5.0 Ecosystems Potentially at Risk

The terrestrial habitat occurring at the BGR ranges falls into two general categories: "cleared" areas and forested areas. The "cleared" areas are those areas that were formerly maintained as lawns or mowed fields. These areas represent the locations where range activities were most prevalent. Since maintenance activities have ceased in these areas, pioneer species are colonizing these areas. Typically, the species most likely to colonize these 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 herbaceous species. These formerly maintained grassy areas are classified as being in an early old field successional state. Over time, these grass and herbaceous species will be followed by shrubs and small trees. The early old field successional areas at the BGR ranges are dominated by various grasses and herbs including *Rumex spp.* (dock), *Trifolium spp.* (clover), *Astragalus spp.* (vetch), *Ascelepias spp.* (milkweed), *Galium spp.* (bed straw), *Chrysanthemum leucanthemum* (ox-eye daisy), and *Sorghum halepense* (Johnson grass). Other old field herbaceous species occurring at the BGR ranges are *Rubus occidentalis* (black raspberry), *Toxicodendron radicans* (poison ivy), *Rubus glabra* (smooth sumac), *Smilax rotundiflora* (green brier), *Lonicera japonica* (Japanese honeysuckle), *Vitus labrusca* (fox grape), and *Rosa multiflora* (multiflora rose). Loblolly pine *(Pinus taeda)* saplings have also begun to encroach on the formerly maintained grassy areas of the BGR ranges.

The forested areas outside of the "cleared" areas are best characterized as mixed deciduous/coniferous forest. The canopy species typically found in the forested areas surrounding the BGR ranges 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 area 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*), southern low blueberry *(Vaccinium pallidum*), southern wild raisin (*Viburnum nudum*), Virginia creeper (*Parthenocissus quinquefolia*), Christmas fern (*Lystrichum acrotichoides*), poison ivy (*Toxicodendron radicans*), and yellowroot (Xanthorhiza simplicissima). Numerous muscadine grape (*Vitis rotundifolia*) vines are also present in this area.

Terrestrial species that may inhabit the area of the BGR ranges include opossum, short-tailed shrew, raccoon, white-tail deer, red fox, coyote, gray squirrel, striped skunk, a number of species of mice and rats (e.g., white-footed mouse, eastern harvest mouse, cotton mouse, eastern wood rat, and hispid cotton rat), and eastern cottontail. 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 BGR ranges 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., Picoides spp.*), and Carolina chickadee (*Parus carolinensis*). Game birds present in the vicinity of the BGR ranges may include northern bobwhite (*Colinus virginianus*), mourning dove (*Zenaida macroura*), and eastern wild turkey (*Meleagris gallopavo*). Woodland hawks (e.g., sharp-shinned hawk) were observed in this area during the ecological investigation (September, 2000) and are expected to use this area for a hunting ground. A variety of other raptors (e.g., red-tailed hawk, barred owl, and great horned owl) could also use portions of this area for a hunting ground, particularly the fringe areas where the forested areas abut roads and cleared areas. Due to the presence of Cane Creek, piscivorous bird species may also be present in the vicinity of the BGR ranges. These piscivorous birds may include great blue heron (*Ardea herodias*), green-backed heron (*Butorides striatus*), and belted kingfisher (*Ceryle alcyon*).

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 BGR ranges are copperhead (*Agkistrodon contortix*), king snake (*Lampropeltis getulus*), black racer (*Coluber constrictor*), fence lizard (*Sceloporour undulatus*), and six-lined racerunner (*Cnemidophorous sexlineatus*).

Descriptions of the habitats at each of the ranges on Bains Gap Road are presented in the following sections.

5.1 Range 21 Habitat

Range 21 is comprised of two main habitat types: "cleared" and forested areas. The cleared area comprises the vast majority of Range 21. The entire area of Range 21, including the extensive safety fan is approximately 2,249 acres. The study area of Range 21 is approximately 15 acres in size and is topographically relatively flat. It is bounded on the north by Bains Gap Road, on the east and south by mixed deciduous/coniferous forest, and on the west by Range 22. A soil berm separates Range 21 from Range 22 to the west. The study area of Range 21 is almost entirely comprised of formerly maintained lawn, mowed fields, and non-vegetated soil. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Loblolly pine (*Pinus taeda)* saplings have also begun to encroach into these previously maintained areas. Significant portions of Range 21 remain non-vegetated, with large areas of bare soil.

The forested areas to the east and south of Range 21 are best characterized as mixed deciduous/coniferous forest. Scrub pine, loblolly pine, white oak, and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. White-tailed deer, wild turkey, gray squirrel, and various song birds have been observed on-site.

Cane Creek flows east-to-west across Range 21 towards Range 22 and through a large concrete culvert beneath the soil berm that separates Range 21 from Range 22 to the west. Several small tributaries also flow across the southern portion of Range 21 and along the eastern and western boundaries of Range 21. Cane Creek is relatively narrow (4 – 6 feet) and shallow (0.5 – 1.0 feet) along its length within Range 21, with steep embankments approximately four feet high. The substrate of Cane Creek is mostly boulders and cobbles with a few small depositional areas with sand substrate. The water level in Cane Creek is highly variable, depending on the amount of precipitation received by the local watershed. Cane Creek is a perennial creek, and as such, maintains water flow even during periods of drought. The vegetative canopy of the Cane Creek corridor within Range 21 is characterized by low-level shrubs and tree saplings (less than 8 feet high) that form a low, dense canopy over the creek. This vegetation extends less than six feet from the creek bed itself. Thus this vegetative canopy is narrow, low and dense. Because Cane Creek bisects Range 21 between the firing line and several of the target areas, vegetation along Cane Creek was previously maintained at a low level so that the target areas would not be obstructed.

The portion of Cane Creek that flows through Range 21 has been identified as low-quality foraging habitat for the Federally-listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This section of Cane Creek has been identified as a gray bat foraging area because it provides habitat for aquatic insects, which are fed upon by the gray bat. However, the gray bat requires continuous cover while traveling to and from its foraging habitats and while foraging. Due to historical maintenance activities along Cane Creek, the forest canopy has been eliminated and has only recently been replaced by low-lying shrubs and saplings. Thus, the currently existing vegetative cover along the Cane Creek corridor may not provide the cover favored by gray bats. In the future, growth of a high canopy of trees along the Cane Creek corridor may improve the gray bat foraging habitat potential.

5.2 Range 22 Habitat

Range 22 is comprised of two main habitat types: "cleared" and forested areas. The cleared area comprises the vast majority of Range 22. The total area of Range 22, including the extensive safety fan, comprises 1,810 acres. The main study area of Range 22 is approximately 12.5 acres and is topographically relatively flat. A rocky, soil berm forms the southern boundary of the main study area. Range 22 is bounded on the north by Bains Gap Road, on the east by Range 21, on the south by mixed deciduous/coniferous forest, and on the east by Range 27. A soil berm separates Range 22 from Range 27 to the west. The study area of Range 22 is comprised almost entirely of formerly maintained lawns, mowed fields, and non-vegetated soil. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Loblolly pine (*Pinus taeda)* saplings have also begun to encroach into these previously maintained areas. Significant portions of Range 22 remain non-vegetated, with large areas of bare soil.

The forested area south of Range 22 is best characterized as mixed deciduous/coniferous forest. Scrub pine, loblolly pine, white oak, and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. White-tailed deer, wild turkey, gray squirrel, and various song birds have been observed on-site.

Cane Creek flows east-to-west across Range 22 towards Range 27. A small tributary that originates southeast of Range 22, flows into Cane Creek at Range 22. Another small tributary that originates north of Range 22, flows into Cane Creek between Ranges 22 and 27. Cane Creek is relatively narrow (4 – 6 feet) and shallow (0.5 – 1.0 feet) along its length within Range 22. The northern bank of Cane Creek is relatively steep and approximately four feet high. The southern bank of Cane Creek is very steep and rises significantly to an elevation of approximately 330 above the firing line elevation. This southern bank effectively forms the impact zone for the majority of Range 22. The substrate of Cane Creek is mostly boulders and cobbles with a few small depositional areas with sand substrate. The water level in Cane Creek is highly variable, depending on the amount of precipitation received by the local watershed. Cane Creek is a perennial creek, and as such, maintains water flow even during periods of drought.

The vegetation adjacent to Cane Creek within Range 22 is sporadic, and where it is present is best characterized by low-level shrubs and tree saplings (less than 8 feet high). This vegetation extends less than six feet from the creek bed to the north. On the southern side of the creek, the bank rises steeply and is largely devoid of vegetation. Because Cane Creek flows along the southern boundary of the impact zone, vegetation along Cane Creek was previously maintained at a low level so that the target areas would not be obstructed.

The portion of Cane Creek that flows through Range 22 has been identified as low-quality foraging habitat for the Federally-listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This section of Cane Creek has been identified as a gray bat foraging area because it provides habitat for aquatic insects, which are fed upon by the gray bat. However, the gray bat requires continuous cover while traveling to and from its foraging habitats and while foraging. Due to historical maintenance activities along Cane Creek, the forest canopy has been eliminated and has only recently been replaced by low-lying shrubs and saplings. Thus, the currently existing vegetative cover along the northern border of the Cane Creek corridor may not provide the cover favored by gray bats. In the future, growth of a high canopy of trees along the Cane Creek corridor may improve the gray bat foraging habitat potential.

5.3 Range 24 Upper Habitat

Range 24 Upper is comprised of two main habitat types: "cleared" and forested areas. The forested area comprises the northern half of Range 24 Upper. The southern half is comprised of "cleared" area. The total area of Range 24 Upper is approximately 11 acres, and there is no defined safety fan. The main study area of Range 24 Upper is on a south-facing slope immediately south of Bains Gap Road. It is bounded on the north by Bains Gap Road, on the east and south by mixed deciduous /coniferous forest, and on the west by Range 21. The northern half of the site slopes from an elevation of approximately 1,050 feet asl to 975 feet asl. This south-facing hillside is best characterized as mixed deciduous/coniferous forest. Scrub pine, loblolly pine, white oak, and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. White-tailed deer, wild turkey, gray squirrel, and various song birds have been observed on-site. At the base of this slope is a cleared area that is best characterized as oldfield, early successional habitat. Various grasses and herbaceous species dominate this habitat type. Loblolly pine (*Pinus taeda)* saplings have also begun to encroach into these areas. Significant portions of the southern half of Range 24 Upper remain non-vegetated, with large areas of bare soil.

