Draft Final

Engineering Evaluation/Cost Analysis
Landfills and Fill Areas

Parcels 78(6), 79(6), 80(6), 81(5), 175(5), 230(7), 227(7), 126(7), 229(7), 231(7), 233(7), and 82(7)

Fort McClellan, Calhoun County, Alabama

Prepared for:

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Task Order CK09
Contract No. DACA21-96-D-0018
IT Project No. 796886

March 2002

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Executive Summary

This Engineering Evaluation/Cost Analysis (EE/CA) provides data to support the Army's actions at ten landfills/fill areas located at Fort McClellan (FTMC) in Calhoun County, Anniston, Alabama. The EE/CA was performed in accordance with current U.S. Environmental Protection Agency (EPA) guidance documents for a non-time-critical removal action under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). This EE/CA summarizes site characterization information and provides human health and ecological risk assessment in accordance with CERCLA criteria. At landfills where CERCLA risks are identified (Landfill Nos. 2 and 3) the EE/CA also identifies remedial action objectives, describes potential remedial action alternatives, contains analysis of these alternatives, and recommends a remedial action alternative. The Army has identified the following 10 landfill/fill areas, consisting of 12 parcels, at FTMC as sites of former disposal actions from a variety of mission-related activities.

Recommendations. Based on data presented in the EE/CA and human health and ecological risk assessment results, the Army recommends the following actions:

- ***Landfill No. 1, Parcel 78(6):*** Landfill No. 1 presents no unacceptable human health or ecological risks under CERCLA. Therefore, No Further Action under CERCLA is required.

- ***Landfill No. 2, Parcel 79(6):*** Lead, polynuclear aromatic hydrocarbons (PAH), and arsenic in surface soils pose unacceptable risks for a potential resident. Proposed reuse for Landfill No. 2 is passive recreation and the parcel presents no unacceptable human health risks for the recreational site-user. Surface water and sediments present no unacceptable risks for ecological receptors; metals and other compounds in surface soils pose potential risks for ecological receptors. However, the screening-level ecological risk assessment (SLERA) presents several uncertainty factors that may mitigate these risks. The Army proposes a land-use control (LUC) to restrict future residential reuse of the property.

- ***Landfill No. 3, Parcel 80(6):*** Exposures to surface soil (thallium) and groundwater (trichloroethene and 1,1,2-2 tetrachloroethane) present unacceptable risks to a resident. Proposed reuse for Landfill No. 3 is passive recreation, and the parcel presents no unacceptable human health risks for the recreational site-user. Additionally, Landfill No. 3 does not present any unacceptable risk to the ecological receptor. However, elevated levels of volatile organic compounds associated with landfilling activities have been detected in groundwater at the site. Therefore, the Army recommends a low permeability soil cover with LUCs and limited long-term groundwater monitoring. The Army is addressing groundwater concerns at this site through an ongoing remedial investigation. The proposed action is compatible with source reduction strategies that will facilitate groundwater treatment options the Army may propose in the future.

- ***Landfill No. 4, Parcel 81(5) and the Industrial Landfill, Parcel 175(5):*** Landfill No. 4 and the Industrial Landfill present no unacceptable human health or ecological risks under CERCLA. The Army proposes No Further Action under CERCLA.

- ***Fill Area North of Landfill No. 2, Parcel 230(7):*** The Fill Area North of Landfill No. 2 presents no unacceptable human health risks under CERCLA. Soils, surface water, and sediments pose potential risks to ecological receptors (metals, pesticides, and semivolatile organic compounds [SVOC]). However, the SLERA presents several uncertainty factors that could mitigate these risks. Therefore, No Further Action under CERCLA is required.

- ***Fill Area East of Reilly Airfield, Parcel 227(7) and the Former Post Garbage Dump, Parcel 126(7):*** The Fill Area East of Reilly Airfield and Former Post Garbage Dump do not pose any unacceptable risks to human health under CERCLA. Metals and pesticides in soils, and metals and SVOCs in surface water pose potential risks to ecological receptors. However, the SLERA presents several uncertainty factors that could mitigate these risks. Therefore, No Further Action under CERCLA is required.

- ***Fill Area Northwest of Reilly Airfield, Parcel 229(7):*** The Fill Area Northwest of Reilly Airfield does not present any unacceptable human health risks under CERCLA. Mercury in surface water presents a potential risk to ecological receptors. However, the SLERA presents several uncertainty factors that could mitigate these risks. Therefore, No Further Action under CERCLA is required.

- ***Fill Area at Range 30, Parcel 21(7):*** The Fill Area at Range 30 presents no unacceptable human health or ecological, risks under CERCLA. The Army proposes No Further Action at this site.

- ***Fill Area West of Iron Mountain Road and Range 19, Parcel 233(7):*** As shown on Table 14-2, the Fill Area West of Iron Mountain Road and Range 19 presents no unacceptable human health or ecological risks under CERCLA. The Army proposes No Further Action at this site.

- ***Stump Dump, Parcel 82(7):*** The Stump Dump presents no unacceptable human health or ecological risks under CERCLA. Therefore, No Further Action under CERCLA is required.

These actions comply with CERCLA, are compatible with reuse plans, and are protective of human health and the environment. The Army also proposes to implement a LUC at Landfill No. 2, Parcel 79(6), and several non-CERCLA actions at certain fill areas to facilitate reuse and minimize safety concerns at these sites. Attachment 2 to this EE/CA contains these proposals.

1.0 Introduction

1.1 Project Description

The U.S. Army is conducting this EE/CA to summarize environmental conditions at multiple landfills and fill area sites at FTMC in Calhoun County, Alabama. This EE/CA was performed in accordance with U.S. Environmental Protection Agency (EPA) guidance for a non-time-critical removal action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This EE/CA report summarizes site characterization, provides human health and ecological risk assessments in accordance with CERCLA criteria. For those sites where risks associated with site activities were determined, remedial action objectives were determined and potential remedial action alternatives were evaluated and analyzed. Recommendations are provided for each fill area. The U.S. Army Corps of Engineers (USACE), Mobile District is overseeing the Base Realignment and Closure (BRAC) program at FTMC. The EE/CA for the fill areas was performed under Task Order CK09, Contract Number DACA21-96-D-0018 (USACE, 1999a). Ten landfills and fill areas, consisting of 12 parcels, all of which are located on the Main Post of FTMC, are addressed in this EE/CA:

- Landfill No. 1, Parcel 78(6)
- Landfill No. 2, Parcel 79(6)
- Landfill No. 3, Parcel 80(6)
- Landfill No. 4, Parcel 81(5), and the Industrial Landfill, Parcel 175(5)
- Fill Area North of Landfill No. 2, Parcel 230(7)
- Fill Area East of Reilly Airfield, Parcel 227(7), and the Former Post Garbage Dump, Parcel 126(7)
- Fill Area Northwest of Reilly Airfield, Parcel 229(7)
- Fill Area at Range 30, Parcel 231(7)
- Fill Area West of Iron Mountain Road and Range 19, Parcel 233(7), and
- Stump Dump, Parcel 82(7).

1.2 Site History

FTMC is located in the foothills of the Appalachian Mountains of northeastern Alabama, near the cities of Anniston and Weaver in Calhoun County (Figure 1-1). FTMC is approximately 60 miles northeast of Birmingham, 75 miles northwest of Auburn, and 95 miles west of Atlanta, Georgia. FTMC consists of two main areas of government-owned properties: Main Post and Pelham Range. A third area, designated Choccolocco Corridor, was previously leased from the State of Alabama; however, the lease was terminated in May 1998. The size of each property is presented below:

- Main Post 18,929 acres
- Pelham Range 22,245 acres
- Choccolocco Corridor (formerly leased) 4,488 acres.

The Main Post is bounded on the east by the Choccolocco Corridor, which connects the Main Post with the Talladega National Forest. Pelham Range is located approximately 5 miles west of the Main Post and adjoins the Anniston Army Depot on the southwest. Pelham Range is bordered on the east by U.S. Highway 431.

FTMC is under the jurisdiction of the U.S. Army Training and Doctrine Command (TRADOC). The installation housed three major organizations including the U.S. Army Military Police School, the U.S. Army Chemical School, and the Training Center (under the direction of the training brigade), in addition to other major support units and tenants.

The U.S. government purchased 18,929 acres of land near Anniston in 1917 for use as an artillery range and a training camp due to the outbreak of World War I. The site was named Camp McClellan in honor of Major General George B. McClellan, a leader of the Union Army during the Civil War. Camp McClellan was used to train troops for World War I from 1917 until the armistice. It was then designated as a demobilization center. Between 1919 and 1929, Camp McClellan served as a training area for active army units and other civilian elements. Camp McClellan was redesignated as FTMC in 1929 and continued to serve as a training area.

In 1940, the government acquired an additional 22,245 acres west of FTMC. This tract of land was named Pelham Range. In 1941, the Alabama Legislature leased approximately 4,488 acres to the U.S. government to provide an access corridor from the Main Post to Talladega National Forest. This corridor provides access to additional woodlands for training.

The U.S. Army operated the Chemical Defense Training Facility (CDTF) at FTMC from 1951 until the school was deactivated in 1973. The school was then reactivated in 1979 and was closed at the time of base closure in 1999 (ESE, 1998). The Chemical Corps School offered advanced training in all phases of chemical, biological, and radiological warfare to personnel from all branches of the military.

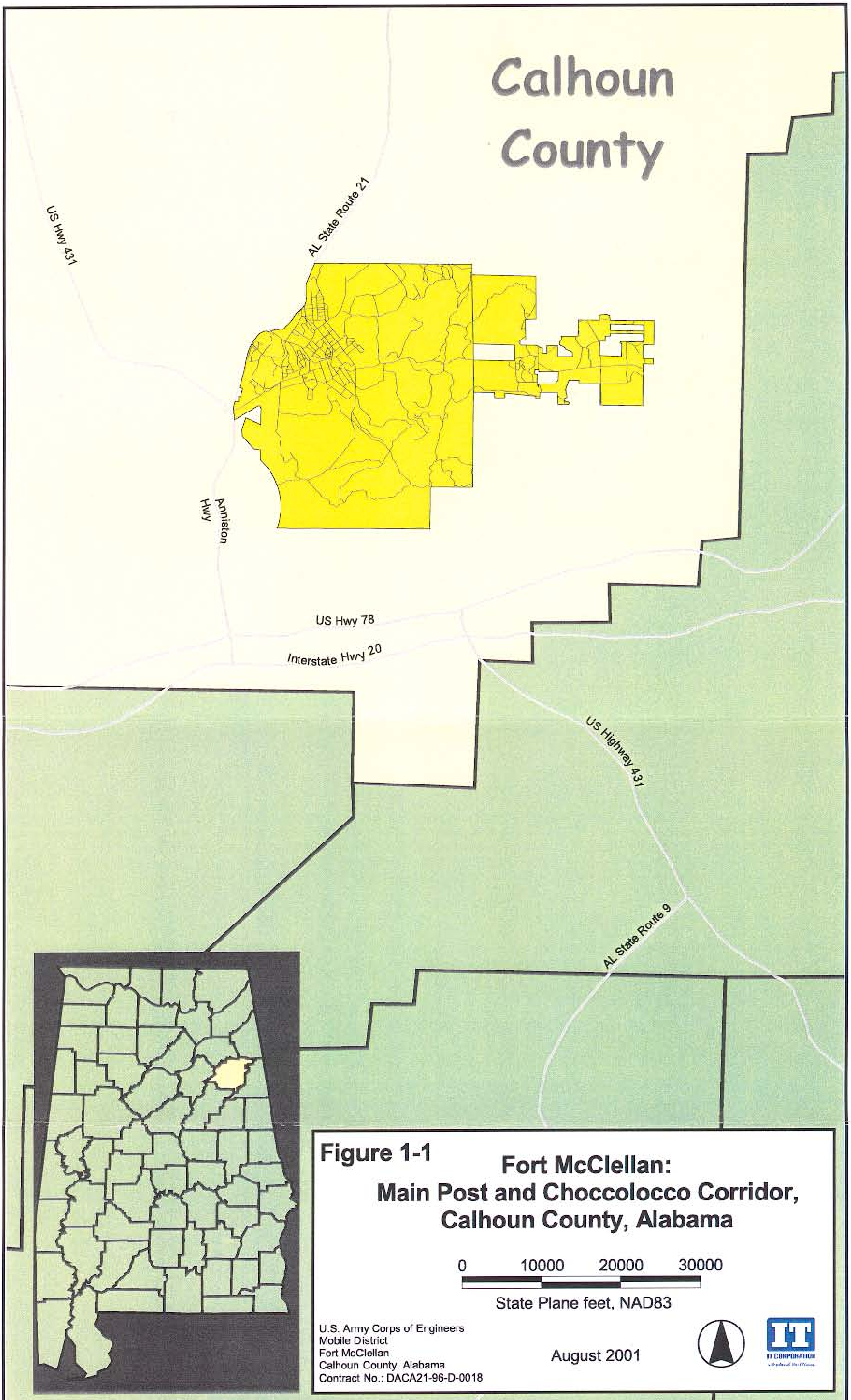

Figure 1-1 **Fort McClellan: Main Post and Choccolocco Corridor, Calhoun County, Alabama**

U.S. Army Corps of Engineers
Mobile District
Fort McClellan
Calhoun County, Alabama
Contract No.: DACA21-96-D-0018

August 2001

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In 1995, the U.S. Department of Defense announced that FTMC would close by October 1999. The BRAC Commission recommended closure of the installation, except for minimum essential land and facilities for a Reserve Component Enclave and essential facilities needed to provide support for the chemical demilitarization operation at Anniston Army Depot. Subsequently, the U.S. Department of Justice (DOJ) requested a transfer of some facilities and training area to their authority for ongoing training exercises. FTMC transferred the CDTF and ancillary support facilities to the DOJ in 2000 to establish the Center for Domestic Preparedness (CFDP).

