mallards, and pheasants are relatively more tolerant to moderate lead exposure, including no effect on growth at dietary levels of 500 ppm and no effect on survival at 2,000 ppm (Hoffman et al., 1985).

Toxicity of lead to birds is dependent upon the form of lead, the route of exposure and exposure duration, and the species and age of the bird. Hatchlings of chickens, Japanese quail, mallards, and pheasants are relatively tolerant to moderate lead exposure (Eisler, 1988). Laboratory toxicity data for American kestrels fed metallic lead in their diet were used to estimate a NOAEL value of 3.85 mg/kg-day (Pattee, 1984). Reproduction was the endpoint for this study.

An avian Eco-SSL for lead has been derived by EPA (2005d) to be 11 mg/kg lead in soil. This avian Eco-SSL for lead is based on the NOAEL for reproduction, growth and survival in a number of avian species.

Aquatic Life. All life stages are sensitive to the toxic effects of lead; however, embryos are more sensitive to lead than are later juvenile stages (Davies et al., 1976). Lead uptake depends on exposure time, aqueous concentration, pH, temperature, salinity, diet, and other factors. For example, gill, liver, kidney, and erythrocytes accumulate lead from aqueous sources in proportion to exposure time and concentration (Holcombe et al., 1976). Direct erythrocyte injury is considered the first and most important sign of lead poisoning in catfish (Dawson, 1935). Respiratory distress occurs in fish living in rivers receiving lead mining wastes in England (Carpenter, 1924; 1925; 1926). Fish are thought to be asphyxiated as a result of a mucous coating over the gills (National Academy of Sciences [NAS], 1972).

No significant biomagnification of lead occurs in aquatic ecosystems (Boggess, 1977). Background concentrations of lead in fish tend to be less than 1 mg/kg (dry weight) (Eisler, 1988). The EPA's National Recommended Water Quality Criteria for lead in freshwater are 65 micrograms per liter ($\mu\text{g/L}$) for acute exposure and 2.5 $\mu\text{g/L}$ for chronic exposure (EPA, 2002). In general, dissolved lead is more toxic than total lead, and organic forms of lead are more toxic than inorganic forms. Soluble lead in the water column becomes less bioavailable as water hardness increases. Chronic exposure of fish to lead may result in signs of lead poisoning such as spinal curvature, anemia, darkening of the dorsal tail region, destruction of spinal neurons, difficulties in swimming, growth inhibition, changes in blood chemistry, retarded sexual development, and death (Eisler, 1988).

Physicochemical conditions within the water may also affect lead uptake and toxicity. Under conditions of low alkalinity (less than 50 microequivalents per liter) and low pH, lead can accumulate in fish, algae, mollusks, and benthic invertebrates (Wiener and Stokes, 1990). Irwin (1988) reported significant accumulations of lead in the Trinity River within mosquitofish, turtles, bullhead minnows, and crayfish. Nevertheless, lead concentrations were not higher in

top-of-the-food-chain predators like gar than they were in mosquitofish, suggesting minimal biomagnification of lead.

The majority of benthic invertebrates do not bioconcentrate lead from water or abiotic sediment particles. There is some evidence of bioaccumulation through the food web of organic forms of lead, such as tetraethyl lead. Anderson et al. (1980) reported a lead LC₅₀ of 258 ppm for the chironomid and that growth of this organism was not reduced above this level in freshwater sediments. In addition, Suter and Tsao (1996) reported effect levels in the water flea (*Daphnia magna*) to be in the 12.26 parts per billion (ppb) range, while Khangrot and Ray (1989) reported an LC₅₀ of 4.89 ppm for *D. magna*.

3.4 Zinc

Zinc is a naturally occurring element that may be found in both organic and inorganic forms and, as such, is commonly found in the environment. In general, zinc is concentrated in the sediments of water bodies. The NAS (1979) has reported that zinc will probably be detected in 75 percent of all water bodies examined for the compound at various locations. The fate of zinc in soils appears to have a pH basis. Studies have shown that a pH of less than 7 often favors zinc desorption (EPA, 1984).

Plants. Background concentrations of zinc in terrestrial plants range from 25 to 150 mg/kg (dry weight) (NAS, 1979). The deficiency content of zinc in plants is between 10 and 20 ppm (dry weight). Roots often contain the highest concentrations of zinc (Kabata-Pendias and Pendias, 1992).

Certain species of plants, particularly those from the families Caryophyllaceae, Cyperaceae, and Plumbaginaceae, and some tree species are extremely tolerant to elevated zinc concentrations (Kabata-Pendias and Pendias, 1992). Concentrations of zinc in these plants may reach 1 percent (dry weight) in the plant. Concentrations in leaf tissue that are excessive or toxic to various plant species range from 100 to 400 mg/kg. Concentrations of 100 to 500 mg/kg are expected to result in a 10 percent loss in crop yield (Kabata-Pendias and Pendias, 1992). General symptoms of zinc toxicity in plants include the presence of chlorotic and necrotic leaf tips, interveinal chlorosis in new leaves, retarded growth of the entire plant, and injured roots that resemble barbed wire (Kabata-Pendias and Pendias, 1992).

Terrestrial Invertebrates. EPA (2000a) has developed an ecological soil screening level (SSL) for zinc in soil of 120 mg/kg. This SSL was based on reproduction and population effects

in experiments conducted with natural soils under conditions of high or very high zinc bioavailability. It is also important to note that in studies conducted with mixtures of cadmium, copper, and zinc, it was concluded that the three metals acted antagonistically. It has also been shown that a decrease in pH and/or organic matter in the soil tends to decrease the concentration of zinc in soil at which toxic effects are observed (Spurgeon and Hopkin, 1996). Zinc has been shown to accumulate in earthworm species (Beyer et al., 1982) but generally is not biomagnified through the food web.

Mammals. Zinc is an essential trace element for normal fetal growth and development. However, exposure to high levels of zinc in the diet has been associated with reduced fetal weights, altered concentrations of fetal iron and copper, and reduced growth in offspring (Cox et al., 1969). Poisoning has been observed in ferrets and mink from chewing corroded galvanized cages (Clark et al., 1981). Symptoms of zinc toxicity include lassitude, slower tendon reflexes, bloody enteritis, diarrhea, lowered leukocyte count, depression of the central nervous system, and paralysis of the extremities (Venugopal and Luckey, 1978). A study by Kinnamon (1963) showed a NOAEL for oral exposure to a zinc compound over a period of 73 days to be 250 mg/kg body weight, and mice given 500 mg/L of zinc as zinc sulfate in drinking-water have shown hypertrophy of the adrenal cortex and pancreas. Young animals are much more susceptible to poisoning by zinc than are mature animals (Clark et al., 1981).

Animals are quite tolerant of high concentrations of zinc in the diet. Levels 100 times that required in the diet usually do not cause detectable symptoms of toxicosis (NAS, 1979). Laboratory data for rats exposed to zinc oxide in their diet were used to estimate a NOAEL value of 160 mg/kg-day (Schlicker and Cox, 1968). Reproduction was the endpoint studied. Symptoms of zinc poisoning in mammals include lameness, acute diarrhea, and vomiting (Eisler, 1993).

Birds. Dietary zinc concentrations of greater than 2,000 mg/kg are known to result in reduced growth of domestic poultry and wild birds (Eisler, 1993). Reduced survival has been documented at zinc concentrations greater than 3,000 mg/kg diet or at a single dose of greater than 742 mg/kg body weight (Eisler, 1993). Laboratory data for white leghorn hens exposed to zinc sulfate in their diet were used to estimate a NOAEL value of 14.5 mg/kg-day (Stahl et al., 1990). Reproduction was the endpoint for this study. A value of 51 mg/L has been calculated as the NOAEL for chronic exposure of birds to zinc carbonate in drinking water (Sample et al., 1996).

Aquatic Life. Zinc residues in freshwater and marine fish are generally much lower than those found in algae and invertebrates. Thus, there is little evidence for bioaccumulation (Moore and Ramamoorthy, 1984). Rainbow trout (*Oncorhynchus mykiss*) have the ability to detect and avoid areas of water containing 5.6 ppb zinc (Sprague, 1968). Cairns and Scheier (1968) reported 96-hour LC₅₀s ranging from 10.13 to 12.5 ppm in hard water for bluegills (*Lepomis macrochirus*), and 96-hour LC₅₀s ranging from 2.86 to 3.78 ppm in soft water. These results demonstrate that water hardness affects the toxicity of zinc to fish. Chronic toxicity tests have been conducted with five species of freshwater fish. Chronic values ranged from 47 µg/L for flagfish (*Jordanella floridae*) to 852 µg/L for brook trout (*Salvenius fontinalis*) (EPA, 1980a).

Acute toxicity to freshwater invertebrates is relatively low and, as with other metals, increasing water hardness decreases the toxicity of zinc (Moore and Ramamoorthy, 1984). As reported by Baudouin and Scoppa (1974), the 48-hour LC₅₀ for the cladoceran *Daphnia hyalina* was 0.055 mg/L, and 5.5 mg/L for the copepod *Cyclops abyssorum*. Four chronic toxicity tests are reported for *Daphnia magna*, with chronic values ranging from 47 µg/L to 136 µg/L (EPA, 1980a). Chronic testing with the saltwater species *Mysidopsis bahia* resulted in a chronic value of 166 µg/L (EPA, 1980a).

3.5 Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbons (PAH) are a diverse group of organic chemicals consisting of substituted and unsubstituted polycyclic and heterocyclic aromatic rings in which interlinked rings have at least two carbon atoms in common (Zander, 1983). They are formed as a result of incomplete combustion of organic materials such as wood, coal, and oil and exist in the environment in quantity, both from anthropogenic and natural sources. Activities associated with large releases of PAHs include coke production, petroleum refining, the manufacture of carbon black, coal tar pitch and asphalt, heating and power generation, and emissions from internal combustion engines. It is estimated that approximately 270,000 metric tons of PAHs reach the environment yearly (Eisler, 1987).

Plants. Some PAHs are synthesized by plants at very low concentrations (Sims and Overcash, 1983). Background concentrations of specific PAH compounds usually range from 22 to 88 µg/kg in tree leaves, 48 to 66 µg/kg in cereal crop plants, 0.05 to 50 µg/kg in leafy vegetables, 0.01 to 6 µg/kg in underground vegetables, and 0.02 to 0.04 µg/kg in fruits (Sims and Overcash, 1983). In general, PAH concentrations are usually greater in above-ground plant parts than in below-ground parts, and are greater on plant surfaces than within internal tissues (Eisler, 1987).

Lower molecular weight PAHs are taken up from soil by plants more readily than higher molecular weight PAHs (Eisler, 1987). Soil-to-plant concentration ratios for total PAHs have been reported to range from 0.001 to 0.183 (Talmage and Walton, 1990). Atmospheric deposition is believed to be the usual source of PAHs in plants, not uptake from soil (Sims and Overcash, 1983).

Limited data exist on the phytotoxicity of PAHs to plants. Benzo(b)fluoranthene concentrations of 6,254 µg/kg in soil were reported to reduce stem growth in wheat but did not affect rye plants. Benzo(a)pyrene and benzo(b)fluoranthene soil concentrations of up to 18,000 µg/kg do not appear to be severely toxic to higher plants. There is some evidence that low concentrations of some PAHs may actually stimulate plant growth (Sims and Overcash, 1983).

Terrestrial Invertebrates. The primary mode of toxicity for PAHs in soil dwelling terrestrial invertebrates is non-specific, non-polar narcosis (Sverdrup et al., 2002). The uptake of PAHs by earthworms occurs primarily by direct contact with the soluble phase of the soil solution (interstitial porewater) (Fairbrother, 2005). The bioavailability of PAHs in soil is influenced by organic carbon quality and quantity, aging and weathering, microbial action, methylation/hydroxylation, adsorption/desorption, and ultraviolet light interaction (Fairbrother, 2005). PAHs in soil undergo a weathering process such that the lighter chain fractions are removed (primarily by volatilization). Heavier fractions bind more readily to the soil organic matter and remain behind in the top soil horizon. Aging reduces the bioavailability of PAHs in soil (Fairbrother, 2005).

In general, the more insoluble the PAH, the higher the uptake by soil invertebrates (Wilcke, 2000). The EPA (2007c) has derived Eco-SSLs for high molecular weight and low molecular weight PAHs. The Eco-SSL for low molecular weight PAHs is the geometric mean of the MATC and the EC₁₀ values for four test species and is equal to 29 mg/kg-dry weight. The Eco-SSL for high molecular weight PAHs is the geometric mean of the MATC and the EC₁₀ values for four test species and is equal to 18 mg/kg-dry weight

Mammals. Most of the PAHs taken into the body are not accumulated but are oxidized, and the metabolites excreted (NLM, 1996). In fact, most PAH compounds are detoxified and excreted from the body (Klaassen et al., 1991). PAHs are metabolized in vertebrates by a group of enzymes known as mixed-function oxidases in the liver. A few laboratory studies on rodents have revealed acute oral toxicities of PAHs are greatest for benzo(a)pyrene, followed in decreasing order of toxicity by phenanthrene, naphthalene, and fluoranthene (Sims and Overcash

(1983). Data from a study of mice fed benzo(a)pyrene in their diets were used to derive a NOAEL value of 1.0 mg/kg/day (MacKenzie and Angevine, 1981). The critical endpoint in this study was reproduction.

Sims and Overcash (1983) have reported LC₅₀ values for rodents (*Rattus* spp. and *Mus* spp.) as 50 mg/kg-day benzo(a)pyrene, 700 mg/kg-day phenanthrene, and 2,000 mg/kg-day fluoranthene. Sublethal effects manifested as decreased pup weight in mice have been reported at 10 mg/kg-day benzo(a)pyrene (MacKenzie and Angevine, 1981). Subchronic and chronic effects of exposure to PAHs in rats include liver and kidney damage, unspecified changes in peripheral blood pattern, body weight loss, genetic aberrations, and increased serum aminotransferase activity (Knobloch et al., 1969).

The EPA (2007c) has derived Eco-SSLs for high molecular weight and low molecular weight PAHs. Eco-SSLs were estimated for mammalian herbivores (vole), mammalian ground insectivores (shrew), and mammalian carnivores (weasel). The Eco-SSLs for low molecular weight PAHs were estimated to be 350 mg/kg, 100 mg/kg, and 1,200 mg/kg, for herbivores, insectivores, and carnivores, respectively. The Eco-SSLs for high molecular weight PAHs were estimated to be 39 mg/kg, 1.1 mg/kg, and 110 mg/kg, for herbivores, insectivores, and carnivores, respectively.

Birds. Patton and Dieter (1980) fed mallards diets that contained 4,000 mg PAHs/kg (mostly as naphthalenes, naphthenes, and phenanthrene) for a period of seven months. No mortality or visible signs of toxicity were evident during exposure; however, liver weight increased 25% and blood flow to liver increased 30% when compared to controls.

Hoffman and Gay (1981) measured embryotoxicity of various PAHs applied externally to the surface of mallard duck eggs. Approximately 0.002 µg/egg of 7,12-dimethylbenz(a)anthracene (DMBA) caused 26 percent mortality in 18 days, and among the survivors, produced significant reduction in embryonic growth and a significant increase in the percent of abnormalities (e.g., incomplete skeletal ossification, defects in eye, brain liver, feathers, and bill). At 0.1 µg DMBA/egg, only 10 percent survived to day 18.

Several investigators have suggested that the presence of PAHs in petroleum significantly enhances the overall embryotoxicity in avian species, and that the relatively small percent of the aromatic hydrocarbons contributed by PAHs in petroleum may confer much of the adverse

biological effects reported after eggs have been exposed to polluting oils (Hoffman and Gay, 1981).

Aquatic Life. In general, PAHs as a group are not appreciably acutely toxic (Eisler, 1987; Neff, 1985). The toxicity of PAH compounds to fish is related to the solubility of the compound in water. The toxicity of PAHs to aquatic organisms is very species-specific and related to the organisms' ability to metabolize and excrete the compound (Eisler, 1987). For aquatic organisms, only PAHs in the molecular weight range from naphthalene to pyrene are considered acutely toxic. Toxicity in this group increases with increasing molecular weight. There is some evidence to suggest that PAHs are responsible for the production of reproductive and teratogenic effects in eggs of the sand sole (*Psettichthys melanostictus*) exposed to 0.1 µg benzo(a)pyrene/L for five days showed reduced and delayed hatch and, when compared to controls, produced larvae with high accumulations (2.1 mg/kg fresh weight) and gross abnormalities, such as tissue overgrowths, in 50 percent of the test larvae (Hose et al., 1982).

Inhibited reproduction of daphnids and the delayed emergence of larval midges by fluorene were reported by Finger et al. (1985). When sediment PAH levels are elevated, benthic organisms obtain a majority of their PAHs from sediments through their ability to mobilize PAHs from the sediment/pore water matrix. The elevated levels in the tissues of these organisms could provide a significant source of PAHs to predatory fish. However, fish do have the ability to efficiently metabolize and degrade PAHs.

3.6 Phthalates

Phthalates are a class of predominantly man-made compounds which do not naturally occur in nature. They are manufactured and commonly used to produce flexible plastics, wetting agents, insecticidal sprays, paints, and glues (NLM, 1996; ATSDR, 1993). Because of their many uses, phthalates are widespread in the environment and have been identified at low levels in the air, water and soil. In air, phthalates may be adsorbed to particulate matter, and can be transferred to water by wet or dry deposition. In water and soil phthalates are subject to microbial degradation. Both aerobic and anaerobic degradation have been reported. Inman et al. (1984) demonstrated that di-n-butyl phthalate in soil was completely degraded within 100 days. Di-n-butyl phthalate and di-n-octyl phthalate have strong ultraviolet absorption bands at 274 nanometers extending beyond 290 nanometers and are therefore strong candidates for photolysis. However, the estimated photolysis half-life in natural waters is 144 days for both compounds (Callahan et al., 1979). There is some evidence that phthalate esters might be biosynthesized and occur naturally in some plants and organisms (Callahan et al., 1979).

Plants. No information was found regarding the toxicity of phthalates to plants.

Terrestrial Invertebrates. No information was found regarding the toxicity of phthalates to terrestrial invertebrates.

Mammals. No studies were located on the effects of phthalate exposure to wildlife. Effects of phthalate esters in laboratory animals were seen at only very high doses (one to two percent di-n-butyl phthalate in the diet in oral studies). The male reproductive system appears to be the most sensitive target organ for acute-duration oral exposure to di-n-butyl phthalate in animals. A LOAEL of 1,000 mg/kg-day was established for decreased testis weight in rats (Oishi and Hiraga, 1980). The mechanism of testicular damage by di-n-butyl phthalate may involve interference with zinc metabolism (Foster et al., 1980). After oral administration, butyl benzyl phthalate was rapidly excreted. Rats and mice exposed to high concentrations of butyl benzyl phthalate experienced weight loss, testicular atrophy, hemorrhages, and hepatomegaly. LD₅₀ values for these experiments were 2.3 g/kg for rats and 4.2 to 6.2 g/kg for mice (DIALOG, 1996).

Mice fed bis(2-ethylhexyl)phthalate in their diets for 105 days were studied for effects on reproduction. While significant reproductive effects were observed among mice on diets containing 0.1 and 0.3 percent bis(2-ethylhexyl)phthalate, no adverse effects were observed among the 0.01 percent dose group. These data were used to derive a NOAEL value of 18.3 mg/kg/day (Lamb et al., 1987).

Birds. Ringed doves were fed bis(2-ethylhexyl)phthalate in their diets for 4 weeks during a critical lifestage and studied for reproductive effects (Peakall, 1974). No significant reproductive effects were observed in the maximally exposed doves (10 ppm). These data were used to derive a NOAEL value of 1.1 mg/kg/day based on reproductive effects.

Aquatic Life. Studies by Sasaki (1978) indicate that both di-n-butyl phthalate and di-n-octyl phthalate are non- or low-bioaccumulative in fishes. Studies by Streufert et al. (1981) showed the acute 48-hour LC₅₀s of di-2-ethylhexyl phthalate and di-n-butyl phthalate to the midge larvae *Chironomus plumosus* to be 18 mg/L and 0.76 mg/L, respectively. Chronic lifecycle toxicity tests showed no effect up to 0.36 mg/L di-2-ethylhexyl phthalate on midge emergence, egg production, or egg hatchability.

4.0 Fate and Transport

The environmental fate and transport of the COPECs in the various media at the T-24A Ranges will govern the potential for exposures to ecological receptors. In general, COPECs in environmental media may be available for direct exposure (e.g., plants exposed to surface soil) and they may also have the potential to migrate to other environmental media or areas of the site. This chapter discusses the mechanisms by which COPECs can be transported and the chemical properties that determine their transport.

4.1 Fate and Transport in Soil

COPECs in surface soil at the T-24A Ranges have the potential to be transported from their source areas to other areas within the respective ranges and to off-site locations by a number of mechanisms, including volatilization, dust entrainment, surface runoff, and infiltration to subsurface soil/groundwater.

Several VOCs were identified in the upper soil horizons at the T-24A Ranges, albeit at very low concentrations. These VOCs have a high potential to volatilize to the atmosphere and be transported from their source area via air movement. The concentrations of VOCs detected in surface soil at the T-24A Ranges are low; therefore, this transport mechanism is expected to be insignificant with respect to other transport mechanisms active at this site. Most of the metals and SVOCs in the surface soil at the T-24A Ranges are not expected to volatilize to any great extent, with the exception of mercury, which would be expected to volatilize relatively rapidly. Most of the metals and SVOCs in the surface soil at the T-24A Ranges are generally closely associated with soil particulate matter and could be transported from their source areas by fugitive dust generation and entrainment by the wind. Subsequent dispersion by atmospheric mixing could transport particulate-associated contaminants to other parts of the T-24A Ranges and to off-site locations. Fugitive dust generation in the forested areas is expected to be minimal due to continuous ground cover; however, in the areas that have been clear-cut or denuded of vegetation, fugitive dust generation could be a significant transport mechanisms for surface soil contaminants. The generation of fugitive dust and subsequent transport by the wind is potentially a significant transport mechanism at the T-24A Ranges, based on the presence of non-vegetated areas and areas of sparse vegetation within certain areas of these ranges (e.g., impact areas and soil berms).

The transport of surface soil-associated contaminants by surface runoff is another potential transport mechanism. Surface water drainage at the T-24A Ranges consists of several intermittent and perennial streams that generally flow to the north and west across these ranges and these drainage features constitute the headwaters of the South Branch of Cane Creek. These drainage features collect surface runoff from the T-24A Ranges and transport it off-site to the west. As such, surface runoff via the small ephemeral and perennial streams and ultimately South Branch of Cane Creek has the potential for significant constituent transport off-site during periods of significant precipitation.

Contaminants in surface soil may be transported vertically to subsurface soils and groundwater via solubilization in rainwater and infiltration. Migration in this manner is dependent upon contaminant solubility and frequency of rainfall. The soil type (rough, stony land) in the vicinity of the T-24A Ranges does not promote rapid infiltration, but rather is more conducive to the promotion of surface runoff. Based on the constituents detected in surface soil and the soil type found at these sites, vertical migration of surface soil constituents is expected to be minimal at the T-24A Ranges.

The transfer of contaminants in surface soil to terrestrial plants through root uptake and transfer to terrestrial animals through ingestion and other pathways are potentially significant transfer mechanisms. Many metals are readily absorbed from soil by plants, but they are not biomagnified to a great extent through the food web. There are several exceptions to this, namely, arsenic and nickel, which may bioconcentrate and/or biomagnify (ATSDR, 1989; 1995a). VOCs and SVOCs do not bioaccumulate to any significant extent (Shugart et al., 1990); therefore, food web transfer of these constituents is expected to be minimal. Many of the SVOCs have the potential to bioaccumulate in lower trophic level organisms (e.g., terrestrial invertebrates), but most higher trophic level animals have the ability to metabolize these compounds rapidly, precluding the potential for bioconcentration (Eisler, 1987).

VOCs in the surface soil at the T-24A Ranges are expected to volatilize and/or photolyze rapidly (half-lives of 3 hours to 5 days) when exposed to sunlight (Burrows et al., 1989). The other surface soil contaminants (metals and SVOCs) are expected to remain in the soil relatively unchanged by physical and/or chemical processes for much longer periods of time.

4.2 Fate and Transport in Surface Water

It is important to preface any discussion about surface water transport with the fact that almost all of the drainage features at the T-24A Ranges are ephemeral and are completely dry for

significant periods of time during most years. Therefore, fate and transport mechanisms that may be applicable to surface water are likely only applicable during periods of significant precipitation and are not continuous or long-term in nature.

Constituents in surface water at the T-24A Ranges may be transported from their sources to other areas at the ranges or to off-site locations by the following mechanisms: 1) volatilization, 2) transfer to groundwater, 3) transfer to sediment, and 4) flow downstream. In general, the majority of the study area of the T-24A Ranges constitutes the headwaters of the South Branch of Cane Creek. Water in the South Branch of Cane Creek and its tributaries originates mainly from overland flow from the surrounding watershed and from seeps located in the surrounding mountains. There also appears to be sporadic and localized contributions to creek flow from groundwater where the potentiometric surface exceeds the creek bed surface. The flow contribution in the South Branch of Cane Creek and its tributaries from groundwater varies according to the amount of precipitation, with an increase of groundwater contribution when precipitation raises the potentiometric surface.

Thus, constituents in groundwater could migrate to surface water in the South Branch of Cane Creek and its tributaries. This transport mechanism appears to be relatively insignificant based on the fact that none of the constituents that are routinely associated with small arms ranges (antimony, copper, lead, and zinc) were detected at elevated concentrations in groundwater at the T-24A Ranges. Constituent transfer to sediments represents another significant transfer mechanism, especially where constituents are in the form of suspended solids, or are hydrophobic substances (e.g., PAHs) that can become adsorbed to organic matter in the sediments. The metals detected in surface water have the potential to associate with suspended particulate matter. VOCs in surface water would be expected to rapidly volatilize from the water-air interface and be dispersed in the atmosphere. Therefore, transport of VOCs in surface water is not expected to occur for any significant distance.

Constituents in surface water could be transported off-site via the South Branch of Cane Creek during periods of significant rainfall. Transfer of constituents in surface water to aquatic organisms is also a potentially significant transfer pathway. Some of the inorganic constituents detected in surface water may bioaccumulate in lower trophic level organisms. Most of the inorganics detected in surface water are not highly bioconcentratable; therefore, transfer through the food web is expected to be minimal for these compounds.

4.3 Fate and Transport in Sediment

Constituent transfer between sediment and surface water potentially represents a significant transfer mechanism, especially when contaminants are in the form of suspended solids. Sediment/surface water transfer is reversible; sediments often act as temporary repositories for constituents and gradually release constituents to surface waters. This is especially true in surface water systems that are acidic, as is the case with the South Branch of Cane Creek and its tributaries in the vicinity of the T-24A Ranges. Sorbed or settled contaminants can be transported with the sediment to downstream locations. Much of the substrate of drainage features in the vicinity of the T-24A Ranges is best characterized as gravel or cobbles. Very few areas of high organic content sediment or muck are present. The very low organic content of gravel and cobble create a substrate with very low binding capacity; therefore, constituents released to the drainage features at the T-24A Ranges via surface runoff or other transport mechanisms would most likely remain suspended in the surface water, be transported downstream, and would not be sequestered in the stream substrate at the T-24A Ranges.

Although transfer of sediment-associated constituents to bottom-dwelling biota also represents a potentially significant transfer mechanism, it is not expected to be a major mechanism at the T-24A Ranges. Lower trophic level organisms may accumulate metals and PAHs; however, higher trophic level organisms have the ability to metabolize PAHs and therefore reduce their accumulative properties. Most of the inorganics detected in sediment are not bioaccumulative. Mercury and copper may bioaccumulate to some extent due to exposures to sediment.

4.4 Fate and Transport in Groundwater

Ecological exposures to groundwater are generally considered incomplete. In general, ecological receptors can only be exposed to groundwater if groundwater is expressed at the surface as a seep, wetland, or discharge to a surface water body, where surface water exposure routes would potentially apply. Groundwater discharge to South Branch of Cane Creek is a potentially viable transport mechanism for dissolved constituents in groundwater during periods of significant precipitation; however, exposure to these constituents by ecological receptors is only possible via surface water exposure routes.

4.5 Constituent-Specific Fate and Transport Properties

The following sub-sections describe the fate and transport properties of each of the COPECs identified at the T-24A Ranges.

4.5.1 Antimony

Little is known of the adsorptive behavior of antimony, its compounds, and ions. The binding of antimony to soil is determined by the nature of the soil and the form of antimony deposited on the soil. The forms of antimony in various soils and the transformations between these forms is poorly understood. Some forms of antimony may bind to inorganic and organic ligands. On the other hand, a mineral form would be unavailable for binding. Since antimony has an anionic character, it is expected to have little affinity for organic carbon (ATSDR, 1992). Antimony binds to soil, particularly to particles containing iron, manganese, or aluminum (ATSDR, 1992). Bodek et al. (1988) indicate that antimony oxides are highly soluble, which suggests environmental mobility. However, Callahan et al. (1979) indicate that antimony may have an affinity for clay and other mineral surfaces. Some studies suggest that antimony is fairly mobile under diverse environmental conditions (Rai and Zachara, 1984), while others suggest that it is strongly adsorbed to soil (Ainsworth, 1988; Foster, 1989; King, 1988). Since antimony forms anionic species, adsorption should be greatest under weakly acidic conditions, which is the case at the T-24A ranges. There are no data available regarding the partitioning of the various forms of antimony to different solvents or environmental media. Therefore, it can be concluded that the fate of antimony in soil is somewhat uncertain, and dependent upon many inter-related environmental factors. Antimony is also oxidized by bacteria in the soil. In water, antimony is oxidized when exposed to atmospheric oxygen.

The forms of antimony and the chemical and biochemical processes that occur in the aquatic environment are not well understood. Antimony does not appear to bioconcentrate appreciably in fish and aquatic organisms. No detectable bioconcentration occurred during a 28-day test using bluegills (EPA, 1980b). Bioconcentration factors for antimony ranged from 0.15 to 390 (Callahan et al., 1979). Uptake of antimony from soil by plants is minor and appears to be correlated with the amount of antimony that is soluble (Ainsworth, 1988). Antimony is not significantly metabolized and is excreted in the urine and feces. It does not biomagnify in terrestrial food chains, but can bioconcentrate to a slight degree in aquatic organisms. Antimony bioconcentration was measured in voles, shrews, rabbits, and invertebrates around a smelter. Analysis of antimony in organs of the small mammals, compared with estimates of their antimony intake from food, showed that, although the amount of antimony in the organs was elevated, it was low compared to the amount ingested. The results suggest that antimony does not biomagnify from lower to higher trophic levels in the food chain (ATSDR, 1992). It should also be noted that antimony is associated with ammunition, being present in lead alloys in bullets and in materials used as primers. Antimony can be present in both the +3 and +5 valence states, depending on pH, oxidation-reduction potential, and several other chemical properties of the

environmental medium in which it is found. Antimony can methylate via chemical and/or biological reactions into an organic form under reducing conditions such as those commonly found within highly organic fine sediments and hydric soils (ATSDR, 1992).

4.5.2 Copper

In general, adsorption is probably the most important controlling mechanism in determining copper mobility in the environment. Copper's movement in soil is determined by a host of physical and chemical interactions with the soil components. In general, copper will adsorb to organic matter, carbonate minerals, clay minerals, or hydrous iron and manganese oxides. Sandy soils with low pHs have the greatest potential for leaching. When the amount of organic matter is low, the mineral content of iron, manganese, and aluminum oxides become important in determining the adsorption of copper. Copper binds to soil much more strongly than other divalent cations, and the distribution of copper in the soil solution is less affected by pH than other metals (ATSDR, 2004). The solubility of copper in soil tends to increase as the pH decreases. Because the soils at the T-24A Ranges exhibit a neutral to somewhat acidic pH, it would be reasonable to assume that the copper in soil would be subject to leaching and somewhat mobile. However, the iron and manganese content of the soil tends to form copper complexes and the copper tends to be fairly immobile at these ranges, as evidenced by the lack of copper contamination in subsurface soils and/or groundwater. There are no data available regarding the partitioning of the various forms of copper to different solvents or environmental media.

Copper binds primarily to organic matter in sediment, unless the sediment is organically poor. It also binds to iron oxides. The solubility of copper in sediments tends to increase as the pH of the sediment decreases.

The bioconcentration factor (BCF) of copper in fish obtained in field studies ranges from 10 to 667, indicating a low potential for bioconcentration. The BCF is higher in mollusks, where it may reach 30,000 (Perwak et al., 1980). This may be due to the fact that many mollusks are filter feeders, and copper concentrations are higher in particulates than in water. There is abundant evidence, however, that there is no biomagnification of copper in the food chain. No evidence of bioaccumulation in herbivorous, omnivorous, and carnivorous mammals was obtained during a study of 10 mammal species in Donana National Park in Spain (Hernandez et al., 1985). A study of metals in cottontail rabbits showed that while the concentration of copper in surface soil was 130 percent higher than in control areas, the concentration of copper in foliar samples was insignificant. No significant increase in copper was observed in rabbit muscle,

femur, kidney, or liver, indicating that copper was not bioaccumulating in the food chain. Even at the lowest levels of the food chain, there is little evidence of copper bioaccumulation. In a study of earthworms and soil from 20 different sites, copper concentrations in earthworms poorly correlated with copper in soil (ATSDR, 2004).

At the pH values and carbonate concentrations characteristic of natural waters, most dissolved copper exists as carbonate complexes rather than as free (hydrated) cupric ions. The concentration of dissolved copper depends on factors such as pH, oxidation-reduction potential, and the presence of competing cations (Ca^{2+} , Fe^{2+} , Mg^{2+} , etc.), anions of insoluble cupric salts (OH^- , S^{2-} , PO_4^{3-} , etc.), and organic and inorganic complexing agents. Allard (1995) reported that copper can exist in the form of freely-dissolved divalent copper cation at a pH of less than 6. Complexation of copper with humic acids can increase the mobility of copper in groundwater and/or surface water but will also reduce the bioavailability to biota. The most significant precipitate formed in natural waters is malachite [$\text{Cu}_2(\text{OH})_2\text{CO}_3$]. As a result of the aforementioned physico-chemical processes, copper in water may be dissolved or associated with colloidal or particulate matter. Copper complexed in colloidal or particulate forms is generally non-mobile. The combined processes of complexation, adsorption, and precipitation control the level of free copper. The chemical conditions in most natural waters are such that, even at relatively large copper concentrations, these processes will reduce the free copper concentration to extremely low values (ATSDR, 2004).

Between pH 5 and 6, adsorption is the principal process for removing copper from water; above pH 6, precipitation becomes more dominant. Copper binding in soil is correlated with pH, cation exchange capacity, organic content of the soil, and presence of iron oxides. Copper may also be incorporated into mineral lattices where it is unlikely to have ecological significance. In soils with high organic carbon content, copper will be tightly bound to organic matter (ATSDR, 2004). The soil/water partition coefficient for copper has been measured to be >64 for mineral soils and >273 for organic soils, indicating a relatively strong affinity for copper to remain adsorbed to soil (ATSDR, 2004). In sediment, copper is generally associated with mineral matter or tightly bound to organic material (Kennish, 1998).

4.5.3 Lead

The chemistry of lead in aqueous solution is highly complex because this element can be found in a multiplicity of forms. The form of lead at any given site is very important since its bioavailability and uptake dynamics are generally dictated by its form. For example, lead fumes, as from a smelter or gasses generated from the discharge of artillery or bullets, are more

bioavailable than mining wastes or intact pieces of lead fragments. The difference is therefore not only the size of the particles but its chemical form. It should also be noted that lead in soil can slowly undergo speciation to more insoluble sulfate, sulfide, oxide, and phosphate salts (NLM, 1996). Lead has a tendency to form compounds of low solubility with the major anions of natural water. In the natural environment, the divalent form is the stable ionic species of lead. Hydroxide, carbonate, sulfide and sulfate may act as solubility controls in precipitating lead from water. The amount of lead that remains in solution depends upon the pH of the water and the dissolved salt content. Lead is more soluble in softer water and low pH water (ATSDR, 2005a). Complexation of lead with humic acids can increase the mobility of lead in groundwater and/or surface water but will also reduce the bioavailability to biota.

A significant fraction of lead carried by surface water is expected to be in an undissolved form, which can consist of colloidal particles or lead compounds incorporated in other components of surface particulate matter from runoff. Lead may occur as sorbed ions or surface coatings on sediment mineral particles, or it may be carried as a part of suspended living or nonliving organic matter in water. The ratio of lead in suspended solids to lead in dissolved form ranges from 4:1 to 27:1 (ATSDR, 2005a).

Most lead in soil is retained there and very little is transported into surface water or groundwater (ATSDR, 2005a). The fate of lead in soil is affected by the adsorption at mineral surfaces, the precipitation of sparingly soluble solid forms of the compound, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter. The mobility of lead increases in environments having low pH due to the enhanced solubility of lead under acidic conditions (ATSDR, 2005a). Lead may be immobilized by ion exchange with hydrous oxides or clays or by chelation with humic or fulvic acids in soil (Olson and Skogerboe, 1975). The downward movement of elemental lead and inorganic lead compounds from soil to groundwater by leaching is very slow under most natural conditions except for highly acidic situations (NSF, 1977). The conditions that induce leaching are the presence of lead in soil at concentrations that either approach or exceed the cation exchange capacity of the soil, the presence of materials in soil that are capable of forming soluble chelates with lead, and a decrease in the pH of the leaching solution (e.g., acid rain) (NSF, 1977).

The mobility of lead increases in environments having low pH due to the enhanced solubility of lead under acidic conditions. Because precipitation in northeastern Alabama is expected to be acidic in nature, it could be concluded that the mobility of lead in soil would be enhanced. However, elevated concentrations of lead in subsurface soil samples and groundwater at the

T-24A Ranges are not prevalent, indicating that lead is not mobile in the environment at the T-24A Ranges. ATSDR (2005) also suggests that the fate of lead in soil is affected by the adsorption at mineral surfaces, the precipitation of sparingly soluble solid forms of the compound, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter. Due to the relatively low organic content of the soils at the T-24A Ranges, the formation of organic-metal complexes with soil organic matter is likely a minor fate process at the T-24A Ranges. The most likely processes affecting the fate of lead in soil are the adsorption of lead at mineral surfaces and the speciation of lead to more insoluble sulfate, sulfide, oxide, and phosphate salts.

Plants and animals may bioconcentrate lead, but biomagnification is not expected. Although the bioavailability of lead in soil to plants is limited because of the strong adsorption of lead to soil organic matter, the bioavailability increases as the pH and the organic matter content of the soil are reduced. Lead may be taken up in edible plants from the soil via the root system, by direct foliar uptake and translocation within the plant, and by surface deposition of particulate matter. The amount of lead in soil that is bioavailable to most plants depends on factors such as cation exchange capacity, pH, amount of organic matter present, soil moisture content, and type of amendments added to the soil (ATSDR, 2005a). Low alkalinity and low pH conditions in soils can enhance the potential for bioconcentration of lead in mammals, birds, mosses, lichens, lower trophic level animals, and plants (Jenkins, 1981).

Most lead does not appear to significantly bioaccumulate in most fish. However, bioaccumulation of tetraethyl lead can occur in aquatic organisms (ATSDR, 2005a). Plants commonly take up lead from soil and, therefore, may return it upon decomposition. Because the bioavailability of lead is dependent upon site-specific conditions, the accuracy of the ecological assessment of lead depends heavily on site-specific tests of bioavailability and subsequent toxicity and accumulation.

4.5.4 Zinc

Zinc occurs in the environment mainly in the +2 oxidation state. Sorption is the dominant reaction, resulting in the enrichment of zinc in suspended and bed sediments. Zinc in aerobic waters is partitioned into sediment through sorption onto hydrous iron and manganese oxides, clay minerals, and organic material. The efficiency of these materials in removing zinc from solution varies according to their concentrations, pH, redox potential, nature and concentration of complexing ligands, cation exchange capacity, and the concentration of zinc (ATSDR, 2005b). Similar to copper, zinc is complexed at high pHs and can exist as freely-dissolved divalent

cations at lower pHs, thus enhancing its bioavailability. Therefore, as the pH of the water decreases, the concentration of zinc ions in the water phase increases at the same rate as that of the release of zinc from the sediment. In anaerobic environments and in the presence of sulfide ions, precipitation of zinc sulfide limits the mobility of zinc. In most waters, zinc exists primarily as the hydrated form of the divalent cation. However, the metal often forms complexes with a variety of organic and inorganic ligands (ATSDR, 2005b). In aquatic environments, zinc partitions to sediments or suspended solids in surface waters through sorption onto hydrous iron and manganese oxides, clay minerals, and organic material.

In general, zinc sorbs strongly onto soil particles. The mobility of zinc in soil depends on the solubility of the speciated forms of the element and on soil properties such as cation exchange capacity, pH, redox potential, and chemical species present in the soil; under anaerobic conditions, zinc sulfide is the controlling species (Kalbasi et al., 1978). Since zinc sulfide is insoluble, the mobility of zinc in anaerobic soil is low. The mobility of zinc in soil increases at lower soil pH under oxidizing conditions and at lower cation exchange capacity of soil (Tyler and McBride, 1982). Distribution constants for zinc in soil range widely from 0.1 to 8,000 liters per kilogram (L/kg) (Baes and Sharp, 1983). Zinc in soluble form (e.g., zinc sulfate) is moderately mobile in most soils; however, the mobility is limited by a slow rate of dissolution. Consequently, movement towards groundwater is expected to be slow unless the zinc in the soil is in the soluble form or is accompanied by corrosive substances (e.g., mine tailings). Zinc in soil at the T-24A Ranges is not in the soluble form or accompanied by corrosive substances; therefore, zinc primarily remains in recalcitrant, immobile forms at the T-24A Ranges.

Zinc is an essential nutrient that is present in all organisms. Although biota appears to be a minor reservoir of zinc relative to soils and sediments, microbial decomposition of biota in water can produce ligands, such as humic acids, that can affect the mobility of zinc in the aquatic environment through zinc precipitation and adsorption (ATSDR, 2005b). Zinc can accumulate in freshwater animals at 51 to 1,130 times the concentration present in water (EPA, 1987). In general, zinc does not biomagnify through food chains. Furthermore, although zinc bioaccumulates to some degree in aquatic systems, biota appears to represent a relatively minor sink compared to sediments. Steady-state zinc BCFs for 12 aquatic species ranged from 4 to 24,000, with most being less than 100 (EPA, 1987). With respect to bioconcentration from soil by terrestrial plants, invertebrates, and mammals, BCFs of 0.4, 8, and 0.6, respectively, have been reported. In general, plants do not concentrate zinc above levels present in the soil (ATSDR, 2005b).

4.5.5 Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbons (PAHs) are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. There are more than 100 different PAHs. PAHs generally occur as complex mixtures, not as single compounds and are found throughout the environment (ATSDR, 1995b).

The global movement of PAHs can be summarized as follows: PAHs released to the atmosphere are subject to short- and long-range transport and are removed by wet and dry deposition onto soil, water, and vegetation. In surface water, PAHs can volatilize, photolyze, oxidize, biodegrade, bind to suspended particulates or sediments, or accumulate in aquatic organisms. In sediments, PAHs can biodegrade or accumulate in aquatic organisms. PAHs in soil can volatilize, undergo abiotic degradation (photolysis and oxidation), biodegrade, or accumulate in plants. PAHs in soil can also enter groundwater and be transported within an aquifer (ATSDR, 1995b). Microbial metabolism is the major process for degradation of PAHs in soil environments. Environmental factors that may influence the rate of PAH degradation in soil include temperature, pH, oxygen concentration, soil type, moisture content, soil nutrients, and other substances that may act as substrate co-metabolites (Sims and Overcash, 1983).

Transport and partitioning of PAHs in the environment are determined to a large extent by physicochemical properties such as water solubility, vapor pressure, Henry's Law constant, octanol-water partition coefficient (K_{ow}), and organic carbon partition coefficient (K_{oc}). In general, PAHs have low water solubilities. The low water solubility, low vapor pressure, and high K_{ow} of most PAHs result in them partitioning mainly to soil and sediment, with approximately 1 percent partitioning to water and 1 percent partitioning to air, suspended sediments, and biota. The water solubilities of the PAHs detected at the T-24A Ranges range from 0.003 mg/L to 0.2 mg/L, indicating low water solubilities. The log octanol-water partition coefficients ($\log K_{ow}$) for the detected PAHs range from 4.88 to 5.61, indicating a strong tendency for the detected PAHs to partition from the water to sediment or soil. Therefore, the PAHs detected in sediment are not expected to solubilize significantly in overlying surface waters, and are expected to remain sorbed to the bed sediments. PAH compounds tend to be removed from the water column by volatilization to the atmosphere, binding to suspended particulates or sediments, or by being accumulated by or sorbed onto aquatic biota. Because of their low solubility and high affinity for organic carbon, PAHs in aquatic systems are primarily found sorbed to particulates that have either settled to the bottom or are suspended in the water column (ATSDR, 1995b). The low molecular weight PAHs have Henry's Law constants in the range of 10^{-3} to 10^{-5} atm-m³/mol; medium molecular weight PAHs (e.g. fluoranthene and pyrene)

have Henry's Law constants in the 10^{-6} range; and high molecular weight PAHs (e.g. benzo(a)anthracene and chrysene) have values in the range of 10^{-5} to 10^{-8} . Compounds with values ranging from 10^{-3} to 10^{-5} are associated with significant volatilization, while compounds with values less than 10^{-5} volatilize from water only to a limited extent (Lyman, et al., 1982). Therefore, the PAHs detected at the T-24A Ranges are not expected to volatilize to any significant extent.

The low molecular weight PAHs have K_{oc} values in the range of 10^3 to 10^4 , which indicates a moderate potential to be adsorbed to organic carbon in the soil and sediments. The medium molecular weight compounds have K_{oc} values in the 10^4 range. High molecular weight PAHs have K_{oc} values in the range of 10^5 to 10^6 , which indicates stronger tendencies to adsorb to organic carbon (Southworth, 1979). Sorption of PAHs to soil and sediments increases with increasing organic carbon content and with increasing surface area of the sorbent particles.

PAHs can be accumulated in aquatic organisms from water, sediments, and food. BCFs for fish and crustaceans have been reported in the range of 10 to 10,000 (Eisler, 1987). In general, bioconcentration potential is greater for the higher molecular weight compounds than the lower molecular weight compounds. Fish and crustaceans readily assimilate PAHs from contaminated food, whereas mollusks and polychaete worms have limited assimilation (Eisler, 1987). Biomagnification of PAHs up the food chain has not been reported because of the tendency of many aquatic organisms to eliminate these compounds readily (Eisler, 1987). In general, PAHs obtained from the diet contribute to total tissue concentrations only to a limited extent. For example, food chain uptake of anthracene by fathead minnows consuming water fleas was estimated to be approximately 15 percent of the amount accumulated from the water (Southworth, 1979). The ability of fish to metabolize PAHs may explain why benzo(a)pyrene frequently is not detected or found only at very low levels in fish from environments heavily contaminated with PAHs (Varanasi and Gmur, 1980, 1981). The breakdown products (polyhydroxy compounds) are eliminated in feces (via bile) and urine.

Some terrestrial plants can take up PAHs from soil via the roots or from the air via the foliage. The uptake of PAHs from soil by plants is generally quite low (Sims and Overcash, 1983). Ratios of PAH concentrations in vegetation to those in soil have been reported to range from 0.001 to 0.18 for total PAHs (Edwards, 1983).

5.0 Ecosystems Potentially at Risk

The Ranges Near Training Area T-24A are located in the southeastern portion of the Main Post and consist of seven individual parcels including:

- Former Machine Gun Range (Parcel 112Q)
- Former Bandholtz Machine Gun Qualification Range (Parcel 213Q)
- Former Bandholtz Field Firing Range (Parcel 214Q)
- Range 24A, Former Multi-Purpose Range (Parcel 108[7]/82Q-X)
- Range 24A, Former Chemical Munitions Disposal Area (Parcel 187[7])
- Former Demolition Area (Parcel 113Q-X)
- Range 24A, Fog Oil Drum Storage (Parcel 88[6]).

Three of the parcels, Parcel 112Q, Parcel 213Q, and Parcel 214Q are firing ranges. The area encompassed by Parcels 213Q and 214Q overlaps the area of Range 24A, Multi-Purpose Range (Parcel 108[7]/82Q-X), which in turn overlaps Parcel 133Q-X, Parcel 187(7), and Parcel 88(6). Four of the seven overlapping parcels (Parcel 108[7]/82Q-X, Parcel 88[6], Parcel 113Q-X, and Parcel 187[7]) that comprise the Ranges Near Training Area T-24A are located within a valley area just south of the edge of the Fort McClellan geologic window. The remaining three overlapping parcels (Parcel 112Q, Parcel 213Q, and Parcel 214Q) cover an extensive area extending to as much as 10,000 feet to the north, east, and south. Stanley Hill and the Skeleton Mountains arise along the southern boundary of these parcels. The elevation across these parcels ranges from a maximum of approximately 1,125 feet above mean sea level (amsl) at the northeastern corner of Parcel 108(7)/82Q-X to valley areas of less than approximately 975 feet amsl. The location of the T-24A ranges is shown in Figure 5-1.

Surface water drainage at the Ranges Near Training Area T-24A consists of several intermittent streams that generally flow to the north and west across these parcels and constitutes the headwaters of the South Branch of Cane Creek.

The environmental setting of the Ranges Near Training Area T-24A is varied. The majority of the area is forest consisting of mixed deciduous/coniferous forest (deciduous trees dominate) with significant underbrush. An area encompassing approximately 1.2 acres in the western portion of the study area is best described as oldfield habitat.