Two small, ephemeral tributaries of Cane Creek occur at the base of the slope and in the cleared area south of the hill at Range 24 Upper. These tributaries only have water after significant rainfall events and are dry most of the year. Their substrates are cobbles and boulders and there are very few areas with sandy deposits. These tributaries run east-to-west across Range 24 Upper and join west of the range to form a portion of the headwaters of Cane Creek. These tributaries have not been identified as being capable of supporting gray bat habitat (Garland, 1996).

5.4 Range 27 Habitat

Range 27 is comprised of two main habitat types: "cleared" and forested areas. The cleared area comprises the vast majority of Range 27. The total area of Range 27, including the extensive safety fan, comprises 954 acres. The main study area of Range 27 is approximately 16 acres and is topographically relatively flat. A rocky, soil berm forms the southern boundary of the main study area. Range 27 is bounded on the north by Bains Gap Road, on the east by Range 22, and on the south and west by mixed deciduous/coniferous forest. A soil berm separates Range 27 from Range 22 to the east. The study area of Range 27 is comprised almost entirely of formerly maintained lawns, mowed fields, and unvegetated soil. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Loblolly pine (*Pinus taeda)* saplings have also begun to encroach into these previously maintained areas. Significant portions of Range 27 remain unvegetated, with large areas of bare soil.

The forested area south of Range 27 is best characterized as mixed deciduous/coniferous forest. Scrub pine, loblolly pine, white oak, and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. White-tailed deer, wild turkey, gray squirrel, and various song birds have been observed on-site.

Cane Creek flows east-to-west across the southern boundary of Range 27. A small tributary that originates southeast of Range 27, flows into Cane Creek at Range 27. Cane Creek is relatively narrow (4 – 6 feet) and shallow (0.5 – 1.0 feet) along its length within Range 27. The northern bank of Cane Creek is gently sloping to a height of approximately three feet. The southern bank of Cane Creek is very steep and rises significantly to an elevation of approximately 330 above the firing line elevation. This southern bank effectively forms the impact zone for the majority of Range 27. The substrate of Cane Creek is mostly boulders and cobbles with a few small depositional areas with sand substrate. The water level in Cane Creek is highly variable, depending on the amount of precipitation received by the local watershed. Cane Creek is a perennial creek, and as such, maintains water flow even during periods of drought.

The vegetation adjacent to Cane Creek within Range 27 is sporadic, ranging from areas completely void of vegetation to areas with relatively mature forest canopy. The western portion of the Cane Creek corridor at Range 27 is mostly void of vegetation, while the eastern portion exhibits mature forest vegetation. On the southern side of the creek, the bank rises steeply and the vegetation is mostly brush and weed species for a distance of approximately 50 feet until it transitions to a mixed deciduous/coniferous forest.

The portion of Cane Creek that flows through Range 27 has been identified as low-quality foraging habitat for the Federally-listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This section of Cane Creek has been identified as a gray bat foraging area because it provides habitat for aquatic insects, which are fed upon by the gray bat. However, the gray bat requires continuous cover while traveling to and from its foraging habitats and while foraging. The forest canopy along the Cane Creek corridor at Range 27 is sporadic and not continuous. Thus, the currently existing vegetative cover along the Cane Creek corridor may not provide the cover favored by gray bats. In the future, growth of a high canopy of trees along the Cane Creek corridor may improve the gray bat foraging habitat potential.

5.5 Cane Creek Habitat

Cane Creek in the vicinity of the BGR ranges is a perennial stream that flows east-to-west across the ranges at Bains Gap Road. The physical characteristics of Cane Creek at the BGR ranges are relatively consistent; however, they differ both upstream and downstream of the BGR ranges. The BGR ranges lie within an east-west trending valley that is formed by Jones Hill, Mount Tylo, and several unnamed hills north of the ranges, and Marcheta Hill and several unnamed hills south of the ranges. Upstream (one-half to three-quarters of a mile east) of the BGR ranges, the headwaters of Cane Creek are formed by several small tributaries that are created by surface runoff and seeps from the hills north, south, and east of the ranges. These headwater streams are small ephemeral streams with boulder and cobble substrate that carry runoff during storm events, but are dry during significant portions of the year. The headwater areas are relatively undeveloped portions of Main Post and are almost entirely mixed deciduous/coniferous forest.

Downstream (west) of the BGR ranges, Cane Creek continues to flow in a westerly direction across the developed portion of Main Post (including the Cane Creek golf course) and off-site along the west-northwest boundary of the Main Post.

In general, the portion of Cane Creek that flows through the BGR ranges is a low-gradient perennial stream with widths ranging from 4 to 10 feet and depths ranging from 0.5 to 2.0 feet. The banks of Cane Creek are steep (4 to 8 feet) and exhibit erosional features characteristic of occasional high velocity flow (i.e., during significant storm events). The substrate of Cane Creek is mostly cobbles and boulders. There is very little evidence of organic matter present as substrate in Cane Creek in the vicinity of the BGR ranges. In fact, large sections of the creek bed in this area are made up of exposed bedrock.

The vegetation surrounding Cane Creek at the BGR ranges is variable. Because Cane Creek bisects these ranges, routine maintenance activities have historically controlled/eliminated the vegetation along the creek banks. Since maintenance activities have ceased, vegetative species have begun to re-colonize the creek banks. Therefore, weeds, low-lying shrubs, and tree saplings dominate the creek banks. The areas directly north of Cane Creek is best characterized as old field early successional habitat and the areas directly south of Cane Creek is mixed deciduous /coniferous forest, except for Range 21. Cane Creek flows through the center of Range 21; therefore, the habitat on both the north and south sides of Cane Creek at Range 21 is characterized as old field, early successional.

The headwaters of Cane Creek are formed by runoff from the hills north, east, and south of the BGR ranges. There also appears to be localized contribution to the creek flow from groundwater where the potentiometric surface exceeds the creek bed surface. The flow contribution from groundwater varies according to the amount of precipitation, with an increase when precipitation raises the potentiometric surface. The contribution of groundwater to the flow of Cane Creek appears to be low in the eastern portion of Cane Creek with an increase in groundwater contribution to Cane Creek flow towards the western ranges (e.g., Range 22 and Range 27). Flow in Cane Creek is highly variable, depending on precipitation in the surrounding watershed.

Although relatively shallow (less than two feet deep) over its entire length at the BGR ranges, Cane Creek has the potential to support a variety of amphibious species and some small fish species. Bullfrog *(Rana catesbeiana)* and leopard frog (*Rana sphenocephala*) are examples of amphibians that may be found in Cane Creek in the vicinity of the BGR ranges. Fish species that may be found in Cane Creek in the vicinity of the BGR ranges include blacknose dace (*Rhinichthys atratulus*), creek chub (*Semotilus atromaculatus*), stoneroller (*Campostoma anomalum*), striped shiner (*Luxilus chrysocephalus*), and various darters (*Etheostoma spp.*). The shallow nature of Cane Creek limits its ability to support many aquatic organisms (e.g., large fish) and other organisms that rely on aquatic species for food (e.g., piscivores). Larger fish species are not expected to inhabit Cane Creek due to its shallow nature.

Cane Creek, in the area of the BGR ranges, has been identified as providing low quality foraging habitat for the Federally endangered gray bat (*Myotis grisescens*) (Garland, 1996). Two major requirements for gray bat foraging habitat are contiguous forest cover and habitat for aquatic insects (one of the gray bat's preferred dietary items). Although aquatic insects may be present in Cane Creek at the BGR ranges, the forest canopy is sporadic, and may not provide the cover required by gray bats. In the future, growth of a high canopy of trees along the Cane Creek corridor may improve the gray bat foraging habitat potential.

5.6 Wetland/Seep Habitat

The wetland/seep habitat present in the vicinity of the BGR Ranges is limited to the area south of Range 21. This area is known as the Marcheta Hill Orchid Seep Special Interest Natural Area (SINA). Special Interest Natural Areas (SINA) at FTMC consist of those biological communities that harbor federal, candidate, or state-listed species, or those habitats containing single or groups of unique or unusual species. SINAs have been identified at Fort McClellan at both the regional and community levels. Additional information regarding each individual SINA and their management practices at Fort McClellan is presented in the *Endangered Species Management Plan for Fort McClellan, Alabama* (Garland, 1996). The only SINA that could potentially be impacted by activities (both past and future) at the BGR ranges is the Marcheta Hill Orchid Seep SINA, as it is located directly adjacent to Range 21. The Bains Gap Seep SINA is located approximately 2,000 feet northeast of the closest BGR range (Range 24 Upper) and is also "upstream" of all of the BGR ranges. Surface water and sediment contaminants from the BGR ranges cannot impact the Bains Gap Seep SINA, and based on the distance separating the BGR ranges and the Bains Gap Seep SINA, it is highly unlikely that soil contaminants could impact the Bains Gap Seep SINA. Figure 5-1 presents the relative locations of the Marcheta Hill Orchid Seep SINA, Bains Gap Seep SINA, and the BGR ranges.

The spring seepage to the west of Marcheta Hill constitutes one of the more important SINAs on Main Post at FTMC. The boundary of the wetland seep is approximately 7.2 acres; however, the integrity of the adjacent watershed is critical to the maintenance of this seep. The area is located directly south of Range 21. This wetland is the largest forested seepage on the installation and contains two federal candidate 2 species: white fringeless orchid (*Plantanthera integrilabia*) and Diana butterfly (*Speyeria diana*). The population of white fringeless orchid is particularly significant with over 250 individuals recorded. Additional plants on the ANHP tracking list include rose pink (*Sabatia capitata*) and soapwort gentian (*Gentiana saponaria*).