The law providing for the BRAC also established guidelines for state and local communities to provide input into reuse of the excised base property. Pursuant to State enabling legislation, the FTMC Reuse and Redevelopment Authority (FTRRA) became the FTMC Development Commission (FMDC) on October 1, 1997. The base reuse plan is shown on Figure 1-2. The Local Reuse Authority, previously known as the FMDC and FTRRA, is currently known as the Joint Powers Authority (JPA).

1.3 Remedial Action Requirements

The regulations that define a remedial action are within Section 101(23) of CERCLA and the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) 40 CFR 300.415 (EPA, 1990a). This EE/CA follows the "Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA" (EPA, 1993a).

Based on the results of the EE/CA, only one landfill (Landfill No. 3) presents unacceptable health risks. Because the CERCLA and NCP do not mandate actions at sites that do not pose threats to human health and the environment, No Further Action is required for those sites at which contamination was not detected at levels associated with unacceptable risks to human health or the environment. CERCLA and the NCP define remedial actions to include "the cleanup or removal of released hazardous substances from the environment, such actions as may necessarily be taken in the event of the threat of release of hazardous substances into the environment, such action as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances, the disposal of removed material, or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release." The EPA has classified remedial actions into three types, based on the circumstances surrounding the release or threat of release: emergency, time-critical, and non-time-critical. The remedial actions selected for the fill areas fall within the non-time critical type because on-site action will be taken more than six months after commencement of the planning period.

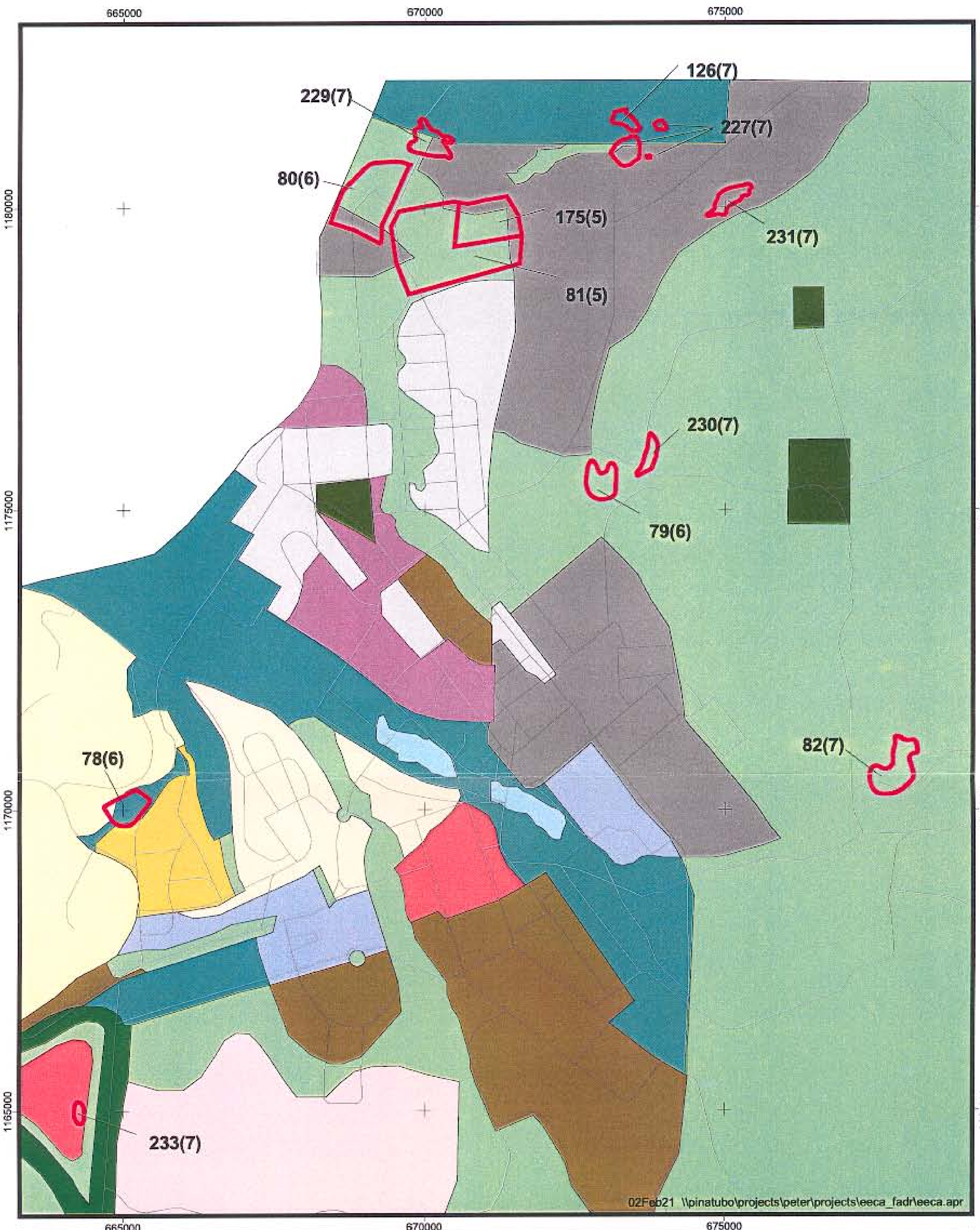
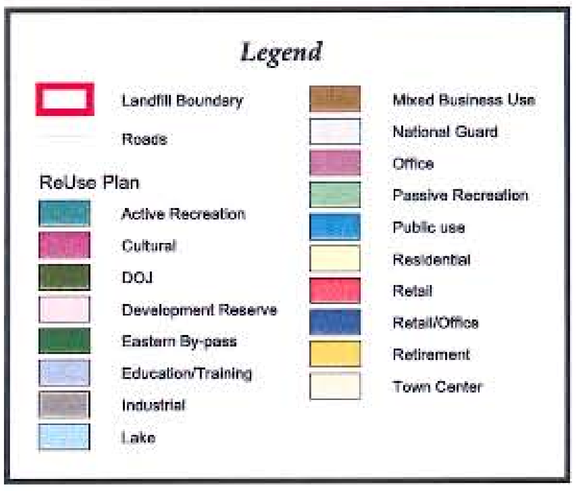


Figure 1-2 Base Reuse Map



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Calhoun County, Alabama
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Consistent with CERCLA Section 120 and the NCP, the U.S. Army is following the CERCLA remedial action process for these actions.

All sites have been evaluated under the CERCLA guidance during the site investigations and nine of the sites do not meet the CERCLA criteria for response [NCP 300.400(a)], which mandates action:

- When there is a release of hazardous substance into the environment, or

- When there is a release into the environment of any pollutant or contaminant that may present an imminent and substantial danger to the public health or welfare.

1.4 EE/CA Requirements

The U.S. Army is the lead agency for the remedial actions. As the lead agency, the Army has final approval authority over the recommended alternatives selected for each site and for public participation. The Army is working in cooperation with the EPA and ADEM to implement these remedial actions.

This EE/CA is being issued in accordance with the base public involvement plan prepared for FTMC to facilitate public involvement in the decision-making process. The public is encouraged to comment on the proposed remedial activities described in the EE/CA. A review of the administrative record is available at the base office of the Environmental Directorate or at these local libraries:

PUBLIC INFORMATION REPOSITORIES
FOR FTMC

Anniston Calhoun County Public Library
Reference Section
Anniston, Alabama 36201
Point of Contact: Ms. Sunny Addison
Telephone: (256) 237-8501
Fax: (256) 238-0474
Hours of Operation: Monday – Friday 9:00 a.m. – 6:30 p.m.
Saturday 9:00 a.m. – 4:00 p.m.
Sunday 1:00 p.m. – 5:00 p.m.

Houston Cole Library
9th Floor
Jacksonville State University
700 Pelham Road
Jacksonville, Alabama 36265

Point of Contact: Ms. Rita Smith (256) 782-5249
Hours of Operation: Monday – Thursday 7:30 a.m. – 11:00 p.m.
Friday 7:30 a.m. – 4:30 p.m.
Saturday 9:00 a.m. – 5:00 p.m.
Sunday 3:00 p.m. – 11:00 p.m.

1.5 Objective

The objective of the detailed comparative analysis presented in the EE/CA report is to analyze the effectiveness, implementability, and cost of various alternatives that may satisfy the remedial action objectives and to assist in the Army's development of an Action Memorandum. The Action Memorandum identifies what remedial actions, if necessary, the Army will take at the sites and provides an administrative record for the subsequent actions.

1.6 EE/CA Report Organization

The EE/CA Report is organized as follows:

- ***Chapter 1.0, Introduction.*** Presents a brief history of the project to date and the organization of the EE/CA report.

- ***Chapter 2.0, Regional Characterization.*** Discusses the regional settings including geology, hydrogeology, wetlands, meteorology, and floodplains.

- ***Chapter 3.0, Streamlined Human Health and Ecological Risk Assessments.*** Describes human health and ecological risk protocols used to evaluate human health and ecological risk at the sites.

- ***Chapter 4.0, Landfill No. 1, Parcel 78(6).*** Discusses site-specific information including general site descriptions, human health and ecological risk assessments, and recommended actions.

- ***Chapter 5.0, Landfill No. 2, Parcel 79(6).*** Discusses site-specific information including general site descriptions, human health and ecological risk assessments, remedial action alternatives, and recommended remedial actions.

- ***Chapter 6.0, Landfill No. 3, Parcel 80(6).*** Discusses site-specific information, including general site descriptions, human health and ecological risk assessments, remedial action alternatives, and recommended remedial actions.

- ***Chapter 7.0, Landfill No. 4 and the Industrial Landfill, Parcels 81(5) and 175(5).*** Discusses site-specific information, including general site descriptions, human health and ecological risk assessments, and recommended actions.

- ***Chapter 8.0, Fill Area North of Landfill No. 2, Parcel 230(7).*** Discusses site-specific information, including general site descriptions, human health and ecological risk assessments, and recommended actions.

- ***Chapter 9.0, Fill Area East of Reilly Airfield and Former Post Garbage Dump, Parcels 227(7) and 126(7).*** Discusses site-specific information, including general site descriptions, human health and ecological risk assessments, and recommended actions.

- ***Chapter 10.0, Fill Area Northwest of Reilly Airfield, Parcel 229(7).*** Discusses site-specific information, including general site descriptions, human health and ecological risk assessments, and recommended actions.

- ***Chapter 11.0, Fill Area at Range 30, Parcel 231(7).*** Discusses site-specific information, including general site descriptions, human health and ecological risk assessments, and recommended actions.

- ***Chapter 12.0, Fill Area West of Iron Mountain Road and Range 19, Parcel 233(7).*** Discusses site-specific information, including general site descriptions, human health and ecological risk assessments, and recommended actions.

- ***Chapter 13.0, Stump Dump, Parcel 82(7).*** Discusses site-specific information, including general site descriptions, human health and ecological risk assessments, and recommended actions.

- ***Chapter 14.0, Summary and Recommendations.*** Provides a summary of the information presented in this report and a brief overview of the recommended actions.

- ***Chapter 15.0, References.*** Lists the references used in preparing the EE/CA report.

- ***Attachment 1. List of Abbreviations and Acronyms.***

- ***Attachment 2. Non-CERCLA Actions.***

2.0 Regional Characterization

This chapter provides a regional characterization for FTMC. The characterization is based on the results of previous investigations and fill area definition activities performed by IT Corporation (IT) in support of the EE/CA (IT, 2001a). A summary of all validated data is included in Appendix A.

The screening criteria for evaluation of all the recent and historical analytical data are documented in the *Final Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000a) and include: site-specific screening levels (SSSL), ecological screening values (ESV), and background values for polynuclear aromatic hydrocarbons (PAH). The SSSLs and ESVs were developed and selected by FTMC in conjunction with EPA Region IV and ADEM, as a means of evaluating human health and ecological risks during site investigations being performed under the BRAC Environmental Restoration Program at FTMC. Background metals screening values are presented in the *Final Background Metals Survey Report, FTMC, Alabama* (SAIC, 1998). Upon acceptance of these screening values by the EPA and ADEM, the values were used to determine environmental impacts as follows:

- Background values: Analyte concentrations in excess of twice the background were flagged as potential impacts and will be evaluated relative to SSSLs and ESVs.

- SSSLs: Analyte concentrations that exceed residential SSSLs were flagged as exceeding environmental and human health risk factors.

- ESVs: Analyte concentrations that exceed ESVs were evaluated in conjunction with the presence of sensitive receptors and ecosystems to determine potential environmental risks.

2.1 Fill Areas

The fill areas identified by the Army and evaluated in this EE/CA are shown on Figure 2-1. Landfill and fill area boundaries are based on the results of the site investigation and fill area definition work carried out by IT between 1998 and 2000. The revised boundaries may not correspond to the original CERFA parcel area due to changes based on the geophysical, trenching, and sampling data. For clarity in referencing these sites, the parcel number association will be maintained with each site, even though the original parcel area may have been modified.

