Volume I

REMEDIAL INVESTIGATION / BASELINE RISK ASSESSMENT REPORT FORT McCLELLAN, ALABAMA

FORT McCLELLAN
Delivery Order 0005
Contract Number DACA15-91-D-0017

FINAL

Prepared for:

U.S. Army Corps of Engineers
Mobile District
109 St. Joseph Street
Mobile, Alabama 36602

Prepared by:

Science Applications International Corporation
11251 Roger Bacon Drive
Reston, Virginia 20190

July, 2000

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ACRONYM LIST

AGS	Alabama Geological Survey
AMCLS	U.S. Army Chemical School
AMPS	U.S. Army Military Police School
ANHP	Alabama Natural Heritage Program
ASTM	American Society for Testing and Materials
BAF	Bioaccumulation Factor
BERA	Baseline Ecological Risk Assessment
BG	Bacillus globigii
BLS	Below Land Surface
BOD	Biological Oxygen Demand
BRAC	Base Realignment and Closure
CBR	Chemical, Biological, and Radiological
CDC	Centers for Disease Control
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CG	Phosgene (Carbonyl chloride)
CK	Cyanogen Chloride
CLP	Contract Laboratory Program
CNB	Chloroacetophenone
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRL	Certified Reporting Limit
CSF	Cancer Slope Factor
CTE	Central Tendency Exposure
CWM	Chemical Warfare Material
CX	Phosgene oxime
DBH	Diameter at Breast Height
DCE	Dichloroethane
DCL	DataChem Laboratories
DES_2	bis(2-diisopropylaminoethyl)
DESMP	S-(diisopropylaminoethyl)methylphosphonothioate
DGPS	Differential Global Positioning System
D&I	Detection and Identification
DIMP	Diisopropyl Methylphosphonate
DNB	Dinitrobenzene
DNT	Dinitrotoluene
DQO	Data Quality Objective
DTW	Depth-to-Water
ECAO	Environmental Criteria and Assessment Office
ecoCOC	Ecological Chemical of Concern
ecoCOPC	Ecological Chemical of Potential Concern
Eh	Oxidation-Reduction Potential
ELCR	Excess Lifetime Cancer Risk
EMO	Environmental Management Office
EMPA	Ethyl Methylphosphonate
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
ES&E	Environmental Science & Engineering
FDEM	Frequency Domain Electromagnetic

ACRONYM LIST (Continued)

FID	Flame Ionization Detector
FS	Feasibility Study
GB	Sarin or (Isopropyl methyl phosphonofluoridate)
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
gpm	Gallons per Minute
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HD	Distilled Mustard
HEAST	Hazard Evaluation Assessment Summary Tables
HI	Hazard Index
HO	Mustard Sulfoxide
HQ	Hazard Quotient
HSDB	Hazard Substances Data Base
ID	Identification
I.D.	Inside Diameter
IDL	Instrument Detection Limit
IMPA	Isopropyl Methylphosphonate
INEL	Idaho National Engineering Laboratory
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information System
K_d	Sorption Coefficient
K_{oc}	Soil Adsorption Coefficient
K_{ow}	Octanol-Water Partition Coefficient
LOAEL	Lowest-Observable-Adverse-Effect Level
MCL	Maximum Contaminant Level
MDL	Maximum Detection Limit
MINICAMS	Miniature Continuous Air Monitoring System
MP	Military Police
mph	Miles per Hour
msl	Mean Sea Level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAD	North American Datum
NAWQC	National Ambient Water Quality Criteria
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NG	Nitroglycerin
NGVD	North American Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No-Observable-Adverse-Effect Level
nT	nanoTeslas
O.D.	Outside Diameter
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PARCC	Precision, Accuracy, Representativeness Comparability, and Completeness
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCP	Pentachlorophenol
PINS	Portable Isotopic Neutron Spectroscopy
POL	Petroleum, Oils, and Lubricants

ACRONYM LIST (Continued)

POW	Prisoner of War
ppt	Parts per Thousand
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPD	Relative Percent Difference
SAIC	Science Applications International Corporation
SCS	Soil Conservation Service
SEETRAC	Small Emplacement Excavator Tractor
SI	Site Investigation
SM	Serratia Mercesans
SOP	Standard Operating Procedure
STB	Supertropical Bleach
STOLS®	Surface Towed Ordnance Locator System
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TDEM	Time Domain Electromagnetic
TIC	Tentatively Identified Compound
TNB	Trinitrobenzene
TNT	Trinitrotoluene
TRADOC	U.S. Army Training and Doctrine Command
TWA	Time Weighted Average
UCL	Upper Confidence Limit
USACE	U.S. Army Corps of Engineers
USAEC	U.S. Army Environmental Center
USAEHA	U.S. Army Environmental Hygiene Agency
USATEU	U.S. Army Technical Escort Unit
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
UST	Underground Storage Tank
UTL	Upper Tolerance Limit
UXO	Unexploded Ordnance
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
VX	O-ethyl-S(diisopropylaminoethyl)methylphosphonothiolate
WAC	Women's Army Corps

EXECUTIVE SUMMARY

Fort McClellan is located in northeastern Calhoun County, Alabama approximately 60 miles northeast of Birmingham, approximately 75 miles northwest of Auburn, and approximately 90 miles west of Atlanta, Georgia. The city of Anniston adjoins the main installation on the south and west. The city of Weaver is located approximately 1 mile northwest of the Main Post and the city of Oxford is approximately 5 miles south of Anniston. Fort McClellan consists of 45,679 acres of Government-owned and leased land situated in the foothills of the Appalachian mountains of northwest Alabama. The Morrisville Maneuver Area, or Pelham Range (22,245 acres), is located approximately 5 miles due west of the Main Post (18,946 acres), and adjoins the Anniston Army Depot along its northern boundary.

This report documents the results of the Remedial Investigations (RI) and Baseline Risk Assessment (BRA) conducted at 12 sites on Fort McClellan and Pelham Range in Anniston, Alabama. The RI/BRA was initiated in 1993 by the Department of the Army under the Installation Restoration Program (IRP). Subsequent to the completion of the Draft RI/BRA, the Post was identified for closure in 1995 to facilitate the transfer of surplus government property under the Base Realignment and Closure (BRAC) program. The RI has been conducted for the purpose of identifying and delineating chemical constituents in environmental media that are associated with pre-closure activities at administrative, light industrial, historical military training, and landfilled areas on Fort McClellan.

The objectives of the RI study were to investigate the presence, nature, and extent of chemical constituents resulting from previous controlled U.S. Army chemical warfare agent training activities and uncontrolled munitions and municipal waste disposal. The chemical warfare agents that were investigated during the RI study were identified from historical site assessment documents. The RI included assessments of the sources of chemical constituents, delineation of the areal extent of detected constituents, geologic/hydrogeologic characterization of several of the sites, and assessment of potential human health and ecological impacts. The chemical agents that were investigated under the RI consisted of the blistering agent mustard (HD), the nerve agents VX and GB and their stable breakdown products. These chemical agents were selected for investigation on the basis of historical documentation for the RI sites. The RI sites are summarized in Table ES-1 and include seven former chemical warfare training areas (T-4, T-5, T-24A, T-38, Range J, Range K, and Detection and Identification [D&I] Area), two reported chemical munitions disposal sites (Old Water Hole and Range L [Lima Pond]), and three former municipal or demolition debris landfills (Landfills #1, #2, and #3). Study areas T-6 (Agent Decontamination Area), T-31 (Technical Escort Reaction Area), and Range I (Shell Tapping Area) were not included for additional study following the 1993 SI conducted under the IRP, however, these sites warrant future investigation to address BRAC issues associated with property transfer. Two additional SI study areas (Old Toxic Training Area [OTTA] and HD Spill/Burial Sites) were not included for further investigation under the RI study on the basis of limited areal extent and non-detection of chemical warfare agent or agent breakdown products (OTTA) or lack of substantive site information (HD sites).

The geologic and hydrogeologic conditions underlying the RI sites at Fort McClellan have been evaluated by investigative drilling and sampling, test pit excavations, groundwater elevation measurements, aquifer (slug) testing, and through available geologic mapping in the vicinity of Fort McClellan and Pelham Range. Geologic conditions in the investigated areas consist of variably weathered claystone and shale with minor sandstone on the Main Post and interlayered limestone, dolomite, and sandstone on Pelham Range. Soil derived from the weathered bedrock consists predominantly of clayey silt and silty clay with localized sand lenses that overlies the weathered rock in each of the study areas. Ledges, seams, and boulders of moderately to slightly weathered bedrock and chert were encountered at many of the investigated sites. The measured depth to groundwater on the Main Post ranged from 0 (flowing artesian) to 129.9 feet below ground surface and from 0.4 to 72.9 feet on Pelham Range.

The nature and extent of chemical constituents attributable to the RI sites was assessed using field screening (MINICAMS®) analyses and soil, groundwater, surface water, and sediment sampling and analysis. Field screening for chemical warfare agent (GB, VX, and HD) was conducted by USATEU on surface and subsurface soils at Areas T-4, T-5, T-24A, and T-38, Old Water Hole, D&I area, Range J, Range K, and Range L. Based on the results of the MINICAMS® analyses, chemical warfare agent was not detected in any screened samples from the RI sites on the Main Post or Pelham Range. A variety of geophysical investigation methods (EM-31, EM-61, STOLS™, magnetometer) were applied to 10 of the RI sites. The geophysical surveys identified the presence of scattered debris (Area T-4, Area T-38, Range J, Range K, Range L, Landfill #1, and Old Water Hole) and subsurface burials (Area T-24A, Detection and Identification Area, and Landfill #2) at the sites. Ordnance was identified at Range K and Area T-24A.

Surface water and sediment samples were obtained near 6 of the RI sites from the Main Post and Pelham Range. Comparatively few organic constituents consisting of variably-detected concentrations of 1,1,1-trichloroethane, chlorobenzene, trichloroethene, α-BHC, δ-BHC, γ-BHC were identified in the surface water near the sites. Concentrations of the explosives compounds 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, and 2,6-dinitrotoluene were detected in pond water at Range L. Concentrations of arsenic, barium, lead, manganese, and zinc variably exceeded background concentrations at Range L, Landfill #1, and Landfill #3. Organic constituents that were detected in sediment samples adjacent to the sites consisted of isolated concentrations of benzyl alcohol, di-n-butyl phthalate, and dieldrin and concentrations of PAH compounds that were detected in a sample from the northeast corner of Landfill 3.

MINICAMS® screening of soil samples from nine former chemical warfare (CW) training sites did not detect the presence of residual VX, GB, or HD chemical agents. Soil analyses from Area T-4, T-5, Range J, Range K, and the Detection and Identification Area did not detect the presence of CWM breakdown products. Chemical constituents were detected in soil samples from excavated training pits within Area T-24A. Concentrations of PAH and pesticide compounds were variably detected in soil samples surrounding Landfill #1, Landfill #3, Area T-38 and the Old Water Hole site.

Groundwater underlying 8 of the sites at which monitoring was conducted is variably affected by concentrations of organic compounds that are potentially related to previous use of the property for training or disposal activities. Groundwater at Range J (Pelham Range) and Area T-38 (Main Post) contained concentrations of acetone, carbon tetrachloride, 1,2-dichloroethene, chloroform, 1,1,2,2 tetrachloroethane, tetrachloroethene, 1,2-trichloroethane, and trichloroethene. These areas have previously been sites of extensive usage of decontamination solutions. Groundwater downgradient of Area T-24A (Main Post) contains concentrations of benzene, pentachlorophenol, phenol, PAH compounds, and pesticides. These constituents are consistent with open burning activities that used petroleum fuels as an ignition source. Groundwater quality at Range L and the Old Water Hole sites (Pelham Range) contains concentrations of PAH compounds and pesticides that may be unrelated to the previous site usage as suspected chemical weapons burial sites. Groundwater surrounding Landfill #1 and #2 on the Main Post contains concentrations of acetone, methylene chloride, toluene, 1,1,1-trichloroethane, and isolated concentrations of 1,3-dinitrobenzene, 4 methyl 2-pentanone, nitroglycerine, and pesticides. Groundwater surrounding Landfill #3 contains the largest variety of detected organic constituents including acetone, benzene, carbon disulfide, chlorobenzene, 1,1-dichloroethene, dichlorobenzene, methylene chloride, pentachlorophenol, trichloroethene, tetrachloroethene, 1,1,2,2-tetrachloroethane, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, xylenes, and vinyl chloride. Elevated concentrations of 1,1,2,2-tetrachloroethane and trichloroethene were detected in monitoring wells located west of the landfill.

The baseline risk assessment (BRA) assessed the potential for potential adverse human health effects that could result from contact with inorganic and organic constituents that were detected at the 12 sites under investigation. Because this RI study was conducted prior to the identification of Fort McClellan for closure under the Base Realignment and Closure (BRAC) program, several of the sites that were evaluated solely for chemical warfare agents (HD, B, VX) were not included in the risk assessment. These sites are Areas T-4, T-5 and Range K. Further, sampling at several study areas did not include assessment of all of the pathways necessary for a complete risk evaluation of the property for the purpose of property transfer. These sites are Area T-4 (soil and groundwater), T-5 (soil and groundwater), T24-A (surface soil), Range K (soil and groundwater), Range J (soil), D&I (soil and groundwater), Landfill #1 (soil), Landfill #2 (soil), and Landfill #3 (soil). This information would be needed prior to assessments are recommended

Non-cancer and cancer risks to humans were estimated for both current and future land uses. Under current land use, occasional visits by trespassing children, adults, and military personnel were considered reasonably likely. Under future land use, higher levels of exposure to residents and construction workers were evaluated on a hypothetical basis. The human health risk estimates are attributable to exposures to both metal and organic substances. Exposure to constituents in groundwater was hypothetically assumed in the future industrial and residential scenario. Groundwater exposures at some sites accounts for the majority of the estimated hazard and risk.

There is no current or imminent hazard present at any of the sites evaluated. Under current land use, the combined non-cancer hazard indices HIs) are less than 1 and cancer risks are near the lower limit of the USEPA's target cancer risk range (1×10^{-4} to $1x\ 10^{-6}$) for the sites where sufficient characterization is available for the risk evaluation. The results of the human health risk assessment are primarily focused on the future land uses, which are summarized for each site evaluated as follows:

- ***Area T-4***—Soil from Area T-4 was field-screened for HD, GB, VX agents and was laboratory-analyzed for chemical warfare agent breakdown products. Target analytes (CWM) were not detected in any samples. Soil and groundwater pathways not fully evaluated for this site for non-CWM parameters. Risk assessment was not conducted for Area T-4.
- ***Area T-5***—Soil from Area T-5 was field-screened for HD, GB, VX agents and was laboratory-analyzed for chemical warfare agent breakdown products. Target analytes (CWM) were not detected in any samples. Soil and groundwater pathways not fully evaluated for this site for non-CWM parameters. Comprehensive risk assessment was not conducted for Area T-5. There were no COPCs for surface water and lead was identified as the only COPC for sediment.
- ***Area T-24A***—Soil from Area T-24A was field-screened for HD, GB, VX agents and was laboratory-analyzed for chemical warfare agent breakdown products. Target analytes (CWM) were not detected in any samples. Soil pathways not fully evaluated for this site for non-CWM parameters. Surface soil samples collected from Area T-24A were analyzed only for agent breakdown products. Because agent breakdown products were not detected in any of the samples, risk assessment for surface soils was not conducted at Area T-24A. There were no COPCs for surface water or sediment at Area T-24A.

  The maximum concentrations of iron in subsurface soil and groundwater exceeded the SSSLs. All noncancer HIs and cancer risks are below EPA targets (i.e., HI< 1 and cancer risk $< 1 \times 10^{-6}$) at Area T-24A under current land use. Under future land use, noncancer HIs exceed 1 for the exposures to soil for the resident child only. Noncancer COCs for the subsurface soil are aluminum and antimony. HIs exceed 1 for groundwater ingestion by all receptors evaluated and for showering by the resident adult. Noncancer COCs in groundwater (HQ > 1) are manganese and benzene. Aluminum is a lesser noncarcinogenic COC for groundwater.

There were no carcinogenic COPCs in subsurface soil therefore risks were not calculated to evaluate soil exposures. Cancer risks for the resident exposed to groundwater reach 2×10^{-4}. The carcinogenic COCs for groundwater are benzene, benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate (B2EHP), hexachlorobenzene, and pentachlorophenol (PCP) (except benzene, all risk estimates for groundwater are within the EPA target range (1×10^{-6} to 1×10^{-4}).

- ***Area T-38***—HIs for surface soil (0 to <1 ft BLS) exceed 1 for the resident and construction worker. The HI for the resident exceeds 1 for subsurface soil (1 to 12 ft BLS). The non-cancer COC in soil is primarily iron (HQ >1). Lesser COCs in soil are aluminum, chromium, and vanadium (HQs < 1); Groundwater HIs exceed 1 for the resident adult and child, and the industrial worker. Non-cancer COCs in groundwater are primarily (HQs >1) iron, manganese, carbon tetrachloride, and trichloroethene. Lesser COCs (HQs <1) are aluminum, barium, nickel, and 1,2-dichloroethene. Cancer risks exceed 1×10^{-4} for the groundwater exposures. Cancer-based COCs the resident exposed to groundwater are primarily 1,1,2,2-tetrachloroethane and carbon tetrachloride. Lesser carcinogenic COCs include tetrachloroethene, trichloroethene, and bis(2-ethylhexyl)phthalate.

- ***Range K***—Soil from Range K was field-screened for HD, GB, VX agents and was laboratory-analyzed for chemical warfare agent breakdown products. Target analytes (CWM) were not detected in any samples. Soil and groundwater pathways not fully evaluated for this site for non-CWM parameters. Comprehensive risk assessment was not conducted for Range K.

- ***Range J***—Soil samples collected from Range J were analyzed only for agent breakdown products. Because agent breakdown products were not detected in any of the samples, risk assessment for soils was not conducted at Range J. Risks for current land use were not calculated at Range J because none of the targeted analytes was detected in soils and there is no current groundwater usage at the site.

  Under future land use, noncancer HIs exceed 1 for the groundwater ingestion, dermal contact, and vapor inhalation pathways. The two COCs for noncancer effects are carbon tetrachloride and chloroform. Cancer risks reach 1×10^{-4} for the industrial worker. The cancer risks are above 1×10^{-4} for the residents. The COC for cancer effects is carbon tetrachloride, although chloroform, PCE, and 1,1,2,2-tetrachloroethane (1,1,2,2-PCA) are lesser COCs.

- ***Detection and Identification Area***—The maximum concentrations of iron in subsurface soil exceeded the SSSL. There are no COPCs under the current land use in any of the currently accessible media sampled at the D&I Area. All noncancer HIs and cancer risks are at or below the EPA targets (i.e., HI < 1 and cancer risk < 1×10^{-4}) for all receptors for future land use. Potential groundwater impacts have not been evaluated at this site.

- ***Range L***—The maximum concentrations of iron in surface soil, subsurface soil, and groundwater exceeded the SSSLs. Under current land use, all noncancer HIs are below the target HI of 1. The greatest cancer risk (1×10^{-6}) is for exposure to surface soil (0 to 1 foot BLS). Under current/future land use all noncancer HIs and cancer risks are below EPA targets (i.e., HI < 1 and cancer risk < 1×10^{-6}).

Under future land use, noncancer HIs for soil exposures to the industrial worker, the resident, and construction worker exceed 1. The noncancer-based COCs in surface soil are primarily aluminum and manganese, and, to a lesser extent, chromium, nickel, and vanadium; whereas, in subsurface soil the COCs are aluminum, chromium, and vanadium. The HIs for groundwater exposures to the industrial worker and resident also exceed 1. For groundwater, the primary noncancer COC is manganese with aluminum, cadmium, nickel, heptachlor epoxide, nitrate, and B2EHP as lesser COCs (i.e., with HQs of less than 1). When noncancer effects are segregated by target organ, manganese is identified as a COC based resulting from exposure to soil and groundwater. ANOVA indicates that the detected concentrations of manganese in the groundwater at Range L are indistinguishable from background. Based on the ANOVA manganese is eliminated as a COC for groundwater at Range L.

The greatest cancer risk for exposure to soil is 2×10^{-5} for inhalation exposures to chromium in surface and subsurface soil. For groundwater exposures, the cancer risk reaches 4×10^{-4}, primarily attributable to an isolated concentration of polychlorinated biphenyl (PCB) 1248. Lesser carcinogenic COCs for the groundwater are isolated concentrations of benzo(a)anthracene, benzo(b)fluoranthene, heptachlor, heptachlor epoxide, indeno(1,2,3-cd)pyrene, Royal Demolition Explosive (RDX), and B2EHP.

- ***Landfill #1***—The maximum concentrations of iron in subsurface soil and groundwater exceeded the SSSLs. The results of the ANOVA indicate that iron is not site-related in groundwater, but too few samples were collected to conduct the ANOVA for subsurface soil. Soil samples were not evaluated from the interior of the landfill site.

  Under current/future land use all noncancer HIs and cancer risks are below EPA targets (i.e., HI < 1 and cancer risk < 1×10^{-6}) at Landfill #1. Under future land use, noncancer HIs do not exceed 1 for any receptors exposed to subsurface soil. Noncancer HIs exceed 1 for the groundwater ingestion pathway for the resident. The primary COC for noncancer effects from exposure to groundwater is manganese. Lesser noncancer COCs for the groundwater are aluminum, barium, 1,3-dinitrobenzene, and nitrate. ANOVA indicates that the detected concentrations of manganese in the groundwater at Landfill #1 are indistinguishable from background.

- ***Landfill #2***—Soil analyses were not conducted at Landfill #2. Under current/future land use all noncancer HIs are below the target HI of 1 and cancer risks are all below 1×10^{-6}. Under future land use, noncancer HIs exceed 1 for groundwater exposures to residents. The primary noncancer COC in groundwater is manganese, with aluminum, beryllium, and chromium as lesser COCs. The greatest cancer risk for exposure to groundwater is 8×10^{-6}, mostly attributable to aldrin.

- ***Landfill #3***—COPCs at Landfill #3 are identified in soil, sediment, surface water, and groundwater. The maximum concentrations of iron in surface soil and groundwater exceeded the SSSLs. The results of the ANOVA indicate that iron is site-related in groundwater and subsurface soil. Under current and current/future land use all noncancer HIs and cancer risks are below EPA targets (i.e., HI < 1 and cancer risk < 1×10^{-6}) at Landfill #3. Under future land use, noncancer HIs exceed 1 for exposure to surface and subsurface soil. The primary COC for noncancer effects related to exposure to the surface soil is manganese (HQ > 1), and aluminum, chromium, and vanadium are lesser COCs (HQs < 1). ANOVA indicates that the concentrations of manganese detected in the surface soil at Landfill #3 are indistinguishable from background.

  For groundwater, HIs exceed 1 for all receptors evaluated. Noncancer COCs are primarily aluminum, chromium, manganese, vanadium, and trichloroethylene. Lesser COCs (HQs < 1) are barium, beryllium, cadmium, cobalt, copper, mercury, nickel, 1,1,2,2-PCA, 1,2-DCE, acetone, aldrin, dieldrin, endrin, PCP, vinyl chloride, and B2EHP. The greatest summed cancer risk for soil exposures is for the industrial worker, and is below 1×10^{-4}. For exposures to the groundwater, the cancer risk reaches 3×10^{-3} for the resident. Carcinogenic COCs for groundwater are primarily (cancer risk > 1×10^{-4}) 1,1,2,2-TCA, dibenzo(a,h)anthracene, PCP, and vinyl chloride. Lesser carcinogenic COCs (cancer risk > 1×10^{-6}) for the groundwater are 1,1,2-TCA, 1,4-dichlorobenzene, aldrin, benzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dieldrin, heptachlor, heptachlor epoxide, indeno(1,2,3-cd)pyrene, PCB 1248, PCE, TCE, alpha-BHC, beta-BHC, B2EHP, and lindane. Dieldrin and 4,4′-DDT were detected in the SI data but not in the RI data. In addition, alpha-BHC and endrin were detected at higher concentrations in the SI data than in the RI data.

- ***Old Water Hole***—The maximum concentrations of iron in subsurface soil and groundwater exceeded the SSSLs. The results of the ANOVA indicate that iron is not site-related in groundwater, but too few samples were collected to conduct the ANOVA analysis in subsurface soil. There were no COPCs in surface soil under current land use; thus, risks were not calculated for current land use at the Old Water Hole. Under future land use, noncancer HIs fall below 1 for the soil exposures to the resident. For groundwater exposures, HIs exceed 1 for the residential exposures. The primary noncarcinogenic COC (HQ > 1) is manganese. Lesser noncarcinogenic COCs (HQs < 1) include aluminum, barium, and aldrin. There were no carcinogenic COPCs to evaluate in soil. Cancer risks for exposure to the groundwater are greatest for the resident, reaching 3×10^{-4}. The cancer risk for groundwater exposures to the industrial worker reaches 1×10^{-4}. The primary carcinogenic COC for groundwater is dibenzo(a,h)anthracene. Aldrin, benzo(a)anthracene, benzo(b)fluoranthene, heptachlor, indeno(1,2,3-cd)pyrene, PCB 1248, RDX, alpha-BHC, and B2EHP are lesser carcinogenic COCs.

A screening-level ecological risk assessment (SERA) was conducted for ecological exposures to surface soil, surface water, and sediment at four of the 12 sites on the Fort McClellan Main Post and Pelham Range. Sampling was limited in scope at the remaining sites. The SERA was performed by screening maximum detected concentrations at each site in each medium against ecological screening values and background concentrations. Food chain modeling also was conducted for ecoCOPCs that are of bioaccumulative concern. Based on the results, a site is recommended for either no further action, additional sampling, refined SERA, or BERA.

It is important in the SERA process to avoid overstating conclusions, especially considering the conservative assumptions used in the SERA and the limited sampling data available for evaluation. EcoCOPCs were selected at each site where chemicals were detected. The selection of a chemical as an ecoCOPC indicates potential for adverse effects to ecological receptors. However, the results are based on maximum comparisons to ecological screening values and, in many instances, limited sampling data. Food chain HQs were above 1 at the four sites evaluated (Area T38, Range L, Landfill #1, and Landfill #3), also suggesting the potential for adverse effects. Again, the risks were based on maximum detected concentrations and limited sample sizes. Very limited, if any, chemical data were available for the remaining RI sites. These sites are recommended for additional chemical sampling and subsequent evaluation in a refined SERA. The surface soil HQs resulting from the abiotic screen were typically highest for aluminum, chromium, iron, and vanadium. In relation to the surface soil risks, surface water and sediment HQs were low. The primary risk driver for the food chain was aluminum. However, this risk was more from incidental ingestion than bioaccumulation in plants and animals. The food chain modeling did not evaluate chemicals that were not selected as ecoCOPCs but could bioaccumulate.

An evaluation of surface soil and/or sediment ecoCOPCs at Areas T-5, T-24A, T-38, Range L, Landfills #1, #2, #3, and the Old Water Hole is recommended in the form of a refined SERA. This refined evaluation would include components of a BERA (more realistic exposure assumptions) without the collection of biological data. Additional chemical sampling may also occur at Area T-4, Area T-5, Area T-24A, Area T-38, Range L, Landfill #2, and Landfill #3. The revised SERA also would incorporate any additional data. From this refinement, the need for biological sampling should be re-evaluated.

Additional information will be needed at the RI sites to assess exposure pathways that were not evaluated during the initial study and to further quantify the environmental chemistry in specific media. The following data are recommended for supplemental analyses:

Site	**Analyses**
Area T-4	Groundwater, soil (non-CWM analyses)
Area T-5	Groundwater, soil (non-CWM analyses)
Area T-24A	Soil (non-CWM analyses)
Area T-38	Surface water, sediment, soil gas, soil
Range J	Soil (non-CWM analyses)
Range K	Groundwater, soil (non-CWM analyses)
Range L	Soil/sediment inside pond (non-CWM analyses)
Detection and Identification	Groundwater, soil (non-CWM analyses)
Old Water Hole	Soil inside burial site
Landfill #1	Soil inside landfill boundaries
Landfill #2	Soil inside landfill boundaries
Landfill #3	Soil gas (source investigation); waste sampling

1. INTRODUCTION

Pursuant to a preliminary Site Investigation (SI) at 17 sites (SAIC 1993) on Fort McClellan and Pelham Range in Anniston, Alabama, a Remedial Investigation (RI) was conducted at 12 of the sites identified by the Department of the Army (DA) as warranting additional study. The DA implemented the environmental study of prioritized sites under the Installation Restoration Program (IRP) in 1991 to evaluate the effects of historical military usage of the properties. Subsequent to the completion of the RI, the installation was identified for closure by the Base Realignment and Closure (BRAC) Commission in 1995. The RI work conducted at Fort McClellan was initiated in 1993 by Science Applications International Corporation (SAIC) under contract number DAAA15-91-D-0017, Task Order 5 with the U.S. Army Environmental Center (USAEC) (formerly the U.S. Army Toxic and Hazardous Materials Agency [USATHAMA]). The project was transferred within the Army in 1997 and is presently under the direction of the U.S. Army Corps of Engineers (USACE), Mobile District in Mobile, Alabama. Field work for the project was conducted by SAIC with support from the U.S. Army Technical Escort Unit (USATEU) from Aberdeen, Maryland, and the Fort McClellan Environmental Management Office (EMO).

1.1 PURPOSE AND SCOPE

The objectives of the RI were to investigate the presence, nature, and extent of mission-related constituents resulting from previous controlled U.S. Army chemical warfare (CW) training activities and uncontrolled munitions and municipal waste disposal. The investigations included assessments of the sources of mission-related constituents, delineation of the areal extent of detected constituents, detailed geologic/hydrogeologic characterization of several of the sites, and assessment of potential human health and ecological impacts. The RI sites are summarized in Table 1-1 and include seven former chemical warfare training areas (Areas T-4, T-5, T-24A, and T-38; Range J; Range K; and Detection and Identification [D&I] Area), two reported munitions disposal sites (Old Water Hole and Range L [Lima Pond]), and three former municipal or demolition debris landfills (Landfills #1, #2, and #3). Study Area T-6 (Agent Decontamination Area), Area T-31 (Technical Escort Reaction Area), and Range I (Shell Tapping Area) were not included for additional study following the 1993 SI conducted under the IRP; however, these sites may warrant further investigation to address BRAC issues associated with property transfer. Two additional SI study areas (Old Toxic Training Area [OTTA] and HD Spill/Burial Sites) were not included for further investigation under the RI on the basis of limited areal extent and non-detection of chemical warfare materials (CWM) or CWM breakdown products (OTTA) or lack of substantive site information (HD sites).