The forested areas of the Ranges Near Training Area T-24A are characteristic of a typical mesophytic forest type. The canopy species typically found in this forest type at FTMC include

yellow poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), black gum (*Nyssa sylvatica*), shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), white oak (*Quercus alba*), and northern red oak (*Quercus rubra*). The dominant understory species of this forest type are red maple (*Acer rubrum*), flowering dogwood (*Cornus florida*), witch hazel (*Hamamelis virginia*), sweetgum (*Liquidambar styraciflua*), wild black cherry (*Prunus serotina*), hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), and sourwood (*Oxydendrum arboreum*). The shrub layer is dominated by mountain laurel (*Kalmia latifolia*), Piedmont azalea (*Rhododendron canescens*), southern low blueberry (*Vaccinium pallidum*), southern wild raisin (*Viburnum nudum*), and yellowroot (*Xanthorhiza simplicissima*). Muscadine grape (*Vitis rotundifolia*) is a common vine found in this forest type.

The relatively small area of oldfield habitat that occurs in the western portion of the study area was formerly maintained as a mowed field. Since maintenance activities have ceased in this area, pioneer species are now colonizing this area. Typically, the species most likely to colonize these types of areas are the “weed” species that tend to be vigorous pioneer plants that grow and spread rapidly. The first of the pioneer species to invade these abandoned areas are the grasses and other herbaceous species. These formerly maintained grassy areas are classified as being in an early oldfield successional state. Over time, the grass and other herbaceous species will be followed by shrubs and small trees. The early oldfield successional area at the Ranges Near Training Area T-24A is dominated by various grasses and herbs, including dock (*Rumex spp.*), clover (*Trifolium spp.*), vetch (*Astragalus spp.*), milkweed (*Asclepias spp.*), bed straw (*Galium spp.*), ox-eye daisy (*Chrysanthemum leucanthemum*), and Johnson grass (*Sorghum halepense*). Other oldfield herbaceous species occurring at the Ranges Near Training Area T-24A are black raspberry (*Rubus occidentalis*), poison ivy (*Toxicodendron radicans*), smooth sumac (*Rubus glabra*), green brier (*Smilax rotundiflora*), Japanese honeysuckle (*Lonicera japonica*), fox grape (*Vitis labrusca*), and multiflora rose (*Rosa multiflora*). Scrub pine (*Pinus virginiana*), loblolly pine (*Pinus taeda*), and longleaf pine (*Pinus palustris*) saplings have also begun to encroach on this formerly cleared area.

Typical terrestrial species that may inhabit the Ranges Near Training Area T-24A include opossum (*Didelphis marsupialis*), short-tailed shrew (*Blarina brevicauda*), raccoon (*Procyon lotor*), white-tail deer (*Odocoileus virginianus*), red fox (*Vulpes fulva*), coyote (*Canis latrans*), gray squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*), a number of species of mice and rats (e.g., white-footed mouse [*Peromyscus leucopus*], eastern harvest mouse [*Reithrodontomys humulis*], cotton mouse [*Peromyscus gossypinus*], eastern woodrat [*Neotoma floridana*], and hispid cotton rat [*Sigmodon hispidus*]), and eastern cottontail (*Sylvilagus*

floridanus). Approximately 200 avian species reside at FTMC at least part of the year (USACE, 1998). Common species expected to occur in the vicinity of the Ranges Near Training Area T-24A include northern cardinal (*Cardinalis cardinalis*), northern mockingbird (*Mimus polyglottus*), warblers (*Dendroica spp.*), indigo bunting (*Passerina cyanea*), red-eyed vireo (*Vireo olivaceus*), American crow (*Corvus brachyrhynchos*), bluejay (*Cyanocitta cristata*), several species of woodpeckers (*Melanerpes spp.*, *Picoices spp.*), and Carolina chickadee (*Parus carolinensis*). Game birds present in the vicinity of the Ranges Near Training Area T-24A may include northern bobwhite (*Colinus virginianus*), mourning dove (*Zenaida macroura*), and eastern wild turkey (*Meleagris gallopavo*). A variety of woodland hawks (e.g., sharp-shinned hawk [*Accipiter striatus*]) and other raptors (e.g., red-tailed hawk [*Buteo jamaicensis*], barred owl [*Strix varia*], and great horned owl [*Bubo virginianus*]) are expected to use this area for hunting and/or nesting.

As stated previously, several small, ephemeral streams drain the Ranges Near Training Area T-24A and conduct surface runoff to the South Branch of Cane Creek which runs east-to-west across the northern portion of the study area. Much of the study area of the Ranges Near Training Area T-24A comprises the headwaters of the South Branch of Cane Creek. The majority of these small streams are narrow (2 to 3 feet wide) and shallow (3 to 6 inches deep). The substrate is mostly cobbles and gravel with small depositional areas of sand and leaf litter, interspersed throughout. A wetland/seep area is present near the northwestern corner of the study area that exhibits very shallow water (less than 6 inches deep) and a substrate of organic muck. The small size of these intermittent drainage features precludes the presence of most larger fish species and most other animals that might prey on fish (piscivores); however, semi-aquatic species (amphibians) and some small, drought-tolerant fish species are likely to occur in these small creeks during periods of significant precipitation. Bullfrog (*Rana catesbeiana*) and leopard frog (*Rana sphenoccephala*) are examples of amphibians that may be found in the ephemeral streams. Fish species that could be found in the streams at the T-24A Ranges include blacknose dace (*Rhinichthys atratulus*), creek chub (*Semotilus atromaculatus*), stoneroller (*Camptostoma anomalum*), striped shiner (*Luxilus chrysocephalus*), and various darters (*Etheostoma spp.*). Larger fish species are not expected to inhabit these drainage features due to habitat restrictions. It is important to note that most of the drainage features at the T-24A Ranges are ephemeral in nature and are dry for extended periods during most years. As such, only drought-tolerant fish species are likely to occur in these drainage features. Piscivores may use the drainage features at the T-24A Ranges for foraging during periods of significant precipitation; however, piscivores are not expected to utilize these drainage features during dry periods as most of these drainage features do not contain water during dry periods.

In general, the terrain at FTMC supports large numbers of amphibians and reptiles. Jacksonville State University has prepared a report titled *Amphibians and Reptiles of Fort McClellan, Calhoun County, Alabama* (Cline and Adams, 1997). The report indicated that surveys in 1997 found 16 species of toads and frogs, 12 species of salamanders, 5 species of lizards, 7 species of turtles, and 17 species of snakes. Typical inhabitants of the area surrounding the CC Ranges are copperhead (*Agkistrodon contortix*), king snake (*Lampropeltis getulus*), black racer (*Coluber constrictor*), fence lizard (*Sceloporus undulatus*), and six-lined racerunner (*Cnemidophorus sexlineatus*).

Portions of the Ranges Near Training Area T-24A are contained within the Stanley Hill Chestnut Oak Forest and South Branch of Cane Creek Special Interest Natural Areas (SINA). The Stanley Hill Chestnut Oak Forest SINA is located on the northern and western slopes of Kings and Stanley Hills, and represents the single largest tract of mesic woodlands on the Main Post. The entire Stanley Hill Chestnut Oak Forest SINA is an inclusion within the extensive "Mountain Longleaf Community Complex." The Stanley Hill Chestnut Oak Forest SINA has been identified separately because of its potential importance to breeding neotropical migratory birds (Garland, 1996).

A significant portion of the Ranges Near Training Area T-24A is contained within the South Branch Cane Creek SINA. The headwaters of the South Branch of Cane Creek include significant stream, mountain seep, and typical mesophytic forest communities. The surrounding forested mountain slopes are critical to the integrity of these aquatic and wetland communities. Much of this watershed includes the forested slopes of the Stanley Hill Chestnut Oak Forest SINA. A candidate 2 caddisfly, *Polycentropus carlsoni*, and an even rarer single site endemic caddisfly, *Hydroptila setigera*, have been collected from this stream (Mettee and Haynes, 1979). An additional thirteen caddisfly species from this stream are included on the Alabama Natural Heritage Program tracking list (Garland, 1996). The primary management goal for this SINA is to ensure the maintenance of water quality and minimize the influx of sediments from surrounding upland areas

The only Federally-listed species that has the potential to occur in the vicinity of the T-24A Ranges is the gray bat. The perennial creeks and ephemeral drainage features at the T-24A Ranges have been designated as providing "low quality" or "moderate quality" foraging habitat for the gray bat (Garland, 1996). However, studies conducted to assess the presence of gray bats

at FTMC and their home ranges have indicated that gray bats do not use this area as foraging habitat (3D International, 1997).

6.0 Complete Exposure Pathways

For exposures to occur, complete exposure pathways must exist between the constituent and the receptor. A complete exposure pathway requires the following four components:

- A source mechanism for constituent release;
- A transport mechanism;
- A point of environmental contact; and
- A route of uptake at the exposure point (EPA, 1989).

If any of these four components are absent, then a pathway is generally considered incomplete. Potentially complete exposure pathways at the T-24A Ranges are depicted in the site conceptual model (SCM) shown on Figure 6-1.

Ecological receptors may be exposed to constituents in soils via direct and/or secondary exposure pathways. Direct exposure pathways include soil ingestion, dermal absorption, and inhalation of volatile COPECs or COPECs adsorbed to fugitive dust. Significant exposure via dermal contact is limited to organic constituents that are lipophilic and can penetrate epidermal barriers. Mammals are less susceptible to exposure via dermal contact with soils because their fur prevents skin from coming into direct contact with soil. However, soil ingestion may occur while grooming, preening, burrowing, or consuming plants, insects, or invertebrates resident in soil.

Ecological receptors could be exposed to constituents in surface water via direct contact or through consumption of water. Aquatic organisms inhabiting contaminated waters would be in constant contact with the surface water COPECs. The fact that most of the streams at the T-24A ranges are ephemeral and are dry for extended periods during most years indicates that exposures to COPECs in surface water are expected to be sporadic in nature.

Constituents present in sediment may result from erosion or adsorption of water-borne constituents onto sediment particles. If sediment is present in an area that is periodically inundated with water, then previous exposure pathways for soils would be applicable during dry periods. Water overlying sediments prevents constituents from being carried by wind erosion. Because the majority of the constituents detected in sediment are inorganic compounds that are not prone to volatilization, volatilization from sediments is not an important fate mechanism at the T-24A Ranges. VOCs were detected in sediment samples, albeit at very low concentrations.

Therefore, inhalation of constituents originating from the sediment is not a significant exposure pathway. Exposure via dermal contact may occur, especially for benthic organisms and wading birds or other animals that may use South Branch of Cane Creek as feeding areas. Some aquatic organisms consume sediment and ingest organic material from the sediment. Inadvertent ingestion of sediments may also occur as the result of feeding on benthic organisms and plants.

Exposure via inhalation of fugitive dust is limited to constituents present in surface soils at areas that are devoid of vegetation. The inherent moisture content of the soil and the frequency of soil disturbance also play important roles in the amount of fugitive dust generated at a particular site. The majority of the area of the T-24A Ranges is forested and covered with vegetation; therefore, the amount of fugitive dust generated in these vegetated areas is expected to be minimal. Because the T-24A Ranges are largely covered with vegetation, inhalation of fugitive dust is not considered a significant exposure pathway.

While constituents in soils may leach into groundwater, environmental receptors will not come into direct contact with constituents in groundwater since there is no direct exposure route. The only potential exposure pathways for ecological receptors to groundwater would be via surface water exposure routes. As described in previous sections of this report, groundwater discharge to surface water in the tributaries to South Branch of Cane Creek is a potentially viable transport mechanism for dissolved constituents during periods of heavy precipitation; however, exposure to these constituents by ecological receptors is only possible via surface water exposure routes. Potential exposure to groundwater-related constituents is expected to be insignificant compared to other exposure pathways (i.e., exposure to constituents in surface water as a result of surface runoff) since groundwater discharge to the tributaries of South Branch of Cane Creek is expected to be localized and sporadic and no COPECs were identified in groundwater.

Secondary exposure pathways involve constituents that are transferred through different trophic levels of the food chain and may be bioaccumulated and/or bioconcentrated. This may include constituents bioaccumulated from soil into plant tissues or into terrestrial species ingesting soils. These plants or animals may, in turn, be consumed by animals at higher trophic levels. Surface water and sediment-borne COPECs may bioaccumulate into aquatic organisms, aquatic plants, or animals which frequent surface waters and then be passed through the food chain to impact organisms at higher trophic levels. Bioaccumulation of surface water COPECs is expected to be minimal due to the limited, sporadic nature of the exposure periods.

In general, the COPECs in surface soil at the T-24A Ranges may bioaccumulate to a limited degree in lower trophic level organisms (i.e., terrestrial invertebrates may bioaccumulate inorganic compounds detected in soil); however, they will not bioconcentrate through the food chain. Inorganic compounds generally do not bioconcentrate to any great extent and PAHs are readily metabolized by higher trophic level organisms.

The constituents detected in sediment may bioaccumulate in lower trophic level organisms (i.e., benthic invertebrates may bioaccumulate inorganic compounds and PAHs detected in sediment); however, they will not bioconcentrate through the food chain. Inorganic compounds and PAHs generally do not bioconcentrate to any great extent. The COPECs identified in surface water (inorganics) are not expected to bioaccumulate or bioconcentrate significantly.

Potential ecological receptors at the T-24A Ranges fall into two general categories: terrestrial and riparian/aquatic. Within these two general categories there are several major feeding guilds that could be expected to occur at the T-24A Ranges: herbivores, invertivores, omnivores, carnivores, and piscivores. All of these feeding guilds have the potential to be directly exposed to various combinations of surface soil at the T-24A Ranges and surface water and sediment in the tributaries to South Branch of Cane Creek via various activities (e.g., feeding, drinking, grooming, bathing, etc.). These feeding guilds may also be exposed to site-related chemicals via food web transfers.

As discussed above, ingestion of COPECs in soil, surface water, and sediment are the pathways that pose the greatest potential for exposure for ecological receptors at the T-24A Ranges. Dermal absorption and inhalation exposures are expected to be insignificant. Food web transfers of COPECs are also possible exposure pathways for ecological receptors at the T-24A Ranges, although most of the COPECs at the T-24A ranges have relatively low bioconcentration and biomagnification potential.

Potentially complete exposure pathways are depicted in the SCM (Figure 6-1) and are described in the following sections for the various feeding guilds.

6.1 Herbivorous Feeding Guild

The major route of exposure for herbivores is through ingestion of plants that may have accumulated constituents from the soil, surface water, or sediment. Since terrestrial herbivores by definition are grazers and browsers, they could be exposed to chemicals that have accumulated in the vegetative tissues of the plants at the site. Terrestrial herbivores may also be

exposed to site-related chemicals in soil through incidental ingestion of soil while grazing, grooming, or other activities. Herbivores could also be exposed to COPECs in surface water and sediment through water ingestion and other foraging activities in the various drainage features at the T-24A Ranges.

Typical herbivorous species that could be expected to occur at the T-24A Ranges and are commonly used as sentinel species in ecological risk assessment include eastern cottontail (*Sylvilagus floridanus*), eastern gray squirrel (*Sciurus carolinensis*), pine vole (*Pitymys pinetorum*), whitetail deer (*Odocoileus virginianus*), and wild turkey (*Meleagris gallopavo*).

Aquatic herbivores, such as muskrat (*Ondatra zibethica*) and mallard (*Anas platyrhynchos*), could theoretically be exposed to site-related constituents in surface water and sediment. However, the ephemeral nature of the drainage features at the T-24A Ranges does not promote the presence of aquatic mammals and waterfowl as water is not present in these drainage features for extended periods during most years. Thus, these drainage features do not provide suitable habitat to support aquatic herbivorous mammals such as muskrat or waterfowl such as mallards.

6.2 Invertivorous Feeding Guild

Invertivores specialize in eating insects and other invertebrates. As such, they may be exposed to site-related chemicals that have accumulated in insects and other invertebrates. Invertivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while probing for insects, grooming, or other activities. Ingestion of soil while feeding is a potential exposure pathway for terrestrial invertivores since much of their food (i.e., earthworms and other invertebrates) lives on or below the soil surface. Invertivores could be exposed to COPECs in surface water or sediment through ingestion of water or foraging for food in the drainage features at the T-24A Ranges.

Typical terrestrial invertivorous species that could be expected to occur at the T-24A Ranges and are commonly used as sentinel species in ecological risk assessment include American woodcock (*Philohela minor*), Carolina wren (*Thryothorus ludovicianus*), shorttail shrew (*Blarina brevicauda*), and eastern mole (*Scalopus aquaticus*). Aquatic invertivores (those species that live in water) that could theoretically inhabit the T-24A Ranges include the wood duck (*Aix sponsa*) and blacknose dace (*Rhinichthys atratulus*). However, due to their ephemeral nature, the drainage features at the T-24A Ranges do not provide suitable habitat to support invertivorous aquatic mammals or invertivorous waterfowl. The drainage features at the T-24A Ranges could potentially support riparian invertivores that feed on aquatic and semi-aquatic insects. These

riparian invertivores include species such as the marsh wren (*Cistothorus palustris*) and little brown bat (*Myotis lucifugus*).

6.3 Omnivorous Feeding Guild

Omnivores consume both plant and animal material in their diet, depending upon availability. Therefore, they could be exposed to chemicals that have accumulated in the vegetative tissues of plants at the site and also chemicals that may have accumulated in smaller animal tissues that the omnivores prey upon. Omnivores may be exposed to site-related chemicals in soil through incidental ingestion of soil while feeding, grooming, or other activities. Omnivores may also be exposed to COPECs in surface water and sediment through ingestion of water in the drainage features and while foraging for food in these drainage features at the T-24A Ranges.

Typical omnivorous species that may occur at the T-24A Ranges and are commonly used as sentinel species in ecological risk assessment include red fox (*Vulpes vulpes*), white-footed mouse (*Peromyscus leucopus*), and American robin (*Turdus migratorius*). Aquatic omnivores are not likely to be significantly exposed to COPECs in surface water in the drainage features at the T-24A Ranges due to their ephemeral nature.

6.4 Carnivorous Feeding Guild

Carnivores are meat-eating animals and are, therefore, potentially exposed to site-related chemicals through consumption of prey animals that may have accumulated constituents in their tissues. Carnivores are quite often top predators in a local food web and are often subject to exposure to constituents that have bioaccumulated in lower trophic-level organisms or biomagnified through the food web. Food web exposures for carnivores are based on the consumption of prey animals that have accumulated COPECs from various means. Smaller, herbivores, omnivores, invertivores, and other carnivores may consume soil, surface water, sediment, plant, and animal material as food and accumulate COPECs in their tissues. Subsequent ingestion of these prey animals by carnivorous animals would expose them to COPECs. Food chain exposures to COPECs in soil, surface water, and sediment are expected to be minimal at the T-24A Ranges because these metals and PAHs are not accumulated in animal tissues to any great extent (Shugart, 1991; U.S. Army Environmental Hygiene Agency, 1994).

Carnivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while feeding, grooming, or other activities. Carnivores could be exposed to COPECs in surface water through ingestion of water from the drainage features and also ingestion of sediment while foraging in the same drainage features at the T-24A Ranges.

Typical carnivorous species that could occur at the T-24A Ranges and are commonly used as sentinel species in ecological risk assessment include red-tailed hawk (*Buteo jamaicensis*), black vulture (*Coragyps atratus*), and bobcat (*Lynx rufus*).

Because the drainage features at the T-24A Ranges are ephemeral, they will not support aquatic carnivores. Carnivorous fish such as largemouth bass (*Micropterus salmoides*) and spotted gar (*Lepisosteus oculatus*) would not be expected to occur in the drainage features at the T-24A Ranges due to the habitat restrictions.

6.5 Piscivorous Feeding Guild

Piscivores are specialists that feed almost exclusively on fish. Therefore, they may be exposed to site-related chemicals that have accumulated in small fish that may inhabit the drainage features at the T-24A Ranges. They may also be exposed to surface water and sediment in these drainage features through ingestion of drinking water and during feeding.

Food web exposures for piscivores are based on the consumption of fish that have accumulated COPECs from surface water and sediment. Forage fish may consume surface water, sediment, benthic invertebrates, aquatic plants, and planktonic material as food and accumulate COPECs in their tissues. Subsequent ingestion of these forage fish by piscivorous animals would expose them to COPECs. However, most inorganic compounds and PAHs (the COPECs identified in surface water and sediment) are not accumulated in fish tissues to any great extent. Furthermore, fish of sufficient size or in sufficient numbers to support piscivorous animals are not expected to inhabit the drainage features at the T-24A ranges due to the small size and ephemeral nature of the drainage features. Therefore, food web exposures for piscivorous animals to COPECs at the T-24A ranges are expected to be minimal.

Although piscivorous species may utilize the drainage features at the T-24A Ranges for foraging during periods of significant precipitation, most of these drainage features are dry during extended periods of low precipitation and are ephemeral in nature. Therefore, long-term, chronic exposures to COPECs by piscivores are not likely at the T-24A Ranges. As such, exposures to site-related COPECs by piscivores are expected to be relatively short-term and sporadic. Due to the limited ability of the habitat provided by the ephemeral drainage features at the T-24A Ranges to support fish species (piscivore's main food supply), piscivores are not expected to occur in the drainage features at the T-24A Ranges for significant periods of time.

6.6 Threatened and Endangered Species

Four species listed as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS) have been recorded at FTMC. These threatened and endangered species are as follows:

- Gray Bat (*Myotis grisescens*)
- Blue Shiner (*Cyprinella caerulea*)
- Mohr's Barbara Buttons (*Marshallia mohrii*)
- Tennessee Yellow-Eyed Grass (*Xyris tennesseensis*).

An additional endangered species, the red-cockaded woodpecker (*Picoides borealis*), historically has inhabited the installation.

The only Federally listed species that has the potential to occur in the vicinity of the T-24A Ranges is the gray bat (Garland, 1996). The ephemeral drainage features in the vicinity of these sites have been designated as providing "low quality" or "moderate quality" foraging habitat for the gray bat (Garland, 1996). The other Federally listed species occur at Pelham Range or Choccolocco Creek corridor.

Mist net surveys were conducted on and adjacent to FTMC in 1995. Gray bats were captured along both Choccolocco Creek (east of FTMC Main Post) and Cane Creek on Pelham Range (west of FTMC Main Post) during these mist net surveys (Garland, 1996). These preliminary data suggest that these major stream corridors at FTMC may provide at least a minimum foraging habitat for gray bats. However, gray bat surveys have not been conducted on the South Branch of Cane Creek or the small drainage features in the vicinity of the T-24A Ranges. The small size and ephemeral nature of many of the drainage features at the T-24A Ranges is expected to limit the potential for gray bats to utilize these drainage features for foraging.

Although historical records indicate the presence of red cockaded woodpeckers (RCW) at FTMC, the last remaining active cluster of RCW at FTMC was recorded in 1968. Subsequent surveys in 1972, 1982, and 1985 failed to find any RCW at FTMC. Thus, it can be concluded that RCW no longer exist at FTMC.

A significant portion of the Ranges Near Training Area T-24A is contained within the South Branch Cane Creek Special Interest natural Area (SINA). The headwaters of the South Branch of Cane Creek include significant stream, mountain seep, and typic mesophytic forest communities. Much of this watershed also includes the forested slopes of the Stanley Hill Chestnut Oak Forest SINA. A candidate 2 caddisfly, *Polycentropus carlsoni*, and an even rarer

single site endemic caddisfly, *Hydroptila setigera*, have been collected from the South Branch of Cane Creek (Mettee and Haynes, 1979). An additional thirteen caddisfly species from this stream are included on the Alabama Natural Heritage Program tracking list (Garland, 1996). The primary management goal for this SINA is to ensure the maintenance of water quality and minimize the influx of sediments from surrounding upland areas.

7.0 Selection of Assessment and Measurement Endpoints

Assessment and measurement endpoints are the basis of the Study Design phase of the BERA and define the ecological values that require protection and the methodologies by which those ecological values are measured, respectively. The following sections describe the assessment endpoints that have been identified for the T-24A Ranges, the risk hypotheses, and the corresponding measurement endpoints. The BERA for the T-24A Ranges will utilize data collected for the Iron Mountain Road (IMR) and Bains Gap Road (BGR) Ranges BERAs. Specifically, because the soil COPECs identified at the T-24A Ranges (antimony, copper, lead, and zinc) are identical to the soil COPECs identified for the IMR and BGR Ranges, terrestrial risk hypotheses and measurement endpoints addressed in the T-24A BERA are identical to the risk hypotheses and measurement endpoints addressed in the BERAs for the IMR and BGR Ranges. As such, the terrestrial assessment endpoints for the T-24A Ranges will be addressed using the data collected for the IMR and BGR Ranges. Likewise, the aquatic/riparian assessment endpoints will also be partially addressed utilizing data collected for the IMR and BGR Ranges.

7.1 Assessment Endpoints

An assessment endpoint is “an explicit expression of the environmental value that is to be protected” (EPA, 1992). Assessment endpoints focus the risk assessment on particular valuable components of the ecosystem(s) that could be adversely affected by contaminants at a site. Individual assessment endpoints usually encompass a group of species or populations with some common characteristic, such as a specific exposure route or contaminant sensitivity.

Assessment endpoints for the BERA for the T-24A Ranges were selected based on the ecosystems, communities, and species present at the T-24A Ranges. Selection of the assessment endpoints was dependent upon the following factors:

- The COPECs, their characteristics, and their concentrations at the T-24A Ranges;
- The mechanisms of toxicity of the COPECs to different groups of organisms;
- Ecologically relevant receptors that are potentially sensitive or highly exposed to the COPECs; and
- The presence of complete exposure pathways contributing to potential risk.

The potential for toxic effects to individual receptors can have consequences at the population, community, and ecosystem level. Population level effects may determine the nature of changes in community structure and function, such as reduction in species diversity, simplification of food webs, and shifts in competitive advantages among species sharing a limited resource. Ecosystem function may also be affected by contaminants, which can cause changes in productivity or disruption of key processes.

Population level assessment endpoints are generally recognized in ecological risk assessments because of their role in maintaining biological diversity, ecological integrity, and productivity in ecosystems.

The terrestrial habitat types and receptor assemblages at the T-24A Ranges are similar in structure and function and should be considered as a single ecological unit to the extent practicable. As such, terrestrial assessment endpoints were selected to be inclusive of the terrestrial systems and receptors at greatest risk across all of the T-24A Ranges. The habitat and receptor assemblages of South Branch of Cane Creek and tributaries at the T-24A Ranges were also determined to be similar in structure and function. Therefore, the assessment endpoints for South Branch of Cane Creek and its tributaries were the same.

Based on the fact that the COPECs in surface soil at the T-24A Ranges (antimony, copper, lead, and zinc) do not bioconcentrate or biomagnify appreciably through the food chain and do not accumulate appreciably in plant tissues (Kabata-Pendias and Pendias, 1992), the terrestrial ecological receptors with the potential for the greatest exposure to COPECs at the T-24A Ranges were determined to be invertivorous and omnivorous small mammals and birds. Herbivores were considered to have a lower exposure potential because the COPECs do not accumulate appreciably in plant tissues, the herbivores' main food source. Carnivores were determined to have lower exposure potential because the COPECs do not biomagnify in the food chain and would not be expected to occur at elevated concentrations in prey animal tissues. Additionally, carnivores in general have larger home ranges which would tend to minimize their exposures to COPECs at the T-24A Ranges. Therefore, the terrestrial assessment endpoints focus on the protection of the terrestrial invertebrate and plant communities, and terrestrial omnivorous and invertivorous feeding guilds present at the T-24A Ranges.

The riparian/aquatic assessment endpoints for the T-24A Ranges focus on the protection of aquatic and benthic communities present in the South Branch of Cane Creek and its tributaries at the T-24A Ranges. Additionally, the protection of riparian insectivorous mammals and birds is

an assessment endpoint for the T-24A Ranges. The protection of riparian insectivorous mammals and birds is an assessment endpoint for the T-24A Ranges because these receptors consume benthic invertebrates that spend a significant portion of their life in sediment and represent a potential conduit for sediment COPECs to upper trophic level organisms.

7.1.1 Terrestrial Assessment Endpoints

Given the overall goal of protecting the integrity and quality of the terrestrial forest and old field ecosystems at the T-24A Ranges, the terrestrial assessment endpoints focus on critical community niches within the mixed deciduous/coniferous forest and old field systems. As discussed above, the ecological receptors with the potential for the greatest exposure to soil COPECs at the T-24A Ranges were determined to be invertivorous and omnivorous small mammals and birds. Additionally, the terrestrial plant and terrestrial invertebrate communities have the potential for significant exposure to COPECs. These ecological communities formed the basis for the assessment endpoints described herein.

The terrestrial plant community has the potential to be significantly exposed to COPECs in surface soil and constitutes a critical food source for herbivorous and omnivorous birds and mammals. Terrestrial plants may also accumulate COPECs in their tissues and act as a conduit for the transfer of COPECs to higher trophic level organisms in the food chain. For these reasons, the terrestrial plant community was identified as an important ecological resource at the T-24A Ranges. The assessment endpoint that has been identified with respect to the terrestrial plant community is the following:

- Survival and growth of the terrestrial plant communities at the T-24A Ranges.

The terrestrial invertebrate community forms a critical link in many terrestrial food webs and constitutes a food source for many omnivorous and invertivorous birds and mammals. Terrestrial invertebrates also perform an important function in the degradation of organic matter in soil through their bioturbative activities. Terrestrial invertebrates may also accumulate COPECs in their tissues and act as a conduit for the transfer of COPECs to higher trophic level organisms in the food chain. For these reasons, the terrestrial invertebrate community was identified as an important ecological resource at the T-24A Ranges. The assessment endpoint that has been identified with respect to the terrestrial invertebrate community is the following:

- Survival and growth of the terrestrial invertebrate communities at the T-24A Ranges.

Invertivorous mammals and birds were identified as having significant potential for exposure to COPECs at the T-24A Ranges, mainly through ingestion of terrestrial invertebrates that may have accumulated COPECs in their tissues. In addition to the fact that this feeding guild has the potential to be maximally exposed to COPECs due to their feeding habits, these species also form an important food group for higher trophic level organisms. Carnivorous mammals and/or birds may prey on small invertivorous mammals and birds and thus become exposed to COPECs through ingestion of COPECs that have become incorporated into the prey species' tissues. For these reasons, invertivorous mammals and birds were identified as being an important ecological resource at the T-24A Ranges. It is important to assess the survival, growth, and reproduction of terrestrial invertivorous small mammals and birds at the T-24A Ranges for the protection of these species themselves, and potentially more importantly, because these species constitute an important food source and a possible conduit for COPECs to upper trophic level organisms. The assessment endpoint that has been identified with respect to the terrestrial invertivorous mammal and bird feeding guilds is the following:

- Survival, growth, and reproduction of terrestrial invertivorous small mammals and birds at the T-24A Ranges.

Omnivorous mammals and birds were identified as having significant potential for exposure to COPECs at the T-24A Ranges, mainly because a portion of their diet includes terrestrial plants and terrestrial invertebrates that may have accumulated COPECs in their tissues. In addition to the fact that this feeding guild has the potential to be maximally exposed to COPECs due to their feeding habits, these species also form an important food group for higher trophic level organisms. Carnivorous mammals and/or birds may prey on small omnivorous mammals and birds and thus become exposed to COPECs through ingestion of COPECs that have become incorporated into the prey species' tissues. For these reasons, omnivorous mammals and birds were identified as being an important ecological resource at the T-24A Ranges. The assessment endpoint that has been identified with respect to the terrestrial omnivorous mammal and bird feeding guilds is the following:

- Survival, growth, and reproduction of terrestrial omnivorous small mammals and birds at the T-24A Ranges.

The assessment endpoints identified for the terrestrial ecosystems at the T-24A Ranges are summarized in Table 7-1.

Because these terrestrial assessment endpoints are highly dependent upon the bioavailability of the COPECs in soil, a study of the binding capacity of soils commonly found at FTMC was conducted and the results presented in the BERA for the Iron Mountain Road (IMR) and Bains Gap Road (BGR) ranges (Shaw, 2004). In summary, a total of eight surface soil samples from the IMR ranges (Parcels 69Q, 70Q, 71Q, and 75Q) and the BGR ranges (Parcels 77Q, 78Q, 80Q, and 85Q) were collected from five soil mapping units (U.S. Department of Agriculture, 1961): Anniston and Allen gravelly loams; Anniston and Allen stony loams; Stony rough land, sandstone; Jefferson stony fine sandy loam; and Jefferson gravelly fine sandy loam. The results of the binding capacity study showed that the soils at the IMR and BGR ranges could be classified as “low”, “medium”, or “high” with regard to their potential metal-binding capacity. However, the terrestrial invertebrate toxicity testing and bioaccumulation testing conducted as part of the BERA for the IMR and BGR ranges (Shaw, 2004) showed no significant differences in toxicity or bioaccumulation potential between the “high”, “medium”, or “low” binding capacity soils. Therefore, it was assumed that all of the soils at the IMR and BGR ranges exhibited similar metal-binding capacities.

The soils at the T-24A Ranges are mapped as either Stony Rough Land, sandstone or Anniston and Allen stony loams. These two soil mapping units are also the dominant soil mapping units at the IMR and BGR ranges. Because the soil mapping units at the T-24A Ranges are the same as the soil mapping units at the IMR and BGR ranges, and all the soil mapping units at the IMR and BGR ranges were found to have similar metal binding capacities, it is assumed for this BERA that the binding capacities for the soils at the T-24A Ranges are all similar and no differentiation will be made between soil mapping units.

7.1.2 Riparian/Aquatic Assessment Endpoints

The overall goal of the riparian/aquatic assessment endpoints is the protection of the integrity and quality of the riparian and aquatic ecosystems in South Branch of Cane Creek and its tributaries at the T-24A Ranges. The aquatic assessment endpoints focus on critical community niches within the surface water and sediment of South Branch of Cane Creek and its tributaries. The ecological receptors with the potential for the greatest exposure to COPECs in the surface water and sediment of South Branch of Cane Creek at the T-24A Ranges are those populations and communities that live in direct contact with the surface water and sediment within the South Branch of Cane Creek and its tributaries, and those feeding guilds that utilize this creek system as a major food source. These ecological communities formed the basis for the riparian/aquatic assessment endpoints described herein.

Aquatic vertebrates (e.g., finfish) are top predators/consumers in many aquatic ecosystems; however, the riparian/aquatic drainage features at the T-24A Ranges do not provide suitable habitat to support most fish species. In fact, the ephemeral nature of these drainage features only provide suitable habitat for drought-tolerant species. Although finfish have the potential to be exposed to COPECs in surface water and/or sediment, potential exposures are expected to be relatively short-term and sporadic. Finfish could act as a food source for piscivorous animals that utilize the South Branch of Cane Creek and its tributaries for a hunting/fishing ground; however, surface water and sediment COPECs are not expected to accumulate significantly in fish inhabiting the drainage features due to the relatively short-term and sporadic exposure periods. In order to assess and protect drought-tolerant fish species that could be present in the drainage features at the T-24A Ranges, the aquatic finfish community and other aquatic and semi-aquatic species were identified as an important ecological resource at the T-24A Ranges. The assessment endpoint that has been identified with respect to the aquatic vertebrate (e.g., finfish) community and other aquatic and semi-aquatic species is the following:

- Survival, growth, and reproduction of drought-tolerant aquatic vertebrate (e.g., finfish) and other aquatic species populations in the drainage features at the T-24A Ranges.

The benthic invertebrate community forms a critical link in many aquatic food webs and constitutes a food source for many aquatic and riparian omnivorous and invertivorous birds and mammals. Aquatic benthic invertebrates also perform an important function in the degradation of organic material in sediment. Aquatic benthic invertebrates may also accumulate COPECs in their tissues and act as a conduit for the transfer of COPECs to higher trophic level organisms in the food chain. For these reasons, the aquatic benthic invertebrate community was identified as an important ecological resource at the T-24A Ranges. The assessment endpoint that has been identified with respect to the aquatic benthic invertebrate community is the following:

- Survival, growth, and reproduction of aquatic benthic invertebrates in the drainage features at the T-24A Ranges.

Riparian invertivorous mammals and birds were identified as having significant potential for exposure to COPECs at the T-24A Ranges, mainly through ingestion of aquatic benthic invertebrates that may have accumulated COPECs in their tissues. In order to differentiate the invertivores that feed mainly on terrestrial invertebrates from those that feed mainly on aquatic invertebrates, this latter group is termed “riparian invertivores” for this assessment. In addition to the fact that this feeding guild has the potential to be maximally exposed to COPECs in

sediment due to their feeding habits, these species also form an important food group for higher trophic level organisms (i.e., raptors). Raptors may prey on flying invertivorous mammals (e.g., bats) and invertivorous birds (e.g., swallows, wrens) and thus become exposed to COPECs through ingestion of COPECs that have become incorporated into the prey species' tissues. For these reasons, riparian invertivorous mammals and birds were identified as being an important ecological resource at the T-24A Ranges. The assessment endpoint that has been identified with respect to the riparian invertivorous mammal and bird feeding guilds is the following:

- Survival, growth, and reproduction of riparian invertivorous small mammals and birds at the T-24A Ranges.

Due to habitat restrictions (small stream size, ephemeral nature of streams, etc.) it was concluded that piscivorous mammals and birds would not utilize the drainage features at the T-24A Ranges to any significant extent. Therefore, assessment endpoints for piscivores were not identified for the BERA at the T-24A Ranges.

The assessment endpoints identified for the T-24A Ranges are summarized in Table 7-1.

7.2 Risk Hypotheses

The risk hypotheses in a BERA are questions about the relationships among the assessment endpoints and the predicted responses at a given site. The risk hypotheses described in the following sections may be more accurately described as “test hypotheses” as they may not actually describe the probability (or risk) that a receptor will develop a toxicological endpoint. Rather, the hypotheses described herein are actually statements of a testing framework, and provide a basis for developing the Study Design for the assessment endpoints. The most basic question applicable to most sites is whether site-related contaminants are causing or have the potential to cause adverse effects on the assessment endpoints. Using this basic premise, risk hypotheses (or test hypotheses) were developed for the assessment endpoints identified in the previous section.

7.2.1 Terrestrial Risk Hypothesis

The test hypothesis that was identified as being appropriate to address the assessment endpoint of “survival and growth of the terrestrial plant communities at the T-24A Ranges” was the following:

- Are concentrations of COPECs in surface soil at the T-24A Ranges greater than ESVs for the survival or growth of terrestrial plants?

The test hypothesis regarding terrestrial plant ESVs will aid in identifying COPECs that may adversely impact terrestrial plant communities at the T-24A Ranges.

Two test hypotheses were identified as being appropriate to address the assessment endpoint of “survival and growth of the terrestrial invertebrate communities at the T-24A ranges.” These test hypotheses were the following:

- Are concentrations of COPECs in surface soil at the T-24A Ranges greater than ESVs for the survival or growth of terrestrial invertebrates?
- Are concentrations of COPECs in surface soil at the T-24A Ranges greater than NOAELs and LOAELs for the survival and growth of terrestrial invertebrates derived in the IMR/BGR BERA?

The test hypothesis regarding ESVs will aid in the interpretation of the toxicity test results and may help in the identification of the most likely causative agent(s) in the terrestrial invertebrate toxicity tests. The test hypothesis relative to the terrestrial invertebrate NOAELs and LOAELs identifies differences in terrestrial invertebrate survivability and growth when exposed to COPECs in impacted soils and off-site reference soils in laboratory toxicity tests.

The test hypothesis that was identified as being appropriate to address the assessment endpoint of “survival, growth, and reproduction of terrestrial invertivorous small mammals and birds” was determined to be the following:

- Does the daily dose of COPECs received by terrestrial invertivorous mammals or birds via consumption of prey species and from other media at the T-24A Ranges exceed the toxicity reference values (TRV) for survival, reproduction, or growth?

This test hypothesis will determine whether calculated daily doses of COPECs exceed feeding guild-specific toxicity reference values.

The test hypothesis that was identified as being appropriate to address the assessment endpoint of “survival, growth, and reproduction of terrestrial omnivorous small mammals and birds” was determined to be the following:

- Does the daily dose of COPECs received by terrestrial omnivorous small mammals or birds via consumption of prey species and from other media at the T-24A Ranges exceed the TRVs for survival, reproduction, or growth?

This test hypothesis will determine whether calculated daily doses of COPECs exceed feeding guild-specific toxicity reference values.

Table 7-1 presents risk hypotheses for each of the terrestrial assessment endpoints. It is important to note that the hypotheses are expressed as a positive response in order to minimize the likelihood of Type II statistical errors (i.e., a false negative decision) at a standard confidence level of $p = 0.05$.

Daily doses of COPECs for terrestrial invertivorous and omnivorous small mammals and birds will be calculated using standard exposure algorithms. These algorithms will incorporate species-specific natural history parameters (i.e., feeding rates, water ingestion rates, dietary composition, etc.) and will also utilize site-specific area use factors (AUF). Soil-to-earthworm bioaccumulation factors (BAF) derived for the IMR and BGR Ranges will be used, in conjunction with literature-derived BAFs, in the exposure algorithm in order to calculate the COPEC concentrations in the invertebrate portion of the diet of the terrestrial invertivorous and omnivorous small mammals and birds. Literature-derived soil-to-plant BAFs will be used to estimate COPEC concentrations in the terrestrial vegetation portions of the receptor species' diets.

In order to calculate COPEC exposures, indicator species that represent the feeding guilds of interest must be identified. For this risk assessment, the small terrestrial invertivorous mammal will be represented by the shorttail shrew (*Blarina brevicauda*) and the terrestrial invertivorous bird will be represented by the American woodcock (*Philohela minor*). The small terrestrial omnivorous mammal will be represented by the white-footed mouse (*Peromyscus leucopus*) and the terrestrial omnivorous bird will be represented by the American robin (*Turdus migratorius*). Natural history parameters for these indicator species (Table 7-2) will be used in combination with site-specific exposure parameters to estimate exposures (total daily doses) to terrestrial invertivorous and omnivorous small mammals and birds at the T-24A Ranges.

The algorithm that will be used to estimate exposures to COPECs by terrestrial invertivorous and omnivorous small mammals and birds is the following:

$$TDD_{wildlife} = \left[(IR_{food} \times f_{worm} \times C_{worm}) + (IR_{food} \times f_{veg} \times C_{veg}) + (IR_{water} \times C_{water}) + (IR_{food} \times f_{soil} \times \{1 - M_{diet}\} \times C_{soil}) \right] \times AUF$$

where:

$TDD_{wildlife}$	=	total daily dose of COPEC received by omnivorous or invertivorous mammals or birds through ingestion (mg/kg/day);
IR_{food}	=	ingestion rate of food by receptor species (kg/kg/day);
f_{worm}	=	fraction of daily diet comprised of invertebrates (percent);
C_{worm}	=	concentration of COPEC in invertebrate tissue (mg/kg);
f_{veg}	=	fraction of daily diet comprised of vegetation (percent);
C_{veg}	=	concentration of COPEC in terrestrial vegetation (mg/kg);
IR_{water}	=	ingestion rate of water by omnivorous mammals or birds (L/kg/day);
f_{water}	=	fraction of drinking water from the T-24A Ranges (percent);
C_{water}	=	concentration of COPEC in drinking water (mg/L);
f_{soil}	=	fraction of daily diet comprised of soil (percent);
M_{diet}	=	weighted average moisture content of diet (percent);
C_{soil}	=	concentration of COPEC in soil (mg/kg); and
AUF	=	area use factor (fraction of site used by receptor species (percent)).

7.2.1.1 Terrestrial Omnivorous Mammal Model Parameters

The surrogate species used in the terrestrial food web model to assess omnivorous mammals was the white-footed mouse (*Peromyscus leucopus*). The home range for white-footed mice ranges from one-half to one and one-half acres in size (Burt and Grossenheider, 1976). For the terrestrial food web model, the mean (one acre) of this range was used as the foraging area. Body weights for white-footed mice range from 14 to 31 grams (Burt and Grossenheider, 1976). The mean of this range (22.5 grams) was used as the representative body weight for white-footed mice in the terrestrial food web model. USEPA (1993) reports a water ingestion rate of 0.19 g/g/day for deer mice (*Peromyscus maniculatus*) based on two studies conducted in laboratories. Since water ingestion rates for white-footed mice were not readily available and the body weights for white-footed mice and deer mice are very similar, the water ingestion rate for deer mice (0.19 g/g/day) was used in the terrestrial food web model. Similarly, the food ingestion rate for deer mice was used in the terrestrial food web model. The food ingestion rates reported by USEPA (1993) for adult male and female non-breeding and lactating deer mice ranged from 0.18 to 0.45 g/g/day. The mean of this range is 0.2683 g/g/day (wet weight). The weighted average moisture content of the white-footed mouse diet (invertebrates and vegetation) has been estimated to be 53.9 percent. Taking this moisture content into account, the food ingestion rate for the white-footed mouse was estimated to be 0.1237 g/g/day (dry weight). The estimated percent of soil in the white-footed mouse diet is less than two percent (USEPA, 1993). For the terrestrial food web model, it was assumed that two percent (0.00247 g/g/day, dry weight) of the white-footed mouse diet was made up of soil. These input parameters are summarized in Table 7-2 and were used to estimate total daily exposures to COPECs for omnivorous mammals.

7.2.1.2 Terrestrial Omnivorous Bird Model Parameters

The surrogate species used in the terrestrial food web model to assess omnivorous birds was the American robin (*Turdus migratorius*). The territory size for adult male and female robins is reported to range from 0.11 to 0.42 hectares (USEPA, 1993). The mean of this range (0.61 acres) was used as the foraging area for American robins in the terrestrial food web model. Body weights for adult male and female robins in New York and Pennsylvania was reported to range from 77.3 grams to 86.2 grams (USEPA, 1993). The mean of this range (81 grams) was used to represent the body weight of American robins in the terrestrial food web model. USEPA (1993) reports an estimated water ingestion rate of 0.14 g/g/day for adult male and female American robins. This estimated water ingestion rate was used in the terrestrial food web model. The food ingestion rate for free-living adult male and female American robins in California is reported to be 0.89 g/g/day (wet weight) (USEPA, 1993). The weighted average moisture content of the American robin diet (invertebrates and vegetation) has been estimated to be 79.6 percent. Taking this moisture content into account, the food ingestion rate for the American robin was estimated to be 0.1816 g/g/day (dry weight). Soil ingestion rates for American robins were not readily available; therefore, the soil ingestion rate of 2 percent of the diet reported for other birds (USEPA, 1993) was assumed to be representative of American robins. Assuming two percent of the robin's diet is made up of soil, the soil ingestion rate was estimated to be 0.00363 g/g/day (dry weight). These input parameters are summarized in Table 7-2 and were used to estimate total daily exposures to COPECs for omnivorous birds.

7.2.1.3 Terrestrial Invertivorous Mammal Model Parameters

The surrogate species used in the terrestrial food web model to assess invertivorous mammals was the short-tailed shrew (*Blarina brevicauda*). The home range for adult male and female short-tailed shrew in a Manitoba bog was reported to be 0.964 acres (USEPA, 1993). This home range was used for the short-tailed shrew in the terrestrial food web model. Body weights for adult male and female short-tailed shrews in New Hampshire and Pennsylvania were reported to range from 15 to 19.2 grams. The mean of this range (16.8 grams) was used as the body weight for short-tailed shrews in the terrestrial food web model. The water ingestion rate used in the terrestrial food web model for short-tailed shrews (0.223 g/g/day) was the water ingestion rate reported by USEPA (1993) for adult male and female short-tailed shrews in an Illinois laboratory. Food ingestion rates for adult male and female short-tailed shrews in a Wisconsin laboratory were reported to range from 0.49 to 0.62 g/g/day (wet weight), with a mean value of 0.555 g/g/day (wet weight). The weighted average moisture content of the short-tailed shrew's diet has been estimated to be 83.8 percent. Taking the moisture content of the shrew's diet into

consideration, the food ingestion rate for the short-tailed shrew that was used in the terrestrial food web model was 0.0899 g/g/day (dry weight). Soil ingestion rates for short-tailed shrews were not readily available; therefore, the soil ingestion rate of 2.4 percent of the diet reported for meadow voles (USEPA, 1993) was assumed to be representative of short-tailed shrews. Assuming 2.4 percent of the shrew's diet is made up of soil, the soil ingestion rate was estimated to be 0.00216 g/g/day (dry weight). These input parameters are summarized in Table 7-2 and were used to estimate total daily exposures to COPECs for invertivorous mammals.

7.2.1.4 Terrestrial Invertivorous Bird Model Parameters

The surrogate species used in the terrestrial food web model to assess invertivorous birds was the American woodcock (*Scolopax minor*). The home range for adult male and female American woodcocks in Pennsylvania and Wisconsin ranges from 7.7 to 182 acres (USEPA, 1993). The mean of this range is 61.3 acres and is the home range for American woodcocks used in the terrestrial food web model. Body weights for adult male and female American woodcocks range from 133 to 218 grams (USEPA, 1993). The mean of this range is 169.4 grams and is the value used to estimate the body weight of American woodcock in the terrestrial food web model. The water ingestion rate for adult male and female American woodcock estimated by USEPA (1993) is 0.1 g/g/day. This value was used as the water ingestion rate for American woodcock in the terrestrial food web model. The food ingestion rate for captive adult male and female American woodcocks in Louisiana fed earthworms was 0.77 g/g/day (wet weight) (USEPA, 1993). The weighted average moisture content of the American woodcock's diet has been estimated to be 80.3 percent. Taking the moisture content of the woodcock's diet into account, the food ingestion rate for the American woodcock that was used in the terrestrial food web model was 0.1517 g/g/day (dry weight). USEPA (1993) reports an estimated percent of soil in a woodcock's diet of 10.4 percent. Assuming 10.4 percent of a woodcock's diet is made up of soil, the soil ingestion rate was estimated to be 0.0158 g/g/day (dry weight). These input parameters are summarized in Table 7-2 and were used to estimate total daily exposures to COPECs for invertivorous birds.