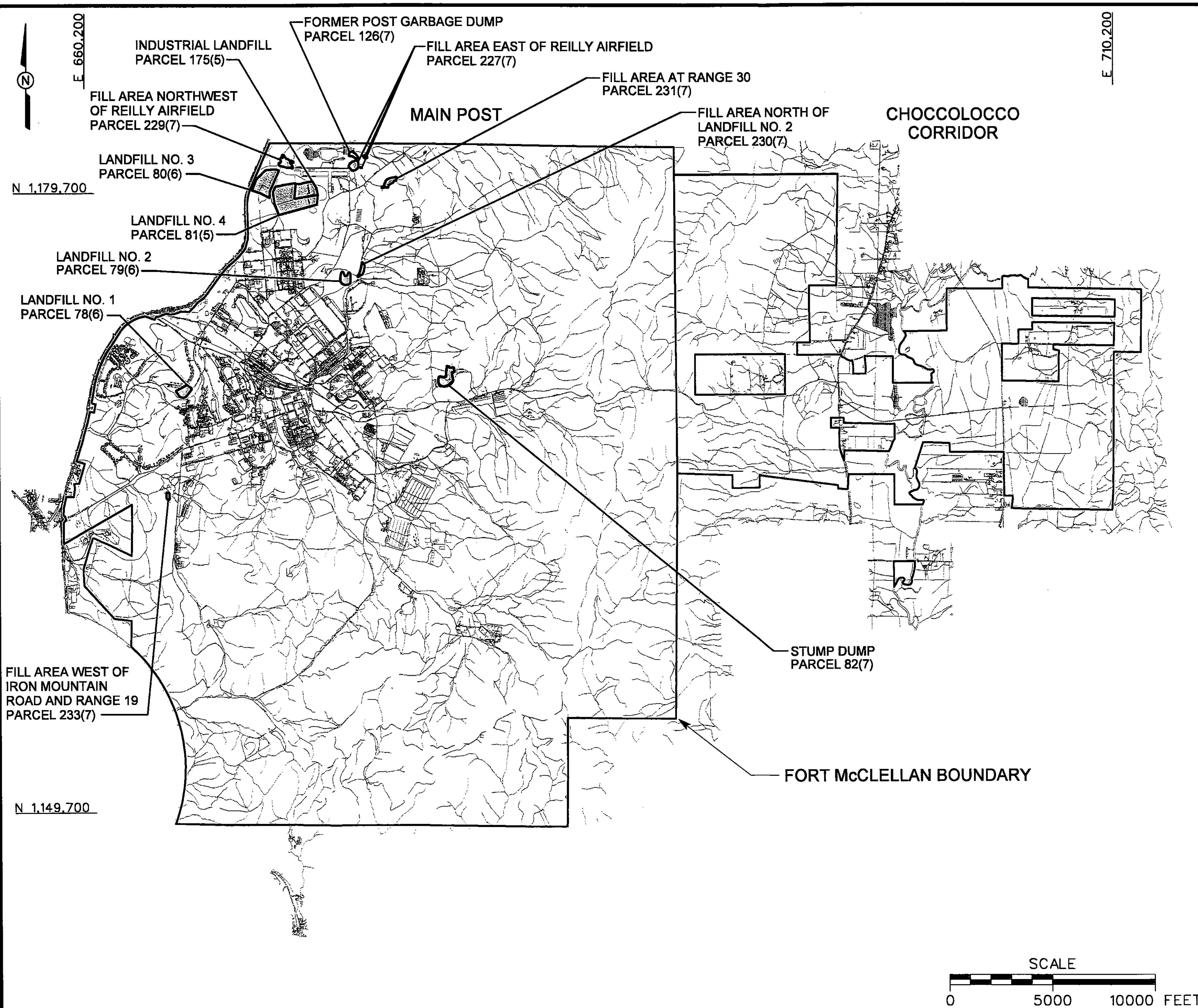

FIGURE 2-1
BASEWIDE SITE LOCATION MAP

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MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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DWG. NO.: ...\796886es.065 | PROJ. NO.: 796886
INITIATOR: J. RAGSDALE | PROJ. MGR.: J. YACOUB
DRAFT. CHCK. BY: | ENGR. CHCK. BY: J. JENKINS
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 01/15/01 | DRAWN BY: D. BOMAR
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2.1.1 Landfill Gas Generation

A typical landfill gas generation curve peaks when the landfill/fill area reaches an age of approximately 10 years. As shown in Appendix B, using a typical scenario involving one million tons of solid waste, the landfill gas generation peaks in the first 10 years. At ten years of age the refuse will produce approximately 230 million cubic feet per year of landfill gasses. By the time the landfill/fill area reaches an age of approximately 40 years, the landfill gas generation is reduced to approximately 80 million cubic feet per year or 35 percent (see Appendix B).

A majority of the landfill/fill areas located on the Main Post are 40 years or older; therefore, the probability of landfill gas production is small. Also, the volume of waste for all but Landfill No. 3, Parcel 80(6), and Landfill No. 4, Parcel 81(5), is significantly less than the example given.

2.2 Regional Geology and Hydrogeology

The regional geology and hydrogeology of FTMC are discussed in the following sections.

2.2.1 Regional Geology

Calhoun County includes parts of two physiographic provinces, the Piedmont Upland Province and the Valley and Ridge Province. The Piedmont Upland Province occupies the extreme eastern and southeastern portions of the county and is characterized by metamorphosed sedimentary rocks. The generally accepted range in age of these metamorphics is Cambrian to Devonian. Figure 2-2 presents the geologic map of the area that includes the fill areas.

The majority of Calhoun County, including the Main Post of FTMC, lies within the Appalachian fold and thrust structural belt (Valley and Ridge Province) where southeastward-dipping thrust faults with associated minor folding are the predominant structural features. The fold and thrust belt consists of Paleozoic sedimentary rocks that have been asymmetrically folded and thrust-faulted with major structures and faults striking in a northeast-southwest direction. Northwestward transport of the Paleozoic rock sequence along the thrust faults has resulted in the imbricate stacking of large slabs of rock referred to as thrust sheets. Within an individual thrust sheet, smaller faults may splay off the larger thrust fault, resulting in imbricate stacking of rock units within an individual thrust sheet (Osborne and Szabo, 1984). Geologic contacts in this region generally strike parallel to the faults and repetition of lithologic units is common in vertical sequences. Geologic formations within the Valley and Ridge Province portion of Calhoun County have been mapped by Warman and Causey (1962), Osborne and Szabo (1984), and Moser and DeJarnette (1992), and vary in age from Lower Cambrian to Pennsylvanian.

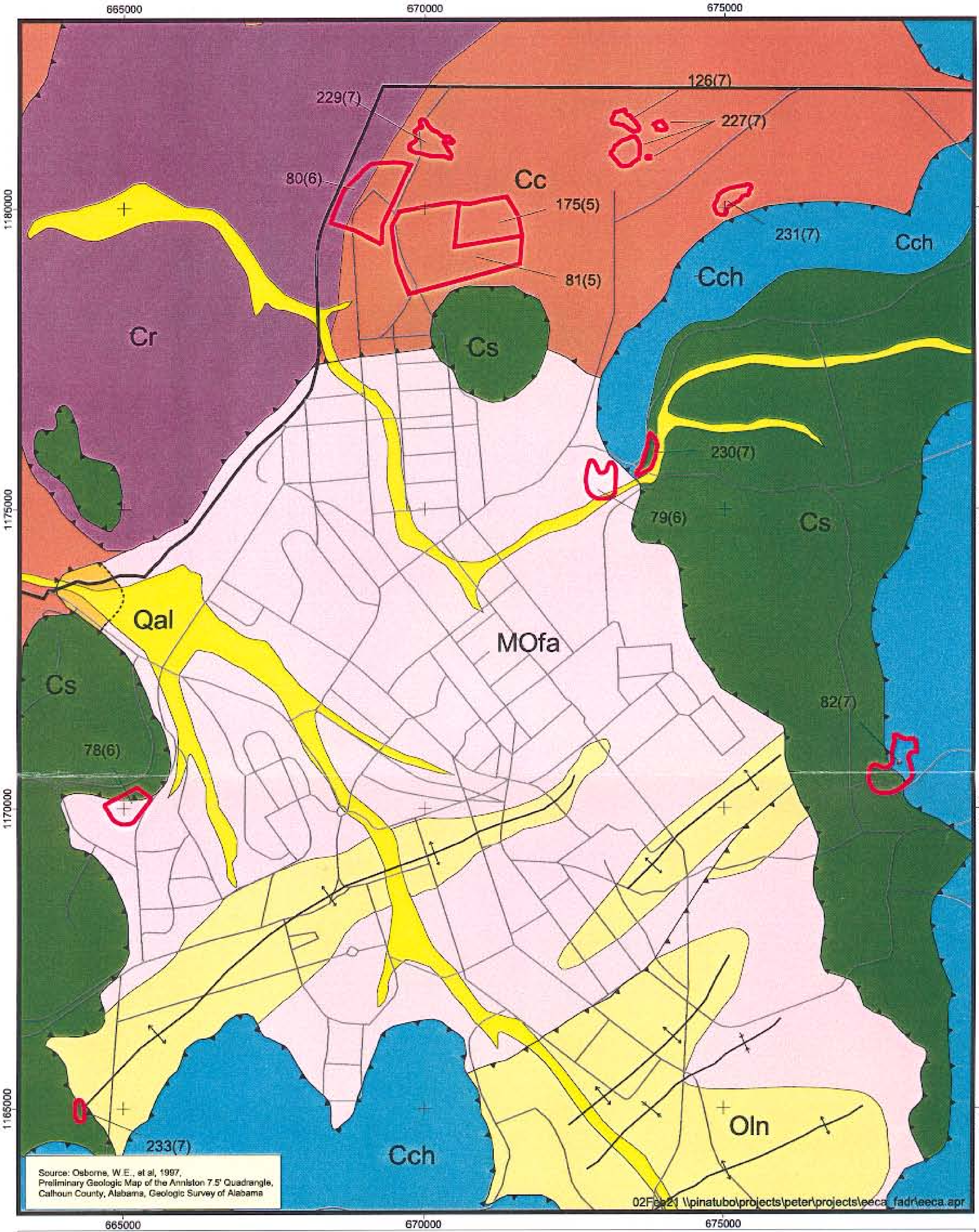

Figure 2-2 Geologic Map

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State Plane feet, NAD 83

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Legend

- Syncline
- Anticline
- Fault
- Roads
- Main Post Boundary
- Landfill Boundary

Geology

- l — Limestone - age unknown
- ls — Terrace Deposit - age unknown
- col — Colluvium - age unknown
- Qal — Quaternary - alluvium
- OCk — Ordovician - Little Oak and Newala Limestones
- MOfa — Cambrian/Ordovician - Knox Group, Undifferentiated
- Oln — Mississippian/Ordovician - Floyd & Athens Shale, Undifferentiated
- Cs — Cambrian - Shady Dolomite
- Cr — Cambrian - Rome Formation
- Cch — Cambrian - Chilhowee Group
- Cc — Cambrian - Conasauga Formation

The basal unit of the sedimentary sequence in Calhoun County is the Cambrian Chilhowee Group. The Chilhowee Group comprises of the Cochran, Nichols, Wilson Ridge, and Weisner Formations (Osborne and Szabo, 1984), but in Calhoun County it is either undifferentiated or divided into the Cochran and Nichols Formations and an upper undifferentiated Wilson Ridge and Weisner Formation. The Cochran is composed of poorly sorted arkosic sandstone and conglomerate with interbeds of greenish-gray siltstone and mudstone. Massive to laminated, greenish-gray and black mudstone makes up the Nichols Formation, with thin interbeds of siltstone and very fine-grained sandstone (Szabo et al., 1988). The Cochran and Nichols formations are mapped only in the eastern part of the county.

The Wilson Ridge and Weisner Formations are undifferentiated in Calhoun County and consist of both coarse-grained and fine-grained clastics. The coarse-grained facies appears to dominate the unit and consists primarily of coarse-grained, vitreous quartzite, and friable, fine- to coarse-grained, orthoquartzitic sandstone, both of which locally contain conglomerate. The fine-grained facies consists of sandy and micaceous shale and silty, micaceous mudstone which are locally interbedded with the coarse, clastic rocks. The abundance of orthoquartzitic sandstone and quartzite suggests that most of the Chilhowee Group bedrock in the vicinity of FTMC belongs to the Weisner Formation (Osborne and Szabo, 1984).

The Cambrian Shady Dolomite overlies the Weisner Formation northeast, east and southwest of the Main Post and consists of interlayered bluish-gray or pale yellowish-gray sandy dolomitic limestone and siliceous dolomite with coarsely crystalline porous chert (Osborne et al., 1989). A variegated shale and clayey silt have been included within the lower part of the Shady Dolomite (Cloud, 1966). Material similar to this lower shale unit was noted in core holes drilled by the Alabama Geologic Survey on FTMC (Osborne and Szabo, 1984). The character of the Shady Dolomite in the FTMC vicinity and the true assignment of the shale at this stratigraphic interval are still uncertain (Osborne, 1999).

The Rome Formation overlies the Shady Dolomite and locally occurs to the northwest and southwest of the Main Post as mapped by Warman and Causey (1962) and Osborne and Szabo (1984), and immediately to the west of Reilly Airfield (Osborne and Szabo, 1984). The Rome Formation consists of variegated, thinly interbedded grayish-red-purple mudstone, shale, siltstone, and greenish-red and light gray sandstone, with locally occurring limestone and dolomite. The Conasauga Formation overlies the Rome Formation and occurs along anticlinal axes in the northeastern portion of Pelham Range (Warman and Causey, 1962), (Osborne and Szabo, 1984) and the northern portion of the Main Post (Osborne et al., 1997). The Conasauga

Formation is composed of dark-gray, finely to coarsely crystalline medium- to thick-bedded dolomite with minor shale and chert (Osborne et al., 1989).

Overlying the Conasauga Formation is the Knox Group, which is composed of the Copper Ridge and Chepultepec dolomites of Cambro-Ordovician age. The Knox Group is undifferentiated in Calhoun County and consists of light medium gray, fine to medium crystalline, variably bedded to laminated, siliceous dolomite and dolomitic limestone that weathers to a chert residuum (Osborne and Szabo, 1984). The Knox Group underlies a large portion of the Pelham Range area.

The Ordovician Newala and Little Oak Limestones overlie the Knox Group. The Newala Limestone consists of light to dark gray, micritic, thick-bedded limestone with minor dolomite. The Little Oak Limestone consists of dark gray, medium- to thick-bedded, fossiliferous, argillaceous to silty limestone with chert nodules. These limestone units are mapped together as undifferentiated at FTMC and in other parts of Calhoun County. The Athens Shale overlies the Ordovician limestone units. The Athens Shale consists of dark-gray to black shale and graptolitic shale with localized interbedded dark gray limestone (Osborne et al., 1989). These units occur within an eroded "window" in the uppermost structural thrust sheet at FTMC and underlie much of the developed area of the Main Post.