The RI field activities followed site-specific project plans that include field sampling and laboratory chemical analyses conducted under project-specific quality assurance/quality control (QA/QC) and health and safety protocols. RI activities were conducted using U.S. Environmental Protection Agency (EPA) and USAEC guidance and available literature, including, but not limited to, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), *Data Quality Objectives for Remedial Response Activities* (EPA 1987), *Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual* (EPA 1991), *Geotechnical Requirements for Drilling, Monitor Wells, Data Acquisition, and Reports* (USATHAMA 1987), and *Quality Assurance Program* (USATHAMA 1990). The RI was conducted under a site-specific *Work Plan* (SAIC 1994a), *Field Sampling Plan* (SAIC 1994b), *Quality Assurance Project Plan* (QAPP) (SAIC 1994c), and the project *Health and Safety Plan* (HASP) (SAIC 1994d). Subsequent to the completion of the RI in August 1995, EPA Region IV guidance relevant to risk assessment was updated in November 1995 and EPA Region IV standard operating procedures (SOPs) were revised in 1996. Supplemental background sampling was conducted on the Main Post and Pelham Range in 1998 (SAIC 1998).

1.2 REPORT ORGANIZATION

The RI Report is structured in accordance with outlines provided in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). The contents of the report by section are presented below:

- ***Section 1. Introduction***—The remainder of this section summarizes the site background and history, describes processes and waste disposal history, summarizes previous studies and investigations, describes each study area under investigation, and discusses current site activities.
- ***Section 2. Environmental Setting***—This section presents the geographic and environmental setting at Fort McClellan. Physiography and topography, climate, demographics and land use, geology, soil, hydrogeology, hydrology, vegetation and habitats, and wildlife are discussed.
- ***Section 3. Methods and Procedures***—The rationale for all field investigation activities, methodologies, and sampling procedures is presented in this section. The section discusses methodologies for monitoring well inventory; aerial and topographic surveying; field screening; geological/geotechnical investigations; groundwater, surface water, and sediment sampling; hydrogeological and ecological investigations; and disposition of investigation-derived waste (IDW).
- ***Section 4. Results of Field Investigations***—This section provides a framework for understanding the potential environmental impact of detected mission-related constituents by first discussing the site-specific geology and hydrogeology at Fort McClellan. An assessment of data quality and the identification of the chemical constituents for all environmental media are provided. Discussions of the nature and extent of site-related constituents in groundwater, soil, surface water, and sediment are provided.
- ***Section 5. Chemical Fate and Transport***—This section discusses the physical and chemical properties of the site-related constituents and their expected fate and transport in soil, groundwater, surface water, and sediment. A conceptual site model for Fort McClellan also is presented that depicts the physiography and interaction of the surface water, soil, and groundwater. An explanation of the approach for the fate and transport analysis, the modeling conducted, and estimated uncertainty in the approach is provided.
- ***Section 6. Human Health Risk Assessment***—This section presents the results of the human health risk assessment, including the methodology, exposure assessment, toxicity assessment, a risk characterization that identifies the chemicals of concern (COCs), the development of remedial goal options (RGOs), and an evaluation of the uncertainty in the assessment.
- ***Section 7. Ecological Risk Assessment***—This section presents the results of the screening-level ecological risk assessment, including the environmental setting, abiotic toxicity screen, background screen, lines of evidence, and an evaluation of the uncertainty in the assessment.
- ***Section 8. Summary and Conclusions***—This section presents the recommendations and conclusions for each study area and lists the COCs for each media that will be used to prepare a Feasibility Study (FS) for sites potentially requiring remediation.
- ***Section 9. References***—This section lists the references that were used during the preparation of this report.

- ***Appendices***—The appendices to the report provide supporting information and data for the following activities: monitoring well inventory; land surveying; geophysical, geotechnical, and hydrogeologic investigations; ecological surveys and investigations; data quality assessment; chemical fate and transport estimates; and the human health and ecological risk assessments. The appendices also provide soil boring logs, monitoring well logs and construction diagrams, summary statistics for comparison of site data to background, summary data tables for laboratory analytical results, and state and Federal applicable or relevant and appropriate requirements (ARARs).

1.3 REMEDIAL INVESTIGATION OVERVIEW

Specific objectives of the RI considered delineation of the nature, extent, and magnitude of mission-related constituents at eight sites on the Main Post at Fort McClellan and four sites on Pelham Range. The goals of the RI program were achieved through extensive field screening for chemical warfare agent at sites T-4, T-5, T-24A, T-38, Range J, Range K, Range L, the D&I Area, and the Old Water Hole sites conducted in cooperation with USATEU; on- and off-Post drilling and installation of groundwater monitoring wells; groundwater, surface water, sediment, and soil sampling and analysis; geophysical surveying to detect, identify, and assess buried ordnance and former trenches; groundwater level measurements, and well (slug) testing. Groundwater samples also were collected from water supply wells in the city of Weaver and from a private well adjacent to the northwest corner of Fort McClellan.

The chemical and biological agent training sites under investigation during the RI were used for the controlled training of military personnel in various facets of chemical and biological warfare agent decontamination, detection, and munitions/agent disposal. Outdoor training at these sites occurred between the early 1950's and 1973, with activities involving various dilute chemical agents, including HD (mustard), sarin (GB), and O-ethyl-S(diisopropylaminoethyl)methylphosphonothiolate (VX). Limited, controlled application or sampling of fixed quantities of dilute CWM was typical during the training exercises. Training included kit detection of CW agents for field identification, agent ordnance disposal, field decontamination exercises, artillery firings, accident simulations, and live animal demonstrations (Small 1983). In addition, field equipment was contaminated with limited quantities of dilute agent for identification and decontamination training. Evidence of widespread dispersal or usage of CW or biological materials at the sites of concern has not been identified based on a review of records at the U.S. Army Chemical Museum at Fort McClellan, installation literature, and discussions with site personnel who were present during training exercises. However, the available literature indicates that training areas (i.e., T-24A, T-38) were routinely sprayed with decontamination solutions following each exercise (ESE 1984). USAEHA (1975) indicates that many of the early chemical training programs that were conducted at Fort McClellan by the Army and the Navy coincided with the development of CWM test kits (M-15, M-18, M18A1, and M18A2).

Documented evidence of munitions disposal activities at two sites on Pelham Range (Range L and Old Water Hole) is unavailable. Unsubstantiated, anecdotal information indicates that Range L was used for the disposal (in drums) of captured World War II munitions, including chemical munitions, and for the detonation of unexploded ordnance (UXO) (ESE 1984). The Old Water Hole site reportedly was used to dispose of a variety of munitions, including chemical munitions (USATHAMA 1977). Although the periods of activity at these sites are not specifically known, site features (pond, topographic depression) are identifiable on site maps and aerial photography dating to 1968. The disposal of municipal waste and demolition debris on Fort McClellan between 1945 and 1967 was conducted at three primary former landfill sites. Information regarding the disposal activities at Landfill #1 and Landfill #2 consists of aerial photograph documentation (Landfill #1) and field observations of surface debris

(Landfill #2). Landfill #3 was an active trench and fill landfill operation for the disposal of installation wastes between 1946 and 1967.

1.4 SITE BACKGROUND

Background information pertinent to the Fort McClellan RI was obtained from USAEC project files, information obtained from Fort McClellan, and literature reviewed from the U.S. Geological Survey (USGS), Alabama Geological Survey (AGS), EPA, Alabama Department of Environmental Management (ADEM), and National Oceanic and Atmospheric Administration (NOAA). The background information includes details of the facilities present on Post, site descriptions, regulatory history, prior environmental activities and investigations, meteorology, demography, geology, and hydrogeology. Interviews with site personnel were conducted during an Installation Assessment (USATHAMA 1977, ESE 1984) and an enhanced Preliminary Assessment (USACE 1990). Supplemental information was obtained during the course of the project through informal discussions with personnel currently assigned to the Fort McClellan environmental office, the Fort McClellan Chemical Museum, site personnel who may have had intimate knowledge of training activities, and site personnel who were involved with ordnance and CWM surface clearance. The information obtained from these conversations is cited throughout the RI Report.

1.4.1 Post Description

Fort McClellan is located in northeastern Alabama in Calhoun County, approximately 60 miles northeast of Birmingham, approximately 75 miles northwest of Auburn, and approximately 90 miles west of Atlanta, Georgia. The city of Anniston adjoins the main post on the west side of the installation (Figure 1-1). The city of Weaver is located approximately 1 mile northwest of the Main Post and the city of Oxford is approximately 5 miles south of Anniston. The Morrisville Maneuver Area, or Pelham Range, is located approximately 5 miles due west of the Main Post, and adjoins the Anniston Army Depot along its northern boundary. Fort McClellan consists of 45,679 acres of Government-owned and leased land situated in the foothills of the Appalachian mountains of northwest Alabama.

The Main Post includes administrative, mission, housing, and commercial buildings. Active training areas on the Main Post are utilized for smoke training exercises, hand grenade training, machine gun training, anti-terrorist training, explosive ordnance disposal (EOD) training, and military police training and additional military physical training. The Main Post also houses state-of-the-art chemical disposal training and chemical agent decontamination training facilities. Pelham Range is an active training area used for artillery firing, smoke operations training, and field training exercises. Adjoining the Main Post to the east is the Choccolocco Corridor, which is leased to the Federal Government by the Alabama State Legislature to provide an access corridor from the Main Post to the Talladega National Park. The size of each main parcel is as follows:

Main Post	18,946 acres
Pelham Range	22,245 acres
Choccolocco Corridor (leased)	4,488 acres
Total (approximate)	45,679 acres

1.4.2 Ownership and Operational History

Fort McClellan is presently under the jurisdiction of the U.S. Army Training and Doctrine Command (TRADOC). The installation houses three major organizations, including the U.S. Army Military Police School (AMPS), U.S. Army Chemical School (AMCLS), and Training Center (under the direction of the Training Brigade), in addition to other support units and tenants. The Federal Government purchased 18,946 acres of land near Anniston in 1917 for use as an artillery range. With the outbreak of World War I, the property (Camp McClellan) was used to train troops for participation in World War I and served in that capacity until the armistice. It then was designated as a demobilization center until 1919 when Camp McClellan served as a training area for active Army units and other civilian elements. Camp McClellan was redesignated as Fort McClellan in 1929 and continued to serve as a training area.

The government acquired an additional 22,245 acres (Pelham Range) west of Fort McClellan in 1940. In 1941, the Alabama Legislature leased approximately 4,488 acres to the Federal Government to provide an access corridor from the Main Post to Talladega National Forest. This corridor provided access to additional woodlands for training and maneuvers. Between 1945 and 1946, Fort McClellan served as a personnel separation point. After a 3-month closing period, it was activated as a Recruit Training Center until May 1947 when it ceased operation and was placed in an inactive status until 1951. The U.S. Army reactivated Fort McClellan in January 1951 for operation of the Chemical Corps School and as a replacement center for the Chemical Corps. The Chemical Corps School offered advance training in all phases of chemical, biological, and radiological warfare to students from all branches of the military service until the school was deactivated in 1973. The Army Combat Development Command Chemical/Biological Radiological Agency moved to Fort McClellan in 1962 and performed its mission until it also was deactivated in 1973.

The mission of the installation was changed in 1966 and Fort McClellan was renamed the U.S. Army School/Training Center and Fort McClellan. The 3rd Army non-Commissioned Officers Academy also was stationed at Fort McClellan from 1967 to 1972. Ongoing activities at Fort McClellan can be divided into support activities, academic training, and practical training. Support activities include housing, feeding, and moving individuals during training. Academic training includes classroom, laboratory, and field instruction. Practical training encompasses weapons, artillery and explosives, vehicle operation and maintenance, and physical and tactical training activities.

1.4.3 Process and Waste Disposal History

Historical information regarding the activities formerly conducted at the sites investigated under the RI program was obtained from ESE (1984), USATHAMA (1990), and SAIC (1993) and is provided in Table 1-2. Information regarding the physical and chemical properties, fate, and transport of the CWM, degradation products, and decontamination solutions is provided in Table 1-3. The chemical and biological agent sites under investigation during the RI were used for the training of personnel in various facets of chemical and biological warfare decontamination, detection, and munitions/agent disposal. Training at these sites occurred at various times between the early 1950's and 1973, with operations involving the controlled usage of various dilute chemical warfare agents and decontamination solutions, some of which have a history of usage on sites investigated during the RI. The chemical agents predominantly consisted of diluted concentrations of HD, the nerve agents VX and GB, and the biological simulants BG (*bacillus globigii*) and SM (*serratia marcesens*).

According to research by M.J. Small (1983) at the U.S. Army Medical Bioengineering Research and Development Laboratory at Fort Dietrich, Maryland, HD may hydrolyze in the environment by two routes depending on the volume of water available for the reaction. Well mixed (with water) or dissolved HD hydrolyzes to unstable hemi-mustard (CH) and thiodyglycol. The second route of HD hydrolysis consists of partially hydrolyzed HD in a soil-water environment, which may form sulfonium salts as a byproduct and "shield" HD droplets from rapid primary hydrolysis. Because the available information indicates that training activities were conducted using dilute (10 percent solution) quantities of HD and was followed with standard decontamination protocols, it is unlikely that sufficient HD is remaining in the site soils as a result of authorized training activities.

Sarin (GB) is a water-soluble, relatively non-persistent nerve agent that evaporates at approximately the same rate as water (Rosenblatt et al. 1995). Hydrolysis of GB in the environment produces hydrofluoric acid and isopropyl methylphosphonic acid (IMPA). The IMPA may further hydrolize to methylphosphonic acid (MPA). The nerve agent VX is more persistent than G-agents because of its low solubility and low vapor pressure which reduces its evaporation rate. Literature indicates that 90% of VX applied to soil would be lost in 15 days (Small 1983). Hydrolysis of VX produces ethyl methyphosphonic acid (EMPA) and diisopropylaminoethanethiol (DESH). Air oxidation of DESH can produce the compound bis(diisopropylaminoethyl) disulfide (EA-4196) which is a strong vesicant similar to HD. The compound S-(2-diisopropylaminoethyl)methylphosphonothioic acid (EA 2192) can be produced from the hydrolysis of VX at pH levels greater than 10 (Rosenblatt et al. 1995).

Live biological agents have not been used in outdoor training at Fort McClellan (USATHAMA 1977). The biological agent simulants *bacillus globigii* (BG) and *serratia marcesens* (SM) were produced in the laboratory for training purposes and relatively small amounts (4 to 8 ounces) were used in individual training exercises and excess simulant cultures were autoclaved (USATHAMA 1977). *Bacillus globigii* is a gram-positive, rod-shaped, spore-producing bacterium that is used to simulate conditions associated with biological attack by anthrax-producing (*bacillus anthracis)* biological agents. The microbial spores are commercially available as a conservative biological tracer for establishing retention times, transit time in rivers, tracking movement of wastewaters, tracing water movement in aquifers, and establishing sources of chemical contamination (Microbe Masters 1998). The *bacillus globigii* spores (0.5-0.8 μm by 1.0-5.0 μm) are generally non-infectious, but are capable of producing infection in a predisposed, compromised host. The laboratory-produced spores are highly persistent, potentially remaining viable in the environment for years (Osterhout 1988 in *Zinser Microbiology* and may be found in soil and plant litter.

Serratia marcesens is a rod-shaped, non-spore forming, red-pigmented bacterium (0.5-0.8 μm by 1.0-5.0 μm) that was used to simulate the airborne dispersal of biological agents in the environment. The organism occurs in soil and water and are found associated with a number of plants and animals, including insects (Zwadyk 1988 in *Zinser Microbiology).* Military applications of the organism are as aerosol sprays. Although documentation of the actual mode of use of the organism at Fort McClellan has not been identified, there are documented large-scale applications of the simulant over metropolitan areas in the United States. The bacteria may be transmitted by direct contact of mucous membranes with the infectious agents, however, the bacteria is not directly transmitted from person to person. Physical inactivation of the organisms is achieved by application of moist heat (121° C for 15 minutes), dry heat (170° C for 60 minutes), application of intense ultraviolet energy, or application of disinfectants including sodium hypochlorite, ethanol, glutaraldehyde, iodines, phenolics and formaldehyde. The *Serratia marcesens* bacteria has been identified as an opportunistic human pathogen that is associated with urinary and respiratory tract, pneumonia, and wound infections in hospital patients. Hospital outbreaks have been associated with contaminated respiratory equipment (Zwadyk 1988 in *Zinser Microbiology)* or irrigation fluids. Decontamination of the biological simulants is achieved using a 0.5 percent sodium hypochlorite solution or DS2.

The persistence of CWM, agent degradation byproducts, decontaminants (DS2 [70 percent diethylenetriamine, 2 percent sodium hydroxide, and 28 percent ethylene glycol monomethyl ether]), super tropical bleach (STB), and byproducts from the reactions of agent with decontaminants has been evaluated for soil at Fort McClellan (Small 1983). Based on the solubility, volatility, toxicity, and formation potential of the compounds evaluated, Small (1983) concluded that the only potentially persistent toxic compounds in the subsurface soils at Fort McClellan are HD and bis(2-diisopropylaminoethyl) disulfide $(DES)_2$. The latter compound is the principal byproduct formed from the decontamination of VX with DS2. The limited quantities of VX used on these sites reduces the potential for sufficiently large quantities of DES_2 to be of significance as an environmental contaminant in soil on the Post. Based on similar considerations, ESE (1983) concluded that toxic compounds with the potential to persist in groundwater included divinyl sulfide, mustard sulfoxide (HO), DES_2, and S-(diisopropylaminoethyl) methylphosphonothioate (DESMP). Divinyl sulfide is formed from the alkaline hydrolysis of HD with DS2, and HO is formed from the oxidation of HD with STB. DESMP is formed from the hydrolysis of VX. Although the potential exists for these compounds to be present in groundwater, detection is unlikely because of the limited quantities of agents used and decontaminated during training exercises.

The potential for the decontamination byproducts to be present in the environment is based on theoretical reactions that may occur as a result of decontamination activities and depends on the amount of agent available for decontamination. The formation of these reaction products is based on the theoretical interaction of pure phase chemical agent with the decontamination solutions. Because of the concentration (10 percent solution), quantities of the agents used during training, and the manner of usage, detection of these compounds in groundwater was determined by the DA to be unlikely. Chemical constituents that are associated with the use of decontamination (STB, DANC, DS2), and CNB solutions include benzene, carbon tetrachloride, tetrachloroethene, trichloroethene, 1,1,1-trichloroethane, and 1,1,2,2-tetrachloroethane. The chemical composition of the decontamination solutions is summarized in Table 1-3.

There has been no evidence of HD, GB, or VX detection above the 0.8 TWA (time weighted average) at the RI sites based on Miniature Continuous Air Monitoring System (MINICAMS®) screening of surface and subsurface soils from higher probability locations. Field-screened samples from these locations were analyzed for HD, GB, or VX breakdown products by an analytical laboratory. The MINICAMS® screening is a standard protocol used by the Army to detect CWM in the environment. The primary route of degradation for HD, GB, and VX in the environment is by hydrolysis to alkyl methylphosphonates with potential secondary hydrolysis to methylphosphonic acid. The aqueous hydrolysis reactions are readily catalyzed by a variety of chemicals (metal hydroxides, hypochlorite) that accelerate the degradation in soil (Kingery and Allen 1994). Biological simulants were only reported to have been used at Area T-4.

Constituents that are associated with uncontrolled burial of chemical or conventional munitions may include the previously detailed chemical agents and decontaminants, in addition to explosive compounds and their breakdown products and leachable metals. The widest possible spectrum of potential constituents may result from uncontrolled landfill areas where a variety of municipal wastes, construction/demolition debris, possible training materials and byproducts, and uncontrolled mission-related wastes may have been buried.

1.4.4 Previous Environmental Studies at Fort McClellan

Assessments of environmental conditions on Fort McClellan and including the RI sites have been conducted since the early 1970's and have included, but are not limited to, the following investigations:

- USAEHA (1975) documented a 2-year investigation into the status and historical use of chemical, biological, and radiological (CBR) training areas. Based on a limited records review and interviews, USAEHA identified 12 areas at Fort McClellan and the Pelham

Range that were possibly contaminated. Restricted access and inclusion in future land restoration and recovery programs were recommended for these areas.

- An installation assessment consisting of records reviews, personnel interviews, and field inspections was conducted in 1977 (USATHAMA 1977). During this assessment, chemical or radiological burial grounds and training areas were identified within the facility. In addition, records indicated that UXO may be present in several training areas. The assessment concluded that CBR constituents were not detected in surface water at Fort McClellan and that a potential may exist for groundwater degradation from documented landfill operations.
- Based on an extensive literature review of fate and transport of chemical agents, decontaminants, agent decontaminant byproducts, and past onsite CBR training practices, Small (1983) identified the potentially mobile groundwater and soil constituents on Fort McClellan and the Pelham Range. The persistence and potential exposure pathways for various chemical breakdown scenarios were investigated.
- The 1977 installation assessment conducted by USATHAMA was re-evaluated and integrated with updated data by ESE in 1984. This study was limited to chemical agents and restricted compounds and resulted in 21 site-specific assessments. The study concluded that Area T-24A, Area T-38, Range J, and Range L had the potential to be impacted by chemical agent or agent breakdown products in either the subsurface soil or groundwater.
- Various U.S. Army agencies, including the Fort McClellan Chemical School and USAEHA, conducted limited surface soil sampling and screening operations at the following sites between 1972 and 1980: Area T-5, D&I Area, Range K, Area T-38, Area T-24A, Range J, Range L, and Landfill #3 (ESE 1984). Field testing for chemical agents was negative in all known samplings and the areas were cleared for surface usage.
- USAEHA conducted an investigation at Fort McClellan in 1986 to identify all solid waste management units (SWMUs) on Post. USAEHA (1986) formally identified 41 SWMUs on Fort McClellan and the Pelham Range. Each SWMU was located, described, and evaluated to the extent possible. Five monitoring wells were installed by the agency at Landfill #3 as part of the investigation.
- An enhanced Preliminary Assessment (PA) was conducted by Roy F. Weston, Inc. in 1990 (USATHAMA 1990) to evaluate the status of active non-Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and inactive CERCLA sites potentially impacting the U.S. Army's planned closure of Fort McClellan. The PA identified 62 active and inactive sites on the Main Post and Pelham Range.
- The U.S. Army Corps of Engineers, Mobile District conducted an investigation in 1991 to evaluate soil and groundwater in the vicinity of five existing or excavated underground storage tank (UST) sites in the northwestern portion of the Main Post. The investigation focused on USTs used for storing petroleum products, including gasoline, diesel, and diesel-based fuel oil. Twenty monitoring wells were installed at these sites during this investigation. Petroleum-related compounds were documented in groundwater and/or soils at four of the five UST sites (Ecology and Environment, Inc. 1991).
- USAEC initiated a Site Investigation (SI) in 1991 at 17 sites identified in the PA on the Main Post and Pelham Range. The investigated areas included 3 former landfill sites (Landfills #1, #2, and #3), 2 potential ordnance disposal areas (Old Water Hole and Range L), and 12 former chemical training areas (Areas T-4, T-5, T-6, T-24A, T-31, and T-38; Ranges I, J, and K; Old Toxic Training Area, HD spill sites, and the D&I Area). Based

on limited environmental sampling of groundwater, surface water, and soil, MINICAMS® screening, potential environmental concerns were identified at 12 of the SI sites (SAIC 1993).

- A hydrogeological evaluation of the former Fort McClellan sanitary landfill site (Landfill #4) was conducted by ADEM (1993) as a component of the overall permit review process. Leachate seeps were observed at the toe of the landfill and along man-made drainage ditches near the site boundary. A program of quarterly groundwater monitoring was implemented by Fort McClellan in 1994 for five wells located around former Landfill #4. Elevated lead (ND to 205 μg/L), arsenic (ND to 23 μg/L), chloride (10 to 482 μg/L), and total organic halogen (ND to 210 μg/L) concentrations were detected in the wells in 1994 (ECG, Inc. 1994).

1.5 SITE DESCRIPTIONS

Physical descriptions of the 12 sites investigated under the Fort McClellan RI are summarized below. Information pertinent to the sites was obtained from USATHAMA (1977), USATHAMA (1990), ESE (1984), and USAEHA (1977, 1986); site visits conducted by SAIC between 1991 and 1994; and the 1993 site investigation report (SAIC 1993). The site locations are shown in Figures 1-2 and 1-3.

Site 1 – Area T-4—Area T-4 (Figure 1-4) was reportedly a Biological Simulant Test Area located on the Main Post. Records indicate that the 0.25-acre site was used by the U.S. Navy between 1965 and 1971 for biological simulant (BG and SM) training (USAEHA 1975, USATHAMA 1977). Documentation of biological simulant training on Fort McClellan dates back to 1952 (USATHAMA 1977); however, the location of the training is not specified as Area T-4. Area T-4 also has been previously cited as a possible location of an HD storage area and an unconfirmed, 110-gallon distilled HD spill in 1955 (ESE 1984). A 1973 U.S. Army photograph (Figure 1-5) of Area T-4 shows a circular disturbed area centrally marked by a concrete monument. Similar concrete markers at Fort McClellan have been associated with former training site locations or burials. Area T-4 has been extensively rearranged, including the removal of the concrete monument, and no evidence of a former site is apparent. Topography across the identified site area ranges from 860 feet above mean sea level (msl) to approximately 880 feet above msl sloping to the north and west. Area T-4 was not investigated during the 1991 site investigation (SAIC 1993) because of the extensive site rearrangement and the inability to locate specific training sites in the area. The study area originally was identified by personnel from Fort McClellan and the perimeter subsequently was staked using survey coordinates in the 1977 USATHAMA installation assessment.

Site 2 – Area T-5—Area T-5 is the Toxic Hazards Detection and Decontamination Training Area located between Sunset Hill and Howitzer Hill. The locations of suspected or potential chemical warfare agent training sites are shown in Figure 1-6. The 11.4-acre wooded site was used between 1961 and 1973 to train students in the methods of detecting and decontaminating toxic agents, including HD, VX, and GB. The quantities of dilute agent used for training purposes ranged from 20 to 40 milliliters per exercise. The training sites reportedly were decontaminated and checked using test kits at the end of each exercise. Decontamination of the residual agent on site soils was completed by adding STB and/or DS2. Former training locations at Area T-5 are marked by concrete monuments. Concrete building foundations are also present, indicating the former presence of building structures on the site. Photographic documentation of training activities at Area T-5 is shown in Figure 1-7.

In addition to HD, GB, and VX used during training, Area T-5 may have been the location of an unconfirmed 110-gallon HD spill (ESE 1984). The spill has been reported in the PA and Enhanced PA as anecdotal and as having occurred alternately either at Areas T-4 or T-5. There is no file information to confirm that the spill occurred at either of these sites. These reports indicate that the contaminated soil from the spill area was chemically decontaminated, removed, and ultimately disposed of at Range J on Pelham Range. Range J contains drums of soil in a shallow pit; however, documentation of the spill from the Main Post to the burial at Range J is not available. Surface soil samples from Area T-5 were analyzed in 1972 and 1973 by U.S. Army personnel and did not indicate the presence of residual CWM (Vanderbleek 1973 and Tedeschi 1973 in ESE 1984). Training ordnance was observed on the site by SAIC in 1991 and during the sampling activities in 1994. Previous soil MINICAMS® screening from high-probability locations for the presence of CWM (HD, GB, and VX) did not detect these compounds above instrumental baseline at the former training area (USATEU 1992, SAIC 1993). Chemical agent degradation products were not reported in site soil above the laboratory detection limits (SAIC 1993). A tributary of the south branch of Cane Creek flows along the eastern site boundary and receives runoff from Area T-5. Topography across the study area ranges from elevation 825 feet above msl to 935 feet above msl sloping steeply from west to east.

Site 3 – Area T-24A—Area T-24A is a 1.5-acre former EOD training area located within Range 24A south of Holloway Hill (Figure 1-8) that was used until 1973 for chemical munitions decontamination and disposal, and training with phosgene (CG), BZ, GB, and HD agents. Surface topography at the site slopes to the northwest and ranges in elevation between approximately 1,040 to 1,012 feet above msl. Surface drainage from the fenced site is to the northwest toward a tributary of the south branch of Cane Creek. A concrete monument (Base E) was located approximately in the center of the fenced site area to mark a former training location or burial.

Two square burning pits, each 16 feet on a side, were used for training exercises and were enclosed by a fenced area measuring 130 by 260 feet. The original fenced area was replaced by the current fence after the 1977 site assessment (USATHAMA 1977). The depths of the pits are unknown; however, SOPs recommended a depth of 6 feet. The fenced area was checked using field portable detection kits by U.S. Army personnel following each training exercise and the area was sprayed with STB (ESE 1984). The training pits reportedly were filled with soil at closure. Surface depressions were observed within the fenced area in 1988 and are observable on historical aerial photographs of the site (Figure 1-9). The photography also shows disturbed areas immediately adjacent to and outside the currently fenced area. An inventory of training aids requiring decontamination in April 1973 included 183, 105- and 155-mm projectiles (Vanderbleek 1973 in ESE 1984). The current site area (approximately 220 by 350 feet) is controlled by a rectangular, 6-foot high, chain-link fence with a single, locked access gate. Approximately 4.46 kilograms of HD reportedly were used during each training exercise; however, first-hand observers reported that as much as 2 gallons of HD were poured on six howitzers and later on armored personnel carriers during training exercises (G. Harvey, written communication 10/7/92). In addition, 40 milliliters of CG, one M-6 canister of BZ, and 740 grams of GB were used per exercise. Limited soil sampling was conducted at the site during the 1991 SI study. MINICAMS® screening of four shallow (1 to 5 feet deep) soil samples during the SI from two locations in the northwestern portion of Area T-24A did not detect the presence of HD or GB chemical agent (USATEU 1992, SAIC 1993). CWM breakdown products in the shallow soils were not detected during laboratory analysis of samples from the screened locations (SAIC 1993).

Area T-24A is located within a multiple-usage, active training range (Range 24A) where various activities, including petroleum, oils, and lubricants (POL) storage, smoke training, and onsite demonstrations including demolition and flame field expedient (FFE) were held. The FFE training on the range included "wall of flame" training where 50 to 100 gallons of MOGAS thickened with M4 was poured into an unlined trench and ignited and also included detonation of containers of thickened MOGAS (2 liters to 55-gallon drums). These training activities took place on the range approximately

30 times per year between 1981 to 1987 and decreased to 2 to 3 times per year between 1987 and 1995 (K. Pinson [FTMC], written communication 2/7/97). Portions of Range T-24A in the vicinity of Area T-24A were used for military training as early as 1949, as documented by historical aerial photographs (EPA 1983). Range activities between 1941 and 1996 also included usage as an artillery impact area with rifle and pistol ranges (K. Pinson [FTMC] written communication 2/7/97). Materials used at Range 24A have included C-4 explosives, trinitrotoluene (TNT), detonation cord, M4 bursters, blasting caps, simulants, smoke, and trip flares (FTMC 1987).