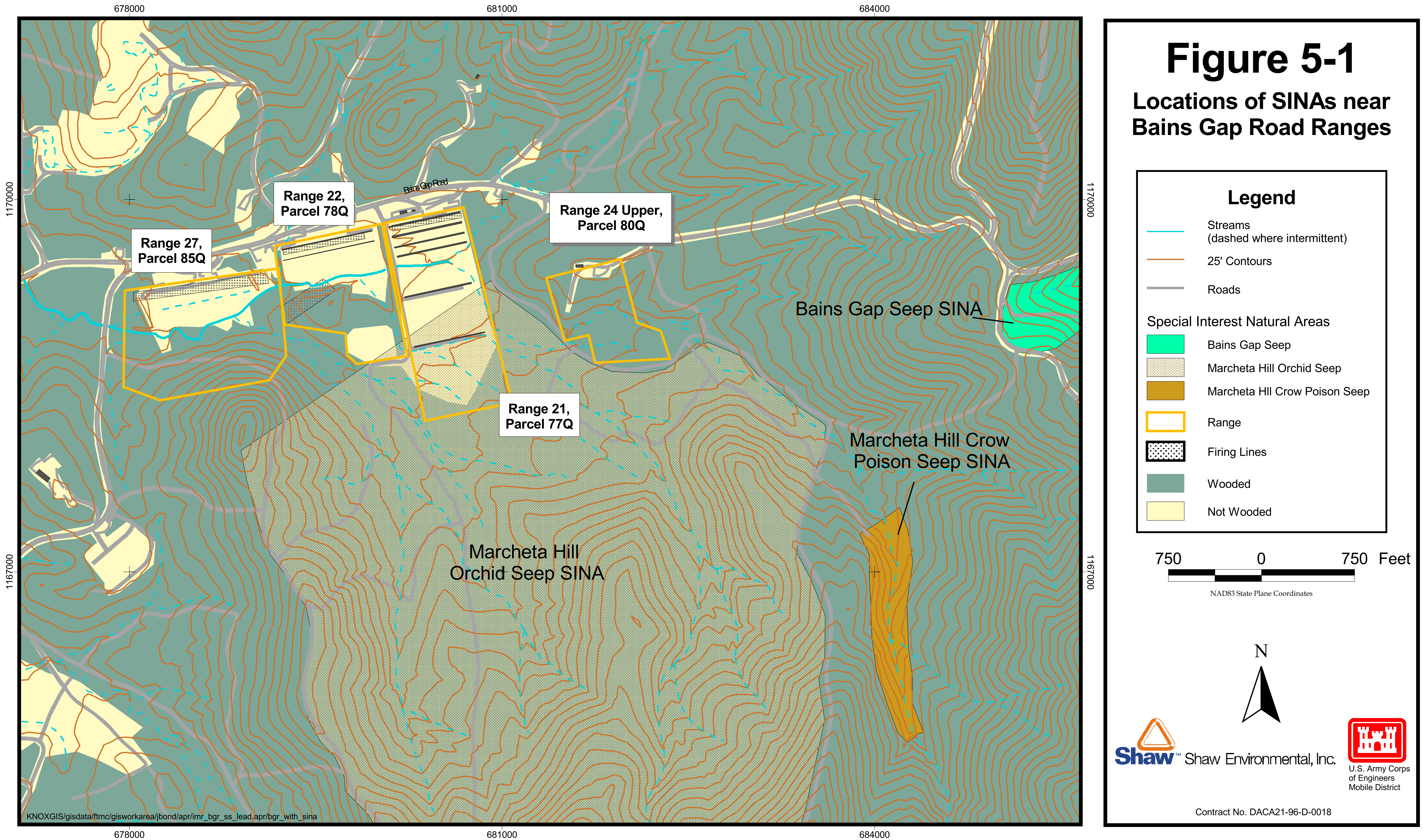


Figure 5-1

Locations of SINAs near Bains Gap Road Ranges

The ecological significance of this wetland has been recognized for several years. "Do Not Disturb Endangered Species Area" signs have been posted along the wetland's boundary. The continuation of the existing fire regime is considered the most critical management requirement. According to verbal accounts, this area experienced a wildfire at least once every two years while the facility was active. Many of these wildfires were due to the training activities that took place at Range 21. In order to insure this fire frequency in the future, the management plan for this area prescribes that a burn will be instituted if the area has not experienced a fire by March 1 of the second year. This permissive burn policy concerning wildfires will benefit this wetland area.

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
- A route of uptake at the exposure point (EPA, 1989).

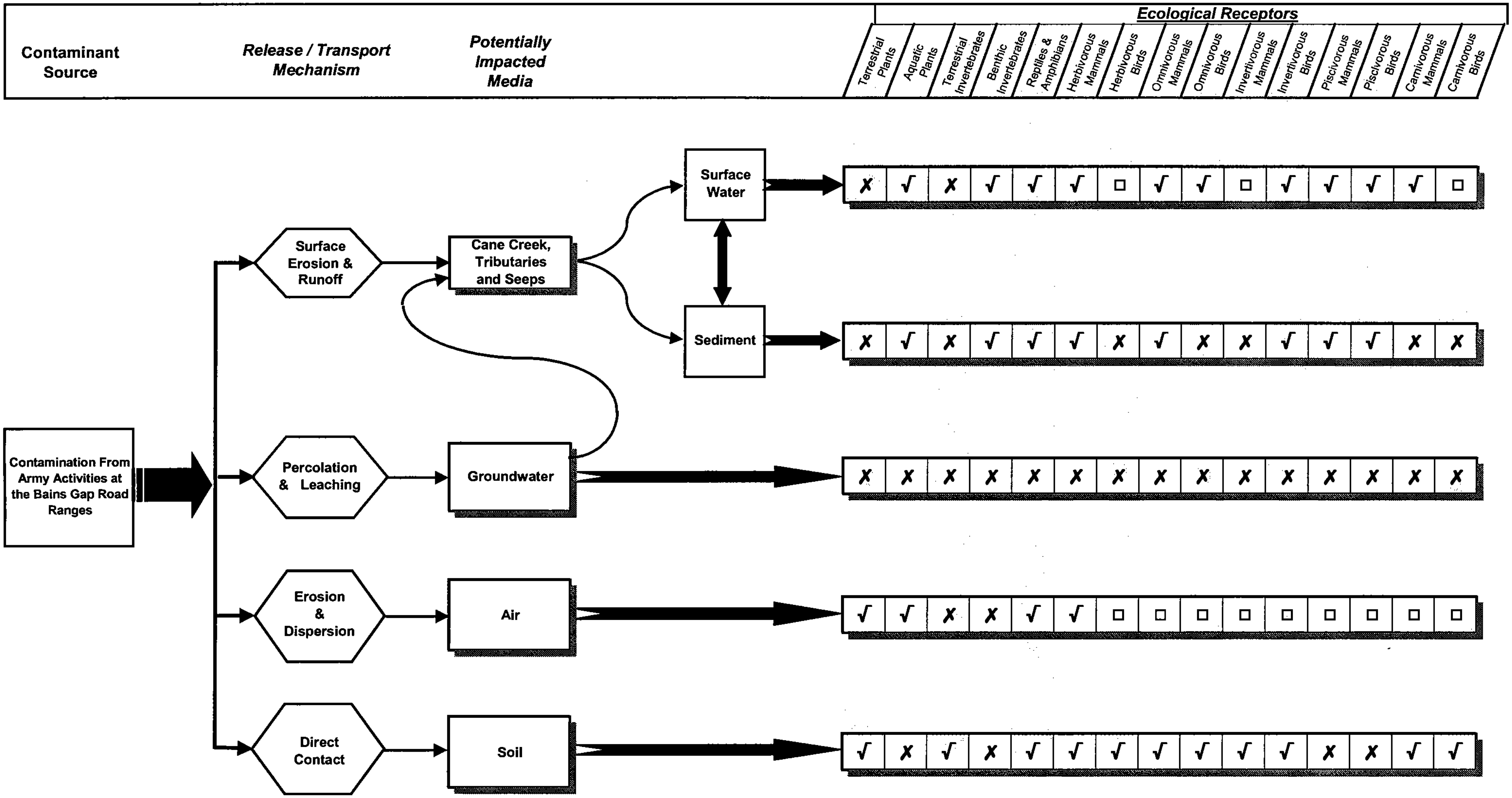
If any of these four components are absent, then a pathway is generally considered incomplete. Potentially complete exposure pathways are depicted in the SCM as Figure 6-1.

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 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. 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.

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 COPECs.

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. Volatile compounds 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

Figure 6 - 1
Site Conceptual Model
For Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama



Medium	Terrestrial Plants	Aquatic Plants	Terrestrial Invertebrates	Benthic Invertebrates	Reptiles & Amphibians	Herbivorous Mammals	Herbivorous Birds	Omnivorous Mammals	Omnivorous Birds	Invertivorous Mammals	Invertivorous Birds	Piscivorous Mammals	Piscivorous Birds	Carnivorous Mammals	Carnivorous Birds
Surface Water	✗	√	✗	√	√	√	□	√	√	□	√	√	√	√	□
Sediment	✗	√	✗	√	√	√	✗	√	✗	✗	√	√	√	✗	✗
Groundwater	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Air	√	√	✗	✗	√	√	□	□	□	□	□	□	□	□	□
Soil	√	✗	√	✗	√	√	√	√	√	√	√	✗	✗	√	√

Key To Potential Exposure Routes

- √ - Potentially complete exposure pathway
- ✗ - Incomplete exposure pathway
- □ - Potentially complete exposure pathway but insignificant

birds or other animals that may use Cane Creek as a feeding area. 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.

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 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 Cane Creek is expected to be localized and sporadic.