Other Ordovician-aged bedrock units mapped in Calhoun County include the Greensport Formation, Colvin Mountain Sandstone, and Sequatchie Formation. These units consist of various siltstones, sandstones, shales, dolomites and limestones and are mapped as one, undifferentiated unit in some areas of Calhoun County. The only Silurian-age sedimentary formation mapped in Calhoun County is the Red Mountain Formation. This unit consists of interbedded red sandstone, siltstone, and shale with greenish-gray to red silty and sandy limestone.

The Devonian Frog Mountain Sandstone consists of sandstone and quartzitic sandstone with shale interbeds, dolomitic mudstone, and glauconitic limestone (Szabo, et al., 1988). This unit locally occurs in the western portion of Pelham Range.

The Mississippian Fort Payne Chert and the Maury Formation overlie the Frog Mountain Sandstone and are composed of dark- to light-gray limestone with abundant chert nodules and greenish-gray to grayish-red phosphatic shale with increasing amounts of calcareous chert toward the upper portion of the formation (Osborne and Szabo, 1984). These units occur in the northwestern portion of Pelham Range. Overlying the Fort Payne Chert is the Floyd Shale, also of Mississippian age, which consists of thin-bedded, fissile brown to black shale with thin intercalated limestone layers and interbedded sandstone. Osborne and Szabo (1984) reassigned the Floyd Shale, which was mapped by Warman and Causey (1962) on the Main Post of FTMC, to the Ordovician Athens Shale on the basis of fossil data.

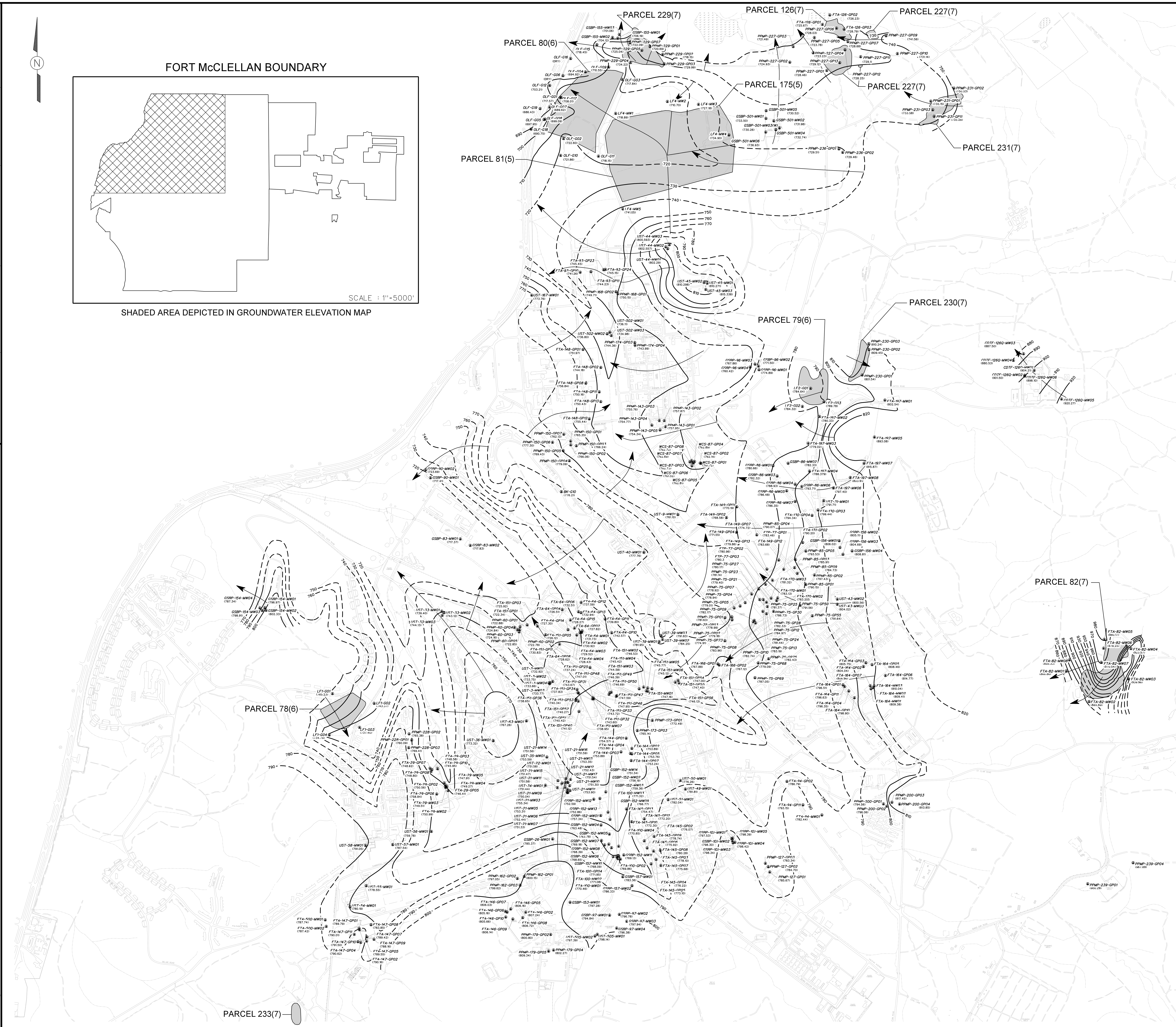
The Jacksonville Thrust Fault is the most significant structural geologic feature in the vicinity of FTMC, both for its role in determining the stratigraphic relationships in the area and for its contribution to regional water supplies. The trace of the fault extends northeastward for approximately 39 miles between Bynum, Alabama and Piedmont, Alabama. The fault is interpreted as a major splay of the Pell City Fault (Osborne and Szabo, 1984). The Ordovician sequence comprising the Eden thrust sheet is exposed at FTMC through an eroded "window" or "fenster" in the overlying thrust sheet. Rocks within the window display complex folding, with the folds being overturned and tight to isoclinal. The carbonates and shales locally exhibit well-developed cleavage (Osborne and Szabo, 1984). The FTMC window is framed on the northwest by the Rome Formation; north by the Conasauga Formation, northeast, east, and southwest by the Shady Dolomite; and southeast and southwest by the Chilhowee Group (Osborne et al., 1997).

2.2.2 Regional Hydrogeology

The hydrogeology of Calhoun County has been investigated by the Geologic Survey of Alabama (Moser and DeJarnette, 1992) and the U.S. Geological Survey (USGS) in cooperation with the General Services Administration (GSA) (Warman and Causey, 1962) and ADEM (Planert and Pritchette, 1989). Groundwater in the vicinity of FTMC occurs in residuum derived from bedrock decomposition within fractured bedrock along fault zones and from the development of karst frameworks. Groundwater flow may be estimated to be toward major surface water features. Figure 2-3 provides the regional potentiometric groundwater map indicating the general direction for groundwater flow at each of the fill areas. Areas with well-developed residuum horizons may subtly reflect the surface topography, but the groundwater flow direction also may exhibit the influence of pre-existing structural fabrics or the presence of perched water horizons on unweathered ledges or impermeable clay lenses.

Precipitation and subsequent infiltration provide recharge to the groundwater flow system in the region. The main recharge areas for the aquifers in Calhoun County are located in the valleys. The ridges generally consist of sandstone, quartzite, and slate which are resistant to weathering, relatively unaffected by faulting, and therefore, relatively impermeable. The ridges have steep slopes and thin to no soil cover, which enhances runoff to the edges of the valleys (Planert and Pritchette 1989).

STARTING DATE: 02/18/01 | DATE LAST REV.: | DRAFT. CHCK. BY: | INITIATOR: J. JENKINS | DWG. NO.: 796886ES.084
DRAWN BY: D. BILLINGSLEY | DRAWN BY: | ENGR. CHCK. BY: J. JENKINS | PROJ. MGR.: J. YACOUB | PROJ. NO.: 796886



LEGEND:

- PARCEL BOUNDARY
- GROUNDWATER ELEVATION CONTOUR (DASHED WHERE INFERRED)
- (754.47) GROUNDWATER ELEVATION (FT MSL) (MARCH 2000)
- GROUNDWATER FLOW DIRECTION
- GROUNDWATER ELEVATION LOCATIONS

SCALE
0 500 1000 FEET

FIGURE 2-3
POTENTIOMETRIC - SURFACE MAP

PARCELS 78(6), 79(6), 80(6), 81(5), 175(5), 230(7), 126(7), 227(7), 229(7), 231(7), 233(7) AND 82(7)

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The thrust fault zones typical of the county form large storage reservoirs for groundwater. Points of discharge occur as springs, effluent streams, and lakes. Coldwater Spring is one of the largest springs in the State of Alabama, with a discharge of approximately 32 million gallons per day. This spring is the main source of water for the Anniston Water Department, from which FTMC buys its water. The spring is located approximately 5 miles southwest of Anniston and discharges from the brecciated zone of the Jacksonville Fault (Warman and Causey, 1962).

Shallow groundwater on FTMC occurs principally in the residuum developed from Cambrian sedimentary and carbonate bedrock units of the Weisner Formation, Shady Dolomite and locally in lower Ordovician carbonates. The residuum may yield adequate groundwater for domestic and livestock needs but may go dry during prolonged dry weather. Groundwater within the residuum serves as a recharge reservoir for the underlying bedrock aquifers. Bedrock permeability is locally enhanced by fracture zones associated with thrust faults and by the development of solution (karst) features.

Two major aquifers were identified by Planert and Pritchette (1989): the Knox-Shady and Tuscumbia-Fort Payne aquifers. The continuity of the aquifers has been disrupted by the complex geologic structure of the region, such that each major aquifer occurs repeatedly in different areas. The Knox-Shady aquifer group occurs over most of Calhoun County and is the main source of groundwater in the county. It consists of the Cambrian-and-Ordovician aged quartzite and carbonates. The Conasauga Dolomite is the most utilized unit of the Knox-Shady aquifer, with twice as many wells drilled as any other unit (Moser and DeJarnette, 1992).

Regional groundwater flow in the bedrock was approximated for the FTMC vicinity by the USGS (Scott, et al., 1987). Regional groundwater elevation ranged from 800 feet above mean sea level (msl) on the Main Post to about 600 feet above msl to the west on Pelham Range based on water depths in wells completed across multiple formations. Groundwater elevation contours seem to suggest that regional groundwater flow is from the Main Post to the northwest. Scott et al., (1987) concluded that the groundwater surface broadly coincides with the surface topography and that the regional aquifers are hydraulically connected. Groundwater flow on a local scale may be more complex and affected by geologic structures such as the shallow thrust faults, rock fracture systems and karst development in soluble formations.

Shallow groundwater occurs in weathered residuum derived from the bedrock and thin sediment deposits that are very similar to the decomposed rock. The shallow groundwater more closely follows the local topography.

Surface water in the form of springs, small streams, and lakes or ponds is present on the base. Regionally, some springs are important sources of water supply (SAIC, 1999). All of the surface water on the base is fed at least in part by springs. Three major creeks (Cane, Cave, and South Branch of Cane Creek) and their tributaries drain the central portion of the Main Post at FTMC. Surface water drainage originates in the Choccolocco Mountains on the eastern boundary of the installation and flows west to northwest, leaving the base on the west and northwest side. The creeks are fed by springs that issue from various forms of strata.

The groundwater measurements displayed on Figure 2-3 are from March 2000. During the March 2000 water level monitoring event, the depths to groundwater at these sites ranged from 0.0 to 91.81 feet below ground surface. Groundwater elevations ranged between 689.62 and 980.17 feet above msl at the respective sites. Groundwater occurs under semi-confined conditions because the soils in which the aquifers lie beneath the Main Post are predominantly silts and clays. Perched groundwater may occur along less weathered bedrock interfaces, including rock ledges and chert boulder horizons.

As shown on Figure 2-3, groundwater flow at the base is variable on a site by site basis. The groundwater flow for the ten sites can be broken down into three general regimes. Flow from the northwestern sites, which include Landfill No. 3, Parcel 80(6); Landfill No. 4, Parcel No 81(5); Industrial Landfill, Parcel 175(5); Fill Area East of Reilly Airfield, Parcel 227(7) and Former Post Garbage Dump, Parcel 126(7); Fill Area Northwest of Reilly Airfield, Parcel 229(7); and Fill Area at Range 30, Parcel 231(7), migrates to the northwest, west, and north from each site. This groundwater feeds into the Reilly Lake drainage. The north-central sites, which include Landfill No. 2, Parcel 79(6), and the Fill Area North of Landfill No. 2, flow into the Cave Creek drainage sub-basin. The remaining three sites, Landfill No. 1, Parcel 78(6); Fill Area West of Iron Mountain Road and Range 19, Parcel 233(7); and the Stump Dump, Parcel 82(7), contribute to the Cane Creek groundwater sub-basin. Local variability in flow direction is likely and dependent on local topography, proximity to surface water bodies, and subsurface geology.