Site 4 – Area T-38—Area T-38 (Technical Escort Reaction Area, formerly Old Toxic Agent Yard) is located on the Main Post along the crest of Reservoir Ridge (Figure 1-10). The 6-acre site was used between 1961 and 1972 for training escort personnel in techniques of eliminating toxic hazards caused by mishaps involving chemical munitions during transport. Military activities reported at the site included artillery shell tapping (CG-filled mortar rounds), CWM (HD) transfer training, and filling of aerial smoke tanks (ESE 1998). The area also was used to store, demonstrate, or dispose of toxic agents and munitions, including GB, VX, and HD. Storage of CWM at the site (ESE 1998) consisted of four 1-ton containers of HD in addition to unspecified decontamination agents (possibly STB and DS2). Extensive decontamination was conducted on this site for reported spills and contaminated training aids, including a railroad flat car (ESE 1984). In addition, unspecified decontaminants (likely STB, CNB, DS2, or DANC) were stored onsite (Buildings 4452 and 4453), used for demonstration purposes, and disposed of onsite. Liquid materials, including tetrachloroethane, were reportedly poured into an unlined pit (sump) measuring approximately 10 feet by 20 feet by 10 feet deep that was used to dispose of decontaminants and other hazardous wastes at the site (G. Harvey, written communication 10/7/92). The sump area was approximately located in the field by Fort McClellan personnel in April 1992 and from geophysical surveys and aerial photographs (Figure 1-11). In addition, there is a report (G. Harvey, written communication 10/7/92) of the burial of a drum of chemical agent (mustard) in the southern portion of the site in approximately 1963. The *Environmental Baseline Survey* (EBS) Report cites interviewees that locate the approximate drum burial in the west-central portion of Area T-38 (ESE 1998). Efforts during the SI to determine the precise location of the drum using geophysical methods were unsuccessful. Chemical screening (MINICAMS®) and analysis of shallow soil samples obtained from high-probability sample locations on Area T-38 did not detect the presence of CWM (HD, GB, or VX) or agent breakdown products at the sampled locations (USATEU 1992, SAIC 1993).

Surface drainage from Area T-38 is predominantly to the east from the crest of Reservoir Ridge with topography ranging from elevation 1,035 feet above msl in the southwest portion of the site to elevation 975 feet above msl in the northeast corner of the site. The nearest surface water body to the site is Cave Creek and its tributaries, which occur approximately 1,500 to 2,100 feet north and east of the site. The perimeter of Area T-38 is controlled by a 6-foot high chain-link fence with a single, locked access gate. Internal fences also are present between portions of the site; however, access is generally unrestricted within the site boundaries. The fenced site area includes the remnants of former training facilities, including buildings, decontamination pads, bleachers, and storage racks.

Site 5 – Range K—Range K was a 2-acre agent training and shell tapping area located on Pelham Range (Figure 1-12). The site is located in a valley flanked by northeast-southwest trending topographic ridges. Surface topography ranges between 570 to 610 feet above msl in the immediate site area. A reported shell tapping area where rounds were opened and decontaminated was operated at Range K prior to 1961 and continued through the summer of 1963 (G. Harvey, written communication 10/7/92). During training exercises, breaking open one 155-mm round of HD, one 105-mm GB, and one 4.2-mortar round of CG was standard practice (G. Harvey, written communication 10/7/92). The identified site has been physically rearranged (bulldozed) and records indicate that the area was cleared for surface usage in 1967. Spent rounds, DANC cans, and DS2 cans were observed by USAEC beyond the tree line to the south and west in November 1992 (T. Perry, written communication 1992) and have been confirmed during subsequent site visits. The U.S. Army presently uses Range K and the surrounding area for ongoing military training maneuvers and bivouac activities. The site was located based on coordinates in the 1977 USATHAMA installation assessment and on the location of a downed fenceline. An ephemeral stream channel occurs southeast of the site and intermittently flows southwest toward Range L and Cane Creek. Limited sampling was conducted at Range K during the 1991 SI study.

Site 6 – Range J—Range J was formerly an agent training area located on the north-central portion of Pelham Range (Figure 1-13). The 60- by 150-foot (0.2-acre) fenced area was used until 1963 for training and agent-contaminated soil disposal. The fenced area investigated during the RI is a small portion of a larger (approximately 60-acre) training area in use as early as 1954. The agents used at the site are unknown, but are believed to be HD. The site was reportedly used for disposal of a 110-gallon HD spill that occurred on the Main Post in 1955. Drummed soil in a surface pit at the site was observed during site walkovers in October 1991, April 1992, and September 1993. The drums are extensively corroded. Previous soil sampling and MINICAMS® screening (SAIC 1993) did not indicate the presence of residual HD or HD breakdown products in the soil contained within the drums or from other high-probability sample locations (USATEU 1992, SAIC 1993) within the fenced enclosure. A concrete monument is located inside the fenced enclosure near the entrance gate. Surface topography at the fenced area is generally flat over three-fourths of the site and slopes to the northwest in the western portion of the site in the vicinity of the drum burial location. Site access is controlled by a 6-foot high, chain-link fence with a single, locked access gate.

Site 7 – Detection and Identification Area—The D&I Area is located on the Main Post north of Area T-5, between Sunset Hill and Howitzer Hill. The 1.1-acre site (Figure 1-14) was used from the early 1950's to 1973 for GB and HD training at the site. The U.S. Navy conducted live mustard exercises in the D&I range in 1955 (USAEHA 1975) coincident with the development of the M-15 test kit. The former training area was completely cleared of vegetation during the time of its use for training (Figure 1-15) but is now completely re-vegetated and forested. Surface topography at the site slopes gradually to the northeast ranging from 822 to 835 feet above msl in the immediate site area. Training routinely consisted of the use of test kits to detect and identify dilute agents contained in 40-mL vials. Agents often were mixed as a 10 percent solution with water. The agent simulants cyanogen chloride (CK), phosgene oxime (CG), CX, and hydrogen cyanide (AC) also were reportedly used in the training area. All training aids from this site and a building from Area T-4 were burned twice in a dug pit and buried. The remains are reportedly still located in the pit. The pit containing the burned materials is identified by concrete monument F, which was located during a walkover in October 1991. MINICAMS® screening for HD and GB and soil samples analyzed for CWM breakdown products did not detect the presence of CWM or breakdown products in the site soils during the 1991 SI study (USATEU 1992, SAIC 1993).

Site 8 – Range L (Lima Pond)—Range L was reported to be a chemical munitions disposal area located on Pelham Range (Figure 1-16). The 0.3-acre site reportedly was used to dispose of captured World War II munitions, including chemical munitions. According to Post personnel, a shallow man-made pond (Lima Pond) was used as a dump site for the munitions. Surface topography at the site generally slopes radially away from the bermed area with an overall topographic slope to the northwest ranging between 560 and 594 feet above msl. The pond is within a bermed area that is approximately 10 to 15 feet higher topographically than the surrounding wooded terrain. The pond is estimated to be approximately 14 feet deep from the top of the berm, although the actual depth of potential burials below the pit bed is unknown. The bermed area was reportedly used for detonating ordnance (FCG Watson, personal communication with R. Levy [FTMC-EMO] 1995); however, there is a general absence of metal shards or exploded materials that have been characteristically observed at other ordnance disposal sites.

An alternative assessment of the site suggests that the pond may be a former borrow pit from which soil was excavated for use as fill or berm material (C. Whitten [CEWES], personal communication 1995). Ammunition storage cases have been found within the fenced enclosure. Previous surface soil sampling by the U.S. Army (1980 and 1982) did not indicate the presence of mission-related constituents at the site. Pond water samples collected for analysis of HD, GB, and VX by the Army in 1982 did not detect those compounds (USAEHA 1986, USATEU 1992). USATEU detected quantities of metallic debris in the pond area based on a qualitative metal detection survey (SAIC 1993). The quantity of surface water within the pond is dependent on the frequency and amount of rainfall and evaporation. Access to the pond site is controlled by a locked steel gate that restricts vehicular movement on the unpaved road leading to the site. The pond area is controlled by a 6-foot high, chain-link fence with a single, locked access gate.

Site 9 – Landfill #1—Landfill #1 operated as the Post sanitary landfill between 1945 and 1947. The identified site area covers approximately 11 densely wooded acres and is located between 16th Avenue and Avery Drive, adjacent to the floodplain of an unnamed intermittent stream draining into Remount Creek (Figure 1-17). The site slopes steeply to the southeast toward 16th Avenue. Information concerning the operation or content of the landfill is not available. The site location on a steep incline is not characteristic of a typical landfill operation; however, the slope may have provided a convenient location for surface dumping. Landfill debris is not visible on the slope area and releases have not been observed during the site preliminary assessment (USATHAMA 1990) or during subsequent site visits by SAIC and USAEC. Aerial photographs of the site dated 1944, 1954, 1957, 1961, and 1969 (Figure 1-18) indicate that portions of the area were cleared and possibly trenched. The slope area topographically above the inferred landfill site has been partially filled to accommodate military housing. A magnetometer survey conducted in 1992 over seven transects at the site (SAIC 1993) did not indicate the presence of large-scale landfilling over the survey area. The geophysical survey extended beyond the landfill boundaries as they were estimated at the time of the survey and extended approximately to Galloway Road. The site boundaries were revised in 1993 based on historical aerial photography. The predominant magnetic anomalies identified during the 1992 geophysical survey occurred along the southwestern portion of the surveyed area in the vicinity of the currently known landfill boundary.

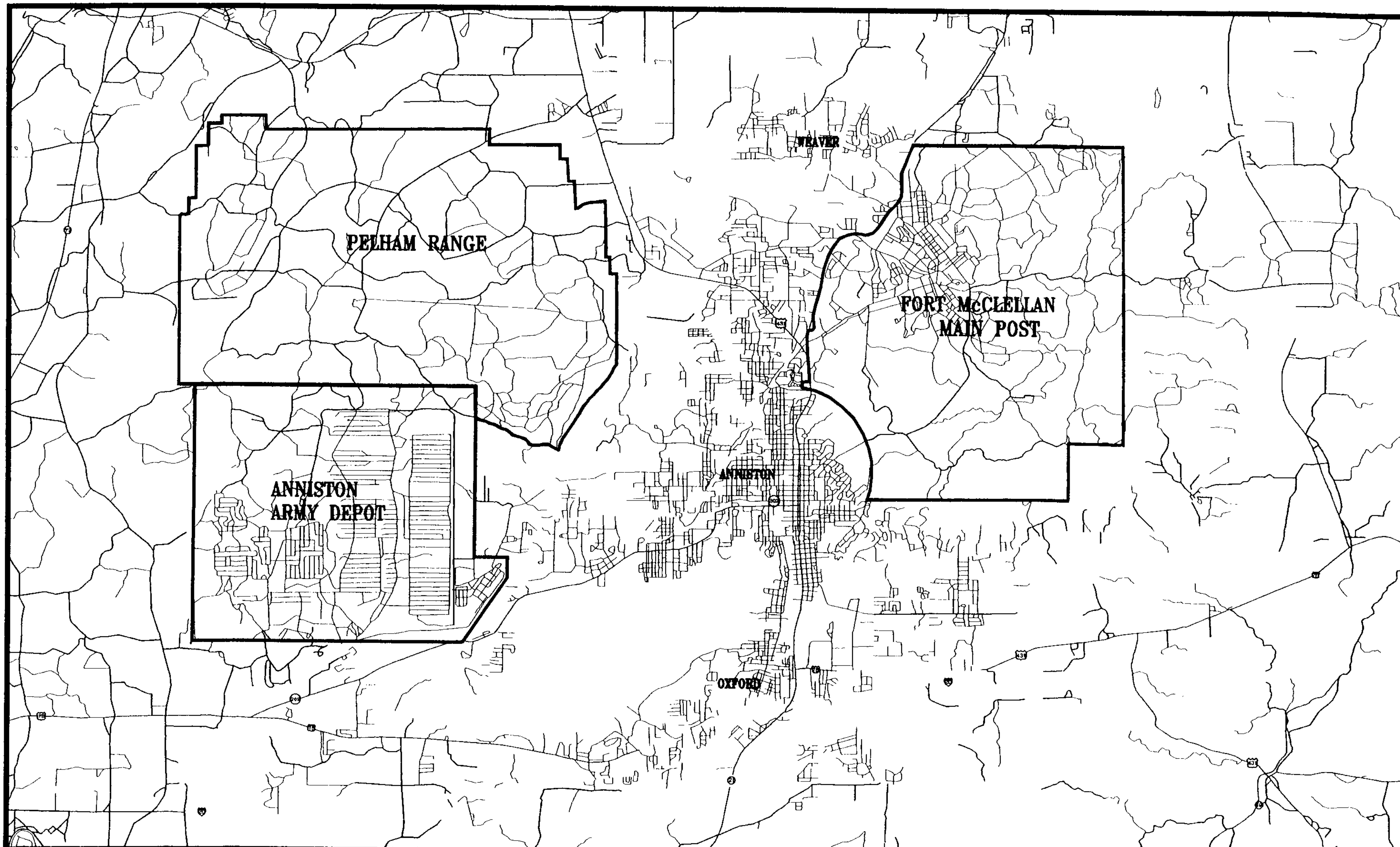
Site 10 – Landfill #2—Landfill #2 was used as the Post sanitary landfill after the closure of Landfill #1 and was active from 1947 to an unknown date (Figure 1-19). The relatively small size of the site (approximately 1.5 acres) and apparent surface disposal suggests that the site was not active for a long time. The landfill is located west of the southern tip of Cemetery Hill, between 2nd Avenue and 10th Street. This site is heavily vegetated and wooded and is located in the floodplain of Cave Creek, which flows south-southeast of the landfill (Figure 1-20). Shallow, weathered bedrock was observed in the creek bed. The EBS Report (ESE 1998) identifies the area at Landfill #2 as the site of a former incinerator that was operated as early as 1927. A crescent-shaped "refuse dump" also was identified on a 1937 map of the Post (ESE 1998). The landfilled area reportedly was used to dispose of unspecified "waste" during deactivation of the installation (USAEHA 1986). Rusted drums, metal, small containers (5-gallon cans and bottles), assorted building materials, and machinery parts were observed at the site in October 1991. Releases from the site have not been documented and evidence of releases (leachate seeps) was not observed during SAIC's initial site visit in 1991 or during subsequent site visits. Demolition debris (asphalt, concrete, and glass) was exposed at the landfill by road-building operations during the 1992 site investigation (SAIC 1993). Laboratory analyses for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides/polychlorinated biphenyls (PCBs), agent breakdown products, and explosives during the 1991 SI (SAIC 1993) did not indicate the presence of mission-related groundwater constituents associated with the site.

Site 11 – Landfill #3—Landfill #3 was the Post sanitary landfill in operation between approximately 1946 and 1967 (Figure 1-21). The landfill was operated using the trench and cover method, with linear trenches trending northwest to southeast. Traces of the trenches due to settling over the old landfill cells have been noted in the past and also have been observed on high-altitude aerial photographs (Figure 1-22). Evidence from available aerial photography indicates that trenches were excavated one at a time and that multiple trenches were not used simultaneously during landfill operation. The area of the former landfill has been replanted and currently supports a dense stand of pine trees. The landfill covers approximately 22 wooded acres and is located east of State Route 21 and north of Cane Creek. This location is northwest of and adjacent to the recently closed sanitary Landfill #4. Access to the landfill area is obtained along unpaved perimeter roads. Groundwater flow across the landfill is to the north and west. Surface topography in the immediate vicinity of the former landfill is relatively flat (elevation 740 feet above msl). North of the landfill, the topography slopes to the north ranging from elevation 725 to 745 feet above msl. The landfill is bounded to the north and west by a man-made drainage ditch. Leachate seeps were observed (R. Hicks, written communication 4/21/93) at the toe of the landfill along the drainage ditch. Two topographic mounds (elevation 750 feet above msl) are located adjacent to the southeast corner of the landfill site.

Landfill #3 was in operation for the longest period of time and has the most documentation of trenching and disposal activity of all of the investigated landfill sites. In addition to municipal waste disposal, one SOP required that dead experimental animals be decontaminated, bagged in plastic, and disposed of in sanitary landfills (USATHAMA 1977). A 1969 SOP for the handling of dead animals resulting from nerve agent effects demonstrations indicates that the carcasses were to be incinerated at the Post hospital after decontamination (USATHAMA 1977). Landfilling practices at the recently closed sanitary Landfill #4 located adjacent to Landfill #3 were described by USAEHA (1975) as a progressive trench method where excavation and disposal occurred simultaneously in two parallel trenches. Excavated trenches were approximately 15 feet wide and 12 feet deep and were excavated using a dragline. The disposed refuse was first tamped in place and the excavated soil was applied as a side and top cover. Landfilling practices were likely to have been similar at Landfill #3 during its period of operation.

Historical groundwater sampling at Landfill #3 has indicated the presence of VOCs, SVOCs, pesticides, metals, and explosive compounds (USAEHA 1986, SAIC 1993). Groundwater samples also were analyzed for chemical agent (HD, GB, VX) breakdown products (SAIC 1993). Organic compounds detected in the wells included trichloroethylene (3.8-6.3 μg/L), 1,1-dichloroethane (9.6 μg/L), 1,1,2,2-trichloroethane (17-22.1 μg/L), benzene (1.9 μg/L), methylisobutyl ketone (3 μg/L), bis-2-ethylhexylphthalate (17-36 μg/L), tetrachloroethene (1.7-4.3 μg/L), and a variety of pesticides. Organic compounds exceeding established EPA (November 1991) maximum contaminant levels (MCLs) included 1,1-dichloroethane (OLF-G04) and trichloroethylene (OLF-G07). The explosive compounds 1,3,5-trinitrobenzene (1.7 μg/L) and 2,4-dinitrotoluene (0.773 μg/L) were detected in well OLF-10 south of Landfill #3. Chemical agent breakdown products were not detected in the groundwater samples collected at Landfill #3. Heavy metals, including arsenic (2.79 to 7.87 μg/L), mercury (0.191 to 1.49 μg/L), zinc (19.6 to 576 μg/L), and lead (1,470 μg/L), were detected in groundwater surrounding the site. USAEHA (1986) detected concentrations of tetrachloroethene (50 to 110 μg/L) 1,1-dichloroethane (18 μg/L), trans-1,2-dichloroethane (24 μg/L) and benzene (4 μg/L) in wells OLF-3, -4, and -5.

Site 12 – Old Water Hole—The Old Water Hole is located between New Mt. Sellers Cemetery and the prisoner of war (POW) camp on Pelham Range (Figure 1-23). The site reportedly was used for the disposal of a variety of munitions, including chemical ordnance, and is possibly a sinkhole or shallow excavation without release controls. A rectangular, shallow, topographic depression approximately 50 by 140 feet (0.2 acres) was located by Fort McClellan Department of Environmental Management personnel in the approximate area between the cemetery and the POW camp. An additional circular depression was located north of the main depression in this area. The immediate vicinity of the Old Water Hole site is located in a topographically low area with subtle topographic variation. Surface topography rises to the northeast and west of the site. The main depression periodically fills with water from precipitation and does not readily drain. Several small-caliber bullet shells, flares, and smoke rounds were found at the site in 1992 and are the result of ongoing military training exercises in the area. A qualitative metal detection sweep was conducted by USATEU in 1992 (USATEU 1992, SAIC 1993) and suggested the possibility of buried metallic objects at the site.



LEGEND:

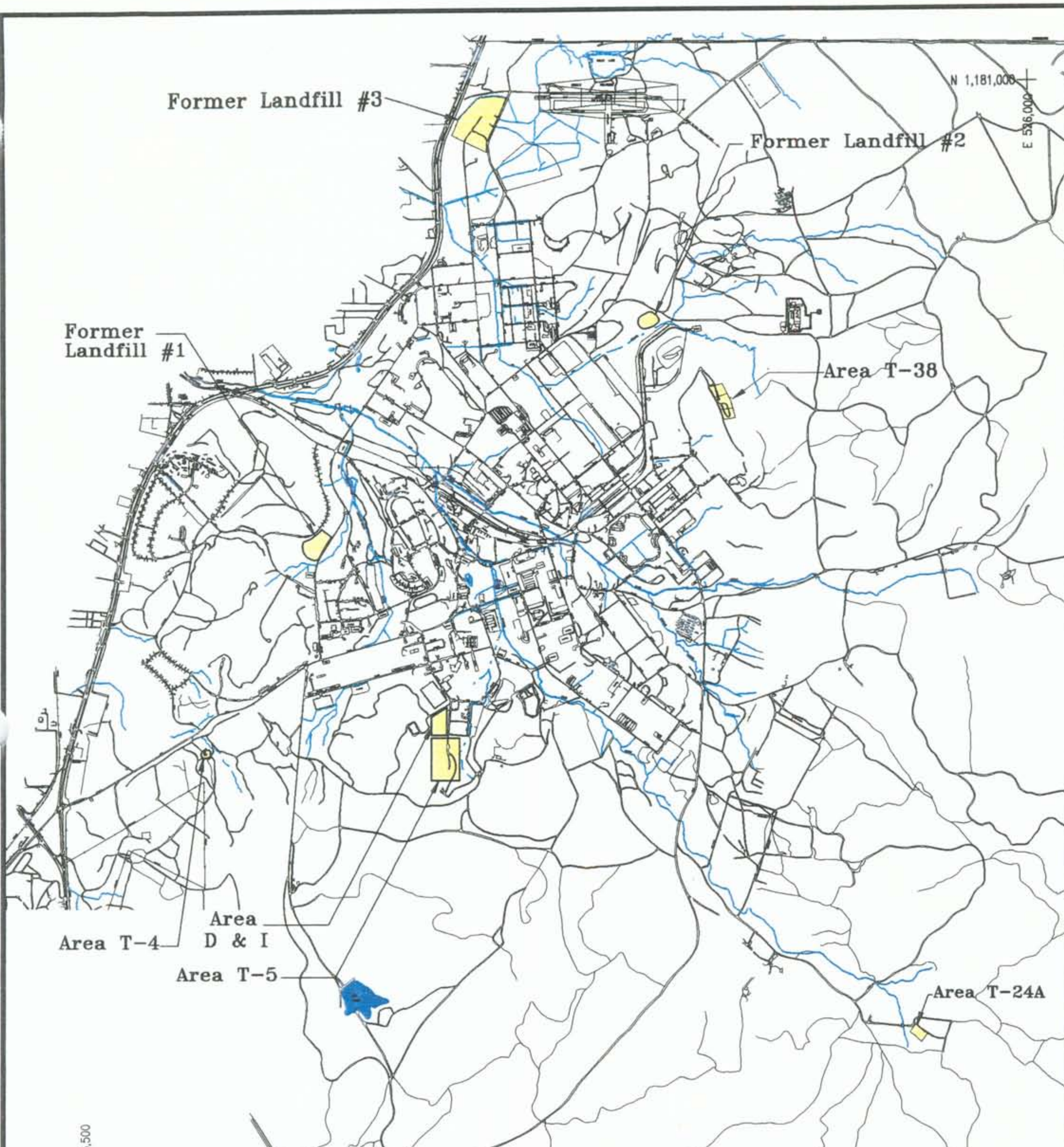
.... PROPERTY BOUNDARY
................RRIMARY ROADS
.... SECOUNDARY ROADS

0 2000 4000
SCALE: 1" = 4000'

U.S. ARMY CORPS OF ENGINEERS
MOBIL DISTRICT
MOBILE, ALABAMA

PROJECT LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-1	01-0827-07-6520-012	FTMC\98-SITE-LOC	Oct. 1998



LEGEND:

- ....BUILDINGS
- ....ASPHALT ROADS
- ....STREAM OR TRIBUTARY
- ....RI/FS SITE
- + ...ALABAMA STATE PLANE COORDINATE

NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.

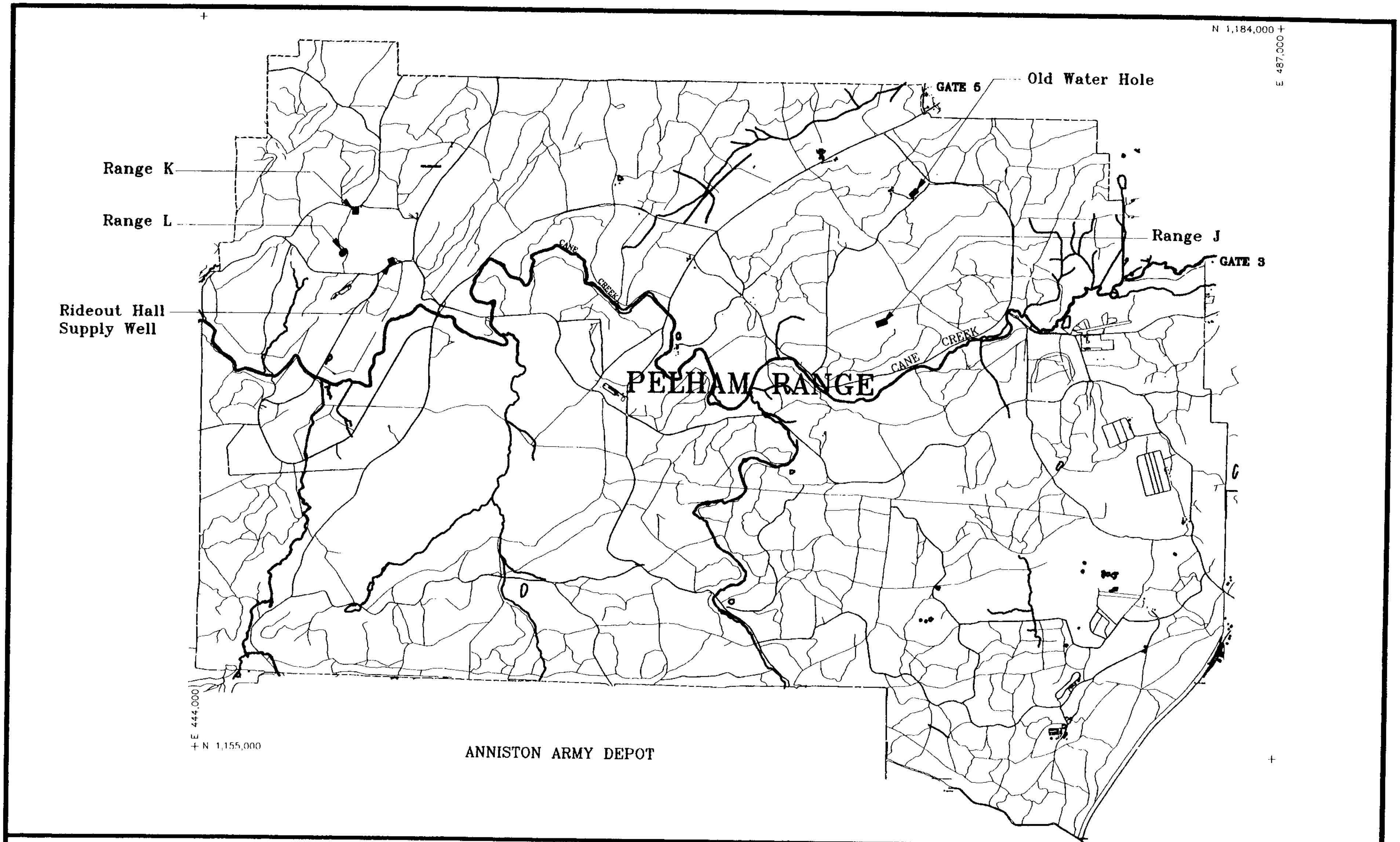
0 1000 2000 3000

SCALE: 1" = 3000'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

SITE LOCATION MAP
MAIN POST
FORT McCLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-2	01-0827-07-6520-012	FTMC\98-FIG1-2	Oct. 1998



LEGEND:

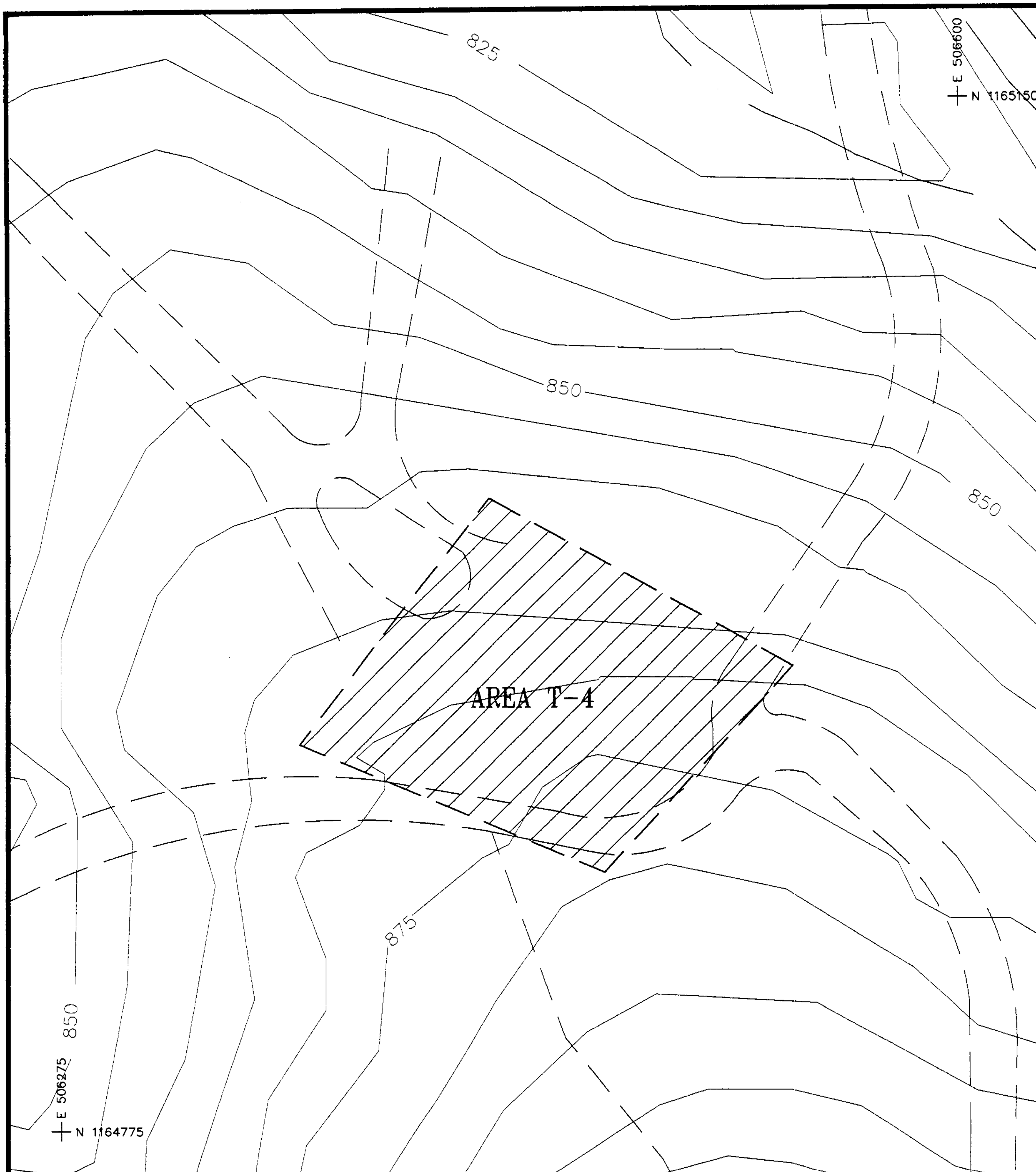
- ....ASPHALT ROADS
- 620 ...TOPOGRAPHIC CONTOUR (CI=25 ft.)
- ....STREAM OR TRIBUTARY
- ...RI/FS SITE LOCATION WITH SITE NAME
- + ...STATE PLANE COORDINATE SYSTEM

NOTE: BASE MAP AND TOPOGRAPHY FROM U.S. ARMY CORPS OF ENGINEERS MOBILE DISTRICT, 1989

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

PELHAM RANGE SITE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-3	01-0827-07-6520-012	FTMC\98-FIG1-3	Oct.1998



LEGEND:

- BUILDINGS
- ASPHALT ROADS
- BOUNDARY
- TOPOGRAPHIC CONTOUR (CI=5 ft.)
- 850 ..TOPOGRAPHIC CONTOUR (CI=25 ft.)

NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989. SITE BOUNDARY FROM USATHAMA, 1977.

0 25 50
SCALE: 1" = 50'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

AREA T-4
SITE LOCATION MAP
FORT McCLELLAN, ALABAMA

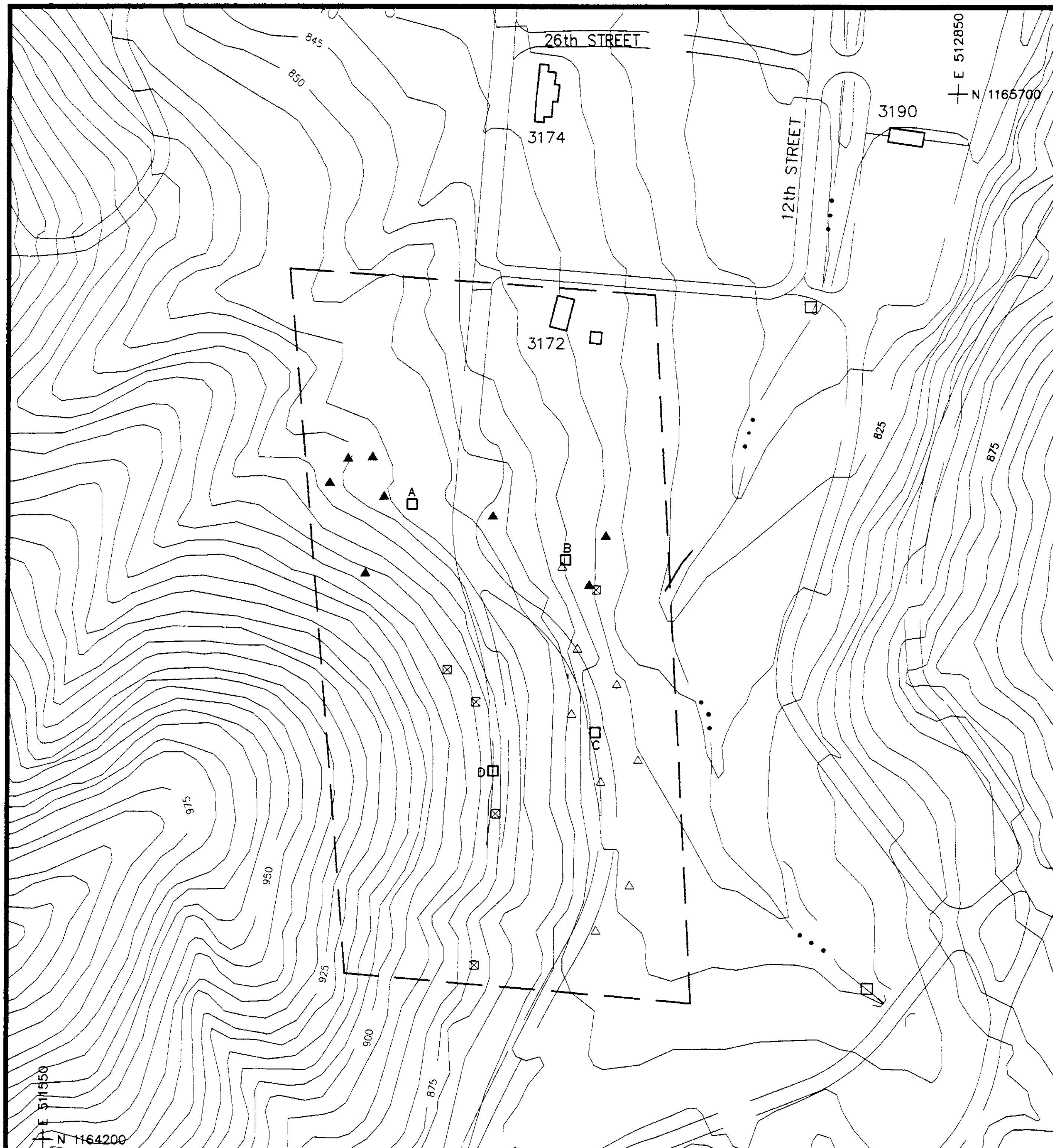
Figure No.	Project No.	File Name	Date
1-4	01-0827-07-6520-012	FTMC\98-FIG1-4	Nov. 1998

Historical photography from U.S. Army Environmental Center

U.S. Army Corps of Engineers
Mobile, Alabama

AREA T-4 HISTORICAL PHOTOGRAPH- 1973
Fort McClellan RI/BRA, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
1-5	01-0827-03-6520-012	FIG1-5.SRF	01-30-95	SAIC-McLean



NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.
SITE BOUNDARY FROM USATHAMA, 1977.

LEGEND:

- .... BUILDINGS
- .... ASPHALT ROADS
- .... STREAM OR TRIBUTARY
- 825 .... TOPOGRAPHIC CONTOUR (CI=25 ft)
- .... TOPOGRAPHIC CONTOUR (CI=5 ft)
- ⊠ .... GB TRAINING LOCATION (USATHAMA 1977)
- △ .... VX TRAINING LOCATION (USATHAMA 1977)
- ▲ .... HD TRAINING LOCATION (USATHAMA 1977)
- □ .... CONCRETE MONUMENT

0 100 200

SCALE: 1" = 200'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

AREA T-5
SITE LOCATION MAP
FORT McCLELLAN, ALABAMA

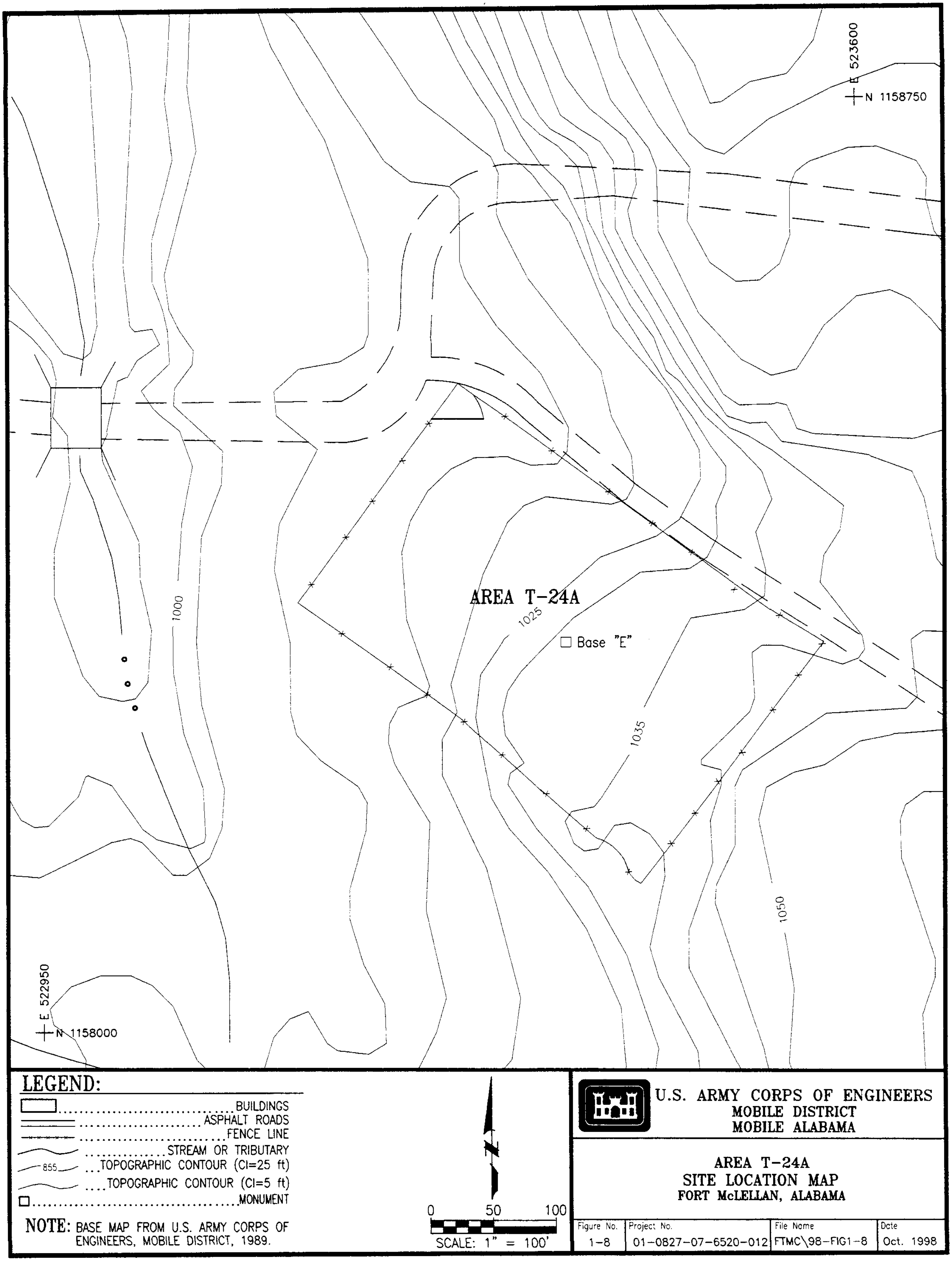
Figure No.	Project No.	File Name	Date
1-6	01-0827-07-6520-012	FTMC\98-FIG1-6	Nov. 1998

Historical photography from US Army Environmental Center

U.S. Army Corps of Engineers
Mobile, Alabama

AREA T-5 CHEMICAL WARFARE AGENT TRAINING
Fort McClellan RI/BRA, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
1-7	01-0827-03-6520-012	FIG1-7.SRF	09-17-98	SAIC/McLean



NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

AREA T-24A
SITE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-8	01-0827-07-6520-012	FTMC\98-FIG1-8	Oct. 1998

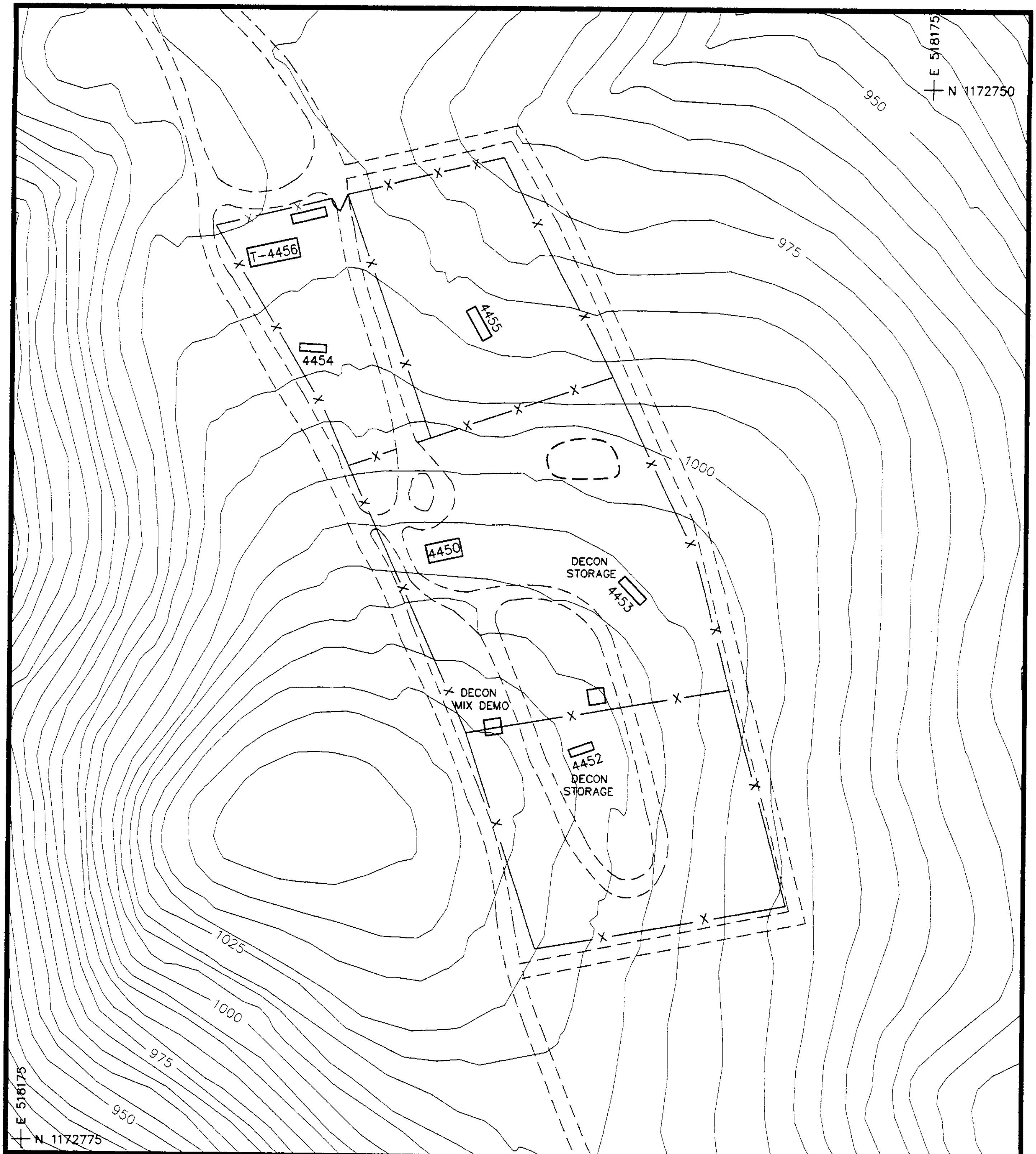
LEGEND
Stream drainage
Fence

Aerial photography compiled and interpreted by U.S. Environmental Protection Agency, September 1983, "Fort McClellan 24 Alpha, T-38, Range J - Alabama"

U.S. Army Corps of Engineers
Mobile, Alabama

AERIAL PHOTOGRAPH - AREA T-24A - 1969
Fort McClellan RI/BRA, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
1-9	01-0827-03-6520-012	FIG1-8.SRF	01-27-95	SAIC-McLean



LEGEND:

- ....BUILDINGS
- ....GRAVEL ROADS
- ....FENCE LINE
- ....STREAM OR TRIBUTARY
- 855 .....TOPOGRAPHIC CONTOUR (CI=25 ft)
- ......TOPOGRAPHIC CONTOUR (CI=5 ft)
- ....APPROXIMATE SUMP LOCATION

NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.

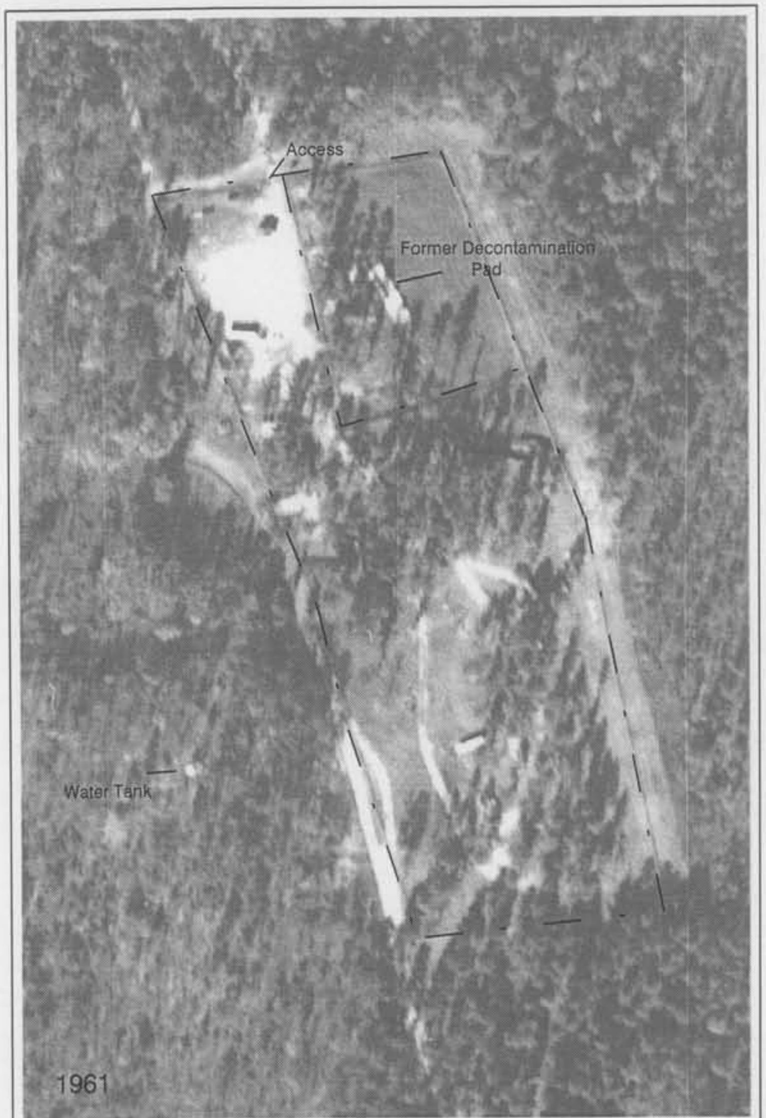
0 50 100 150

SCALE: 1" = 150'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

AREA T-38
SITE LOCATION MAP
FORT McCLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-10	01-0827-07-6520-012	FTMC\98-FIG1-10	Nov. 1998



LEGEND

— — Fenced Area
GB,HB,VX Former Training/ Demonstration Areas

N

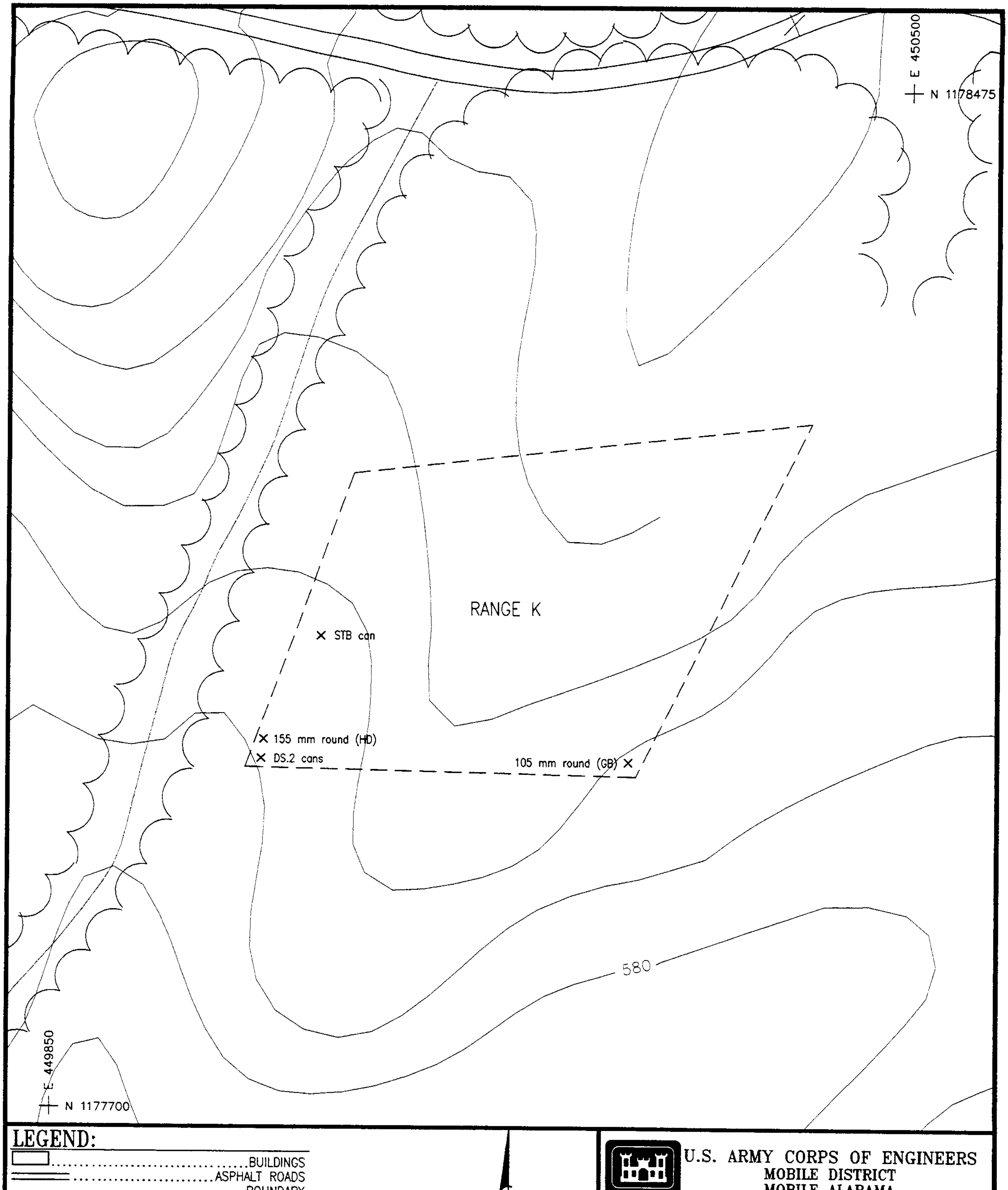
Historical photography compiled and interpreted by U.S. Environmental Protection Agency, September 1983, "Fort McClellan 24 Alpha, T-38, Range J, Alabama", TS-PIC-83003. Site features from Environmental Science and Engineering, 1984.

U.S. ArmyCorps of Engineers
Mobile, Alabama

AREA T-38 - 1961,1969

Fort McClellan RI/BRA, Anniston, Alabama

Figure:	Project:	File Name:	Date:
1-11	01-0827-03-6520-012	FIG1-10.SRF	01-30-95



LEGEND:

- ....BUILDINGS
- ....ASPHALT ROADS
- ....BOUNDARY
- 855 .....TOPOGRAPHIC CONTOUR (CI=25 ft)
- ......TOPOGRAPHIC CONTOUR (CI=5 ft)
- ....TREE LINE
- X.....................SURFACE DEBRIS (USAEC 1992)

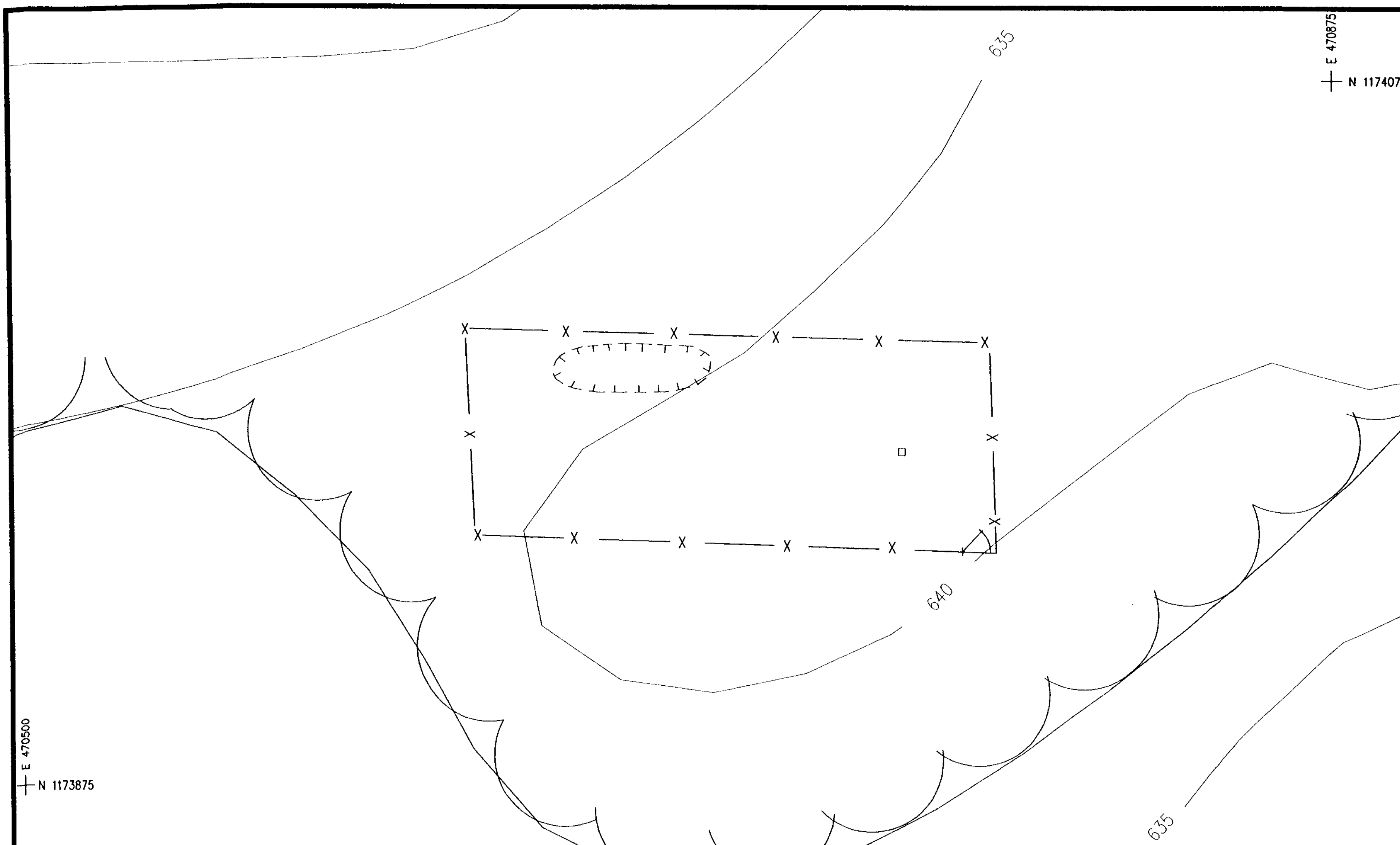
NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS MOBILE DISTRICT, 1989. SITE LOCATION FROM USATHAMA, 1977.

0 50 100
SCALE: 1" = 100'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

AREA T-38
SITE LOCATION MAP
FORT McCLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-12	01-0827-07-6520-012	FTMC\98-FIG1-12	Nov. 1998



LEGEND:

- ....FENCE LINE
- ....TOPOGRAPHIC CONTOUR (CI=5 ft)
- ....DRUM DISPOSAL PIT
- ....CONCRETE MONUMENT

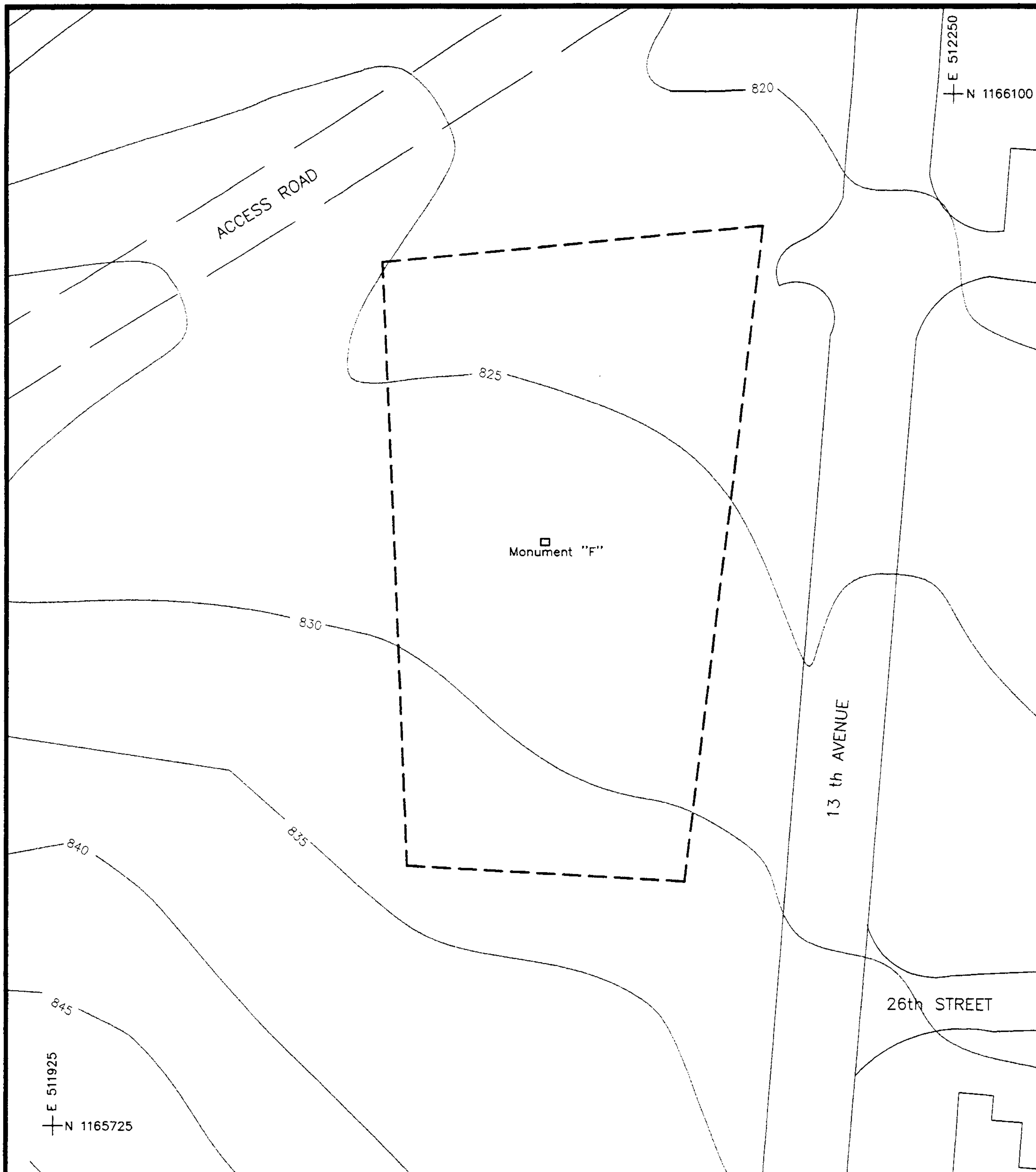
0 20 40
SCALE: 1" = 40'

NOTE: SITE BOUNDARY FROM USATHATMA 1977. FENCE CORNERS RE-SURVEYED BY H. HOLLIS AND ASSOCIATES, 1995, (APPENDIX J)
BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

RANGE J
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-13	01-0827-07-6520-012	FTMC\98-FIG1-13	Nov. 1998



LEGEND:

- .... ASPHALT ROADS
- .... GRAVEL ROADS
- .... BOUNDARY
- ...... TOPOGRAPHIC CONTOUR (CI=5 ft)
- □ .... CONCRETE MONUMENT F

NOTE: SITE BOUNDARY FROM USATHATMA 1977.
BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.