Groundwater discharge to the ground surface via seeps is also a potential exposure pathway for a number of different organisms in the vicinity of the BGR ranges. Specifically, the area south of Range 21 is dominated by groundwater seeps and is known as the Marcheta Hill Orchid Seep SINA. This SINA is described in Section 4.2.6 of this report and is also described in detail in the *Endangered Species Management Plan for Fort McClellan, Alabama* (Garland, 1996). These groundwater seep areas could be used by various animals as a source of drinking water and they also provide unique habitat for a number of plant and animal species. Semi-aquatic organisms (e.g., amphibians) could utilize these seeps as breeding grounds as they are inundated during portions of the year when precipitation is heavy and maintain vegetation that is characteristic of saturated soils throughout the year.

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. 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.

In general, the constituents detected in surface soil at the BGR ranges may bioaccumulate in lower trophic level organisms (i.e., terrestrial invertebrates may bioaccumulate inorganic compounds and PAHs 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. However, several chlorinated herbicides and pesticides were detected in surface soil that have a propensity to bioconcentrate (4,4'-DDE, 4,4'-DDT, MCPP, aldrin, alpha-BHC, and endrin). These chlorinated herbicides and pesticides have a propensity to bioconcentrate through the food chain, and therefore may be available to higher trophic level organisms through food chain interactions.

The constituents detected in sediment may bioaccumulate in lower trophic level organisms (i.e., benthic invertebrates may bioaccumulate inorganic compounds detected in sediment); however, they will not bioconcentrate through the food chain. Inorganic compounds and volatile organics generally do not bioconcentrate to any great extent. The constituents detected in groundwater are not expected to bioaccumulate of bioconcentrate significantly.

Potential ecological receptors at the BGR ranges fall into two general categories: terrestrial and aquatic. Within these two general categories there are several major feeding guilds that could be expected to occur at the BGR 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 BGR ranges and surface water and sediment in Cane Creek and its tributaries in the vicinity of the BGR ranges 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 BGR 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 BGR ranges, although none of the COPECs at the BGR ranges have high bioconcentration or biomagnification potential.

Potentially complete exposure pathways are depicted in the SCM as presented in 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. The vegetation at the formerly maintained areas at the BGR ranges is mainly grasses and sedges, which are remnants of the maintained grass that was present when the BGR ranges were operational. 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.

Typical herbivorous species that could be expected to occur at the BGR 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 zibethicus*) and mallard (*Anas platyrhynchos*) could be exposed to site-related constituents in surface water and sediment in Cane Creek at the BGR ranges.

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.

Typical terrestrial invertivorous species that could be expected to occur at the BGR 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 or Blarina carolinensis*), and eastern mole (*Scalopus aquaticus*). Aquatic invertivores (those species that live in water) could include the wood duck (*Aix sponsa*) and blacknose dace (*Rhinichthys atratulus*).

Invertivores that feed on emergent aquatic insects but do not live in the water have the potential to feed in the vicinity of the BGR ranges. These riparian invertivores could be exposed to site-related chemicals in sediment through the ingestion of emergent aquatic insects that live in the sediment of Cane Creek and its tributaries. Aquatic insects could accumulate site-related chemicals from the sediment and could potentially be ingested by invertivores that feed in the vicinity of the BGR ranges. Typical riparian invertivores that feed on emergent aquatic insects include the little brown bat (*Myotis lucifugus*) and the marsh wren (*Cistothorus palustris*).

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 surface water through ingestion of water in Cane Creek at the BGR ranges.

Typical omnivorous species expected to occur at the BGR 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, such as raccoon (*Procyon lotor*) and creek chub (*Semotilus atromaculatus*) could be exposed to COPECs in surface water and sediment in Cane Creek at the BGR ranges.

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. Most inorganic compounds and volatile organic compounds are not accumulated in animal tissues to any great extent (Shugart, et al., 1990 and USAEHA, 1994). Therefore, food web exposures to these chemicals are expected to be minimal. PAHs have the potential to accumulate in lower trophic level organisms but not in higher trophic level organisms because they have mechanisms for metabolizing and excreting this class of compounds. Chlorinated herbicides and pesticides have the potential to bioaccumulate and biomagnify through the food chain; therefore, there is the potential for significant exposure to these classes of chemicals by carnivores. Carnivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while feeding, grooming, or other activities.

Typical carnivorous species expected to occur at the BGR 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 Cane Creek and its tributaries at the BGR ranges are relatively narrow and shallow, they do not have the capability to support large aquatic carnivores on a full-time basis. Carnivorous fish such as largemouth bass (*Micropterus salmoides*) and spotted gar (*Lepisosteus oculatus*) would not be expected to occur in Cane Creek at the BGR ranges due to the habitat restrictions. Carnivorous mammals such as the mink (*Mustela vison*), may feed along Cane Creek during certain periods of the year when significant water is present in the creek, but most likely would not live adjacent to Cane Creek at the BGR ranges because of the creek's inability to support large individuals of fish or other aquatic species.

6.5 Piscivorous Feeding Guild

Piscivores are specialists that feed mostly on fish. Therefore, they may be exposed to site-related chemicals that have accumulated in small fish that may inhabit Cane Creek at the BGR ranges. They may also be exposed to surface water and sediment in the creek through ingestion of drinking water and during feeding. Cane Creek is a perennial creek at the BGR ranges and as such, has flowing water throughout the year. Therefore, it is expected that Cane Creek could be utilized for drinking purposes by a number of different species. Although piscivorous species could be expected to visit the areas around Cane Creek at the BGR ranges during certain periods of the year when the creek flow is significant, they would not be expected to live near the BGR ranges due to the fact that Cane Creek is not large enough to support larger fish species.

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 are not accumulated in fish tissues to any great extent. Therefore, food web exposures to these chemicals are expected to be minimal. Semivolatile and volatile organic compounds are readily metabolized by most fish species and are not accumulated to any extent. Thus, the piscivorous feeding guild is not expected to have significant exposure to COPECs at the BGR ranges through the food web.

Typical piscivorous species expected to occur near the BGR ranges and are commonly used as sentinel species in ecological risk assessment include great blue heron (*Ardea herodias*) and belted kingfisher (*Ceryle alcyon*). Larger piscivorous fish species (e.g., smallmouth bass, spotted gar, etc.) and piscivorous mammals (e.g., mink) are not expected to occur in Cane Creek due to the habitat limitations of Cane Creek in this area and its inability to support larger fish and other aquatic species.

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 caerules*)
- Mohr's Barbara Buttons (*Marshallia mohrii*)
- Tennessee Yellow-Eyed Grass (*Xyris tennesseensis*).

The only Federally listed species that has the potential to occur in the vicinity of the BGR ranges is the gray bat (Garland, 1996). Cane Creek at the BGR ranges has been designated as providing "low quality" foraging habitat for the gray bat (Garland, 1996). The other Federally listed species occur at Pelham Range or Choccolocco Creek corridor.

The gray bat is almost entirely restricted to cave habitats, and, with rare exceptions, roosts in caves year-round. Approximately 95 percent of the entire known population hibernates in only nine caves each winter, with more than half in a single cave. Gray bat summer foraging habitat is found primarily over open water of rivers and reservoirs. They apparently do not forage over sections of rivers or reservoirs that have lost their normal woody vegetation along the banks (USFWS, 1982). Gray bats usually follow wooded corridors from their summer caves to the open water areas used as foraging sites. Forested areas surrounding and between caves, as well as over feeding habitats, are clearly advantageous to gray bat survival as the cover provides increased protection from predators such as screech owls. In addition, surveys have demonstrated that reservoirs and rivers that have been cleared of their adjacent forest canopy are avoided as foraging areas by gray bats (USFWS, 1982).

The gray bat is entirely insectivorous, and surveys have shown that gray bats feed almost exclusively on mayflies at certain times of the year (Mount, 1986). Therefore, gray bats could be exposed to site-related constituents that have accumulated in aquatic insects from Cane Creek. Because gray bats are flying mammals and the BGR ranges do not provide roosting habitat, no other exposure pathways are potentially complete for the gray bat.

Most foraging occurs within 5 meters of the water's surface, usually near a shoreline or stream bank. 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 Cane Creek in the vicinity of the BGR ranges.

Although not officially listed by USFWS as threatened or endangered, two species that are candidates for federal listing are known to occur at the Marcheta Hill Orchid Seep SINA located directly south of Range 21; the white fringeless orchid (*Plantanthera integrilabia*) and the Diana butterfly (*Speyeria diana*). The white fringeless orchid occurs in bogs and seepages along wooded stream banks and ravines from the coastal plain of Mississippi through Alabama, Georgia, Tennessee, Kentucky, the Carolinas, and Virginia. The plant was recorded within two SINAs on Main Post: Marcheta Hill Orchid Seep and Cave Creek Seep (Garland, 1996).

The other candidate species that is known to occur at the Marcheta Hill Orchid Seep is the Diana butterfly (*Speyeria diana*). Habitat affinity for this butterfly includes wet, rich forested valleys and mountainsides, and relatively undisturbed forests, especially near streams (Garland, 1996).

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 BGR ranges, the risk hypotheses, and the corresponding measurement endpoints.

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 BGR ranges were selected based on the ecosystems, communities, and species present at the BGR ranges. Selection of the assessment endpoints was dependent upon the following factors:

- The COPECs, their characteristics, and their concentrations at the BGR 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
- 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.

Following a site walk of the BGR ranges on May 10, 2002 by EPA, USFWS, FTMC and IT personnel, it was agreed that the terrestrial habitat types and receptor assemblages at the four BGR ranges were similar in structure and function and that they should be considered as a single ecological unit to the extent practicable. As such, assessment endpoints were selected to be inclusive of the systems and receptors at greatest risk across the four ranges. The habitat and receptor assemblages of Cane Creek and its tributaries at the BGR ranges were also determined to be similar in structure and function; therefore, the creek system was also addressed as a single ecological unit.

Based on the fact that the COPECs in surface soil at the BGR 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 BGR ranges were determined to be invertivorous and omnivorous small mammals and birds. Herbivores were considered to have a lower exposure potential to COPECs because the COPECs do not accumulate appreciably in plant tissues, the herbivores' main food source. Carnivores were determined to have lower exposure potential to COPECs 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 BGR ranges. Likewise, piscivores were determined to have lower exposure potential to COPECs because the COPECs do not bioconcentrate or biomagnify in fish tissue to any appreciable extent. Therefore, the terrestrial assessment endpoints for the BGR ranges focus on the protection of the terrestrial omnivorous and invertivorous feeding guilds present at the BGR ranges.