2.2.3 Wetlands

Figure 2-4 indicates the areas that are identified as wetlands and as potential habitat for the gray bat. As indicated on the map, the following landfills or fill areas are reportedly located in or adjacent to wetlands:

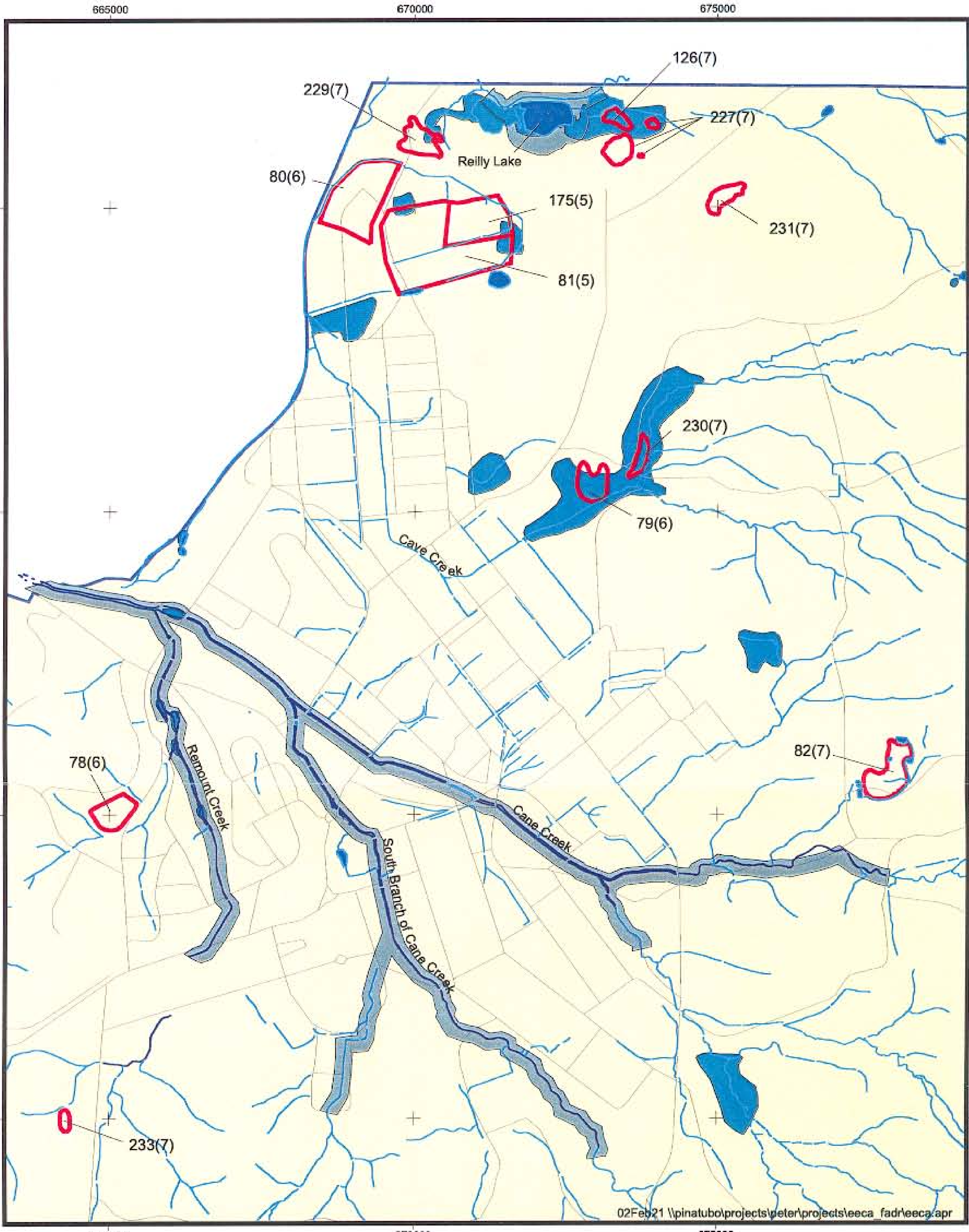

Figure 2-4

Base Wetlands/Sensitive Gray Bat Habitat Map

N

0 2000 4000

State Plane feet, NAD 83

Legend

- Creeks - Intermittent
- Creeks
- Roads
- Lakes
- Wetlands
- Moderate Gray Bat Habitat
- Main Post
- Landfill Boundary

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Mobile District
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Calhoun County, Alabama
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- Landfill No. 2, Parcel 79(6)

- Landfill No. 4 and the Industrial Landfill, Parcels 81(5) and 175(5)

- Fill Area North of Landfill No. 2, Parcel 230(7)

- Fill Area East of Reilly Airfield and Former Post Garbage Dump, Parcels 227(7) and 126(7)

- Fill Area Northwest of Reilly Airfield, Parcel 229(7).

Although Base maps indicate the presence of wetlands within several landfill/fill areas, physical inspection of these areas has shown that wetlands may not exist as currently mapped. For example, Figure 2-4 shows the entire area of the Fill Area North of Landfill No. 2, Parcel 230(7), within a wetland. Physical inspection of the Fill Area North of Landfill No. 2 revealed a steep embankment adjacent to a dirt road, along which material was historically dumped. At the base of this embankment lies Cave Creek. Wetlands occur to the east of Cave Creek but the dirt road and steep embankment west of Cave Creek preclude the existence of wetlands west of Cave Creek. It could be concluded that although the eastern edge of the fill area may encroach on wetlands associated with Cave Creek, the majority of the Fill Area North of Landfill No. 2 is not located within a wetland area.

2.3 Meteorology

FTMC has a temperate continental, humid climate. The annual rainfall is distributed throughout the year but tends to be heavier during the winter and spring months. The average annual precipitation totals about 53 inches. Most flood producing storms are frontal type, and occur during the winter and spring. Summer thunderstorms sometimes cause serious local floods. Snow accumulation is generally 1 inch or less. Temperature extremes are a few degrees below freezing to just over 100 degrees Fahreinheit (°F). Summer temperatures of 90°F or more occur about 70 days per year, and the average annual temperature is 63°F. Frosts are common but usually of short duration.

Winds are typically light breezes with no persistent direction. Tornadoes are rare but do occur in the area. Humidity is moderate during cooler months to high during the warmer part of the year.

2.4 Floodplain

The floodplain map (Figure 2-5) indicates the Federal Emergency Management Agency "Special Flood Hazard Areas." These are based on an area with a 1 percent annual chance of inundation by flooding for which Base flood elevations or velocities may have been determined. As shown on the figure, the following sites may be impacted:

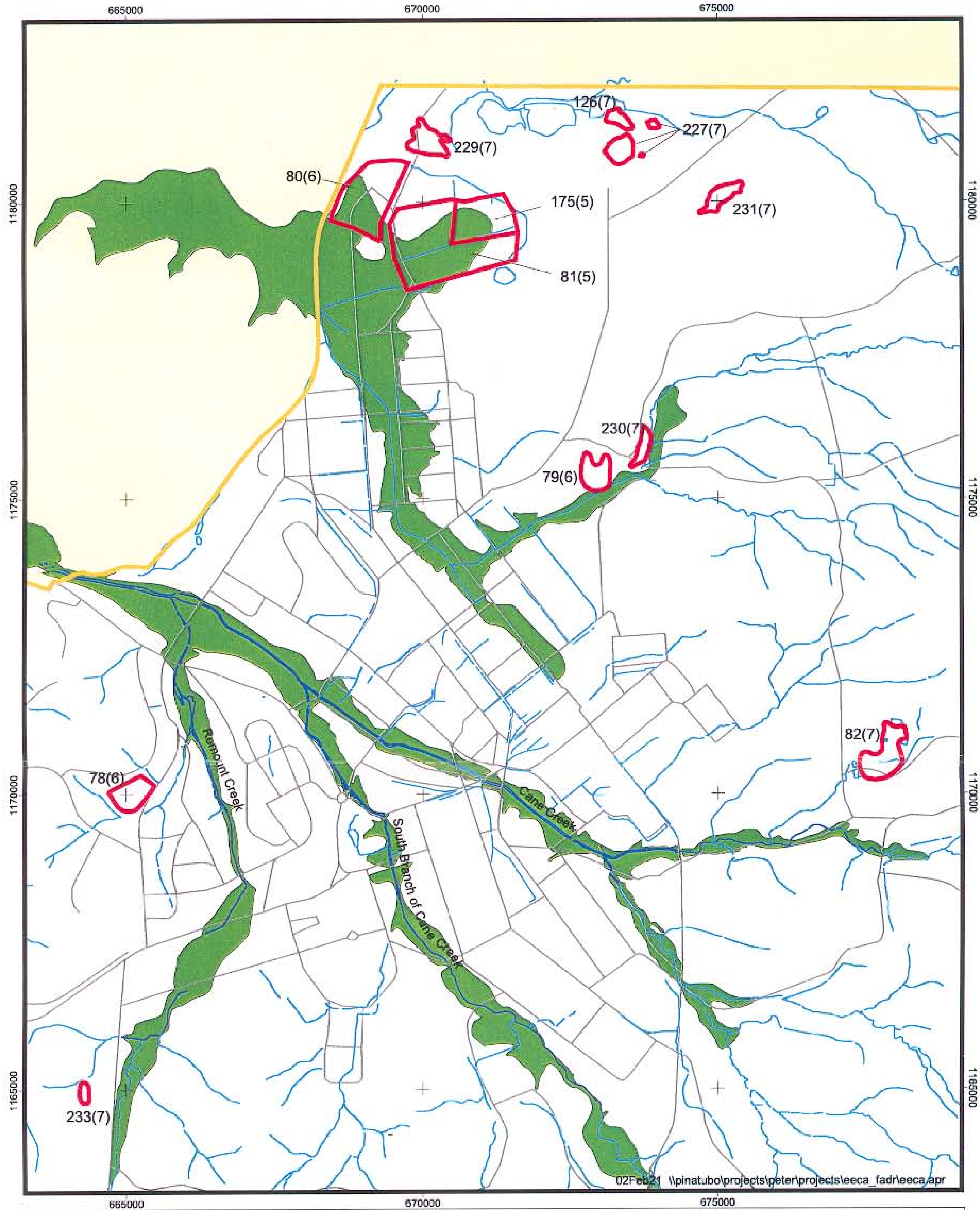

Figure 2-5 Floodplain Map

The "Special Flood Hazard Areas", as determined by FEMA, is an area inundated by 1% annual chance flooding for which Base Flood Elevations or velocity may have been determined. These areas were created at a scale of 1:24,000 and therefore are not as spatially accurate as the planimetric data. Use with caution.

Legend

- Creeks - Intermittent
- Creeks
- Roads
- EE/CA Area
- Special Flood Hazard Area
- Main Post Boundary

0 1500 3000

State Plane feet, NAD 83

N

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Calhoun County, Alabama
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- Landfill No. 2, Parcel 79(6)
- Landfill No. 3, Parcel 80(6)
- Landfill No. 4 and the Industrial Landfill, Parcels 81(5) and 175(5)
- Fill Area North of Landfill No. 2, Parcel 230(7).

Current landfill cover elevations at Landfill No. 4 and the Industrial Landfill, Parcels 81(5) and 175(5), would preclude flood waters from overtopping the existing landfill. The map does not reflect the current elevation of the landfill and soil cover. Current flood levels do not reflect this higher elevation at the site.

3.0 Streamlined Human Health and Ecological Risk Assessments

3.1 Introduction

Because of the large size, multiple parcels, and complexity of the FTMC installation, the Army, in cooperation with EPA Region IV and ADEM, developed a streamlined human health risk assessment (SRA) using SSSLs. The SSSLs are medium- and receptor-specific, risk-based screening concentrations that are used to quickly and efficiently screen FTMC sites for potential cancer risk and noncancer hazards from residual chemicals in environmental media. The SSSLs address all significant exposure pathways and are sufficiently site-specific with regard to exposure assumptions that they are used to estimate risk with as much precision as a typical baseline risk assessment. They reflect all the Superfund protocol, documentation, and assumptions specified by EPA (1989, 2001) guidance. The exposure assumptions and SSSL methodology are described in detail in the *Final Installation-Wide Work Plan* (IT, 1998a). The SSSLs were recently updated with the most current toxicity values and are compiled in the *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000a); this document also presents toxicity profiles, which are brief descriptions of the physical and toxicological properties of the chemicals that may be identified as contaminants at FTMC sites.

During the SRA, it became apparent that a new receptor scenario, a highway construction worker, would be required for evaluation of the Fill Area West of Iron Mountain Road and Range 19, Parcel 233(7). A memorandum developing the exposure assumptions and equations for the SSSLs for this scenario, as well as the other SSSLs, is presented in Appendix C, Attachment C-1. The chemical-specific variable values used in the SSSL calculations are presented in the *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000c).

This chapter also presents the results of the Screening-Level Ecological Risk Assessment (SLERA) (Section 3.3). The SLERA was conducted to determine ecological risks posed by site-related chemicals at each fill area.

3.2 Streamlined Human Health Risk Assessment Protocol

The SRA consists of the steps described in the following sections.

3.2.1 Develop a Conceptual Site Exposure Model

A conceptual site exposure model (CSEM) identifies the potentially contaminated environmental media, contaminant migration pathways, exposure media, plausible receptors, and exposure routes. A minimum of two receptor scenarios are evaluated for each site or parcel in the fill areas. One is the most highly exposed receptor consistent with the future use of the parcel as proposed in the *Fort McClellan Comprehensive Reuse Plan, Implementation Strategy* (EDAW, 1997). The second is the residential scenario, which is included to provide additional information to risk managers. The residential scenario is generally considered to be the most conservative of all exposure scenarios.

3.2.2 Select Site-Related Chemicals

Generally, chemicals are excluded from the SRA if they are essential nutrients, occur at such a low detection frequency that they are considered to be artifacts of sampling or laboratory analysis, or if they are present at concentrations comparable to background. Comparison with background is limited to metals, because data are not sufficient for quantifying anthropogenic background levels of organic chemicals. The background data utilized within this SRA are presented in the *Final Background Metals Survey Report* (SAIC, 1998).

Background screening of metals may include several steps. The first step involves comparing the maximum detected concentration (MDC) from the site data with the background screening criterion (BSC), computed as two times the mean of the background data set, consistent with EPA (1995) Region IV guidance. If the metal MDC is less than, or equal to, the BSC, the chemical is not selected as a site-related chemical. If the MDC exceeds the BSC, the MDC is compared with the 95 percent upper tolerance limit (UTL) as a more refined statistical approach to comparing site data with background data. The UTL is the upper 95 percent confidence limit of the 95th quantile. The UTLs were calculated from the background metals data set (SAIC, 1998). Further information regarding the calculation of the UTLs is presented in Appendix C, Attachment C-2.