0 25 50
SCALE: 1" = 50'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

D AND I AREA
SITE LOCATION MAP
FORT McLELLAN, ALABAMA

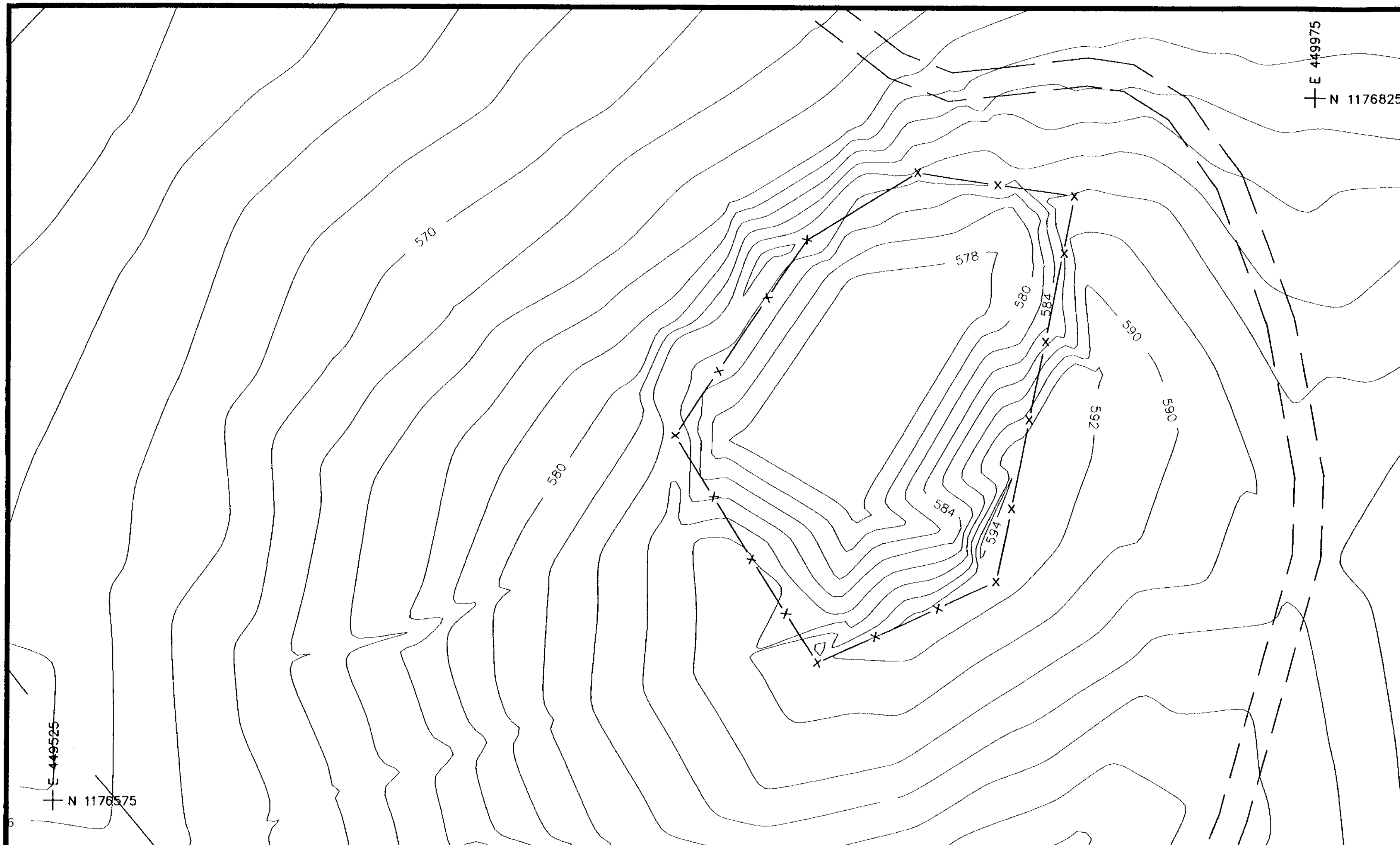
Figure No.	Project No.	File Name	Date
1-14	01-0827-07-6520-012	FTMC\98-FIG1-14	Nov. 1998

Historical photography from U.S. Army Environmental Center

U.S. ARMY CORPS OF ENGINEERS
MOBILE, ALABAMA

DETECTION AND IDENTIFICATION AREA - 1973
Fort McClellan RI/BRA, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
1-15	01-0827-03-6520-012	FIG1-15.SRF	01-30-95	SAIC-McLean



LEGEND:

- .... GRAVEL ROADS
- .... FENCE LINE
- 620 ... TOPOGRAPHIC CONTOUR (CI=25 ft.)
- .... TOPOGRAPHIC CONTOUR (CI=5 ft.)
- ................INTERMITTENT STREAM

NOTE: BASE MAP PREPARED BY FRANK HOLLIS AND ASSOCIATES (1994)

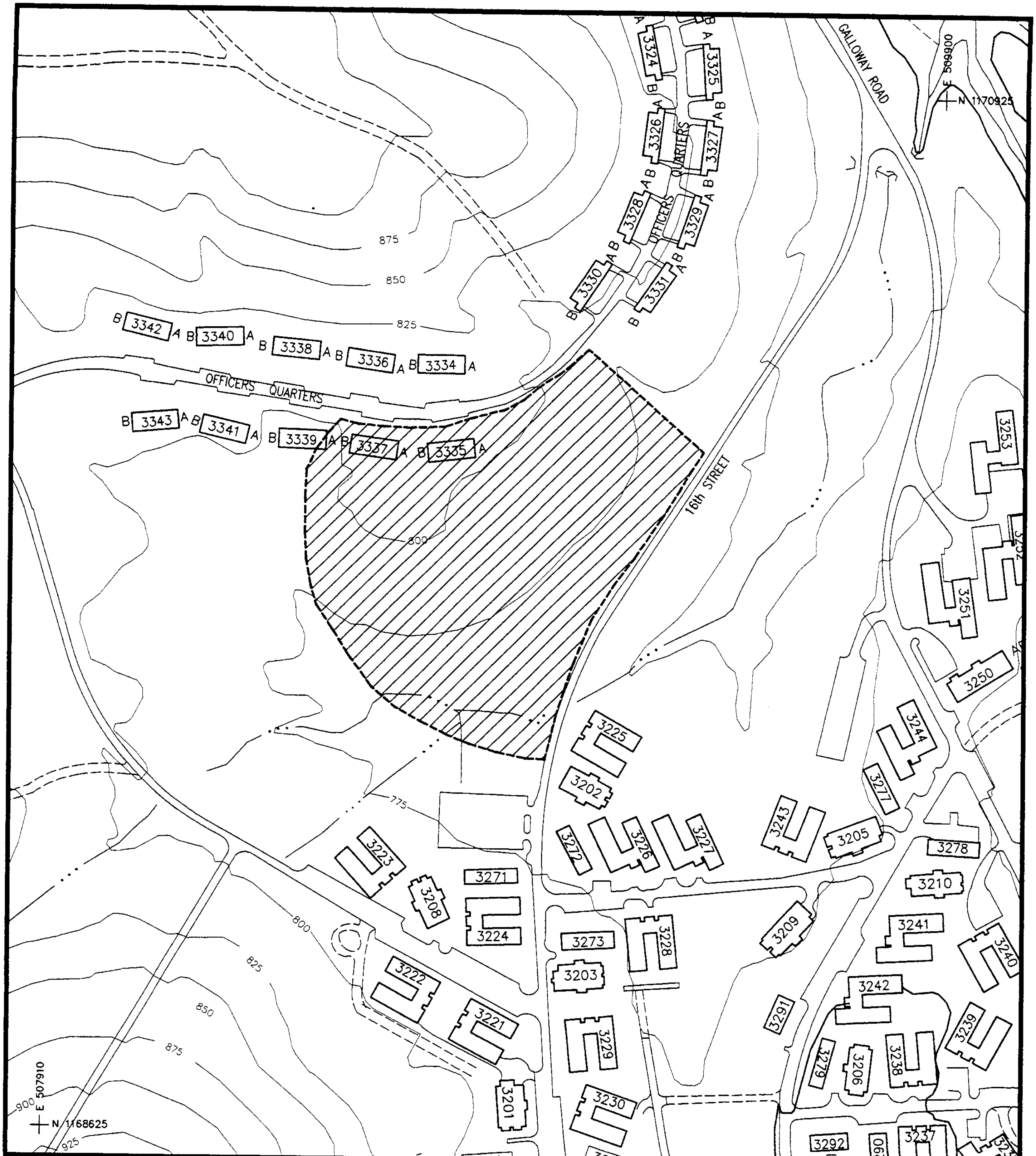
0 25 50

SCALE: 1" = 50'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

RANGE L
SITE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-16	01-0827-07-6520-012	FTMC\98-FIG1-16	Nov. 1998



LEGEND:

▨ .... SITE BOUNDARY
═ .... ASPHALT ROADS
~ .... STREAM OR TRIBUTARY
—855— ..... TOPOGRAPHIC CONTOUR (CI=25 ft)

NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS MOBILE DISTRICT, 1989. SITE BOUNDARY FROM USDA-ASCS AERIAL PHOTOGRAPH (12-09-54)

0 100 200 300

SCALE: 1" = 300'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

FORMER LANDFILL #1
SITE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-17	01-0827-07-6520-012	FTMC\98-FIG1-17	Nov. 1998

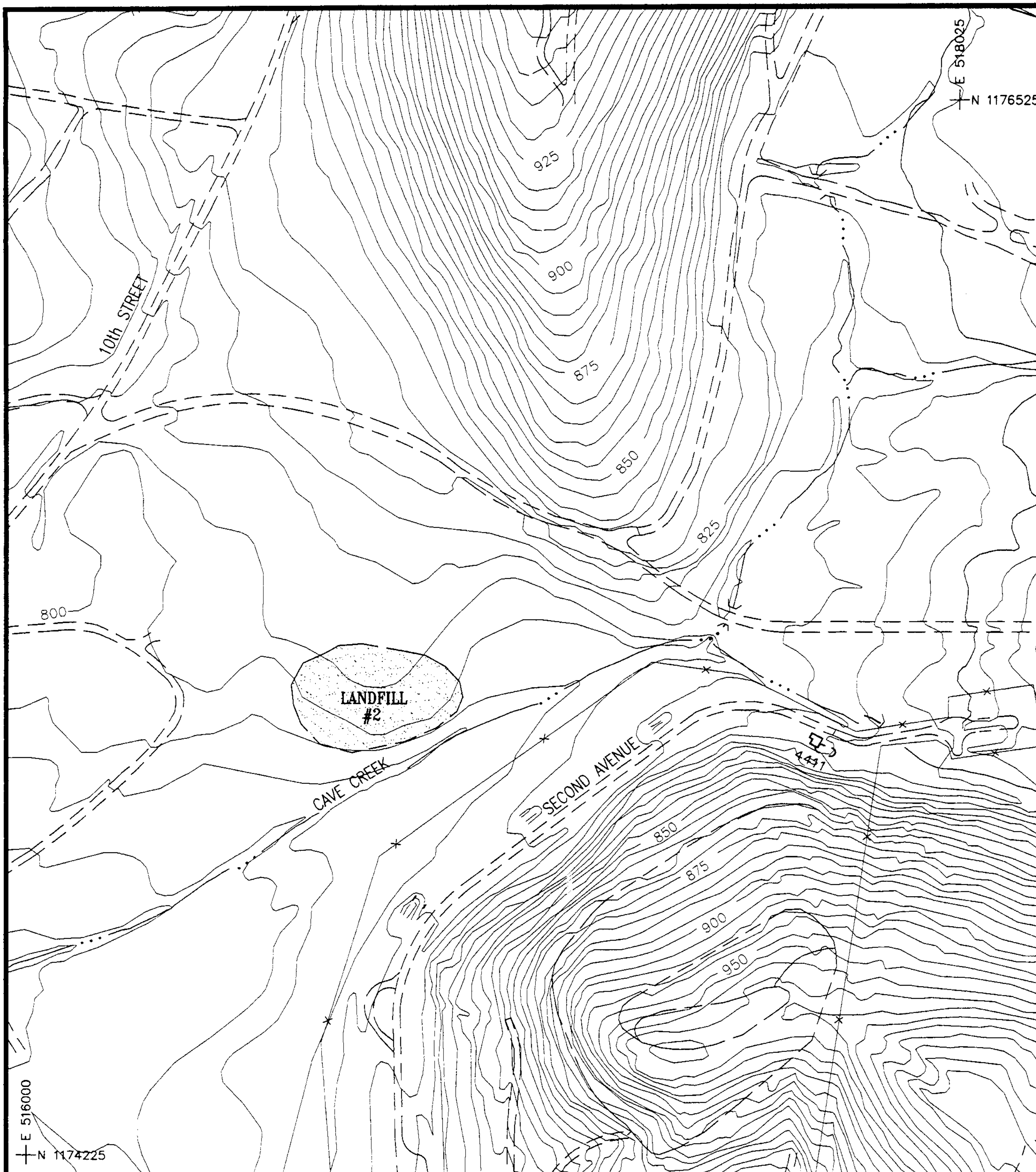
N

Aerial photography from Soil Conservation Service

U.S. Army Corps of Engineers
Mobile, Alabama

FORMER LANDFILL #1 AERIAL PHOTOGRAPHS
1954-1969
Fort McClellan RI/BRA, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
1-18	01-0827-03-6520-012	FIG1-18.SRF	01-27-95	SAIC-McLean



LEGEND:

- ============ GRAVEL ROADS
- ——x——x—— FENCE LINE
- —·—·— STREAM OR TRIBUTARY
- —855— TOPOGRAPHIC CONTOUR (CI=25 ft)
- ——— TOPOGRAPHIC CONTOUR (CI=5 ft)

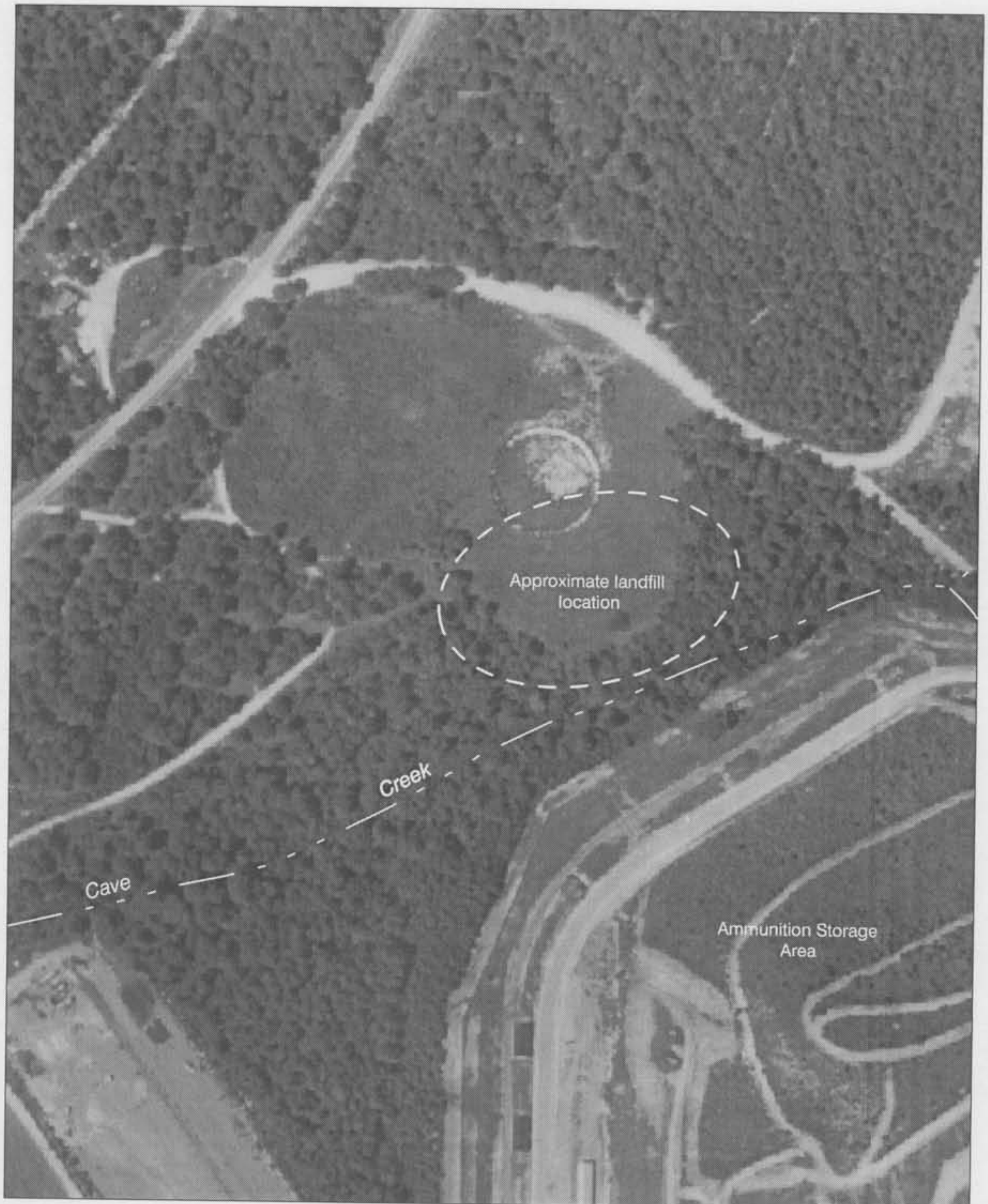
NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.

0 100 200 300
SCALE: 1" = 300'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

FORMER LANDFILL #2
SITE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-19	01-0827-07-6520-012	FTMC\98-FIG1-19	Nov. 1998



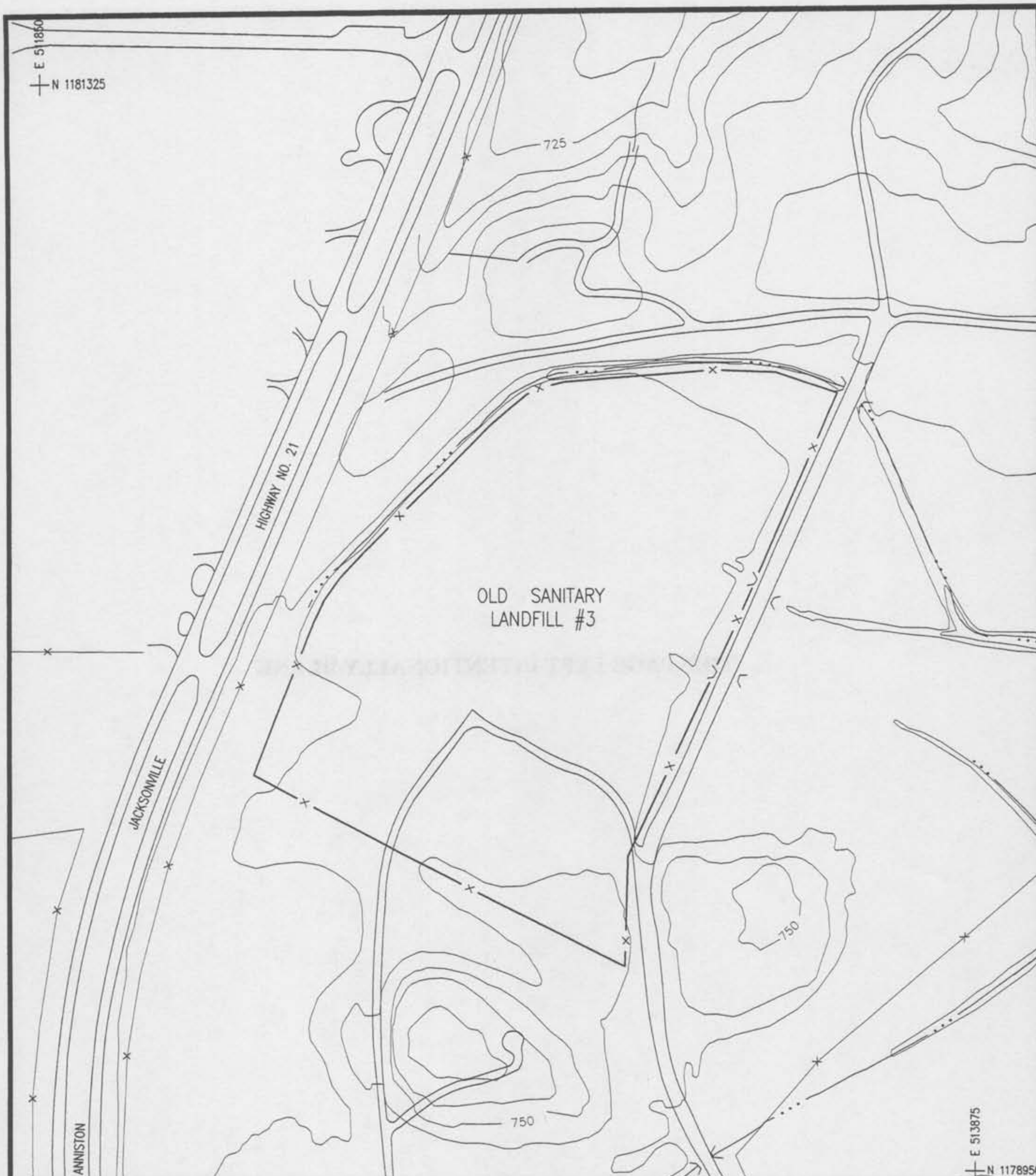
Historical photography from US Army Environmental Center

U.S. Army Corps of Engineers
Mobile, Alabama

LANDFILL #2 HISTORICAL PHOTOGRAPHY -1965

Fort McClellan RI/BRA, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
1-20	01-0827-03-6520-012	FIG1-20.SRF	09-17-98	SAIC/McLean



LEGEND:

- ....ASPHALT ROADS
- ....FENCE LINE
- ....STREAM OR TRIBUTARY
- 855 .....TOPOGRAPHIC CONTOUR (CI=25 ft)
- ......TOPOGRAPHIC CONTOUR (CI=5 ft)

NOTE: BASE MAP FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.

0 100 200 300

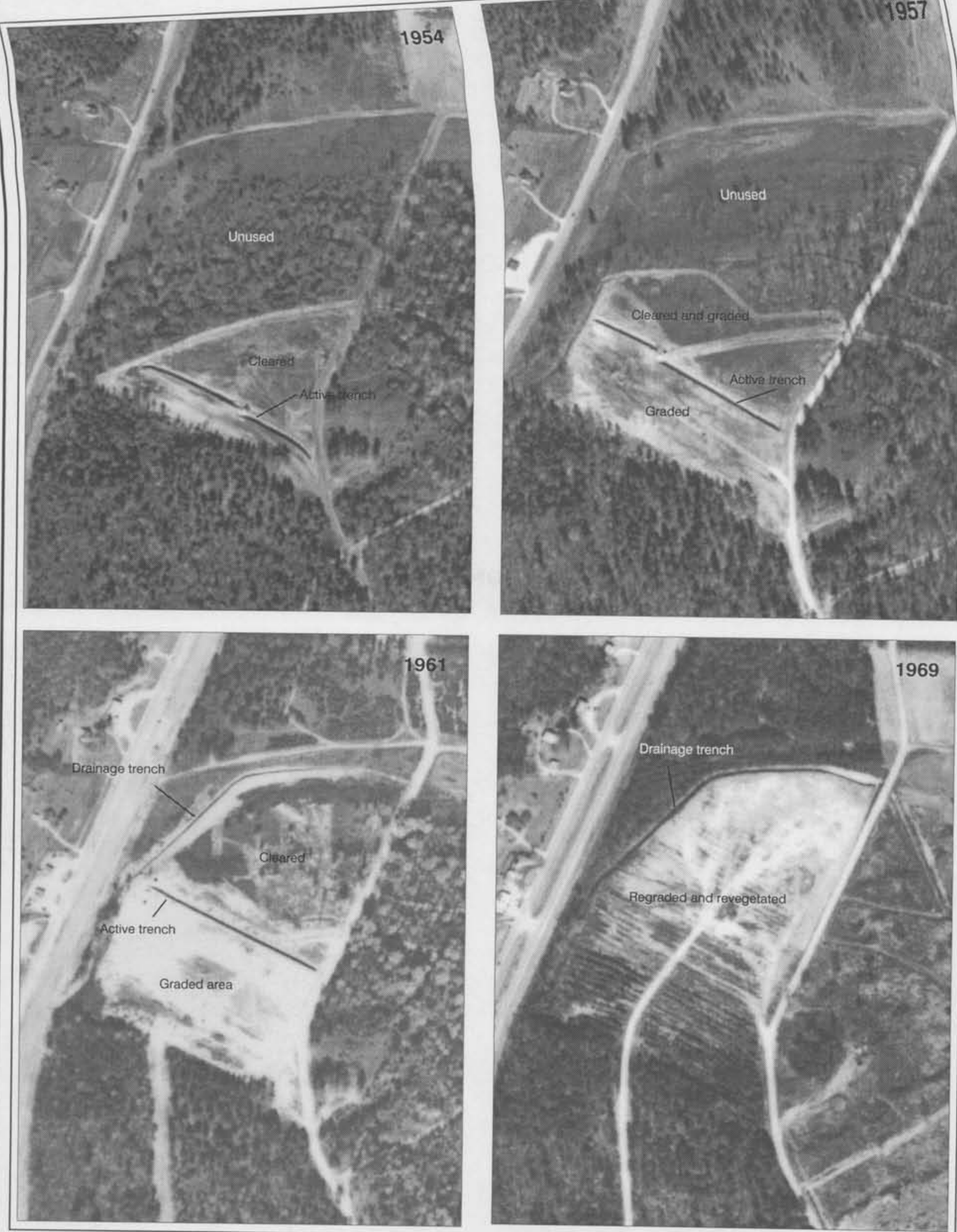
SCALE: 1" = 300'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

FORMER LANDFILL #3 SITE LOCATION MAP

FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-21	01-0827-07-6520-012	FTMC\98-FIG1-21	Nov. 1998



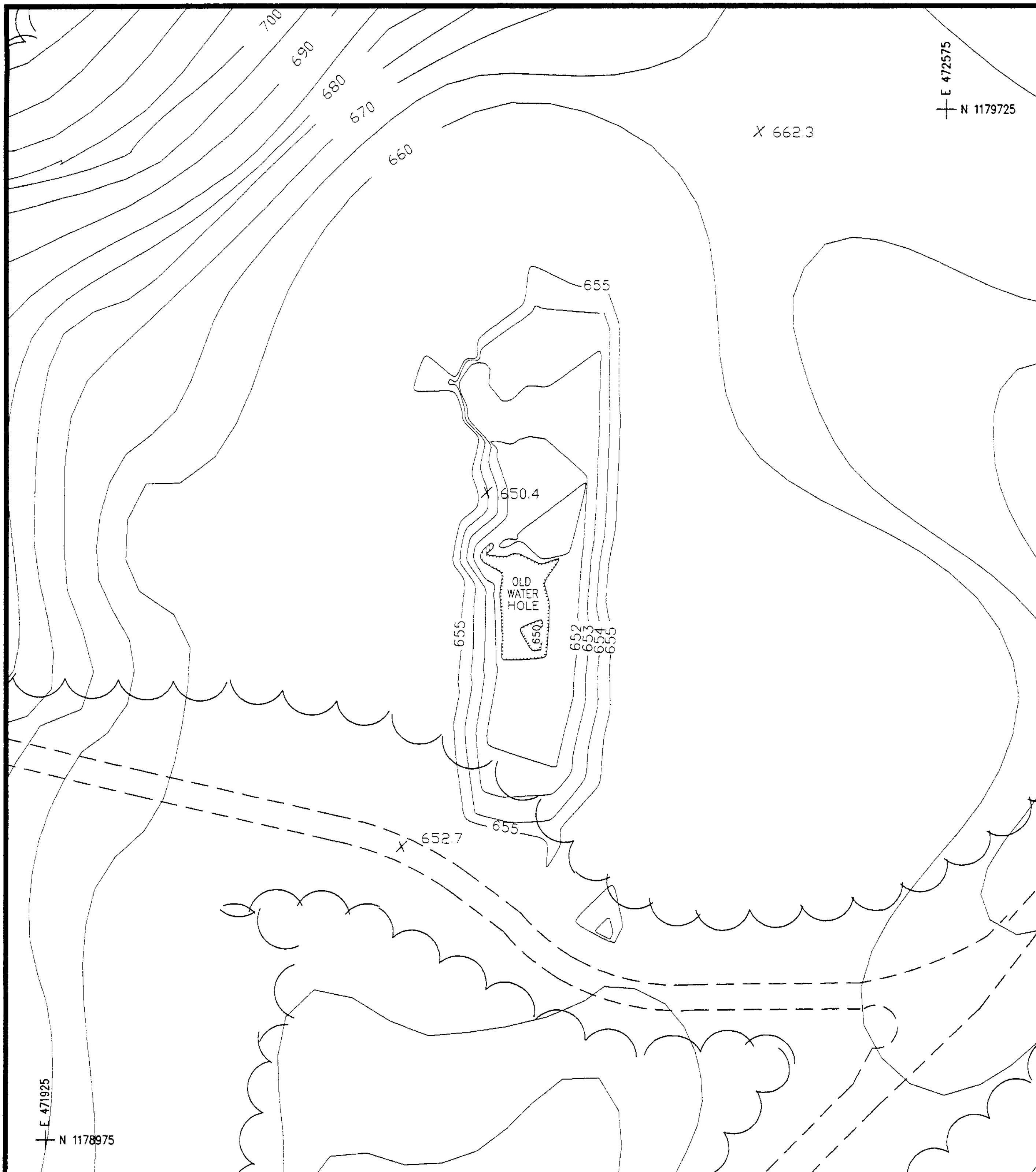
Aerial photography from Soil Conservation Service.