The aquatic assessment endpoints for the BGR ranges focus on the protection of aquatic and benthic communities present in Cane Creek and its tributaries. Additionally, the protection of riparian insectivorous mammals and birds is an assessment endpoint for the BGR ranges. Because the COPECs identified in surface water (copper and lead) and sediment (barium, copper, lead, manganese, and thallium) do not bioconcentrate or biomagnify in fish tissue to any appreciable extent and fish are not readily found in Cane Creek, piscivorous species that may frequent Cane Creek for feeding purposes were not considered to have significant exposure potential.

7.1.1 Terrestrial Assessment Endpoints

Given the overall goal of protecting the integrity and quality of the terrestrial old field ecosystem at the BGR ranges, the terrestrial assessment endpoints focus on critical community niches within the old field system. As discussed above, the ecological receptors with the potential for the greatest exposure to COPECs at the BGR ranges were determined to be invertivorous and omnivorous small mammals and birds. Additionally, the terrestrial invertebrate community has the potential for significant exposure to COPECs. These ecological communities formed the basis for the assessment endpoints described herein.

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 BGR ranges. The assessment endpoint that has been identified with respect to the terrestrial invertebrate community is the following:

- Maintenance of a healthy terrestrial invertebrate community at the BGR ranges.

Invertivorous mammals and birds were identified as having significant potential for exposure to COPECs at the BGR 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 BGR ranges. The assessment endpoint that has been identified with respect to the terrestrial invertivorous mammal and bird feeding guild is the following:

- Maintenance of healthy populations and communities of terrestrial invertivorous small mammals and birds at the BGR ranges.

Omnivorous mammals and birds were identified as having significant potential for exposure to COPECs at the BGR ranges, mainly because a portion of their diet includes 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 BGR ranges. The assessment endpoint that has been identified with respect to the terrestrial omnivorous mammal and bird feeding guild is the following:

- Maintenance of healthy populations and communities of terrestrial omnivorous small mammals and birds at the BGR ranges.

The assessment endpoints that have been identified for the BGR 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 the soils found at the Iron Mountain Road (IMR) ranges and the BGR ranges was conducted. It was assumed that soils with similar physical and chemical binding capacities would exhibit similar bioavailabilities for a given COPEC, regardless of where the soil and COPEC were located (i.e., regardless of what range the soil or COPEC were found). IT collected 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). The surface soil samples were collected from four soil mapping units (USDA, 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. Figure 7-1 shows the location of the surface soil samples and the soil mapping units.

The surface soil samples were laboratory analyzed for the following physical and chemical characteristics:

- Texture
- pH
- Phosphate
- Total Organic Carbon (TOC)
- Total Carbonate
- Cation Exchange Capacity (CEC)

Table 7-1

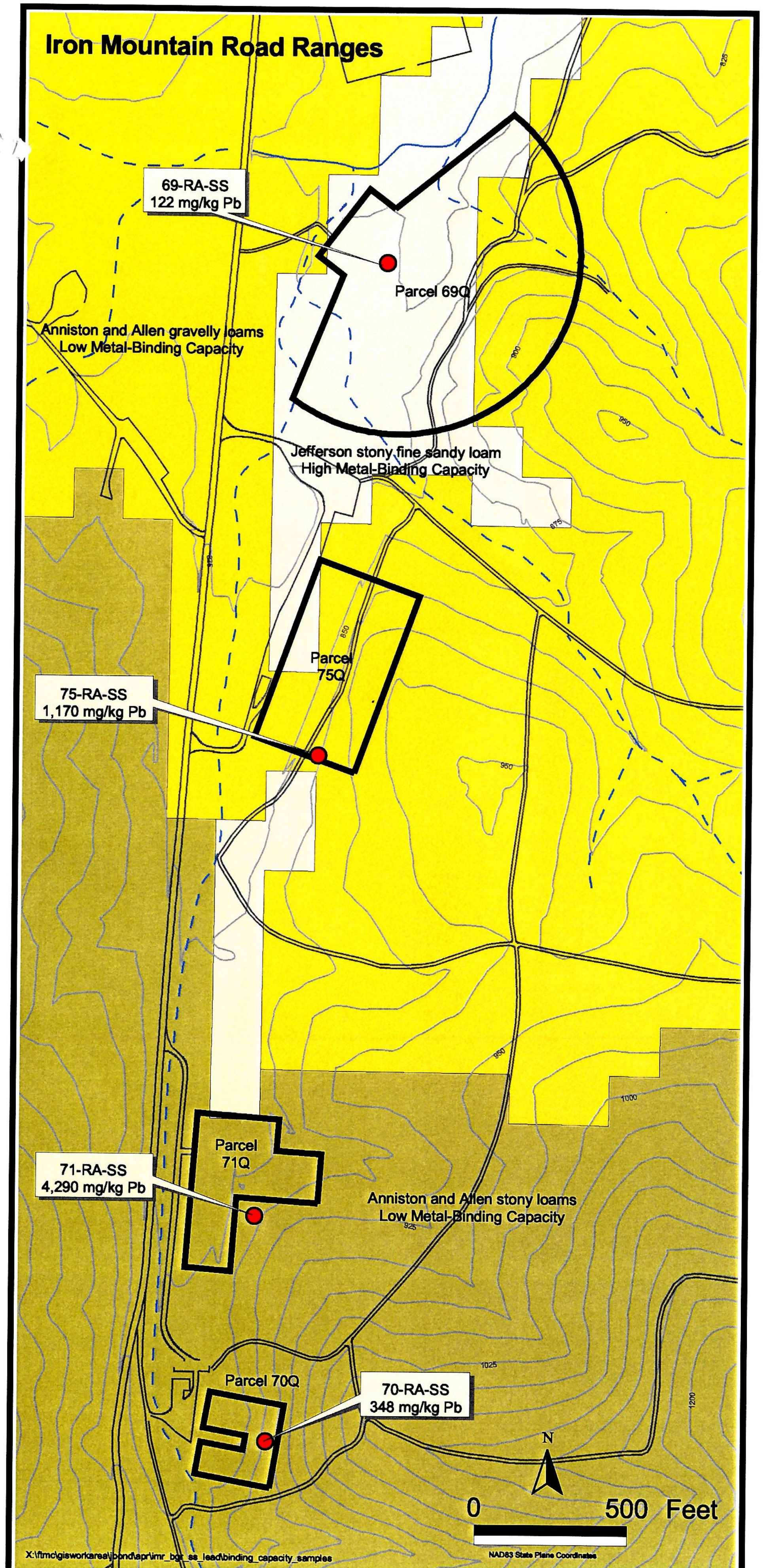
Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints for the BGR Ranges Fort McClellan, Calhoun County, Alabama

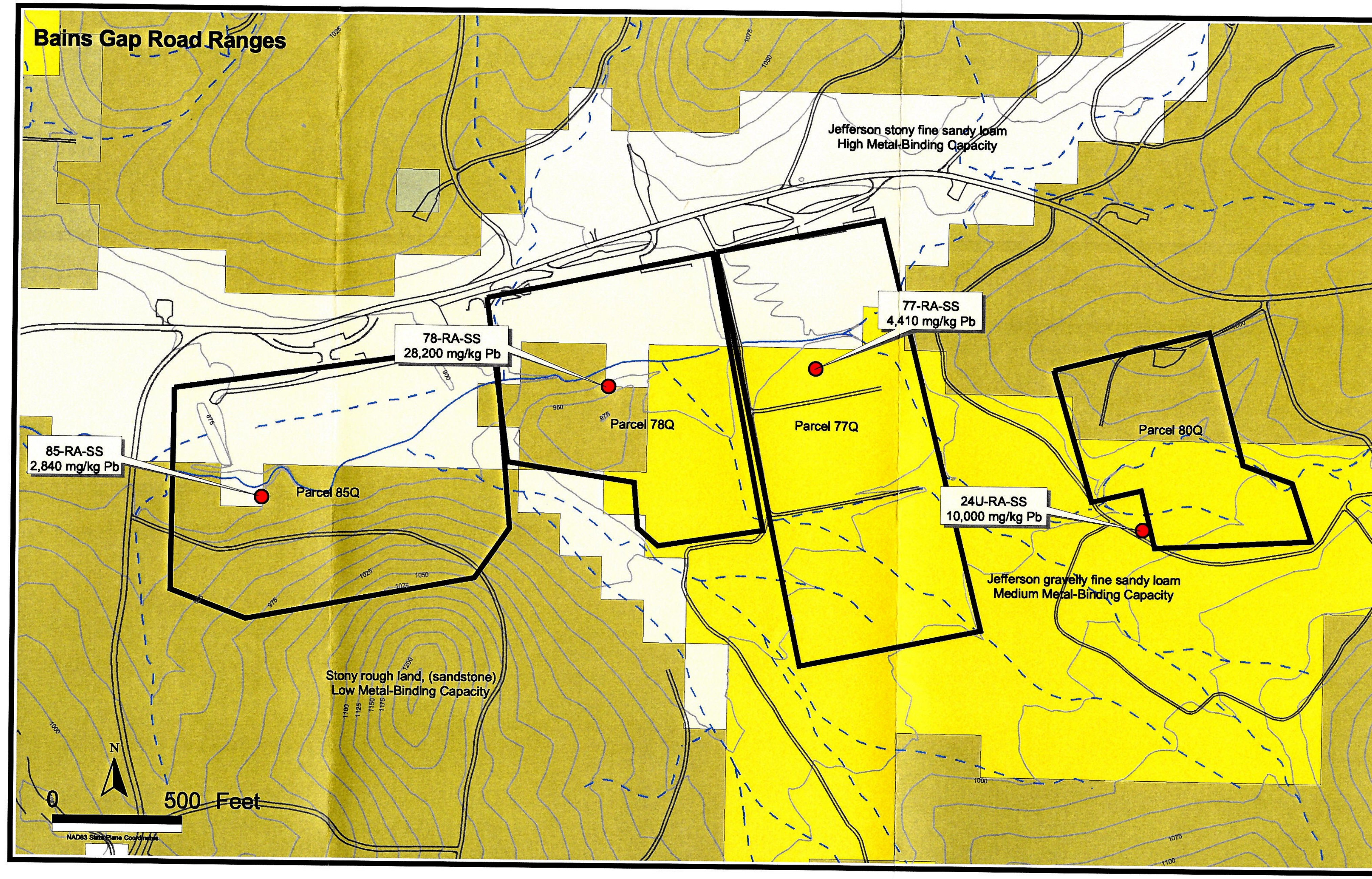
Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Terrestrial Ecosystems :		
I. Maintenance of a healthy terrestrial invertebrate community.	I. Survival and growth of terrestrial invertebrates exposed to surface soil collected from BGR ranges is statistically significantly different from that of invertebrates exposed to reference soil from non-impacted areas.	I. Statistical comparison of earthworm survival and growth rates between earthworms exposed to soils from the BGR ranges to earthworms exposed to reference site soils.
II. Maintenance of healthy local populations and communities of terrestrial invertivorous small mammals and birds.	II. Calculated hazard quotients using measured body burdens of COPECs in earthworms, site-specific diet composition, and area use factors indicate statistically significant potential for risk to either terrestrial invertivorous small mammals or birds.	II. Calculation of hazard quotients for terrestrial invertivorous small mammal (shorttail shrew) and invertivorous bird (American woodcock) using measured earthworm tissue concentrations of COPECs.
III. Maintenance of healthy local populations and communities of terrestrial omnivorous small mammals and birds.	III. Calculated hazard quotients using measured body burdens of COPECs in earthworms, site-specific diet composition, and area use factors indicate statistically significant potential for risk to terrestrial omnivorous small mammals or birds.	III. Calculation of hazard quotients for terrestrial omnivorous small mammal (white-footed mouse) and omnivorous bird (American robin) using measured earthworm tissue concentrations of COPECs and modeled vegetation concentrations of COPECs.