COPEC concentrations in terrestrial invertebrate tissues will need to be estimated in order to calculate a total COPEC dose. The COPEC concentrations in terrestrial invertebrate tissues will be estimated using soil-to-invertebrate bioaccumulation factors ($BAF_{\text{soil-to-worm}}$) derived through the analysis of earthworm tissue samples and soil samples as presented in the IMR and BGR Ranges BERA. Literature-derived $BAF_{\text{soil-to-worm}}$ will also be used to estimate concentrations of COPECs in terrestrial invertebrate food material. These $BAF_{\text{soil-to-worm}}$ will be applied to the soil

concentrations of COPECs at the T-24A Ranges to estimate concentrations of COPECs in terrestrial invertebrate food material in the following manner:

$$C_{worm} = C_{soil} \times BAF_{soil-to-worm}$$

where:

- C_{worm} = COPEC concentration in terrestrial invertebrates (mg/kg-dry weight);
 C_{soil} = COPEC concentration in soil (mg/kg-dry weight);
 $BAF_{soil-to-worm}$ = soil-to-worm bioaccumulation factor (unitless); and

Because portions of the receptor species' diets consist of vegetative material, COPEC concentrations in terrestrial plant matter will need to be estimated in order to calculate a total COPEC dose. The COPEC concentrations in terrestrial plant matter will be estimated using literature-derived soil-to-plant BAFs ($BAF_{soil-to-plant}$). These soil-to-plant BAFs will be applied to the soil concentrations of COPECs at the T-24A Ranges to estimate concentrations of COPECs in terrestrial vegetative food material in the following manner:

$$C_{plant} = C_{soil} \times BAF_{soil-to-plant}$$

where:

- C_{plant} = COPEC concentration in terrestrial plants (mg/kg-dry weight);
 C_{soil} = COPEC concentration in soil (mg/kg-dry weight);
 $BAF_{soil-to-plant}$ = soil-to-plant bioaccumulation factor (unitless); and

The soil ingestion rate for the receptor species is most often represented as a percentage of a receptor species' diet. In order to account for the methodology used in the estimation of the soil ingestion rates, the moisture content of the receptor species' diets must be accounted for. The relationship used to estimate the soil ingestion rates for the terrestrial invertivorous and omnivorous small mammals and birds that have been identified as receptors in this ecological risk assessment is as follows:

$$IR_{soil} = IR_{food} \times Diet_{soil}$$

where:

- IR_{soil} = ingestion rate of soil (kg/kg/day, dry weight);
 IR_{food} = ingestion rate of food (kg/kg/day, wet weight);
 $Diet_{soil}$ = portion of diet that is soil (percent); and

The moisture contents of the invertebrate and vegetative material in the receptor species' diets are referenced from the EPA's *Wildlife Exposure Factors Handbook* (EPA, 1993) as follows:

- Earthworms - 84%
- Fruit - 77%
- Roots / young grass - 82%
- Seeds - 9.3%
- Fruit / young grass - 78%.

The weighted-average moisture contents of the diets of the receptor species of interest are as follows:

Receptor Species Dietary Components	Percent Moisture	Weighted-Average Moisture Content
White-footed mouse:		
invertebrates =	84%	53.9%
vegetation =	43.6%	
American robin:		
invertebrates =	84%	79.6%
vegetation =	77%	
Shorttail shrew:		
invertebrates =	84%	83.8%
vegetation =	82%	
American woodcock:		
invertebrates =	84%	80.3%
vegetation =	9.3%	

It is also assumed that if a receptor species' diet contains multiple vegetative components, then the percentage of each vegetative component will be equal. For instance, the vegetative component of the shorttail shrew's diet is assumed to be comprised of 50 percent roots and 50 percent young grass.

Dietary composition of the indicator species will be simplified for modeling purposes but will incorporate the major food types for the different feeding guilds. It will be assumed that food intake for invertivores is comprised almost entirely of terrestrial invertebrates (i.e., earthworms). It will also be assumed that omnivores consume both plant and animal material, a portion of which will consist of terrestrial invertebrates.

The AUFs for each of the indicator species will take into account the home range and habitat requirements for each species and the size of the contaminated areas and viable habitat at the T-24A Ranges.

7.2.2 Riparian/Aquatic Risk Hypothesis

Three test hypotheses were identified as being appropriate to address the assessment endpoint of “survival, growth, and reproduction of aquatic benthic invertebrates in the drainage features at the T-24A Ranges.” The test hypothesis relative to benthic invertebrates in South Branch of Cane Creek and its tributaries was the following:

- Are the concentrations of COPECs in sediment samples from the drainage features at the T-24A Ranges greater than ecological screening values for the survival, growth, and reproduction of aquatic invertebrates?

This test hypothesis will aid in the interpretation of the toxicity test results and may help in the identification of the most likely causative agent(s) in the aquatic invertebrate toxicity tests.

The second test hypothesis relative to benthic invertebrates in the South Branch of Cane Creek and its tributaries was the following:

- Is the survival and growth of aquatic benthic invertebrates exposed to sediment from the drainage features at the T-24A Ranges significantly lower than that for aquatic benthic invertebrates exposed to sediment from reference streams?

This test hypothesis will identify differences in aquatic benthic invertebrate survivability and growth when exposed to on-site sediments from the South Branch of Cane Creek and its tributaries and off-site reference sediments in laboratory toxicity tests.

The third test hypothesis relative to benthic invertebrates in South Branch of Cane Creek and its tributaries was the following:

- Is the benthic community structure (using Rapid Bioassessment Protocol [RBP] II) significantly different in reaches of the drainage features at the T-24A Ranges compared to benthic communities in a non-impacted reference stream?

This test hypothesis will identify differences in aquatic benthic invertebrate community structure in reaches of the South Branch of Cane Creek and its tributaries when compared to the benthic

invertebrate community structure in a non-impacted stream using in-situ RBP II assessment techniques.

Two test hypotheses were identified as being appropriate to address the assessment endpoint of “survival, growth, and reproduction of drought-tolerant aquatic vertebrate (e.g., finfish) and other aquatic species populations in the drainage features at the T-24A Ranges” and are the following:

- Are the concentrations of COPECs in surface water samples from the T-24A Ranges greater than ecological screening values for the survival and growth of fish and other aquatic species?
- Are the concentrations of COPECs in surface water samples from the T-24A Ranges greater than NOAELs and LOAELs for the survival, reproduction, and growth of aquatic invertebrates (i.e. daphnids) or aquatic vertebrates (i.e. fathead minnows) derived in the IMR/BGR BERA?

These test hypotheses will assess whether COPEC concentrations in surface water (when present) have the potential to cause ecological hazards to drought-tolerant aquatic species that may be present in the drainage features at the T-24A Ranges.

The test hypothesis that was identified as being appropriate to address the assessment endpoint of “survival, growth, and reproduction of riparian invertivorous small mammals and birds at the T-24A Ranges” was determined to be the following:

- Does the daily dose of COPECs received by riparian invertivorous small mammals or birds via consumption of prey species and from other media at the T-24A Ranges exceed the TRVs for survival, reproduction, or growth?

This test hypothesis will determine whether calculated daily doses of COPECs exceed feeding guild-specific toxicity reference values and will determine if COPECs in surface water and sediment have the potential to be transferred through the riparian food chain via aquatic insects.

Table 7-1 presents risk hypotheses for each of the riparian/aquatic assessment endpoints. It is important to note that the hypotheses are expressed as a positive response in order to minimize the likelihood of Type II statistical errors (i.e., a false negative decision) at a standard confidence level of $p = 0.05$.

In order to calculate COPEC exposures, indicator species that represent the feeding guilds of interest must be identified. For this risk assessment, the riparian invertivorous mammal will be

represented by the little brown bat (*Myotis lucifugus*) and the riparian invertivorous bird will be represented by the marsh wren (*Cistothorus palustris*). Natural history parameters for these indicator species (Table 7-3) will be used in combination with site-specific exposure parameters to estimate exposures to riparian invertivorous mammals and birds at the T-24A Ranges.

Daily doses of COPECs for riparian invertivorous mammals and birds will be calculated using standard exposure algorithms. These algorithms will incorporate species-specific natural history parameters (i.e., feeding rates, water ingestion rates, dietary composition, etc.) and will also use site-specific AUFs. Laboratory-derived bioaccumulation factors will be used to estimate COPEC concentrations in the aquatic insect portions of the receptor species' diets. In addition, measured concentrations of COPECs in chironomid tissues will also be used as input to the riparian food web model to calculate dosages of COPECs potentially received by the riparian receptor species.

The following algorithm will be used to estimate exposures to COPECs by riparian invertivorous mammals and birds:

$$TDD_{wildlife} = \left[(IR_{food} \times f_{invert} \times C_{invert}) + (IR_{water} \times C_{water}) + (IR_{food} \times f_{sed} \times \{1 - M_{diet}\} \times C_{sed}) \right] \times AUF$$

where:

$TDD_{wildlife}$	=	total daily dose of COPEC received by riparian invertivorous mammals or birds through ingestion (mg/kg/day);
IR_{food}	=	ingestion rate of food by receptor species (kg/kg/day);
f_{invert}	=	fraction of daily diet comprised of benthic invertebrates (percent);
C_{invert}	=	concentration of COPEC in sediment (mg/kg-dry wt.);
IR_{water}	=	ingestion rate of water by receptor species (L/kg/day);
C_{water}	=	concentration of COPEC in surface water (mg/L);
C_{sed}	=	concentration of COPEC in sediment (mg/kg-dry wt.);
f_{sed}	=	fraction of daily diet comprised of sediment (percent);
M_{diet}	=	average moisture content of diet (percent); and
AUF	=	area use factor (fraction of site used by receptor species) (percent).

7.2.2.1 Riparian Invertivorous Mammal Model Parameters

The surrogate species used in the riparian food web model to assess invertivorous mammals was the little brown bat (*Myotis lucifugus*). The foraging area of the little brown bat was estimated by University of Michigan (2006) students to be approximately 40 acres in size, based on radiotelemetry studies of females in June and August. Using this foraging area and the study area of the T-24A ranges (approximately 52 acres), the area use factor (AUF) for the little brown

bat was estimated to be 1.0. The body weights of adult male and female little brown bats range from 7 to 9 grams, with a mean of 8 grams. The mean body weight of 8 grams was used as the body weight for the little brown bat in the riparian food web model. The water ingestion rate for little brown bats was estimated using the allometric equation presented in Sample, et al. (1997). Assuming a mean body weight of 8 grams, the water ingestion rate for little brown bats was estimated to be 0.16 L/kg/day. The food ingestion rates for pregnant, lactating, and juvenile little brown bats in New Hampshire were reported by Anthony and Kunz (1977) to be 0.23, 0.48, and 0.29 g/g/day, respectively, with a mean value of 0.333 g/g/day. The average moisture content of aquatic isopods, amphipods, caldocerans, and insect larvae is 79 percent (USEPA, 1993). Taking the moisture content of the little brown bat's diet into consideration, the food ingestion rate for the little brown bat that was used in the riparian food web model was 0.0699 g/g/day (dry weight). Since little brown bats are assumed to feed exclusively on emergent benthic invertebrates (aerial insectivore), their potential exposures to sediment is expected to be negligible. These input parameters are summarized in Table 7-3 and were used to estimate total daily exposures to COPECs for invertivorous mammals.

7.2.2.2 Riparian Invertivorous Bird Model Parameters

The surrogate species used in the riparian food web model to assess invertivorous birds was the marsh wren (*Cistothorus palustris*). The size of an adult male marsh wren's territory ranges from 0.015 acres to 0.42 acres, with a mean value of 0.13 acres (USEPA, 1993). This value was used as the foraging area for the marsh wren in the riparian food web model. This foraging area results in an area use factor for the marsh wren of 1.0. Body weights for adult male and female marsh wrens range from 9.4 to 11.9 grams (USEPA, 1993), with a mean value of 10.38 grams. This mean value was used as the marsh wren's body weight in the riparian food web model. USEPA (1993) has estimated the water ingestion rate for marsh wrens to be 0.26 g/g/day for adult males and 0.28 g/g/day for adult females. The mean value (0.27 g/g/day) was used for the water ingestion rate for marsh wrens in the riparian food web model. Food ingestion rates for adult male and female free-living marsh wrens range from 0.67 to 0.99 g/g/day (wet weight) (USEPA, 1993), with a mean value of 0.873 g/g/day. The average moisture content of aquatic isopods, amphipods, cladocerans, and insect larvae is 79 percent (USEPA, 1993). Taking the moisture content of the marsh wren's diet into consideration, the food ingestion rate for the marsh wren that was used in the riparian food web model was 0.1833 g/g/day (dry weight). Since marsh wrens are assumed to feed exclusively on emergent benthic invertebrates (aerial insectivore), their potential exposures to sediment is expected to be negligible. These input parameters are summarized in Table 7-3 and were used to estimate total daily exposures to COPECs for invertivorous birds.

It will be assumed that the riparian invertivore's diets consist entirely of emergent benthic invertebrates; therefore, COPEC concentrations in benthic invertebrate tissues will need to be estimated in order to calculate a total COPEC dose. The COPEC concentrations in emergent benthic invertebrate tissues will be estimated using site-specific sediment-to-invertebrate bioaccumulation factors ($BAF_{sed-to-invert}$) determined through the analysis of chironomid tissue samples and the sediment samples used in the chironomid toxicity/bioaccumulation studies. These $BAF_{sed-to-invert}$ will be applied to the sediment concentrations of COPECs to estimate concentrations of COPECs in emergent benthic invertebrate food material in the following manner:

$$C_{invert} = C_{sed} \times BAF_{sed-to-invert}$$

where:

C_{invert}	=	COPEC concentration in emergent benthic invertebrates (mg/kg-dry weight);
C_{sed}	=	COPEC concentration in sediment (mg/kg-dry weight);
$BAF_{sed-to-invert}$	=	sediment-to-invertebrate bioaccumulation factor (unitless); and

Measured COPEC concentrations in chironomid tissues from the bioaccumulation tests will also be used as input to the riparian food web model. The total daily doses of COPECs received by the riparian invertivorous mammals and birds will not include the ingestion of soil or sediment as the receptors' diets are assumed to consist solely of emergent aquatic insects and the potential for exposure to site-related soil or sediment is minimal for these receptors. The moisture content of the receptor species' diets (aquatic benthic invertebrates) will be assumed to be 79 percent (EPA, 1993).

7.3 Selection of Measurement Endpoints

A measurement endpoint is "a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint" and is a measure of biological effects (e.g., mortality, reproduction, growth) (EPA, 1992). Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity test results, community diversity measures) that can be compared statistically to a control or reference site to detect adverse responses to site contaminants.

7.3.1 Terrestrial Measurement Endpoints

The terrestrial measurement endpoints described herein have been designed such that the information garnered from them can adequately address the assessment endpoints identified previously. It is important to note that the terrestrial measurement endpoints will largely be those terrestrial measurement endpoints derived in the IMR and BGR Ranges BERA. Because the soil COPECs identified for the T-24A Ranges (antimony, copper, lead, and zinc) are identical to the soil COPECs identified for the IMR and BGR Ranges, the terrestrial measurement endpoints for those ranges are also applicable to the T-24A Ranges.

In order to identify constituents that may cause adverse effects to the terrestrial plant communities at the T-24A Ranges, the following measurement endpoint has been identified:

- Comparison of COPEC concentrations in surface soil at the T-24A Ranges to ecological screening values for the survival or growth of terrestrial plants.

In order to identify constituents that may cause adverse effects to terrestrial invertebrate communities at the T-24A Ranges, the following measurement endpoints have been identified:

- Comparison of COPEC concentrations in surface soil at the T-24A Ranges to ecological screening values for the survival or growth of terrestrial invertebrates.
- Comparison of COPEC concentrations in surface soil at the T-24A Ranges to NOAELs and LOAELs for the survival and growth of terrestrial invertebrates derived in the IMR/BGR BERA.

The measurement endpoint that has been identified to address the assessment endpoint of “survival, growth, and reproduction of terrestrial invertivorous small mammals and birds at the T-24A Ranges” is the following:

- Comparison of calculated total daily doses of COPECs for terrestrial invertivorous mammal (shorttail shrew) and invertivorous bird (American woodcock) to TRVs.

The measurement endpoint that has been identified to address the assessment endpoint of “survival, growth, and reproduction of terrestrial omnivorous small mammals and birds at the T-24A Ranges” is the following:

- Comparison of calculated total daily doses of COPECs for terrestrial omnivorous mammal (white-footed mouse) and omnivorous bird (American robin) to TRVs.

In order to estimate the bioavailability of the COPECs in soil at the T-24A Ranges, and to provide data for the other assessment endpoints, a second measurement endpoint has been established to address the assessment endpoints of “survival, growth, and reproduction of terrestrial invertivorous small mammals and birds at the T-24A Ranges” and “survival, growth, and reproduction of terrestrial omnivorous small mammals and birds at the T-24A Ranges”.

This measurement endpoint is the following:

- Quantification of COPEC concentrations in tissues of earthworms using soil-to-earthworm BAFs derived in the IMR/BGR BERA.

In order to provide site-specific information regarding the potential for COPEC accumulation in plant tissues, and its effect on the food web interactions of herbivores and omnivores at the T-24A Ranges, the following measurement endpoint has been identified:

- Quantification of COPEC concentrations in tissues of terrestrial plants using literature-derived soil-to-plant BAFs.

As stated previously, some of these terrestrial measurement endpoints will be addressed using data collected for the BERAs conducted for the IMR and BGR Ranges. No new toxicity or bioaccumulation testing will be conducted using soils from the T-24A Ranges.

These measurement endpoints will provide the necessary data to answer the risk/test hypotheses for the terrestrial ecosystems at the T-24A Ranges presented in previous sections of this report. An important factor in assessing these measurement endpoints is an understanding of the degree of impairment to a biological attribute that is understood to be biologically or ecologically significant. Statistically significant differences in population survivability, growth, reproduction, or hazard quotient values that cannot be related to biological or ecological significance should not be interpreted as indicating a population or community is at risk or that a remedy is necessary (Tannenbaum, 2005). Therefore, ecological and biological significance will be considered within the context of these measurement endpoints.

Table 7-1 presents the measurement endpoints corresponding to each assessment endpoint and risk hypothesis. The methodologies used to collect the necessary data and how the data will be used to answer the risk hypotheses are presented in the following chapters.

7.3.2 Riparian/Aquatic Measurement Endpoints

The riparian/aquatic measurement endpoints described herein have been designed such that the information garnered from them can adequately address the assessment endpoints identified previously.

In order to facilitate the interpretation of the aquatic benthic invertebrate toxicity test results and aid in the identification of the most likely causative agent(s) in the benthic invertebrate toxicity tests, the following measurement endpoint has been identified:

- Comparison of COPEC concentrations in sediment from the drainage features at the T-24A Ranges to ecological screening values for the survival, growth, and reproduction of aquatic benthic invertebrates.

The measurement endpoints that have been identified to address the assessment endpoint of “survival, growth, and reproduction of aquatic benthic invertebrates in the drainage features at the T-24A Ranges” are the following:

- Comparison of survival and growth of the benthic amphipod *Chironomus tentans* exposed to “on-site” sediment to survival and growth of *Chironomus tentans* exposed to sediment from a reference stream.
- Comparison of the benthic community assemblage from the drainage features at the T-24A Ranges with the benthic community assemblages from a reference stream using RBP II methodology.

The measurement endpoints that have been identified to address the assessment endpoint of “survival, growth, and reproduction of the drought-tolerant aquatic vertebrate (fish) and other aquatic species populations in the drainage features at the T-24A Ranges” are the following:

- Comparison of COPEC concentrations in surface water at the T-24A Ranges to ecological screening values for the survival or growth of fish and other aquatic species.
- Comparison of COPEC concentrations in surface water at the T-24A Ranges to NOAELs and LOAELs for survival, growth, and reproduction of daphnids and fathead minnows derived in the IMR/BGR BERA.

The measurement endpoint that has been identified to address the assessment endpoint of “survival, growth, and reproduction of riparian invertivorous small mammals and birds at the T-24A Ranges” is the following:

- Comparison of calculated total daily doses of COPECs for riparian invertivorous mammal (little brown bat) and invertivorous bird (marsh wren) to TRVs.

In order to provide site-specific information regarding the potential for COPEC accumulation in benthic invertebrate tissues, and its effect on the food web interactions of riparian invertivorous mammals and birds, the following measurement endpoint has been identified:

- Quantification of COPEC concentrations in tissues of chironomids exposed to sediment from the drainage features at the T-24A Ranges and tissues of chironomids exposed to sediment from a non-impacted reference stream.

These measurement endpoints will provide the necessary data to answer the risk/test hypotheses for the riparian/aquatic ecosystems at the T-24A Ranges presented in previous sections of this report. An important factor in assessing these measurement endpoints is an understanding of the degree of impairment to a biological attribute that is understood to be biologically or ecologically significant. Statistically significant differences in population survivability, growth, reproduction, or hazard quotient values that cannot be related to biological or ecological significance should not be interpreted as indicating a population or community is at risk or that a remedy is necessary (Tannenbaum, 2005). Therefore, ecological and biological significance will be considered within the context of these measurement endpoints.

Another important factor to recognize while interpreting the results of the toxicity tests is the fact that the organisms used in the laboratory toxicity tests may not be indigenous to the Fort McClellan area. As such, the laboratory species may be more or less sensitive to the COPECs than indigenous organisms. Therefore, the results of the toxicity tests and the conclusions rendered from these tests will consider these uncertainties.

Table 7-1 presents the measurement endpoints corresponding to each assessment endpoint and risk hypothesis. The methodologies used to collect the necessary data and how the data will be used to answer the risk hypotheses are presented in the following chapters.

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, 2000b). 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 for the T-24A Ranges (Shaw, 2005a) identified four metals (antimony, copper, lead, and zinc) as COPECs in surface soil. Copper, lead, and zinc were identified as COPECs in surface water and lead, benzo(a)anthracene, chrysene, di-n-butyl phthalate, fluoranthene, and pyrene were identified as COPECs in sediment. No COPECs were identified in groundwater.

The T-24A Ranges Problem Formulation and SCM (Chapters 1.0 through 7.0) suggest that exposure pathways for the inorganic and organic constituents identified as COPECs to terrestrial and riparian/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, bioaccumulation potential, and site-specific toxicity.

Based on the findings of the SLERA and Problem Formulation, the objectives of the BERA for the T-24A Ranges include the following:

- Collect site-specific data and utilize data from previous BERA studies to address bioavailability and bioaccumulation potentials in lower trophic level organisms that form the basis of the terrestrial and riparian/aquatic food webs at the T-24A Ranges.
- Collect site-specific data and utilize data from previous BERA studies 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 T-24A Ranges at which ecological hazards could occur.
- Provide data of sufficient quality to develop a technically defensible characterization of the potential ecological hazards at the T-24A Ranges for use by risk managers in their acceptance or rejection of present and future ecological hazards 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 or data developed in previous BERA efforts at FTMC in order to address the issues identified in the Problem Statement presented in the previous section.

- Determine if the COPECs at the T-24A Ranges are available for uptake (i.e., bioavailable) in terrestrial or aquatic systems
- Determine what levels of COPECs in soil, surface water, and sediment promote 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 if the binding capacity/bioavailability of soils from the T-24A ranges are similar to the binding capacity/bioavailability of soils from the IMR and BGR ranges
- Determine whether the tissue burdens of COPECs in terrestrial 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 the drainage features at the T-24A Ranges are adversely affected by exposure to COPECs in surface water or 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 hazard.

8.3 Decision Inputs

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

- Surface soil concentrations of the four surface soil COPECs at the T-24A Ranges;
- Surface soil concentrations of soil chemistry parameters that determine the binding capacity/bioavailability of COPECs;
- Earthworm mortality based on earthworm NOAEL and LOAEL data for the COPECs in soil from the IMR and BGR BERA;
- Earthworm growth based on total tissue weight measured at the termination of the toxicity tests conducted for the IMR and BGR BERA;
- Bio-uptake and accumulation potential of soil COPECs in terrestrial invertebrates based on the ratio of soil COPEC concentrations to earthworm tissue concentrations as measured in the IMR and BGR BERA;
- Accumulation potential of soil COPECs in terrestrial plants based on literature-derived soil-to-plant bioaccumulation factors;
- Total daily 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 for 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);
- Surface water concentrations of copper, lead, and zinc;
- Sediment concentrations of lead, benzo(a)anthracene, chrysene, di-n-butyl phthalate, fluoranthene, and pyrene;
- *Chironomus tentans* mortality based on exposure to various COPEC concentrations in sediment and derivation of sediment NOAEL and LOAEL values;
- Bio-uptake and accumulation potential of sediment COPECs in benthic invertebrates based on the ratio of sediment COPEC concentrations to *Chironomus sp.* tissue concentrations;

- Total daily dose estimates of the sediment 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, surface water, or sediment at the T-24A Ranges present (or might present) the potential to pose harm to ecological receptors. If potential hazards to ecological receptors are predicted using the information presented above, then this information will also be used to determine the concentrations of COPECs in surface soil, surface water, or sediment that may be more protective of the terrestrial and riparian/aquatic receptors at the T-24A Ranges. The Uncertainty Analysis of the BERA will describe the limitations associated with the various assessment techniques and in establishing protective COPEC concentrations.

8.4 Study Boundaries

Study boundaries define the spatial scale of the assessment at the T-24A Ranges. In order to conduct a useful BERA, it is imperative to define the geographic and temporal boundaries of the potential hazard and to identify the target populations of interest. The SLERA for the T-24A Ranges identified the mixed deciduous/coniferous forest and oldfield ecosystems at the T-24A Ranges and the riparian/aquatic habitats associated with the drainage features as the habitats with the greatest potential risk given their quality, level of contamination, and receptors likely to be exposed to the COPECs. Therefore, the T-24A Ranges BERA will focus on the forest and oldfield terrestrial habitats, and the riparian/aquatic ecosystems associated with these ranges.

Additionally, based on the historical nature of the contamination at the T-24A 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 habitats. However, the temporal variability of the drainage features will be considered in the study boundaries. The drainage features at the T-24A Ranges only transport water during certain periods of most years and are dry for extended periods of time. Therefore, the riparian/aquatic receptors are only sporadically exposed to surface water and sediment COPECs, and these exposures are normally not long-term.

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 T-24A 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, 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 ecological hazard and, if necessary, in generating ecological-based cleanup goals. The decision rules proposed for the T-24A Ranges BERA include the following:

- If concentrations of COPECs in surface soil at the T-24A Ranges are greater than ESVs for the survival and growth of terrestrial plants, then there is the potential for adverse effects to terrestrial plant communities at the T-24A Ranges.
- If concentrations of COPECs in surface soil at the T-24A Ranges are greater than ESVs for the survival and growth of terrestrial invertebrates, then there is the potential for adverse effects on terrestrial invertebrate communities at the T-24A Ranges.
- If concentrations of physical/chemical parameters that determine the binding capacity/bioavailability of COPECs in soils from the T-24A ranges are similar to the same parameters in soils from the IMR and BGR ranges, then the toxicity and bioaccumulation test results from the IMR and BGR ranges BERA are also applicable to the T-24A ranges.
- If concentrations of COPECs in surface soil at the T-24A Ranges are greater than the NOAEL or LOAEL values for terrestrial invertebrate survival and growth derived in the IMR/BGR BERA, then there is the potential for unacceptable hazards to terrestrial invertebrate receptors at the T-24A Ranges.
- 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 ecological hazard to terrestrial invertivorous mammals or birds at the T-24A 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 ecological hazard to terrestrial invertivorous mammals or birds at the T-24A Ranges.

- If, based on the collective evaluation of the lines-of-evidence, COPECs are determined to pose hazards to terrestrial receptors at the T-24A Ranges, then risk-based remedial goals for soil will be developed using the data collected during this and other BERAs at FTMC.
- If concentrations of COPECs in the surface water of the drainage features are greater than ecological screening values designed to be protective of fish and other aquatic organisms, then there is the potential for ecological hazards to fish and other riparian/aquatic species at the T-24A Ranges.
- If concentrations of COPECs in the surface water of the drainage features are greater than the NOEALs or LOAELs for survival, growth, or reproduction of daphnids and fathead minnows derived in the IMR/BGR BERA, then there is the potential for ecological hazards to aquatic invertebrates and or fish in the drainage features at the T-24A Ranges.
- If COPECs in the sediments of the drainage features cause acute toxicity to the benthic invertebrate *Chironomus sp.*, which is statistically greater than toxicity from reference sediments, then there is the potential for ecological hazard to emergent benthic invertebrates at the T-24A Ranges.
- If chironomids exposed to sediment from the drainage features demonstrate statistically higher tissue concentrations of COPECs 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 the drainage features at the T-24A Ranges is significantly different than the benthic community assemblage in a non-impacted reference stream, then there is the potential for ecological hazard to the benthic ecosystem in the on-site drainage features.
- 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 ecological hazard to riparian invertivorous mammals or birds at the T-24A 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 ecological hazard. Therefore, background will be considered within the context of each of the aforementioned decision rules.

It is also important to consider the effects that physical disturbance of the ecosystems at many of the T-24A Ranges may have on the ecology. Routine maintenance activities at many of these ranges (e.g., grading of soil, removal of trees, continuous mowing of grass) have altered the ecosystems greatly from their “native” state and it may take many years for the “native” ecosystems to re-establish themselves. For instance, the grading of soil may have removed the very shallow layer of topsoil from certain range areas. Without the layer of topsoil, it is very difficult for certain plant species to establish themselves and grow successfully. Therefore, physical disturbance of a site will also be considered when interpreting the results of the established decision rules.

Additionally, it is important to understand the temporal variability of the riparian/aquatic ecosystems at the T-24A Ranges. Almost all of the drainage features at the T-24A Ranges are completely dry during extended periods of most years. Therefore, during certain times of the year (summer and fall of most normal years), aquatic species will not be present in most of the drainage features. Alternately, during periods of significant precipitation (winter and spring), drought-tolerant species will likely be present. Because of this temporal variability, riparian/aquatic receptors will not experience continuous exposures to COPECs in surface water and exposures to sediment will differ based on the presence or absence of water. It is important to recognize this temporal variability when interpreting the results of the established decision rules.

8.6 Tolerable Limits on Decision Errors

Chemical and biological data obtained 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 T-24A Ranges. Since the collected data are only small sub-populations of the entire T-24A Ranges, they can only be used to predict responses that may actually occur at these and other 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 data employed in the BERA will be of sufficient quantity and quality as to result in a decision confidence level of 95 percent. The tolerable limit will be made on statistical probabilities of less than 95 percent.

8.7 Design Optimization

The objective in design optimization is to develop a “resource-effective” sampling and analysis plan for generating data. The use of soil-related data collected as part of the BERA for the IMR and BGR Ranges BERA is one example of how the study design for the T-24A Ranges has been optimized. The sampling and analysis plans presented in Appendices A through C have been optimized to ensure that the tolerable limits on decision errors will be met.

9.0 Site Investigation Tasks

The BERA for the T-24A Ranges will focus on characterizing risk associated with the COPECs in surface soil within the forest and oldfield terrestrial habitats, as well as surface water and sediments within the South Branch of Cane Creek and its tributaries. The site investigation tasks are directly linked to the assessment and measurement endpoints described in Chapter 7.0.

The principal objective of this 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 terrestrial receptor study design will rely almost exclusively on data collected during the IMR and BGR Ranges BERA (Shaw, 2004; Shaw, 2007). Specifically, the terrestrial receptor study design for the T-24A Ranges will utilize the following data collected and/or derived in previous BERAs at FTMC:

- Earthworm toxicity test results (mortality and growth) from the IMR and BGR Ranges BERA;
- Earthworm bioaccumulation results from the IMR and BGR Ranges BERA;

The chemical analyses of surface soil that were conducted as part of the remedial investigation for the T-24A Ranges will be utilized in the T-24A Ranges BERA. Five (5) additional surface soil samples will be collected from the T-24A ranges and analyzed for physical/chemical properties that could affect the binding capacity/bioavailability of the COPECs identified in soil at the T-24A Ranges. The analyses that will be conducted on these surface soil samples are the following:

- pH
- Phosphate
- Total Organic Carbon (TOC)
- Total Carbonate
- Cation Exchange Capacity
- Iron Oxyhydroxide Content
- Grain Size

- Calcium
- Iron
- Magnesium
- Potassium
- Sodium.

These physical/chemical properties will be compared to the binding capacity data that were collected for soils at the IMR and BGR Ranges (*Baseline Ecological Risk Assessment Study Design for the Iron Mountain Road Ranges*, IT, 2002) to determine if the bioavailability of the COPECs in the IMR and BGR ranges soil is similar to the bioavailability of the COPECs in T-24A Ranges soil. If the bioavailability/binding capacity data from the T-24A ranges are similar to the bioavailability/binding capacity data from the IMR and BGR ranges, then the results of the earthworm toxicity tests from the IMR/BGR ranges can be applied to the T-24A ranges. Table 9-1 presents a summary of the proposed surface soil sample locations and the COPEC concentrations detected in samples from these locations collected as part of the remedial investigation. The locations of the five surface soil samples for physical/chemical analysis are presented in Figure 9-1. The yellow-shaded sample locations in Figure 9-1 indicate the locations where surface soil samples are proposed for collection.

Details of the collection methods, decontamination procedures, quality assurance/quality control, and other sampling procedures are presented in the FTMC Installation-Wide Sampling and Analysis Plan (SAP) (IT, 2002a) and are summarized in Appendix C of this document.

9.2 Riparian/Aquatic Study Design

The riparian/aquatic habitat to be addressed in the BERA for the T-24A Ranges consists of the surface water and sediments in the South Branch of Cane Creek and its tributaries. The riparian/aquatic study design is designed to address exposure and potential effects to receptors within and around the South Branch of Cane Creek and its tributaries as they flow through the T-24A Ranges. Elevated levels of COPECs may or may not pose a risk to aquatic or riparian receptors depending upon their availability for uptake (bioavailability) from the surface water and sediments. Therefore, the study is designed to assess bioavailability of the COPECs in surface water and sediment as well as the potential for acute or chronic toxicity and bioaccumulation to lower trophic level organisms that are closely associated with the surface water and/or sediment within the South Branch of Cane Creek and its tributaries.

It is important to recognize that the drainage features at the T-24A ranges are highly seasonal in nature and their characteristics vary greatly depending on the amount of precipitation received by

the local watershed. As such, a given “stream” reach could exhibit widely different characteristics based on recent precipitation events, or lack thereof. For instance; immediately after a storm event a given drainage feature may exhibit high velocity flow, several weeks later the same “stream” reach might exhibit very low flow with frequent pools, and several weeks later the same “stream” reach could be completely dry. The stream habitat and physical characteristics will be described in detail at the time of sampling and will be used in the assessment of the surface water drainage features in the BERA.

9.2.1 Sediment Collection for Chemical Analysis

The sediment assessment will focus on characterization of potential hazards 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 hazards to aquatic systems because the receptors are generally less mobile and the COPECs can accumulate within depositional zones. Sediment samples will be collected from eight (8) locations within the drainage features representing different COPEC concentrations detected in previous investigations at the T-24A Ranges. Additionally, two (2) sediment samples will be collected from locations outside the influence of FTMC with the intention of being representative of naturally occurring conditions. These 2 sample locations will be the site-specific reference locations.

Lead and polynuclear aromatic hydrocarbons (PAHs) will be used as the indicators of COPEC concentrations. Lead has been detected in sediment at the T-24A Ranges, is a major component of small arms munitions, and has been used as an indicator of contamination resulting from small arms range activity. PAHs have also been detected in sediment at the T-24A ranges, albeit infrequently and at low concentrations, and can be associated with the use of fog oil at training areas. Figure 9-1 presents the proposed locations for sediment samples that will be collected to represent the range of COPEC concentrations in sediment at the T-24A Ranges. The blue-shaded sample locations in Figure 9-1 indicate the locations where sediment samples are proposed for collection. The lead concentrations detected in sediment at these sample locations in previous investigations are also presented in Figure 9-1. These sediment samples will be used in the toxicity and bioaccumulation tests described in the following sections. Two sediment sample will also be collected from drainage features with similar substrate characteristics as the on-site drainage features but outside the influence of the T-24A Ranges to be used as site-specific reference locations. Table 9-2 presents a summary of the proposed sediment sample locations and the COPEC concentrations detected in sediment samples collected and analyzed from these locations as part of the remedial investigation. All sediment samples will be analyzed for TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides,

chlorinated herbicides, total organic carbon, pH, and grain size. The COPEC concentrations in sediment samples from the drainage features 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.

In order to ensure that the nature and extent of sediment contamination has been sufficiently characterized at the T-24A ranges, four (4) additional sediment samples will be collected from the drainage features at the T-24A ranges. These additional sediment samples will be collected from locations not previously sampled during the remedial investigation and will be analyzed for TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, total organic carbon, pH, and grain size. The results of the chemical analysis of these samples will be incorporated with the results of the other sediment samples collected at the T-24A ranges and 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.

To summarize, a total of fourteen (14) sediment samples will be collected from the drainage features in and around the T-24A ranges study area as detailed below:

- 8 samples to address the BERA assessment and measurement endpoints
- 2 site-specific reference samples
- 4 samples to verify the nature and extent of sediment contamination.

Details of the collection methods, decontamination procedures, quality assurance/quality control, and other sampling procedures are presented in the FTMC Installation-Wide Sampling and Analysis Plan (SAP) (IT, 2002a) and are summarized in Appendix B of this document.

9.2.2 Sediment Collection for Benthic Invertebrate Studies

In order to evaluate potential toxicity to benthic invertebrates, the standard 21-day *Chironomus tentans* survival and growth test will be conducted using 8 sediment samples collected from the drainage features representative of the range of COPECs detected in sediment samples during previous investigations at the T-24A Ranges. Test procedures for the sediment toxicity tests will be in accordance with the guidance set forth by EPA (2000c) in *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates* and ASTM (2000) in *Standard Guide for Determination of the Bioaccumulation of Sediment-Associated Contaminants by Benthic Invertebrates*. Appendix B references the test protocol for *Chironomus tentans* survival and growth tests. Five replicates for each of the 8 sediment locations, 2 site-specific reference locations, and laboratory controls, will be used for

measurements of mortality 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 8 sediment sample locations will represent a gradient of COPEC concentrations previously detected at the T-24A Ranges. This field-collected concentration gradient will allow investigators to generate sediment NOAELs and LOAELs based on mortality and growth. Additionally, the various sediment concentrations and corresponding chironomid tissue concentrations of COPECs will provide data for the calculation of sediment-to-invertebrate bioaccumulation factors ($BAF_{\text{sed-to-invert}}$).

In addition to laboratory-based sediment toxicity testing, direct in-field measurements of benthic invertebrate community structure using rapid bioassessment protocol (RBP II) will be conducted (Barbour et al., 1999). 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 T-24A Ranges. The presence or absence of habitat degradation assists in evaluating the present level of hazard or impact to existing receptors. When combined with laboratory toxicity testing, direct field measurements reduce uncertainty and strengthen the line-of-evidence relative to potential hazard levels.

For the drainage features at the T-24A Ranges, benthic macroinvertebrate surveys will be conducted within riffle and pool zones of the streams as they flow through the T-24A 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. For example, due to natural erosional processes and the ephemeral nature of many of the drainage features, a diverse and well-established in-faunal community may not be present. A similar reference area(s) will be located in order to properly compare the benthic assemblage in the drainage features to a similar stream un-impacted by small arms range activities. Great care will 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., the drainage features at the T-24A Ranges), may support a diverse macroinvertebrate fauna, but only support a limited fish community.

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 coarse particulate organic matter (CPOM) sample, *in situ* water quality parameters (temperature, conductivity, dissolved oxygen, and 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 an appropriate laboratory for identification and analysis.

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 the 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.

According to the *Endangered Species Management Plan for Fort McClellan* (Garland, 1996), a Federal C2 candidate caddisfly species (*Polycentropus carlsoni*) and a site endemic caddisfly species (*Hydroptila setigera*) have been collected from the South Branch of Cane Creek. An additional 13 caddisfly species from the South Branch of Cane Creek are included on the Alabama Natural Heritage Program tracking list. Therefore, special care will be given to the

macroinvertebrate samples in order to maximize the potential for identifying these species. It should be noted, however, that the identification of benthic macroinvertebrates in the RBPII protocol rarely identifies organisms to the species level due to the difficulty in determining specific species of certain benthic macroinvertebrates. Benthic macroinvertebrates are normally only identified to the Family-level in the RBPII protocol.

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* (Barbour et al., 1999). 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 increases 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 Bodek et al. (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 table:

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. 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.

9.2.3 Surface Water Collection for Chemical Analysis

The surface water assessment will focus on characterization of ecological hazards to water column invertebrates as well as vertebrates. Surface water samples will be collected from the same 8 locations within the drainage features at the T-24A Ranges as the sediment samples identified in previous sections and the same 2 site-specific reference locations identified in previous sections. These surface water samples will be analyzed for TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, pH, total suspended solids, and hardness. The analytical results from these surface water samples will be used to address the assessment and measurement endpoints detailed in Chapter 7 of this report. Table 9-3 presents a summary of the proposed surface water sample locations and the COPEC concentrations detected in samples from these locations collected as part of the remedial investigation. Figure 9-1 presents the proposed surface water sampling locations. The blue-shaded sample locations in Figure 9-1 indicate the locations where surface water samples are proposed for collection. The lead concentrations detected in surface water at these sample locations in previous investigations are also presented in Figure 9-1.

In order to ensure that the nature and extent of surface water contamination has been sufficiently characterized at the T-24A ranges, four (4) additional surface water samples will be collected from the drainage features at the T-24A ranges. These additional surface water samples will be collected from locations not previously sampled during the remedial investigation and will be analyzed for TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, pH, total suspended solids, and hardness. The results of the chemical analysis of these samples will be incorporated with the results of the other surface water samples collected at the T-24A ranges and 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.

To summarize, a total of 14 surface water samples will be collected from the drainage features in and around the T-24A study area as summarized below:

- 8 samples to address the BERA assessment and measurement endpoints
- 2 site-specific reference samples
- 4 samples to verify the nature and extent of surface water contamination.

It is important to recognize that surface water is not present at many of these sampling locations during significant periods of most years and is highly dependent upon precipitation in the area. Therefore, surface water samples will only be collected if surface water is present during the ecological sampling event. If surface water is not present in the drainage features at the time of sampling, surface water data from the samples collected as part of the remedial investigation of the T-24A Ranges will be utilized in the BERA. All surface water samples will be analyzed for TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, total suspended solids, hardness, and pH.

The COPEC concentrations in surface water samples from the drainage features will be used to determine if there is the potential for hazards to aquatic vertebrates (e.g., fish) and other aquatic organisms. The detected concentrations of COPECs in surface water samples will also be utilized in the food web models that will be used to calculate the total dose of COPECs potentially received by invertivorous and omnivorous mammals and birds.

Details of the collection methods, decontamination procedures, quality assurance/quality control, and other sampling procedures are presented in the SAP (IT, 2002a) and are summarized in Appendix A of this document.

10.0 Data Analysis, Validation, and Interpretation

Data usefulness is paramount relative to the BERA and related testing and analysis. The principal objective in the Study Design is to ensure that the hypotheses are effectively tested and rejected or accepted with a high degree of confidence. A summary of the statistical methods is provided below and a discussion of hypothetical results follows. These hypothetical results should assist the reader in better understanding the usefulness of the collected data as they relate to characterizing risk to terrestrial receptors within and around the T-24A Ranges, as well as the riparian/aquatic data associated with the drainage features at the T-24A Ranges.

10.1 Data Analysis and Validation

As described in the previous sections, surface soil samples will not be collected from the T-24A Ranges for the purposes of conducting toxicity or bioaccumulation data. Most of the terrestrial receptor measurement endpoints will be referenced from the BERAs that were conducted for the IMR and BGR Ranges (Shaw, 2004; Shaw, 2007). As such, most of the data validation and analysis has already been completed for the soil-related data that will be used in this BERA for the T-24A Ranges. The data analyses and validation procedures for soil and soil-related analyses are presented in the Problem Formulation and Study Design documents for the aforementioned IMR and BGR Ranges (IT, 2002b; IT, 2002c; Shaw, 2003; and Shaw, 2006).

Specifically, the BERA for the T-24A Ranges will utilize the following data collected and/or derived in previous BERAs at FTMC:

- Earthworm toxicity test results (mortality and growth) from the IMR and BGR Ranges BERA;
- Earthworm bioaccumulation results from the IMR and BGR Ranges BERA;
- Daphnid and fathead minnow toxicity test results (mortality, growth, and reproduction) from the IMR and BGR Ranges BERA.

The chemical analyses of surface soil that were conducted as part of the remedial investigation for the T-24A Ranges will be utilized in the T-24A Ranges BERA. Five additional surface soil samples will be collected from the T-24A ranges and analyzed for physical/chemical properties that could affect the binding capacity/bioavailability of the COPECs identified in soil at the T-24A Ranges.

The sediment chironomid toxicity tests in conjunction with the RBP will provide lines of evidence regarding potential sediment toxicity (e.g., NOAEL and LOAEL values for sediment) and also quantitative comparisons of benthic invertebrate assemblages in the South Branch of Cane Creek and its tributaries with benthic invertebrate assemblages from an un-impacted reference stream. The results of these analyses will be used, along with other lines of evidence, to determine whether ecological hazards exist in the drainage features at the T-24A Ranges and to develop ecological sediment clean-up goals, if deemed appropriate.

The overall objective in conducting the field- and laboratory-based studies is to test the null hypotheses stated in Chapter 7.0. Each hypothesis will be accepted or rejected based on findings from the relevant toxicity test or field measurement. Acceptance or rejection of each hypothesis will be instrumental in characterizing ecological hazards/risks associated with the surface soils, surface water, and sediment at the T-24A Ranges.

NOAEL and LOAEL values will be derived using Dunnett's procedure or Steel's Many-One Rank Test. Dunnett's procedure is a parametric test that assumes that observations within treatments are independent and normally distributed and that the variance of the observations is homogenous across all toxicant concentrations. The Shapiro-Wilk's test will be used to test for normality in order to decide whether to use parametric (Dunnett's) or nonparametric (Steel's Many-One Rank) analyses. In order to test the variances of the data obtained from each toxicant concentration and the control, Bartlett's test for variance will be employed.

It is important to note that the sediment samples will not be cut or diluted into a dilution series but will be tested as 100 percent "un-cut" samples. Derivation of toxicity response curves in the form of NOAELs and LOAELs will be done via the lead concentration gradient detected in the various sediment samples. By collecting sediment samples with varying concentrations of ICOPECs, a gradient series will be present and appropriate toxicity response curves can be computed. Therefore, Dunnett's Procedure (for parametric distributions) or Steel's Many-One Rank Test (for nonparametric distributions) can be applied.

In addition to deriving toxicant dose-response curves (i.e., NOAEL, LOAEL), it is critical to apply Analysis of Variance (ANOVA) tests to determine if sediment samples differ from off-site reference samples, thus dictating whether null hypotheses are accepted or rejected. A significance level of $\alpha = 0.05$ will be adopted as a probability of committing a Type I or Type II error. In comparing toxicity or biomeasurement results, single and nested ANOVAs will be conducted coincident with appropriate normality and variance testing.

Data validation will be conducted in accordance with the SAP (IT, 2002a).

10.2 Data Interpretation

Interpretation of bioassay results is dependent upon bracketing a response or effect level and a no-effect level. Effects will be measured via toxicity responses within a specified exposure period, depending on the exposure medium and test species. At a confidence level of 95 percent ($p \leq 0.05$), test responses consisting of acute toxicity will be compared to reference sediment responses. Test chambers that are statistically different from reference chambers will be characterized as “effect concentrations,” while those exhibiting no significant difference will be listed as “no-effect concentrations.” The highest no-effect concentration and the lowest effect concentration will be reported as the NOAEL and LOAEL, respectively.

A second use of the data relates to COPEC concentrations measured within tissues following completion of exposure periods. Organisms from each replicate chamber will be tested as separate and distinct composite samples. The mean concentration and 95 percent UCL for each exposure concentration will be used to derive body burden concentrations which will then be used as input values for the food chain models as described in Chapter 5.0. These models, representing the various terrestrial and riparian trophic levels, will then be employed for HQ derivations.

11.0 Data Management Plan

The primary data management activities for the T-24A Ranges BERA will include:

- Data transfer from field and laboratory activities to a project filing system
- Data management to ensure that data are stored and output in a manner that continues the chain of custody
- Review of requirements to ensure that plans for data collection were fulfilled
- Validation of analytical data that will report data to be used for treatment interpretation activities
- Evaluation of analytical and field data resulting in a report of guidance to be followed for using project data in treatment interpretation
- Reporting functions, which may include outputting data for report tables, statistical analysis, interpretation of data, and electronic transfer.

The FTMC ShawView™ database will be used for data management. A series of programs allows electronic reporting of data. The laboratory is responsible for reporting data in both hard copy and electronic data deliverable formats.

11.1 Records Control

All project documentation and original reports will be maintained in a central file for the project.

11.2 Document Filing and Access

At least two copies of all data forms and deliverables will be generated during the project and sorted at different locations. Wherever practical, original forms will be archived at the Shaw-Environmental and Infrastructure, Inc. office in Knoxville, Tennessee, and the laboratory and field personnel will retain copies. Analytical data, hard copy, and electronic files will be archived at least seven years by the laboratory.