N

U.S. Army Corps of Engineers
Mobile, Alabama

FORMER LANDFILL #3 AERIAL PHOTOGRAPHS
1954-1969
Fort McClellan RI/BRA, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
1-22	01-0827-03-6520-012	FIG1-22.SRF	01-27-95	SAIC-McLean



LEGEND:

- = = = = = ... GRAVEL ROADS
- 855 ..... TOPOGRAPHIC CONTOUR (CI=5 ft)
- ..... TOPOGRAPHIC CONTOUR (CI=1 ft)
- X 662.3 .... SPOT ELEVATION

NOTE: BASE MAP FROM F. HOLLIS AND ASSOCIATES, 3/94 CONTOUR INTERVAL 1 FOOT.

0 15 30

SCALE: 1" = 30'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

OLD WATER HOLE
SITE LOCATION MAP
FORT McCLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
1-23	01-0827-07-6520-012	FTMC\98-FIG1-23-B	Nov. 1998

Table 1-1. Sites Investigated Under RI Program, Fort McClellan, Alabama

Site	Acres	Location	Activity Period	Site Activity
Site 1: Area T-4	0.25	Main Post	1965-1971	Biological simulant training; possible HD storage
Site 2: Area T-5	11.4	Main Post	1961-1973	CWA decontamination and detection training area
Site 3: Area T-24A	1.5	Main Post	1949-1973	Former EOD training area
Site 4: Area T-38	6.0	Main Post	1961-1972	Former Technical Escort Reaction Training Area
Site 5: Range K	2.0	Pelham	1961-1963	Former CWA shell tapping area
Site 6: Range J	0.2	Pelham	1963	Drum disposal location
Site 7: D&I Area	1.1	Main Post	1950's-1972	CWA detection and identification training area
Site 8: Range L	0.35	Pelham	Unknown	Possible WWII CWA munitions disposal
Site 9: Landfill #1	11.2	Main Post	1945-1947	Former post sanitary landfill
Site 10: Landfill #2	1.5	Main Post	1947- unknown	Former post sanitary landfill
Site 11: Landfill #3	22.0	Main Post	1946-1967	Former post sanitary landfill
Site 12: Old Water Hole	0.2	Pelham	Post WWII	Possible WWII CWA munitions disposal

HD - Distilled Mustard
CWA - Chemical Warfare Agent
EOD - Explosive Ordnance Disposal

Table 1-2. Summary of Process and Waste Disposal Activity Remedial Investigation Sites, Fort McClellan, Alabama

Range	Range Size	Probable Date Opened	Last Used	Agents Used	Process and Waste Disposal History
T-4	0.3 acres	1965	1971	BG, SM, HD**, VX**	Testing biologic simulants BG, SM.
T-5	11.4 acres	1961	1973	HD, GB, VX, BG, SM	Training for detection and decontamination of HD, GB, VX agents and simulants BG, SM. Possible 110-gallon HD spill.
T-24 Alpha	1.5 acres	Unknown	1973	HD, GB*	Chemical munitions disposal training for CG, BZ, HD, GB agents. Two square (256 sq ft) decontamination burn pits, depth possibly 6 feet. Possible HD spill (unconfirmed).
T-38	6.0 acres	1961	1972	HD, GB, VX	Training in elimination of toxic hazards for chemical munitions and storage of HD, GB, VX agents. STB, DANC, DS-2 decontaminants used.
Pelham Range J	0.1 acres	Unknown	1963	HD**	Training and chemical/biological agent disposal, possibly HD. Possible HD spill disposal area.
Pelham Range K	2.0 acres	Unknown	Unknown	HD**	Chemical/biological agent (GB, HD) training; shell tapping area for GB, CG rounds.
Detection and Identification	1.1 acres	Early 1950s	1973	HD, GB*	Testing and training with chemical/biological agents HD, GB, CK, GC, CX, AC. Training aids burned in pit onsite.
Pelham Range L	0.5 acres	Unknown	Unknown	Unknown	Disposal of captured WWII munitions, including chemical munitions (Lima Pond).
Former Landfill 1	2 acres	1945	1947	None	Sanitary landfill disposal.
Former Landfill 2	4 acres	1947	Unknown	None	Waste disposal during deactivation of installation
Former Landfill 3	22 acres	1946	1967	None	Sanitary landfill disposal.
Old Water Hole	2,975 sq ft	Unknown	Unknown	Unknown	Disposal site (possible sinkhole), chemical agents, munitions.

*	Other simulants also used
**	Assumed HD or VX used
BG	bacillus globigii
SM	serratia marcescens

Reference: Solid Waste Study No. 99-056-73/76, Fort McClellan, AL, Jul 73-Aug 75

Table 1-3. Physical and Chemical Properties for Chemical Warfare Agents and Decontamination Solutions Fort McClellan, Alabama

Name	CAS No.	Formula Weight	Physical State	Odor	Relative Vapor Density (Air=1)	Density (g/mL) (@20-25° C)	Boiling Point (° C)	Vapor Pressure (mm Hg) (@20-25° C)	Flash Point (° C)	Decomposition Temp (° C)	Solubility in Water (mg/L)	log Kow	log Koc	Use
Chemical Agents														
Cyanogen chloride (CK)	506-77-4	61.48	Gas	Bitter almonds	2.1	1.18	12.8	1000	None	>100	Soluble	0.46		Casualty Agent
Hydrogen cyanide (AC)	74-90-8	27.02	liquid	Bitter almonds	0.93-1.007	0.687	25.7	742	0	66	Soluble	0.004		Casualty Agent
Mustard (HD)	505-60-2	159.08	liquid	Garlic	5.5	1.2685	217.5	0.082-0.1059	105	177	810-920	1.37-2.03	2.0-2.1	Blistering Agent
-Hemi mustard (CH)	693-30-1	140.6						4.6E-3			8100	0.3	1.54	HD hydrolysis product
-thiodiglycol (TDG)	111-48-8	122.18	liquid			1.18	283	1.9E-05	160		Infinite	-0.77	0.96	HD hydrolysis product
-divinyl sulfide (DVS)	627-51-0	86.15						60			2500	0.85	1.84	HD decon product w/ DS-2
-mustard sulfoxide (HO)	5819-08-9							0.81			93000	-0.85	0.91	HD oxidation product w/ STB
-mustard sulfone (HO2)	471-03-4							1.6			11000	-0.51	1.1	HD oxidation product w/ STB
-1,4 dithiane	505-29-3	120.24					176.1	.8-1.21			2900	0.77	1.8	Dealkylation product HD
-1,2 dichloroethane	107-06-2	98.96	liquid	sweet	3.42	1.25	83.5	64	13-21		7986-8800	1.45-1.48	1.15-2.18	Dealkylation product HD
Phosgene (CG)	75-44-5	98.92	Gas	Mown grass, hay	3.4	1.373	7.6	1.173	None	800	Low	1.05[4]		Choking Agent
Sarin (GB)	107-44-8	140.10	liquid	None	4.86	1.0887	157.8	2.94	NF	150	Infinite	0.15	0.45	Nerve Agent
-Isopropyl methylphosphonic acid (IMPA)	1832-54-8							.0034			48000	-0.54	1.08	Hydrolysis product of GB
VX	50782-69-9	267.38	liquid	None	9.2	1.0083	298.4	3.00E-04	159	295	30,000	1.992-2.36	2.52	Nerve Agent
-diisopropylamine (DPA)	108-18-9	101.19	liquid	ammonia	3.49	.72	84	840	-6.7		400	1.72	2.31	VX decon product w/ STB
-ethyl methylphosphonic acid (EMPA)	1832-53-7							1.7E-4			1100	-1.15	0.75	VX hydrolysis product
-Methylphosphonic Acid (MPA)	993-15-3										Infinite	-2.28	0.136	EMPA hydrolysis product
-bis-(2-diisopropylaminoethyl)disulfide [(DES)2]	65332-44-7							1.5E-8			9.5	3.48	3.28	Oxidized DESH
-bis-(2-diisopropylaminoethyl)sulfide [(DE2)S]								6.67E-07			1.2	4.47	3.81	VX hydrolysis product
-diisopropylaminoethyl mercaptan (DESH)	5482-07-9							1.1			100	2.36	2.66	VX impurity, hydrolysis product
-EA-2192		124.11	liquid	Matches		1.83	290	NA		None				Incendiary/smoke training
-EA-4196		124.11		Matches		1.83	290	NA		None				Smoke training
Fog Oil														Smoke training
BZ	1619-34-7	337.41	Solid	None	11.6	0.51	320	Negligible	246	200				Incapacitating agent
CNB (Chloroacetophenone in benzene and carbon tetrachloride)	532-27-4	154.59	liquid	gasoline	~4	1.14	75-247	1	<4.44	>247	2815	2.08	1.87	Riot Control (Tearing) Agent
FS Solution		96.47	liquid	Acrid	NA	1.9	80							Smoke training
-sulfur trioxide (55%)	7449-11-9		solid											
-chlorosulfonic acid (45%)	7790-94-5		liquid	pungent		1.77	158							
Decontaminants														
STB (Super Tropical Bleach)			Liquid	Chlorine		1.085	^100				Miscible			Decontamination of HD,GB, VX
- calcium hypochlorite chloride														
HTH (Calcium Hypochlorite)	7778-54-3		Solid	Chlorine		2.35		NA	NA		21%			
DS-2														
- Sodium hydroxide (2%)	1310-73-2	40.01	Solid	None							>1000 mg/L			
- Diethylenetriamine (DETA)	111-40-0	103.17	liquid	Ammonia		0.96	207	0.53	102		Infinite	-1.67	0.46	
- 2-methoxy ethanol (MET)	109-86-4	76.09	liquid			0.97		8.2	46		Infinite	-0.77	0.96	
DANC	79-34-5											2.39-2.56		
6.25% RH 195 in acetylene tetrachloride														
1,3-dichloro-5,5-dimethylhydantoin (DDH)	118-52-5	197.02	solid	chlorine		1.5			174.4		0.21 wt %	NA	NA	hypochlorous acid
Sodium Carbonate	497-19-8	105.99	solid	oderless		2.509	Decomposes	eff=0	NC		497000 @35°C			
CLOROX bleach (5.25% sodium hypochlorite)	7681-52-9	74.44	liquid	Chlorine		1.085	100				Soluble			

Table 1-3. Physical and Chemical Properties for Chemical Warfare Agents and Decontamination Solutions
Fort McClellan, Alabama

Name	CAS No.	Formula Weight	Physical State	Odor	Relative Vapor Density (Air=1)	Density (g/mL) (@20-25° C)	Boiling Point (° C)	Vapor Pressure (mm Hg) (@20-25° C)	Flash Point (° C)	Decomposition Temp (° C)	Solubility in Water (mg/L)	log Kow	log Koc	Use
Chemicals														
benzene	71-43-2	78.11	liquid	gasoline	2.7	0.87	80.1	^76-95.2	-11		820-1800	1.56-2.15	1.69-2.0	
carbon tetrachloride	56-23-5	153.82	liquid	sweet	5.31	1.59	76.5	90-113	NC		757-800	2.73-2.83	2.35-2.64	chloroform; CO_2; HCl
1,1,1, Trichloroethane	71-55-6	133.4	liquid	sweet	4.6	^1.32	74.1	96-124	<25		300-4400	2.17-2.49	2.02-2.18	acetic acid; 1,1 DCE
1,1,2,2-tetrachloroethane=(acetylene tetrachloride)	79-34-5	167.85	liquid	sweet	5.8	1.59	146.2	5-8	NF		2900-3230	2.39-2.56	1.66-2.07	

U.S. Army Chemical Research, Development, and Engineering Center, Material Safety Data Sheets, 3 December 1990.
U.S. Army Technical Escort Unit, Standard Operating Procedures for Chemical surety Activities, Fort McClellan Site Investigation, March, 1993.
Small, M.J., Soil Detection Limits for Potential Chemical Warfare-Related Contaminants at Fort McClellan, Alabama, May 1983.
Montgomery and Welkom, "Groundwater Chemicals Desk Reference, Vols I, II, 1991.
[1]Sage and Howard, "Environmental Fate Assessments of Chemical Agents HD and VX", CRDEC-CR-034, 1989.
[2]"Military Chemistry and Chemical Agents", U.S. Army technical manual TM 8-9, 1963.
[3]VX hydrolysis products include: diethyl methylphosphonate, 2-diiisoprpylaminoethyl mercaptan, ethyl hydrogen methylphosphonate, bis (ethylmethylphosphonic) anhydride, bis S-(2-disopropylaminoethyl)methylphosphonodithioate.
Toxic hydrolysis products form at pH 7-10.
[4]RISKPRO, General Sciences Corporation, 1990.
*- Solid below 39°C, liquid above 39°C
NA= Not applicable.
NC=Non combustible
ND= Data not available.
NF= Non-flammable

2. STUDY AREA CHARACTERISTICS

Information regarding the physical characteristics of the environment at and surrounding Fort McClellan and Pelham Range was obtained from the Fort McClellan Department of Environmental Management, analysis of topographic maps and historical aerial photography, compilation of meteorological data, research conducted by the Alabama Geological Survey (AGS), and literature pertinent to Calhoun County.

2.1 PHYSIOGRAPHY

Topographic relief across the Main Post at Fort McClellan exceeds 1,320 feet (Figure 2-1). The lower elevations (700 feet above mean sea level [msl]) occur along Cane Creek, near Baltzell Gate Road, while the highest elevation (2,063 feet above msl) occurs on Choccolocco Mountain, which traverses the area in a north/south direction, with the steep easterly slopes grading abruptly into Choccolocco Valley. The western slopes are more continuous, with the southern extension maintaining elevations up to 900 feet above msl near the western reservation boundary. The northern extension decreases in elevation in the vicinity of Reilly Heliport. The central portion (cantonment area) of the Main Post is characterized by flat to gently sloping land. The Choccolocco Mountains, located in the eastern portion of the Post, form a major surface water divide. East of this divide, the reservation consists of a relatively narrow strip called Choccolocco Corridor, which extends approximately 3.5 to 4 miles from the mountains across the floodplain of Choccolocco Creek, to the base of Rattlesnake Mountain. Choccolocco Creek and its tributaries drain this portion of Fort McClellan and flow southward to the Coosa River.

The topographic relief at Pelham Range is on the order of 445 feet (Figure 2-2). The minimum elevation near the western egress of Cane Creek from the range is 500 feet above msl and the maximum elevation is approximately 945 feet above msl near the southeastern range boundary. The northern portion of Pelham Range contains broad rolling topography with northeast to southwest oriented ridges and isolated round knobs rising 75 to 90 feet above the surrounding terrain. A large, relatively flat area called Battle Drill Area is situated near the western boundary.

2.2 METEOROLOGY

Fort McClellan is situated in a region with a temperate, humid climate. The average annual temperature is 63°F, with summer temperatures usually reaching 90°F or higher about 70 days per year. Temperatures above 100°F are relatively rare. Freezing temperatures are common, but are usually of short duration. The first frost may arrive by late October. At Anniston, the average date of the first 32°F temperature is November 6 and the last date is March 30. Snowfall averages 0.5 to 1 inch. Several inches of snow may accumulate from a single storm on rare occasions as was the case during the blizzard of 1993. The average annual rainfall is approximately 53 inches and is fairly well-distributed throughout the year, as indicated in Table 2-1. The more intense rains usually occur during the warmer months and some flooding occurs nearly every year. Approximately 80 percent of the flood-producing storms are of the frontal-type and occur in the winter and spring, lasting from 2 to 4 days each. Summer storms are usually thunderstorms with intense precipitation over small areas, and these sometimes result in serious local floods.

A study of wind velocity, duration, and direction indicates that winds in the Fort McClellan area are seldom strong and frequently blow down valley from the northeast. However, there is no truly persistent wind direction. Most of the time, only light breezes or calm prevail, except during passages of cyclonic disturbances, when destructive local wind storms may develop into tornadoes, with wind speeds of 100 miles per hour (mph) or more.

2.3 SURFACE HYDROLOGY

The Cane/Cave Creek watershed is among the six major watersheds occurring within Calhoun County. Cane Creek, with its tributaries (Remount, South Branch, and Ingram Creeks), originates on the Fort McClellan Reservation. Cave Creek, which occurs as a separate body while on installation lands, also originates on Post. The on-Post drainage area of this system covers approximately 20 square miles. Dothard Creek has headwaters originating both on and off the installation. These creek systems originate in the Choccolocco Mountains on the eastern boundary of the installation and flow west through the main cantonment. They are fed by springs originating from underlying limestone strata. Cane Creek also passes through the entire length of Pelham Range, but its size and volume are greatly increased by the time it reaches this land area. The Choccolocco Creek watershed occurs to the east of the Choccolocco Mountains passing in a northerly to southerly direction through the Choccolocco Corridor.

The entire central portion of the Main Post at Fort McClellan west of the Choccolocco drainage divide is drained by three major creeks and their tributaries. South Branch receives runoff from the south-central portion, then joins Cane Creek before leaving the reservation on the western boundary. Cane Creek receives surface runoff from the central section. The north-central section of the Post is drained by Cave Creek, which leaves the Post on the northwestern boundary. Other surface water features within Fort McClellan include Lake Yahou (13.5 acres), Reilly Lake (8.5 acres), Cappington Ridge (0.3 acres), Duck Pond (0.5 acres), and an aqueduct. Surface drainage is collected in small, independent networks that drain areas varying from 20 to 60 acres.

Cane Creek, which flows westward across the center of Pelham Range and its tributaries, drains almost all of Pelham Range. Drainage entering the range from the south originates at Anniston Army Depot, which joins Pelham Range to the south. One drainageway located in the southwestern corner flows in a northerly direction and empties into a large topographic low (Battle Drill Area). Cane Creek traverses this low some 800 yards to the north, and all water collected in the low eventually drains into Cane Creek. Other surface water features include Lake Contreras (27 acres), Cane Creek Lake (7.5 acres), Willet Springs (0.8 acres), and Blue Hole (0.2 acres). Drainage from the Cane/Cave Creek watershed on Fort McClellan and Pelham Range ultimately empties into the Coosa River. Floodplains up to 2,500 feet wide traverse this sector and slope toward the center of the range. The wide floodplains are absent in the southern portion of the range.

2.3.1 Ponds, Lakes, and Springs

The named water bodies on the Main Post include Lake Yahou (13.5 acres), Reilly Lake (8.5 acres), Cappington Ridge (0.3 acres), and Duck Pond (0.5 acres), or approximately 23 acres of named water bodies. Pelham Range includes Lake Contreras (27 acres), Cane Creek Lake (7.5 acres), Willet Spring (0.8 acres), and Blue Hole (0.2 acres), or approximately 36 acres of named water bodies. Fresh water springs occur abundantly on installation lands, often appearing along the trace of thrust faults. This is especially true of Pelham Range. All described water bodies are at least in part spring fed with the exception of Lakes Yahou and Contreras. Several high-capacity springs have been mapped (Moser and DeJarnette 1992) on the Main Post and Pelham Range, including Welbourne Spring (200 gallons per minute [gpm]), Reeves-Truitt Spring (58 gpm), Training Lake Spring (1,505 gpm), Camp Zinn Spring (130 gpm), unnamed spring R-48 (175 gpm), and Willett Spring (200 gpm). Unmapped springs potentially occur over much of the Fort McClellan area. Karst features, including developed caves and sinkholes, have been identified in the area of Fort McClellan. Weaver Cave is located approximately 1 mile northwest of the Main Post near the city of Weaver and unmapped, unnamed sinkholes, have been identified on Pelham Range by Fort McClellan Natural Resources personnel. Weaver Cave interrupts the drainage of Cave Creek from Fort McClellan prior to its re-emergence approximately 1,300 feet downstream.

2.3.2 Fresh-water Marshes

Expansion of the installation over the years has altered the drainage patterns of the flat-lying areas on the Main Post. Although many fresh-water marshes are located along Cane Creek, most are limited to the cumulatively larger downstream watershed of Pelham Range. Only one major area, the 25-acre marsh near Reilly Lake, occurs on the Main Post. The drainage area of Cane Creek on Pelham Range has an abundance of riparian flora and fauna. Marsh areas include the 75-acre marsh beginning to the right of the Gate 3 entrance, a 75-acre area to the right of Cane Creek on the Battle Drill Area, a seasonal area surrounding Blue Hole Pond, an area south of the impact area road, and a large block from Gate 13 to the Battle Drill Area where flats occur.

2.4 REGIONAL GEOLOGY

Fort McClellan (Main Post) and Pelham Range lie 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 faulting 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. The extreme eastern portion of Fort McClellan lies within the Piedmont physiographic province. Geologic formations within Fort McClellan and Pelham Range have been mapped by Warman and Causey (1962), Osborne and Szabo (1984), and Moser and DeJarnette (1992), and vary in age from Precambrian to Mississippian. On the eastern boundary of Fort McClellan, Talladega Slate occurs in a narrow band between the county line and the easternmost exposure of the Paleozoic rocks (Warman and Causey 1962). The regional geology in the vicinity of Fort McClellan is shown in Figure 2-3.

The Jacksonville and Pell City Thrust Faults are the most significant structural geologic features in the vicinity of Fort McClellan both for their role in determining the stratigraphic relationships in the area and for their contribution to regional water supplies. The trace of the faults extends northeastward for approximately 39 miles between Bynum and Piedmont, Alabama. The Jacksonville Fault is interpreted as a major splay of the Pell City Fault (Osborne and Szabo 1984). In the vicinity of Fort McClellan, the Jacksonville Fault has juxtaposed the Cambrian Chilhowee Group and Shady Dolomite against Ordovician rocks of the underlying Eden thrust sheet (Osborne and Szabo 1984). The Ordovician sequence comprising the Eden thrust sheet is exposed at Fort McClellan through an eroded "window" or "fenster" in the overlying thrust sheet. The Fort McClellan window is framed on the northwest by the Rome and Conasauga formations, and by the Knox Group of the Pell City thrust sheet. Exposures of the Jacksonville Fault are rare because of deep weathering and thick colluvium accumulation. The fault contact has been observed (Osborne and Szabo 1984) in an excavated trench at Fort McClellan and was marked by approximately 6 feet of brecciated shale and mudstone in thrust contact with residuum of

Shady Dolomite. The Jacksonville Fault is thought to provide a principal reservoir and conduit for groundwater movement in the region, including the consistent supply of groundwater to Coldwater Spring. The Coldwater Spring has supplied water to the Anniston and Fort McClellan areas since 1890, producing an average of 32 million gallons per day (mgd) (Moser and DeJarnette 1992). Large-scale lineaments have been mapped in the vicinity of Fort McClellan by the AGS (Guthrie 1993) from satellite imagery with conjugate lineament sets trending NE-SW and NW-SE crossing regional geological structures.

The Cambrian Weisner Formation consists of interlayered shale, siltstone, sandstone, quartzite, and conglomerate and is the basal formation of the sedimentary rock sequence (Warman and Causey 1962). The Weisner Formation is mapped by Osborne and Szabo (1984) as the uppermost formation in the undifferentiated Chilhowee Group.

The Cambrian Shady Dolomite overlies the Weisner Formation east and south of the Main Post and consists of interlayered limestone and dolomite. The Cambrian Rome Formation is composed of red and green shale and siltstone with thinly interbedded light gray sandstone and calcareous layers. The Rome Formation locally occurs to the northwest and southeast of the Main Post as mapped by Warman and Causey (1962) and Osborne and Szabo (1984). The Conasauga Formation comprises the uppermost Cambrian unit and occurs northwest and southeast of the Main Post. A narrow band of the Conasauga Formation has been mapped (Osborne and Szabo 1984) immediately to the west of Reilly airfield. The Conasauga Formation also occurs along anticlinal axes in the northeastern portion of Pelham Range (Warman and Causey 1962). The Conasauga Formation is composed of interbedded limestone, dolomite, and shale.

Overlying the Conasauga Formation is the Knox Group, composed of the Copper Ridge and Chepultepec dolomite of Cambro-Ordovician age. The Knox Group carbonates consist of light medium gray, fine to medium crystalline, variably bedded to laminated, siliceous dolostone that weathers to a chert residuum (Osborne and Szabo 1984). The Knox Group underlies a large portion of the Pelham Range area. The Knox Group is overlain by Ordovician limestone and shale formations, including the Newala and Longview Limestones, Lenoir Limestone, Athens Shale, Little Oak Limestone, and Chickamauga Limestone. These units occur within an eroded “window” in the uppermost structural thrust sheet at Fort McClellan and underlie much of the developed area of the Main Post. The Devonian Frog Mountain Sandstone consists of sandstone and quartzitic sandstone and 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 claystone with increasing amounts of calcareous chert toward the upper portion of the formation. 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. Floyd Shale mapped by Warman and Causey (1962) on the Main Post of Fort McClellan was reassigned to the Ordovician Athens Shale by Osborne and Szabo (1984) on the basis of fossil data.

2.4.1 Soils

The distribution of surface soil types on the Main Post and Pelham Range are shown in Figures 2-4 and 2-5. In general, the soils are acidic to very strongly acidic with pH between 4.5 and 5.5 units. The soil associations found at Fort McClellan and Pelham Range (SCS 1961) include:

- ***Anniston-Allen-Decatur-Cumberland***—Aluvium resulting from weathering of older saprolitic soils developed from sandstone, shale, and quartzite; deep, well-drained, level to moderately steep soils in valleys underlain by limestone and shale; subsoil is dark red sandy clay loam; Cumberland and Decatur soils are dark reddish-brown gravelly loam developed from limestone saprolite source.
- ***Clarksville-Fullerton***—Well-drained to moderately well-drained stony or cherty soils developed in the residuum of cherty limestone. This association is limited to the Pelham Range. The soils are generally dark brown to dark gray brown silt loam.
- ***Rarden-Montevallo-Lehew***—Moderately deep or shallow soils on ridgetops and steep slopes and in local alluvium in draws; soils developed from the residuum of shale and fine-grained, micaceous sandstone; reddish-brown to dark gray brown to yellow-brown silt loam, clay, or silty clay.
- ***Stony Rough Land***—Shallow, steep, and stony soils formed from the weathering of sandstone, limestone, and Talladega Slate; infiltration slow; contains many boulders and fragments with clayey residuum. This association underlies a large portion of the Main Post at Fort McClellan.

2.5 REGIONAL HYDROGEOLOGY

Regional groundwater flow in the vicinity of Fort McClellan was approximated in 1987 by the U.S. Geological Survey (USGS) (Scott et al. 1987) using existing monitoring and water supply wells in the region. Based on groundwater depth measurements obtained from wells in the composited aquifer (multiple formations) in 1985, regional groundwater elevation ranged from 800 feet above msl on the Main Post to approximately 600 feet above msl on Pelham Range. The developed groundwater elevation contours (50-foot intervals), indicate that groundwater flow is from the Main Post cantonment area toward the city of Weaver to the northwest. Groundwater movement on a local scale is potentially more complex, exhibiting the influences resulting from large-scale geologic structures and topographic variability. Because of the impacts of differential weathering, variable fracturing, and the potential for conduit flow (karst) development, the use of surface topography as an indicator of groundwater flow direction is approximate. Aquifers in the vicinity of Fort McClellan and Pelham Range are developed in residuum derived from bedrock decomposition; within fractured bedrock; along fault zones; and from the development of karst frameworks. Scott et al. (1987) concluded that the aquifers in the region are hydraulically connected and that the slope of the groundwater surface broadly coincides with the surface topography. Groundwater intersection with the ground surface has resulted in the occurrence of springs in the area (including Coldwater Spring), which act as important sources of discharge and water supply in the region. Continuous discharge from many springs has resulted in the formation of standing surface water bodies that do not exhibit significant low-flow water level reduction.

The infiltration of precipitation in the form of rain is the source of most groundwater in Calhoun County, and the thrust fault zones typical of the county form large storage reservoirs for groundwater. Precipitation and subsequent infiltration provide recharge to the groundwater flow system. Points of discharge occur as springs, effluent streams, and lakes. Shallow groundwater on Fort McClellan occurs principally in the residuum developed from Cambrian sedimentary and carbonate bedrock units of the Weisner Formation and locally in lower Ordovician carbonates. Bedrock permeability may be locally enhanced by fracture zones associated with thrust faults and by the development of solution (karst) features (predominantly on Pelham Range). Several sinkholes have been mapped within the Pelham Range boundaries.

Groundwater quality in the area surrounding Fort McClellan and Pelham Range was investigated by Moser and Dejarnette (1992) and is summarized in Appendix E (Table E-1). Samples were collected in 1987 and 1988 from springs and wells ranging in depth from 65 to 263 feet below land surface (BLS). A trilinear (Piper) diagram (Figure 2-6) of the regional groundwater analyses indicates that the water is predominantly a calcium-bicarbonate type that is characteristic of carbonate regions. Physical parameters for the analyses and the ranges of cation, anion, and heavy metal components are summarized in Table 2-2.

2.6 DEMOGRAPHICS AND LAND USE

Two major municipalities are located near Fort McClellan. The city of Anniston (population 26,623; 1990 census) adjoins the main installation on the south and west, and the town of Gadsden (population 47,565; 1990 census) is located 28 miles to the north. The town of Weaver (population 2,715; 1990 census) is located less than 1 mile northwest of the Main Post and the town of Oxford (population 9,362; 1990 census) is located immediately south of the city of Anniston. The city of Jacksonville (population 10,283; 1990 census) is located approximately 4 miles north-northeast of the Main Post. Smaller municipalities, including Pelham Heights, Sherman Heights, and Anniston Beach, are located immediately west or north of the Main Post. Population figures were provided by the Calhoun County Chamber of Commerce (personal communication 1993).

The Anniston area, of which Fort McClellan is a part, is one of two major population concentrations (population 25,000 or more) in the region. Fort McClellan contributes to the population of Anniston and surrounding areas. Besides the military personnel living off-Post, retired military personnel and their dependents live in the area surrounding Fort McClellan. Fort McClellan provides family housing units, Bachelor Officer Quarters, and Bachelor Enlisted Quarters to military personnel and their dependents.

2.7 SENSITIVE ENVIRONMENTS

Information on the sensitive species and habitats on Fort McClellan, Pelham Range, and the Choccolocco Corridor was obtained from the 1977 USATHAMA installation assessment, the *Natural Heritage Inventory of Fort McClellan, Main Post* (Alabama Natural Heritage Program [ANHP] 1994a,b) and the companion volume for Pelham Range, and wetland maps generated by the U.S. Army Corps of Engineers (USACE). The ANHP conservatively identified 12 general ecosystem community types (8 upland, 4 wetland) occurring on Fort McClellan (Main Post) and 8 communities (4 upland, 4 wetland) on Pelham Range.

The habitats at each site are described in Section 6.2. A description of wetland plant communities (Gaddy 1984) provides information on the nature and locations of different types of wetland communities at Fort McClellan, as well as recommendations for their management. Inventories of Federal endangered, threatened, candidate, and state-listed species at both the Main Post (ANHP 1994a) and Pelham Range (ANHP 1994b) have been prepared. Management plans for the Main Post

(Law 1993) and Pelham Range (Geo-Marine 1993) describe the ecological settings of several management areas.