Table 7-1

Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints for the BGR Ranges Fort McClellan, Calhoun County, Alabama

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Aquatic Ecosystems :		
I. Maintenance of a healthy aquatic benthic invertebrate community.	I. Survival and growth of aquatic benthic invertebrates exposed to sediment collected from Cane Creek is statistically significantly different from that of benthic invertebrates exposed to sediment from non-impacted reference stream.	IA. Statistical comparison of survival and growth of *Chironomus sp.* exposed to sediment from Cane Creek to survival and growth of *Chironomus sp.* exposed sediment from reference stream.
		IB. Comparison of benthic community assemblage from Cane Creek with the benthic community assemblage from a reference stream using RBPII methodology and literature-based community assemblages.
II. Maintenance of a healthy aquatic water-column invertebrate community.	II. Survival and reproduction of aquatic water-column invertebrates exposed to surface water collected from Cane Creek is statistically significantly different from that of aquatic water-column invertebrates exposed to surface water from non-impacted reference stream.	II. Statistical comparison of survival and growth of *Ceriodaphnia dubia* exposed to surface water from Cane Creek to survival and growth of *Ceriodaphnia dubia* exposed surface water from reference stream.
III. Maintenance of a healthy aquatic vertebrate (e.g., finfish) community.	III. Survival and growth of aquatic vertebrates exposed to surface water collected from Cane Creek is statistically significantly different from that of aquatic vertebrates exposed to surface water from non-impacted reference stream.	III. Statistical comparison of survival and growth of *Pimephales promelas* exposed to surface water from Cane Creek to survival and growth of *Pimephales promelas* exposed to surface water from reference stream.
IV. Maintenance of healthy local populations and communities of riparian invertivorous mammals and birds.	IV. Calculated hazard quotients using modeled COPEC concentrations in aquatic insects, site-specific diet composition, and area use factors indicate statistically significant potential for risk to either riparian invertivorous mammals or birds.	IV. Calculation of hazard quotients for riparian invertivorous mammal (little brown bat) and invertivorous bird (marsh wren) using modeled tissue concentrations of COPECs in emergent benthic invertebrates.





Legend

- Study Area
- Roads
- Streams (dashed where intermittent)
- Topographic Contours (25-foot interval)
- Location of sample collected for soil binding capacity determination

Soil Mapping Units

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

Figure 7-1

Surface Soil Sample Locations and Lead Results Used to Determine Soil Metal-Binding Capacity

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

Shaw Environmental, Inc.

U.S. Army Corps of Engineers Mobile District

Contract No. DACA21-96-D-0018

- Iron Oxyhydroxide Content
- Total metals concentrations (aluminum, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, silicon, sodium, and titanium).

These physical and chemical analyses were conducted on "whole" surface soil samples. Sieving was not conducted prior to analysis. Table 7-2 presents the results of the analyses conducted on the eight surface soils from the IMR and BGR ranges. To determine the relative metal-binding capacity of the soils present at the sample locations, the analytical results for pH, CEC, TOC, texture (used in conjunction with the physical description recorded by the sampler at the time of sample collection), and total lead concentrations were used. Lead was used in this analysis because it is a significant COPEC at all of these ranges and has been used to identify areas of contamination at all of these ranges.

Based on the analysis of the results, the relative metal-binding capacities of the soils present at the sample locations were divided into three categories: low, medium, and high. The low, medium, and high metal-binding capacities were then assigned to the soil mapping units present at the ranges. The table below lists the relative metal-binding capacity assigned to each soil mapping unit.

Metal-Binding Capacity	Soil Mapping Unit
Low	Stony rough land (sandstone)
	Anniston and Allen stony loams
	Anniston and Allen gravelly loams
Medium	Jefferson gravelly fine sandy loam
High	Jefferson stony fine sandy loam

These three "soil types", based on metal-binding capacity, are used in the Study Design to identify sample locations and COPEC concentration gradients. Based on the data collected as part of the BERA, the soil classifications may be refined to reflect the inherent variability expected in the sample analyses.

7.1.2 Aquatic Assessment Endpoints

The overall goal of the aquatic assessment endpoints is the protection of the integrity and quality of the aquatic ecosystem in Cane Creek and its tributaries at the BGR ranges. The aquatic assessment endpoints focus on critical community niches within the aquatic system of Cane

Table 7-2

Physical/Chemical Properties of Soil Related to Binding Capacity
Ft McClellan, Calhoun County, Alabama

Parameter	Sample Number							
	69Q	70Q	71Q	75Q	77Q	78Q	80Q	85Q
	JSFSL	AASL	AASL	AAGL	JGFSL	SRLS	JGFSL	JSFSL
pH (s.u.)	6.3	4.7	4.1	4.1	5.1	5.9	5.7	5.3
Phosphate (mg/kg)	76	48	52	33	110	1000	180	38
Total Organic Carbon (mg/kg)	22000	22000	58000	15000	19000	52000	20000	18000
Total Carbonate (mg/kg)	53000	40000	82000	62000	16000	68000	47000	57000
Cation Exchange Capacity (meq Na/100g)	26.0	20.5	42.7	25.8	13.8	27.7	26.6	27.7
Iron Oxyhydroxide Content (mg/kg)	1600	1300	1110	1310	893	751	579	1480
Total Aluminium (mg/kg)	5590	6490	4770	4300	3890	1820	2030	3880
Total Barium (mg/kg)	78.1	33.5	85.2	48.3	81.6	181	122	214
Total Cadmium (mg/kg)	<0.684	<0.676	1.48	1.23	2.42	2.52	2.66	1.42
Total Calcium (mg/kg)	1330	153	1010	616	562	3170	9000	1930
Total Chromium (mg/kg)	11.2	6.84	7.30	6.32	6.42	2.80	7.17	5.07
Total Copper (mg/kg)	12.6	64.5	454	234	657	3780	927	94.8
Total Iron (mg/kg)	12900	5100	5200	5260	9780	3000	8720	5900
Total Lead (mg/kg)	122	348	4290	1170	4410	28200	10000	2840
Total Magnesium (mg/kg)	290	195	232	165	337	273	479	317
Total Manganese (mg/kg)	452	97.2	303	50.9	637	1290	397	817
Total Nickel (mg/kg)	8.37	1.66	1.76	<1.44	3.51	1.90	4.60	2.01
Total Potassium (mg/kg)	262	89.6	151	127	463	182	241	451
Total Silicon (mg/kg)	125.3	59.26	140.9	133.9	126.1	45.06	8.015	116.5
Total Sodium (mg/kg)	8.55	6.86	8.41	5.18	7.34	6.93	7.08	6.39
Total Titanium (mg/kg)	10.66	12.76	18.48	12.68	6.637	7.942	5.321	3.67

Table 7-2

Physical/Chemical Properties of Soil Related to Binding Capacity
Ft McClellan, Calhoun County, Alabama