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ATTACHMENT 1
LIST OF ABBREVIATIONS AND ACRONYMS

List of Abbreviations and Acronyms

2-ADNT	2-amino-4,6-dinitrotoluene	AST	aboveground storage tank	CAIS	chemical agent identification set
4-ADNT	4-amino-2,6-dinitrotoluene	ASTM	American Society for Testing and Materials	CAMU	corrective action management unit
2,4-D	2,4-dichlorophenoxyacetic acid	AT	averaging time	CBR	chemical, biological, and radiological
2,4,5-T	2,4,5-trichlorophenoxyacetic acid	atm-m ³ /mol	atmospheres per cubic meter per mole	CCAL	continuing calibration
2,4,5-TP	2,4,5-trichlorophenoxypropionic acid	ATSDR	Agency for Toxic Substances and Disease Registry	CCB	continuing calibration blank
3D	3D International Environmental Group	ATV	all-terrain vehicle	CCV	continuing calibration verification
AB	ambient blank	AUF	area use factor	CD	compact disc
AbB3	Anniston gravelly clay loam, 2 to 6 percent slopes, severely eroded	AWARE	Associated Water and Air Resources Engineers, Inc.	CDTF	Chemical Defense Training Facility
AbC3	Anniston gravelly clay loam, 6 to 10 percent slopes, severely eroded	AWQC	ambient water quality criteria	CEHNC	U.S. Army Engineering and Support Center, Huntsville
AbD3	Anniston and Allen gravelly clay loams, 10 to 15 percent slopes, eroded	AWWSB	Anniston Water Works and Sewer Board	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
ABLM	adult blood lead model	'B'	Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero)	CERFA	Community Environmental Response Facilitation Act
Abs	skin absorption	BAF	bioaccumulation factor	CESAS	Corps of Engineers South Atlantic Savannah
ABS	dermal absorption factor	BBGR	Baby Bains Gap Road	CF	chloroform
AC	hydrogen cyanide	BCF	blank correction factor; bioconcentration factor	CF	conversion factor
ACAD	AutoCadd	BCT	BRAC Cleanup Team	CFC	chlorofluorocarbon
AcB2	Anniston and Allen gravelly loams, 2 to 6 percent slopes, eroded	BERA	baseline ecological risk assessment	CFDP	Center for Domestic Preparedness
AcC2	Anniston and Allen gravelly loams, 6 to 10 percent slopes, eroded	BEHP	bis(2-ethylhexyl)phthalate	CFR	Code of Federal Regulations
AcD2	Anniston and Allen gravelly loams, 10 to 15 percent slopes, eroded	BFB	bromofluorobenzene	CG	phosgene (carbonyl chloride)
AcE2	Anniston and Allen gravelly loams, 15 to 25 percent slopes, eroded	BFE	base flood elevation	CGI	combustible gas indicator
ACGIH	American Conference of Governmental Industrial Hygienists	BFM	bonded fiber matrix	ch	inorganic clays of high plasticity
AdE	Anniston and Allen stony loam, 10 to 25 percent slope	BG	Bacillus globigii	CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
ADEM	Alabama Department of Environmental Management	BGR	Bains Gap Road	CIH	Certified Industrial Hygienist
ADPH	Alabama Department of Public Health	bgs	below ground surface	CK	cyanogen chloride
AEC	U.S. Army Environmental Center	BHC	hexachlorocyclohexane	cl	inorganic clays of low to medium plasticity
AEDA	ammunition, explosives, and other dangerous articles	BHHRA	baseline human health risk assessment	Cl	chlorinated
AEL	airborne exposure limit	BIRTC	Branch Immaterial Replacement Training Center	CLP	Contract Laboratory Program
AET	adverse effect threshold; apparent effects threshold	bkg	background	cm	centimeter
AF	soil-to-skin adherence factor	bls	below land surface	CN	chloroacetophenone
AHA	ammunition holding area	BOD	biological oxygen demand	CNB	chloroacetophenone, benzene, and carbon tetrachloride
AL	Alabama	Bp	soil-to-plant biotransfer factors	CNS	chloroacetophenone, chloropicrin, and chloroform
ALARNG	Alabama Army National Guard	BRAC	Base Realignment and Closure	CO	carbon monoxide
ALAD	δ-aminolevulinic acid dehydratase	Braun	Braun Intertec Corporation	CO ₂	carbon dioxide
ALDOT	Alabama Department of Transportation	BSAF	biota-to-sediment accumulation factors	Co-60	cobalt-60
amb.	amber	BSC	background screening criterion	CoA	Code of Alabama
amsl	above mean sea level	BSV	background screening values	COC	chain of custody; chemical of concern
ANAD	Anniston Army Depot	BTAG	Biological Technical Assistance Group	COE	Corps of Engineers
ANOVA	Analysis of Variance	BTEX	benzene, toluene, ethyl benzene, and xylenes	Con	skin or eye contact
AOC	area of concern	BTOC	below top of casing	COPC	chemical of potential concern
AOI	area of investigation	BTV	background threshold value	COPEC	constituent of potential ecological concern
AP	armor piercing	BW	biological warfare; body weight	CPOM	coarse particulate organic matter
APEC	areas of potential ecological concern	BZ	breathing zone; 3-quinuclidinyl benzilate	CPSS	chemicals present in site samples
APT	armor-piercing tracer	C	ceiling limit value	CQCSM	Contract Quality Control System Manager
AR	analysis request	Ca	carcinogen	CRDL	contract-required detection limit
ARAR	applicable or relevant and appropriate requirement	CaCO ₃	calcium carbonate	CRL	certified reporting limit
AREE	area requiring environmental evaluation	CAA	Clean Air Act	CRQL	contract-required quantitation limit
AS/SVE	air sparging/soil vapor extraction	CAB	chemical warfare agent breakdown products	CRZ	contamination reduction zone
ASP	Ammunition Supply Point	CACM	Chemical Agent Contaminated Media	Cs-137	cesium-137
ASR	Archives Search Report			CS	ortho-chlorobenzylidene-malononitrile

List of Abbreviations and Acronyms (Continued)

CSEM	conceptual site exposure model	EB	equipment blank	FedEx	Federal Express, Inc.
CSM	conceptual site model	EBC	Eastern Bypass Corridor	FEMA	Federal Emergency Management Agency
CT	central tendency	EBS	environmental baseline survey	FFCA	Federal Facilities Compliance Act
CT	carbon tetrachloride	EBV	EBV Explosives Environmental Co.	FFE	field flame expedient
ctr.	container	EC ₂₀	effects concentration for 20 percent of a test population	FFS	focused feasibility study
CWA	chemical warfare agent; Clean Water Act	EC ₅₀	effects concentration for 50 percent of a test population	FI	fraction of exposure
CWM	chemical warfare materiel; clear, wide mouth	ECBC	Edgewood Chemical Biological Center	Fil	filtered
CX	dichloroformoxime	ED	exposure duration	Flt	filtered
'D'	duplicate; dilution	EDD	electronic data deliverable	FMDC	Fort McClellan Development Commission
D&I	detection and identification	EF	exposure frequency	FML	flexible membrane liner
DAAMS	depot area agent monitoring station	EDQL	ecological data quality level	f _{oc}	fraction organic carbon
DAF	dilution-attenuation factor	EE/CA	engineering evaluation and cost analysis	FOMRA	Former Ordnance Motor Repair Area
DANC	decontamination agent, non-corrosive	Eh	oxidation-reduction potential	FOST	Finding of Suitability to Transfer
°C	degrees Celsius	Elev.	elevation	Foster Wheeler	Foster Wheeler Environmental Corporation
°F	degrees Fahrenheit	EM	electromagnetic	FR	Federal Register
DCA	dichloroethane	EMI	Environmental Management Inc.	Frtn	fraction
DCE	dichloroethene	EM31	Geonics Limited EM31 Terrain Conductivity Meter	FS	field split; feasibility study; fuming sulfuric acid
DD	Defense Department	EM61	Geonics Limited EM61 High-Resolution Metal Detector	FSP	field sampling plan
DDD	dichlorodiphenyldichloroethane	EOD	explosive ordnance disposal	ft	feet
DDE	dichlorodiphenyldichloroethene	EODT	explosive ordnance disposal team	ft/day	feet per day
DDT	dichlorodiphenyltrichloroethane	EPA	U.S. Environmental Protection Agency	ft/ft	feet per foot
DEH	Directorate of Engineering and Housing	EPC	exposure point concentration	ft/yr	feet per year
DEHP	di(2-ethylhexyl)phthalate	EPIC	Environmental Photographic Interpretation Center	FTA	Fire Training Area
DEP	depositional soil	EPRI	Electrical Power Research Institute	FTMC	Fort McClellan
DFTPP	decafluorotriphenylphosphine	EPT	Ephemeroptera, Plecoptera, Trichoptera	FTRRA	FTMC Reuse & Redevelopment Authority
DI	deionized	ER	equipment rinsate	g	gram
DID	data item description	ERA	ecological risk assessment	g/m ³	gram per cubic meter
DIMP	di-isopropylmethylphosphonate	ER-L	effects range-low	G-856	Geometrics, Inc. G-856 magnetometer
DM	dry matter; adamsite	ER-M	effects range-medium	G-858G	Geometrics, Inc. G-858G magnetic gradiometer
DMBA	dimethylbenz(a)anthracene	ESE	Environmental Science and Engineering, Inc.	GAF	gastrointestinal absorption factor
DMMP	dimethylmethylphosphonate	ESL	ecological screening level	gal	gallon
DNAPL	dense nonaqueous-phase liquid	ESMP	Endangered Species Management Plan	gal/min	gallons per minute
DNT	dinitrotoluene	ESN	Environmental Services Network, Inc.	GB	sarin (isopropyl methylphosphonofluoridate)
DO	dissolved oxygen	ESV	ecological screening value	GC	gas chromatograph
DOD	U.S. Department of Defense	ET	exposure time	GCL	geosynthetic clay liner
DOJ	U.S. Department of Justice	EU	exposure unit	GC/MS	gas chromatograph/mass spectrometer
DOT	U.S. Department of Transportation	Exp.	Explosives	GCR	geosynthetic clay liner
DP	direct-push	EXTOXNET	Extension Toxicology Network	GFAA	graphite furnace atomic absorption
DPDO	Defense Property Disposal Office	E-W	east to west	GIS	Geographic Information System
DPT	direct-push technology	EZ	exclusion zone	gm	silty gravels; gravel-sand-silt mixtures
DQO	data quality objective	FAR	Federal Acquisition Regulations	gp	poorly graded gravels; gravel-sand mixtures
DRMO	Defense Reutilization and Marketing Office	FB	field blank	gpm	gallons per minute
DRO	diesel range organics	FBI	Family Biotic Index	GPR	ground-penetrating radar
DS	deep (subsurface) soil	FD	field duplicate	GPS	global positioning system
DS2	Decontamination Solution Number 2	FDC	Former Decontamination Complex	GRA	general response action
DSERTS	Defense Site Environmental Restoration Tracking System	FDA	U.S. Food and Drug Administration	GS	ground scar
DWEL	drinking water equivalent level	Fe ⁺³	ferric iron	GSA	General Services Administration; Geologic Survey of Alabama
E&E	Ecology and Environment, Inc.	Fe ⁺²	ferrous iron		

List of Abbreviations and Acronyms (Continued)

GSBP	Ground Scar Boiler Plant	IP	ionization potential	MCS	media cleanup standard
GSSI	Geophysical Survey Systems, Inc.	IPS	International Pipe Standard	MD	matrix duplicate
GST	ground stain	IR	ingestion rate	MDC	maximum detected concentration
GW	groundwater	IRDMIS	Installation Restoration Data Management Information System	MDCC	maximum detected constituent concentration
gw	well-graded gravels; gravel-sand mixtures	IRIS	Integrated Risk Information Service	MDL	method detection limit
H&S	health and safety	IRP	Installation Restoration Program	m	meter
HA	hand auger	IS	internal standard	mg	milligrams
HC	mixture of hexachloroethane, aluminum powder, and zinc oxide (smoke producer)	ISCP	Installation Spill Contingency Plan	mg/kg	milligrams per kilogram
HCl	hydrochloric acid	IT	IT Corporation	mg/kg/day	milligram per kilogram per day
HD	distilled mustard (bis-[dichloroethyl]sulfide)	ITEMS	IT Environmental Management System™	mg/kgbw/day	milligrams per kilogram of body weight per day
HDPE	high-density polyethylene	ITRC	Interstate Trade and Regulatory Council	mg/L	milligrams per liter
HE	high explosive	IWWP	installation-wide work plan	mg/m ³	milligrams per cubic meter
HEAST	Health Effects Assessment Summary Tables	'J'	estimated concentration	mh	inorganic silts, micaceous or diatomaceous fine, sandy or silt soils
Herb.	herbicides	JeB2	Jefferson gravelly fine sandy loam, 2 to 6 percent slopes, eroded	MHz	megahertz
HHRA	human health risk assessment	JeC2	Jefferson gravelly fine sandy loam, 6 to 10 percent slopes, eroded	m/yr	meters per year
HI	hazard index	JfB	Jefferson stony fine sandy loam, 0 to 10 percent slopes have strong slopes	µg/g	micrograms per gram
HN	hydrogen mustard	JPA	Joint Powers Authority	µg/kg	micrograms per kilogram
H ₂ O ₂	hydrogen peroxide	K	conductivity	µg/L	micrograms per liter
HPLC	high-performance liquid chromatography	K _d	soil-water distribution coefficient	µmhos/cm	micromhos per centimeter
HNO ₃	nitric acid	kg	kilogram	MEC	munitions and explosives of concern
HQ	hazard quotient	KeV	kilo electron volt	MeV	mega electron volt
HQ _{screen}	screening-level hazard quotient	K _{oc}	organic carbon partitioning coefficient	min	minimum
hr	hour	K _{ow}	octonal-water partition coefficient	MINICAMS	miniature continuous air monitoring system
HRC	hydrogen releasing compound	KMnO ₄	potassium permanganate	ml	inorganic silts and very fine sands
HSA	hollow-stem auger	L	liter; Lewisite (dichloro-[2-chloroethyl]sulfide)	mL	milliliter
HSDB	Hazardous Substance Data Bank	L/kg/day	liters per kilogram per day	mm	millimeter
HTRW	hazardous, toxic, and radioactive waste	l	liter	MM	mounded material
'I'	out of control, data rejected due to low recovery	LAW	light anti-tank weapon	MMBtu/hr	million Btu per hour
IASPOW	Impact Area South of POW Training Facility	lb	pound	MNA	monitored natural attenuation
IATA	International Air Transport Authority	LBP	lead-based paint	MnO ₄ -	permanganate ion
ICAL	initial calibration	LC	liquid chromatography	MOA	Memorandum of Agreement
ICB	initial calibration blank	LCS	laboratory control sample	MOGAS	motor vehicle gasoline
ICP	inductively-coupled plasma	LC ₅₀	lethal concentration for 50 percent population tested	MOUT	Military Operations in Urban Terrain
ICRP	International Commission on Radiological Protection	LD ₅₀	lethal dose for 50 percent population tested	MP	Military Police
ICS	interference check sample	LEL	lower explosive limit	MPA	methyl phosphonic acid
ID	inside diameter	LOAEL	lowest-observed-adverse-effects-level	MPC	maximum permissible concentration
IDL	instrument detection limit	LOEC	lowest-observable-effect-concentration	MPM	most probable munition
IDLH	immediately dangerous to life or health	LRA	land redevelopment authority	MQL	method quantitation limit
IDM	investigative-derived media	LT	less than the certified reporting limit	MR	molasses residue
IDW	investigation-derived waste	LUC	land-use control	MRL	method reporting limit
IEUBK	Integrated Exposure Uptake Biokinetic	LUCAP	land-use control assurance plan	MS	matrix spike
IF	ingestion factor; inhalation factor	LUCIP	land-use control implementation plan	mS/cm	millisiemens per centimeter
ILCR	incremental lifetime cancer risk	max	maximum	mS/m	millisiemens per meter
IMPA	isopropylmethyl phosphonic acid	MB	method blank	MSD	matrix spike duplicate; minimum separation distance
IMR	Iron Mountain Road	MCL	maximum contaminant level	MTBE	methyl tertiary butyl ether
in.	inch	MCLG	maximum contaminant level goal	msl	mean sea level
Ing	ingestion	MCPA	4-chloro-2-methylphenoxyacetic acid	MtD3	Montevallo shaly, silty clay loam, 10 to 40 percent slopes, severely eroded
Inh	inhalation	MCPP	2-(2-methyl-4-chlorophenoxy)propionic acid	mV	millivolts

List of Abbreviations and Acronyms (Continued)

MW	monitoring well	O&G	oil and grease	ppbv	parts per billion by volume
MWI&MP	Monitoring Well Installation and Management Plan	O&M	operation and maintenance	PPE	personal protective equipment
Na	sodium	OB/OD	open burning/open detonation	ppm	parts per million
NA	not applicable; not available	OD	outside diameter	PPMP	Print Plant Motor Pool
NAD	North American Datum	OE	ordnance and explosives	ppt	parts per thousand
NAD83	North American Datum of 1983	oh	organic clays of medium to high plasticity	PR	potential risk
NaMnO ₄	sodium permanganate	OH•	hydroxyl radical	PRA	preliminary risk assessment
NAVD88	North American Vertical Datum of 1988	ol	organic silts and organic silty clays of low plasticity	PRG	preliminary remediation goal
NAS	National Academy of Sciences	OP	organophosphorus	PS	chloropicrin
NCEA	National Center for Environmental Assessment	ORC	Oxygen Releasing Compound	PSSC	potential site-specific chemical
NCP	National Contingency Plan	ORP	oxidation-reduction potential	pt	peat or other highly organic silts
NCRP	National Council on Radiation Protection and Measurements	OSHA	Occupational Safety and Health Administration	PVC	polyvinyl chloride
ND	not detected	OSWER	Office of Solid Waste and Emergency Response	QA	quality assurance
NE	no evidence; northeast	OVM-PID/FID	organic vapor meter-photoionization detector/flame ionization detector	QA/QC	quality assurance/quality control
ne	not evaluated	OWS	oil/water separator	QAM	quality assurance manual
NEW	net explosive weight	oz	ounce	QAO	quality assurance officer
NFA	No Further Action	PA	preliminary assessment	QAP	installation-wide quality assurance plan
NG	National Guard	PAH	polynuclear aromatic hydrocarbon	QC	quality control
NGP	National Guardsperson	PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity	QST	QST Environmental, Inc.
ng/L	nanograms per liter	Parsons	Parsons Engineering Science, Inc.	qty	quantity
NGVD	National Geodetic Vertical Datum	Pb	lead	Qual	qualifier
Ni	nickel	PBMS	performance-based measurement system	QuickSilver	QuickSilver Analytics, Inc.
NIC	notice of intended change	PC	permeability coefficient	R	rejected data; resample; retardation factor
NIOSH	National Institute for Occupational Safety and Health	PCB	polychlorinated biphenyl	R ²	coefficient of determination
NIST	National Institute of Standards and Technology	PCDD	polychlorinated dibenzo-p-dioxins	R&A	relevant and appropriate
NLM	National Library of Medicine	PCDF	polychlorinated dibenzofurans	RA	remedial action
NO ₃ ⁻	nitrate	PCE	perchloroethene	RAO	remedial action objective
NOEC	no-observable-effect-concentration	PCP	pentachlorophenol	RBC	risk-based concentration; red blood cell
NPDES	National Pollutant Discharge Elimination System	PDS	Personnel Decontamination Station	RBP	Rapid Bioassessment Protocol
NPW	net present worth	PEF	particulate emission factor	RBRG	risk-based remedial goal
No.	number	PEL	permissible exposure limit	RCRA	Resource Conservation and Recovery Act
NOAA	National Oceanic and Atmospheric Administration	PERA	preliminary ecological risk assessment	RCWM	Recovered Chemical Warfare Material
NOAEL	no-observed-adverse-effects-level	PERC	perchloroethene	RD	remedial design
NR	not requested; not recorded; no risk	PES	potential explosive site	RDX	cyclotrimethylenetrinitramine
NRC	National Research Council	Pest.	pesticides	ReB3	Rarden silty clay loams
NRCC	National Research Council of Canada	PETN	pentaerythritoltetranitrate	REG	regular field sample
NRHP	National Register of Historic Places	PFT	portable flamethrower	REL	recommended exposure limit
NRT	near real time	PG	professional geologist	RFA	request for analysis
ns	nanosecond	PID	photoionization detector	RfC	reference concentration
N-S	north to south	PkA	Philo and Stendal soils local alluvium, 0 to 2 percent slopes	RfD	reference dose
NS	not surveyed	PM	project manager	RGO	remedial goal option
NSA	New South Associates, Inc.	POC	point of contact	RI	remedial investigation
nT	nanotesla	POL	petroleum, oils, and lubricants	RL	reporting limit
nT/m	nanoteslas per meter	POTW	publicly owned treatment works	RME	reasonable maximum exposure
NTU	nephelometric turbidity unit	POW	prisoner of war	ROD	Record of Decision
nv	not validated	PP	peristaltic pump; Proposed Plan	RPD	relative percent difference
O ₂	oxygen	ppb	parts per billion	RR	range residue
O ₃	ozone			RRF	relative response factor

List of Abbreviations and Acronyms (Continued)

RRSE	Relative Risk Site Evaluation	SS	surface soil	TR	target cancer risk
RSD	relative standard deviation	SSC	site-specific chemical	TRADOC	U.S. Army Training and Doctrine Command
RTC	Recruiting Training Center	SSHO	site safety and health officer	TRPH	total recoverable petroleum hydrocarbons
RTECS	Registry of Toxic Effects of Chemical Substances	SSHP	site-specific safety and health plan	TRV	toxicity reference value
RTK	real-time kinematic	SSL	soil screening level	TSCA	Toxic Substances Control Act
RWIMR	Ranges West of Iron Mountain Road	SSSL	site-specific screening level	TSDF	treatment, storage, and disposal facility
SA	exposed skin surface area	SSSSL	site-specific soil screening level	TSS	total suspended solids
SAD	South Atlantic Division	STB	supertropical bleach	TWA	time-weighted average
SAE	Society of Automotive Engineers	STC	source-term concentration	UCL	upper confidence limit
SAIC	Science Applications International Corporation	STD	standard deviation	UCR	upper certified range
SAP	installation-wide sampling and analysis plan	STEL	short-term exposure limit	'U'	not detected above reporting limit
SARA	Superfund Amendments and Reauthorization Act	STL	Severn-Trent Laboratories	UIC	underground injection control
sc	clayey sands; sand-clay mixtures	STOLS	Surface Towed Ordnance Locator System®	UF	uncertainty factor
Sch.	schedule	Std. units	standard units	URF	unit risk factor
SCM	site conceptual model	SU	standard unit	USACE	U.S. Army Corps of Engineers
SD	sediment	SUXOS	senior UXO supervisor	USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
SDG	sample delivery group	SVOC	semivolatile organic compound	USAEC	U.S. Army Environmental Center
SDWA	Safe Drinking Water Act	SW	surface water	USAEHA	U.S. Army Environmental Hygiene Agency
SDZ	safe distance zone; surface danger zone	SW-846	U.S. EPA's <i>Test Methods for Evaluating Solid Waste: Physical/Chemical Methods</i>	USACMLS	U.S. Army Chemical School
SEMS	Southern Environmental Management & Specialties, Inc.	SWMU	solid waste management unit	USAMPS	U.S. Army Military Police School
SF	cancer slope factor	SWPP	storm water pollution prevention plan	USATCES	U.S. Army Technical Center for Explosive Safety
SFSP	site-specific field sampling plan	SZ	support zone	USATEU	U.S. Army Technical Escort Unit
SGF	standard grade fuels	TAL	target analyte list	USATHAMA	U.S. Army Toxic and Hazardous Material Agency
Shaw	Shaw Environmental, Inc.	TAT	turn around time	USC	United States Code
SHP	installation-wide safety and health plan	TB	trip blank	USCS	Unified Soil Classification System
SI	site investigation	TBC	to be considered	USDA	U.S. Department of Agriculture
SINA	Special Interest Natural Area	TCA	trichloroethane	USEPA	U.S. Environmental Protection Agency
SL	standing liquid	TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin	USFWS	U.S. Fish and Wildlife Service
SLERA	screening-level ecological risk assessment	TCDF	tetrachlorodibenzofurans	USGS	U.S. Geological Survey
sm	silty sands; sand-silt mixtures	TCE	trichloroethene	UST	underground storage tank
SM	<i>Serratia marcescens</i>	TCL	target compound list	UTL	upper tolerance level; upper tolerance limit
SMDP	Scientific Management Decision Point	TCLP	toxicity characteristic leaching procedure	UXO	unexploded ordnance
s/n	signal-to-noise ratio	TDEC	Tennessee Department of Environment and Conservation	UXOQCS	UXO Quality Control Supervisor
SO ₄ ⁻²	sulfate	TDGCL	thiodiglycol	UXOSO	UXO safety officer
SOD	soil oxidant demand	TDGCLA	thiodiglycol chloroacetic acid	V	vanadium
SOP	standard operating procedure	TEA	triethylaluminum	VC	vinyl chloride
SOPQAM	U.S. EPA's <i>Standard Operating Procedure/Quality Assurance Manual</i>	TeCA	1,1,2,2-tetrachloroethane	VOA	volatile organic analyte
sp	poorly graded sands; gravelly sands	Tetryl	trinitrophenylmethyl nitramine	VOC	volatile organic compound
SP	submersible pump	TERC	Total Environmental Restoration Contract	VOH	volatile organic hydrocarbon
SPCC	system performance calibration compound	TEU	Technical Escort Unit	VQlfr	validation qualifier
SPCS	State Plane Coordinate System	THI	target hazard index	VQual	validation qualifier
SPM	sample planning module	TIC	tentatively identified compound	VX	nerve agent (O-ethyl-S-[diisopropylaminoethyl]-methylphosphonothiolate)
SQRT	screening quick reference tables	TLV	threshold limit value	WAC	Women's Army Corps
Sr-90	strontium-90	TN	Tennessee	Weston	Roy F. Weston, Inc.
SRA	streamlined human health risk assessment	TNB	trinitrobenzene	WP	white phosphorus
SRI	supplemental remedial investigation	TNT	trinitrotoluene	WRS	Wilcoxon rank sum
SRM	standard reference material	TOC	top of casing; total organic carbon	WS	watershed
Ss	stony rough land, sandstone series	TPH	total petroleum hydrocarbons	WSA	Watershed Screening Assessment

List of Abbreviations and Acronyms (Continued)

WWI	World War I
WWII	World War II
XRF	x-ray fluorescence
yd ³	cubic yards
ZVI	zero-valent iron

TABLES

Table 2-1

Constituents of Potential Ecological Concern in Surface Soil^a
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama

(Page 1 of 2)

Constituents	Background Threshold Value ^b (mg/kg)	Ecological Screening Value ^c (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
Metals									
Aluminum	1.63E+04	5.00E+01	3.85E+04	4.52E+03	1.33E+04	110 / 110	770	265.9	YES ^{5,7}
Antimony	1.99E+00	3.50E+00	3.19E+02	4.04E+00	5.65E+00	9 / 110	91	1.6	YES
Arsenic	1.37E+01	1.00E+01	1.02E+01	3.37E-01	3.53E+00	109 / 109	1.02	0.35	3,4
Barium	1.24E+02	1.65E+02	3.75E+02	1.60E+01	9.37E+01	109 / 110	2.27	0.57	YES ^{5,7}
Beryllium	8.00E-01	1.10E+00	2.35E+00	1.81E-01	6.38E-01	96 / 106	2.14	0.58	YES ^{5,7}
Cadmium	2.90E-01	1.60E+00	1.70E+00	1.70E+00	2.40E-01	1 / 110	1.06	0.15	YES ^{5,7}
Calcium	1.72E+03	NA	1.71E+04	5.30E+01	6.72E+02	106 / 109	ND	ND	2,5
Chromium	3.70E+01	4.00E-01	1.09E+02	3.89E+00	1.45E+01	110 / 110	273	36.2	YES ^{5,7}
Cobalt	1.52E+01	2.00E+01	4.18E+01	6.79E-01	7.51E+00	101 / 107	2.09	0.38	YES ^{5,7}
Copper	1.27E+01	4.00E+01	3.43E+02	3.64E+00	3.49E+01	110 / 110	8.58	0.87	YES
Iron	3.42E+04	2.00E+02	8.15E+04	4.53E+03	1.95E+04	110 / 110	408	97.7	YES ^{5,7}
Lead	4.01E+01	5.00E+01	1.09E+05	5.80E+00	1.21E+03	110 / 110	2180	24.2	YES
Magnesium	1.03E+03	4.40E+05	4.21E+03	1.60E+02	6.79E+02	106 / 110	0.0096	0.0015	1,2,5
Manganese	1.58E+03	1.00E+02	2.76E+03	2.41E+01	4.00E+02	110 / 110	28	4.0	4
Mercury	8.00E-02	1.00E-01	2.88E-01	2.50E-02	4.21E-02	73 / 105	2.88	0.42	YES ⁷
Nickel	1.03E+01	3.00E+01	3.77E+01	1.40E+00	6.68E+00	103 / 104	1.26	0.22	YES ⁷
Potassium	8.00E+02	NA	4.40E+03	1.66E+02	1.33E+03	84 / 90	ND	ND	2,5
Selenium	4.80E-01	8.10E-01	2.40E+00	4.66E-01	5.82E-01	30 / 92	2.96	0.72	YES ^{5,7}
Silver	3.60E-01	2.00E+00	5.87E-01	5.00E-01	5.34E-01	4 / 110	0.29	0.27	1,4
Sodium	6.34E+02	NA	1.32E+02	2.38E+01	5.17E+01	58 / 97	ND	ND	2,3
Thallium	3.43E+00	1.00E+00	2.36E+00	4.20E-01	4.59E-01	9 / 108	2.36	0.46	3
Vanadium	5.88E+01	2.00E+00	4.31E+01	6.62E+00	1.74E+01	107 / 110	22	8.7	3
Zinc	4.06E+01	5.00E+01	3.44E+02	1.03E+01	3.91E+01	106 / 106	6.88	0.78	YES
Chlorinated Pesticides									
4,4'-DDE	NA	2.50E-03	7.00E-04	7.00E-04	1.49E-03	1 / 16	0.28	0.60	1
alpha-BHC	NA	2.50E-03	2.10E-03	2.10E-03	1.80E-03	1 / 16	0.84	0.72	1
Endrin aldehyde	NA	1.05E-02	1.00E-03	1.00E-03	1.57E-03	1 / 16	0.10	0.15	1
Endrin ketone	NA	1.05E-02	1.30E-03	1.30E-03	1.60E-03	1 / 16	0.12	0.15	1
Nitroaromatics									
2,4-Dinitrotoluene	NA	1.28E+00	1.20E+00	1.20E+00	5.68E-02	1 / 62	0.94	0.044	1

Table 2-1

**Constituents of Potential Ecological Concern in Surface Soil^a
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 2 of 2)

Constituents	Background Threshold Value ^b (mg/kg)	Ecological Screening Value ^c (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
Semivolatile Organic Compounds									
2,4-Dinitrotoluene	NA	1.28E+00	8.60E-01	8.60E-01	9.31E-02	1 / 62	0.67	0.073	1
2-Methylnaphthalene	NA	NA	2.10E-01	2.10E-01	1.15E-01	1 / 81	ND	ND	6
Bis(2-Ethylhexyl)phthalate	NA	9.26E-01	6.00E-02	6.00E-02	8.85E-02	1 / 73	0.065	0.10	1
Butyl benzyl phthalate	NA	2.39E-01	4.20E-02	4.20E-02	1.00E-01	1 / 81	0.18	0.42	1
N-Nitrosodiphenylamine	NA	2.00E+01	5.50E-01	5.50E-01	1.05E-01	1 / 81	0.028	0.005	1
Phenanthrene	NA	1.00E-01	1.90E-01	1.90E-01	9.96E-02	1 / 81	1.90	1.00	YES ⁷
Volatile Organic Compounds									
1,2,4-Trimethylbenzene	NA	1.00E-01	3.50E-03	3.50E-03	1.34E-03	1 / 44	0.035	0.013	1
2-Butanone	NA	8.96E+01	2.30E-02	2.90E-03	4.99E-03	9 / 37	0.00026	0.00006	1
Acetone	NA	2.50E+00	1.40E+00	5.10E-02	2.40E-01	24 / 24	0.56	0.10	1
Bromomethane	NA	NA	3.40E-03	3.40E-03	1.55E-03	1 / 27	ND	ND	6
Chloroform	NA	1.00E-03	3.20E-01	1.90E-03	8.67E-03	2 / 44	320	8.67	YES ⁷
Cis-1,2-Dichloroethene	NA	1.00E-01	8.30E-03	8.30E-03	1.43E-03	1 / 44	0.083	0.014	1
Ethylbenzene	NA	5.00E-02	7.00E-03	7.00E-03	1.42E-03	1 / 44	0.14	0.028	1
m,p-Xylenes	NA	5.00E-02	7.00E-02	7.00E-02	3.03E-03	1 / 44	1.40	0.061	YES ⁷
Naphthalene	NA	1.00E-01	1.10E-03	1.10E-03	2.13E-03	1 / 44	0.011	0.021	1
p-Cymene	NA	NA	1.80E-02	1.20E-03	1.69E-03	6 / 44	ND	ND	6
Styrene	NA	1.00E-01	8.90E-04	8.90E-04	1.34E-03	1 / 44	0.009	0.013	1
Toluene	NA	5.00E-02	6.30E-03	6.70E-04	1.38E-03	12 / 44	0.13	0.028	1
Trichlorofluoromethane	NA	1.00E-01	2.00E-01	2.20E-03	7.09E-03	3 / 44	2.00	0.071	YES ⁷
Chemical Agent Breakdown									
Methylphosphonic Acid	NA	NA	6.20E-02	6.20E-02	2.94E-02	1 / 8	ND	ND	6

^a Surface soil at the T-24A Ranges is defined as the interval from 0 to 0.5 feet below ground surface.

^b Background threshold value is two times (2x) the arithmetic mean of background metals (SAIC, 1998). For SVOCs, the BTV is the background screening value for soils adjacent to asphalt as given in IT Corporation (IT), 2000, *Final Human Health and Ecological Screening Values and PAH Background Summary Report, Fort McClellan, Calhoun County, Alabama*, July.

^c Ecological Screening Values (ESV) are presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000).

NA - Not available.

ND - Not determined.

Rationale for exclusion as a COPEC:

- 1 - Maximum detected concentration is less than ESV
- 2 - Essential macro-nutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentrations).
- 3 - Maximum detected concentration is less than the background threshold value (BTV).
- 4 - Slippage Test and Wilcoxon Rank Sum Test indicate the concentration of this constituent is statistically similar to background concentrations.
- 5 - Geochemical evaluation of the data indicate that this constituent is naturally occurring.
- 6 - No ESV available; however, maximum detected concentration of this constituent is less than ESV for similar compounds.
- 7 - Additional lines of evidence indicate that this constituent may not be a COPEC (see text).

Table 2-2

**Constituents of Potential Ecological Concern in Surface Water
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 1 of 2)

Constituents	Background Threshold Value ^a (mg/L)	Ecological Screening Value ^b (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Mean Detected Conc. (mg/L)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
Metals									
Aluminum	5.26E+00	8.70E-02	6.43E+01	4.71E-02	8.53E+00	8 / 8	739.1	98.1	YES ^{5,7}
Antimony	NA	1.60E-01	3.00E-02	2.77E-02	2.39E-02	2 / 11	0.19	0.15	1,5
Arsenic	2.17E-03	1.90E-01	9.05E-03	2.41E-03	3.75E-03	2 / 11	0.048	0.020	1,5
Barium	7.54E-02	3.90E-03	4.91E-01	1.31E-02	7.89E-02	11 / 11	125.9	20.2	YES ^{5,7}
Beryllium	3.90E-04	5.30E-04	2.24E-03	2.24E-03	1.48E-03	1 / 11	4.23	2.79	YES ^{5,7}
Calcium	2.52E+01	1.16E+02	8.75E+01	2.94E-01	9.15E+00	11 / 11	0.75	0.079	1,2,5
Chromium	1.11E-02	1.10E-02	4.07E-02	5.34E-03	8.65E-03	3 / 11	3.70	0.79	YES ^{5,7}
Cobalt	NA	3.00E-03	1.81E-02	1.81E-02	1.51E-02	1 / 11	6.03	5.03	4,5,7
Copper	1.27E-02	6.54E-03	1.07E-01	3.25E-03	1.85E-02	3 / 10	16.36	2.83	YES
Iron	1.96E+01	1.00E+00	4.56E+01	3.25E-02	5.26E+00	11 / 11	45.6	5.26	4
Lead	8.67E-03	1.32E-03	4.31E-01	1.18E-02	4.48E-02	3 / 11	326.5	33.9	YES
Magnesium	1.10E+01	8.20E+01	8.10E+00	3.41E-01	1.88E+00	11 / 11	0.10	0.023	1,2,3
Manganese	5.65E-01	8.00E-02	9.49E-01	3.35E-03	1.27E-01	11 / 11	11.9	1.58	4
Mercury	NA	3.00E-06	6.60E-05	6.30E-05	7.08E-05	3 / 11	22.0	23.6	4,5,7
Nickel	2.25E-02	8.77E-02	3.00E-02	1.04E-02	1.52E-02	3 / 11	0.34	0.17	1,4
Potassium	2.56E+00	5.30E+01	1.38E+01	1.40E+00	3.60E+00	7 / 11	0.26	0.07	1,2,5
Selenium	NA	5.00E-03	2.60E-03	2.60E-03	1.74E-03	1 / 11	0.52	0.35	1,4
Sodium	3.44E+00	6.80E+02	3.97E+00	1.23E+00	1.82E+00	10 / 10	0.0058	0.0027	1,2,5
Vanadium	1.52E-02	1.90E-02	6.62E-02	5.20E-03	1.64E-02	2 / 11	3.48	0.87	YES ^{5,7}
Zinc	4.04E-02	5.89E-02	3.27E-01	5.88E-03	6.62E-02	4 / 6	5.55	1.12	YES
Semivolatile Organic Compounds									
2-Methylphenol	NA	4.89E-01	9.50E-03	9.50E-03	3.57E-03	1 / 11	0.019	0.0073	1
4-Methylphenol	NA	4.89E-01	1.00E-01	1.00E-01	1.19E-02	1 / 11	0.204	0.024	1
Bis(2-Ethylhexyl)phthalate	NA	3.00E-04	1.60E-02	8.50E-03	5.00E-03	2 / 11	53.3	16.7	YES ⁷
Volatile Organic Compounds									
2-Butanone	NA	7.10E+00	3.20E-02	3.20E-02	8.13E-03	1 / 6	0.0045	0.0011	1
Acetone	NA	7.80E+01	1.70E-02	1.70E-02	1.70E-02	1 / 1	0.00022	0.00022	1
Toluene	NA	1.75E-01	1.30E-02	1.30E-02	1.63E-03	1 / 11	0.074	0.0093	1

Table 2-2

Constituents of Potential Ecological Concern in Surface Water Ranges Near Training Area T-24A Fort McClellan, Calhoun County, Alabama

(Page 2 of 2)

^a Background threshold value is two times (2x) the arithmetic mean of background metals (SAIC, 1998).

^b Ecological Screening Values (ESV) are presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000).

NA - Not available.

ND - Not determined.

Rationale for exclusion as a COPEC:

- 1 - Maximum detected concentration is less than ESV
- 2 - Essential macro-nutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentrations).
- 3 - Maximum detected concentration is less than the background threshold value (BTV).
- 4 - Slippage Test and Wilcoxon Rank Sum Test indicate the concentration of this constituent is statistically similar to background concentrations.
- 5 - Geochemical evaluation of the data indicate that this constituent is naturally occurring.
- 6 - No ESV available; however, maximum detected concentration of this constituent is less than ESV for similar compounds.
- 7 - Additional lines of evidence indicate that this constituent may not be a COPEC (see text).

Table 2-3

**Constituents of Potential Ecological Concern in Sediment
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 1 of 2)

Constituents	Background Threshold Value ^a (mg/kg)	Ecological Screening Value ^b (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
Metals									
Aluminum	8.59E+03	NA	1.20E+04	5.56E+03	8.30E+03	11 / 11	ND	ND	YES ^{5,7}
Antimony	7.30E-01	1.20E+01	5.46E+00	5.46E+00	4.54E+00	1 / 11	0.46	0.38	1,5
Arsenic	1.13E+01	7.24E+00	9.20E+00	1.56E+00	4.42E+00	11 / 11	1.27	0.61	3
Barium	9.89E+01	NA	1.26E+02	4.13E+01	7.97E+01	11 / 11	ND	ND	YES ^{5,7}
Beryllium	9.70E-01	NA	2.40E+00	5.20E-01	9.40E-01	11 / 11	ND	ND	YES ^{5,7}
Calcium	1.11E+03	NA	1.03E+04	1.07E+02	1.25E+03	11 / 11	ND	ND	2,5
Chromium	3.12E+01	5.23E+01	2.89E+01	7.19E+00	1.61E+01	11 / 11	0.55	0.31	1,3
Cobalt	1.10E+01	5.00E+01	1.11E+01	2.74E+00	6.68E+00	10 / 11	0.22	0.13	1,5
Copper	1.71E+01	1.87E+01	3.57E+01	3.78E+00	1.74E+01	11 / 11	1.91	0.93	YES ^{5,7}
Iron	3.53E+04	2.00E+04	7.44E+04	7.14E+03	2.67E+04	11 / 11	3.72	1.34	YES ^{5,7}
Lead	3.78E+01	3.02E+01	1.56E+02	6.04E+00	4.86E+01	11 / 11	5.17	1.61	YES
Magnesium	9.06E+02	NA	5.21E+03	3.60E+02	9.04E+02	11 / 11	ND	ND	2,5
Manganese	7.12E+02	NA	6.17E+02	3.88E+01	2.83E+02	11 / 11	ND	ND	3
Mercury	1.10E-01	1.30E-01	2.10E-01	2.10E-01	4.05E-02	1 / 7	1.62	0.31	YES ^{5,7}
Nickel	1.30E+01	1.59E+01	2.77E+01	5.00E+00	9.82E+00	10 / 11	1.74	0.62	YES ^{5,7}
Potassium	1.01E+03	NA	3.41E+03	5.75E+02	2.06E+03	11 / 11	ND	ND	2,5
Selenium	7.20E-01	NA	1.00E+00	5.20E-01	4.94E-01	3 / 11	ND	ND	4
Sodium	6.92E+02	NA	2.27E+02	2.62E+01	5.17E+01	5 / 7	ND	ND	2,3
Thallium	1.30E-01	NA	1.20E+00	1.20E+00	7.39E-01	1 / 11	ND	ND	YES ⁷
Vanadium	4.09E+01	NA	2.41E+01	8.59E+00	1.64E+01	11 / 11	ND	ND	3
Zinc	5.27E+01	1.24E+02	1.86E+02	1.35E+01	4.80E+01	11 / 11	1.50	0.39	YES ^{5,7}
Semivolatile Organic Compounds									
Acenaphthylene	NA	3.30E-01	4.10E-02	4.10E-02	2.13E-01	1 / 11	0.12	0.65	1
Anthracene	NA	3.30E-01	6.80E-02	6.50E-02	1.93E-01	2 / 11	0.21	0.58	1
Benzo(a)anthracene	NA	3.30E-01	9.90E-01	2.20E-01	2.89E-01	2 / 11	3.00	0.87	YES
Benzo(a)pyrene	NA	3.30E-01	3.40E-01	1.70E-01	2.33E-01	2 / 11	1.03	0.71	1
Benzo(b)fluoranthene	NA	6.55E-01	6.80E-01	2.40E-01	2.83E-01	2 / 11	1.04	0.43	1
Benzo(ghi)perylene	NA	6.55E-01	1.20E-01	1.00E-01	1.95E-01	2 / 11	0.18	0.30	1
Benzo(k)fluoranthene	NA	6.55E-01	5.80E-01	2.10E-01	2.48E-01	2 / 11	0.89	0.38	1
Chrysene	NA	3.30E-01	9.80E-01	4.20E-01	3.14E-01	2 / 11	2.97	0.95	YES
Dibenz(a,h)anthracene	NA	3.30E-01	6.60E-02	5.00E-02	1.80E-01	2 / 11	0.20	0.54	1
Di-n-butyl phthalate	NA	1.11E-01	3.20E-01	1.90E-01	2.24E-01	2 / 11	2.88	2.01	YES ⁷
Fluoranthene	NA	3.30E-01	1.50E+00	3.00E-01	3.44E-01	2 / 11	4.55	1.04	YES
Indeno(1,2,3-cd)pyrene	NA	6.55E-01	1.20E-01	1.10E-01	1.89E-01	2 / 11	0.18	0.29	1
Phenanthrene	NA	3.30E-01	6.70E-02	6.70E-02	2.10E-01	1 / 11	0.20	0.64	1
Pyrene	NA	3.30E-01	2.00E+00	3.10E-01	3.97E-01	2 / 11	6.06	1.20	YES

Table 2-3

**Constituents of Potential Ecological Concern in Sediment
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 2 of 2)

Constituents	Background Threshold Value ^a (mg/kg)	Ecological Screening Value ^b (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
Volatile Organic Compounds									
2-Butanone	NA	1.37E-01	3.90E-02	5.70E-03	1.64E-02	6 / 11	0.28	0.12	1
Acetone	NA	4.53E-01	3.80E-01	3.70E-02	1.62E-01	9 / 9	0.84	0.36	1
Chloromethane	NA	7.85E-05	3.30E-03	3.30E-03	6.93E-03	1 / 11	42.0	88.2	YES⁷
Methylene chloride	NA	1.26E+00	2.30E-01	2.30E-01	2.30E-01	1 / 1	0.18	0.18	1
p-Cymene	NA	NA	2.40E-02	1.40E-03	6.90E-03	4 / 11	ND	ND	6
Toluene	NA	6.70E-01	4.40E-03	1.10E-03	3.79E-03	5 / 11	0.0066	0.0057	1
Chemical Agent Breakdown									
Thiodiglycol	NA	NA	3.20E-02	7.60E-03	1.32E-02	3 / 4	ND	ND	6

^a Background threshold value is two times (2x) the arithmetic mean of background metals (SAIC, 1998).

^b Ecological Screening Values (ESV) are presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000).

NA - Not available.

ND - Not determined.

Rationale for exclusion as a COPEC:

- 1 - Maximum detected concentration is less than ESV
- 2 - Essential macro-nutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentrations).
- 3 - Maximum detected concentration is less than the background threshold value (BTV).
- 4 - Slippage Test and Wilcoxon Rank Sum Test indicate the concentration of this constituent is statistically similar to background concentrations.
- 5 - Geochemical evaluation of the data indicate that this constituent is naturally occurring.
- 6 - No ESV available; however, maximum detected concentration of this constituent is less than ESV for similar compounds.
- 7 - Additional lines of evidence indicate that this constituent may not be a COPEC (see text).