The Main Post offers a wide variety of habitats, including highly disturbed areas (parking lots and building sites), maintained fields, training areas, parade grounds, and mature forest. Topography ranges from relatively level areas through much of the developed part of the Main Post to hills and mountainous ridges. The total area on the Main Post providing suitable habitat for wildlife is 18,946 acres. Nearly all of the forested area of the Main Post has been cut in the past, leaving only very small stands of original timber. Eight major forest communities were summarized by ANHP (1994a). Typical plant species found in these communities are listed in Table 2-3.

Stream habitats include permanent streams with gravel and silt bottoms (e.g., Ingram Creek and South Branch of Cane Creek) that arise in the low elevations of the mountains and flow through the lowlands, semi-permanent tributaries to the permanent streams and their ephemeral pools, and large permanent streams with bedrock bottoms (e.g., Remount Creek and the lower part of Cane Creek) (ANHP 1994a). Several of the Remedial Investigation (RI) sites at the Main Post are located near or adjacent to a major stream or tributary, including Landfills #1, #2, and #3; Area T-5; and Area T-24A. Aquatic habitats are provided by Cane Creek, Cave Creek, and their tributaries; several ponds, lakes, and springs; and numerous fresh-water marshes. Cane Creek arises on the Main Post and flows through Pelham Range to the Coosa River. Cave Creek originates on the Main Post and flows into Cane Creek. Among the areas of concern, Landfills #2 and #3 are within the 100-year floodplain of the drainage system, and therefore, could directly affect surface water quality by erosion during floods.

Animal populations on the Main Post and Pelham Range are typical of open and forested areas in the region. A variety of aquatic, riparian, and terrestrial habitats provide for numerous species of mammals, birds, fish, reptiles, and amphibians. Populations of game and non-game animals are present. The most popular game species include white-tailed deer, wild turkey, bobwhite quail, mourning dove, wood duck, eastern cottontail, gray squirrel, and opossum.

Wildlife management efforts at Pelham Range focus on wild turkeys and deer. Quality brood habitat for turkeys was evaluated as being of relatively low abundance because of a lack of herbaceous vegetation within forested stands and a low abundance of hard mast-producing tree species. Pine pulpwood stands were of the lowest quality for potential turkey habitat, whereas hardwood-pine pulpwood stands were of the highest quality. Of the forested areas analyzed, approximately one-third was classified as high quality and two-thirds were classified as low quality for turkey habitat. Hardwood sawtimber stands, which contained abundant browse, provided the best habitat for deer. Pine pulpwood stands provided the least browse. Of the forested areas evaluated, approximately 16 percent provided high-quality winter food for deer. Deer populations at Pelham Range appear to be near the carrying capacity (Geo-Marine 1993).

Pelham Range lies in the Coosa Valley in a region that was settled and partially cleared for agriculture before the Army assumed control of the land in 1942. Therefore, much of the original habitat had been altered prior to the influence of Army activities, and much of the remaining natural vegetation has been altered. Much of Pelham Range is wooded, generally with longleaf pine and mixed pine/hardwood forest on the hills and ridges, hardwood forests on the lower slopes and along streams, and bottomland hardwoods mixed with pine along the valley bottoms. There are large open areas for training and maneuvers, as well as old field habitats where land had been cleared for activities that have since ceased. The total area of Pelham Range providing suitable habitat for wildlife is 16,915 acres (Weston 1990).

Seven major plant community types were discussed by ANHP (1994b). Table 2-4 lists typical plant species and the communities to which they belong. Upland dry-mesic oak-hickory-pine forest occurs on slopes and low ridges. Lower elevations are forested predominantly with pine-dominated communities. Vines and grasses may be abundant, whereas herbaceous species are less common in most wooded areas.

2.7.1 Wetlands

Wetlands are protected by the Federal Government primarily through Section 404 of the Clean Water Act (CWA). This act empowered USACE and the U.S. Environmental Protection Agency (EPA) to regulate most forms of wetlands destruction. Wetland areas on Fort McClellan and Pelham Range have been catalogued by USACE (Fort McClellan map data 1986). Wetland communities at Fort McClellan have been described by Gaddy (1984) and Ogden Environmental (1992). In addition to the stream habitats described above, two distinct wetland community types, sweetgum-mixed bottomland oak forest and forested mountain seep, were described by ANHP (1994a). Plant species occurring in this area are listed in Table 2-5. Beaver ponds and the associated wetlands, including mixed-shrub, mixed shrub-bulrush-needlerush, buttonbush-bulrush, sweet gum-bulrush, and bulrush-needlerush-cattail communities also occur at several locations. These habitats may be ephemeral because they usually depend on beaver activity.

Fort McClellan, Pelham Range, and the Choccolocco Corridor have an abundance of wetlands representing important habitats for a wide variety of plants and animals as well as providing a wealth of other values for the public, including:

- Flood control
- Water quality maintenance
- Erosion buffers
- Groundwater recharge and stream flow maintenance
- Timber production.

Fort McClellan's wetlands typically are found in the valley along creek floodplains, near stream terraces, and in areas of low-lying topography. USACE-catalogued wetland areas occur in the vicinity of Landfills #2 and #3, and downgradient from (southeast of) Area T-38 on the Main Post. Wetland areas have not been catalogued at the RI sites on Pelham Range, although wetland areas are documented within a half-mile radius of the sites.

Thirteen types of wetlands plant communities have been described on the reservation (USATHAMA 1990). These communities and their National Wetlands Inventory (NWI) designations are as follows:

- Mixed bottomland hardwoods: first bottoms (Palustrine, forested [deciduous], seasonally flooded wetlands)
- Mixed bottomland hardwoods: second bottoms (Palustrine, forested [deciduous or deciduous-evergreen], temporarily flooded wetlands)
- Stream terrace hardwoods (Palustrine, forested [deciduous or deciduous-evergreen], temporarily flooded wetlands)
- Creekbank hardwoods (Palustrine, forested [deciduous], seasonally flooded wetlands)
- Water oak flat (Palustrine, forested [deciduous], temporarily flooded wetlands)

- Sweetgum/bulrush community (Palustrine, forested [deciduous], seasonally flooded wetlands)
- Sweetgum depression (Palustrine, forested [deciduous], temporarily flooded wetlands)
- Mixed shrub community (Palustrine, scrub/shrub [deciduous], temporarily and seasonally flooded wetlands)
- Mixed shrub/bulrush/needlerush community (Palustrine, scrub/shrub/emergent [persistent], seasonally flooded, impounded, or seasonally flooded wetlands)
- Buttonbush/bulrush community (Palustrine, shrub/scrub [deciduous], semipermanently flooded wetlands)
- Bulrush/needlerush/cattail community (Palustrine, emergent [persistent], temporarily and seasonally flooded wetlands)
- Non-forested creekback community (Palustrine, emergent [persistent and non-persistent], seasonally flooded wetlands)
- Mud flat community (Palustrine, emergent [non-persistent], seasonally flooded, and semipermanently flooded wetlands).

Differences between the catalogued number of wetland communities described on the Fort McClellan properties by various studies are related to variability allowed in the community designations of the hierarchical Southeastern Regional Classification scheme (ANHP 1994a).

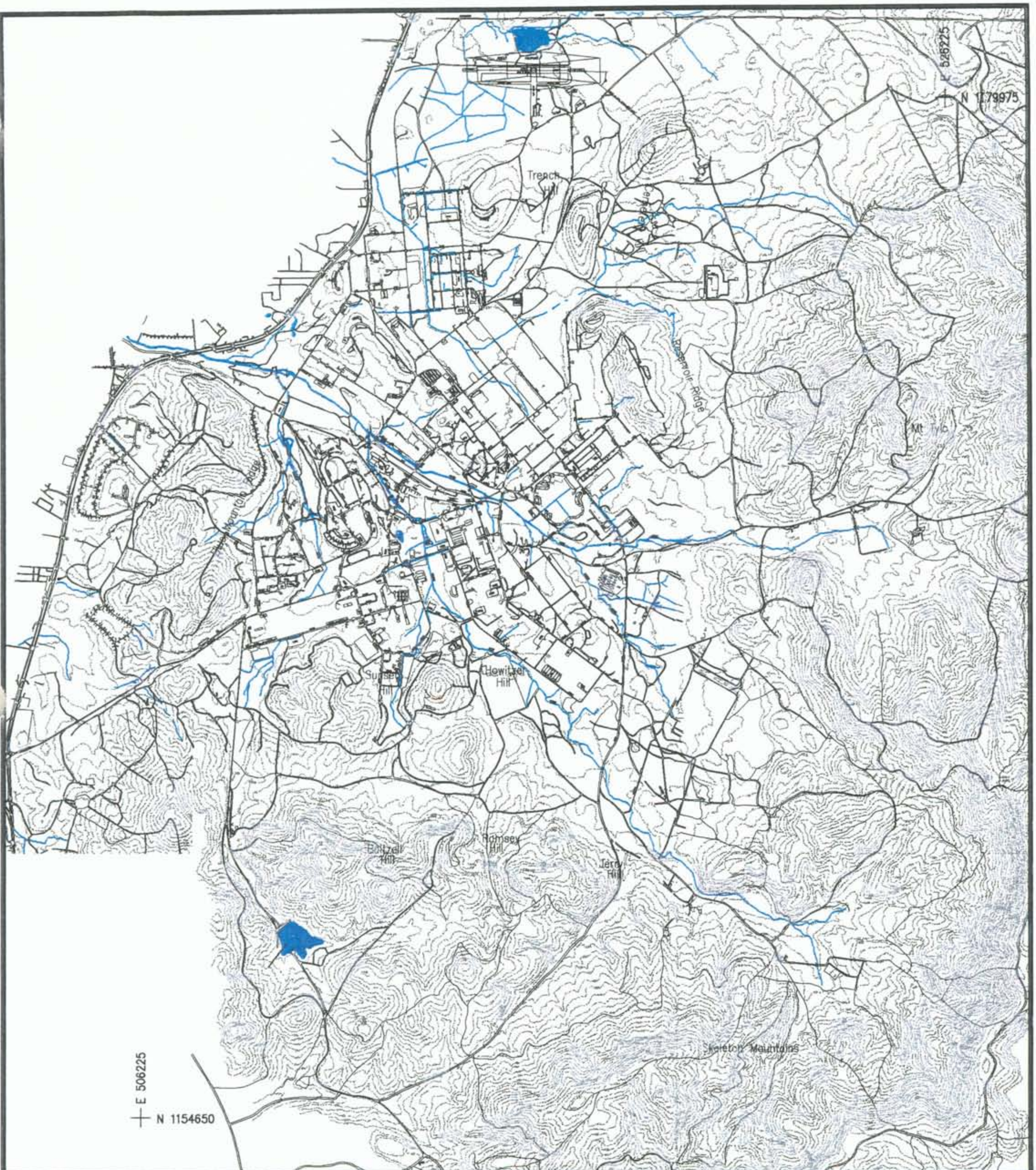
2.7.2 Flora and Fauna

Fort McClellan and its adjoining grounds consist of a variety of aquatic, riparian, and terrestrial habitats that provide for numerous species of game and non-game animals. An estimate of populations and habitats based on surveys conducted in 1986 (USATHAMA 1990) is as follows:

- Approximately 38,361 acres (Government-owned or leased from the State of Alabama) are suitable for wildlife habitat; this includes 16,915 acres in Pelham Range, 18,946 acres in the Main Post, and 2,500 acres in the Choccolocco Corridor.
- Range conditions are generally good, with the exception of numerous areas where dense growth prohibits the production of certain wildlife foods.
- The popular game species at Fort McClellan are white-tailed deer, northern bobwhite, turkey, mourning dove, eastern cottontail, gray squirrel, raccoon, wood duck, and opossum.

The Federal Endangered Species Act (USDOI 1973) defines an *endangered species* as one in danger of extinction in all or a significant portion of its range; *threatened species* are defined as those likely to become endangered within the foreseeable future (West 1992). The Federal Endangered Species Act also protects critical habitats of threatened and endangered species (USDOI 1973). Natural heritage inventories of Federal endangered, threatened, and candidate species, and state-listed species have been prepared for the Main Post (ANHP 1994a) and Pelham Range (ANHP 1994b). No protected species have been identified in the sites at the Main Post or Pelham Range, and no habitats at sites on either the Main Post or Pelham Range have been designated as critical habitats. However, the forests could provide habitat for the gray bat (*Myotis sodalis*). Wet areas along Lake Reilly and around the edges of the beaver ponds provide habitat for plants requiring a large amount of water. These wet habitat areas also attract migrant waterfowl (e.g., wood ducks), many species of which are protected by the Endangered Species Act.

A study conducted from April through October 1979 (USATHAMA 1990) concluded that the only federally recognized endangered species potentially occurring on Fort McClellan is the red-cockaded woodpecker (*Picoides borealis*). Summermour (1992) concluded that the last active colony of the birds in training area 16B probably disappeared around 1970 and that the birds are no longer occupying habitats on the Post. A total of six Category 2 (i.e., some evidence that a species may warrant Federal endangerment listing) candidate species, including one vertebrate (*Sylvilagus obscurus*), two plants (*Lysimachia fraseri* and *Platanthera integrilabia*), and three invertebrates (*Elimia gerhardti, Speyeria diana,* and *Polycentropus carlsoni*), have been observed on the Main Post (ANHP 1994a). The red-cockaded woodpecker is the only state-protected species identified from the installation (exclusive of game species). Endangered vertebrate or invertebrate species have not been identified on Pelham Range. Endangered plant species have been identified at two sites on Pelham Range, including Willett Spring and Lloyd's Chapel. The federally protected plant species include Tennessee yellow-eyed grass (*Xyris tennesseenis*) and Mohr's Barbara's buttons (*Marshallia mohrii*). Endangered species have not been identified in the vicinity of the Old Water Hole or Ranges J, K, and L.



LEGEND:

- ....ASPHALT ROADS
- ....STREAM OR TRIBUTARY
- .....TOPOGRAPHIC CONTOUR (CI=25 ft)

NOTE: Base map from U. S. Army Corps of Engineers, Mobile District, 1989.

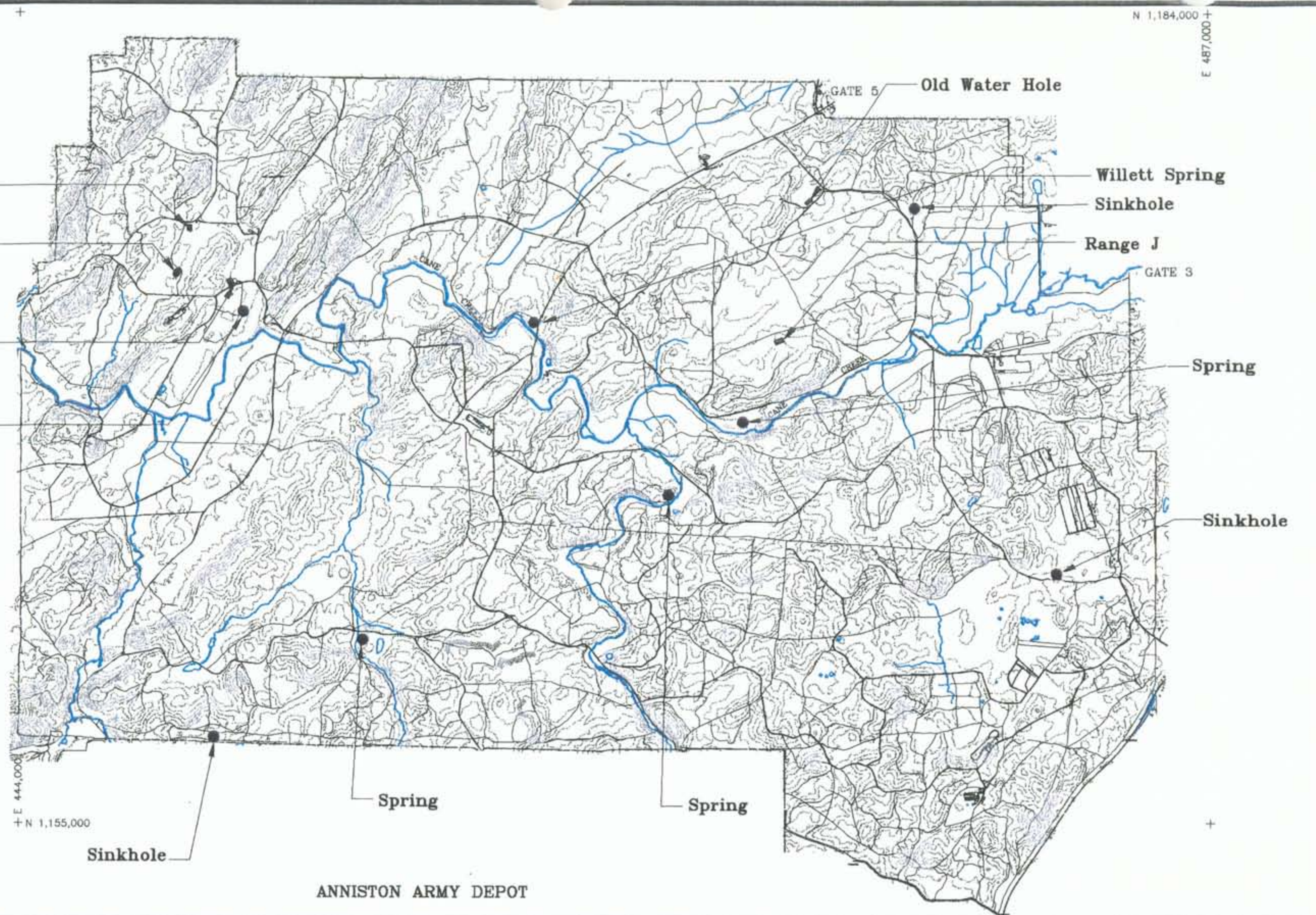
0 3400

SCALE: 1" = 3400'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

SURFACE TOPOGRAPHY & HYDROLOGY–MAIN POST SITE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
2–1	01–0827–07–6520–012	FTMC\98–FIG2–1	Oct. 1998



LEGEND:
- ASPHALT ROADS
- 620 TOPOGRAPHIC CONTOUR (CI=25 ft.)
- STREAM OR TRIBUTARY
- RI/FS SITE LOCATION WITH SITE NAME
- STATE PLANE COORDINATE SYSTEM

NOTE: BASE MAP AND TOPOGRAPHY FROM U.S. ARMY CORPS OF ENGINEERS, MOBILE DISTRICT, 1989.

0 2750 5500 11000

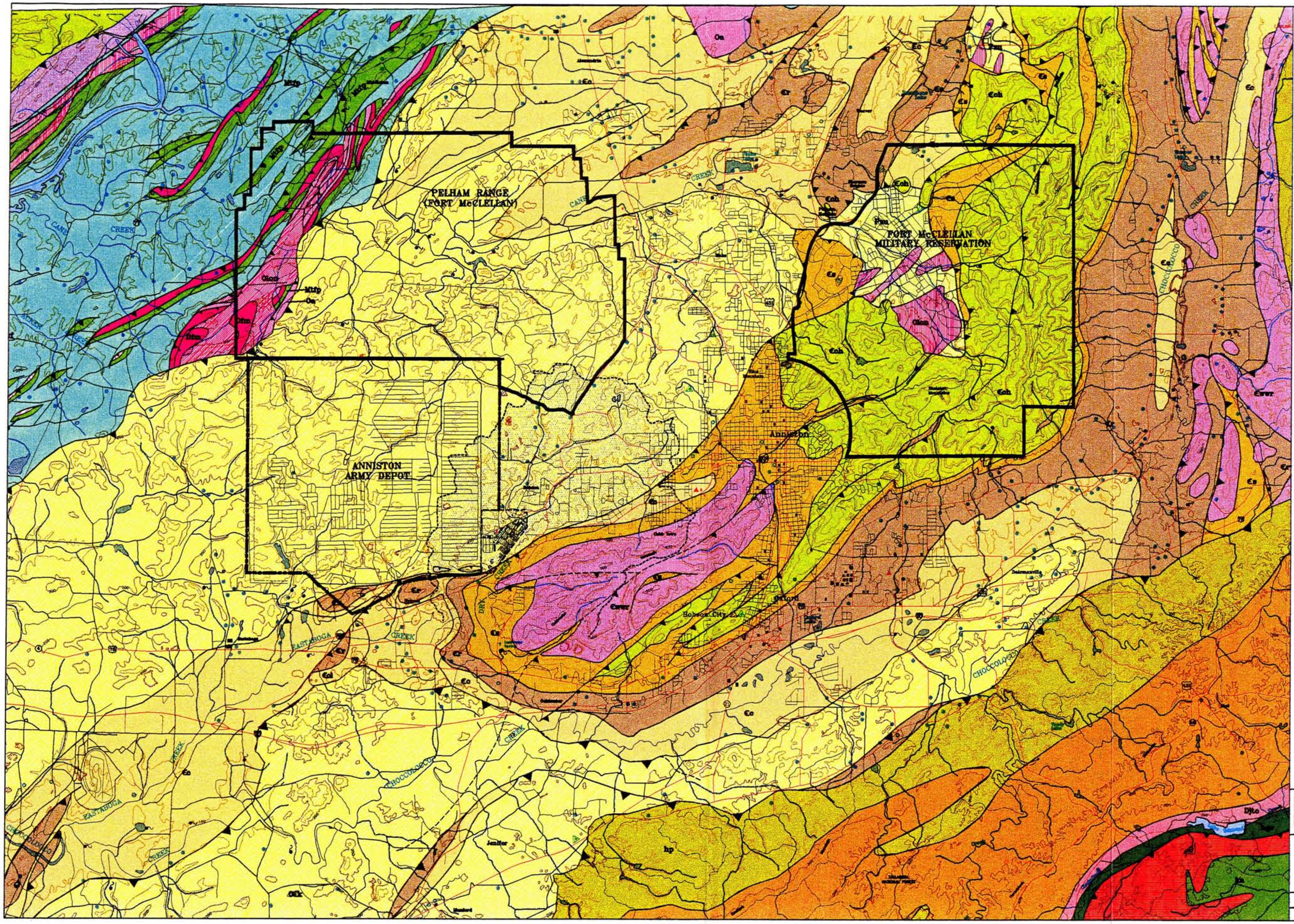
SCALE: 1" = 5500'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

SURFACE TOPOGRAPHY & HYDROLOGY RANGE SITE LOCATION MAP

FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
2-2	01-0827-07-6520-012	FTMC\98-FIG2-2	Oct.1998



LEGEND:

- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- CLASSS 3 OR 4 ROADS
- ROUTE MARKER: INTERSTATE; U.S.; STATE
- RIVER, STREAM, LAKE OR SHORELINE
- CONTOURS: INDEX, INTERMEDIATE (40 M)
- SINKHOLE OR CLOSED DEPRESSION
- THRUST OR REVERSE FAULT (DASHED WHERE INFERRED)
- LITHOLOGIC CONTACT (DASHED WHERE INFERRED)
- POTTSVILLE FORMATION
- PARKWOOD FORMATION
- PARKWOOD FORMATION AND FLOYD SHALE
- PALEOZOIC SHALE UNDIFFERENTIATED
- FLOYD SHALE
- HARTSELLE SANDSTONE
- PRIDE MOUNTAIN FORMATION
- TUSCUMBIA LIMESTONE AND FORT PAYNE CHERT UNDIFFERENTIATED
- CHATTANOOGA SHALE & FROG MOUNTAIN SANDSTONE UNDIFFERENTIATED
- ATHENS SHALE
- LITTLE OAK AND NEWALA LIMESTONE
- KNOX GROUP UNDIFFERENTIATED IN PART
- CONASAUGA FORMATION
- ROME FORMATION
- SHADY DOLOMITE
- CHILHOWEE GROUP UNDIFFERENTIATED
- WEISNER AND WILSON RIDGE FORMATIONS UNDIFFERENTIATED
- HILLABEE GREENSTONE
- JEMISON CHERT AND CHULAFINNE SHCIST UNDIFFERENTIATED
- LAY DAM FORMATION
- HEFLIN PHYLLITE
- POE BRIDGE MOUNTAIN GROUP
- KETCHEPEDRAKEE AMPHIBOLITE

SOURCE:

Alabama Dept. of Environmental Management, Solid Waste Branch, Land Division. 1989.

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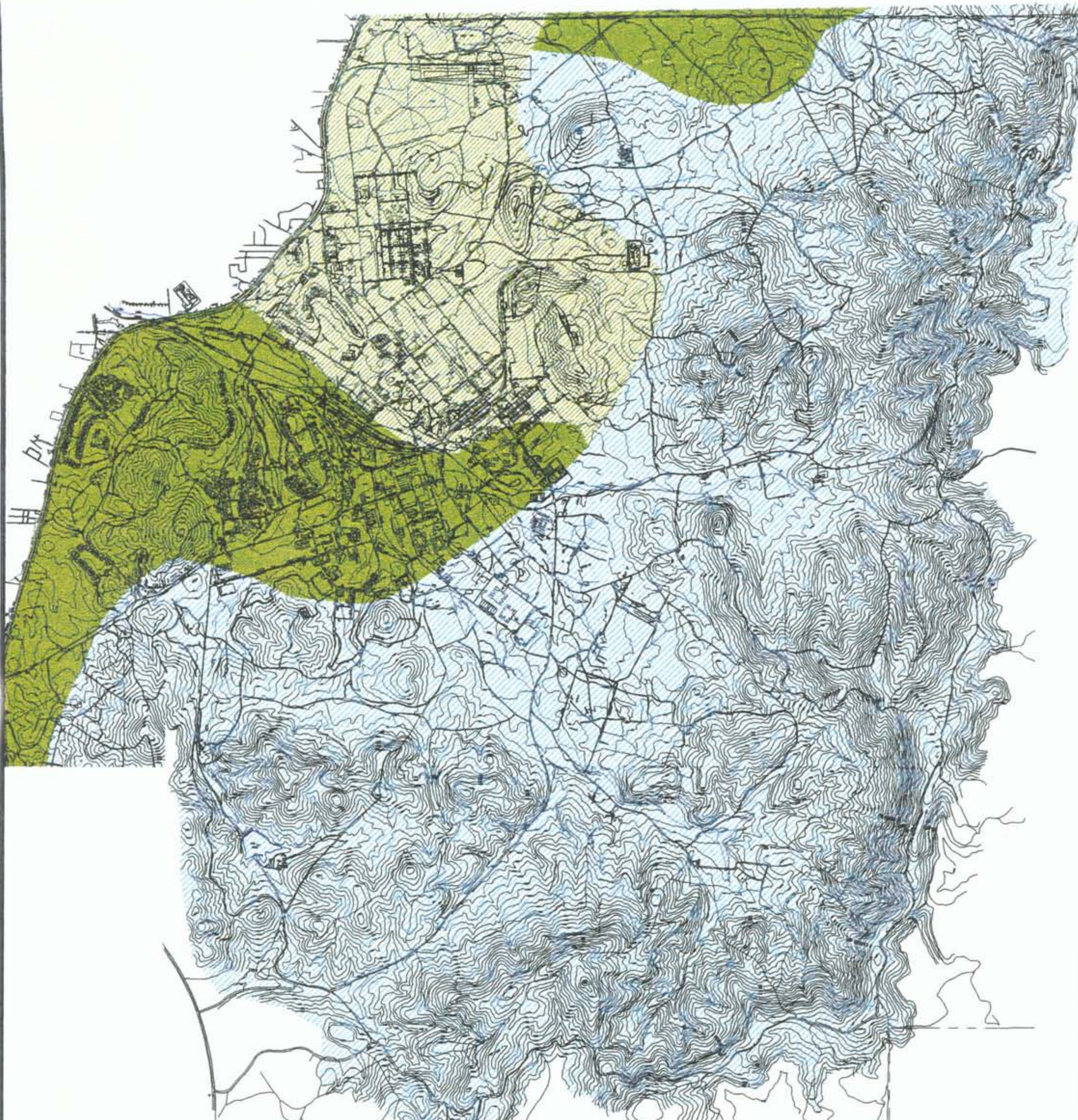
0 650 1300 2600
SCALE: 1 = 1300'

U.S. ARMY
CORPS OF ENGINEERS

FIG 2-3
REGIONAL GEOLOGY MAP
FORT McCLELLAN, ALABAMA

10-06-98	/95037/DWGS/A31MGEO-A
REV. / DATE	CAD FILE #



NOTES:

1. Soil distributions from Soil Conservation Service, 1961
2. Base map from U.S. Army Corps of Engineers, Mobile District, 1989.