Comparison of the MDC with the BSC or UTL is a simple screen that relates the highest detection from site data to a reasonable upper bound for background. This comparison, however, does not relate the entire site data set to the entire background data set, which provides a more appropriate comparison when exposure is expected to occur randomly and uniformly over the entire site. Therefore, if the MDC from site data exceeds the UTL, it may be prudent to use the Mann-Whitney U Test to compare the site data set with the background data set.

It should be noted that metals in groundwater were routinely selected in many parcels as site-related chemicals and chemicals of potential concern (COPC) because the MDCs exceeded their respective BSCs and UTLs. Also, the Mann-Whitney U Test was not performed because the magnitude of the discrepancy suggested that the test would not support the de-selection of these metals as site-related chemicals. However, it is understood that turbidity was a major problem during sampling, indicating gross contamination of the groundwater with sediment. Most metal concentrations from samples with high turbidity were one to two orders of magnitude higher than concentrations from samples with low turbidity (IT, 2000b). Several metals detected in samples with high turbidity (beryllium, cadmium, chromium, lead, mercury, selenium) were undetected in samples with low turbidity. Metals whose concentrations were likely to have been inflated by turbidity were not de-selected as COPCs or removed from the risk assessment, but are identified in the "Results" sections that follow.

Site-related chemicals are carried to the next step of the SRA.

3.2.3 Select Chemicals of Potential Concern

COPCs are the chemicals that may contribute significantly to risk. They are selected by comparing the MDCs of site-related chemicals to their respective SSSLs. Because the SSSLs are receptor-specific, COPCs are also receptor-specific. In other words, a chemical may be selected as a COPC for residential exposure but not for recreational site use. This occurs because the SSSL for residential exposure is lower than that for recreational site use, because the resident is more highly exposed. Source-term concentrations (STC) are estimated for the COPCs. STCs are conservative estimates of the concentration of the COPC averaged over the entire site. COPCs are carried to the risk characterization step of the SRA.

3.2.4 Characterize Risk

The appropriate SSSL is applied to the STC to estimate an incremental lifetime cancer risk (ILCR) or hazard index (HI) for each COPC in each environmental medium (IT, 1998a). The ILCRs and HIs are summed across all exposure routes and chemicals to yield a total ILCR or total HI for a given receptor exposed to a given medium. The total ILCRs and HIs for each medium are summed to yield a total ILCR and a total HI for a given receptor exposed to all media. Total ILCR estimates for a receptor below 1E-6 are considered to be negligible. ILCR estimates between 1E-6 and 1E-4 are considered to fall within a risk management range. ILCR estimates that exceed 1E-4 are considered to be unacceptable and trigger estimation of remedial goal options (RGO). HI estimates for a receptor above the threshold level of 1 raise concern for the occurrence of adverse noncancer effects (EPA, 1989). However, adding HI values for all chemicals may overstate the potential for adverse effects. EPA (1989) believes that the assumption of additivity is valid only for chemicals that operate by the same mechanism of toxicity; therefore, the HI values may be segregated on the basis of mechanism of toxicity. Mechanisms of toxicity data are available for very few chemicals; therefore, a target organ is used as a surrogate, assuming that chemicals that act on the same target organ may operate by the same mechanism of toxicity.

3.2.5 Identify Chemicals of Concern

Chemicals of concern (COC) are chemicals that contribute significantly to ILCR or HI for a receptor scenario with unacceptable risk levels; i.e., a total ILCR summed across all COPCs and media greater than 1E-4 or a total HI greater than 1 (after segregation by target organ).

3.2.6 Develop Remedial Goal Options

RGOs are risk-specific concentrations developed for chemicals identified as COCs (EPA, 1995). The cancer-based SSSLs are adopted as RGOs based on an ILCR of 1E-6; RGOs are also developed for cancer risks of 1E-5 and 1E-4. The noncancer-based SSSLs are adopted as RGOs based on a noncancer HI of 0.1; RGOs are also developed for HI values of 1 and 3.

3.2.7 Uncertainty Analysis

EPA (1992) requires a clear and transparent articulation of the sources of uncertainty and their potential impact on the numerical results and interpretation of a risk assessment. This enhances the credibility of the assessment and facilitates its prudent application. Uncertainty is introduced at each stage of a risk assessment, including sampling, analysis, estimating exposure-point concentrations, establishing receptor scenarios, evaluating the toxicity of the detected chemicals, and combining the acquired data to estimate ILCR and HI values. Most of the sources of uncertainty, however, are common to all risk assessments, including analytical laboratory measurement variability, the imprecision (largely unknown) of models for estimating exposures, and the unknowns of extrapolating toxicity data from animals to humans. These sources of uncertainty are discussed briefly in IT (1998a) and in much more detail in EPA (1989).

No attempt is made to discuss in detail all the sources of uncertainty for each of the ten sites that comprise the fill areas. Instead, the uncertainty analysis discussion for each of the sites will be limited to those issues that may have a significant impact on the numerical results or their use in decision-making. Particular care will be exercised to identify sources of uncertainty that could impart a non-conservative bias to the results. Sources of uncertainty that could impart an overly conservative bias may not be discussed unless they result in unacceptable risk estimates that could trigger further action.

One source of uncertainty common to many of the fill areas is the age of the data. Some sites have data no more recent than 1994. However, the majority of the landfills have not been operated for many years, so it is very unlikely that contamination would have increased since the samples were taken. Actually, levels of organic chemicals may have decreased due to natural degradation.

A very important source of uncertainty common to many of the parcels is the occurrence of high turbidity during groundwater sampling. High turbidity has been shown to increase the apparent concentrations of many metals in groundwater from one to two orders of magnitude (IT, 2000b). Generally metals were not expected to appear in groundwater as a result of site-related activities in the various fill areas investigated herein. Support is provided by the observation that extraordinarily high levels of metals were not observed in surface water or sediment. Many metals were selected as COPCs in groundwater, probably because of the high turbidity. They were not eliminated from the quantitation, but were carried through in order to preserve the integrity, completeness, and clarity of the risk assessment. However, they are generally dismissed in the narrative as arising from sample contamination with sediment. The dismissal of metals in groundwater may impart a non-conservative bias to the SRA.

3.3 Screening-Level Ecological Risk Assessment

In order to determine the potential for ecological risks posed by site-related chemicals at the landfills and fill areas, a SLERA was conducted. This SLERA consisted of a description of the habitat(s) in and around the landfills and fill areas, a discussion of the constituents detected in samples collected from environmental media at the various landfills and fill areas, a discussion of the conceptual site models, an estimation of the screening-level risk, the identification of the constituents of potential ecological concern (COPEC), an uncertainty analysis, a discussion of the different lines of evidence, and a summary of the results and conclusions.

3.3.1 Environmental Setting

Because the landfills and fill areas occur at various locations throughout FTMC, the habitats vary from site-to-site. The major habitat types that occur at the landfills and fill areas and surrounding areas are the following:

- Coniferous forest
- Mixed deciduous/coniferous forest
- Forested bottomland
- Old-field succession
- Maintained lawn
- Emergent wetland
- Freshwater stream.

The following sections describe the habitat found at each of the landfills and fill areas that are the subject of this EE/CA.

3.3.2 Site Conceptual Model

The ecological site conceptual model (SCM) is a simplified, schematic diagram of possible exposure pathways and the means by which contaminants are transported from the primary contaminant source(s) to ecological receptors. Figures D-1 through D-9 in Appendix D provide SCM models used for these sites. The exposure scenarios include the sources, environmental transport, partitioning of the contaminants amongst various environmental media, potential chemical/biological transformation processes, and identification of potential routes of exposure for the ecological receptors. In this section the SCM will be described in relation to constituent fate and transport properties, the ecotoxicity of the various constituents, potential ecological receptors at the fill areas, and the complete exposure pathways expected to exist at the fill areas.

3.3.2.1 Chemical Fate and Transport

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

Fate and Transport in Soil. Contaminants in surface soil at the fill areas have the potential to be transported from their source areas to other areas within their respective fill areas and to off-site locations by a number of mechanisms including: volatilization; dust entrainment; surface runoff; and infiltration to subsurface soil/groundwater.

Several VOCs were identified in the upper soil horizons at several of the fill areas. These volatile constituents have a high potential to volatilize to the atmosphere and be transported from their source areas via air movement. The concentrations of VOCs detected in surface soil at the fill areas are low; therefore, this transport mechanism is expected to be insignificant with respect to other transport mechanisms active at these sites. Most of the metals and SVOCs in the surface soil at the fill areas are not expected to volatilize to any great extent, with the exception of mercury, which would be expected to volatilize relatively rapidly. Most of the metals and SVOCs in the surface soil at the fill areas are generally closely associated with particulate matter and would be transported from their source areas by fugitive dust generation and entrainment by the wind. Subsequent dispersion by atmospheric mixing could transport particulate-associated contaminants to other parts of the fill areas and to off-site locations. The generation of fugitive dust and subsequent transport by the wind is potentially a significant transport mechanism at some of the fill areas; namely those with significant areas of exposed soil (i.e., Fill Area at Range 30).

The transport of surface soil-associated contaminants by surface runoff is another potential transport mechanism. Surface soil contaminants may be solubilized by rainwater and subsequently transported to drainage ditches, low-lying areas, and nearby surface water bodies via surface runoff. The solubility of inorganics (metals) in rainwater is largely dependent upon the pH of the rainwater. Because the rainwater in this region is most likely slightly acidic, the metal constituents in surface soil are likely to solubilize in the rainwater and be subject to transport via runoff. Most of the SVOCs are strongly associated with soil particles and would not solubilize to a large extent. Contaminants that may be more strongly bound to particulate matter in surface soil (i.e., SVOCs and some of the metals) may be entrained in surface water runoff and transported to drainage ditches, low-lying areas, and nearby surface water bodies via surface runoff. Many of the metals and SVOCs are strongly sorbed to soil particles and could be transported from their source areas via this mechanism.

Contaminants in surface soil may be transported vertically to subsurface soils and groundwater via solubilization in rainwater and infiltration. Migration in this manner is dependent upon contaminant solubility and frequency of rainfall. Although the soil types (sand, clay, stone, and gravel) in the vicinity of some of the fill areas are expected to promote relatively rapid infiltration of rainwater, the less soluble constituents (i.e., SVOCs) found at the fill areas are not likely to migrate to any great extent vertically due to their relatively low solubilities. Additionally, some of the fill areas are located near or adjacent to wetlands and other low-lying areas where the soil is high in organic matter. These highly organic soils would inhibit the infiltration of most organic compounds as these compounds would be strongly bound to the organic carbon in the soil. Metals in soil at the fill areas may migrate vertically due to the acidic nature of the rainwater in this area and the increased solubility of metals that it produces.

The transfer of contaminants in surface soil to terrestrial plants through root uptake and terrestrial animals through ingestion and other pathways are potentially significant transfer mechanisms. Many metals are readily absorbed from soil by plants, but they are not biomagnified to a great extent through the food web. There are several exceptions to this; namely arsenic and nickel, which may bioconcentrate and/or biomagnify (ATSDR, 1989; 1995). Many of the SVOCs have the potential to bioconcentrate in lower trophic level organisms (i.e., terrestrial invertebrates), but most higher trophic level animals have the ability to metabolize these compounds rapidly, precluding the potential for bioconcentration (Eisler, 1987). Pesticides (i.e., 4,4'-dichlorodiphenyltrichloroethane [DDT] and 4,4'-dichlorodephenyldichloroethene [DDE]) are known to bioconcentrate and biomagnify in a number of different ecosystems; thus, these processes are important in considering the fate and transport of pesticides at the fill areas.

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

Fate and Transport in Surface Water. In general, contaminants present in the various surface water bodies associated with the fill areas are the result of erosion and runoff from the fill areas. Contaminants in surface water at the fill areas may be transported from their sources to other locations at the fill areas or to off-site locations by the following mechanisms: 1) volatilization; 2) transfer to groundwater; 3) transfer to sediment; and 4) flow downstream. VOCs in surface water would be expected to rapidly volatilize from the water-air interface and be dispersed in the atmosphere. Therefore, transport of volatile constituents in surface water is not expected to occur for any significant distance.

Depending on the local hydrogeology, significant surface water/groundwater exchange could take place. As such, contaminants in surface water at the fill areas could migrate to the groundwater. The metals detected in surface waters in the vicinity of the fill areas have the potential to migrate to groundwater. Contaminant transfer to sediments represents another significant transfer mechanism, especially where contaminants are in the form of suspended solids, or are hydrophobic substances (i.e., PAHs) that can become adsorbed to organic matter in the sediments. The metals detected in surface water have the potential to associate with suspended particulate matter.

Contaminants in surface water can be transported off-site via the various surface water bodies associated with the fill areas. Transfer of contaminants in surface water to aquatic organisms is also a potentially significant transfer pathway. Most of the metals detected in surface water are not highly bioconcentratable; therefore, transfer through the food web is expected to be minimal for these compounds. However, mercury and copper, which were detected in surface waters at low concentrations, have the potential to bioconcentrate from surface water to aquatic organisms.

Fate and Transport in Sediment. Contaminant transfer between sediment and surface water potentially represents a significant transfer mechanism; especially, when contaminants are in the form of suspended solids. Sediment/surface water transfer is reversible; sediments often act as temporary repositories for contaminants and gradually release contaminants to surface waters. This is especially true in surface water systems that are acidic. Sorbed or settled contaminants can be transported with the sediment to downstream locations. The substrate of the water bodies on or near the various fill areas ranges from gravel or cobbles (Cave Creek adjacent to Landfill No. 2, Parcel 79[6]) to organic muck (wetland adjacent to Former Post Garbage Dump, Parcel 126[7]). The very low organic content of the gravel and cobble create a substrate with very low binding capacity; therefore, constituents released to water bodies with this type of substrate via surface runoff or other transport mechanisms would most likely remain suspended in the surface water and be transported downstream and would not be sequestered in the stream substrate near the source. Conversely, water bodies with sediments containing high organic carbon content would tend to bind many constituents and sequester them in the sediment in close proximity to the source.