Table 2-4

**Constituents of Potential Ecological Concern in Groundwater
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 1 of 2)

Constituents	Background Threshold Value ^a (mg/L)	Ecological Screening Value ^b (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Mean Detected Conc. (mg/L)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
Metals									
Aluminum	2.34E+00	8.70E-02	5.38E+00	5.00E-02	4.11E-01	29 / 37	61.8	4.73	YES ^{5,7}
Antimony	3.19E-03	1.60E-01	3.57E-02	3.09E-02	1.55E-02	2 / 38	0.22	0.097	1
Arsenic	1.78E-02	1.90E-01	2.98E-03	2.71E-03	1.39E-03	2 / 36	0.016	0.0073	1,3
Barium	1.27E-01	3.90E-03	3.14E+00	3.53E-03	1.30E-01	37 / 37	805.1	33.2	YES ⁷
Calcium	5.65E+01	1.16E+02	1.73E+02	1.02E-01	8.95E+00	38 / 38	1.49	0.077	2,5
Chromium	1.11E-02	1.10E-02	1.23E-02	3.40E-03	2.83E-03	4 / 38	1.12	0.26	YES ^{5,7}
Cobalt	2.34E-02	3.00E-03	2.21E-02	1.81E-02	6.79E-03	4 / 38	7.37	2.26	3
Copper	2.55E-02	6.54E-03	6.44E-03	3.39E-03	2.33E-03	7 / 35	0.98	0.36	1,3
Iron	7.04E+00	1.00E+00	1.17E+01	2.55E-02	2.32E+00	34 / 35	11.7	2.3	YES ^{5,7}
Lead	8.00E-03	1.32E-03	5.63E-03	1.61E-03	8.44E-04	2 / 35	4.27	0.64	3
Magnesium	2.13E+01	8.20E+01	2.89E+01	1.58E-01	3.91E+00	38 / 38	0.35	0.048	1,2,5
Manganese	5.81E-01	8.00E-02	2.29E+00	3.25E-03	5.08E-01	37 / 37	28.6	6.4	YES ^{5,7}
Mercury	NA	3.00E-06	2.46E-04	2.46E-04	7.01E-05	1 / 38	82.0	23.4	YES ^{5,7}
Nickel	2.25E-02	8.77E-02	3.08E-02	3.10E-03	7.49E-03	10 / 36	0.35	0.085	1,5
Potassium	7.20E+00	5.30E+01	1.52E+02	1.52E+00	1.02E+01	31 / 37	2.87	0.19	2,5
Selenium	NA	5.00E-03	5.06E-03	1.96E-03	1.32E-03	7 / 36	1.01	0.26	4
Silver	4.00E-03	1.20E-05	6.91E-03	6.91E-03	2.56E-03	1 / 33	575.8	213.2	4
Sodium	1.48E+01	6.80E+02	5.10E+01	7.91E-01	5.76E+00	37 / 37	0.075	0.0085	1,2,5
Vanadium	1.70E-02	1.90E-02	8.85E-03	8.85E-03	2.71E-03	1 / 38	0.47	0.14	1,3
Zinc	2.20E-01	5.89E-02	2.97E-01	4.20E-03	1.47E-02	12 / 35	5.04	0.25	4
Chemical Agent Breakdown									
Thiodiglycol	NA	NA	1.40E-02	1.40E-02	1.21E-03	1 / 37	ND	ND	6
Chlorinated Pesticides									
beta-BHC	NA	5.00E+01	2.70E-05	1.90E-05	2.47E-05	2 / 14	0.0000005	0.0000005	1
Nitroaromatics									
4-Amino-2,6-dinitrotoluene	NA	NA	7.80E-04	7.80E-04	1.19E-04	1 / 37	ND	ND	6
Semivolatile Organic Compounds									
Bis(2-Ethylhexyl)phthalate	NA	3.00E-04	4.30E-03	3.90E-03	1.66E-03	2 / 37	14.3	5.5	YES ⁷
Diethyl phthalate	NA	5.21E-01	2.50E-03	2.50E-03	1.31E-03	1 / 37	0.0048	0.0025	1
Phenol	NA	2.56E-01	1.30E-02	1.30E-02	1.24E-03	1 / 37	0.051	0.0048	1

Table 2-4

**Constituents of Potential Ecological Concern in Groundwater
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 2 of 2)

Constituents	Background Threshold Value ^a (mg/L)	Ecological Screening Value ^b (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Mean Detected Conc. (mg/L)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
Volatile Organic Compounds									
1,2,4-Trimethylbenzene	NA	NA	2.70E-03	1.10E-03	1.30E-04	2 / 61	ND	ND	6
1,2-Dimethylbenzene	NA	NA	3.70E-04	1.50E-04	6.80E-05	3 / 61	ND	ND	6
1,3,5-Trimethylbenzene	NA	NA	6.80E-04	6.80E-04	8.49E-05	1 / 61	ND	ND	6
2-Butanone	NA	7.10E+00	4.70E-02	1.10E-02	1.23E-02	4 / 11	0.0066	0.0017	1
2-Hexanone	NA	1.71E+00	1.90E-03	1.90E-03	5.25E-04	1 / 55	0.0011	0.0003	1
Acetone	NA	7.80E+01	5.10E-02	4.20E-02	6.01E-03	2 / 18	0.00065	0.00008	1
Benzene	NA	5.30E-02	9.70E-01	2.40E-04	1.60E-02	4 / 61	18.3	0.3	YES ⁷
Carbon disulfide	NA	8.40E-02	4.30E-03	2.20E-04	1.75E-04	8 / 59	0.051	0.0021	1
Carbon tetrachloride	NA	3.52E-01	3.80E-01	3.00E-03	6.92E-03	3 / 61	1.08	0.020	YES ⁷
Chloroform	NA	2.89E-01	1.70E-01	2.40E-04	3.08E-03	7 / 61	0.59	0.011	1
Chloromethane	NA	5.50E+00	1.10E-03	5.90E-04	2.34E-04	3 / 61	0.00020	0.00004	1
N-Propylbenzene	NA	NA	4.90E-04	4.90E-04	8.18E-05	1 / 61	ND	ND	6
p-Cymene	NA	NA	2.70E-04	2.70E-04	9.30E-05	1 / 61	ND	ND	6
sec-Butylbenzene	NA	NA	5.50E-04	5.50E-04	9.75E-05	1 / 61	ND	ND	6
tert-Butylbenzene	NA	NA	2.30E-04	2.30E-04	6.77E-05	1 / 61	ND	ND	6
Tetrachloroethene	NA	8.40E-02	6.40E-04	6.40E-04	9.90E-05	1 / 61	0.0076	0.0012	1
Toluene	NA	1.75E-01	1.40E-04	1.30E-04	6.28E-05	2 / 54	0.00080	0.00036	1

^a Background threshold value is two times (2x) the arithmetic mean of background metals (SAIC, 1998).

^b Ecological Screening Values (ESV) are presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000).

NA - Not available.

ND - Not determined.

Rationale for exclusion as a COPEC:

- 1 - Maximum detected concentration is less than ESV
- 2 - Essential macro-nutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentrations).
- 3 - Maximum detected concentration is less than the background threshold value (BTV).
- 4 - Slippage Test and Wilcoxon Rank Sum Test indicate the concentration of this constituent is statistically similar to background concentrations.
- 5 - Geochemical evaluation of the data indicate that this constituent is naturally occurring.
- 6 - No ESV available; however, maximum detected concentration of this constituent is less than ESV for similar compounds.
- 7 - Additional lines of evidence indicate that this constituent may not be a COPEC (see text).

Table 2-5

**Comparison of Soil ESVs to Eco-SSLs
Ranges Near Training Area T-24A
Fort McClellan, Alabama**

(Page 1 of 2)

Constituents	Background Threshold Value ^a (mg/kg)	Ecological Screening Value ^b (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Eco-SSL				
							Terrestrial Plants (mg/kg)	Terrestrial Inverts (mg/kg)	Avian Wildlife (mg/kg)	Mammalian Wildlife (mg/kg)	
Metals											
Aluminum	1.63E+04	5.00E+01	3.85E+04	4.52E+03	1.33E+04	110 / 110	NA	NA	NA	NA	
Antimony	1.99E+00	3.50E+00	3.19E+02	4.04E+00	5.65E+00	9 / 110	NA	78	NA	0.27	
Arsenic	1.37E+01	1.00E+01	1.02E+01	3.37E-01	3.53E+00	109 / 109	18	NA	43	46	
Barium	1.24E+02	1.65E+02	3.75E+02	1.60E+01	9.37E+01	109 / 110	NA	330	NA	2000	
Beryllium	8.00E-01	1.10E+00	2.35E+00	1.81E-01	6.38E-01	96 / 106	NA	40	NA	21	
Cadmium	2.90E-01	1.60E+00	1.70E+00	1.70E+00	2.40E-01	1 / 110	32	140	0.77	0.36	
Calcium	1.72E+03	NA	1.71E+04	5.30E+01	6.72E+02	106 / 109	NA	NA	NA	NA	
Chromium	3.70E+01	4.00E-01	1.09E+02	3.89E+00	1.45E+01	110 / 110	NA	NA	26	34	
Cobalt	1.52E+01	2.00E+01	4.18E+01	6.79E-01	7.51E+00	101 / 107	13	NA	120	230	
Copper	1.27E+01	4.00E+01	3.43E+02	3.64E+00	3.49E+01	110 / 110	70	80	28	49	
Iron	3.42E+04	2.00E+02	8.15E+04	4.53E+03	1.95E+04	110 / 110	NA	NA	NA	NA	
Lead	4.01E+01	5.00E+01	1.09E+05	5.80E+00	1.21E+03	110 / 110	120	1700	11	56	
Magnesium	1.03E+03	4.40E+05	4.21E+03	1.60E+02	6.79E+02	106 / 110	NA	NA	NA	NA	
Manganese	1.58E+03	1.00E+02	2.76E+03	2.41E+01	4.00E+02	110 / 110	220	450	4300	4000	
Mercury	8.00E-02	1.00E-01	2.88E-01	2.50E-02	4.21E-02	73 / 105	NA	NA	NA	NA	
Nickel	1.03E+01	3.00E+01	3.77E+01	1.40E+00	6.68E+00	103 / 104	38	280	210	130	
Potassium	8.00E+02	NA	4.40E+03	1.66E+02	1.33E+03	84 / 90	NA	NA	NA	NA	
Selenium	4.80E-01	8.10E-01	2.40E+00	4.66E-01	5.82E-01	30 / 92	0.52	4.1	1.2	0.63	
Silver	3.60E-01	2.00E+00	5.87E-01	5.00E-01	5.34E-01	4 / 110	560	NA	4.2	14	
Sodium	6.34E+02	NA	1.32E+02	2.38E+01	5.17E+01	58 / 97	NA	NA	NA	NA	
Thallium	3.43E+00	1.00E+00	2.36E+00	4.20E-01	4.59E-01	9 / 108	NA	NA	NA	NA	
Vanadium	5.88E+01	2.00E+00	4.31E+01	6.62E+00	1.74E+01	107 / 110	NA	NA	7.8	280	
Zinc	4.06E+01	5.00E+01	3.44E+02	1.03E+01	3.91E+01	106 / 106	160	120	46	79	
Chlorinated Pesticides											
4,4'-DDE	NA	2.50E-03	7.00E-04	7.00E-04	1.49E-03	1 / 16	NA	NA	0.093	0.021	
alpha-BHC	NA	2.50E-03	2.10E-03	2.10E-03	1.80E-03	1 / 16	NA	NA	NA	NA	
Endrin aldehyde	NA	1.05E-02	1.00E-03	1.00E-03	1.57E-03	1 / 16	NA	NA	NA	NA	
Endrin ketone	NA	1.05E-02	1.30E-03	1.30E-03	1.60E-03	1 / 16	NA	NA	NA	NA	
Nitroaromatics											
2,4-Dinitrotoluene	NA	1.28E+00	1.20E+00	1.20E+00	5.68E-02	1 / 62	NA	NA	NA	NA	

Table 2-5

**Comparison of Soil ESVs to Eco-SSLs
Ranges Near Training Area T-24A
Fort McClellan, Alabama**

(Page 2 of 2)

Constituents	Background Threshold Value ^a (mg/kg)	Ecological Screening Value ^b (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Eco-SSL				
							Terrestrial Plants (mg/kg)	Terrestrial Inverts (mg/kg)	Avian Wildlife (mg/kg)	Mammalian Wildlife (mg/kg)	
Semivolatile Organic Compounds											
2,4-Dinitrotoluene	NA	1.28E+00	8.60E-01	8.60E-01	9.31E-02	1 / 62	NA	NA	NA	NA	NA
2-Methylnaphthalene	NA	NA	2.10E-01	2.10E-01	1.15E-01	1 / 81	NA	NA	NA	NA	NA
Bis(2-Ethylhexyl)phthalate	NA	9.26E-01	6.00E-02	6.00E-02	8.85E-02	1 / 73	NA	NA	NA	NA	NA
Butyl benzyl phthalate	NA	2.39E-01	4.20E-02	4.20E-02	1.00E-01	1 / 81	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine	NA	2.00E+01	5.50E-01	5.50E-01	1.05E-01	1 / 81	NA	NA	NA	NA	NA
Phenanthrene	NA	1.00E-01	1.90E-01	1.90E-01	9.96E-02	1 / 81	NA	29	NA	NA	100
Volatile Organic Compounds											
1,2,4-Trimethylbenzene	NA	1.00E-01	3.50E-03	3.50E-03	1.34E-03	1 / 44	NA	NA	NA	NA	NA
2-Butanone	NA	8.96E+01	2.30E-02	2.90E-03	4.99E-03	9 / 37	NA	NA	NA	NA	NA
Acetone	NA	2.50E+00	1.40E+00	5.10E-02	2.40E-01	24 / 24	NA	NA	NA	NA	NA
Bromomethane	NA	NA	3.40E-03	3.40E-03	1.55E-03	1 / 27	NA	NA	NA	NA	NA
Chloroform	NA	1.00E-03	3.20E-01	1.90E-03	8.67E-03	2 / 44	NA	NA	NA	NA	NA
Cis-1,2-Dichloroethene	NA	1.00E-01	8.30E-03	8.30E-03	1.43E-03	1 / 44	NA	NA	NA	NA	NA
Ethylbenzene	NA	5.00E-02	7.00E-03	7.00E-03	1.42E-03	1 / 44	NA	NA	NA	NA	NA
m,p-Xylenes	NA	5.00E-02	7.00E-02	7.00E-02	3.03E-03	1 / 44	NA	NA	NA	NA	NA
Naphthalene	NA	1.00E-01	1.10E-03	1.10E-03	2.13E-03	1 / 44	NA	NA	NA	NA	NA
p-Cymene	NA	NA	1.80E-02	1.20E-03	1.69E-03	6 / 44	NA	NA	NA	NA	NA
Styrene	NA	1.00E-01	8.90E-04	8.90E-04	1.34E-03	1 / 44	NA	NA	NA	NA	NA
Toluene	NA	5.00E-02	6.30E-03	6.70E-04	1.38E-03	12 / 44	NA	NA	NA	NA	NA
Trichlorofluoromethane	NA	1.00E-01	2.00E-01	2.20E-03	7.09E-03	3 / 44	NA	NA	NA	NA	NA

^a Background threshold value is two times (2x) the arithmetic mean of background metals presented in *Background Metals Survey Report, Fort McClellan, Alabama* (SAIC, 1998).

^b Ecological Screening Values (ESV) are presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000).

Eco-SSL - ecological soil screening level.

mg/kg - milligrams per kilogram.

NA - Not available.

Table 2-6

**Comparison of Surface Water ESVs to Ambient Water Quality Criteria
Ranges Near Training Area T-24A
Fort McClellan, Alabama**

Constituents	Background Threshold Value ^a (mg/L)	Ecological Screening Value ^b (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Mean Detected Conc. (mg/L)	Frequency of Detection	Alabama Chronic AWQC ^c (mg/L)
Metals							
Aluminum	5.26E+00	8.70E-02	6.43E+01	4.71E-02	8.53E+00	8 / 8	NA
Antimony	NA	1.60E-01	3.00E-02	2.77E-02	2.39E-02	2 / 11	NA
Arsenic	2.17E-03	1.90E-01	9.05E-03	2.41E-03	3.75E-03	2 / 11	0.15
Barium	7.54E-02	3.90E-03	4.91E-01	1.31E-02	7.89E-02	11 / 11	NA
Beryllium	3.90E-04	5.30E-04	2.24E-03	2.24E-03	1.48E-03	1 / 11	NA
Calcium	2.52E+01	1.16E+02	8.75E+01	2.94E-01	9.15E+00	11 / 11	NA
Chromium	1.11E-02	1.10E-02	4.07E-02	5.34E-03	8.65E-03	3 / 11	0.0327
Cobalt	NA	3.00E-03	1.81E-02	1.81E-02	1.51E-02	1 / 11	NA
Copper	1.27E-02	6.54E-03	1.07E-01	3.25E-03	1.85E-02	3 / 10	0.0034
Iron	1.96E+01	1.00E+00	4.56E+01	3.25E-02	5.26E+00	11 / 11	NA
Lead	8.67E-03	1.32E-03	4.31E-01	1.18E-02	4.48E-02	3 / 11	0.0007
Magnesium	1.10E+01	8.20E+01	8.10E+00	3.41E-01	1.88E+00	11 / 11	NA
Manganese	5.65E-01	8.00E-02	9.49E-01	3.35E-03	1.27E-01	11 / 11	NA
Mercury	NA	3.00E-06	6.60E-05	6.30E-05	7.08E-05	3 / 11	0.000012
Nickel	2.25E-02	8.77E-02	3.00E-02	1.04E-02	1.52E-02	3 / 11	0.019
Potassium	2.56E+00	5.30E+01	1.38E+01	1.40E+00	3.60E+00	7 / 11	NA
Selenium	NA	5.00E-03	2.60E-03	2.60E-03	1.74E-03	1 / 11	0.005
Sodium	3.44E+00	6.80E+02	3.97E+00	1.23E+00	1.82E+00	10 / 10	NA
Vanadium	1.52E-02	1.90E-02	6.62E-02	5.20E-03	1.64E-02	2 / 11	NA
Zinc	4.04E-02	5.89E-02	3.27E-01	5.88E-03	6.62E-02	4 / 6	0.044
Semivolatile Organic Compounds							
2-Methylphenol	NA	4.89E-01	9.50E-03	9.50E-03	3.57E-03	1 / 11	NA
4-Methylphenol	NA	4.89E-01	1.00E-01	1.00E-01	1.19E-02	1 / 11	NA
Bis(2-Ethylhexyl)phthalate	NA	3.00E-04	1.60E-02	8.50E-03	5.00E-03	2 / 11	NA
Volatile Organic Compounds							
2-Butanone	NA	7.10E+00	3.20E-02	3.20E-02	8.13E-03	1 / 6	NA
Acetone	NA	7.80E+01	1.70E-02	1.70E-02	1.70E-02	1 / 1	NA
Toluene	NA	1.75E-01	1.30E-02	1.30E-02	1.63E-03	1 / 11	NA

^a Background threshold value is two times (2x) the arithmetic mean of background metals presented in *Background Metals Survey Report, Fort McClellan, Alabama* (SAIC, 1998).

^b Ecological Screening Values (ESV) are presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000).

^c Ambient water quality criteria (AWQC) calculated using the mean water hardness of surface water samples collected as part of the remedial investigation at the T-24A ranges (30.6 mg/L).

mg/L - milligrams per liter.

NA - Not available.

Table 2-7

**Comparison of Groundwater ESVs to Ambient Water Quality Criteria
Ranges Near Training Area T-24A
Fort McClellan, Alabama**

(Page 1 of 2)

Constituents	Background Threshold Value ^a (mg/L)	Ecological Screening Value ^b (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Mean Detected Conc. (mg/L)	Frequency of Detection	Alabama Chronic AWQC ^c (mg/L)
Metals							
Aluminum	2.34E+00	8.70E-02	5.38E+00	5.00E-02	4.11E-01	29 / 37	NA
Antimony	3.19E-03	1.60E-01	3.57E-02	3.09E-02	1.55E-02	2 / 38	NA
Arsenic	1.78E-02	1.90E-01	2.98E-03	2.71E-03	1.39E-03	2 / 36	0.15
Barium	1.27E-01	3.90E-03	3.14E+00	3.53E-03	1.30E-01	37 / 37	NA
Calcium	5.65E+01	1.16E+02	1.73E+02	1.02E-01	8.95E+00	38 / 38	NA
Chromium	1.11E-02	1.10E-02	1.23E-02	3.40E-03	2.83E-03	4 / 38	0.0327
Cobalt	2.34E-02	3.00E-03	2.21E-02	1.81E-02	6.79E-03	4 / 38	NA
Copper	2.55E-02	6.54E-03	6.44E-03	3.39E-03	2.33E-03	7 / 35	0.0034
Iron	7.04E+00	1.00E+00	1.17E+01	2.55E-02	2.32E+00	34 / 35	NA
Lead	8.00E-03	1.32E-03	5.63E-03	1.61E-03	8.44E-04	2 / 35	0.0007
Magnesium	2.13E+01	8.20E+01	2.89E+01	1.58E-01	3.91E+00	38 / 38	NA
Manganese	5.81E-01	8.00E-02	2.29E+00	3.25E-03	5.08E-01	37 / 37	NA
Mercury	NA	3.00E-06	2.46E-04	2.46E-04	7.01E-05	1 / 38	0.000012
Nickel	2.25E-02	8.77E-02	3.08E-02	3.10E-03	7.49E-03	10 / 36	0.019
Potassium	7.20E+00	5.30E+01	1.52E+02	1.52E+00	1.02E+01	31 / 37	NA
Selenium	NA	5.00E-03	5.06E-03	1.96E-03	1.32E-03	7 / 36	0.005
Silver	4.00E-03	1.20E-05	6.91E-03	6.91E-03	2.56E-03	1 / 33	NA
Sodium	1.48E+01	6.80E+02	5.10E+01	7.91E-01	5.76E+00	37 / 37	NA
Vanadium	1.70E-02	1.90E-02	8.85E-03	8.85E-03	2.71E-03	1 / 38	NA
Zinc	2.20E-01	5.89E-02	2.97E-01	4.20E-03	1.47E-02	12 / 35	0.044
Chemical Agent Breakdown							
Thiodiglycol	NA	NA	1.40E-02	1.40E-02	1.21E-03	1 / 37	NA
Chlorinated Pesticides							
beta-BHC	NA	5.00E+01	2.70E-05	1.90E-05	2.47E-05	2 / 14	NA
Nitroaromatics							
4-Amino-2,6-dinitrotoluene	NA	NA	7.80E-04	7.80E-04	1.19E-04	1 / 37	NA
Semivolatile Organic Compounds							
Bis(2-Ethylhexyl)phthalate	NA	3.00E-04	4.30E-03	3.90E-03	1.66E-03	2 / 37	NA
Diethyl phthalate	NA	5.21E-01	2.50E-03	2.50E-03	1.31E-03	1 / 37	NA
Phenol	NA	2.56E-01	1.30E-02	1.30E-02	1.24E-03	1 / 37	NA

Table 2-7

**Comparison of Groundwater ESVs to Ambient Water Quality Criteria
Ranges Near Training Area T-24A
Fort McClellan, Alabama**

(Page 2 of 2)

Constituents	Background Threshold Value ^a (mg/L)	Ecological Screening Value ^b (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Mean Detected Conc. (mg/L)	Frequency of Detection	Alabama Chronic AWQC ^c (mg/L)
Volatile Organic Compounds							
1,2,4-Trimethylbenzene	NA	NA	2.70E-03	1.10E-03	1.30E-04	2 / 61	NA
1,2-Dimethylbenzene	NA	NA	3.70E-04	1.50E-04	6.80E-05	3 / 61	NA
1,3,5-Trimethylbenzene	NA	NA	6.80E-04	6.80E-04	8.49E-05	1 / 61	NA
2-Butanone	NA	7.10E+00	4.70E-02	1.10E-02	1.23E-02	4 / 11	NA
2-Hexanone	NA	1.71E+00	1.90E-03	1.90E-03	5.25E-04	1 / 55	NA
Acetone	NA	7.80E+01	5.10E-02	4.20E-02	6.01E-03	2 / 18	NA
Benzene	NA	5.30E-02	9.70E-01	2.40E-04	1.60E-02	4 / 61	NA
Carbon disulfide	NA	8.40E-02	4.30E-03	2.20E-04	1.75E-04	8 / 59	NA
Carbon tetrachloride	NA	3.52E-01	3.80E-01	3.00E-03	6.92E-03	3 / 61	NA
Chloroform	NA	2.89E-01	1.70E-01	2.40E-04	3.08E-03	7 / 61	NA
Chloromethane	NA	5.50E+00	1.10E-03	5.90E-04	2.34E-04	3 / 61	NA
N-Propylbenzene	NA	NA	4.90E-04	4.90E-04	8.18E-05	1 / 61	NA
p-Cymene	NA	NA	2.70E-04	2.70E-04	9.30E-05	1 / 61	NA
sec-Butylbenzene	NA	NA	5.50E-04	5.50E-04	9.75E-05	1 / 61	NA
tert-Butylbenzene	NA	NA	2.30E-04	2.30E-04	6.77E-05	1 / 61	NA
Tetrachloroethene	NA	8.40E-02	6.40E-04	6.40E-04	9.90E-05	1 / 61	NA
Toluene	NA	1.75E-01	1.40E-04	1.30E-04	6.28E-05	2 / 54	NA

^a Background threshold value is two times (2x) the arithmetic mean of background metals presented in *Background Metals Survey Report, Fort McClellan, Alabama* (SAIC, 1998).

^b Ecological Screening Values (ESV) are presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000).

^c Ambient water quality criteria (AWQC) calculated using the mean water hardness of surface water samples collected as part of the remedial investigation at the T-24A ranges (30.6 mg/L).

mg/L - milligrams per liter.

NA - Not available.

Table 2-8

**Summary of COPECs Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

COPECs	Surface Soil	Surface Water	Sediment	Groundwater
Aluminum	O	O	O	O
Antimony	X			
Barium	O	O	O	O
Beryllium	O	O	O	
Cadmium	O			
Chromium	O	O		O
Cobalt	O			
Copper	X	X	O	
Iron	O		O	O
Lead	X	X	X	
Manganese				O
Mercury	O		O	O
Nickel	O		O	
Selenium	O			
Thallium			O	
Vanadium		O		
Zinc	X	X	O	
Benzene				O
Benzo(a)anthracene			X	
Bis(2-ethylhexyl)phthalate		O		O
Carbon Tetrachloride				O
Chrysene			X	
Di-n-butyl Phthalate			O	
Fluoranthene			X	
Phenanthrene	O			
Pyrene			X	
Total PAHs			X	
Chloroform	O			
Chloromethane			O	
Trichlorofluoromethane	O			
Xylenes	O			

O - HQ > 1.0; however, additional lines of evidence indicate that this constituent is not a COPEC
X - Constituent identified as a COPEC

Table 7-1

**Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 1 of 4)

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Terrestrial Ecosystems		
I. Survival and growth of the terrestrial plant communities at the T-24A Ranges.	I. Are concentrations of COPECs in surface soil at the T-24A Ranges greater than ESVs for the survival or growth of terrestrial plants?	I. Comparison of COPEC concentrations in surface soil at the T-24A Ranges to ESVs for the survival and growth of terrestrial plants.
II. Survival and growth of the terrestrial invertebrate communities at the T-24A Ranges.	IIA. Are concentrations of COPECs in surface soil at the T-24A Ranges greater than NOAEL and LOAELs for the survival and growth of terrestrial invertebrates derived in the IMR/BGR BERA?	IIA. Comparison of COPEC concentrations in surface soil at the T-24A Ranges to NOAELs and LOAELs for the survival and growth of terrestrial invertebrates derived in the IMR/BGR BERA.
	IIB. Are concentrations of COPECs in surface soil at the T-24A Ranges greater than ESVs for the survival or growth of terrestrial invertebrates?	IIB. Comparison of COPEC concentrations in surface soil at the T-24A Ranges to ESVs for the survival and growth of terrestrial invertebrates.
III. Survival, growth, and reproduction of terrestrial invertivorous small mammals and birds at the T-24A Ranges.	III. Does the daily dose of COPECs received by terrestrial invertivorous small mammals or birds via consumption of prey species and from other media at the T-24A Ranges exceed the toxicity reference values (TRVs) for survival, reproduction, or growth?	IIIA. Comparison of calculated daily doses of COPECs for terrestrial invertivorous small mammal (shorttail shrew) and invertivorous bird (American woodcock) to TRVs.
		IIIB. Quantification of COPEC concentrations in tissues of earthworms using soil-to-earthworm BAFs derived in the IMR/BGR BERA.

Table 7-1

**Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 2 of 4)

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Terrestrial Ecosystems		
IV. Survival, growth, and reproduction of terrestrial omnivorous small mammals and birds at the T-24A Ranges.	IV. Does the daily dose of COPECs received by terrestrial omnivorous small mammals or birds via consumption of prey species and from other media at the T-24A Ranges exceed the toxicity reference values (TRVs) for survival, reproduction, or growth?	IVA. Comparison of calculated daily doses of COPECs for terrestrial omnivorous small mammal (white-footed mouse) and omnivorous bird (American robin) to TRVs. IVB. Quantification of COPEC concentrations in tissues of earthworms using soil-to-earthworm BAFs derived in the IMR/BGR BERA. IVC. Quantification of COPEC concentrations in tissues of terrestrial plants using literature-derived soil-to-plant BAFs.

Table 7-1

**Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 3 of 4)

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Riparian / Aquatic Ecosystems		
I. Survival, growth, and reproduction of aquatic benthic invertebrates in the drainage features at the T-24A Ranges.	IA. Is the survival and growth of aquatic benthic invertebrates exposed to sediment from the drainage features at the T-24A Ranges significantly lower than that for aquatic benthic invertebrates exposed to sediment from reference sites?	IA. Comparison of survival and growth of the benthic amphipod <i>Chironomus tentans</i> exposed to "on-site" sediment to survival and growth of <i>Chironomus tentans</i> exposed to sediment from a reference stream.
	IB. Is the benthic community structure significantly different in reaches of the drainage features at the T-24A Ranges compared to benthic communities in reference streams?	IB. Comparison of benthic community assemblage in the drainage features at the T-24A Ranges with the benthic community assemblage in a reference stream using RBPII methodology.
	IC. Are the concentrations of COPECs in sediment from the drainage features at the T-24A Ranges greater than ESVs for the survival, growth, and reproduction of aquatic benthic invertebrates?	IC. Comparison of COPEC concentrations in sediment from the drainage features at the T-24A Ranges to ESVs for the survival, growth, and reproduction of aquatic benthic invertebrates.
II. Survival, growth, and reproduction of riparian invertivorous small mammals and birds at the T-24A Ranges.	II. Does the daily dose of COPECs received by riparian invertivorous small mammals or birds via consumption of prey species and from other media at the T-24A Ranges exceed the toxicity reference values (TRVs) for survival, reproduction, or growth?	IIA. Comparison of calculated total daily doses of COPECs for riparian invertivorous mammal (little brown bat) and invertivorous bird (marsh wren) to TRVs.
		IIB. Quantification of COPEC concentrations in tissues of chironomids exposed to sediment from the drainage features at the T-24A Ranges and from a reference stream.

Table 7-1

**Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

(Page 4 of 4)

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Riparian / Aquatic Ecosystems		
III. Survival, growth, and reproduction of drought-tolerant aquatic vertebrate (fish) and other aquatic species populations in the drainage features at the T-24A Ranges.	IIIA. Are concentrations of COPECs in surface water at the T-24A Ranges greater than ESVs for the survival, growth, or reproduction of fish and other aquatic species?	IIIA. Comparison of COPEC concentrations in surface water at the T-24A Ranges to ESVs for the survival, growth, and reproduction of fish and other aquatic species.
	IIIB. Are concentrations of COPECs in surface water at the T-24A Ranges greater than NOAELs and LOAELs for the survival, reproduction, and growth of aquatic invertebrates (i.e. daphnids) or aquatic vertebrates (i.e. fathead minnows) derived in the IMR/BGR BERA?	IIIB. Comparison of COPEC concentrations in surface water at the T-24A Ranges to NOAELs and LOAELs for survival, growth, and reproduction of daphnids and fathead minnows derived in the IMR/BGR BERA.

Table 7-2

**Terrestrial Foodweb Model Input Parameters
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

Common Name	Scientific Name	Feeding Guild	Foraging Area (acres)	Area Use Factor (unitless)	Body Weight (kg)	Water Ingestion Rate (L/kg/day)	Food Ingestion Rate (kg/kg/day)	Soil Ingestion Rate ^d (kg/kg/day)	Dietary Fraction (unitless)	Dietary Component
White-Footed Mouse	<i>Peromyscus leucopus</i>	Omnivorous Mammal	1.0 (b)	1.0	0.0225 (b)	0.190 (a)	0.1237 (a)	0.00247 (a)	0.254 0.746	Terrestrial Invertebrates Terrestrial Vegetation (seeds & young grass / fruit)
American Robin	<i>Turdus migratorius</i>	Omnivorous Bird	0.61 (a)	1.0	0.081 (a)	0.140 (a)	0.1816 (a)	0.00363 (c)	0.375 0.625	Terrestrial Invertebrates Terrestrial Vegetation (fruit)
Shorttail Shrew	<i>Blarina brevicauda</i>	Invertivorous Mammal	0.964 (a)	1.0	0.0168 (a)	0.223 (a)	0.0899 (a)	0.00216 (a)	0.887 0.113	Terrestrial Invertebrates Terrestrial Vegetation (roots / young grass)
American Woodcock	<i>Scolopax minor</i>	Invertivorous Bird	61.3 (a)	1.0	0.169 (a)	0.10 (a)	0.1517 (a)	0.0158 (a)	0.95 0.05	Terrestrial Invertebrates Terrestrial Vegetation (seeds)

Notes:

All of the values presented in this table represent arithmetic mean values if more than one value was presented in the referenced source.

a USEPA, 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187a

b Burt, W.H. and R.P. Grossenheider. *Mammals, Peterson Field Guide*.

c Assumed value based on soil ingestion values for other birds presented in USEPA (1993).

d Soil ingestion rates (dry weight) were calculated using the following relationship: $IR_{soil} = IR_{food} \times Diet_{soil}$

where:

IR_{soil} = ingestion rate of soil (kg/kg/day, dry weight);

IR_{food} = food ingestion rate (kg/kg/day, dry weight);

$Diet_{soil}$ = percentage of diet that is soil (percent); and

Table 7-3

Riparian/Aquatic Foodweb Model Input Parameters
 Ranges Near Training Area T-24A
 Fort McClellan, Calhoun County, Alabama

Common Name	Scientific Name	Feeding Guild	Foraging Area (acres)	Area Use Factor (unitless)	Body Weight (kg)	Water Ingestion Rate (L/kg/day)	Food Ingestion Rate (kg/kg/day)	Sediment Ingestion Rate ^e (kg/kg/day)	Dietary Fraction (unitless)	Dietary Component
Little Brown Bat	<i>Myotis lucifugus</i>	Invertivorous Mammal	40 (c)	1.0	0.008 (b)	0.160 (e)	0.0699 (d)	NA	1.0	Aquatic Emergent Invertebrates
Marsh Wren	<i>Cistothorus palustris</i>	Invertivorous Bird	0.13 (a)	1.0	0.01038 (a)	0.270 (a)	0.1833 (a)	NA	1.0	Aquatic Emergent Invertebrates

Notes:

- All of the values presented in this table represent arithmetic mean values if more than one value was presented in the referenced source.
- a USEPA, 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187a
- b Burt, W.H. and R.P. Grossenheider. *Mammals, Peterson Field Guide*.
- c University of Michigan, 2006. Spatial Foraging Habits of the Little Brown Bat (*Myotis lucifugus*) and Northern Long-Eared Bat (*Myotis septentrionalis*).
- d Anthony and Kunz, 1977. Feeding Strategies of the Little Brown Bat, *Myotis lucifugus*, in Southern New Hampshire.
- e Sample, et al., 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants.

Table 9-1

**Surface Soil Sample Location Summary
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

Sample Location	Antimony Concentration (mg/kg)	Copper Concentration (mg/kg)	Lead Concentration (mg/kg)	Zinc Concentration (mg/kg)
R24A-187-GP17	ND	5.67	11	15.3
R24A-187-GP16	ND	4	19	15
FTA-108-GP07	ND	22	189	19
R24A-187-GP05	ND	62	214	21
R24A-187-MW03	ND	13.2	16.7	344

mg/kg - milligrams per kilogram.

ND - Not detected

Table 9-2

**Sediment Sample Location Summary
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

Sample Location	Lead Concentration (mg/kg)	Benzo(a)anthracene Concentration (mg/kg)	Chrysene Concentration (mg/kg)	Fluoranthene Concentration (mg/kg)	Pyrene Concentration (mg/kg)
FTA-88-SW/SD01	22.5	ND	ND	ND	ND
T24A-BERA-SW/SD01	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD02	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD03	Unknown	Unknown	Unknown	Unknown	Unknown
FTA-108-SW/SD01	24.8	0.99	0.98	1.5	2.0
FTA-108-SW/SD03	34.8	ND	ND	ND	ND
R24A-187-SW/SD07	148	ND	ND	ND	ND
R24A-187-SW/SD06	94	ND	ND	ND	ND
FTA-108-SW/SD02 (reference)	15.7	ND	ND	ND	ND
R24A-187-SW/SD01 (reference)	6.04	ND	ND	ND	ND
T24A-BERA-SW/SD04	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD05	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD06	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD07	Unknown	Unknown	Unknown	Unknown	Unknown

mg/kg - milligrams per kilogram.

ND - Not detected

Unknown - Concentrations unknown. Sample location has not been previously sampled.

Table 9-3

**Surface Water Sample Location Summary
Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

Sample Location	Copper Concentration (mg/L)	Lead Concentration (mg/L)	Zinc Concentration (mg/L)
FTA-88-SW/SD01	ND	ND	R
T24A-BERA-SW/SD01	Unknown	Unknown	Unknown
T24A-BERA-SW/SD02	Unknown	Unknown	Unknown
T24A-BERA-SW/SD03	Unknown	Unknown	Unknown
FTA-108-SW/SD01	ND	ND	R
FTA-108-SW/SD03	ND	ND	R
R24A-187-SW/SD07	0.107	0.431	0.327
R24A-187-SW/SD06	0.0208	0.04	0.0478
FTA-108-SW/SD02 (reference)	ND	ND	R
R24A-187-SW/SD01 (reference)	ND	ND	ND
T24A-BERA-SW/SD04	Unknown	Unknown	Unknown
T24A-BERA-SW/SD05	Unknown	Unknown	Unknown
T24A-BERA-SW/SD06	Unknown	Unknown	Unknown
T24A-BERA-SW/SD07	Unknown	Unknown	Unknown

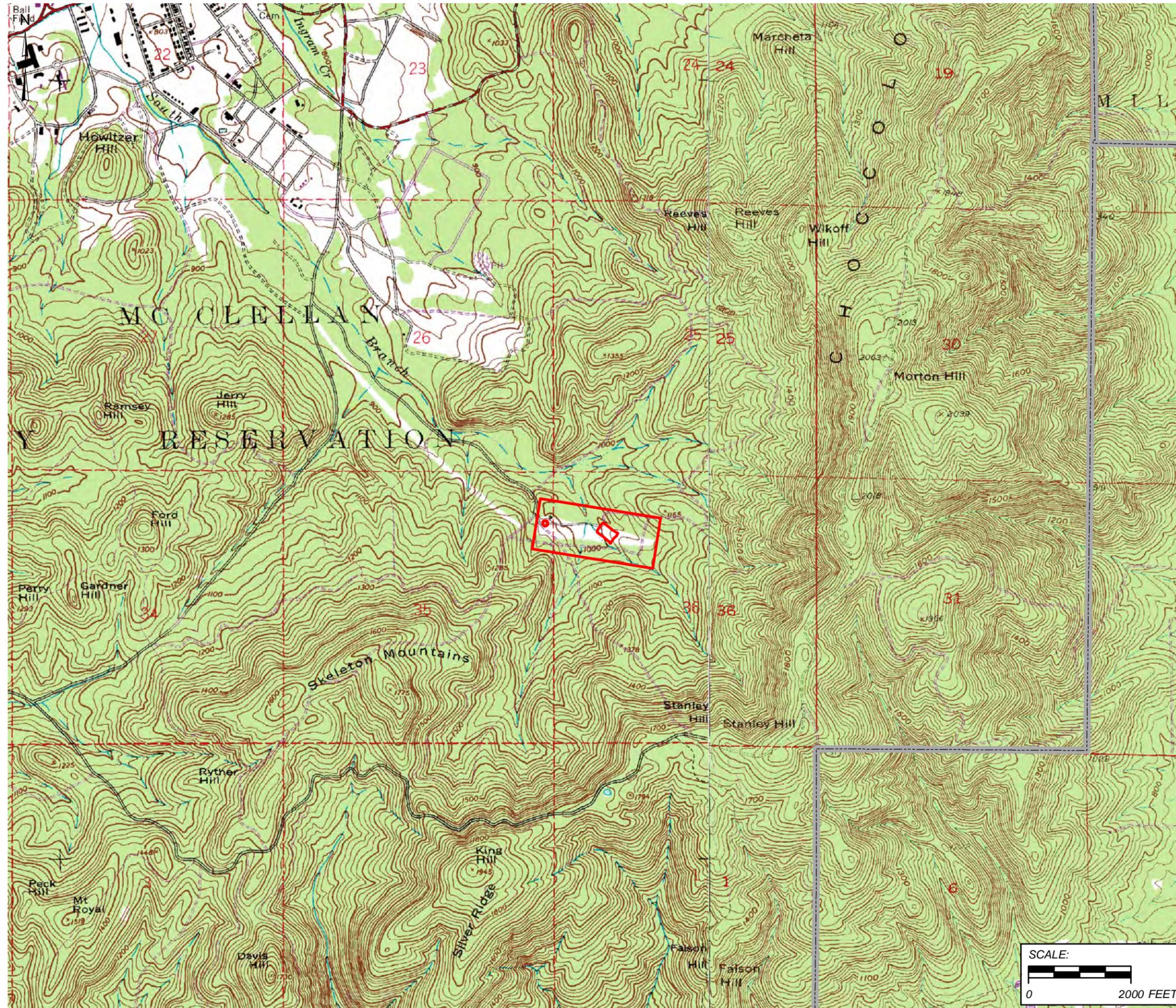
mg/L - milligrams per liter.

ND - Not detected

Unknown - Concentrations unknown. Sample location has not been previously sampled.

R - Data rejected during data validation due to blank contamination

FIGURES



LEGEND

-  Study Area Boundary
-  Fort McClellan Boundary
-  USGS 1:24,000 Topographic Quadrangles

FIGURE 5-1

SITE LOCATION MAP
T-24 ALPHA

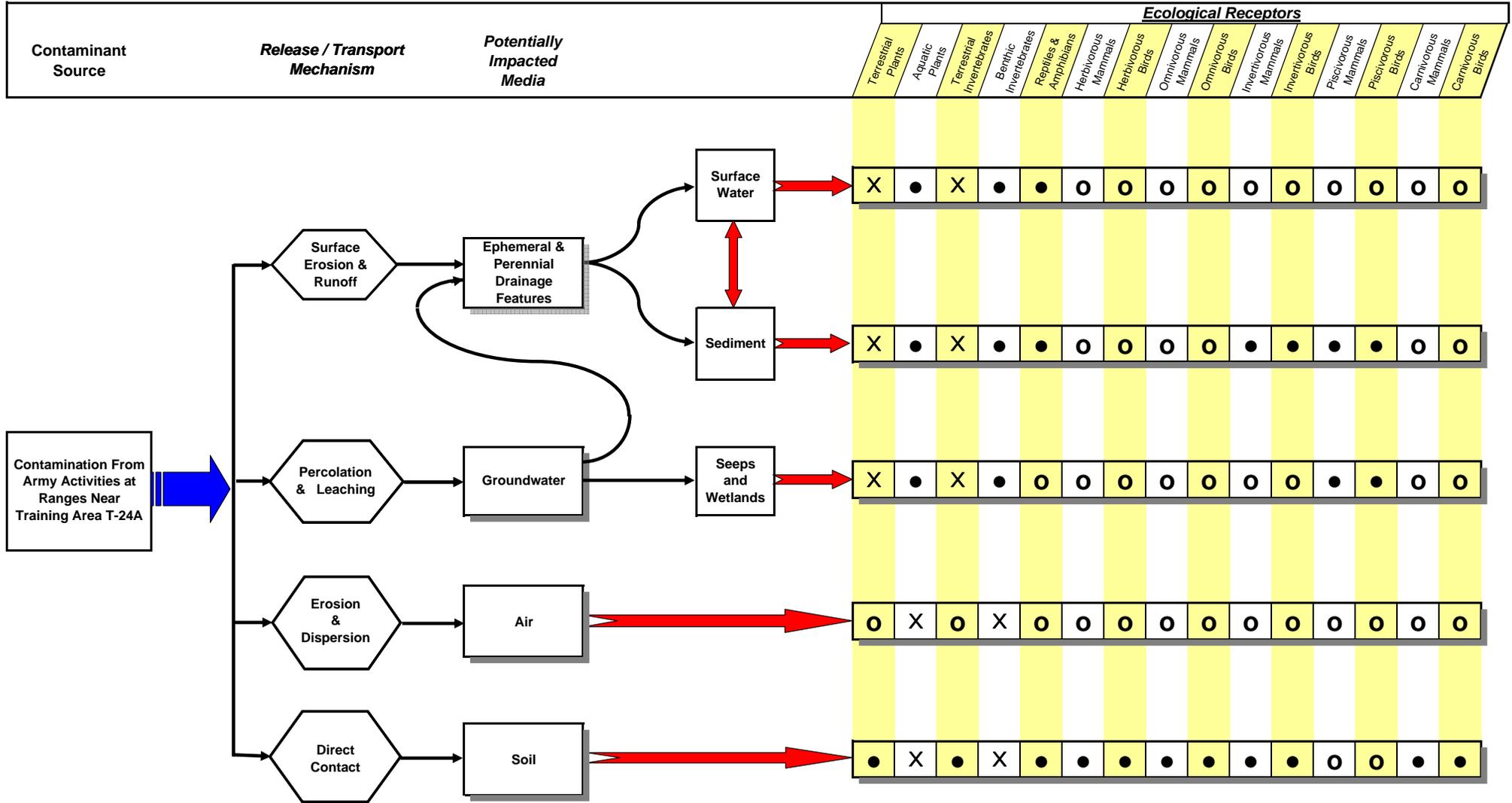
Baseline Ecological Risk Assessment Problem Formulation
and Study Design Report for the Ranges Near
Training Area T-24A

FORT MCCLELLAN
ANNISTON, ALABAMA



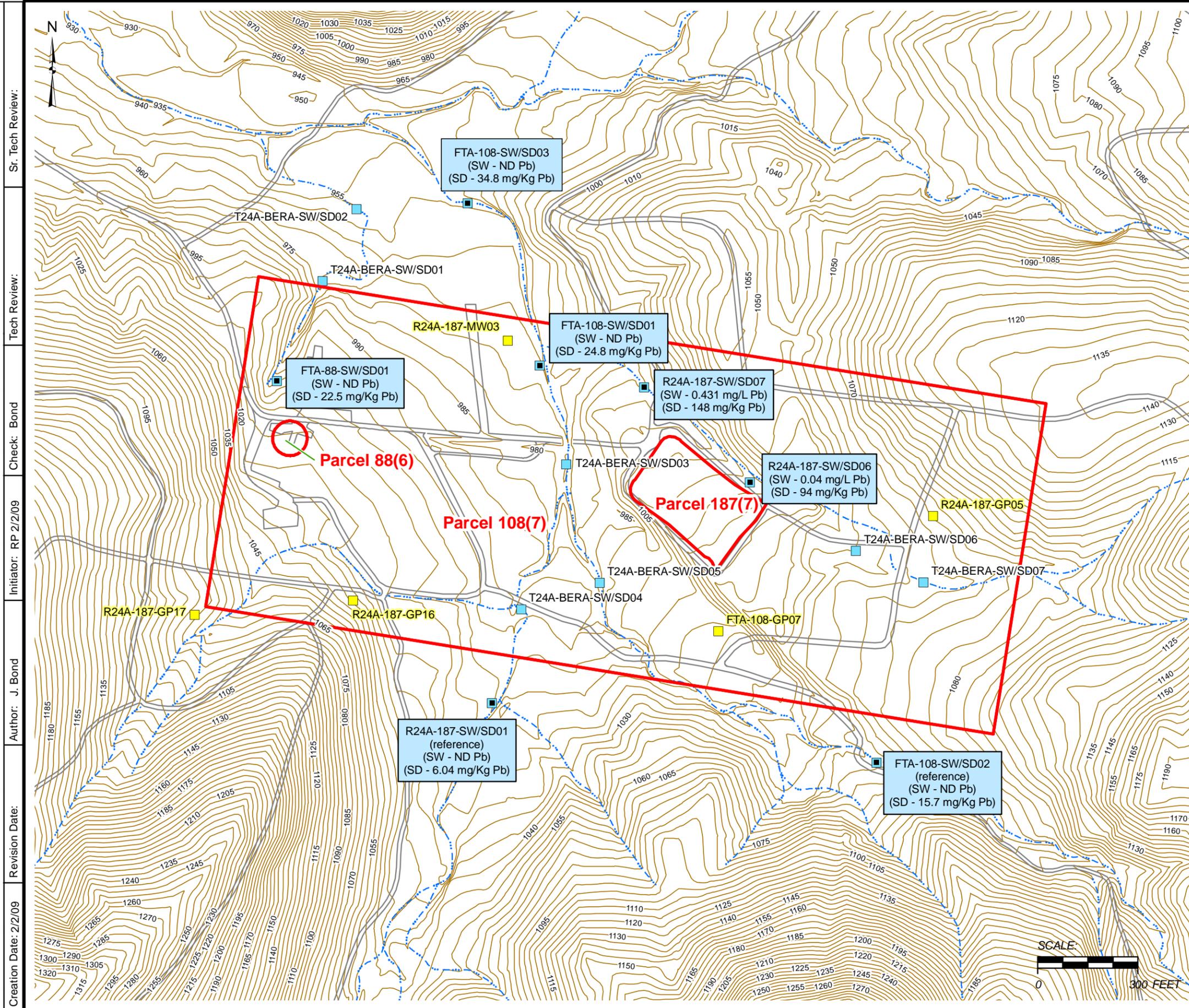
Figure 6-1

Site Conceptual Model
 Ranges Near Training Area T-24A
 Fort McClellan, Calhoun County, Alabama



Key To Potential Exposure Routes

- - Potentially complete exposure pathway
- X - Incomplete exposure pathway
- - Potentially complete exposure pathway but insignificant



LEGEND

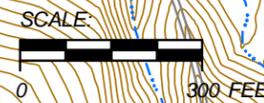
- Proposed BERA Surface Soil Sample Location
 - Proposed BERA Surface Water / Sediment Sample Location (Existing Location)
 - Proposed BERA Surface Water / Sediment Sample Location (New Location)
 - Roads
 - Surface Drainage / Creek
 - Topographic Contour (5-ft Interval)(NAVD)
 - Study Area Boundary
- mg/Kg milligrams per Kilogram
 ND Not detected
 SW Surface Water
 SD Sediment
 Pb Lead

FIGURE 9-1

PROPOSED SAMPLE LOCATIONS

Baseline Ecological Risk Assessment Problem Formulation and Study Design Report for the Ranges Near Training Area T-24A

FORT MCCLELLAN
 CALHOUN COUNTY, ALABAMA



Sr. Tech Review:

Tech Review:

Check: Bond

Initiator: RP 2/2/09

Author: J. Bond

Revision Date:

Creation Date: 2/2/09

APPENDIX A

FIELD SAMPLING AND ANALYSIS PLAN FOR SURFACE WATER AT THE RANGES NEAR TRAINING AREA T-24A

Appendix A

Field Sampling and Analysis Plan For Surface Water at the Ranges Near Training Area T-24A Fort McClellan, Calhoun County, Alabama

A.1.0 Introduction

As presented in the in the *Baseline Ecological Risk Assessment Problem Formulation for the Ranges Near Training Area T-24A* (Shaw, 2007), copper, lead, and zinc were identified as constituents of potential ecological concern (COPECs) in surface water at the Ranges Near Training Area T-24A. To provide information for the baseline ecological risk assessment (BERA), surface water samples will be collected and analyzed for target analyte list (TAL) metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, pH, total suspended solids, and hardness. COPEC concentrations in surface water samples will be compared to screening values for the protection of aquatic life and will also be used in the food web models to predict the total daily doses of COPECs in invertivorous mammals and birds.