Tyler Sieve	Diameter (mm)	Sample Number/Percent Finer							
		69Q	70Q	71Q	75Q	77Q	78Q	80Q	85Q
3"	75.0	100	100	100	100	100	100	100	100
1.5"	37.5	100	100	100	100	100	100	100	100
0.75"	19.0	100	93.2	100	96.2	100	97.3	93.6	96.5
0.375"	9.50	91.2	80.7	81.9	88.8	81.0	74.9	78.1	81.7
#4	4.75	88.6	68.5	60.9	79.6	72.1	48.8	62.3	73.7
#10	2.00	86.0	61.8	55.5	75.1	65.1	33.3	51.9	70.8
#20	0.850	83.2	59.2	52.8	71.9	59.9	25.5	45.7	67.1
#40	0.425	74.1	56.4	46.6	63.8	49.3	17.4	37.3	58.6
#60	0.250	64.2	53.3	39.7	54.4	40.2	12.5	29.7	48.5
#100	0.149	54.2	42.4	31.5	42.7	31.4	9.4	22.9	37.7
#140	0.106	46.4	31.2	25.0	34.1	25.4	8.0	19.4	30.9
#200	0.075	40.1	26.1	20.2	28.0	19.5	7.0	16.6	25.1
--	0.0478	37.6	25.0	--	26.6	17.9	--	--	--
--	0.0340	33.6	22.3	16.2	24.6	13.6	5.8	15.2	18.5
--	0.0226	29.7	19.1	13.7	22.6	11.9	4.8	12.1	16.6
--	0.0131	22.7	14.9	11.2	18.0	7.1	4.2	11.1	12.8
--	0.00931	18.0	12.8	9.1	13.3	6.5	3.9	8.6	8.9
--	0.00665	14.1	9.6	7.1	10.7	4.9	3.0	8.1	7.0
--	0.00473	11.0	6.4	5.6	9.3	3.8	2.1	6.6	5.1
--	0.00329	9.4	5.3	5.1	7.3	2.7	1.8	5.6	4.5
--	0.00138	5.5	3.7	3.0	5.3	2.2	1.8	4.0	3.2
% Gravel		11.4	32.5	39.1	20.4	27.9	51.2	37.7	26.3
% Sand		48.5	41.4	40.7	51.5	52.6	41.8	45.7	48.6
% Silt/Clay		40.1	26.1	20.2	28.0	19.5	7.0	16.6	25.1
USCS Code		SC	SM	SM	SM	SM	GP-GM	SM	SM

Soil Mapping Units: AAGL – Anniston and Allen gravelly loams
AASL – Anniston and Allen stony loams
SRLS – Stony rough lane, sandstone
JGFSL – Jefferson gravelly fine sandy loam
JSFSL – Jefferson stony fine sandy loam

Creek and its tributaries. The ecological receptors with the potential for the greatest exposure to COPECs in Cane Creek at the BGR ranges are those populations and communities that live in direct contact with the surface water and sediment within Cane Creek, and those feeding guilds that utilize Cane Creek as a major food source. These ecological communities formed the basis for the aquatic assessment endpoints described herein.

The benthic invertebrate community forms a critical link in many aquatic foodwebs 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 BGR ranges. The assessment endpoint that has been identified with respect to the aquatic benthic invertebrate community is the following:

- Maintenance of healthy aquatic benthic invertebrate populations and communities in Cane Creek at the BGR ranges.

The aquatic water-column invertebrate community forms a critical link in many aquatic foodwebs. Aquatic water-column invertebrates may 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 water-column invertebrate community was identified as an important ecological resource at the BGR ranges. The assessment endpoint that has been identified with respect to the aquatic water-column invertebrate community is the following:

- Maintenance of healthy aquatic water-column invertebrate populations and communities in Cane Creek at the BGR ranges.

Aquatic vertebrates (e.g., finfish) are top predators/consumers in many aquatic ecosystems similar to that found at Cane Creek at the BGR ranges. As such, finfish have the potential to be exposed to COPECs that may have accumulated in benthic and/or water-column invertebrates, as well as aquatic plants and other food items in Cane Creek. Finfish could also act as a food source for piscivorous animals that utilize Cane Creek for a hunting/fishing ground. For these reasons, the aquatic finfish community was identified as an important ecological resource at the BGR ranges. The assessment endpoint that has been identified with respect to the aquatic vertebrate (e.g., finfish) community is the following:

- Maintenance of healthy aquatic vertebrate (e.g., finfish) populations and communities in Cane Creek at the BGR ranges.

Riparian invertivorous mammals and birds were identified as having significant potential for exposure to COPECs at the BGR 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 BGR ranges. The assessment endpoint that has been identified with respect to the riparian invertivorous mammal and bird feeding guild is the following:

- Maintenance of healthy populations and communities of riparian invertivorous small mammals and birds at the BGR ranges.

The assessment endpoints that have been identified for the BGR 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 are based on the assessment endpoints and provide a basis for developing the study design. 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 were developed for the assessment endpoints identified in the previous section.

7.2.1 Terrestrial Risk Hypothesis

Two risk hypotheses were identified as being appropriate to address the assessment endpoint of "maintenance of a healthy terrestrial invertebrate community." These risk hypotheses were determined to be the following:

- Survival of terrestrial invertebrates exposed to surface soil collected from the BGR ranges is significantly different from that of terrestrial invertebrates exposed to soil from a non-impacted reference area.

This risk hypothesis will identify differences in terrestrial invertebrate survivability when exposed to on-site soils and off-site reference soils in laboratory toxicity tests.

The second risk hypothesis identified to address the assessment endpoint of "maintenance of a healthy terrestrial invertebrate community" was the following:

- Growth of terrestrial invertebrates (as measured by weight gain) exposed to surface soil collected from the BGR ranges is significantly different from that of terrestrial invertebrates exposed to soil from a non-impacted reference area.

This risk hypothesis will identify sub-lethal differences in earthworm growth potential when exposed to on-site soils and off-site reference soils in laboratory toxicity tests.

It is anticipated that if significant differences in earthworm survivability or growth exist between the on-site soils and reference soils, the on-site soils would exhibit lower survival and growth rates. However, it is possible that the reference soils could exhibit lower survival or growth rates than the on-site soils. Results of this nature would be interpreted as no impact on earthworm survivability or growth from soil COPECs.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy local populations and communities of terrestrial invertivorous small mammals and birds" was determined to be the following:

- Calculated hazard quotients using measured body burdens of COPECs in earthworms, site-specific diet composition, and area use factors indicate statistically significant risk potential to terrestrial invertivorous small mammals or birds.

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

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy local populations and communities of terrestrial omnivorous small mammals and birds" was determined to be the following:

- Calculated hazard quotients using measured body burdens of COPECs in earthworms, site-specific diet composition, and area use factors indicate statistically significant risk potential to terrestrial omnivorous small mammals or birds.

This risk 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). Additionally, measured COPEC concentrations in earthworms will be used as input to the exposure algorithm as the concentration in the invertebrate portion of the food of the terrestrial invertivorous and omnivorous small mammals and birds. Literature-derived bioaccumulation factors will be used to estimate COPEC concentrations in the terrestrial vegetation portions of the receptor species' diets. If the food web models indicate that the vegetative portion of the receptors' diets represent a significant contribution of the total COPEC dose, then site-specific vegetation concentrations of COPECs derived from on-site sampling will be proposed.

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 7-3) will be used in combination with site-specific exposure parameters to estimate exposures to terrestrial invertivorous and omnivorous small mammals and birds at the BGR 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)

Table 7-3

Terrestrial Foodweb Model Input Parameters
Bains Gap Road Ranges
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) (wet weight)	Soil Ingestion Rate [f] (kg/kg/day) (dry weight)	Dietary Fraction (unitless)	Dietary Component
White-Footed Mouse	*Peromyscus leucopus*	Omnivorous Mammal	1.0 (b)	1.0	0.0225 (b)	0.2180 (a)	0.2588 (a)	0.0012 (c)	0.254 0.746	Terrestrial Invertebrates Terrestrial Vegetation (seeds & young grass / fruit)
American Robin	*Turdus migratorius*	Omnivorous Bird	0.61 (a)	1.0	0.081 (a)	0.140 (a)	1.181 (a)	0.0246 (d)	0.375 0.625	Terrestrial Invertebrates Terrestrial Vegetation (fruit)
Short-Tailed Shrew	*Blarina brevicauda*	Invertivorous Mammal	0.964 (a)	1.0	0.0168 (a)	0.223 (a)	0.547 (a)	0.00845 (e)	0.887 0.113	Terrestrial Invertebrates Terrestrial Vegetation (roots / young grass)
American Woodcock	*Scolopax minor*	Invertivorous Bird	74.7 (a)	0.24	0.1700 (a)	0.10 (a)	0.754 (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 Talmage and Walton, 1993. *Food Chain Transfer and Potential Renal Toxicity of Mercury to Small Mammals at a Contaminated Terrestrial Field Site*. Ecotoxicology 2: 243-256.

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

e Sample, B.E., M.S. Alpin, R.A. Efroymson, G.W. Suter, and C.J.E. Welsh, 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants.

f Soil ingestion rates (dry weight) were calculated using the following relationshi| $IR_{soil} = IR_{food} \times Diet_{soil} \times (1 - Diet_{moist})$

where:

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

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

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

$Diet_{moist}$ = weighted average moisture content of diet (percent).

f_{worm}	=	fraction of daily diet comprised of invertebrates (unitless fraction)
C_{worm}	=	concentration of COPEC in invertebrate tissue (mg/kg)
f_{veg}	=	fraction of daily diet comprised of vegetation (unitless fraction)
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 BGR ranges (unitless fraction)
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 (unitless fraction)
C_{soil}	=	concentration of COPEC in soil (mg/kg)
AUF	=	area use factor (fraction of site used by receptor species (unitless fraction).

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 the empirically-derived plant BCF reported in Baes, et al., (1984) and recommended by EPA (1999). These plant BCFs will be applied to the soil concentrations of COPECs to estimate concentrations of COPECs in terrestrial vegetative food material in the following manner:

$$C_{veg} = C_{soil} \times BCF_{veg} \times \left(1 - M_{veg}\right)$$

where:

C_{veg}	=	COPEC concentration in terrestrial vegetation (mg/kg, wet weight);
C_{soil}	=	COPEC concentration in soil (mg/kg, dry weight);
BCF_{veg}	=	soil-to-plant bioconcentration factor (unitless); and
M_{veg}	=	average moisture of vegetative material in diet (percent).

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:

$$IR_{soil} = IR_{food} \times Diet_{soil} \times \left(1 - M_{diet}\right)$$

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)
M_{diet} =		weighted-average moisture content of receptor species' diet (percent).

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

	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 was also assumed that if a receptor species' diet contained multiple vegetative components, then the percentage of each vegetative component would be equal. For instance, the vegetative component of the shorttail shrew's diet was 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 BGR ranges.

The use of measured COPEC concentrations in earthworms from a broad range of soil concentrations will allow for the calculation of daily doses at a number of different COPEC concentrations. Different COPEC concentrations in the various exposure media will provide valuable information necessary to estimate media concentrations that are protective of the ecological communities at the BGR ranges.