Although transfer of sediment-associated contaminants to bottom-dwelling biota also represents a potentially significant transfer mechanism, it is not expected to be a major mechanism at the fill areas. Lower trophic level organisms may accumulate metals and PAHs; however, higher trophic level organisms have the ability to metabolize PAHs and therefore reduce their accumulative properties. Most of the metals detected in sediment are not bioaccumulative. Mercury and copper may bioaccumulate to some extent due to exposures to sediment. Although 4,4'-DDT and 4,4'-DDE were detected in sediment associated with two of the fill areas, these constituents were infrequently detected. These pesticides do have the potential to bioconcentrate and biomagnify in aquatic food chains and these transfer properties may contribute significantly to their overall fate and transport.

3.3.2.2 Ecotoxicity

The ecotoxicological properties of the constituents detected in the various environmental media at the fill areas are discussed in Appendix D.

3.3.2.3 Potential Receptors

Potential ecological receptors at the fill areas 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 fill areas: herbivores, invertivores, omnivores, carnivores, and piscivores. All of these feeding guilds are expected to be directly exposed to various combinations of surface soil at the fill areas and surface water and sediment in the various water bodies near the fill areas 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.

In addition to the various feeding guilds described above, several receptor groups could be expected to be exposed directly to contaminants in the environmental media at the different fill/landfill areas. These receptor groups include the following:

- Aquatic and terrestrial plants
- Aquatic and terrestrial invertebrates
- Fish.

These receptor groups interact directly with the environmental media with which they are associated and also act as integral food sources for a number of higher trophic level organisms and feeding guilds (i.e., herbivores feeding on terrestrial plants).

Herbivorous Feeding Guild. The major route of exposure for herbivores is through ingestion of plants that may have accumulated contaminants from the soil, surface water, or sediment. The vegetation at the various fill areas ranges from old-field grasses and sedges, to mature coniferous/deciduous forests. Because terrestrial herbivores by definition are grazers and browsers, they could be exposed to chemicals that have accumulated in the vegetative tissues of plants at the fill areas. Terrestrial herbivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while grazing, grooming, or other activities.

Dermal absorption of PAHs from soil is a potential exposure pathway for herbivores at the fill areas; however, birds and mammals are less susceptible to dermal exposures because their feathers or fur prevents skin from coming into direct contact with the soil (EPA, 1993b). Dermal absorption of metals from direct contact with soil is expected to be minimal due to the low dermal permeability of these compounds. Inhalation of VOCs from surface soil, surface water, and/or sediment is a potentially viable exposure pathway; however, volatile compounds were only detected sporadically in environmental media at the various fill areas. Inhalation of constituents sorbed to soil particles and inhaled as dust is a potential exposure pathway for herbivores.

Terrestrial herbivores may also be exposed to COPECs in surface water through ingestion of water in the surface water bodies that are adjacent to the various fill areas. Typical herbivorous species that could be expected to occur at the various fill areas 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 would have a greater potential for exposure to COPECs in surface water and/or sediment as they spend a majority of their lifetime in close proximity to water bodies. Aquatic herbivores could potentially be exposed to COPECs in surface water and/or sediment via direct contact, ingestion of surface water and sediment and ingestion of aquatic vegetation that may have accumulated site-related constituents. Metals are the major COPECs in surface water that could be ingested. Aquatic herbivores, such as muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), and mallard (*Anas platyrhynchos*) could also be exposed to site-related constituents in surface water and/or sediment in the surface water bodies adjacent to the various fill areas.

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 potentially a major exposure pathway for invertivores since much of their food (i.e., earthworms and other invertebrates) lives on or below the soil surface.

Dermal absorption of PAHs from soil is a potential exposure pathway for invertivores at fill areas; however, birds and mammals are less susceptible to dermal exposures because their feathers or fur prevents skin from coming into direct contact with the soil (EPA, 1993b). Dermal absorption of metals from direct contact with soil is expected to be minimal due to the low dermal permeability of these compounds. Inhalation of VOCs from surface soil, surface water, and/or sediment is a potentially viable exposure pathway; however, volatile compounds were only detected sporadically in environmental media at the various fill areas. Inhalation of constituents sorbed to soil particles and inhaled as dust is a potential exposure pathway for invertivores.

Terrestrial invertivores could also be exposed to COPECs in surface water and sediment in the various surface water bodies near the fill areas by utilizing them for drinking water. Typical invertivorous species that could be expected to occur at the fill areas 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*).

Because aquatic invertivores spend a majority of their life closely associated with water bodies, the potential for exposure to COPECs in surface water and sediment is high for this feeding guild. Aquatic invertivores could potentially be exposed to COPECs in surface water and/or sediment via direct contact, ingestion of surface water and sediment and ingestion of aquatic invertebrates that may have accumulated site-related constituents from surface water and/or sediment. Aquatic invertivores could include the wood duck (*Aix sponsa*) and blacknose dace (*Rhinichthys atratulus*).

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 fill areas and also chemicals that may have accumulated in smaller animal tissues that the omnivores prey upon. They may also be exposed to surface water through ingestion of water in the various water bodies near the fill areas. Omnivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while feeding, grooming, or other activities.

Dermal absorption of PAHs from soil is a potential exposure pathway for omnivores at the fill areas; however, birds and mammals are less susceptible to dermal exposures because their feathers or fur prevents skin from coming into direct contact with the soil (EPA, 1993b). Dermal absorption of metals from direct contact with soil is expected to be minimal due to the low dermal permeability of these compounds. Inhalation of VOCs from surface soil, surface water, and/or sediment is a potentially viable exposure pathway; however, volatile compounds were only detected sporadically in environmental media at the various fill areas. Inhalation of constituents sorbed to soil particles and inhaled as dust is a potential exposure pathway for omnivores.

Terrestrial omnivores could be exposed to COPECs in surface water and sediment in the various surface water bodies near the fill areas by utilizing them for drinking water. Typical omnivorous species expected to occur at the fill areas 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 have a greater potential for exposure to COPECs in surface water and sediment because they spend a majority of their lifetime closely associated with water bodies. Aquatic omnivores could potentially be exposed to COPECs in surface water and/or sediment via direct contact, ingestion of surface water and sediment, ingestion of aquatic invertebrates, and ingestion of aquatic plants that may have accumulated site-related constituents from surface water and/or sediment. Aquatic omnivores, such as raccoon (*Procyon lotor*) and creek chub (*Semotilus atromaculatus*) could be exposed to COPECs in surface water and sediment in the various surface water bodies in the vicinity of the fill areas.

Carnivorous Feeding Guild. Carnivores are meat-eating animals and are; therefore, exposed to site-related chemicals through consumption of prey animals that may have accumulated contaminants in their tissues. Carnivores are quite often top predators in a local food web and are often subject to exposure to contaminants that have 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 metals are not accumulated in animal tissues to any great extent (Shugart, 1991; 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.

Carnivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while feeding, grooming, or other activities. These species may occupy the woodlands that surround the fill areas and the open old-field areas of some of the fill areas themselves.

Dermal absorption of PAHs from soil is a potential exposure pathway for carnivores at the fill areas; however, birds and mammals are less susceptible to dermal exposures because their feathers or fur prevents skin from coming into direct contact with the soil (EPA, 1993b). Dermal absorption of metals from direct contact with soil is expected to be minimal due to the low dermal permeability of these compounds. Inhalation of VOCs from surface soil, surface water, and/or sediment is a potentially viable exposure pathway; however, volatile compounds were only detected sporadically in environmental media at the various fill areas. Inhalation of constituents sorbed to soil particles and inhaled as dust is a potential exposure pathway for carnivores.

Terrestrial carnivores could be exposed to COPECs in surface water in the various surface water bodies near the fill areas by utilizing them for drinking water. Metals and PAHs are the major COPECs in surface water and sediment that could be ingested. Typical carnivorous species expected to occur at the fill areas 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*).

Aquatic carnivores have a greater potential for exposure to COPECs in surface water and sediment because they spend the majority of their lifetime closely associated with water bodies. Aquatic carnivores could potentially be exposed to COPECs in surface water and sediment via direct contact, ingestion of surface water and sediment, and ingestion of prey animals that may have accumulated COPECs. Because the water bodies in the vicinity of the fill areas are generally small and shallow, they do not have the capability to support large aquatic carnivores. Carnivorous fish such as largemouth bass (*Micropterus salmoides*) and spotted gar (*Lepisosteus oculatus*) would not be expected to occur in the water bodies in the vicinity of the fill areas due to the habitat restrictions. Additionally, carnivorous mammals such as the mink (*Mustela vison*), which depends on larger fish to eat, would not be expected to occur in the vicinity of the fill areas, except possibly the Former Post Garbage Dump, Parcel 126(7); Fill Area East of Reilly Airfield, Parcel 227(7); and the Fill Area Northwest of Reilly Airfield, Parcel 229(7). The surface water bodies adjacent to these areas may be large enough to support aquatic carnivores.

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 the various water bodies in the vicinity of the fill areas. They may also be exposed to surface water and sediment in these water bodies through ingestion of drinking water and during feeding.

Dermal absorption of COPECs from surface water and sediment are a potential exposure pathway for piscivores at the fill areas. Absorption of metals from direct contact with sediment is expected to be minimal due to the low dermal permeability of these compounds. Inhalation of volatiles from surface water and sediment is expected to be insignificant due to the fact that volatile compounds were detected infrequently in surface water and sediment. Also, it is expected that if volatile compounds were present in surface water, they would volatilize rapidly and disperse in the atmosphere.

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 PAHs and metals are not accumulated in fish tissues to any great extent. Therefore, food web exposures to these chemicals are expected to be minimal.

SVOCs are readily metabolized by most fish species and are not accumulated to any extent. Mercury in surface water and/or sediment may accumulate in fish tissues and biomagnify through the aquatic food chains; therefore, food web exposure to mercury is potentially a significant exposure pathway for piscivorous animals at the fill areas.

Typical piscivorous species expected to occur near the fill areas 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 most of the creeks near the fill areas due to small size and ephemeral nature of these creeks. However, the creeks and ponds in the vicinity of the Former Post Garbage Dump, Parcel 126(7), Fill Area East of Reilly Airfield, Parcel 227(7), and the Fill Area Northwest of Reilly Airfield, Parcel 229(7) may support these larger piscivorous fish and mammal species.

3.3.2.4 Complete Exposure Pathways

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

- A source mechanism for contaminant 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 for each of the fill areas addressed in this EE/CA are depicted in the SCMs for each fill area as Figures D-1 through D-9 in Appendix D.

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, which are lipophilic and can penetrate epidermal barriers. Mammals are less susceptible to exposure via dermal contact with soils because their fur prevents skin from coming into direct contact with soil. However, soil ingestion may occur while grooming, preening, burrowing, or consuming plants, insects, or invertebrates resident in soil.

Ecological receptors may 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 COPECs.

Exposure via inhalation of fugitive dust is limited to contaminants 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.

Chemicals present in the sediment may result from erosion or adsorption of water-borne constituents onto sediment particles. If sediments are 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 contaminants from either volatilizing or being carried by wind erosion. Exposure via dermal contact may occur, especially for benthic organisms and wading birds. 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 generally will not come into direct contact with constituents in groundwater since there is no direct exposure route.

Secondary exposure pathways involve constituents that are transferred through different trophic levels of the food chain and may be bioaccumulated. 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. Water-borne and sediment-borne COPECs may bioaccumulate into aquatic organisms, aquatic plants, or animals which frequent surface waters and then be passed through the food chain to impact organisms at higher trophic levels.

Summaries of the potentially complete exposure pathways for the terrestrial and aquatic ecosystems at the fill areas are presented in Tables D-1 and D-2, respectively, in Appendix D.

3.3.3 Screening-Level Risk Estimation

A screening-level estimation of potential risk can be accomplished by comparing the exposure point concentration of each detected constituent in each environmental medium to a corresponding screening-level ecological toxicity value. In order to conduct the SLERA, the following steps must be followed:

- Determine appropriate screening assessment endpoints

- Determine the ecological toxicity values that are protective of the selected assessment endpoints

- Determine the exposure point concentrations of constituents detected at the site

- Calculate screening-level hazard quotients.

These steps are summarized below.

3.3.3.1 Ecological Screening Assessment Endpoints

Most ecological risk assessments focus on population measures as endpoints since population responses are better defined and predictable than are community or ecosystem responses. For SLERAs, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments.

Adverse effects on populations can be inferred from measures related to impaired reproduction, growth, and survival. Adverse effects on communities can be inferred from changes in community structure or function. Adverse effects on habitats can be inferred from changes in composition and characteristics that reduce ability of the habitat to support plant and animal populations and communities.

Because of the nature of the SLERA process, most of the screening assessment endpoints are generic in nature (i.e., protection of sediment benthic communities from adverse changes in structure or function).

The assessment endpoints identified for this SLERA were identified for each environmental medium and are summarized below:

- ***Soil***

  - Protection of the terrestrial invertebrate community from adverse changes in structure and function.

  - Protection of the terrestrial plant community from adverse changes in structure and function.

- ***Surface Water***

    - Protection of the aquatic community from adverse changes in structure and function.

- ***Sediment***

    - Protection of the benthic community from adverse changes in structure and function.

3.3.3.2 Ecological Screening Values

The ESVs used in this assessment represent the most conservative values available from various literature sources and have been selected to be protective of the assessment endpoints described above. These ESVs were selected specifically for FTMC in conjunction with EPA Region IV and are presented in the *Final Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000c). The ESVs used in this assessment are based on no-observed-adverse-effects-levels (NOAEL) when available. If a NOAEL-based ESV was not available for a certain COPEC, then the most health-protective value available from the scientific literature was used in this assessment.