A.2.0 Selection of Sample Locations

Eight (8) surface water samples will be collected from locations representative of the full range of historical COPEC concentrations detected in sediment at the T-24A Ranges. Sediment lead and PAH concentrations will be used to identify surface water sampling locations because the drainage features at the T-24A Ranges are largely ephemeral in nature and are dry for extended periods of time. Therefore, historical surface water concentrations are not appropriate for locating these proposed surface water sampling locations. Lead has been identified as a COPEC in surface water at a number of ranges at FTMC and has been used as one of the indicators of potential contamination from Army activities at small arms ranges at FTMC. PAHs have also been detected in sediment at the T-24A ranges, albeit infrequently and at low concentrations, and can be associated with the use of fog oil at training areas. Two (2) additional surface water samples will be collected from stream locations with similar physical characteristics as the drainage features at the T-24A Ranges but outside the influence of FTMC, with the intention of being representative of naturally occurring conditions. These 2 sample locations will be the site-specific reference locations. The eight on-site surface water sample locations and two reference sample locations were summarized in Table 9-3 of the BERA Problem Formulation and Study Design report (Shaw, 2009) and are also summarized below.

Sample Location	Surface Water Copper Concentration (mg/L)	Surface Water Lead Concentration (mg/L)	Surface Water Zinc Concentration (mg/L)
FTA-88-SD01	ND	ND	R
T24A-BERA-SW/SD01	Unknown	Unknown	Unknown
T24A-BERA-SW/SD02	Unknown	Unknown	Unknown
T24A-BERA-SW/SD03	Unknown	Unknown	Unknown
FTA-108-SW/SD01	ND	ND	R
FTA-108-SW/SD03	ND	ND	R
R24A-187-SW/SD07	0.107	0.431	0.327
R24A-187-SW/SD06	0.0208	0.04	0.0478
FTA-108-SW/SD02 (reference)	ND	ND	R
R24A-187-SW/SD01 (reference)	ND	ND	ND
T24A-BERA-SW/SD04	Unknown	Unknown	Unknown
T24A-BERA-SW/SD05	Unknown	Unknown	Unknown
T24A-BERA-SW/SD06	Unknown	Unknown	Unknown
T24A-BERA-SW/SD07	Unknown	Unknown	Unknown

ND – Not Detected

Unknown – Concentration unknown. Sample location has not been previously sampled.

R – Data rejected by data validator due to blank contamination.

In order to ensure that the nature and extent of surface water contamination has been sufficiently characterized at the T-24A ranges, four (4) additional surface water samples will be collected from the drainage features at the T-24A ranges. These four additional surface water sample locations will be designated the following:

- T24A-BERA-SW/SD04
- T24A-BERA-SW/SD05
- T24A-BERA-SW/SD06
- T24A-BERA-SW/SD07.

These additional surface water samples will be collected from locations not previously sampled during the remedial investigation and will be analyzed for TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, pH, total suspended solids, and hardness. The results of the chemical analysis of these samples will be incorporated with the results of the other surface water samples collected at the T-24A ranges and 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.

In summary, a total of fourteen (14) surface water samples will be collected from the drainage features in and around the T-24A study area as summarized below:

- 8 samples to address the BERA assessment and measurement endpoints
- 2 site-specific reference samples
- 4 samples to verify the nature and extent of surface water contamination.

Due to the ephemeral nature of the drainage features at the T-24A Ranges, surface water samples will only be collected if surface water is present during the ecological sampling event. If the proposed sampling location is dry during the ecological sampling event, then no surface water samples will be collected from that particular sample location

A.3.0 Sampling and Analysis Procedures

Unless otherwise specified, sample collection procedures will follow the *Installation-Wide Sampling and Analysis Plan* (IT, 2002). At each location, surface water samples will be collected first, followed by sediment samples. Surface water samples will be collected from the farthest downstream location first and then proceed upstream.

A.3.1 Surface Water Sampling

Surface water samples will be collected as grab samples from mid-depth and the center of the stream according to the procedures identified in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002). As surface water samples are collected, in-stream measurements of the following parameters will be recorded:

- pH
- conductivity
- dissolved oxygen
- temperature
- oxidation reduction potential.

At each location, the water depth, stream width, and approximate flow velocity will also be recorded. Other observations that may be recorded include weather conditions, surrounding vegetative cover and evidence of erosion.

As indicated in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002), care will be taken so that bottom sediment is not disturbed and introduced into the surface water sample containers. The plan also provides a list of the sample containers and preservatives required for each analysis for surface water samples.

A.3.2 Decontamination Procedures

All equipment used for surface water sampling, collection, and transfer will be properly decontaminated prior to collecting samples and between sampling locations, as described in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002).

A.3.3 Quality Assurance/Quality Control Samples

As established by the DQO process, field and laboratory QA/QC indicator surface water samples and analyses will be collected to provide information concerning the measured quality and usability of the field data. As presented in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002), the frequency of field duplicates, MS/MSDs, and equipment rinse blanks will be 1 in 10 (10%), 1 in 20 (5%), and once per sampling event, respectively.

A.3.4 Sample Labeling, Packaging, and Shipment

All prepared samples will be labeled, packaged, and shipped to the appropriate analytical or biological testing laboratory as presented in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002).

A.3.5 Surface Water Chemical Analysis

All surface water samples will be analyzed for TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, pH, total suspended solids, and hardness.

A.4.0 Health and Safety and Unexploded Ordnance Support

All BERA field work for the T-24A Ranges will be conducted in accordance with the *Site Investigations, Site-Specific Field Sampling Plan and Site-Specific Safety and Health Plan Attachments, Range 24A Fog Oil Drum Storage (Parcel 88), Range 24A Multi-Purpose Range (Parcel 108), Smoke Area BVZ (Parcel 124), Smoke Area S (Parcel 106), Smoke Area R (Parcel 105), Old Incinerator (Parcel 125), Former Smoke Area Choccolocco Corridor (Parcel 107), and Former Smoke, Fort McClellan, Calhoun County, Alabama*, Final, (IT Corporation, 1998); *Supplemental Remedial Investigation, Site-Specific Field Sampling Plan, Site-Specific Safety and Health Plan, and Site-Specific Unexploded Ordnance Safety Plan Attachments, Ranges Near Training Area T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama*, Final (IT Corporation, 2000); *Site-Specific Work Plan, Remedial Investigation, Addendum IV, Ranges Near Training Area T-24 Alpha, Parcels 88(7), 108(7), 112Q, 113Q-X, 123Q, 187(7), 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama*, Draft (Shaw Environmental, Inc., 2003, October); and *Site-Specific Field Sampling Plan Addendum and UXO Safety Plan Addendum for the Supplemental Remedial Investigation at Ranges Near T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q* (IT Corporation, 2001, July). These attachments will be updated to be consistent with the February 2002, *Draft Revision 3, Installation-Wide Sampling and Analysis Plan, Fort McClellan, Calhoun County, Alabama* (IT, 2002), for the final BERA study design for the T-24A Ranges.

A.5.0 References

IT Corporation, 2002, *Installation-Wide Sampling and Analysis Plan*, Fort McClellan, Calhoun County, Alabama, Draft Revision 3, February.

IT Corporation (IT), 2001, *Site-Specific Field Sampling Plan Addendum and UXO Safety Plan Addendum for the Supplemental Remedial Investigation at Ranges Near T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q*, letter work plan, July.

IT Corporation (IT), 2000, *Supplemental Remedial Investigation, Site-Specific Field Sampling Plan, Site-Specific Safety and Health Plan, and Site-Specific Unexploded Ordnance Safety Plan Attachments, Ranges Near Training Area T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama*, Final, September.

IT Corporation (IT), 1998, *Site Investigations, Site-Specific Field Sampling Plan and Site-Specific Safety and Health Plan Attachments, Range 24A Fog Oil Drum Storage (Parcel 88), Range 24A Multi-Purpose Range (Parcel 108), Smoke Area BVZ (Parcel 124), Smoke Area S (Parcel 106), Smoke Area R (Parcel 105), Old Incinerator (Parcel 125), Former Smoke Area Choccolocco Corridor (Parcel 107), and Former Smoke, Fort McClellan, Calhoun County, Alabama*, Final, September.

Shaw, 2009, *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Ranges Near Training Area T-24A*. Fort McClellan, Calhoun County, Alabama, Final, February.

Shaw Environmental, Inc. (Shaw), 2003, *Site-Specific Work Plan, Remedial Investigation, Addendum IV, Ranges Near Training Area T-24 Alpha, Parcels 88(7), 108(7), 112Q, 113Q-X, 123Q, 187(7), 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama*, Draft, October.

Table A-1

**Surface Water Sample Designations and QA/QC Sample Quantities
Ranges Near Training Area T-24A BERA
Fort McClellan, Alabama**

(Page 1 of 2)

Sample Location	Sample Designation	QA/QC Samples		Analytical Suite
		Field Duplicates	MS/MSD	
FTA-88-SW/SD01	FTA-88-SW01-SW-RWT1001-REG	FTA-88-SW01-SW-RWT1002-FD		TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
T24A-BERA-SW/SD01	T24A-BERA-SW01-SW-RWT1003-REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
T24A-BERA-SW/SD02	T24A-BERA-SW02-SW-RWT1004-REG		T24A-BERA-SW02-SW-RWT1004-MS/MSD	TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
T24A-BERA-SW/SD03	T24A-BERA-SW03-SW-RWT1005-REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
FTA-108-SW/SD01	FTA-108-SW01-SW-RWT1006-REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
FTA-108-SW/SD03	FTA-108-SW03-SW-RWT1007-REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
R24A-187-SW/SD07	R24A-187-SW07-SW-RWT1008--REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
R24A-187-SW/SD06	R24A-187-SW06-SW-RWT1009-REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.

Table A-1

Surface Water Sample Designations and QA/QC Sample Quantities
Ranges Near Training Area T-24A BERA
Fort McClellan, Alabama

(Page 2 of 2)

Sample Location	Sample Designation	QA/QC Samples		Analytical Suite
		Field Duplicates	MS/MSD	
FTA-108-SW/SD02	FTA-108-SW02-SW-RWT1010-REF			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
R24A-187-SW/SD01	R24A-187-SW01-SW-RWT1011-REF			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
T24A-BERA-SW/SD04	T24A-BERA-SW04-SW-RWT1012-REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
T24A-BERA-SW/SD05	T24A-BERA-SW05-SW-RWT1013-REG	T24A-BERA-SW05-SW-RWT1014-FD		TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
T24A-BERA-SW/SD06	T24A-BERA-SW06-SW-RWT1015-REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.
T24A-BERA-SW/SD07	T24A-BERA-SW07-SW-RWT1016-REG			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. pH by SW_9045C, Total suspended solids by 160.2, and Hardness by 130.1.

FD - Field duplicate.

MS/MSD - Matrix spike/matrix spike duplicate.

QA/QC - Quality assurance/quality control.

TOC - Total Organic Carbon.

REG - Field sample.

REF - Reference sample

TAL - Target analyte list.

VOC - volatile organic compound.

SVOC - semivolatle organic compound.

SW - U.S. Environmental Protection Agency's *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846).

APPENDIX B

FIELD SAMPLING AND ANALYSIS PLAN FOR SEDIMENT AT THE RANGES NEAR TRAINING AREA T-24A

Appendix B
Field Sampling and Analysis Plan
For Sediment at the Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama

B.1.0 Introduction

As presented in the baseline ecological risk assessment (BERA) Problem Formulation for the Ranges Near Training Area T-24A (Shaw, 2009), one inorganic constituent (lead) and several semi-volatile organic compounds (SVOCs), namely benzo(a)anthracene, chrysene, fluoranthene, and pyrene, were identified as chemicals of potential ecological concern (COPEC) in sediment at the Ranges Near Training Area T-24A. To provide information for the BERA, sediment samples will be collected and analyzed for TAL metals, volatile organic compounds (VOCs), SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, pH, grain size, and total organic carbon (TOC). In addition, sediment samples will be analyzed for toxicity and bioaccumulation in chironomid larva. COPEC concentrations in sediments will also be used in food web models to predict the total daily doses of COPECs in invertivorous mammals and birds.

B.2.0 Selection of Sample Locations

Eight (8) sediment samples will be collected from locations representative of the full range of historical COPEC concentrations detected in sediment at the T-24A Ranges. Lead has been identified as a COPEC in sediment at a number of ranges at FTMC and has been used as one of the indicators of potential contamination from Army activities at small arms ranges at FTMC. PAHs have also been detected in sediment at the T-24A ranges, albeit infrequently and at low concentrations, and can be associated with the use of fog oil at training areas. Two (2) additional sediment samples will be collected from stream locations with similar physical characteristics as the drainage features at the T-24A Ranges but outside the influence of FTMC, with the intention of being representative of naturally occurring conditions. These 2 sample locations will be the site-specific reference locations. The eight on-site sediment sample locations and two reference sediment sample locations were summarized in Table 9-2 of the BERA Problem Formulation and Study Design report and are also summarized below.

Sample Location	Sediment Lead Conc. (mg/kg)	Sediment Benzo(a)A Conc. (mg/kg)	Sediment Chrysene Conc. (mg/kg)	Sediment Fluoranthene Conc. (mg/kg)	Sediment Pyrene Conc. (mg/kg)
FTA-88-SD01	22.5	ND	ND	ND	ND
T24A-BERA-SW/SD01	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD02	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD03	Unknown	Unknown	Unknown	Unknown	Unknown
FTA-108-SW/SD01	24.8	0.99	0.98	1.5	2.0
FTA-108-SW/SD03	34.8	ND	ND	ND	ND
R24A-187-SW/SD07	148	ND	ND	ND	ND
R24A-187-SW/SD06	94	ND	ND	ND	ND
FTA-108-SW/SD02 (reference)	15.7	ND	ND	ND	ND
R24A-187-SW/SD01 (reference)	6.04	ND	ND	ND	ND
T24A-BERA-SW/SD04	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD05	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD06	Unknown	Unknown	Unknown	Unknown	Unknown
T24A-BERA-SW/SD07	Unknown	Unknown	Unknown	Unknown	Unknown

ND – Not Detected

Unknown – Concentration unknown. Sample location has not been previously sampled.

Additionally, the benthic invertebrate community will be analyzed using the rapid bioassessment protocol II (RBP II) (Barbour, et al., 1999) at each of the 8 on-site sediment sample locations and the 2 site-specific reference locations.

In order to ensure that the nature and extent of sediment contamination has been sufficiently characterized at the T-24A ranges, four (4) additional sediment samples will be collected from the drainage features at the T-24A ranges. These four additional sediment sample locations will be designated the following:

- T24A-BERA-SW/SD04
- T24A-BERA-SW/SD05
- T24A-BERA-SW/SD06
- T24A-BERA-SW/SD07.

These additional sediment samples will be collected from locations not previously sampled during the remedial investigation and will be analyzed for TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, pH, total organic carbon, and grain size. The results of the chemical analysis of these samples will be incorporated with the results of the other sediment samples collected at the T-24A ranges and 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.

In summary, a total of fourteen (14) sediment samples will be collected from the drainage features in and around the T-24A study area as summarized below:

- 8 samples to address the BERA assessment and measurement endpoints
- 2 site-specific reference samples
- 4 samples to verify the nature and extent of sediment contamination.

B.3.0 Sampling and Analysis Procedures

Unless otherwise specified, sample collection procedures will follow the *Installation-Wide Sampling and Analysis Plan* (IT, 2002). The benthic macroinvertebrate community (riffle/run and CPOM samples) will be sampled first at each sediment sampling location, followed by the collection of sediment samples for chemical and toxicity testing. Sediment samples will be collected from the farthest downstream location first and then proceed upstream.

B.3.1 Sediment Sampling

Prior to the collection of sediment samples, the following in-stream water quality measurements will be recorded:

- pH
- conductivity
- dissolved oxygen
- temperature
- oxidation reduction potential.

Sediment samples will be collected from the zero to six-inch depth interval with a stainless steel spoon or trowel and homogenized in a stainless steel bowl following the procedures outlined in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002). A list of the sample containers and preservatives required for each analysis for sediment samples is also provided in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002).

At each sediment sampling location, the water depth, stream width, substrate type, and approximate flow velocity will also be recorded. Other observations that will be recorded include weather conditions, surrounding vegetative cover, surrounding land-use, and evidence of erosion.

B.3.2 Decontamination Procedures

All equipment used for collection, homogenization, and transfer will be properly decontaminated prior to collecting samples and between sampling locations, as described in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002).

B.3.3 Quality Assurance/Quality Control Samples

As established by the DQO process, field and laboratory QA/QC indicator sediment samples and analyses will be collected to provide information concerning the measured quality and usability of the field data. As presented in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002), the frequency of field duplicates, MS/MSDs, and equipment rinse blanks will be 1 in 10 (10%), 1 in 20 (5%), and once per sampling event, respectively.

B.3.4 Sample Labeling, Packaging, and Shipment

All prepared samples will be labeled, packaged, and shipped to the appropriate analytical or biological testing laboratory as presented in the *Installation-Wide Sampling and Analysis Plan* (IT, 2002).

B.3.5 Chemical Analysis

As presented in Table B-1, chemical analyses of sediments collected for chironomid toxicity and bioaccumulation testing will include TAL metals, VOCs, SVOCs, chlorinated pesticides, organophosphorus pesticides, chlorinated herbicides, total organic carbon, pH, and grain size. Chemical analyses of chironomid tissue after termination of the toxicity/bioaccumulation tests will include the sediment COPECs (TAL metals, and SVOCs) (Table B-2).

B.3.6 Chironomid Toxicity Testing

Biological testing of sediments collected at the T-24A Ranges will consist of toxicity testing and a bioaccumulation study of the benthic invertebrate *Chironomus tentans*.

B.3.6.1 Test Objective

The direct toxicity of sediment-bound COPECs will be measured by exposing benthic invertebrates (*Chironomus tentans*) to streambed sediment. Use of chironomids to measure toxicity of sediment-associated contaminants is quite common and has been standardized by the U.S. Environmental Protection Agency (USEPA, 2000).

Measuring growth as well as survival over the 21-day exposure period permits an evaluation of chronic (sub-lethal) endpoints in addition to acute toxicity. Adverse sub-lethal responses could affect the long-term viability of benthic invertebrate communities within impact zones and, therefore, affect the stability of the stream ecosystem. A summary of the test conditions is provided in Table B-3.

B.3.6.2 Test Sediment Dilution Series

Given the uncertainties and difficulties associated with laboratory dilution and subsequent mixing of sediments, test organisms will be exposed to 100 percent undiluted field collected sediment. Tests will be set up with exposure to laboratory-based synthetic control sediment, reference sediment, and on-site sediment representing the full range of COPEC concentrations detected in historical sediment samples from the T-24A Ranges.

B.3.6.3 Test Initiation

Tests will be initiated within 10 days of sample collection, and the laboratory grade overlying test water will be maintained at 23 ± 1 degrees Celsius ($^{\circ}\text{C}$). Test chambers will consist of 1-liter high form lipless beakers containing 150 milligrams (mg) of sediment and 800 milliliters (ml) of overlying water. Ten second-to-third instar *C. tentans* midges (approximately 10 days old) will be used at test initiation. A total of 5 replicates will be employed for each parallel test.

Midges within each test chamber will be fed 1-5 ml of a 4-g/100 ml tetrafin suspension on a daily basis throughout the 21-day test period. Each replicate test chamber will receive two-volume additions/day of overlying water. Water renewals will be conducted in a manner that minimizes suspension of sediment. All testing will, therefore, be static daily renewals with careful monitoring of physico-chemical parameters within the overlying water. These parameters will include pH, temperature, ammonia, alkalinity, hardness, conductivity, and dissolved oxygen.

B.3.6.4 Test Monitoring

All chambers will be checked daily and observations made to assess test organism behavior such as sediment avoidance.

B.3.6.5 Measurement of Overlying Water-Quality Characteristics

Conductivity, hardness, pH, alkalinity, and ammonia will be measured in all treatments at the beginning and end of the test. Overlying water will be sampled just before water renewal from about 1 to 2 centimeters (cm) above the sediment surface using a pipette.

B.3.6.6 Test Termination

At the termination of the toxicity test (day 21 of the exposure period), immobile organisms isolated from the sediment surface or from sieved material will be considered dead. A #40 sieve (425-micrometer [μm] mesh) will be used to remove midges from sediment. Surviving midges will be removed from the sediment and enumerated to determine survivability. All live organisms will then be pooled and weighed to determine weight change.

B.3.6.7 Test Data

Ash-free dry weight (AFDW) and survival will be the endpoints measured at the end of the 21-day sediment toxicity test.

For determination of AFDW, all living larvae in each replicate will be pooled and the sample will be dried to a constant weight (e.g., 60 °C for 24 hours). At the termination of the test and after determination of AFDW, each pooled sample will be analyzed for the COPECs as presented in Table B-2.

B.3.7 Rapid Bioassessment

A biological assessment of the benthic invertebrate community using the EPA's Rapid Bioassessment Protocol II (RBP II) (Barbour, et. al., 1999) will be performed at each sediment sampling location. RBP II will be used to determine whether on-site benthic invertebrate community structure is being adversely affected by COPECs at the T-24A Ranges

The locations for benthic invertebrate community analysis will be co-located with the sediment sample locations. The sampling locations will be located in areas similar in habitat so that the benthic community can be evaluated under similar environmental conditions.

RBP II as developed by EPA (Plafkin et. al., 1989) will be used to quantitatively assess the biotic health of the benthic community in the drainage features at the T-24A Ranges. RBPs were initially designed as a relatively inexpensive screening tool for use in determining if freshwater streams were capable of supporting designated aquatic life uses. However, according to EPA, the bioassessment protocols have also been found useful in characterizing the existence and severity of use impairment within freshwater systems including full watersheds, as well as identifying sources and causes to the impairment. RBP II is well-suited for screening the streams within FTMC for biotic integrity.

At each sampling location, water quality measurements will be obtained. Habitat quality observations including substrate type, surrounding land use, evidence of erosion and pollutant sources, vegetative stream canopy, and other relevant data will be noted.

According to the *Endangered Species Management Plan for Fort McClellan* (Garland, 1996), a Federal C2 candidate caddisfly species (*Polycentropus carlsoni*) and a site endemic caddisfly species (*Hydroptila setigera*) have been collected from the South Branch of Cane Creek. An additional 13 caddisfly species from the South Branch of Cane Creek are included on the

Alabama Natural Heritage Program tracking list. Therefore, special care will be given to the macroinvertebrate samples in order to maximize the potential for identifying these species. It should be noted, however, that the identification of benthic macroinvertebrates in the RBPII protocol rarely identifies organisms to the species level due to the difficulty in determining specific species of certain benthic macroinvertebrates. Benthic macroinvertebrates are normally only identified to the Family-level in the RBPII protocol.

B.3.7.1 Macroinvertebrate Sampling

Two macroinvertebrate samples will be collected at each sampling station, the riffle/run sample will be collected with a kick net and the coarse particulate organic matter (CPOM) sample will be collected by hand.

B.3.7.1.1 Kick Net Samples

The kick net sample provides data as to the abundance of the scraper and filtering collector functional feeding groups and is generally collected in a riffle and a run area of the stream. The riffle and the 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 approximately 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% ethanol to preserve the organisms.

B.3.7.1.2 Coarse Particulate Organic Matter Samples

One coarse particulate organic matter (CPOM) sample will be collected at each location from depositional areas with low current velocity within 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% ethanol.

B.4.0 Health and Safety and Unexploded Ordnance Support

All work conducted during the BERA for the T-24A Ranges will be conducted in accordance with the site-specific work plans for the Ranges Near Training Area T-24A (IT, 2002, 2001, 2000, and 1998, and Shaw, 2003). These attachments will be updated to be consistent with the February 2002, *Draft Revision 3, Installation-Wide Sampling and Analysis Plan, Fort McClellan, Calhoun County, Alabama*, for the final BERA study design for the T-24A Ranges.

B.5.0 References

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IT Corporation (IT), 1998, *Site Investigations, Site-Specific Field Sampling Plan and Site-Specific Safety and Health Plan Attachments, Range 24A Fog Oil Drum Storage (Parcel 88), Range 24A Multi-Purpose Range (Parcel 108), Smoke Area BVZ (Parcel 124), Smoke Area S (Parcel 106), Smoke Area R (Parcel 105), Old Incinerator (Parcel 125), Former Smoke Area Choccolocco Corridor (Parcel 107), and Former Smoke, Fort McClellan, Calhoun County, Alabama*, Final, September.

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U.S. Environmental Protection Agency (EPA), 2000, *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants With Freshwater Invertebrates*. Office of Research and Development, Mid-Continent Ecology Division, Duluth, MN, EPA 600/R-99/064.

Table B-1

**Sediment Sample Designations and QA/QC Sample Quantities
Ranges Near Training Area T-24A BERA
Fort McClellan, Alabama**

(Page 1 of 2)

Sample Location	Sample Designation	Sample Depth (ft)	QA/QC Samples		Analytical Suite
			Field Duplicates ^a	MS/MSD ^a	
FTA-88-SW/SD01	FTA-88-SD01-SD-RWT2001-REG	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
T24A-BERA-SW/SD01	T24A-BERA-SD01-SD-RWT2002-REG	0 - 0.5	T24A-BERA-SD01-SD-RWT2003-FD		TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
T24A-BERA-SW/SD02	T24A-BERA-SD02-SD-RWT2004-REG	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
T24A-BERA-SW/SD03	T24A-BERA-SD03-SD-RWT2005-REG	0 - 0.5		T24A-BERA-SD03-SD-RWT2005-MS/MSD	TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
FTA-108-SW/SD01	FTA-108-SD01-SD-RWT2006-REG	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
FTA-108-SW/SD03	FTA-108-SD03-SD-RWT2007-REG	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
R24A-187-SW/SD07	R24A-187-SD07-SD-RWT2008-REG	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.

Table B-1

**Sediment Sample Designations and QA/QC Sample Quantities
Ranges Near Training Area T-24A BERA
Fort McClellan, Alabama**

(Page 2 of 2)

Sample Location	Sample Designation	Sample Depth (ft)	QA/QC Samples		Analytical Suite
			Field Duplicates ^a	MS/MSD ^a	
R24A-187-SW/SD06	R24A-187-SD06-SD-RWT2009-REG	0 - 0.5	R24A-187-SD06-SD-RWT2010-FD		TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
FTA-108-SW/SD02	FTA-108-SD02-SD-RWT2011-REF	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
R24A-187-SW/SD01	R24A-187-SD01-SD-RWT2012-REF	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, Grain Size by ASTM 421/422, <i>Chironomus tentans</i> 21-day Survival and Growth Test by EPA 100.5.
T24A-BERA-SW/SD04	T24A-BERA-SD04-SD-RWT2013-REG				TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, and Grain Size by ASTM 421/422
T24A-BERA-SW/SD05	T24A-BERA-SD05-SD-RWT2014-REG	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, and Grain Size by ASTM 421/422
T24A-BERA-SW/SD06	T24A-BERA-SD06-SD-RWT2015-REG	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, and Grain Size by ASTM 421/422
T24A-BERA-SW/SD07	T24A-BERA-SD07-SD-RWT2016-REG	0 - 0.5			TAL Metals by SW_6010B/SW7470A, VOCs by SW_8260B, SVOCs by SW_8270C, Chlorinated Pesticides by SW_8081A, Organophosphorus Pesticides by SW_8141A, and Chlorinated Herbicides by SW_8151A. TOC by Walkley Black, pH by SW_9045C, and Grain Size by ASTM 421/422

^a Field duplicates and MS/MSDs are collected for chemical analysis only and not for biological testing.

FD - Field duplicate.

MS/MSD - Matrix spike/matrix spike duplicate.

QA/QC - Quality assurance/quality control.

REF - Reference sample

REG - Field sample.

TAL - Target analyte list.

TOC - Total Organic Carbon.

VOC - volatile organic compound.

SVOC - semivolatile organic compound.

SW - U.S. Environmental Protection Agency's (EPA) *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846).

Table B-2

**Chironomid Tissue Sample Designations
BERA Study Design for the Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

Sample Location	Sample Designation	Analytical Suite
FTA-88-SW/SD01	FTA-88-SD01-CR-RWT3001-REG	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
T24A-BERA-SW/SD01	T24A-BERA-SD01-CR-RWT3002-REG	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
T24A-BERA-SW/SD02	T24A-BERA-SD02-CR-RWT3003-REG	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
T24A-BERA-SW/SD03	T24A-BERA-SD03-CR-RWT3004-REG	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
FTA-108-SW/SD01	FTA-108-SD01-CR-RWT3005-REG	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
FTA-108-SW/SD03	FTA-108-SD03-CR-RWT3006-REG	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
R24A-187-SW/SD07	R24A-187-SD07-CR-RWT3007-REG	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
R24A-187-SW/SD06	R24A-187-SD06-CR-RWT3008-REG	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
FTA-108-SW/SD02	FTA-108-SD02-CR-RWT3009-REF	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C
R24A-187-SW/SD01	R24A-187-SD01-CR-RWT3010-REF	TAL Metals by SW_6010B/SW7471A; SVOCs by SW_8270C

REF - Reference sample

REG - Field sample.

SVOC - Semivolatile organic compound.

SW - U.S. Environmental Protection Agency's *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846)*.

TAL - Target Analyte List.

Table B-3

**Summary of Chironomus tentants Survival and Growth Test
Ranges Near Training Area T24-A
Fort McClellan, Calhoun County, Alabama**

(Page 1 of 2)

<i>Parameter</i>	<i>Conditions</i>
Test Type	Whole-sediment toxicity with renewal of overlying water
Temperature	23 ± 1°C
Light Quality	Wide-spectrum fluorescent lights
Illuminance	~100 – 1,000 lux
Photoperiod	16 hours light:8 hours dark
Test chamber	300-ml high form lipless beaker
Sediment volume	100 ml
Overlying water volume	175 ml
Renewal of overlying water	2 volume additions per day, either continuous or Intermittent
Age of organisms	<24 hour old larvae at start of test
Number of organisms per chamber	10
Number of replicate chambers per treatment	5
Feeding	Tetrafin goldfish food, fed 1.5 ml daily to each test chamber starting day-1. If fungal or bacterial growth develops on sediment surface, feeding should be suspended for one or more days. If DO drops below 2.5 mg/L during the test, feeding should be suspended for the amount of time necessary to increase the DO. If feeding is suspended in one treatment, it is suspended in all treatments.
Aeration	None, unless DO in overlying water drops below 2.5 mg/L
Overlying water	Culture water, laboratory-grade freshwater, or reconstituted water
Test chamber cleaning	Gently brush outside of overflow screens if they become clogged

Table B-3

**Summary of Chironomus tentans Survival and Growth Test
Ranges Near Training Area T24-A
Fort McClellan, Calhoun County, Alabama**

(Page 2 of 2)

<i>Parameter</i>	<i>Conditions</i>
Overlying water quality	Hardness, alkalinity, conductivity, and ammonia at the beginning and at the end of the test (day 21). Temperature daily. DO and pH three times/week. Conductivity weekly. Concentrations of DO should be measured more often if DO has declined by more than 1 mg/L since previous measurement. Overlying water quality should be measured just prior to water renewals. Overlying water should be measured from about 1 to 2 cm above the sediment surface.
Test duration	Five replicates are ended at 21 days for survival and weight.
Endpoints	21-day survival and weight; COPEC concentrations in chironomid tissues
Test acceptability	Average size of <i>C. tentans</i> in control sediment at 21 days \geq 0.6 mg/surviving organism as dry weight or 0.48 mg/surviving organisms as AFDW. Emergence \geq 50%

APPENDIX C

FIELD SAMPLING AND ANALYSIS PLAN FOR SURFACE SOIL AT THE RANGES NEAR TRAINING AREA T-24A

Appendix C

Field Sampling and Analysis Plan for Surface Soil at the Ranges Near Training Area T-24A Fort McClellan, Alabama

C.1.0 Introduction

The screening-level ecological risk assessment (SLERA) for the Ranges Near training Area T-24A (Shaw Environmental, Inc., 2005) identified antimony, copper, lead, and zinc as chemicals of potential ecological concern (COPEC) in surface soil. These COPECs are identical to the COPECs identified in soil at the Iron Mountain Road (IMR) and Bains Gap Road (BGR) ranges at FTMC. The soil mapping units at the T-24A ranges are also identical to the soil mapping units at the IMR and BGR ranges. Therefore, it has been proposed that the BERA for the T-24A ranges utilize the results of the toxicity and bioaccumulation tests that were conducted for the IMR and BGR ranges. In order to provide empirical evidence that the COPEC binding capacity of the soils at the T-24A ranges is similar to the COPEC binding capacity of the soils at the IMR and BGR ranges, five surface soil samples will be collected from the T-24A ranges and analyzed for physical/chemical properties that could affect the binding capacity/bioavailability of the COPECs identified in soil at the T-24A Ranges. The analyses that will be conducted on these surface soil samples are the following:

- pH
- phosphate
- total organic carbon (TOC)
- total carbonate
- cation exchange capacity
- iron oxyhydroxide content
- grain size
- calcium
- iron
- magnesium
- potassium
- sodium.

These physical/chemical properties will be compared to the binding capacity data that were collected for soils at the IMR and BGR Ranges (*Baseline Ecological Risk Assessment Study Design for the Iron Mountain Road Ranges*, IT, 2002a) to determine if the bioavailability of the COPECs in the IMR and BGR ranges soil is similar to the bioavailability of the COPECs in T-4A Ranges soil. If the bioavailability/binding capacity data from the T-24A ranges are similar to the bioavailability/binding capacity data from the IMR and BGR ranges, then the results of the

earthworm toxicity tests from the IMR/BGR ranges can be applied to the T-24A ranges. The locations of the five surface soil samples for physical/chemical analysis are presented in Figure 9-1.

C.2.0 Selection of Sample Locations

Surface soil sample will be collected from the two soil mapping units present at the T-24A ranges: Stony Rough Land, sandstone and Anniston and Allen stony loam as summarized below.

Sample Location	Soil Mapping Unit
R24A-187-GP17	Stony Rough Land, sandstone
R24A-187-GP16	Stony Rough Land, sandstone
FTA-108-GP07	Anniston and Allen stony loam
R24A-187-GP05	Anniston and Allen stony loam
R24A-187-MW03	Anniston and Allen stony loam

Figure 9-1 in the BERA Problem Formulation and Study Design report presents the approximate locations of the 5 surface soil samples that will be used to characterize the soil COPEC binding capacity/bioavailability of the surface soils at the T-24A ranges.

C.3.0 Sampling and Analysis Requirements

The following sections present the soil sampling and analysis requirements for the assessment of the surface soils that will be conducted in order to characterize the binding capacity/bioavailability of surface soils at the T-24A ranges.

C.3.1 Sample Collection Procedures

Once the sample location has been confirmed with regard to its soil mapping unit, soil will be collected to a depth of 0.5 feet, using a stainless-steel hand auger or spoon and homogenized in a stainless-steel bowl, following the sampling procedures outlined in the installation-wide sampling and analysis plan (IT, 2002b). Soil samples will then be transferred to the appropriate sample containers. Samples for chemical analysis will not be sieved.

C.3.2 Decontamination Procedures

All equipment used for collection, homogenization, and transfer will be properly decontaminated prior to collecting samples and between sampling locations, as described in the installation-wide sampling and analysis plan (IT, 2002b).

Appendix C

Field Sampling and Analysis Plan for Surface Soil at the Ranges Near Training Area T-24A Fort McClellan, Alabama

C.1.0 Introduction

The screening-level ecological risk assessment (SLERA) for the Ranges Near training Area T-24A (Shaw Environmental, Inc., 2005) identified antimony, copper, lead, and zinc as chemicals of potential ecological concern (COPEC) in surface soil. These COPECs are identical to the COPECs identified in soil at the Iron Mountain Road (IMR) and Bains Gap Road (BGR) ranges at FTMC. The soil mapping units at the T-24A ranges are also identical to the soil mapping units at the IMR and BGR ranges. Therefore, it has been proposed that the BERA for the T-24A ranges utilize the results of the toxicity and bioaccumulation tests that were conducted for the IMR and BGR ranges. In order to provide empirical evidence that the COPEC binding capacity of the soils at the T-24A ranges is similar to the COPEC binding capacity of the soils at the IMR and BGR ranges, five surface soil samples will be collected from the T-24A ranges and analyzed for physical/chemical properties that could affect the binding capacity/bioavailability of the COPECs identified in soil at the T-24A Ranges. The analyses that will be conducted on these surface soil samples are the following:

- pH
- phosphate
- total organic carbon (TOC)
- total carbonate
- cation exchange capacity
- iron oxyhydroxide content
- grain size
- calcium
- iron
- magnesium
- potassium
- sodium.

These physical/chemical properties will be compared to the binding capacity data that were collected for soils at the IMR and BGR Ranges (*Baseline Ecological Risk Assessment Study Design for the Iron Mountain Road Ranges*, IT, 2002a) to determine if the bioavailability of the COPECs in the IMR and BGR ranges soil is similar to the bioavailability of the COPECs in T-4A Ranges soil. If the bioavailability/binding capacity data from the T-24A ranges are similar to the bioavailability/binding capacity data from the IMR and BGR ranges, then the results of the

earthworm toxicity tests from the IMR/BGR ranges can be applied to the T-24A ranges. The locations of the five surface soil samples for physical/chemical analysis are presented in Figure 9-1.

C.2.0 Selection of Sample Locations

Surface soil sample will be collected from the two soil mapping units present at the T-24A ranges: Stony Rough Land, sandstone and Anniston and Allen stony loam as summarized below.

Sample Location	Soil Mapping Unit
R24A-187-GP17	Stony Rough Land, sandstone
R24A-187-GP16	Stony Rough Land, sandstone
FTA-108-GP07	Anniston and Allen stony loam
R24A-187-GP05	Anniston and Allen stony loam
R24A-187-MW03	Anniston and Allen stony loam

Figure 9-1 in the BERA Problem Formulation and Study Design report presents the approximate locations of the 5 surface soil samples that will be used to characterize the soil COPEC binding capacity/bioavailability of the surface soils at the T-24A ranges.

C.3.0 Sampling and Analysis Requirements

The following sections present the soil sampling and analysis requirements for the assessment of the surface soils that will be conducted in order to characterize the binding capacity/bioavailability of surface soils at the T-24A ranges.

C.3.1 Sample Collection Procedures

Once the sample location has been confirmed with regard to its soil mapping unit, soil will be collected to a depth of 0.5 feet, using a stainless-steel hand auger or spoon and homogenized in a stainless-steel bowl, following the sampling procedures outlined in the installation-wide sampling and analysis plan (IT, 2002b). Soil samples will then be transferred to the appropriate sample containers. Samples for chemical analysis will not be sieved.

C.3.2 Decontamination Procedures

All equipment used for collection, homogenization, and transfer will be properly decontaminated prior to collecting samples and between sampling locations, as described in the installation-wide sampling and analysis plan (IT, 2002b).

C.3.3 Quality Assurance/Quality Control Samples

As established by the data quality objectives process, field and laboratory quality assurance/quality control indicator soil samples and analyses will be collected to provide information concerning the measured quality and usability of the field data. As presented in the installation-wide sampling and analysis plan (IT, 2002b), the frequency of field duplicates, matrix spike/matrix spike duplicates, and equipment rinse blanks will be 1 in 10 (10 percent), 1 in 20 (5 percent), and once per sampling event, respectively.

C.3.4 Sample Labeling, Packaging, and Shipment

All prepared samples will be labeled, packaged, and shipped to the appropriate analytical laboratory as presented in the installation-wide sampling and analysis plan (IT, 2002b).

C.3.5 Chemical Analyses

The analyses that will be conducted on the five surface soil samples from the T-24A ranges are the following:

- pH
- phosphate
- TOC
- total carbonate
- cation exchange capacity
- iron oxyhydroxide content
- grain size
- calcium
- iron
- magnesium
- potassium
- sodium.

C.4.0 Safety and Health and Unexploded Ordnance Support

All work conducted during the BERA for the T-24A Ranges will be conducted in accordance with the site-specific work plans for the Ranges Near Training Area T-24A (IT, 2002, 2001, 2000, and 1998, and Shaw, 2003). These attachments will be updated to be consistent with the February 2002, *Draft Revision 3, Installation-Wide Sampling and Analysis Plan, Fort McClellan, Calhoun County, Alabama*, for the final BERA study design for the T-24A Ranges.

C.5.0 References

Shaw Environmental, Inc. (Shaw), 2005, *Remedial Investigation Report, Ranges Near Training Area T-24A, Parcels 187(7), 88(6), 108(7)/82Q-X, 112Q, 113Q-X, 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama*, Draft, April.

Shaw Environmental, Inc. (Shaw), 2003, *Site-Specific Work Plan, Remedial Investigation, Addendum IV, Ranges Near Training Area T-24 Alpha, Parcels 88(7), 108(7), 112Q, 113Q-X, 123Q, 187(7), 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama*, Draft, October.

IT Corporation (IT), 2002a, *Baseline Ecological Risk Assessment Problem Formulation for Small Arms Ranges at Iron Mountain Road, Fort McClellan, Calhoun County, Alabama*, Final, Revision 1, November.

IT Corporation (IT), 2002b, *Installation-Wide Sampling and Analysis Plan, Fort McClellan, Calhoun County, Alabama*, Revision 3, February.

IT Corporation (IT), 2001, *Site-Specific Field Sampling Plan Addendum and UXO Safety Plan Addendum for the Supplemental Remedial Investigation at Ranges Near T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q*, letter work plan, July.

IT Corporation (IT), 2000, *Supplemental Remedial Investigation, Site-Specific Field Sampling Plan, Site-Specific Safety and Health Plan, and Site-Specific Unexploded Ordnance Safety Plan Attachments, Ranges Near Training Area T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama*, Final, September.

IT Corporation (IT), 1998, *Site Investigations, Site-Specific Field Sampling Plan and Site-Specific Safety and Health Plan Attachments, Range 24A Fog Oil Drum Storage (Parcel 88), Range 24A Multi-Purpose Range (Parcel 108), Smoke Area BVZ (Parcel 124), Smoke Area S (Parcel 106), Smoke Area R (Parcel 105), Old Incinerator (Parcel 125), Former Smoke Area Choccolocco Corridor (Parcel 107), and Former Smoke, Fort McClellan, Calhoun County, Alabama*, Final, September.

Table C-1

**Surface Soil Sample Designations and QA/QC Sample Quantities
BERA Study Design for the Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

Sample Location	Sample Designation	Sample Depth (ft)	QA/QC Samples		Analytical Suite
			Field Duplicates	MS/MSD	
R24A-187-GP17	R24A-187-GP17-SS-RWT4001-REG	0 - 0.5	R24A-187-GP17-SS-RWT4002-FD		pH (SW_9045A), TOC (Walkley Black), Total phosphorus (SW_365.2M), Total carbonate/alkalinity (SW_310.1M), Cation Exchange Capacity (SW_9081); Iron Oxyhydroxide (SW_6010B for total iron, SW_3500 for Fe[II] ferrous iron, Fe[III] ferric iron by difference); Grain Size (ASTM 421/422); and Calcium, Iron, Magnesium, Potassium, Sodium (SW_6010B).
R24A-187-GP16	R24A-187-GP16-SS-RWT4003-REG	0 - 0.5			pH (SW_9045A), TOC (Walkley Black), Total phosphorus (SW_365.2M), Total carbonate/alkalinity (SW_310.1M), Cation Exchange Capacity (SW_9081); Iron Oxyhydroxide (SW_6010B for total iron, SW_3500 for Fe[II] ferrous iron, Fe[III] ferric iron by difference); Grain Size (ASTM 421/422); and Calcium, Iron, Magnesium, Potassium, Sodium (SW_6010B).
FTA-108-GP07	FTA-108-GP07-SS-RWT4004-REG	0 - 0.5			pH (SW_9045A), TOC (Walkley Black), Total phosphorus (SW_365.2M), Total carbonate/alkalinity (SW_310.1M), Cation Exchange Capacity (SW_9081); Iron Oxyhydroxide (SW_6010B for total iron, SW_3500 for Fe[II] ferrous iron, Fe[III] ferric iron by difference); Grain Size (ASTM 421/422); and Calcium, Iron, Magnesium, Potassium, Sodium (SW_6010B).
R24A-187-GP05	R24A-187-GP05-SS-RWT4005-REG	0 - 0.5			pH (SW_9045A), TOC (Walkley Black), Total phosphorus (SW_365.2M), Total carbonate/alkalinity (SW_310.1M), Cation Exchange Capacity (SW_9081); Iron Oxyhydroxide (SW_6010B for total iron, SW_3500 for Fe[II] ferrous iron, Fe[III] ferric iron by difference); Grain Size (ASTM 421/422); and Calcium, Iron, Magnesium, Potassium, Sodium (SW_6010B).
R24A-187-MW03	R24A-187-MW03-SS-RWT4006-REG	0 - 0.5			pH (SW_9045A), TOC (Walkley Black), Total phosphorus (SW_365.2M), Total carbonate/alkalinity (SW_310.1M), Cation Exchange Capacity (SW_9081); Iron Oxyhydroxide (SW_6010B for total iron, SW_3500 for Fe[II] ferrous iron, Fe[III] ferric iron by difference); Grain Size (ASTM 421/422); and Calcium, Iron, Magnesium, Potassium, Sodium (SW_6010B).

ASTM - American Society for Testing and Materials.
MS/MSD - Matrix spike/matrix spike duplicate.
REG - Field sample.

SW - U.S. Environmental Protection Agency's *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846).
TOC - Total organic carbon.

RESPONSE TO COMMENTS

**Response to U.S. Environmental Protection Agency Ecological Review Comments on the
Draft Problem Formulation/Study Design for Ranges Near Training Area T-24A,
Parcels 187(7), 88(6), 108(7)/82Q-X, 112Q, 113Q-X, 213Q, and 214Q
Fort McClellan, Calhoun County, Alabama**

Comments from Doyle T. Brittain, Senior Remedial Project Manager, dated January 10, 2008.

General Comments

Comment 1: The proposed list of refined chemicals of potential ecological concern is acceptable.

Response 1: No response is necessary.

Comment 2: The assessment endpoints, risk questions, and risk measures are appropriate.

Response 2: No response is necessary.

Comment 3: The Army has proposed utilizing the data pertaining to the ecological risk assessment from the Iron Mountain Road Ranges (IMR), Bains Gap Road Ranges (BGR) and Baby Bains Gap Road Ranges (BBGR) for the soils at the Ranges Near Training Area T-24A. The study design explains how bioaccumulation factors and No Observable Adverse Effects Level (NOAEL) to Lowest Observable Adverse Effects Level (LOAEL) ranges developed for the IMR/BGR/BBGR will be applied in this effort. This approach is reasonable. The text is generally consistent with this approach. However, a few places in the document were not changed to reflect the new approach. These are pointed out in Specific Comment 1.

Response 3: Agreed. The text will be revised to reflect the fact that data from the IMR and BGR BERA will be utilized to address surface soil endpoints identified for the T-24A Ranges. Data from the BBGR BERA will not be used in the T-24A Ranges BERA. The text will be revised accordingly.

Comment 4: EPA is amenable to the idea of using the data from the IMR/BRG/BBGR ranges for the Ranges Near Training Area T-24A, but conditionally accepts the approach at this time, not having seen the final cleanup goals for the IMR/BGR ranges. EPA continues to recommend an effort to derive consistent cleanup goals for soils among ranges, given that it now appears as if the IMR/BGR, 81-mm Mortar Range, and T-24 Alpha ranges will utilize the same data and cleanup goals. EPA recommends a subgroup to work on the cleanup goals to reduce comment and response cycles on the documents.

Response 4: As clean-up goals are the purview of risk managers and not risk assessors, specific clean-up goals will not be selected in the various risk assessments at FTMC, rather, a range of risk-based clean-up goals will be derived and presented in the risk assessments based on the specific endpoints assessed in the risk assessment. The risk management team may consider these risk-based clean-up goals along with a number of other remedial options when making risk management decisions regarding a particular site. As such, the formation of a subgroup to select clean-up goals at this time may be premature and not warranted until after the IMR/BGR BERA is finalized.

Comment 5: **This report was not released prior to the November 2007 BCT meeting. The November BCT meeting participants discussed how the 81-mm Mortar Range would use the data from the Iron Mountain Road Ranges (IMR) and Bains Gap Road Ranges (BGR) RI report instead of collecting more biological data. At the BCT meeting EPA was told that a separate risk assessment will be performed for the IMR/BRG, Choccolocco Corridor, and T-24A Ranges. The subject ranges will apparently receive risk assessments. The Final SLERA report for the Ranges Near T-24A indicated that no site-specific data will be collected for soils at the T-24A Ranges, because the BERA will use data from the IMR/BGR/BBGR BERAs. This means that the T-24A Ranges and the 81-mm Mortar Range are both relying on the same existing data. My point is that if the Ranges Near Training Area T-24A is getting a baseline ecological risk assessment, the 81-mm Mortar range should also get a baseline ecological risk assessment. The baseline ecological risk assessments can use the existing data to characterize the risks, but each site should have its own human health and ecological risk characterizations per NCP [FR 55 No. 46 §300.430 (d) (4)]. Site-specific means the risk assessment should be prepared for the particular site versus relying on a risk assessment for another site. Conclusions of the RI Report for the 81-mm Mortar Range indicated that a BERA was needed. This comment is recommending that the Army prepare an ecological risk assessment that covers both the 81-mm Mortar Range and the Ranges Near Training Area T-24A in the same report to meet the requirements of CERCLA while streamlining the report submissions. The 81-mm Mortar Range could be added to the current document on the baseline problem formulation and study design for the T-24A Ranges.**

This suggestion basically means the addition of a few tables and figures to cover the added range. The bulk of the text could cover all eight ranges without significant revision. The risk characterization for soils would involve comparison of the detected concentrations of COPECs to risk assessment results from the IMR/BGR/BBGR BERAs. I think that the risk characterization for the 81-mm Mortar would be more transparent and understandable if it was presented in the context of the supporting information on the identification of chemicals of potential concern, ecotoxicity, fate and transport, etc., that is normally contained in the

BERA. My suggestion is a reasonable compromise that will allow the information to be presented without adding a new deliverable or an unreasonable increase in the level of effort.