Based upon the binding capacities of the soils at the BGR ranges, it will be necessary to assess these terrestrial risk hypotheses for each of the three "soil types" that were determined based on metal-binding capacity. Therefore, the earthworm toxicity/bioaccumulation tests and the food web models will be assessed for the three binding capacity-related soils ("high", "medium", and "low") at the BGR ranges.

7.2.2 Aquatic Risk Hypothesis

Two risk hypotheses were identified as being appropriate to address the assessment endpoint of "maintenance of healthy aquatic benthic invertebrate populations and communities in Cane Creek at the BGR ranges." The first risk hypothesis relative to benthic invertebrates in Cane Creek was the following:

- Survival and growth of aquatic benthic invertebrates exposed to sediment collected from the BGR ranges is statistically significantly different from that of aquatic benthic invertebrates exposed to sediment from a non-impacted reference stream.

This risk hypothesis will identify differences in aquatic benthic invertebrate survivability and growth when exposed to on-site sediments from Cane Creek and off-site reference sediments in laboratory toxicity tests.

The second risk hypothesis relative to benthic invertebrates in Cane Creek was the following:

- Benthic community structure (using Rapid Bioassessment Protocol [RBP] II) is statistically significantly different in reaches of Cane Creek at the BGR ranges compared to benthic communities in a non-impacted reference stream or literature-based community assemblages.

This risk hypothesis will identify differences in aquatic benthic invertebrate community structure in Cane Creek when compared to the benthic invertebrate community structure in a non-impacted stream using *in situ* RBP II assessment techniques and to literature-based benthic community assemblages.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy aquatic water-column invertebrate populations and communities in Cane Creek at the BGR ranges" was determined to be the following:

- Survival and reproduction of aquatic water-column invertebrates exposed to surface water collected from Cane Creek at the BGR ranges is statistically significantly different from that of aquatic water-column invertebrates exposed to surface water from a non-impacted reference stream.

This risk hypothesis will identify differences in aquatic water-column invertebrate survivability and reproduction when exposed to on-site surface water from Cane Creek and off-site reference surface water in laboratory toxicity tests.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy aquatic vertebrate (e.g., finfish) populations and communities in Cane Creek at the BGR ranges" was determined to be the following:

- Survival and growth of aquatic vertebrates (e.g., finfish) exposed to surface water collected from Cane Creek at the BGR ranges is statistically significantly different from that of aquatic vertebrates exposed to surface water from a non-impacted reference stream.

This risk hypothesis will identify differences in aquatic vertebrate survivability and growth when exposed to on-site surface water from Cane Creek and off-site reference surface water in laboratory toxicity tests.

It is anticipated that if significant differences in ceriodaphnid, chironomid, or fish survivability or growth exist between on-site surface water or sediment and reference surface water or sediment, the on-site surface water or sediment would exhibit lower survival or growth rates. However, it is possible that the reference surface water or reference sediment could exhibit lower survival or reproduction rates than the on-site surface water or sediment. Results of this nature would be interpreted as the COPECs in surface water or sediment having no impact on ceriodaphnid, chironomid, or fish survivability, growth, or reproduction.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy local populations and communities of riparian invertivorous mammals and birds" was determined to be the following:

- Calculated hazard quotients using modeled COPEC concentrations in aquatic insects, site-specific diet composition, and area use factors indicate statistically significant risk potential to riparian invertivorous mammals or birds.

This risk 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/or 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 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 $p = 0.05$.

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 utilize site-specific area use factors (AUF). Laboratory-derived bioaccumulation factors will be used to estimate COPEC concentrations in the aquatic insect 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 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 7-4) will be used in combination with site-specific exposure parameters to estimate exposures to riparian invertivorous mammals and birds at the BGR ranges.

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

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

where:

Table 7-4

Riparian Foodweb Model Input Parameters
Bains Gap Road Ranges
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) (wet weight)	Soil Ingestion Rate [e] (kg/kg/day) (dry weight)	Dietary Fraction (unitless)	Dietary Component
Little Brown Bat	*Myotis lucifugus*	Invertivorous Mammal	12 Km (c)	0.1	0.008 (b)	0.1680 (e)	0.5300 (d)	NA	1.0	Aquatic Emergent Invertebrates
Marsh Wren	*Cistothorus palustris*	Invertivorous Bird	0.13 (a)	1.0	0.0106 (a)	0.270 (a)	0.870 (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 LaVal, et al., 1977. Foraging Behavior and Nocturnal Activity Patterns of Missouri Bats, with Emphasis on the Endangered Species *Myotis grisescens* and *Myotis sodalis*.

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.

$TDD_{wildlife}$	=	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_{insect}	=	fraction of daily diet comprised of benthic invertebrates (unitless fraction)
C_{sed}	=	concentration of COPEC in sediment (mg/kg)
IR_{water}	=	ingestion rate of water by invertivorous mammals or birds (L/kg/day)
f_{water}	=	fraction of drinking water from the BGR ranges (unitless fraction)
C_{water}	=	concentration of COPEC in drinking water (mg/L)
M_{insect}	=	average moisture content of benthic invertebrates (unitless fraction)
AUF	=	area use factor (fraction of site used by receptor species) (unitless fraction).

It will be assumed that the receptor species' 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 benthic invertebrate tissue will be estimated using laboratory-derived sediment-to-invertebrate BCF values as described in Appendix B. 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 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 BGR ranges.

The calculation of COPEC concentrations in benthic invertebrates from a broad range of sediment concentrations will allow for the calculation of daily doses at a number of different COPEC concentrations. Different COPEC concentrations in the surface water and sediment will provide valuable information necessary to estimate media concentrations that are protective of the aquatic ecological communities at the BGR ranges.

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

Two measurement endpoints have been identified to address the assessment endpoint of "maintenance of a healthy terrestrial invertebrate community." They are the following:

- Statistical comparison of earthworm survival rates between earthworms exposed to soils exhibiting a gradient of COPEC concentrations from the BGR and IMR ranges to earthworms exposed to soils from a non-impacted reference location.

- Statistical comparison of earthworm growth rates (weight gain) between earthworms exposed to soils from the BGR and IMR ranges to earthworms exposed to reference site soils.

Additionally, in order to estimate the bioavailability of the COPECs in soil at the BGR ranges, and to provide data for the other assessment endpoints, COPEC concentrations in tissues of earthworms exposed to soil from the IMR and BGR ranges will be compared to COPEC concentrations in earthworms exposed to soil from a nonimpacted reference location. These data will be used to derive a soil-to-invertebrate bioaccumulation factor.

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of a healthy local population of small terrestrial terrestrial invertivorous mammals and birds" is the following:

- Calculation of hazard quotients for invertivorous mammal (shorttail shrew) and invertivorous bird (American woodcock) using measured earthworm tissue concentrations of COPECs and modeled terrestrial vegetation concentrations of COPECs.

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of a healthy local population of small omnivorous mammals and birds" is the following:

- Calculation of hazard quotients for omnivorous mammal (white-footed mouse) and omnivorous bird (American robin) using measured earthworm tissue concentrations of COPECs and modeled terrestrial vegetation concentrations of COPECs.

These measurement endpoints will provide the necessary data to answer the risk hypotheses for the terrestrial ecosystems at the BGR 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 may not necessarily indicate a natural population or community is at risk. However, for this risk assessment, the measurement endpoints and data quality objectives are assumed to relate to natural communities and populations at the BGR ranges, recognizing that the test species are surrogates for natural communities at the BGR ranges, and will be used to assess risk at the BGR ranges.

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 Aquatic Measurement Endpoints

The measurement endpoints that have been identified to address the assessment endpoint of "maintenance of healthy aquatic benthic invertebrate populations and communities in Cane Creek at the BGR ranges" are the following:

- Comparison of survival and growth of the benthic amphipod *Chironomus riparius* exposed to "on-site" sediment to survival and growth of *Chironomus riparius* exposed to sediment from a reference stream.

- Comparison of the benthic community assemblage from Cane Creek adjacent to the Bains Gap Road ranges with the benthic community assemblages from a reference stream using RBPII methodology and comparison to literature-based benthic community assemblages.

Additionally, in order to estimate the bioavailability of the COPECs in sediment in Cane Creek and to provide data for the other assessment endpoints, COPEC concentrations in tissues of chironomids exposed to sediment from Cane Creek will be compared to COPEC concentrations in chironomids exposed to sediment for a nonimpacted reference stream. These data will be used to derive a sediment-to-invertebrate bioaccumulation factor.

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of healthy aquatic water-column invertebrate populations and communities in Cane Creek at the BGR ranges" is the following:

- Comparison of survival and reproduction of the water flea *Ceriodaphnia dubia* exposed over 7 days to "on-site" surface water (Cane Creek and tributaries) to survival and reproduction of *Ceriodaphnia dubia* exposed over 7-days to surface water from a reference stream.

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of healthy aquatic vertebrate (e.g., finfish) populations and communities in Cane Creek at the BGR ranges" is the following:

- Comparison of survival and growth of the fathead minnow *Pimephales promelas* exposed over 7-days to "on-site" surface water to survival and growth of *Pimephales promelas* exposed over 7-days to surface water from a reference stream.

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of healthy populations and communities of riparian invertivorous small mammals and birds at the BGR ranges" is the following:

- Calculation of hazard quotients for riparian invertivorous mammal (little brown bat) and invertivorous bird (marsh wren) using modeled tissue concentrations of COPECs in emergent benthic invertebrates.

These measurement endpoints will provide the necessary data to answer the risk hypotheses for the aquatic ecosystems at the BGR 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 may not necessarily indicate a natural population or community is at risk. However, for this risk assessment, the measurement endpoints and data quality objectives are assumed to relate to natural communities and populations at the BGR ranges, recognizing that the test species are surrogates for natural communities at the BGR ranges, and will be used to assess risk at the BGR ranges.

Another important factor to recognize while interpreting the results of the toxicity tests is the fact that the test 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 incorporate 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.