For each environmental medium sampled at the fill areas (soil, surface water, and sediment), a hierarchy has been developed which presents an orderly method for selection of ESVs. The hierarchy for selecting ESVs for soil is as follows:

- EPA Region IV constituent-specific ecological screening values
- EPA Region IV ecological screening values for general class of constituents
- EPA Region V ecological data quality levels (EDQL)
- EPA Region III Biological Technical Advisory Group (BTAG) values
- Ecological screening values from Talmage, et al., 1999.

The hierarchy for selecting ESVs for surface water is as follows:

- EPA Region IV constituent-specific ecological screening values

- NOAA Screening Quick Reference Tables (SQRT), chronic freshwater ambient water quality criteria

- EPA Region V EDQLs

- Office of Solid Waste and Emergency Response (OSWER) Ecotox Threshold values

- EPA Region III BTAG values

- Lowest chronic value from Suter and Tsao, 1996
- Ecological screening values from Talmage, et al., 1999.

The hierarchy for selecting ESVs for sediment is as follows:

- EPA Region IV constituent-specific ecological screening values
- NOAA SQRTs, chronic freshwater ambient water quality criteria
- EPA Region V EDQLs
- OSWER ecotox threshold values
- EPA Region III BTAG values
- Lowest effect levels from Ontario Ministry of the Environment (1992) presented in Jones, et al., (1997)
- Ecological screening values from Talmage, et al., 1999
- Sediment quality adverse effect threshold (AET) values from the Puget Sound Estuary Program.

3.3.3.3 Determination of Exposure Point Concentrations

Exposure point concentrations represent the chemical concentrations in environmental media that a receptor may contact. Because the exposure point concentration is a value that represents the most likely concentration to which receptors could be exposed, a value that reflects the central tendency of the data set is most appropriate to use. However, at the screening-level stage, the data sets are generally not robust enough for statistical analysis and the level of conservatism in the exposure estimates is high to account for uncertainties. Therefore, in the screening-level stage, the maximum detected constituent concentration in each environmental medium is used as the exposure point concentration. The use of the maximum detected constituent concentration as the exposure point concentration ensures that the exposures will not be under-estimated, and therefore, constituents will not be inadvertently eliminated from further assessment.

The statistical summaries (including the exposure point concentrations) for surface soil, surface water, and sediment at the various fill areas are presented in Tables D-3 through D-27 (Appendix D).

3.3.3.4 Screening-Level Hazard Quotients

In order to estimate whether constituents detected in environmental media at the site have the potential to pose adverse ecological risks, screening-level hazard quotients were developed. The screening-level hazard quotients were developed via a three-step process as follows:

- Comparison to naturally-occurring background concentrations
- Identification of essential macro-nutrients
- Comparison to ESVs.

A study of the natural geochemical composition associated with FTMC (SAIC, 1998) determined the mean concentrations of 24 metals in surface soil, surface water, and sediment samples collected from presumably unimpacted areas. Per agreement with EPA Region IV, the background threshold value (BTV) for each metal was calculated as two times the mean background concentration for that metal. The BTV for each metal was used to represent the upper boundary of the range of natural background concentrations expected at FTMC, and was used as the basis for evaluating metal concentrations measured in site samples.

In order to determine whether metals detected in site samples were the result of site-related activities or were indicative of naturally occurring conditions, the maximum metal concentrations measured in site samples were compared to their corresponding BTVs. Site sample metal concentrations less than or equal to the corresponding BTV represent the natural geochemical composition of media at FTMC, and not contamination associated with site activity. Site sample metal concentrations greater than the corresponding BTV represent contaminants that may be the result of site-related activities and require further assessment.

The EPA recognizes several constituents in abiotic media that are necessary to maintain normal function in many organisms. These essential macronutrients are iron, magnesium, calcium, potassium, and sodium. Most organisms have mechanisms designed to regulate nutrient fluxes within their systems; therefore, these nutrients are generally only toxic at very high concentrations. Essential macronutrients were only considered COPECs if they were present in site samples at concentrations ten times the naturally occurring background concentration.

Chemicals that exceeded their naturally occurring background concentrations and were not essential macronutrients were evaluated against the ESVs by calculating a screening-level hazard quotient (HQ_{screen}) for each constituent in each environmental medium. A hazard quotient was calculated by dividing the maximum detected constituent concentration in each environmental medium by its corresponding ESV as follows:

$$HQ_{SCREEN} = \frac{MDCC}{ESV}$$

where:

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

A calculated HQ_{screen} value of one indicated that the MDCC was equal to the chemical's conservative ESV and was interpreted in this assessment as a constituent that does not pose the potential for adverse ecological risk. An HQ_{screen} value less than one indicated that the MDCC was less than the conservative ESV, and that the chemical is not likely to pose adverse ecological hazards to most receptors. Conversely, an HQ_{screen} value greater than one indicated that the MDCC was greater than the ESV and that the chemical might pose adverse ecological hazards to one or more receptors.

In order to better understand the potential risks posed by chemical constituents at the fill areas, a mean hazard quotient was also calculated by comparing the arithmetic mean constituent concentration in each environmental medium to the corresponding ESV. The calculated screening-level hazard quotients for surface soil, surface water, and sediment at the fill areas are presented in Tables D-3 through D-27 (Appendix D).

3.3.4 Identification of Chemicals of Potential Ecological Concern

Chemicals were identified as COPECs if the following conditions were met:

- The maximum detected constituent concentration exceeded the BTV for metals
- The maximum detected constituent concentration was 10-times BTV if constituent is a macronutrient
- The maximum detected constituent concentration exceeded the ESV.

If a constituent in a given environmental medium did not meet these conditions, then it was not considered a COPEC at the given fill area and was not considered for further assessment. If a constituent met these conditions, then it was considered a COPEC. Identification of a constituent as a COPEC indicates that further assessment of that particular constituent in a given environmental medium at a given fill area is appropriate. It does not imply that a particular constituent poses risk to ecological receptors.

The COPECs that have been identified for surface soil, surface water, and sediment at the IMR ranges are presented in Tables D-3 through D-27 and summarized in Table D-28 and D-29 (Appendix D).

3.3.5 Uncertainty Analysis

Uncertainties are inherent in any risk assessment, and even more so in a SLERA due to the nature of the assessment process and the assumptions used in the process. A number of the major areas of uncertainty in this assessment are presented below.

A significant level of uncertainty is introduced into this assessment due to the sampling and analysis program conducted at the fill areas. The sampling and analysis program was designed to determine the presence or absence of contamination resulting from historical fill activities at these sites. The sampling and analysis program was not designed to determine the nature and extent of contamination at each of the fill areas. As such, the number of samples at each of the fill areas is relatively small.

An area of uncertainty that is inherent in a SLERA is the use of the maximum detected constituent concentration as the exposure point concentration for all receptors in a given medium. Most receptors have a home range large enough that precludes individuals from being exposed to the maximum constituent concentration for their entire lifetimes. Therefore, the actual exposure point concentration of a given constituent for most receptor species would be less than the maximum detected concentration. The use of the maximum detected constituent concentrations as the exposure point concentrations for all receptors results in an overestimation of exposure for many receptors.

Additionally, there is no consideration given to the bioavailability of COPECs to different organisms. In this SLERA it is assumed that all constituents are 100 percent bioavailable to all receptor organisms. It is known that many constituents (particularly metals) have significantly lower bioavailabilities (i.e., 1 to 10 percent for some metals in soil) than the 100 percent that was assumed in this assessment. This assumption has the potential to greatly overestimate exposures to certain COPECs.

Several COPECs do not have ESVs. The lack of toxicity data for certain COPECs makes it impossible to determine the potential for ecological risk posed by those constituents. Risks may be underestimated due to this uncertainty.

The ESVs used in this assessment are all the most conservative values from the scientific literature and many are based on the most sensitive endpoint (NOAEL values) for the most sensitive species tested. A less sensitive endpoint that is still protective of the ecological populations or communities of interest may be the lowest-observed-adverse-effect-level (LOAEL) or some other endpoint. The use of NOAEL-based ESVs may over-estimate potential for risks from certain COPECs. Additionally, certain ESVs may not be applicable to conditions at the fill areas. For instance, a number of the sediment ESVs are referenced from MacDonald (1994) which presents sediment benchmark values for coastal waters (saline) in Florida. The surface water bodies at the fill areas are fresh water and exhibit significantly different physical and chemical characteristics compared to those found in the coastal waters of Florida. Therefore, the use of sediment ESVs developed for the coastal water of Florida to determine risks in the freshwater streams of FTMC introduces a significant level of uncertainty. Similarly, the surface water and soil ESVs do not take into account site-specific conditions at the fill areas and thus, introduce a potentially significant level of uncertainty into the assessment.

Another area of uncertainty is the lack of consideration of synergism and/or antagonisms between COPECs. Although it is widely accepted that synergism and antagonisms occur between certain constituents under certain conditions, current science does not provide methods for assessing these potential synergism/antagonisms.

Although the SLERA process stipulates the use of maximum detected constituent concentrations and the most conservative ESVs for estimating HQ_{screen} values, it is sometimes useful to incorporate additional lines-of-evidence when making risk management decisions at the screening-level stage. For this reason, an assessment of the COPECs was conducted using several additional lines-of-evidence including:

- Magnitude of the HQ_{screen}
- Frequency of detection
- Habitat quality
- Constituent bioaccumulation potential.

These additional lines-of-evidence were used to focus risk management decisions on the COPECs that have the greatest potential to pose adverse ecological impacts. Generally speaking, the COPECs that were screened-out using these additional lines-of-evidence were those COPECs whose HQ_{screen} was calculated to be less than ten, were infrequently detected in environmental media at a given fill area, were detected within ecological habitats that were degraded or did not provide unique or sensitive wildlife habitat, or do not bioaccumulate significantly in most ecological receptors.

The magnitude of an HQ can provide information regarding the potential for adverse effects to sensitive organisms. For instance, an HQ of 100 or 1,000 indicates a greater potential for adverse ecological effects than an HQ of 2 or 3. Because the ESVs are based on the most sensitive endpoints and the most sensitive organisms tested and not necessarily the organisms present at a given site at FTMC, the ESVs used in this assessment are very conservative. When available, ESVs are based on NOAELs. A less conservative toxicity value, the LOAEL, is the lowest concentration at which adverse ecological effects are observed. In general, if test data are not available to determine a LOAEL, then it can be estimated by applying a conversion factor of 10 to the NOAEL (Sample et al., 1996). Thus a NOAEL of 3 milligrams per kilogram (mg/kg) for a given chemical in soil can be converted to a LOAEL by multiplying the NOAEL by 10 to get a LOAEL of 30 mg/kg.

Another important factor in comparing constituent concentrations to ESVs is the fact that ESVs are designed to be protective of sensitive individual organisms. A less conservative, yet still protective approach is a comparison of constituent concentrations to ESVs protective of populations and/or communities. Because community or population-level ESVs are generally not available in the scientific literature, they are often estimated by applying a conversion factor of 10 to the NOAEL (Sample et al., 1996). Thus, a NOAEL based on effects to sensitive individual organisms can be converted to a population- or community-level NOAEL by multiplying the individual NOAEL by 10. Using the previous example, an ESV of 3 mg/kg can be converted to a LOAEL-based population-level ESV by applying a conversion factor of 10 to convert from a NOAEL to a LOAEL and a conversion factor of 10 to convert from an individual-based NOAEL to a population-based NOAEL.

Based on the example presented above, the ESVs used in this assessment may be over 100 times more protective than LOAEL-based population-level ESVs. Therefore, in this assessment using the additional lines-of-evidence, a conservative HQ value of 10 (greater than 1, but less than 100) was used as the cut-off for identifying constituents with the potential to pose adverse risks to ecological populations at the fill areas. Constituents whose maximum detected concentrations resulted in an HQ of 10 or less were considered to pose insignificant risks to ecological populations at the fill areas, unless other lines of evidence indicated the potential for ecological risk.

Another line of evidence used in the additional lines-of-evidence assessment was the frequency of detection. If a constituent was infrequently detected in a given medium, it was not considered to be a wide-spread contaminant and was considered to pose insignificant risk to ecological populations and/or communities at the fill areas, unless other lines of evidence indicated the potential for ecological risk.

The presence or absence of unique or sensitive habitat at a particular site was used as a line-of-evidence for identifying constituents that have the potential to pose significant ecological risk. Wetlands and stream corridors were generally defined as sensitive habitat types at the fill areas. Additionally, the presence of mountain longleaf pine, white fringeless orchid, or gray bat habitat was considered a unique habitat. Constituents detected in these habitat types with maximum concentrations exceeding their respective ESVs were considered COPECs, regardless of the magnitude of the ESV exceedance or frequency of detection. This approach is very conservative and is designed to be protective of the most sensitive individual organisms in these unique or sensitive habitats. Constituents detected at concentrations that exceeded their respective ESVs in habitat types not considered sensitive or unique were considered COPECs depending on a number of other lines-of-evidence.

The potential for bioaccumulation was also used as a line-of-evidence for selecting COPECs. If a constituent had a high potential for bioaccumulation (e.g., log K_{ow} value greater than 4.0), then it was considered a potential COPEC depending on a number of other lines-of-evidence.

3.3.6 Summary and Conclusions

The potential for ecological risks at the fill areas was determined through a SLERA. This ecological screening process consisted of the characterization of the ecological setting at the various fill areas, the development of a SCM for each fill area, a description of the fate and transport of constituents detected in various environmental media, a description of the ecotoxicity of the various constituents detected at the fill areas, a description of the ecological receptors, a description of the complete exposure pathways, the calculation of screening-level hazard quotients, and a description of the uncertainties within the process.