Response 5: As discussed at the November 2007 BCT meeting, the Army does not wish to conduct and further investigative work at the 81mm Mortar Range. In lieu of further investigation, detected concentrations of soil COPECs at the 81mm Mortar Range will be compared to remedial goals derived for the Iron Mountain Road (IMR) and Bains Gap Road (BGR) Ranges. This comparison will take place in the Feasibility Study for the 81mm Mortar Range, thus eliminating the need for a Problem Formulation, Study Design, and Baseline Ecological Risk Assessment for the 81mm Mortar Range. This approach saves time, money, and effort. It is the Army's understanding that USEPA Region 4 personnel had agreed to this approach at the November 2007 BCT meeting.

The Choccolocco Corridor Ranges and the T-24A Ranges both have surface water and/or sediment COPECs that are not found at the IMR or BGR Ranges; therefore, separate BERAs for these two sets of ranges are warranted. Since the 81mm Mortar Range has identical soil COPECs as the IMR and BGR Ranges and does not have any surface water or sediment COPECs, additional site-specific investigations (i.e. BERA) for the 81mm Mortar Range are not warranted.

Comment 6: **The Baseline Ecological Risk Assessment (Section 7.0) in the draft Remedial Investigation Report for the Bains Gap Road Ranges, dated May 2004, covered the IMR and BGR Ranges at Fort McClellan. The Constituents of Potential Ecological Concern (COPECs) in soils are the same in the IMR/BGR/BBGR BERAs as at the T-24A Ranges. Soils data, such as toxicity to soil invertebrates, toxicity to plants, bioaccumulation into the tissues of soil invertebrates, and bioaccumulation into the tissues of plants, from the IMR/BGR/BBGR BERAs will be sufficient to cover the data needs of the BERA for the T-24A Ranges.**

Response 6: No response is necessary; however, please note that data from the BBGR BERA will not be used in the BERA for the T-24A Ranges.

Comment 7: **The assessment endpoints for the terrestrial ecosystems at the Ranges Near Training Area T-24A included a few assessment endpoints and measures that rely on data exclusively available in the BBGR Ranges BERA:**

- ❖ **Survival and growth of terrestrial plant communities at the T-24A Ranges**
 - **Statistical comparison of perennial ryegrass seed germination success, plant height, above ground biomass, root length, and root**

biomass between plants grown in soils with site-related COPECs to plants grown in soils from a reference location.

- ❖ **Survival, growth, and reproduction of terrestrial omnivorous small mammals and birds at the T-24A Ranges**
 - **Quantification of COPEC concentrations in tissues of terrestrial plants from COPEC-impacted soils and terrestrial plants from a reference location.**

The BERA for the T-24A Ranges, as presented in the report, was designed to use the plant toxicity testing and the plant tissue bioaccumulation data that was collected as part of the BERA for BBGR Ranges. Data for toxicity to plants and bioaccumulation into plants was not collected for the IMR/BRG Ranges. As expressed in EPA's comments on the BERA for the BBGR Ranges, plants, such as pine trees, can be sensitive to low levels of lead in soils. The assessment of risks to plants is important at the T-24A Ranges, because the property is being transferred over to the U.S. Fish and Wildlife Service to serve as a longleaf pine reserve. The BERA for the BBGR Ranges factored in the site-specific measurement of bioaccumulation of COPECs into plant tissues in the context of assessing the risks to omnivorous mammals and birds. Use of the site-specific bioaccumulation estimates in the BBGR BERA resulted in a less conservative estimate of risk. If the site-specific bioaccumulation relationships derived from the BBGR BERA were not used to assess the potential risk to omnivores at the T-24A Ranges, the more conservative default literature values would be needed. This could result in a more conservative cleanup goal for COPECs in soils and could potentially increase cleanup costs. This comment was written because the Army currently plans not to use the data from the BBGR Ranges BERA, because most of the property covered by the BBGR Ranges BERA has become part of the ESCA agreement with the JPA. The JPA will assess the risks for BBGR Ranges under this agreement. This comment is recommending that at least the data for toxicity and bioaccumulation into plants from the BBGR Ranges BERA be used to support the risk assessments at the T-24A Ranges and the 81-mm Mortar Range to fill a potentially costly data gap that would otherwise exist. EPA thinks that use of a limited amount of data from the BBGR Ranges will improve the cleanup decision for the T-24A Ranges without interfering with the JPA's cleanup decisions at the BBGR Ranges.

Response 7: The assessment endpoints, risk hypotheses, and measurement endpoints for the T-24A BERA will be revised to reflect the fact that data from the BBGR BERA will not be utilized in the T-24A Ranges BERA.

Specific Comments

Comment 1: Section 7.2.1, Terrestrial Risk Hypotheses, Pages 7-7 through 7-8. The test hypotheses, such as lines 30-32 on Page 7-7 and lines 8-10 on Page 7-8, need to be revised to replace comparisons to a reference station to comparisons of soil concentrations at the T-24A Ranges to NOAELs and LOAELs derived for protection of terrestrial plants and terrestrial invertebrates from the IMR/BGR/BBGR BERAs. This comment applies to Pages 7-7 and 7-8 or any other place in the document where a comparison to a reference site is used in a test hypothesis statement for soils. For example, there are a couple of changes of this nature on Page 7-16 and in Table 7-1. Text on Page 8-3 can serve as a positive example for the wording of text.

Response 1: Agreed. Terrestrial risk hypotheses will be revised to reflect the fact that the results of the IMR/BGR BERA will be utilized to assess risks from soil COPECs.

**Response to ADEM's Evaluations of Army's Responses to ADEM Comments on the
Draft Baseline Ecological Risk Assessment Problem Formulation and
Study Design for the Ranges Near Training Area T-24A
Fort McClellan, Calhoun County, Alabama**

General Comments

Comment 2: **Technical evaluation of the screening-level ecological risk assessment (SLERA) requested clarification of how detected cobalt and mercury concentrations in surface water were determined to be similar to undetected background levels and therefore not considered constituents of possible ecological concern (COPECs). This concern appears applicable to the baseline ecological risk assessment (BERA). Please address.**

Response 2: This comment was satisfactorily addressed in the *Response to ADEM Review Comments, Final SLERA for Ranges Near Training Area T-24A, Parcels 187(7), 88(6), 108(7)/82Q-X, 112Q, 113Q-X, 213Q, and 214Q, Dated January 3, 2007*. For reference, the response is included here as well.

Although cobalt and mercury in FTMC background surface water do not have Tier 1 background screening values (2-times the mean), they did pass the Tier 2 step of the FTMC site-to-background comparison process. This step consists of a hot measurement test (comparison of the site MDC to the background 95th upper tolerance limit [UTL] or 95th percentile, depending on the background distribution) and the Wilcoxon rank sum test (which is performed for elements with less than 50 percent non-detects in both the site and background data sets). During the hot measurement test, the 95th UTL is used as the background screening value for elements with normal or lognormal distributions in the background data set, and the 95th percentile is used as the background screening value for elements that are characterized as having nonparametric distributions (due either to the presence of greater than 15 percent non-detects or to failure of the Shapiro-Wilk test to indicate a normal or lognormal distribution). For those elements with high non-detect frequencies and non-detects in the upper decile of the background distribution (i.e., cobalt and mercury in background surface water), the maximum reporting limit is used as the background screening value and it represents an upper limit to the background distribution. This information is provided in the approved installation-wide work plan, which was issued in February 2002 (IT Corporation, 2002).

In accordance with the BCT-approved site-to-background comparison methodology, elements without Tier 1 screening values are carried forward for Tier 2 screening. In the case of cobalt and mercury in the surface water samples from the Ranges Near T-24A, the maximum detected concentrations (18.1 J µg/L and 0.066 J µg/L, respectively) are below the Tier 2 background

screening values of < 25 µg/L (cobalt) and < 0.243 µg/L (mercury). Therefore, these two elements are not carried forward for additional evaluation in the site-to-background comparison. It is important to note that both of the site MDCs are low, estimated values below the reporting limit, which suggests that they do not represent site-related contamination.

Evaluation 2: *Use of background values is not acceptable for surface water, nor sediment, especially when concentrations exceed ESVs, as they do for cobalt and mercury. Use of Tier 1 or Tier 2 background values to eliminate COPECs was accepted and approved by ADEM for soils only. Exceedances of ESVs for cobalt and mercury require these to be retained as COPECs in the BERA. Upstream or reference habitat samples should be used to assess incremental site surface water risk. Please address.*

Response to

Evaluation 2: Per discussions and agreements made between Army, ADEM, USFWS, and USEPA personnel at the December 11 - 12 2008 meeting at FTMC, the 3-tier background screening process of surface water and sediment constituents for the purpose of identifying COPECs is consistent with ARBCA guidance and is a valid process for identifying COPECs at FTMC.

Alternative screening values (in conjunction with other lines of evidence) will be considered in the COPEC refinement process for cobalt and mercury in surface water at the T-24A ranges. The USEPA Region 3 BTAG Freshwater Screening Benchmark for cobalt (23 µg/L) will be used as an alternative screening value for cobalt and the National Recommended Water Quality Criteria for mercury (CCC = 0.77 µg/L) will be used as an alternative screening value for mercury. The maximum detected concentrations of both cobalt and mercury are less than their respective alternative screening values; therefore, they will not be identified as COPECs in surface water at the T-24A ranges.

Specific Comments

Comment 2: **Section 2.0.** The use of background threshold values (BTVs) to eliminate inorganic constituents was for only the selection of soil COPECs. The *Army's Response to ADEM Review Comments of the Final SLERA for Ranges Near Training Area T-24A*, dated August 20, 2007 General Comment #2 does not justify the elimination of cobalt and mercury as surface water COPECs based on the Tier 2 site-to-background comparison process. Not only did these and other compounds exceed their ecological screening values (ESVs) for surface water and sediments, but neither metal was detected in reference stream or upstream surface water samples located upgradient of site influences. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance for ecological risk assessment (ERA) does encourage the use of background/upstream sediment and surface water data to calculate

incremental, site-derived risks relative to upstream or reference habitat locations in the SLERA and BERA after COPECs are selected using only a screen against their ESVs (USEPA, 2001). Please address.

Response 2:

The use of background screening values to identify constituent concentrations that are similar to naturally occurring concentrations is applicable to all environmental media, not just soil. With regard to screening out cobalt and mercury as COPECs in surface water, please see Response to General Comment 2 above, which was satisfactorily addressed in *Response to ADEM Review Comments, Final SLERA for Ranges Near Training Area T-24A, Parcels 187(7), 88(6), 108(7)/82Q-X, 112Q, 113Q-X, 213Q, and 214Q, Dated January 3, 2007.*

COPECs were identified in the SLERA for T-24A Ranges as they have been in numerous other SLERAs conducted at FTMC using the procedures outlined in Chapter 2 of the T-24A Problem Formulation and Study Design. The initial COPEC identification process included the following:

- Comparison of maximum detected constituent concentrations to ecological screening values (ESVs);
- Identification of essential macro-nutrients; and
- Comparison of the maximum detected constituent concentrations to background screening values (2x the arithmetic mean of the background data set).

Subsequent to the initial COPEC identification process, additional lines of evidence were evaluated to refine the initial list of COPECs. Some of the additional lines of evidence used in the process of refining the list of COPECs included: 1) frequency of detection, 2) magnitude of the HQ_{screen} value, 3) spatial distribution, 4) comparison to alternative ESVs; 5) statistical and geochemical background evaluation; and 6) association of a chemical with known Army activities. This COPEC identification process has been employed in numerous SLERAs over the course of a number of years at FTMC and is consistent with Step 3 of the eight-step ecological risk assessment process as described in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997).

Evaluation 2:

Please see Evaluation for General Comment 2. All analytes that exceed the lowest applicable ESVs, such as AWQC, should be retained as sediment and surface water COPECs and carried through the BERA. Also, other lines of evidence should not be used up front in the Problem Formulation to eliminate COPECs from further characterization in the BERA. Such weight of evidence

considerations should be provided only in the risk characterization and uncertainty analysis of the BERA.

**Response to
Evaluation:**

Per discussions and agreements made between Army, ADEM, USFWS, and USEPA personnel at the December 11 - 12 2008 meeting at FTMC, the 3-tier background screening process of surface water and sediment constituents for the purpose of identifying COPECs is consistent with ARBCA guidance and is a valid process for identifying COPECs at FTMC.

Alternative screening values will be considered (in conjunction with other lines of evidence) in the COPEC refinement process for cobalt and mercury in surface water at the T-24A ranges. The USEPA Region 3 BTAG Freshwater Screening Benchmark for cobalt (23 µg/L) will be used as an alternative screening value for cobalt and the National Recommended Water Quality Criteria for mercury (CCC = 0.77 µg/L) will be used as an alternative screening value for mercury. The maximum detected concentrations of both cobalt and mercury are less than their respective alternative screening values; therefore, they will not be identified as COPECs in surface water at the T-24A ranges.

The refinement of COPECs at the end of the SLERA process or the beginning of the problem formulation process is explicitly prescribed in federal USEPA (1997) and USEPA Region 4 (2000) ecological risk assessment guidance, and has been practiced at FTMC for over 10 years. Whether the process of COPEC refinement is conducted at the end of the SLERA (Step 2) or the beginning of the Problem Formulation (Step 3) is, in practice, inconsequential from a technical perspective. Incorporating elements of Step 3 into the SLERA provides for the presentation of additional information into the SLERA that allows risk managers to make more informed risk management decisions at the completion of the SLERA. It is the Army's belief that providing risk managers with as much pertinent information at each risk management decision point is imperative to making informed decisions and that delaying the transfer of information to a later stage in the ecological risk assessment process substantially reduces the efficiency and transparency of the process.

COPECs were initially identified in the SLERA by comparing the maximum detected concentrations of constituents to appropriately conservative and agreed-upon screening values (IT, 2000). Those constituents whose maximum detected concentrations exceeded their respective conservative screening values were identified as COPECs in the SLERA per USEPA (2007) guidance. Consistent with Step 3 of the 8-step ecological risk assessment process, additional lines of evidence were used to further refine the list of COPECs that would be carried forward into the baseline ecological risk assessment. The process of refining the initial list of COPECs prior to developing assessment and measurement endpoints and study design is

explicitly stated on page 3-1 of the USEPA's *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997) which states: "Problem formulation at Step 3 includes several activities:

- Refining preliminary contaminants of ecological concern;"

Furthermore, USEPA Region 4 guidance (*Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders*, June 23, 2000) states that "Problem formulation begins with the refinement of the COPCs. This step is an opportunity for facilities to present a reasoned toxicological approach for the elimination of one or more COPCs from future consideration. At this step, negotiations are undertaken to alter assumptions associated with the Screening Level ERA. These assumptions include but are not limited to area use factors (e.g. home ranges), incidental soil/sediment intakes, **background/reference location comparisons**, and the nature of the contaminants." (underline and bold added for emphasis). Further justification for including a background comparison within the COPEC refinement process is found in "Step 3: Problem Formulation" of the USEPA Region 4 guidance (2000) which states: "Risk management issues such as background comparison, are introduced for discussion among stakeholders at this stage."

It is clear from these passages from the federal USEPA (1997) and USEPA Region 4 (2000) guidance documents that comparison to background is an accepted practice in the refinement of COPECs during the SLERA/Problem Formulation step of the ecological risk assessment process. This process for refining the initial list of COPECs at the end of the SLERA and/or beginning of the Problem Formulation has been thoroughly vetted through numerous BCT meetings and comment response cycles and it remains consistent with all existing ecological risk assessment guidance. Therefore, the Army does not feel it is necessary or warranted to change the COPEC identification process at this time.

Comment 3: **Section 2.0. Please revise the text so that surface water and sediment COPECs that exceed their ESVs are not eliminated upfront. Such COPEC evaluation may be applied during the risk characterization for those COPECs as part of a weight of evidence approach to evaluating the significance of any site-derived increments of total risk. For example, COPECs also may be eliminated as potential drivers of remedial action or risk management decisions, during the risk characterization, based on a lack of bioavailability to ecological receptors (e.g., dissolved concentrations of metal COPECs that are below their chronic ambient water quality criteria [AWQC] for dissolved metals, despite total metal exceedances of AWQC in unfiltered samples). Elimination of surface water and sediment COPECs based on "other lines of evidence" such as geochemical evaluation is not appropriate in the Problem Formulation,**

and should be relegated to the risk characterization. If such discussions are presented in the risk characterization, they should be supported by incorporating the geochemical evaluations, currently absent from the Problem Formulation, into the BERA. Please address.

Response 3: Please see Response to Specific Comment 2. COPECs are not identified in the Problem Formulation and Study Design, but are identified in the SLERA using the methodologies described above and approved by the BCT and through precedent over numerous years at FTMC.

Evaluation 3: *Please see Evaluation for Specific Comment 2.*

**Response to
Evaluation 3:**

Please see Response to Evaluation 2. The process of refining the initial list of COPECs at the end of the SLERA and/or beginning of the Problem Formulation has been thoroughly vetted through numerous BCT meetings (in which USEPA, ADEM, USFWS, and Army personnel were participants) and comment response cycles and it remains consistent with all existing ADEM and USEPA ecological risk assessment guidance. Therefore, the Army does not feel it is necessary or warranted to change the COPEC identification process at this time.

Comment 4: **Section 2.3. The lowest available sediment ESVs should be used in COPEC selection. However, the use of soil ESVs such as ecological soil screening levels (EcoSSLs) may be more ecologically appropriate than using sediment ESVs if dry stream channel deposits are sampled from intermittent reaches of streams that only carry ephemeral flows after precipitation events. If such reaches are usually dry and do not retain sufficient moisture to support aquatic or wetland vegetation, they are probably best classified as upland soils for the purposes of ESV/COPEC selection, and food chain exposure assessments. Please address.**

Response 4: Appropriate ESVs were identified in the SLERA based on the samples at the time of collection. If a soil sample was collected from an upland area, then soil ESVs were used for comparison. If a sample was collected from a drainage feature that contained water at the time of collection, then sediment ESVs were most appropriately used for comparison. If a sample was collected from a drainage feature that was dry at the time of collection (depositional soil sample), then soil ESVs were used for comparison. COPEC identification was accomplished in the SLERA and is not part of the subject Problem Formulation and Study Design report.

Evaluation 4: *Response regarding habitat-based decisions on use of soil versus sediment ESVs is accepted. However, the original selection of ESVs made in 2000 should be revalidated, and the validity of the original COPEC screening tables of the SLERA also should be validated and incorporated into the Problem Formulation. Please address.*

**Response to
Evaluation 4:**

As agreed upon by USEPA, ADEM, USFWS, and Army personnel at the December 11 - 12 2008 meeting at FTMC, Ecological Soil Screening Levels (Eco-SSLs) and Alabama freshwater ambient water quality criteria (AQWC) will be compared to corresponding ESVs used in the selection of COPECs and that the Eco-SSLs and AQWC will be evaluated with regard to their impact on COPEC selection. It was also agreed upon at the December 11 - 12 2008 meeting at FTMC that the sediment ESVs used in the COPEC selection process are valid and no revisions are necessary.

Comment 6:

Section 2.4. Please revise the text to clarify if there are groundwater seeps within the area. If there are no seeps, then the groundwater constituents may be eliminated from further consideration. Groundwater data were discussed and subjected to COPEC screening for the SLERA, apparently using surface water ESVs (as noted above, the types and sources of ESVs used for COPEC screening in each medium were not explicitly described). However, the discussion of potentially complete exposure pathways did not conclusively rule out the possible exposures of ecological receptors to elevated COPEC concentration in full strength groundwater that might be encountered at terrestrial, wetland or stream-associated seeps, prior to the mixing of the groundwater with and dilution by surface waters. Such exposures could occur at seeps during seasonal and/or drought conditions when site-impacted groundwater might upwell into otherwise dry reaches of stream channels. Elimination of groundwater from consideration in the BERA, thus, might best be supported by documenting the lack of groundwater seepage or breakout areas downgradient of those monitoring wells where the (presumably unfiltered) groundwater samples exceeded ESVs for aluminum, barium, iron, lead, manganese, mercury, and zinc. Please address.

Response 6:

The types and sources of ESVs are appropriately discussed in detail in the SLERA, where COPEC identification is accomplished. The Problem Formulation and Study Design simply summarizes the COPEC selection process in order to provide an introduction to the BERA process.

The study area of the T-24A Ranges forms the headwaters of the South Branch of Cane Creek (as described in Chapter 5). As such, there are a number of areas of seepage and wetland areas at the T-24A Ranges, which are highly dependent upon the amount of precipitation received in the vicinity of the T-24A Ranges. As such, there is the potential for ecological receptors to be exposed to constituents in groundwater if groundwater is expressed at the surface as a seep or wetland area. However, based on the COPEC identification process described in detail in the T-24A SLERA and summarized in Chapter 2 of the Problem Formulation and Study Design

report, no constituents in groundwater were identified as COPECs, regardless of what monitoring well certain constituents may have been detected.

Evaluation 6: *Please add the discussion in the response to the text of Section 2.4 to clearly acknowledge and explain where and how ground water seeps may represent points of ecological exposure to COPECs in ground water. Also, please present results of the ground water COPEC selection for seep locations from the SLERA.*

Response to

Evaluation 6: The discussion provided in Response 6 will be added to the text of Section 2.4. The results of the groundwater COPEC selection process are presented in Table 2-4 and discussed in Section 2.4. Please note that seeps were not specifically sampled at the T-24A Ranges because no seeps were identified at the T-24A Ranges. The Army has taken a conservative approach and agreed to screen COPECs in groundwater because there is the potential for groundwater to discharge to surface water at the T-24A Ranges, as discussed in Section 2.4.

Comment 7: **Section 3.0. Please discuss all of the ESVs used in COPEC screening, their sources and derivation *sensu* ecological receptor groups, including soil EcoSSLs and the lower of National (USEPA 2006) or Alabama chronic AWQC, to complement the requested ESV summary table. Please explain all bioavailability-related adjustments made to the ESVs using site-specific data and clearly indicate if any ESV conversions are being made using the EPA-prescribed conversion factors. Please discuss any site-specific sediment ESV adjustments using total organic carbon (TOC) and/or considerations of metal bioavailability in relation to ratios of simultaneously extracted metals (SEM) to acid volatile sulfides (AVS), if such SEM:AVS data are available and considered relevant for site-derived sediments. Also, when discussing aquatic toxicity thresholds, please indicate whether the value is for total or dissolved metal concentrations.**

Response 7: All ESVs are described in detail in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000). As described in that report, all of the ESVs are values extracted from the scientific literature. No adjustments were made to these values for bioavailability or site-specificity. ESV screening and COPEC identification are accomplished in the T-24A SLERA and are not part of the Problem Formulation and Study Design report. For clarity, a reference to the *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000) will be added to the beginning of Chapter 2.

Evaluation 7: *Please see Evaluation for Specific Comment 4. Also, please add text to clearly explain that no bioavailability adjustments were made to ESVs before*

COPEC screening. However, if surface water hardness data are available, hardness dependent AWQC should be adjusted before use.

Response to

Evaluation 7: Text will be added in Chapter 2, Identification of COPECs, to explain that no bioavailability adjustments were made to the ecological screening values. The average surface water hardness for samples collected at the T-24A ranges will be used to estimate Alabama chronic AWQC.

Comment 9: **Section 3.1. The mammalian EcoSSL of 0.27 mg/kg was discussed appropriately on Page 3-3 but was not used in the COPEC screening of Table 2-1. As the lowest available soil ESV, this EcoSSL should be used to evaluate antimony as a possible COPEC. Please address.**

Response 9: Initial COPEC screening is accomplished in the SLERA using the ecological screening values (ESVs) presented in the *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000). Additional lines of evidence are subsequently considered in the SLERA in order to include or exclude certain constituents from the list of COPECs as discussed in Response to Specific Comment 2. Eco-SSLs are considered as alternative ESVs in the additional lines of evidence evaluation. Any discussion of ESVs or COPEC identification should be addressed with respect to the SLERA, which has been commented on by EPA, USFWS, and ADEM, revised by the Army in response to those comments, and all revisions agreed to by EPA, USFWS, and ADEM.

Evaluation 9: *Please see Evaluation for Specific Comment 2. EcoSSLs should not be treated as "alternative ESVs", but as the preferred soil ESVs when available. EcoSSLs should be used unless lower and more protective soil ESVs are available and can be scientifically justified. Please address.*

Response to

Evaluation 9: Please see Response to Evaluation 4.

Comment 10: **Section 3.1. On Page 3-8, the avian lead EcoSSL of 11 mg/kg is discussed, but this lowest available soil ESV was not used in the COPEC screen of Table 2-1. Please revise the COPEC screening and Table 2-1 accordingly.**

Response 10: Please see response to Specific Comment 9.

Evaluation 10: *Please see Evaluation for Specific Comment 9.*

Response to

Evaluation 10: Please see Response to Evaluation 4.

Comment 12: **Section 3.5.** On Page 3-14, the toxicity threshold for PAHs applied to mallard duck eggs was discussed, although that exposure pathway/scenario and related assessment/measurement endpoints were not proposed for the BERA in Section 7.0 or Table 7-1. Please provide relevant avian toxicity data for ingestion of PAHs, since that pathway will be assessed in the BERA.

Response 12: Chapter 3 summarizes available information regarding the toxicity of the identified COPECs to various groups of ecological receptors, regardless of their direct applicability to the T-24A ranges, in order to give the reader an idea of the relative toxicities of the COPECs to various ecological receptors. If information regarding a specific feeding guild or exposure pathway is missing from this discussion, it is because this information was not readily available in the scientific literature.

The PAH toxicity data for birds summarized in EPA's *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (1999) will be added to the discussion in Section 3.5; however, it should be noted that these additional toxicity data are also for bird embryos and not from studies of birds ingesting PAHs.

Evaluation 12: *Please identify PAH avian toxicity effects data for the ingestion of PAHs, rather than using data on the embryonic effects of applying PAHs to egg shells.*

Response to

Evaluation 12: An additional avian toxicity study reporting the effects of PAHs on birds after ingestion of PAHs will be included in Section 3.5.

Comment 13: **Section 4.0.** Figure 6-1 indicates some complete or potentially complete exposure pathways for groundwater. For completeness, please provide a separate section discussing in general the fate and transport potential associated with groundwater, however limited.

Response 13: Chapter 4 presents a discussion of the fate and transport mechanisms for the environmental media and the chemical-specific properties of the identified COPECs that are present at the T-24A ranges. Because no COPECs were identified in groundwater at the T-24A Ranges, it is inappropriate to discuss groundwater fate and transport in this chapter.

Potentially complete exposure pathways for groundwater and ecological receptors are discussed in the second full paragraph on page 6-2 with respect to potential exposure pathways, but are dismissed as being incomplete due to the fact that no COPECs have been identified in groundwater.

Evaluation 13: *Please revise Figure 6-1 to reflect the clarification provided in the response.*

Response to

Evaluation 13: Revisions to Figure 6-1 are not necessary. The figure only identifies “potentially complete” exposure pathways for all the environmental media at the T-24A ranges. The text in Chapter 6 identifies complete exposure pathways based on the COPECs identified in the various environmental media and the different feeding guilds potentially present at the T-24A Ranges.

In response to the original comment, a brief description of the potential fate and transport mechanisms associated with groundwater at the T-24A ranges will be incorporated into Chapter 4.

Comment 18: **Section 6.0. The discussion in this section is not consistent with the list of riparian ecological receptor species in Table 7-3. The last sentence in Section 6.5 states that “piscivores are not expected to occur in drainage features at the T-24A Ranges for significant periods of time,” and similar statements are made in Section 7.0. Please clarify why the piscivorous mink and great blue heron are included in Table 7-3. Please revise text and tables for consistency across Sections 6.0 and 7.0.**

Response 18: Table 7-3 is incorrect. Mink and great blue heron should not be included in Table 7-3 and will be removed in the revised T-24A Ranges Problem Formulation and Study Design report.

Evaluation 18: *Response accepted. However, please include additional discussion in Section 6.0 to justify the exclusion of piscivores from the BERA.*

Response to

Evaluation 18: Additional justification for the exclusion of piscivores will be incorporated into the text of Chapter 6.

Comment 19: **Section 6.4. The last sentence in the 1st paragraph of this section overstates the assumption that food chain exposures to all metals are expected to be minimal. This would not be true for mercury in aquatic ecosystems, especially for piscivorous food chains, unless all mercury detected in sediments and surface water is inorganic mercury and no methyl mercury occurs in these media. However, as noted above in specific comment #7, the surface water ESV used for mercury (0.003 µg/L) was not explained but appears to be for methyl mercury, since it is orders of magnitude lower than the 2006 national chronic AWQC of 0.77 µg/L for inorganic mercury. Please discuss the site-specific scientific basis for assuming whether or not methyl mercury occurs in sediments or surface water and discuss the related issue of mercury bioaccumulation and bioavailability to piscivorous species.**

Response 19: The sentence in question refers to COPECs in soil at the T-24A Ranges and not all metals in soil. For clarity, the sentence will be revised to read; “Food chain exposures to COPECs in soil, surface water, and sediment are expected

to be minimal at the T-24A Ranges because these metals and PAHs are not accumulated in animal tissues to any great extent (Shugart, 1991; U.S. Army Environmental Hygiene Agency, 1994).”

No site-specific assumptions were made regarding methyl mercury in surface water or sediment at the T-24A Ranges. The SLERA for the T-24A Ranges did not identify mercury as a COPEC in any environmental media; therefore, mercury was not specifically discussed in the T-24A Problem Formulation and Study Design report.

Evaluation 19: *The proposed text revision is accepted. However, please see the Evaluation for General Comment 2 with regard to mercury not being selected as a COPEC.*

Response to

Evaluation 19: Please see Response to Evaluation 2 with regard to mercury in surface water.

Comment 21: **Section 7.3. The current wording about evaluations of “soils with site-related COPECs” should be revised to clarify that the tests will be performed using “site-derived soil samples” to “determine whether the mixtures of COPECs in site-derived soil samples exhibit toxicity” to test organisms. Using data from plant and invertebrate toxicity tests of soils at other sites is not an appropriate or defensible approach to evaluating site-specific reasons, such as the significant site to site variability of complex COPEC mixtures and soil biochemical parameters that influence the relative solubility, bioavailability, and toxicity of soil COPECs to the test organisms. Rather, as appropriately proposed for the aquatic assessment of potential sediment toxicity to benthic macroinvertebrates, all toxicity testing for terrestrial receptors should be conducted with site-derived soil samples, rather than attempting to apply toxicity test results from different COPEC mixtures and different soils from other sites. Please clarify.**

Response 21: It is unclear how the use of toxicity test results from soils exhibiting identical COPECs, similar physical/chemical properties, and from identical soil mapping units as are found at the T-24A Ranges and the IMR and BGR Ranges at FTMC is not appropriate or defensible. Soils used in the invertebrate toxicity tests conducted as part of the IMR/BGR Ranges BERA exhibit identical COPECs as the soils at the T-24A ranges and were collected from identical soil mapping units as soils at the T-24A ranges. Therefore, there is no “...significant site to site variability of complex COPEC mixtures and soil biochemical parameters...” as the commentor suggests. The soil assessment methodologies are entirely appropriate and defensible; therefore, no changes to the surface soil assessment methodologies are warranted or necessary.

Evaluation 21: *The microbiological, macrobiological, and nutrient cycling profiles of soils that affect bioavailability, uptake, and in situ transformation of COPECs in soils vary greatly even among sites falling within the same geological unit of soil series mapping. Therefore, please provide additional supporting evidence that the physical and chemical properties of the soils are similar among the sites.*

Response to

Evaluation 21: As agreed to at the December 11 – 12 2008 meeting at FTMC, five surface soil samples will be collected from the T-24A Ranges and analyzed for physical/chemical properties that could affect the binding capacity/bioavailability of the COPECs identified in soil at the T-24A Ranges. These physical/chemical properties will be compared to the binding capacity data that were collected for soils at the IMR and BGR Ranges (*Baseline Ecological Risk Assessment Study Design for the Iron Mountain Road Ranges, IT, 2002*) to determine if the bioavailability of the COPECs in the IMR and BGR ranges soil is similar to the bioavailability of the COPECs in T-24A Ranges soil.

Comment 22: **Section 9.0. If possible, one sample should be obtained from an upstream location along each onsite tributary to provide stream-specific reference locations. Currently, a single, offsite upstream reference location (FTA-108-SW/SD-02) is proposed for sampling of surface water and sediments from a stream channel (see Table 9-1 and Figure 9-1). Other upstream locations may be available upgradient of site influences, from which media could be collected to provide upstream reference data specific to one or more individual stream segments. Please address.**

Response 22: As stated in the SLERA for the T-24A Ranges and reiterated in the Problem Formulation and Study Design for the T-24A Ranges, the ephemeral and perennial drainage features present at the T-24A Ranges constitute the headwaters of the South Branch of Cane Creek; therefore, “upstream” locations, upgradient of site influences are extremely limited. Because all of the drainage features at the T-24A Ranges exhibit similar physical characteristics, a single reference location is appropriate for the assessments proposed in the T-24A Problem Formulation and Study Design. No changes to the surface water and sediment sampling strategy are necessary.

Evaluation 22: *While choices for additional upstream locations may be limited, the response implies that they do exist. Please obtain at least one additional sample from an upstream location.*

Response to

Evaluation 22: The terminology “extremely limited” in the response was meant to imply that “upstream” sample locations may not exist. As stated numerous times, the drainage features at the T-24A Ranges are ephemeral and depending on the amount of precipitation received by the local drainage basin prior to sampling,

many of the drainage features may be completely dry. Two additional “upstream” sample locations will be identified where water has the highest probability of occurring; however, the feasibility of sampling water from these locations will be entirely dependent upon localized weather patterns immediately preceding the sampling event.

Comment 23: **Section 9.0.** The report should present the ecological rationale for the existing sample locations used in the COPEC selection of the SLERA and new locations proposed for sampling and use in the BERA. This rationale would assist in verifying the adequacy of the habitat coverage by existing and proposed numbers and placement of media samples. Detailed information for each existing and proposed media sample location should be tabulated to complement the sample location map in Figure 9-1, so as to indicate which habitat types are represented by each existing/proposed sample location (e.g., upland soil vs. wetland sediment, sediment of intermittent vs. perennial stream reach), as a basis for selecting/using ecologically appropriate ESVs (e.g., soil EcoSSLs vs. sediment benchmarks) in the COPEC screening for the BERA. The sample locations table should classify and indicate the subset of raw analytical data by media type and associated ESVs used to identify COPECs and calculate the screening-level HQs, in the SLERA and in this BERA Problem Formulation. Habitat-oriented data subsetting also should be used to calculate average and maximum HQs for each COPEC in the species-specific exposure assessment and risk characterization of the BERA. Please address.

Response 23: The rationale for all sampling locations utilized in the T-24A SLERA were summarized in the *Remedial Investigation Report, Ranges Near Training Area T-24 Alpha, Parcels 88(7), 108(7), 112Q, 113Q-X, 123Q, 187(7), 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama, Draft, April* (Shaw, 2005), and also the numerous work plans submitted to and accepted by the BCT as referenced below:

- IT Corporation (IT), 1998a. *Site Investigations, Site-Specific Field Sampling Plan and Site-Specific Safety and Health Plan Attachments, Range 24A Fog Oil Drum Storage (Parcel 88), Range 24A Multi-Purpose Range (Parcel 108), Smoke Area BVZ (Parcel 124), Smoke Area S (Parcel 106), Smoke Area R (Parcel 105), Old Incinerator (Parcel 125), Former Smoke Area Choccolocco Corridor (Parcel 107), and Former Smoke, Fort McClellan, Calhoun County, Alabama, Final, September.*
- IT Corporation (IT), 2000a. *Supplemental Remedial Investigation, Site-Specific Field Sampling Plan, Site-Specific Safety and Health Plan, and Site-Specific Unexploded Ordnance Safety Plan Attachments, Ranges Near Training Area T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama, Final, September.*

- IT Corporation (IT), 2001. *Site-Specific Field Sampling Plan Addendum and UXO Safety Plan Addendum for the Supplemental Remedial Investigation at Ranges Near T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q*. This work plan addendum described installation and sampling of additional monitoring wells to aid in determining the extent of benzene contamination in groundwater.
- IT Corporation (IT), 2002a. *Site-Specific Field Sampling Plan Addendum II for the Supplemental Remedial Investigation (Source Area) at Ranges Near T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q*. This work plan addendum described installation of additional monitoring wells and collection and analysis of additional soil and groundwater samples for a source area investigation of the Training Area T-24A fenced area.
- IT Corporation (IT), 2002b. *Site-Specific Field Sampling Plan Addendum III for the Supplemental Remedial Investigation (Horizontal Extent-Surface Soil and Groundwater) at Ranges Near Training Area T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q*. This work plan addendum described installation of additional monitoring wells and collection and analysis of additional soil and groundwater samples to further define the horizontal and vertical extent of soil and groundwater contamination. This work plan also proposed x-ray fluorescence (XRF) screening for lead in surface soils within the range safety fans of Parcels 112Q and 213Q.
- Shaw, 2003a. *Site-Specific Work Plan, Remedial Investigation, Addendum IV, Ranges Near Training Area T-24 Alpha, Parcels 88(7), 108(7), 112Q, 113Q-X, 123Q, 187(7), 213Q, and 214Q, Fort McClellan, Calhoun County, Alabama*. This work plan addendum described installation and sampling of additional monitoring wells as well as re-sampling of select existing wells to further define the horizontal and vertical extent of groundwater contamination.
- Shaw, 2004. *Additional X-Ray Fluorescence (XRF) Surface Soil Screening at the Ranges Near Training Area T-24A, Parcels 187(7), 112Q, 113Q-X, 213Q, and 214Q*. This work plan addendum described XRF screening within a gridded area to further delineate the horizontal extent of lead contamination in surface soil.

Because the investigations conducted at the T-24A Ranges were part of a remedial investigation, the overall rationale for sample locations was the determination of the nature and extent of contamination at the T-24A Ranges and to provide data of sufficient quantity and quality to assess the potential risks to human health and the environment.

COPEC screening was accomplished in the SLERA and is not the subject of the Problem Formulation and Study Design portion of the BERA. It is unnecessary and unwarranted to re-visit the COPEC selection process for the T-24A Ranges.

The rationale for the sampling locations proposed in the Problem Formulation and Study Design is to represent the full range of surface water and sediment COPEC concentrations detected in the remedial investigation for the T-24A Ranges. By assessing the full range of COPEC concentrations detected in surface water and sediment at the T-24A Ranges, site-specific toxicity values (i.e. NOAELs and LOAELs) can be identified for each COPEC using the assessment techniques outlined in the Problem Formulation and Study Design report.

Evaluation 23: *The original intent of the comment was to request a table of ESVs used versus subsets of corresponding media samples to which they were and will be applied in the SLERA and BERA to document ecological rationale for choices of media-specific ESVs to be used at each sample location. Please address.*

Response to

Evaluation 23: The ESVs used to identify COPECs in surface soil, surface water, sediment, and groundwater were presented in Tables 2-1 through 2-4 of the Problem Formulation and Study Design Report (Shaw, 2007). Soil ESVs were used for soil and depositional soil samples. Surface water ESVs were used for surface water and groundwater samples. Sediment ESVs were used for sediment samples. As stated in previous comment responses, if water was present in a stream at the time of sampling, then sediment samples collected from that stream were compared to sediment ESVs. If water was not present in a stream at the time of sampling, then the samples collected from that stream were designated as depositional soil samples and were compared to soil ESVs. Tables 2-1 through 2-4 of the Problem Formulation and Study Design Report (Shaw, 2007) are self-explanatory; no additional tables are necessary.

Comment 24: **Section 9.0. Please provide representative photographs of sample locations within examples of each major habitat type to be sampled and evaluated in the BERA, especially depositional reaches of streams, wetlands, and floodplain habitats that may accumulate water-borne COPECs, to support ESV choices.**

Response 24: It is unclear how photographs of representative habitats will serve to support ESV choices. ESVs, by definition, are very conservative and generic in nature, and are not differentiated by specific habitat types. Rather, ESVs are applied to general habitats (e.g. sediment ESVs are applied to all aquatic [stream] and semi-aquatic [wetlands] habitats, and soil ESVs are applied to all upland habitats). If a flood plain is regularly inundated for significant periods of time, then sediment ESVs are applied. If a flood plain is normally dry (as evidenced by the presence of upland vegetation), then soil ESVs are applied.

Furthermore, ESVs are used at the SLERA stage of the ecological risk assessment process to identify COPECs in the various environmental media at a site. The subject report is a Baseline Ecological Risk Assessment Problem Formulation and Study Design in which site-specific studies are proposed and described in order to more accurately define the potential ecological hazards at the T-24A Ranges. Due to their very conservative nature, ESVs are generally not used in the BERA, of which the Problem Formulation and Study Design is a part. Discussion of ESVs in the Baseline Ecological Risk Assessment Problem Formulation and Study Design is not germane to the subject report.

Photographs of each sample location used in the BERA will be included in the BERA report.

Evaluation 24: *The response agreeing to provide photographs is accepted.*

Response to

Evaluation 24: No response is necessary.

Comment 25: **Section 9.0. The spatial coverage of proposed surface water and sediment samples across numerous tributary streams within the gray-shaded parcel does not appear sufficient to characterize COPEC concentrations within these stream channel habitats. Three different site-affected stream segments between 700 and 900 feet in length have not been sampled within the gray shaded parcel and no samples were proposed for these (an 800 foot segment upstream of monitoring well FTA-108-GP03; 800 foot segment downstream of this well, between the well and location FTA-108-SW/SD05; 900 foot segment upstream of proposed location R24A-187-SW/SD05, extending to and above the Parcel 112Q boundary). An 800+ foot meandering stream segment, in a low-lying and presumably depositional area within Parcel 214Q, also has not been sampled nor proposed for sampling to support the BERA; two samples should be collected in depositional areas along this meandering channel. Within the gray shaded parcel, please add at least one new SW/SD sample location per 300 feet of stream channel including one sample just inside/south of the shaded parcel boundary within the lower stream reach, about 300 feet downstream of proposed location FTA-88-SW/SD01, at a location most likely to be depositional. Please explain why no stream channel samples are proposed adjacent to or upstream of the Parcel 112Q boundary either at soil sample location R24A-187-GP10 or the cluster of five surface soil samples (incl. R24A-187-GP09) located on a different tributary of the stream located within the shaded parcel. Also, please explain whether either of these tributaries upstream of the Parcel 112Q boundary represents suitable upstream reference locations for use in the BERA.**

Response 25: The studies proposed in the Baseline Ecological Risk Assessment Problem Formulation and Study Design are not designed for the purpose of

characterizing the nature and extent of contamination at the T-24A Ranges. The nature and extent of contamination was determined and reported in the Remedial Investigation Report for the T-24A Ranges (Shaw, 2005). As discussed in previous comment responses, the sample locations proposed in the T-24A Problem Formulation and Study Design report represent the full range of COPEC concentrations in each environmental medium as determined in the remedial investigation, such that the data provided by each of the proposed samples can be used to adequately fulfill the data quality objectives described in detail in Chapter 8 of the Problem Formulation and Study Design report.

Sample location FTA-108-SW/SD02, located immediately south of the Parcel 108(7)/82Q-X boundary, is proposed as the site-specific surface water and sediment reference location.

As discussed in the Response to Specific Comment 16, in order to ensure the wetland area in the northwestern corner of the study area is adequately addressed in the BERA, one additional surface water and sediment sampling location will be added to this wetland area and assessed using the same assessment techniques as the other surface water and sediment samples at the T-24A Ranges.

Evaluation 25: *Please propose several additional sample locations to increase the frequency of sample along the combined 2,900 to 3,500 linear feet of stream segments that were identified in the original comment.*

Response to

Evaluation 25: As discussed in previous comment responses, surface water and sediment samples will be collected from stream locations exhibiting the full range of COPEC concentrations. The “spatial coverage” of the samples collected for the BERA is irrelevant. It is not the purpose of the BERA, nor should it be, to delineate the nature and extent of contamination. The nature and extent of contamination was delineated in the Remedial Investigation and summarized in the SLERA. Rather, the BERA has been designed to identify the concentrations of COPECs that may pose adverse impacts to ecological receptors that may inhabit the T-24A Ranges. By sampling the full range of COPEC concentrations (regardless of location within the T-24A Ranges), the Army will be able to derive NOAELs, LOAELs, and AETs that will be useful in the derivation of ecological risk-based remedial goals.

As the result of discussions between ADEM, USEPA, USFWS, and Army personnel at the meeting held December 11-12 2008 at FTMC, 5 additional surface water and sediment samples will be collected from the drainage features at the T-24A ranges. These 5 additional surface water and sediment samples will be collected for chemical analysis only in order to ensure that the nature and extent of “contamination “ in the drainage features at the T-24A ranges has been fully characterized. These additional samples will not be

used for toxicity testing, but may be utilized for input to food web modeling and incorporated as such into the BERA. Two “upstream” surface water and sediment sample locations (FTA-108-SW/SD02 and R24A-187-SW/SD01) will also be targeted for sampling site-specific reference conditions.

Comment 26: **Section 9.1. Site-derived soil samples should be collected for chemical analysis and use in toxicity testing for terrestrial plants and for toxicity testing and COPEC uptake/bioaccumulation studies in earthworms. Although it may be appropriate to use soil-to-plant COPEC bioaccumulation factors derived from uptake studies at other sites and from rigorous screening of literature on uptake (e.g., studies screened and used by USEPA to derive soil EcoSSLs for plants and plant eaters) in herbivorous food chain exposure assessments of the BERA, attempts to infer toxicity of mixtures of soil COPECs to plants and earthworms by using results of toxicity testing of soils from other sites are scientifically problematic and ill-advised. Soil samples collected from representative onsite foraging habitats of invertivorous birds and mammals should be used in earthworm toxicity and uptake studies, and plant toxicity tests should be conducted using these same site-derived soil samples. If soil HQs based on the lowest available soil ESVs for plants and invertebrates do not indicate likely soil toxicity to plants and/or invertebrates from average or maximum concentrations of COPEC mixtures, then plant or earthworm toxicity testing may not be warranted in the BERA. Conversely, if significant, site-derived food chain risks to invertivorous wildlife from exposures to soil COPECs are documented in the BERA, then earthworm toxicity testing offers critical insight not only regarding risks to the invertebrates, but also to validate the exposure assumption that earthworms can survive in soils onsite and thus provide for a complete dietary exposure pathway for soil COPECs to be ingested by invertivores. Please consider phasing the BERA tasks so that the need for and benefits of plant and earthworm toxicity testing can be determined by the interim BERA results before testing site-derived soils for toxicity. Please address.**

Response 26: Please see Response to Specific Comment 21.

Evaluation 26: *Please see the Evaluation for Specific Comment 21.*

Response to Evaluation 26: Five surface soil samples will be collected from the T-24A Ranges and analyzed for physical/chemical properties that could affect the binding capacity/bioavailability of the COPECs identified in soil at the T-24A Ranges. These physical/chemical properties will be compared to the binding capacity data that were collected for soils at the IMR and BGR Ranges (*Baseline Ecological Risk Assessment Study Design for the Iron Mountain Road Ranges, IT, 2002*) to determine if the bioavailability of the COPECs in the IMR and

BGR ranges soil is similar to the bioavailability of the COPECs in T-24A Ranges soil.

Comment 29: **Section 10.1. Data on the earthworm and plant toxicity of surface soil samples observed during toxicity tests of complex COPEC mixtures in soil from other sites, such as the Iron Mountain Road, Bains Gap Road, and Baby Bains Gap Road Ranges at Fort McClellan, are not an acceptable substitute for toxicity testing of site-derived soils from the T-24A Ranges. If interim results of the exposure assessment and toxicity assessments for soil invertebrates and invertivorous wildlife species do indicate significant risks to one or both receptor groups, then additional soil samples should be collected from representative habitats for chemical analysis and earthworm toxicity testing. During such sampling, the presence and abundance of earthworms and other soil invertebrates also should be documented to verify the presence of soil invertebrate prey and a complete soil-to-invertivore dietary exposure pathway. Please address.**

Response 29: Please see Response to Specific Comment 21.

Evaluation 29: *Please see the Evaluation for Specific Comment 21.*

Response to

Evaluation 29: Please see Response to Evaluation 21.

Comment 31: **Figure 9-1. Please label the *Proposed BERA Surface Water and Sediment Sample Locations* map to indicate depositional channel segments, reference habitats to be sampled upstream/upgradient of all site influences, and provide a matching summary table of all media sample locations, grouped by habitat type, as requested above in Specific Comment #23.**

Response 31: The drainage features at the T-24A Ranges are highly seasonal in nature and their characteristics vary greatly depending on the amount of precipitation received in the vicinity of the T-24A Ranges. As such, a given “stream” reach could exhibit widely different characteristics based on recent precipitation events, or lack thereof. For instance; immediately after a storm event a given drainage feature may exhibit high velocity flow, several weeks later the same “stream” reach might exhibit very low flow with frequent pools, and several weeks later the same “stream” reach could be completely dry. Therefore, labeling the drainage features at the T-24A Ranges with a single characteristic label is impossible.

The stream habitat and physical characteristics will be described in detail at the time of sampling and will be used in the assessment of the surface water drainage features in the BERA.

As presented in the Response to Specific Comment 25, sample location FTA-108-SW/SD02 is proposed as one of the site-specific surface water and sediment reference locations. An additional site-specific surface water and sediment reference location will be identified pursuant to discussions between ADEM, USEPA, USFWS, and Army personnel at the December 11-12 meeting at FTMC. Additional labeling on Figure 9-1 will identify these locations as the surface water and sediment reference locations.

By default, all sediment samples will be collected from depositional areas as only these areas contain sufficient sediment for sampling. The vast majority of the drainage features exhibit cobble substrate, indicative of high energy flow during storm events, with very little sediment. Benthic macroinvertebrate samples will be collected from both riffle and run areas as well as from within coarse particulate organic matter (CPOM) in order to collect different feeding groups of invertebrates.

Evaluation 31: *Please add the discussions of the response to the text explanations of Figure 9-1. Also, please revise the figure to improve clarity and labeling to better benefit the reader.*

Response to Evaluation 31: The discussion provided in the Response to Comment 31 will be included in the text describing Figure 9-1. Figure 9-1 will be revised to improve clarity.

RESPONSES TO EPA AND ADEM COMMENTS

**FINAL BASELINE ECOLOGICAL RISK ASSESSMENT PROBLEM
FORMULATION AND STUDY DESIGN FOR THE
RANGES NEAR TRAINING AREA T-24A**

**Final Responses to
USEPA Region 4 Review Comments
Final Baseline Ecological Risk Assessment Problem Formulation and Study Design for the
Ranges Near Training Area T-24A (February 2009)**

Comments from Doyle Brittain, EPA Remedial Project Manager, dated July 31, 2009.

General Comments

Comment 1: The changes made to the document have addressed my comments on the draft document. Responses to these comments may cover the issues without having to revise the document. The issues remaining with the study are:

- a. Locations of background stations in creeks
- b. Location of site sampling stations in creeks with respect to areas with higher PAH concentrations
- c. Contingency plan in case of unexplained toxicity of sediments due to fog oil
- d. Data evaluation method or criteria applied to physical chemical data for the soils to determine whether the soils at Ranges near T-24A are similar to soils at Bains Gap Road Ranges or Iron Mountain Road Ranges.

Some remaining issues can be addressed by documenting agreements made in the October 28-30, 2008 BCT meeting minutes.

Response 1: No response necessary.

Comment 2: **Background.** Because this year has been wetter than the two previous years, perhaps it will be possible to collect a background sample at the headwaters of the T-24 Alpha site per ADEM's comment. However, the background sampling locations in nearby creeks that do not flow through the site should remain in the study design as a contingency.

Was the resolution to the issue of the appropriate location of the surface water and sediment reference station that the Army would attempt to collect a reference sample from the headwaters of the stream running through T-24 Alpha Ranges, if possible? However, reference stations in the study design are located on creeks outside the site. The dry conditions in the creeks in general and especially in the last two years have made it nearly impossible to collect such a sample, and certainly impossible to guarantee one. Due to the wetter conditions in the last 6 months, will the sampling in the headwaters of

the creek be attempted? Please document agreements on this issue in either the problem formulation study design or the BCT meeting minutes.

Response 2:

The resolution at the December 10-11, 2008 meeting at FTMC was that an attempt would be made to collect “upstream” surface water and sediment samples to serve as site-specific reference samples for the T-24A ranges. Sample locations R24A-187-SW/SD01 and FTA-108-SW/SD02 represent the site-specific reference locations as presented on Figure 9-1 of the *Final Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Ranges Near Training Area T-24A* (Shaw, February 2009).

Comment 3:

Background. I commented at the October 2008 BCT meeting that the stations in the creeks for toxicity testing should move some stations or add some stations to target the creek areas with the highest PAH concentrations. This change was intended to target stations where fog oil might be present in surface water or sediment based on moderately high PAH concentrations and proximity to the fog oil drum storage area. Four new surface water and sediment stations were added to the study design to address a comment by ADEM. The text in Appendix B does not indicate specifically how the selection of stations will target a gradient of PAH contamination. A response to this comment could clarify the sampling design.

At the October 2008 BCT meeting, October 28-29, it was agreed that a surface water and sediment sample should be relocated to the station with the highest PAH contamination to obtain a gradient of contamination for PAHs and to target where fog oil might be present. Was this change made to the study design? Please explain in the response to comments and make sure this change is documented in the subject document or the October BCT meeting minutes.

Response 3:

Surface water and sediment samples were added and shifted to target areas where PAHs were previously detected in sediment and where the probability of detecting PAHs related to fog oil were greatest. Specifically, 3 new sample locations (T24A-BERA-SW/SD03, T24A-BERA-SW/SD04, and T24A-BERA-SW/SD05) have been added to the stream that runs through the central portion of the T-24A study area where PAHs have been previously detected, and 2 new sample locations (T24A-BERA-SW/SD01 and T24A-BERA-SW/SD02) have been added to the stream in the northwestern corner of the study area that drains from the location of the former oil water separator. These new surface water and sediment sample locations are presented on Figure 9-1 of the *Final Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Ranges Near Training Area T-24A* (Shaw, February 2009).

Comment 4: **Background.** At the October 2008 BCT meeting we discussed how fog oil, if present, can suffocate aquatic organisms in the creeks. Standard analytical methods do not detect fog oil. Therefore, the BCT decided to test the sediment for unexplained toxicity before conducting non-standard analytical tests for fog oil. The plan for managing this uncertainty is not expressed in the study design. A response to comments could clarify the sampling design in this regard.

Fog oil can be toxic to aquatic organisms in the creeks (Cropek et al. 2008). Standard analytical methods do not detect fog oil. Therefore, the BCT decided to test the sediment for unexplained toxicity before conducting non-standard analytical tests to detect fog oil. The plan for managing this uncertainty is not expressed in the study design. A response to comments could clarify the sampling design in this regard. Please make sure that the path forward and plans for managing uncertainties are documented for this site.

Response 4: The standard 21-day chronic toxicity test using *Chironomus tentans* (USEPA, 2000) will be run to determine the potential for adverse effects on chironomid survival and growth due to exposure to constituents in on-site sediment samples. If significant adverse effects are observed in chironomid survival and/or growth that cannot be explained by correlation with sediment constituent concentrations, then it may be concluded that fog oil could be the causative agent in the observed adverse effects. If such a case arises, the sediment samples will be subjected to non-standard analytical tests to determine if fog oil is present in the sediment samples, and if so, what concentrations are present.

Comment 5: To address an ADEM comment, the study design has added physical/chemical properties of the soils at T-24 Alpha Ranges to compare with similar measurements made at the IMR/BGR ranges. Some discussion is recommended of how this information will be used to compare soils at the two ranges with respect to bioavailability of lead.

Dayton and others (2006) have examined soil properties related to bioavailability of lead in soil. Their methods or findings may be of use to determine if the lead in soils at T-24 Alpha Ranges is of similar bioavailability compared to lead at the IMR/BGR ranges. This comment is asking for a discussion of how the data on physical/chemical properties will be used to assess the relative bioavailability of lead between two sites in the response to comments. A method that relies on quantitative criteria versus qualitative comparisons is preferred.

Response 5: Soil properties measured at the IMR and BGR ranges related to bioavailability and toxicity (e.g. total organic carbon, cation exchange

capacity, pH) will be compared statistically to the same soil properties at the T-24A ranges. The soil properties will be compared using both the t-test and Wicoxon-Rank Sum test.

References:

Cropek, D.M.; Esarey, J.C. Conner, C.L.; Goran, J.M.; Smith, T.; and Soucek, D.J., 2008, Toxicological effects of military fog oil obscurant on *Daphnia magna* and *Ceriodaphnia dubia* in field and laboratory exposures. *Ecotoxicology* 17(6): 517-525.

Dayton E.A.; Basta, N.T., Payton M.E., Bradham K.D., Schroder J.L., Lanno R.P., 2006, Evaluating the contribution of soil properties to modifying lead phytoavailability and phytotoxicity. *Environ. Toxicol. Chem.* 25(3):719-725.

**Final Responses To
ADEM Review Comments**
*Final Baseline Ecological Risk Assessment Problem Formulation and Study Design for the
Ranges Near Training Area T-24A, dated February 2009*
Fort McClellan, Calhoun County, Alabama

Comments from Stephen Cobb, ADEM Chief Governmental Hazardous Waste Branch, dated July 10, 2009.

Section I: Unresolved Comments from the Draft BERA PF/SD

Specific

Comment 3: **Section 2.0.** Please revise the text so that surface water and sediment COPECs that exceed their ESVs are not eliminated upfront. Such COPEC evaluation may be applied during the risk characterization for those COPECs as part of a weight of evidence approach to evaluating the significance of any site-derived increments of total risk. For example, COPECs also may be eliminated as potential drivers of remedial action or risk management decisions, during the *risk characterization*, based on a lack of bioavailability to ecological receptors (e.g., dissolved concentrations of metal COPECs that are below their chronic ambient water quality criteria [AWQC] for dissolved metals, despite total metal exceedances of AWQC in unfiltered samples). Elimination of surface water and sediment COPECs based on “other lines of evidence” such as geochemical evaluation is not appropriate in the Problem Formulation, and should be relegated to the risk characterization. If such discussions are presented in the risk characterization, they should be supported by incorporating the geochemical evaluations, currently absent from the Problem Formulation, into the BERA. Please address.

Response 3: Please see Response to Specific Comment 2. COPECs are not identified in the Problem Formulation and Study Design, but are identified in the SLERA using the methodologies described above and approved by the BCT and through precedent over numerous years at FTMC. (**Response to Specific Comment 2:** The use of background screening values to identify constituent concentrations that are similar to naturally occurring concentrations is applicable to all environmental media, not just soil. With regard to screening out cobalt and mercury as COPECs in surface water, please see Response to General Comment 2 above, which was satisfactorily addressed in *Response to ADEM Review Comments, Final SLERA for Ranges Near Training Area T-24A, Parcels 187(7), 88(6), 108(7)/82Q-X, 112Q, 113Q-X, 213Q, and 214Q, Dated January 3, 2007.*

COPECs were identified in the SLERA for T-24A Ranges as they have been in numerous other SLERAs conducted at FTMC using the procedures outlined in Chapter 2 of the T-24A Problem Formulation and

Study Design. The initial COPEC identification process included the following:

- Comparison of maximum detected constituent concentrations to ecological screening values [ESVs];
- Identification of essential macro-nutrients; and
- Comparison of the maximum detected constituent concentrations to background screening values [2x the arithmetic mean of the background data set].

Subsequent to the initial COPEC identification process, additional lines of evidence were evaluated to refine the initial list of COPECs. Some of the additional lines of evidence used in the process of refining the list of COPECs included: 1) frequency of detection, 2) magnitude of the HQ_{screen} value, 3) spatial distribution, 4) comparison to alternative ESVs; 5) statistical and geochemical background evaluation; and 6) association of a chemical with known Army activities. This COPEC identification process has been employed in numerous SLERAs over the course of a number of years at FTMC and is consistent with Step 3 of the eight-step ecological risk assessment process as described in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* [USEPA, 1997].)

Evaluation 3:

Please see Evaluation for Specific Comment 2: All analytes that exceed the lowest applicable ESVs, such as AWQC, should be retained as sediment and surface water COPECS and carried through the BERA. Also, other lines of evidence should not be used up front in Problem Formulation to eliminate COPECS from further characterization in the BERA. Such weight of evidence considerations should be provided only in the risk characterization and uncertainty analysis of the BERA.

Response to Evaluation 3:

Please see Response to Evaluation 2. The process of refining the initial list of COPECs at the end of the SLERA and/or beginning of the Problem Formulation has been thoroughly vetted through numerous BCT meetings (in which USEPA, ADEM, USFWS, and Army personnel were participants) and comment response cycles and it remains consistent with all existing ADEM and USEPA ecological risk assessment guidance. Therefore, the Army does not feel it is necessary or warranted to change the COPEC identification process at this time. **(Response to Evaluation 2:** Per discussions and agreements made between Army, ADEM, USFWS, and USEPA personnel at the December 11 – 12 2008 meeting at FTMC, the 3-tier background screening process of surface water and sediment constituents for the purpose of identifying COPECs is consistent

with ARBCA guidance and is a valid process for identifying COPECs at FTMC.

Alternative screening values will be considered [in conjunction with other lines of evidence] in the COPEC refinement process for cobalt and mercury in surface water at the T-24A ranges. The USEPA Region 3 BTAG Freshwater Screening Benchmark for cobalt [23 µg/L] will be used as an alternative screening value for cobalt and the National Recommended Water Quality Criteria for mercury [CCC = 0.77 µg/L] will be used as an alternative screening value for mercury. The maximum detected concentrations of both cobalt and mercury are less than their respective alternative screening values; therefore, they will not be identified as COPECs in surface water at the T-24A ranges.

The refinement of COPECs at the end of the SLERA process or the beginning of the problem formulation process is explicitly prescribed in federal USEPA [1997] and USEPA Region 4 [2000] ecological risk assessment guidance, and has been practiced at FTMC for over 10 years. Whether the process of COPEC refinement is conducted at the end of the SLERA [Step 2] or the beginning of the Problem Formulation [Step 3] is, in practice, inconsequential from a technical perspective. Incorporating elements of Step 3 into the SLERA provides for the presentation of additional information into the SLERA that allows risk managers to make more informed risk management decisions at the completion of the SLERA. It is the Army's belief that providing risk managers with as much pertinent information at each risk management decision point is imperative to making informed decisions and that delaying the transfer of information to a later stage in the ecological risk assessment process substantially reduces the efficiency and transparency of the process.

COPECs were initially identified in the SLERA by comparing the maximum detected concentrations of constituents to appropriately conservative and agreed-upon screening values [IT, 2000]. Those constituents whose maximum detected concentrations exceeded their respective conservative screening values were identified as COPECs in the SLERA per USEPA [2007] guidance. Consistent with Step 3 of the 8-step ecological risk assessment process, additional lines of evidence were used to further refine the list of COPECs that would be carried forward into the baseline ecological risk assessment. The process of refining the initial list of COPECs prior to developing assessment and measurement endpoints and study design is explicitly state on page 3-1 of the USEPA's *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* [USEPA, 1997] which states: "Problem formulation at Step 3 includes several activities:

- Refining preliminary contaminants of ecological concern;"

Furthermore, USEPA Region 4 guidance [*Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders*, June 23, 2000] states that “Problem formulation begins with the refinement of the COPCs. This step is an opportunity for facilities to present a reasoned toxicological approach for the elimination of one or more COPCs from future consideration. At this step, negotiations are undertaken to alter assumptions associated with the Screening Level ERA. These assumptions include but are not limited to area use factors [e.g. home ranges], incidental soil/sediment intakes, **background/reference location comparisons**, and the nature of the contaminants.” [underline and bold added for emphasis]. Further justification for including a background comparison within the COPEC refinement process is found in “Step 3: Problem Formulation” of the USEPA Region 4 guidance [2000] which states: “Risk management issues such as background comparison, are introduced for discussion among stakeholders at this stage.”

It is clear from these passages from the federal USEPA [1997] and USEPA Region 4 [2000] guidance documents that comparison to background is an accepted practice in the refinement of COPECs during the SLERA/Problem Formulation step of the ecological risk assessment process. This process for refining the initial list of COPECs at the end of the SLERA and/or beginning of the Problem Formulation has been thoroughly vetted through numerous BCT meetings and comment response cycles and it remains consistent with all existing ecological risk assessment guidance. Therefore, the Army does not feel it is necessary or warranted to change the COPEC identification process at this time.)

Comment:

At the meeting held December 11 - 12, 2008, the Army agreed to comply with the Department’s request to revise and update the original compilation of ESVs with newer ESVs issued during the past 8 years, and then to apply the updated ESVs to revise both the COPEC selection and calculations of screening-level hazard quotients (HQs) in Tables 2-1 through 2-4. However, the newer ESVs were not incorporated into the HQ calculation tables. Thus, the Final BERA PF/SD does not provide an adequate tabulation of HQs in support of the COPEC refinement. To resolve this issue without revising/reissuing the Final BERA PF/SD, please incorporate all of the updated ESVs, including alternative ESVs, into the Draft BERA report as revisions of both the COPEC selection tables and screening-level HQ calculations from the Final BERA PF/SD.

Final Response to Comment 3:

Disagree. The Army agreed at the December 11 – 12, 2008 meeting to evaluate “newer ESVs” (e.g. Eco-SSLs for soil and Alabama ambient water quality criteria for surface water) with respect to the COPEC selection and refinement process. The *Final Baseline Ecological Risk*

Assessment Problem Formulation and Study Design for the Ranges Near Training Area T-24A (Shaw, 2009) presents these evaluations in Chapter 2 and summarizes them in Tables 2-5 through 2-7. All of the surface soil, surface water, and sediment data (relevant historical data and data collected as part of the BERA) will be evaluated with respect to ESVs and Eco-SSLs, Alabama AWQC, and consensus-based sediment quality guidelines (MacDonald, et al., 2000) in the BERA. Any exceedances of ESVs or “newer ESVs” will be noted and addressed in the BERA uncertainty analysis with regard to potential impacts on the results of the BERA.

Comment 4: **Section 2.3. The lowest available sediment ESVs should be used in COPEC selection. However, the use of soil ESVs such as ecological soil screening levels (EcoSSLs) may be more ecologically appropriate than using sediment ESVs if dry stream channel deposits are sampled from intermittent reaches of streams that only carry ephemeral flows after precipitation events. If such reaches are usually dry and do not retain sufficient moisture to support aquatic or wetland vegetation, they are probably best classified as upland soils for the purposes or ESV/COPEC selection, and food chain exposure assessments. Please address.**

Response 4: Appropriate ESVs were identified in the SLERA based on the samples at the time of collection. If a soil sample was collected from an upland area, then soil ESVs were used for comparison. If a sample was collected from a drainage feature that contained water at the time of collection, then sediment ESVs were most appropriately used for comparison. If a sample was collected from a drainage feature that was dry at the time of collection (depositional soil sample), then soil ESVs were used for comparison. COPEC identification was accomplished in the SLERA and is not part of the subject Problem Formulation and Study Design report.

Evaluation 4: *Response regarding habitat-based decisions on use of soil versus sediment ESVs is accepted. However, the original selection of ESVs made in 2000 should be revalidated, and the validity of the original COPEC screening tables of the SLERA also should be validated and incorporated into the Problem Formulation. Please address.*

Response to Evaluation 4: As agreed upon by USEPA, ADEM, USFWS, and Army personnel at the December 11 – 12, 2008 meeting at FTMC, Ecological Soil Screening Levels (Eco-SSLs) and Alabama freshwater ambient water quality criteria (AWQC) will be compared to corresponding ESVs used in the selection of COPECs and that the Eco-SSLs and AWQC will be evaluated with regard to their impact on COPEC selection. It was also agreed upon at the December 11 – 12, 2008 meeting at FTMC that the sediment ESVs used in the COPEC selection process are valid and no revisions are necessary.

Comment: ADEM had requested that the updated ESVs be used to revise the COPEC selection and HQ calculation tables, not just to compare them to existing ESVs during refinement of the COPEC list. Although updates to sediment ESVs and revisions of screening-level sediment HQs were not requested for the Final BERA PF/SD, there are uncertainties related to the current use of sediment ESVs for eight different PAHs that are based on practical quantitation limits (PQLs) rather than ecotoxicity effect threshold concentrations. Please reassess and refine the sediment COPEC selection and recalculate sediment HQs in the Draft BERA Report using alternative/updated sediment ESVs and the new cumulative sediment database after analysis of the supplemental sediment samples.

Final Response to Comment 4:

Please see Final Response to Comment 3. Although it was agreed to at the December 11 – 12, 2008 meeting that the sediment ESVs used in the T-24A SLERA and Problem Formulation and Study Design were appropriate, because several PAH compounds were initially identified as COPECs in sediment, the sediment ESVs will be reviewed and revised as necessary in the BERA to incorporate the consensus-based sediment quality guidelines described by MacDonald, et al. (2000). If additional PAHs are identified, they will be assessed in the BERA.

Comment 12: Section 3.5. On Page 3-14, the toxicity threshold for PAHs applied to mallard duck eggs was discussed, although that exposure pathway/scenario and related assessment/measurement endpoints were not proposed for the BERA in Section 7.0 or Table 7-1. Please provide relevant avian toxicity data for ingestion of PAHs, since that pathway will be assessed in the BERA.

Response 12:

Chapter 3 summarizes available information regarding the toxicity of the identified COPECs to various groups of ecological receptors, regardless of their direct applicability to the T-24A ranges, in order to give the reader an idea of the relative toxicities of the COPECs to various ecological receptors. If information regarding a specific feeding guild or exposure pathway is missing from this discussion, it is because this information was not readily available in the scientific literature.

The PAH toxicity data for birds summarized in EPA's *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (1999) will be added to the discussion in Section 3.5; however, it should be noted that these additional toxicity data are also for bird embryos and not from studies of birds ingesting PAHs.

Evaluation 12: *Please identify PAH avian toxicity effects data for the ingestion of PAHs, rather than using data on the embryonic effects of applying PAHs to egg shells.*

Response to Evaluation 12: An additional avian toxicity study reporting the effects of PAHs on birds after ingestion of PAHs will be included in Section 3.5.

Comment: **The response suggests only one new PAH ingestion TRV for birds will be discussed in the text, however there are two additional TRVs available. Please review two studies presented in the EcoSSL document for PAHs and other studies of avian ingestion of PAHs to be used as potential sources of avian TRVs for PAHs (e.g., Beall, 2007; Hough et al., 1993; Klasing, 2007).**

Final Response to Comment 12: The two studies for which data are presented in the Eco-SSL document for PAHs (USEPA, 2007) assessed naphthalene and 7,12-dimethylbenz(a)anthracene, which are not COPECs at the T-24A ranges. Therefore, these data are not directly applicable to the COPECs identified at the T-24A ranges. However, the toxicity discussions in Chapter 3 of the *Final Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Ranges Near Training Area T-24A* (Shaw, 2009) are general in nature, and no constituent-specific toxicity reference values (TRVs) are identified in this report. All of the available toxicity information for PAHs (and other COPECs) will be reviewed for the BERA and the most appropriate values will be selected for quantifying risks to ecological receptors.

Comment 25: **Section 9.0. The spatial coverage of proposed surface water and sediment samples across numerous tributary streams within the gray-shaded parcel does not appear sufficient to characterize COPEC concentrations within these stream channel habitats. Three different site-affected stream segments between 700 and 900 feet in length have not been sampled within the gray shaded parcel and no samples were proposed for these (an 800 foot segment upstream of monitoring well FTA-108-GP03; 800 foot segment downstream of this well, between the well and location FTA-108-SW/SD05; 900 foot segment upstream of proposed location R24A-187-SW/SD05, extending to and above the Parcel 112Q boundary). An 800+ foot meandering stream segment, in a low-lying and presumably depositional area within Parcel 214Q, also has not been sampled nor proposed for sampling to support the BERA; two samples should be collected in depositional areas along this meandering channel. Within the gray shaded parcel, please add at least one new SW/SD sample location per 300 feet of stream channel including one sample just inside/south of the shaded parcel boundary within the lower stream reach, about 300 feet downstream**

of proposed location FTA-88-SW/SD01, at a location most likely to be depositional. Please explain why no stream channel samples are proposed adjacent to or upstream of the Parcel 112Q boundary either at soil sample location R24A-187-GP10 or the cluster of five surface soil samples (incl. R24A-187-GP09) located on a different tributary of the stream located within the shaded parcel. Also, please explain whether either of these tributaries upstream of the Parcel 112Q boundary represents suitable upstream reference locations for use in the BERA.

Response 25:

The studies proposed in the Baseline Ecological Risk Assessment Problem Formulation and Study Design are not designed for the purpose of characterizing the nature and extent of contamination at the T-24A Ranges. The nature and extent of contamination was determined and reported in the Remedial Investigation Report for the T-24A Ranges (Shaw, 2005). As discussed in previous comment responses, the sample locations proposed in the T-24A Problem Formulation and Study Design report represent the full range of COPEC concentrations in each environmental media as determined in the remedial investigation, such that the data provided by each of the proposed samples can be used to adequately fulfill the data quality objectives described in detail in Chapter 8 of the Problem Formulation and Study Design report.

Sample location FTA-108-SW/SD02, located immediately south of the Parcel 108(7)/82Q-X boundary, is proposed as the site-specific surface water and sediment reference location.

As discussed in the Response to Specific Comment 16, in order to ensure the wetland area in the northwestern corner of the study area is adequately addressed in the BERA, one additional surface water and sediment sampling location will be added to this wetland area and assessed using the same assessment techniques as the other surface water and sediment samples at the T-24A Ranges.

Evaluation 25:

Please propose several additional sample locations to increase the frequency of sample along the combined 2,900 to 3,500 linear feet of stream segments that were identified in the original comment.

Response to Evaluation 25:

As discussed in previous comment responses, surface water and sediment samples will be collected from stream locations exhibiting the full range of COPEC concentrations. The “spatial coverage” of the samples collected for the BERA is irrelevant. It is not the purpose of the BERA, not should it be, to delineate the nature and extent of contamination. The nature and extent of contamination was delineated in the Remedial Investigation and summarized in the SLERA. Rather, the BERA has been designed to identify the concentrations of COPECs that may pose adverse impacts to

ecological receptors that may inhabit the T-24A Ranges. By sampling the full range of COPEC concentrations (regardless of location within the T-24A Ranges), the Army will be able to derive NOAELs, LOAELs, and AETs that will be useful in the derivation of ecological risk-based remedial goals.

As the result of discussions between ADEM, USEPA, USFWS, and Army personnel at the meeting held December 11-12, 2008 at FTMC, 5 additional surface water and sediment samples will be collected from the drainage features at the T-24A ranges. These 5 additional surface water and sediment samples will be collected for chemical analysis only in order to ensure that the nature and extent of “contamination” in the drainage features at the T-24A ranges has been fully characterized. These additional samples will not be used for toxicity testing, but may be utilized for input to food web modeling and incorporated as such into the BERA. Two “upstream” surface water and sediment sample locations (FTA-108-SW/SD02 and R24A-187-SW/SD01) will also be targeted for sampling site-specific reference conditions.

Comment: **The response states that 5 additional surface water and sediment samples will be collected. However, ADEM notes that actually 7 additional samples will be collected according to text in Section 9.0, Table 9-2, Table 9-3, Figure 9-1, and Appendices B and C. The Army’s response states that these additional samples will be used for chemical analysis only. Please combine all newly collected media data with existing data in a cumulative database to be used to reconfirm the COPEC selection in the Final BERA PF/SD, recalculate screening-level HQs for all COPECs, and calculate new COPEC concentrations to be used in the Draft BERA.**

Final Response to Comment 25: Consistent with the practice in previous BERAs conducted at FTMC, all chemical data collected as part of the BERA will be combined with the data that were collected as part of the remedial investigations that were conducted at the T-24A ranges to form a single database that will be utilized in the BERA (e.g. food web modeling). These additional sampling locations will not be utilized for toxicity or bioaccumulation testing.

Comment 29: **Section 10.1. Data on the earthworm and plant toxicity of surface soil samples observed during toxicity tests of complex COPEC mixtures in soil from other sites, such as the Iron Mountain Road, Bains Gap Road, and Baby Bains Gap Road Ranges at Fort McClellan, are not an acceptable substitute for toxicity testing of site-derived soils from the T-24A Ranges. If interim results of the exposure assessment and toxicity assessments for soil invertebrates and invertivorous wildlife species do indicate significant risks to one or both receptor groups,**

then additional soil samples should be collected from representative habitats for chemical analysis and earthworm toxicity testing. During such sampling, the presence and abundance of earthworms and other soil invertebrates also should be documented to verify the presence of soil invertebrate prey and a complete soil-to-invertivore dietary exposure pathway. Please address.

Response 29: Please see Response to Specific Comment 21: It is unclear how the use of toxicity test results from soils exhibiting identical COPECs, similar physical/chemical properties, and from identical soil mapping units as are found at the T-24A Ranges and the IMR and BGR Ranges at FTMC is not appropriate or defensible. Soils used in the invertebrate toxicity tests conducted as part of the IMR/BGR Ranges BERA exhibit identical COPECs as the soils at the T-24A ranges and were collected from identical soil mapping units as soils at the T-24A ranges. Therefore, there is no "...significant site to site variability of complex COPEC mixtures and soil biochemical parameters..." as the commenter suggests. The soil assessment methodologies are entirely appropriate and defensible; therefore, no changes to the surface soil assessment methodologies are warranted or necessary.

Evaluation 29: *Please see the Evaluation for Specific Comment 21: The microbiological, macrobiological, and nutrient cycling profiles of soils that affect bioavailability, uptake, and in situ transformation of COPECs in soils vary greatly even among sites falling within the same geological unit of soil series mapping. Therefore, please provide additional supporting evidence that the physical and chemical properties of the soils are similar among the sites.*

Response to Evaluation 29: Please see Response to Evaluation 21: As agreed to at the December 11 – 12, 2008 meeting at FTMC, five surface soil samples will be collected from the T-24A Ranges and analyzed for physical/chemical properties that could affect the binding capacity/bioavailability of the COPECs identified in soil at the T-24A Ranges. These physical/chemical properties will be compared to the binding capacity data that were collected for soils at the IMR and BGR Ranges (*Baseline Ecological Risk Assessment Study Design for the Iron Mountain Road Ranges, IT, 2002*) to determine if the bioavailability of the COPECs in the IMR and BGR Ranges soil is similar to the bioavailability of the COPECs in T-24A Ranges soil.

Comment: **The response does not address the Army's agreement to document the presence and abundance of earthworms and other soil invertebrates during the supplemental soil sampling, as stated in the draft December 11 – 12, 2008 meeting minutes. Please include the results of the field survey for a soil invertebrate community to verify the**

presence of soil invertebrate prey and determine a complete soil-to-invertivore dietary exposure pathway.

Final Response to

Comment 29:

The Army will document the presence or absence of earthworms and other terrestrial invertebrates in the supplemental soil samples and will report the results of this field survey in the BERA.

Section II: New Specific Comments from the Final BERA PF/SD

Comment 32:

Section 2.1 COPECs in Surface Soil. Selenium (Se) should be retained as a COPEC because Se in several samples exceeded the EcoSSLs for plants, birds, and mammals, both the maximum and mean Se concentrations exceed both the plant EcoSSL and BTV, Se bioaccumulates significantly in terrestrial food chains, and at least one genus of plants (*Astragalus*) known to hyperaccumulate Se from soils was identified in the Final BERA PF/SD as found onsite. Please add discussion in the text about the exceedances of Se and evaluate potential bioaccumulation risks to terrestrial food chains. Also, please provide more scientific evidence that Se may be associated with naturally-occurring background levels.

Response 32:

As described in Section 2.1 of the Problem Formulation and Study Design report, geochemical evaluation of the data indicated that the detected concentrations of selenium at the T-24A ranges were consistent with background concentrations of selenium. Furthermore, the detected concentrations of selenium were found to be consistent across the site, with no “hot spots” or “source areas” evident, which would be indicative of a naturally-occurring constituent. Additionally, none of the Army activities known to have occurred at the T-24A ranges utilized selenium in any way. Therefore, the relatively low levels detected in soil were considered to be background and selenium was not considered a COPEC in surface soil at the T-24A ranges. This conclusion remains valid and the rationale will be included in the BERA.

Comment 33:

Section 2.2 COPECs in Surface Water. Please explain the rationale for eliminating mercury (Hg) as a surface water COPEC since the maximum detected Hg concentration exceeded both the default ESV in Table 2-2 and the Alabama water quality criterion (WQC). Please provide justification for using the National Ambient WQC of 0.77 µg/L (USEPA, 2006) as an alternative ESV from an ecotoxicological perspective instead of the 2008 Alabama WQC of 0.012 µg/L for total Hg by discussing the basis for the Alabama WQC in terms of exposure pathways (apparently based on the superseded, Final Residue Value for food chain exposures of piscivorous wildlife to methyl-mercury from the 1984 NAWQC), and the absence of a

significant piscivorous food chain exposure pathway for mercury in surface water due to mostly ephemeral stream flows at the site.

Response 33:

The text in Section 2.2 discusses the detected concentrations of mercury in surface water in relation to the ESV, the National Recommended Water Quality Criteria (USEPA, 2002), and the Alabama freshwater AWQC. This section also describes the fact that statistical comparison to background surface water indicated that the detected concentrations of mercury on-site were consistent with background concentrations of mercury in surface water, implying that the detected mercury in surface water at the T-24A ranges was indicative of background and was not site-related. Furthermore, the applicability of the Alabama AWQC of 0.012 µg/L is questionable. The Alabama chronic AWQC appears to be based on food chain exposures of piscivorous wildlife. However, the ephemeral nature of the streams at the T-24A ranges precludes the presence of piscivores throughout much of the year; therefore, the Alabama AWQC would not be applicable to conditions at the T-24A ranges. The chronic National Recommended Water Quality Criteria (USEPA, 2002) for mercury (0.77 µg/L) is based on the protection of aquatic life and not food web exposures; therefore, it is more applicable to conditions at the T-24A ranges. This additional rationale for not including mercury as a COPEC in surface water will be included in the BERA.

Comment 34:

Section 2.2 COPECs in Surface Water. The average aluminum concentration results in a HQ of 98, and it is two orders of magnitude higher than the BTV. Therefore, aluminum should be retained as a surface water COPEC in the BERA. Please address.

Response 34:

As presented in Section 2.2, one surface water sample out of a total of 8 samples exhibited an aluminum concentration that exceeded the background screening value. Geochemical evaluation of the surface water data indicated that all of the detected concentrations of aluminum were consistent with background concentrations of aluminum. Army records indicate that aluminum was never used in any of the activities that took place at the T-24A ranges. The low frequency of detection at “elevated” concentrations, the fact that aluminum is the most abundant element in the Earth’s crust, and the fact that geochemical evaluation indicated that the detected aluminum in surface water was consistent with background concentrations of aluminum in surface water, resulted in the conclusion that aluminum should not be included as a COPEC in surface water. That conclusion remains valid. If “upstream” background data for surface water are available as the result of BERA sampling, then the “upstream” background data set will be compared to the off-site background data set used in the SLERA for the T-24A ranges, and any differences in the data sets will be addressed in the uncertainty analysis with respect to the potential impacts on the results of the BERA.

Comment 35: Section 2.2 COPECs in Surface Water. **The average barium concentration results in a HQ of 20 for direct toxicity effects on aquatic biota. Also, its low potential to bioaccumulate in food chains does not justify its elimination as a COPEC. Therefore, barium should be retained as a surface water COPEC in the BERA. Please address.**

Response 35: As presented in Section 2.2, two surface water samples out of a total of 11 samples exhibited barium concentrations that were greater than the background screening level. Geochemical evaluation of the surface water data indicated that all of the detected concentrations of barium were consistent with background concentrations of barium. Army records indicate that barium was never used in any of the activities that took place at the T-24A ranges. Therefore, the detected concentrations of barium were considered to be consistent with background concentrations of barium in surface water and barium was not identified as a COPEC in surface water. That conclusion remains valid. If “upstream” background data for surface water are available as the result of BERA sampling, then the “upstream” background data set will be compared to the off-site background data set used in the SLERA for the T-24A ranges, and any differences in the data sets will be addressed in the uncertainty analysis with respect to the potential impacts on the results of the BERA.

Comment 36: Section 2.2 COPECs in Surface Water. **Surface water COPEC judgments should preferentially be based on comparisons to data of upstream sample locations not impacted by the site. Comparisons to BTVs and geochemical evaluations should be used only when upstream samples are unavailable. Therefore, please revise any portions of text that state that inorganic COPECs are or are not “consistent with naturally occurring background concentrations”. For example, this statement does not justify elimination of copper and lead as surface water COPECs because the mean concentration of these COPECs exceed their respective BTVs.**

Response 36: As stated in the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Ranges Near Training Area T-24A* (Shaw, 2009) and reiterated numerous times during the December 11 – 12, 2008 meeting at FTMC, the streams at the T-24A ranges represent the headwaters of the South Branch of Cane Creek. As such, “upstream” surface water sampling locations un-impacted by the site are unavailable throughout much of the year. In lieu of background samples from “upstream” locations, a background data set has been collected from streams in the vicinity of FTMC that are presumably un-impacted by Army activities. The background data sets for soil, surface water, sediment, and groundwater (IT, 2000) have been thoroughly vetted by ADEM, USEPA, and USFWS, and have been utilized for background comparisons at FTMC for well over 10 years. Therefore, per Section

2.3.7(d) of the *Alabama Environmental Investigation and Remediation Guidance* (ADEM, March 2005), which states that “If an upstream sample is unattainable, a nearby site that has not been affected by the release should be used”, the “off-site” background data set for surface water is appropriate for background comparisons at the T-24A ranges. However, if “upstream” background data for surface water are available as the result of BERA sampling, then the “upstream” background data set will be compared to the off-site background data set used in the SLERA for the T-24A ranges, and any differences in the data sets will be addressed in the uncertainty analysis with respect to the potential impacts on the results of the BERA.

Comment 37: **Section 2.2 COPECs in Surface Water. Please revise the discussion on Page 2-12 to justify the elimination of bis(2-ethylhexyl)phthalate as a surface water COPEC by using the Tier II toxicity threshold as an alternative ESV instead of suggesting that concentrations detected exceeding the ESV were resulted from either suspended sediment or laboratory contaminants.**

Response 37: The discussion regarding bis(2-ethylhexyl)phthalate includes a number of lines of evidence for not including bis(2-ethylhexyl)phthalate as a surface water COPEC; including the fact that the detected concentrations are less than the Tier II toxicity threshold values and the fact that the detected concentrations may be attributable to suspended solids in the water sample. All of the lines of evidence presented in this discussion are valid; however, in order to avoid confusion, the potential presence of bis(2-ethylhexyl)phthalate as the result of suspended particulate matter will be removed from the rationale for excluding bis(2-ethylhexyl)phthalate as a COPEC.

Comment 38: **Section 2.3 COPECs in Sediment. Please retain copper as a sediment COPEC because it is a munition related COPEC in both soil and surface water for which the mean sediment concentration exceeds its BTV. Since the intermittent streams of the site are only infrequently flooded, it is reasonable to assume direct contact and/or food chain-mediated exposures to terrestrial wildlife will occur to copper in exposed sediments to a significant extent during extended dry periods. Thus, combined food chain exposures of wildlife to copper should be calculated using data for terrestrial soils and intermittent stream sediments that are often exposed.**

Response 38: Although copper was detected at relatively low levels compared to the ESV (HQ_{screen} value = 1.9) and geochemical evaluation indicated that the detected copper in sediment was consistent with background copper concentrations, copper will be retained as a sediment COPEC. However, maximum copper concentrations in sediment are an order of magnitude less than maximum copper concentrations in soil; therefore, a combined

food web exposure for sediment/soil would essentially “dilute” the exposure point concentration of copper used in the terrestrial food web model. In order to maintain a conservative assessment for each medium, exposures to copper in surface soil and sediment will be assessed separately in the BERA.

Comment 39: **Section 2.3 COPECs in Sediment. Please retain benzo(a)pyrene and benzo(b)fluoranthene as sediment COPECs because they are incorrectly footnoted in Table 2-3 as having maximum detected concentrations less than their respective ESV.**

Response 39: Benzo(a)pyrene and benzo(b)fluoranthene were eliminated as sediment COPECs because their HQ_{screen} values were equal to one when rounded to one significant figure, as is the norm in risk assessment practice. HQ_{screen} values of less than or equal to one were considered to indicate constituent concentrations that would not pose significant ecological risk, and constituents with HQ_{screen} values of less than or equal to one were not considered COPECs in the SLERA. Table 2-3 is accurate. However, based on responses to previous comments, all of the surface soil, surface water, and sediment data (relevant historical data and data collected as part of the BERA) will be evaluated with respect to ESVs and Eco-SSLs, Alabama AWQC, and consensus-based sediment quality guidelines (MacDonald, et al., 2000) in the BERA. Any exceedances of ESVs or “newer ESVs” will be noted and addressed in the BERA uncertainty analysis with regard to potential impacts on the results of the BERA.

Comment 40: **Section 2.3 COPECs in Sediment. Please use alternative sediment ESVs, such as the consensus-based threshold effect concentrations (TECs) published by MacDonald et al. (2000) to refine the sediment COPEC selection since ESVs for several other PAHs not identified as COPECs are actually PQLs rather than toxicity effects-based ESVs. In the Draft BERA, please evaluate the chemical-specific risks for anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene, since both their maximum and mean concentrations exceed their respective TECs, as well as evaluating Total PAHs as a “class-level” COPEC.**

Response 40: Per agreements between ADEM, USEPA, USFWS, and the Army made during the December 11 – 12, 2008 meeting at FTMC, the sediment ESVs used in the SLERA and Problem Formulation and Study Design were adequate and no revisions or changes were necessary. However, in order to expedite the BERA process at the T-24A ranges and to keep the process moving forward, the BERA will include anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene as additional sediment COPECs because the maximum concentrations of these PAH compounds exceeded their respective consensus-based sediment quality guidelines (MacDonald, et al., 2000). Benzo(a)anthracene was already identified as a

sediment COPEC in the SLERA and Problem Formulation and Study Design for the T-24A ranges.

Comment 41: **Section 2.3 COPECs in Sediment. The minimum lead concentration reported in Table 2-3 is 6.04 mg/kg, which is the lead concentration for upstream reference sample R24A-187-SW/SD01 (reference). Please explain why reference sample data were used in the sediment COPEC selection table and revisit the segregation of data as site-impacted versus reference samples in the Draft BERA report.**

Response 41: Tables 2-1 through 2-4 summarize all of the relevant data collected as part of the remedial investigations conducted at the T-24A ranges. As such, the sampling locations to date have been designed to determine the nature and extent of contamination at the T-24A ranges, and have not been designed specifically for risk assessment purposes. The data collected as part of the BERA will be combined with the historical data from the T-24A ranges to determine which sample locations and data can be considered un-impacted or characteristic of background.

Comment 42: **Section 3.0 Ecotoxicity. The section contains insufficient COPEC-specific relevant data such as the soil EcoSSLs for plants, soil invertebrates, and/or wildlife receptors, as well as the toxicity reference values (TRVs) for birds and/or mammals. Please add more discussion to present wildlife EcoSSLs, and the TRVs on which they are based, for all receptor groups that are available in each of the EcoSSL-specific guidance documents.**

Response 42: Additional COPEC-specific toxicity data will be incorporated into the toxicity discussions in the BERA.

Comment 43: **Section 9.2.1 Sediment Collection for Chemical Analysis. The bulleted summary of sediment samples on Page 9-4 implies that 4 of the 12 site-affected samples will only be used for nature and extent characterization. Please use all cumulative sediment data to calculate COPEC concentrations for the exposure assessment of the BERA.**

Response 43: Consistent with the practice in previous BERAs conducted at FTMC, all chemical data collected as part of the BERA will be combined with the data that were collected as part of the remedial investigations that were conducted at the T-24A ranges to form a single database that will be utilized in the BERA (e.g. food web modeling). These additional sampling locations will not be utilized for toxicity or bioaccumulation testing.

Comment 44: **Section 9.2.3 Surface Water Collection for Chemical Analysis. The bulleted summary of surface water samples on Page 9-10 implies that 4 of the 12 site-affected samples will only be used for nature and**

extent characterization. Please use all cumulative surface water data to calculate COPEC concentrations for the exposure assessment of the BERA.

Response 44: Consistent with the practice in previous BERAs conducted at FTMC, all chemical data collected as part of the BERA will be combined with the data that were collected as part of the remedial investigations that were conducted at the T-24A ranges to form a single database that will be utilized in the BERA (e.g. food web modeling). These additional sampling locations will not be utilized for toxicity or bioaccumulation testing.

Comment 45: **Section 12 References. Please provide the following literature references for sediment ESVs for mercury that were discussed on Page 2-15: 1) MacDonald et al., 2000; 2) USEPA, 1996; and 3) Persaud et al., 1993.**

Response 45: The aforementioned references will be provided in the BERA.

Comment 46: **Table 2-2 Constituents of Potential Ecological Concern in Surface Water. Table 2-2 reports a frequency of detection (FOD) to be 3/10 for copper, 3/11 for lead, and 4/6 for zinc. However, Table 9-2 indicates a FOD to be 2/7 for the three metals. Please clarify.**

Response 46: Table 2-2 presents data summaries for constituents detected in surface water. Table 9-2 presents COPEC concentrations in proposed sediment samples, not surface water. The frequency of detection (FOD) reported in Tables 2-2 and 9-3 are not comparable due to the fact that Table 2-2 reports the results of surface water samples that have been collected as part of the remedial investigations that have been conducted at the T-24A ranges, while Table 9-3 presents the data for the proposed samples to be collected as part of the BERA, some of which have not been sampled previously.

Comment 47: **Table 2-3 Constituents of Potential Ecological Concern in Sediment. Table 2-3 reports a frequency of detection (FOD) to be 11/11 for lead and 2/11 for the four PAHs. However, Table 9-2 indicates a FOD to be 7/7 for lead and 1/7 for the PAHs. Please clarify.**

Response 47: Please see Response to Comment 46.

Comment 48: **Table 2-3 Constituents of Potential Ecological Concern in Sediment. Please clarify the discrepancy of the maximum lead concentration reported in Table 2-3 (156 mg/kg) and Table 9-2 (148 mg/kg).**

Response 48: There is no discrepancy between Tables 2-3 and 9-2. Table 2-3 correctly reports the maximum detected concentration of lead as 156 mg/kg, which

occurred in sample R24A-187-SW/SD05. Table 9-2 correctly reports the lead concentration detected in sample R24A-187-SW/SD07 as 148 mg/kg. Sample R24A-187-SW/SD05 was not proposed as a sample location for the BERA due to the very similar lead concentrations in sediment detected at these two locations.

Comment 49: **Table 2-3 Constituents of Potential Ecological Concern in Sediment.** Please revise the table to identify benzo(a)pyrene and benzo(b)fluoranthene as sediment COPECs.

Response 49: Based on responses to previous comments, copper, benzo(a)pyrene, benzo(b)fluoranthene, anthracene, and dibenz(a,h)anthracene will be included as sediment COPECs in the T-24A BERA.

Comment 50: **Figure 9-1 Proposed Sample Locations.** As reflected in ADEM's edits on the Army's draft minutes from the December 2008 meeting, ADEM had requested at the meeting that Army collect samples from an additional 8 to 10 locations, including 3 or 4 that were marked by Army's contractor with Post-it® notes on Figure 9-1. Based on a review of elevated concentrations of lead in surface soils, plotted as isocontours on Figure 4-1, ADEM marked Figure 9-1 with additional requested SW/SD locations. However, the new locations proposed in Figure 9-1 of the Final BERA PF/SD exclude several of the more critical "hot spot" locations requested by ADEM, while proposing some new locations that are less likely or unlikely to have been affected by elevated lead in surface soils, such as one that is located upstream of the areas with elevated lead in soils (T24A-BERA-SW/SD-04). Please relocate or add the following sediment and surface water locations to document the effects of elevated soil lead on stream sediments and surface water:

- Move T24A-BERA-SW/SD04 about 500 feet East into the wet area located between XRF Locations T24-RI-(S200, W400) and (S200, W500).
- Move T24A-BERA-SW/SD06 100 to 150 feet NNW across the road and into the main channel downgradient of XRF Location T24-RI-(N300, W100).
- Add a sample location about midway between R24A-187-SW/SD06 and R24A-187-SW/SD07 downgradient of R24A-187-GP78
- Resample sediment at R24A-187-SW/SD03 or at a new depositional location just above the road culvert, downstream of FTA-108-SW/SD03

Response 50: Disagree. The revised surface water and sediment sampling locations presented on Figure 9-1 of the *Final Problem Formulation and Study Design for the Ranges Near Training Area T-24A* (Shaw, 2009) reflect the

same locations marked on Figure 9-1 by ADEM's contractor at the December 11 – 12, 2008 meeting at FTMC. Sample location T24A-BERA-SW/SD06 appears approximately 75 feet west of its intended position due to a mapping error. All other sampling locations are as proposed by ADEM's contractor.

- There is no “wet area” 500 feet east of sample location T24A-BERA-SW/SD04. Sample location T24A-BERA-SW/SD04 is located as marked on Figure 9-1 just upstream of the road near the southern boundary of the T-24A study area.
- As noted previously, sample location T24A-BERA-SW/SD06 should be shifted approximately 75 feet east so that its location corresponds to the location of the ephemeral stream.
- The utility of an additional sediment sample between sample locations R24A-187-SW/SD07 and R24A-187-SW/SD06 is questionable. Sample location R24A-187-SW/SD06 exhibited a lead concentration of 94 mg/kg, and sample location R24A-187-SW/SD07 exhibited a lead concentration of 148 mg/kg. Both of these lead concentrations are greater than the proposed RBRG for lead in sediment of 68 mg/kg presented in the *Identification of Ecological Risk-Based Remedial Goals* (Shaw, 2009). However, in order to identify the stream segment that could potentially exhibit “worst case” sediment concentrations of lead, an additional surface water and sediment sampling location will be added along the stream segment that runs adjacent to Parcel 187, approximately half-way between sampling locations R24A-187-SW/SD06 and R24A-187-SW/SD07.
- Historical sediment sample location R24A-187-SW/SD03 was not marked by ADEM's contractor as a location that should be sampled during the December 11 – 12, 2008 meeting at FTMC. Furthermore, the data from previous sediment samples collected at this location indicated that the lead in sediment was characteristic of background conditions (9.67 mg/kg). The utility of additional data from this sampling location is dubious.

Comment 51: **Appendix A – Field Sampling Plan for Surface Water.** Please indicate whether surface water samples will be filtered prior to analysis for TAL metals. Please apply both total and dissolved metal concentrations appropriately in the Draft BERA.

Response 51: Surface water samples collected as part of the T-24A BERA will analyzed for both total recoverable TAL metals and dissolved TAL metals.