LEGEND:

- .... PRIMARY AND SECONDARY ROADS
- .... BUILDINGS
- ....STREAM & TRIBUTARY
- .... FENCE
- .... RAILROAD
- ....PROPERTY BOUNDARY
- 1400 ..TOPOGRAPHIC CONTOUR (25 ft. INTERVAL)
- +...................ALABAMA STATE PLANE GRID
- .. ANNISTON-ALLEN-DECATUR-CUMBERLAND SERIES
- .... CLARKSVILLE-FULLERTON SERIES
- . RARDEN-MONTEVALLO-LEHEW SERIES

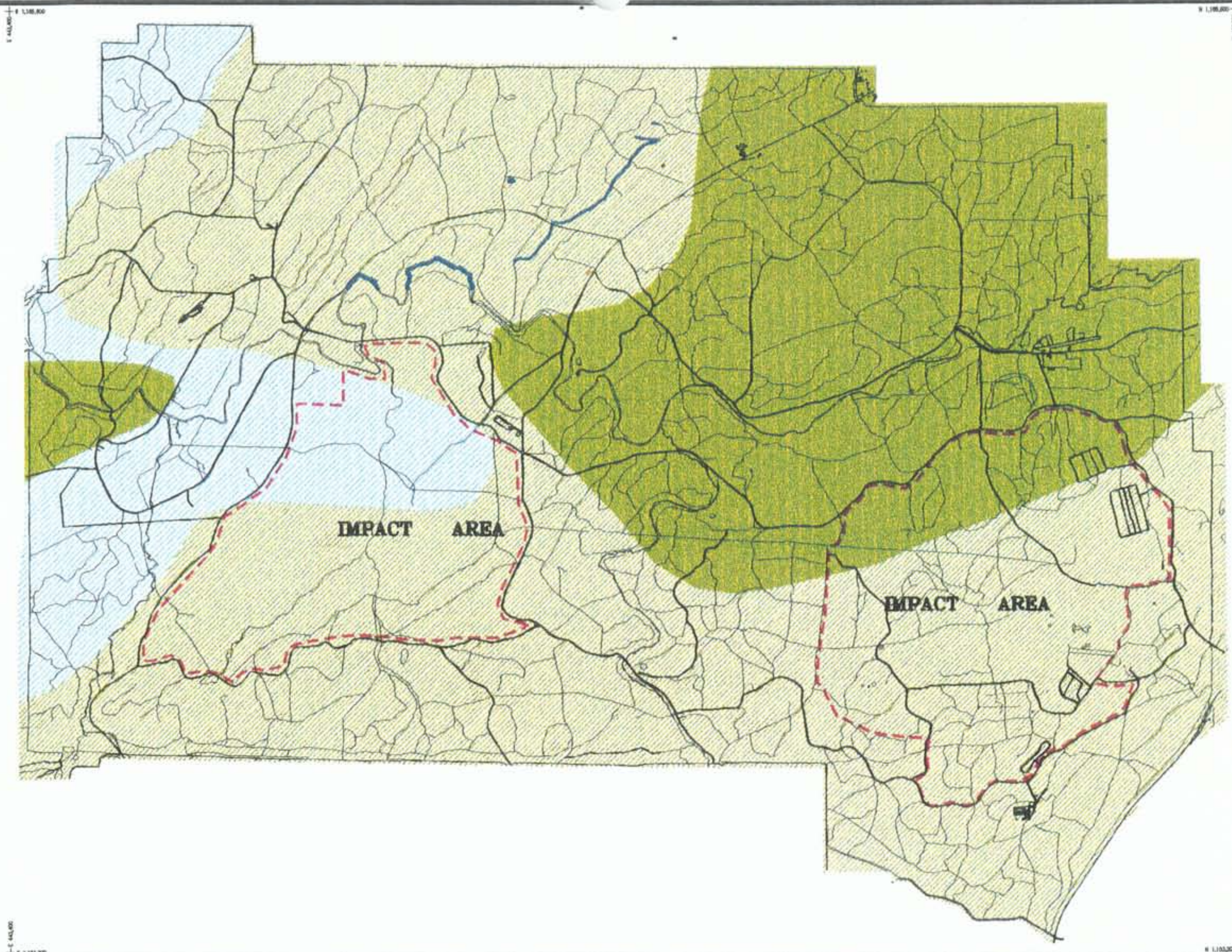
0 4000

SCALE: 1" = 4000'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

REGIONAL SOIL MAP
MAIN POST
FORT McCLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
2-4	01-0827-07-6520-012	FTMC\98-FIG2-4	Oct.1998



LEGEND:

- PRIMARY ROADS
- SECONDARY ROADS
- BUILDINGS
- STREAM & TRIBUTARY
- FENCE
- RAILROAD
- IMPACT AREA
- TOPOGRAPHIC CONTOUR (25 ft. INTERVAL)
- TOPOGRAPHIC CONTOUR (5 ft. INTERVAL)
- ALABAMA STATE PLANE GRID
- CLARKSVILLE-FULLERTON SERIES
- RARDEN-MONTEVALLO-LEHEW SERIES
- ANNISTON-ALLEN-DECATUR-CUMBERLAND SERIES

NOTES:

1. Soil distributions from Soil Conservation Service, 1961.
2. Base map from U.S. Army Corps of Engineers, Mobile District, 1989.

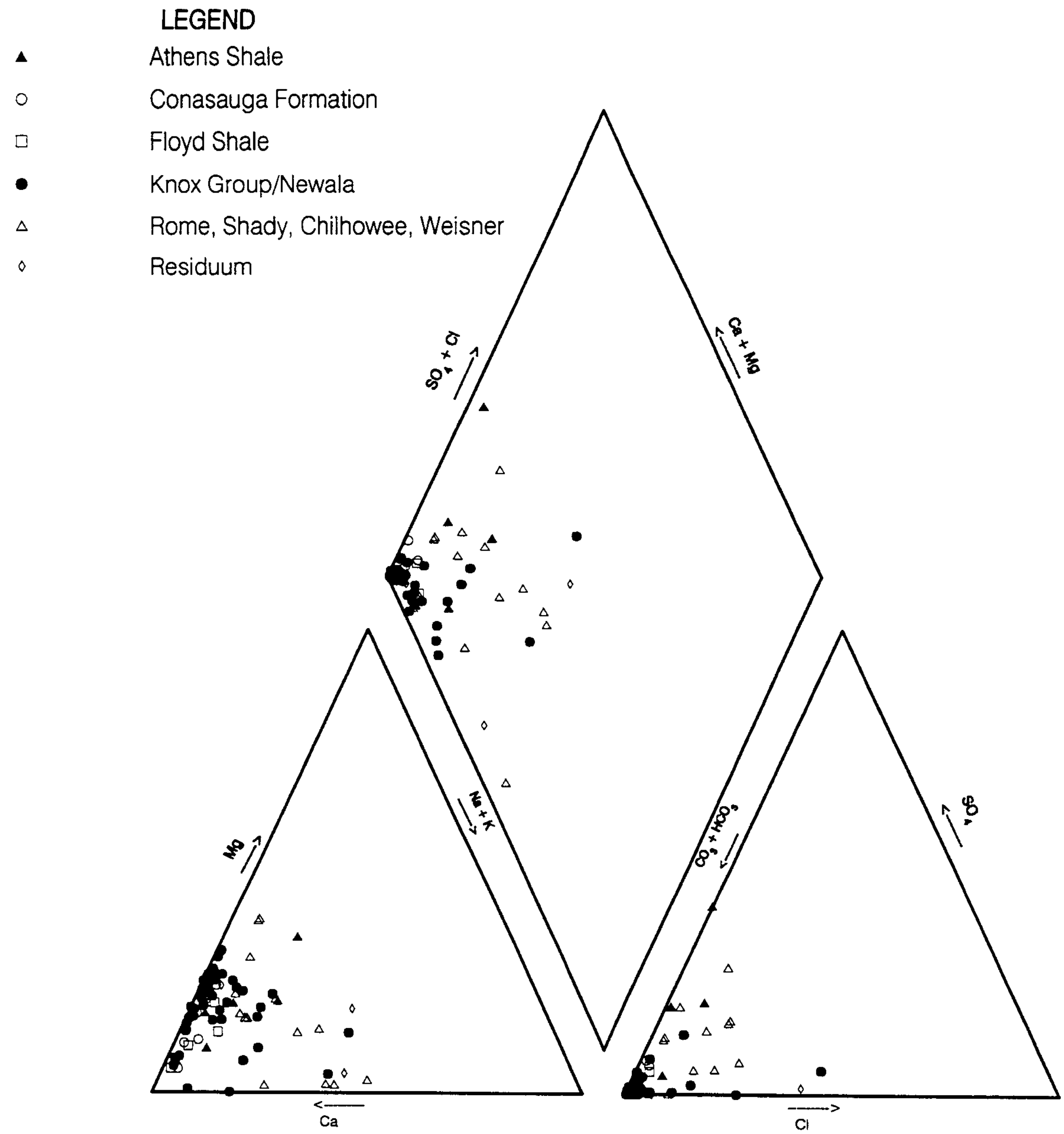
0 2500 5000

SCALE: 1" = 5000'

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

REGIONAL SOIL MAP
PELHAM RANGE
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
2-5	01-0827-07-6520-012	FTMC\98-FIG2-5	Oct.1998



Groundwater analyses from "Groundwater Availability in Calhoun County, Alabama", Geological Survey of Alabama Special Map 228, "Groundwater Availability in Talladega County, Alabama, Geological Survey of Alabama Special Map 207, 1988, Samples obtained 1997.

U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE, ALABAMA

GROUNDWATER QUALITY
FORT McCLELLAN AND VICINITY

FORT McCLELLAN, ALABAMA

Figure:	Project:	File:	Date:
2-6	01-0827-03-6520-025	FTMC_WQ.GRF	JAN 1998

Table 2-1. Normal and Total Precipitation (inches) by Month at Anniston Airport, Anniston, Alabama

Month	Average 1961-1990[a]	1990[b]	1991[c]	1992[d]	1993[e]	1994[f]	1995[g]	1996[g]	1997[h]
January	5.30	7.56	4.25	4.09	7.67	3.50	3.43	7.99	5.08
February	5.07	8.99	6.24	6.32	2.54	5.04	7.35	3.58	5.07
March	6.34	8.65	6.45	4.47	7.17	7.42	4.26	8.75	6.34
April	5.25	1.90	4.76	2.85	3.19	5.81	2.54	2.81	5.25
May	4.23	2.94	7.61	2.17	5.11	2.95	2.36	3.63	4.23
June	3.71	2.63	7.29	5.96	4.96	6.6	2.4	2.63	3.71
July	4.46	3.37	2.39	4.44	0.80	8.3	2.44	--	4.46
August	3.90	0.58	2.4	6.47	3.16	2.89	2.92	--	3.9
September	3.57	0.58	3.53	5.28	1.71	2.69	7.12	--	3.57
October	2.74	2.65	0.53	2.12	2.68	3.68	9.35	--	2.74
November	3.72	3.03	3.82	10.32	3.96	4.33	6.94	--	3.72
December	4.81	2.47	4.66	5.71	4.42	3.62	4.77	--	4.81

[a] Data obtained from *Monthly Station Normals, Anniston FAA AP, 1961-1990*, NOAA, National Climatic Data Center, 1992.

[b] Data obtained from *Climatological Data Annual Summary, Alabama, 1990,* Vol. 96, No. 13, NOAA.

[c] Data obtained from *Annual Climatological Summary for 1991, Anniston FAA Airport* , NOAA, National Climatic Data Center, 1993.

[d] Data obtained from *Summary of the Day Data (Form 5670) for 1992, Anniston FAA Airport*, NOAA, National Climatic Data Center, 1993.

[e] Data obtained from *Summary of the Day Data (Form 5670) for 1993, Anniston FAA Airport*, NOAA, National Climatic Data Center, 1994.

[f] Data obtained from *Summary of the Day Data (Form 5670) for 1994, Anniston FAA Airport*, NOAA, National Climatic Data Center, 1994.

[g] Data obtained from *The Weather Resource* at www.cdc.noaa.com on June 25, 1998.

[h] Data obtained from National Weather Service, Birmingham, Alabama, Anniston monthly normals and records 1997.

– Data not available

Table 2-2. Average Groundwater Quality from Wells in the Vicinity of Fort McClellan/Pelham Range, Anniston, Alabama (1988)*

Parameter	Minimum	Maximum	Average
Specific Conductance (umhos/cm)	19	560	215.1
Temperature (°C)	10	19	15.4
Bicarbonate (mg/L)	5	310	128.2
Alkalinity as CaCO3 (mg/L)	4	250	103.7
pH	4.4	8	6.9
Sulfate (mg/L)	0.1	31	3.3
Chloride (mg/L)	0.7	100	4.2
Arsenic (μg/L)	<0.5	6	1.0
Barium (μg/L)	<0.5	300	52.8
Cadmium (μg/L)	<0.5	2	0.5
Chromium (μg/L)	<0.5	5	1.1
Iron (μg/L)	ND	11,000	538.0
Lead (μg/L)	<0.5	15	2.9
Manganese (μg/L)	<5	190	47.6
Strontium (μg/L)	<5	480	43.7
Zinc (μg/L)	<5	860	127.0
Total Dissolved Solids (mg/L)	21	321	134.0
Hardness as CaCO3 (mg/L)	4	250	107.0

*Data summarized from Moser and Dejarnette (1992).

Table 2-3. Typical Plant Species Found in Main Post Upland Communities

Species	Typic Mesophytic Forest	Piedmont Monadock Forest	Interior Calcareous Oak-Hickory Forest	Basic Oak-Hickory Forest	Loblolly Pine Shortleaf Pine Oak Forest	Xeric Virginia Pine Ridge Forest	Dry Virginia Pine-Oak Forest	Mountain Longleaf Pine Forest
Canopy species								
Carya alba								+
C. tomentosa		+						
Liriodendron tulipifera	+							
Liquidambar styraciflua	+							
Nyssa sylvatica	+							+
Pinus echinata	+				+			+
P. palustris					+			+
P. taeda	+				+			+
P. virginiana				+		+	+	
Quercus alba	+	+		+				
Q. coccinea		+						
Q. falcata							+	+
Q. marilandica						+	+	
Q. muehlenbergii				+				
Q. nigra				+				
Q. phellos			+					
Q. prinus		+	+			+	+	+
Q. rubra	+							
Q. stellata				+			+	+
Q. velutina	+			+				
Q. spp.					+			
Understory species								
Acer leucoderme				+				
A. negundo			+					
A. rubrum	+	+						
A. saccharum			+					
Carpinus caroliniana			+					
Cercis canadensis			+	+				
Cornus florida	+	+						
Fagus grandifolia			+					
Hamamelis virginia	+							
Juniperus communis								+
J. virginiana			+					
Liquidambar styraciflua	+							

Table 2-3. Typical Plant Species Found in Main Post Upland Communities

Species	Typic Mesophytic Forest	Piedmont Monadock Forest	Interior Calcareous Oak-Hickory Forest	Basic Oak-Hickory Forest	Loblolly Pine Shortleaf Pine Oak Forest	Xeric Virginia Pine Ridge Forest	Dry Virginia Pine-Oak Forest	Mountain Longleaf Pine Forest
Nyssa sylvatica		+						
Ostrya virginiana			+					
Oxydendrum arboreum	+	+						+
Quercus laevis								+
Q. marilandica								+
Rhamnus caroliniana			+					
Shrubs								
Aronia arbutifolia						+		
Kalmia latifolia	+							
Rhododendron canescens								+
Symphoricarpos orbiculatus				+				
Vaccinium arboreum						+	+	
V. pallidum	+	+						+
V. stamineum								+
Viburnum nudum	+							
V. spp.				+				
Xanthorhiza simplicissima	+							
Vines								
Gelsemium sempervirens							+	
Vitis rotundifolia	+							
Herbaceous species								
Aureolaria pectinata								+
Pteridium aquilinum								+
Schizachyrium scoparium							+	
Schrankia microphylla								+
Stipa avenacea							+	
Stylosanthes biflora								+
Tephrosia virginiana								+
Toxicodendron toxicarium								+

Source: ANHP 1994a

Table 2-4. Typical Plant Species Found in Pelham Range Ecological Communities

Species	Upland Dry-mesic Oak-hickory-pine Forest	Upland Dry Oak-hickory-pine Forest	Dry Post Aak-blackjack Oak Hardpan Forest	Typic Mesophytic Forest	Sweetgum-mixed Bottomland Oak Forest	Sycamore-sweetgum American Elm Bottomland Forest	Natural Impoundment Pond
Canopy species							
Acer floridanum				+			
A. rubrum				+		+	
Betula nigra						+	
Carya glabra	+						
C. tomentosa	+						
Carya spp.			+				
Celtis laevigata					+		
Liriodendron tulipifera	+			+		+	
Liquidambar styraciflua	+			+	+	+	
Pinus echinata	+		+				
P. palustris		+	+				
P. taeda	+		+	+			
Platanus occidentalis						+	
Quercus alba	+			+			
Q. falcata	+	+	+				
Q. marilandica		+	+				
Q. nigra					+		
Q. phellos					+		
Q. prinus		+					
Q. stellata		+	+				
Q. velutina	+						
Ulmus americana					+	+	
Understory species							
Acer negundo					+	+	
A. rubrum	+		+	+	+		
Asimina triloba						+	
Carpinus caroliniana					+	+	
Cercis canadensis			+	+			
Cornus florida	+	+	+	+			
Diospyros virginia			+				
Nyssa sylvatica	+	+	+				
Oxydendrum arboreum	+	+					

Table 2-4. Typical Plant Species Found in Pelham Range Ecological Communities

Species	Upland Dry-mesic Oak-hickory-pine Forest	Upland Dry Oak-hickory-pine Forest	Dry Post Aak-blackjack Oak Hardpan Forest	Typic Mesophytic Forest	Sweetgum-mixed Bottomland Oak Forest	Sycamore-sweetgum American Elm Bottomland Forest	Natural Impoundment Pond
Shrubs							
Aesculus pavia			+	+			
Alnus serrulata						+	+
Arundinaria gigantea					+		
Asimina parviflora	+						
Callicarpa americana		+					
Cephalanthus occidentalis							+
Corylus americana				+			
Euonymus americana				+	+		
Hamamelis virginiana				+			
Hydrangea cinerea	+			+			
H. quercifolia	+						
Itea virginica						+	
Ligustrum sinense					+		
Rhamnus caroliniana	+						
Rhus copallina			+				
Salix nigra							+
Sambucus canadensis					+	+	
Sassafras albidum	+						
Vaccinium arboreum		+	+				
V. pallidum		+	+				
V. stamineum	+						
Vines							
Bignonia capreolata				+	+		
Campsis radicans					+		
Decumaria barbara				+			
Lonicera japonica	+			+	+		
Parthenocissus quinquefolia	+			+			
Smilax spp.					+		
Toxicodendron radicans	+				+		
Vitis cordifolia	+						
V. rotundifolia				+			

Table 2-4. Typical Plant Species Found in Pelham Range Ecological Communities

Species	Upland Dry-mesic Oak-hickory-pine Forest	Upland Dry Oak-hickory-pine Forest	Dry Post Aak-blackjack Oak Hardpan Forest	Typic Mesophytic Forest	Sweetgum-mixed Bottomland Oak Forest	Sycamore-sweetgum American Elm Bottomland Forest	Natural Impoundment Pond
Herbaceous species							
Aletris farinosa			+				
Amsonia tabernaemontana						+	
Andropogon scoparius			+				
Arisaema dracontium					+		
Bartonia virginica					+		
Boehmeria cylindrica					+	+	
Cardamine bulbosa					+		
Carex caroliniana			+				
Chasmanthium latifolium						+	
Ch. sessiliflorum					+		
Chimaphila maculata	+						
Claytonia virginica					+		
Coreopsis major	+	+	+				
Danthonia spicata		+	+				
Desmodium nudiflorum	+						
Elymus virginicus						+	
Eupatorium perfoliatum			+				
Galium circaezans				+			
Geranium maculatum				+			
Geum canadensis						+	
Helianthus spp.			+				
Hexastylis arifolia				+			
Impatiens capensis						+	
Juncus effusus							+
Juncus spp.			+				
Marshallia mohrii			+				
Microstegium vimineum	+			+	+		
Monotropa hypopithys					+		
Orbexilum pedunculatum			+				
Pityopsis graminifolia		+					
Platanthera flava					+		
Podophyllum peltatum				+			
Polemonium reptans						+	

Table 2-4. Typical Plant Species Found in Pelham Range Ecological Communities

Species	Upland Dry-mesic Oak-hickory-pine Forest	Upland Dry Oak-hickory-pine Forest	Dry Post Aak-blackjack Oak Hardpan Forest	Typic Mesophytic Forest	Sweetgum-mixed Bottomland Oak Forest	Sycamore-sweetgum American Elm Bottomland Forest	Natural Impoundment Pond
Polygonatum biflorum				+			
Pycnanthemum tenuifolium			+				
Rhynchospora spp.			+				
Sanicula canadensis						+	
Scirpus cyperinus							+
Senecio pauperculus					+		
Silphium trifoliatum var. laevigatum			+				
S. terebinthinaceum			+				
Smilacina racemosa				+			
Stipa avenacea		+					
Tephrosia virginiana		+					
Trillium lancifolium					+		
Typha latifolia							+
Verbesina alternifolia						+	

Source: ANHP 1994b

Table 2-5. Typical Species Found in Main Post Wetland Plant Communities

Species	Sweetgum-mixed bottomland oak forest	Forested mountain seep
Canopy species		
Acer rubrum	+	
Fagus grandifolia		+
Liriodendron tulipifera	+	+
Liquidambar styraciflua	+	
Pinus taeda		+
Quercus alba	+	+
Q. falcata		+
Q. nigra	+	
Q. phellos	+	
Q. prinus		+
Q. velutina	+	+
Understory species		
Carpinus caroliniana	+	
Shrubs		
Kalmia latifolia		+
Lyonia ligustrina		+
Magnolia virginiana		+
Viburnum nudum		+
Xanthorhiza simplicissima		+
Herbaceous species		
Athyrium filix-femina		+
Gentiana saponaria		+
Osmunda cinnamomea		+
O. regalis		+
Oxypolis rigidior		+
Platanthera clavellata		+
Pl. integrilabia		+
Sphagnum spp.		+
Thelypteris nova-boracensis		+
Tiarella cordifolia		+
Woodwardia areolata		+

Source: ANHP 1994a

3. METHODS AND PROCEDURES

This section provides details regarding the specific tasks and procedures that were completed at Fort McClellan during the 1993 Remedial Investigation (RI). The principal project tasks, including field investigation, hydrogeologic characterization, multimedia sampling and chemical analysis, and human health and ecological risk assessment, are described below. The techniques and procedures that were used during this effort were developed using guidance from the *Geotechnical Requirements for Drilling, Monitor Wells, Data Acquisition, and Reports* (USATHAMA 1987), *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), and *Environmental Compliance Branch Standard Operating Procedures* (EPA 1991). Areas of conflict between these guidance documents were resolved within the project Work Plan, Quality Assurance Project Plan (QAPP), and Sampling and Analysis Plan (SAIC 1994a, b, and c), which were approved for implementation by the U.S. Army Environmental Center (USAEC) and the Alabama Department of Environmental Management (ADEM). The investigation activities completed at each site are summarized in Table 3-1.

3.1 TOPOGRAPHIC SURVEYING

Digital topographic maps (5-foot contour interval, Intergraph™ format) for the area of Fort McClellan and Pelham Range were obtained from the U.S. Army Corps of Engineers (USACE) in Mobile, Alabama. Base maps for each RI site were developed from the digital data where the contour interval was sufficient to resolve the salient site features. Detailed topographic surveying and mapping was necessary at the Old Water Hole site and Range L (Lima Pond) because topographic features associated with these sites were not sufficiently resolved by the 5-foot contour interval. Topographic mapping of the Old Water Hole and Range L was completed by Frank Hollis and Associates, Oneonta, Alabama, using 1- and 2-foot contour intervals, respectively. Additional land surveying to quantitatively locate site features, sample locations, and Miniature Continuous Air Monitoring System (MINICAMS®) screening locations was conducted at Range J, Area T-38, Area T-24A, Area T-4, Area T-5, and the Detection and Identification (D&I) Area. Survey data are provided in Appendix J.

Monitoring wells that were installed during the RI were surveyed in the Alabama State Plane Coordinate System (east) to within 1.0 foot horizontal accuracy. The ground surface elevation, top of concrete pad, and top of the polyvinyl chloride (PVC) well casing elevations also were surveyed to within 0.05 foot vertical accuracy. Geophysical survey grids and transects were quantitatively surveyed at Landfill #1, Landfill #2, Area T-38, and the Old Water Hole. Grids and transects were surveyed to a 1-foot horizontal accuracy with staked hubs driven on 20-foot centers. Global positioning system (GPS) surveying was attempted at Fort McClellan; however, numerous obstructions within the wooded site areas resulted in data of limited quality and utility. Conventional land surveying was used to achieve the accuracy necessary for the investigations. All topographic surveying for this investigation was completed by a licensed surveyor from the State of Alabama using the Alabama State Plane Coordinate System (east) and the horizontal North American Datum of 1927 (NAD 1927). The National Vertical Geodetic Datum of 1929 (NVGD 1929) was used to reference all vertical elevation determinations.

3.2 SOURCE AREA INVESTIGATIONS

Although considerable information is available regarding the historical activities conducted at the RI sites, potential sources of mission-related constituents within the sites are variably identified. Potential sources were investigated through the use of historical records, including scaled drawings, historical aerial photography, historical site photography, and historical reports. The results of surface geophysical surveys conducted at several sites (Area T-4, Area T-24A, Area T-38, the D&I Area, Landfill #1, Landfill #2, Range J, Range K, Range L, and the Old Water Hole) were used to delineate potential source areas. The U.S. Army Technical Escort Unit (USATEU) conducted intrusive trenching at Area T-24A, the D&I Area, and Range J in order to more fully investigate potential source areas delineated by geophysical or historical information. A soil boring was drilled at the identified location of a reported disposal sump at Area T-38.

3.2.1 Historical Photography Evaluation

Low altitude, historical aerial photography for several site areas, including Range J, Area T-24A, Area T-38, and the northeastern portions of Pelham Range (EPA 1982, 1983), was reviewed by SAIC to identify potential source areas that may have existed in the past and that are now obscured. Intermittent photography dating between 1949 and 1972 for various sites was compiled and interpreted by the U.S. Environmental Protection Agency (EPA) Environmental Photographic Interpretation Center (EPIC). Photographic scales for the low-altitude photography ranged from 1":3200" to 1":4300". Higher altitude aerial photography with coverage of Fort McClellan and Pelham Range was obtained from the Soil Conservation Service (SCS) and the Fort McClellan Environmental Management Office (EMO) for the years between 1954 and 1993. Historical site photography documenting activities conducted at several RI sites was obtained from USAEC archives. Site photography for Areas T-4, T-5, T-24A, the D&I Area, and Range J was reviewed and attempts were made to locate observable site features in the field and on site maps.

3.2.2 Intrusive Investigation

Potential source areas delineated by surface geophysics were further investigated by intrusive trenching. Trenching was conducted by USATEU utilizing an armored M419, small emplacement excavator tractor (SEETRAC) with a backhoe attachment under the direction of SAIC personnel. Trenching was conducted at Area T-24A, the D&I Area, and Range J. MINICAMS® monitoring was conducted by USATEU during both excavation of the trenches and soil sample collection from the trenches. USATEU explosive ordnance personnel were onsite during each trenching operation to monitor for buried ordnance. The test pit locations were based on visual observations, location of historical concrete base markers, geophysical surveys, and MINICAMS® screening results conducted at each site prior to intrusive activity. The test pits were placed in a diamond or cross pattern to provide aerial coverage of each suspected burn or burial pit.

Each test pit was excavated by scraping the backhoe in 4-inch depth increments. USATEU collected disturbed soil samples from the test pits at intervals selected by the field geologist. Field screening for the chemical warfare agents (mustard [HD], Sarin [GB], and O-ethyl-S(diisopropylamino-ethyl)methylphosphonothiolate [VX]) was conducted on all soil samples. Soil samples also were collected for laboratory analysis of HD, GB, and VX agent breakdown products.

A soil boring was drilled to 50 feet below land surface (BLS) at Area T-38 at the location of a former sump that was identified by Fort McClellan personnel and further delineated by surface geophysics and historical photography. Soil samples collected from the borehole were screened for CWM by USATEU personnel.

3.3 FIELD SCREENING

Field screening was conducted at Fort McClellan to rapidly assess broad site areas for potential buried mission-related sources and hot spots, and to assess subsurface samples for the presence of CWM prior to offsite laboratory handling and analysis. Field screening was conducted using surface geophysical techniques (EM-31®, EM-61®, magnetometer, Surface Towed Ordnance Location System [STOLS™]) and onsite MINICAMS® analyses for CWM. MINICAMS® screening was conducted by the USATEU operating out of Aberdeen Proving Ground, Maryland. SAIC conducted geophysical surveying at Area T-38, Landfill #1, Landfill #2, the D&I Area, the Old Water Hole, Range K, and Range L. Additional geophysical surveying at Area T-4, Area T-24A, Area T-38, and Range K was conducted by Geo-Centers, Inc. using an arrayed magnetometer system (STOLS™). MINICAMS® screening was conducted by USATEU at Areas T-4, T-5, T-24A, and T-38, the D&I Area, the Old Water Hole, Range K, and Range L.

3.3.1 Geophysical Surveys

Geophysical surveys were conducted at Fort McClellan during three field periods between March 1994 and February 1995. Surveys were conducted at eight sites, including the D&I Area, Landfill #1, Landfill #2, the Old Water Hole, Range K, Range L, Area T-24A, and Area T-38. Dependent on the suspected nature of the targets at a particular site, geophysical measurements were obtained either over detailed grids to provide spatial resolution of buried targets or along transects to provide reconnaissance of areas with limited source area distribution information. Surveys may have been conducted at several separate locations or areas at an individual site to search for a suspected buried target or areal surveys conducted to investigate an entire site. Frequency domain electromagnetic (FDEM-EM31®), time domain electromagnetic (TDEM-EM61®), magnetometer (G-856AX) and magnetic gradiometer, and arrayed magnetometer (STOLS™) techniques were used to investigate the site areas based on expected changes in subsurface electrical and magnetic properties produced by the targets. This information was used to help delineate potential contaminant source areas and to guide the placement of sampling locations. Overviews of FDEM, TDEM, and magnetic methods are provided in Appendix A. Because the shallow site soils are predominantly clayey and two of the sites were beneath ponded water, ground penetrating radar (GPR) surveys were determined to be of limited use at the sites. Single point and arrayed magnetometer surveying were used at the sites where GPR was initially planned in order to more readily detect buried ordnance.

3.3.1.1 Electromagnetic Methods – EM 31® and EM 61®

FDEM measurements were made using a Geonics EM31-DL® ground conductivity meter with data recorded by an Omnidata data logger. The meter consists of transmitter and receiver coils that are separated by 12 feet. The instrument has a nominal depth of investigation of approximately 20 feet when operated in the vertical dipole mode in the absence of near-surface conductive layers or materials. The instrument measures both quadrature-phase and in-phase components of an induced magnetic field. The quadrature-phase component is a measure of apparent ground conductivity, while the in-phase component is sensitive to the presence of metal. Apparent ground conductivity is measured with a precision of about ± 2 percent of full-scale meter reading, which corresponds to approximately 2 millimhos per meter (mmhos/m) for the present survey.

A base station was established at each area to assess meter drift and check the calibration during and after each site survey. The instrument was calibrated prior to each day's measurements. Portions of profiles were reoccupied at the beginning and end of each survey to assess repeatability among data sets that were collected on different days. The reoccupied portions usually represented 5 to 10 readings, and were conducted on those portions thought to be representative of natural conditions. Values of apparent conductivity typically agreed to within 2 mmhos/m and values of in-phase agreed to at least 3 parts per thousand (ppt). All pertinent readings and observations were recorded in a bound field notebook.

All single gate TDEM measurements were made using a Geonics EM61® conductivity meter with data recorded using an Omnidata data logger. The meter consists of a transmitter and two receiver coils, which are arranged in a square configuration. The instrument generates EM pulses at 150 times per second and measures the secondary field response generated by metallic conductors buried beneath the surface. By sensing the induced secondary EM fields generated by buried metallic objects, the effects of conductive earth surrounding the object are reduced and the metallic response is enhanced. The instrument records the secondary EM responses using two "channels." Channel 1 is more susceptible to near-surface or surface metallic material due to the built in gain on this channel, while channel 2 yields response from deeper targets, and the differential provides a filtering by further removing the effect of near-surface metallic material. Numerous metallic (including aluminum) targets were observed on the surface during the surveys. Since the target for the EM 61® surveys was deeper-buried metallic material, interpretation is presented for channel 2 and the differential data in order to investigate the deeper targets.

During the course of each field day, FDEM and TDEM data were transferred from the data logger to diskettes using a portable computer. The data were processed using DAT31 (FDEM) or DAT61 (TDEM) software (DAT31 1988; DAT61 1994) and plotted using Grapher for Windows (Golden Software 1992) and Surfer for Windows (Golden Software 1994) software. Tabulated field data and data plots from the surveys are provided in Appendix A.

3.3.1.2 Magnetometer Surveys

Total field and vertical gradient magnetic readings were collected at a 5- to 10-foot station spacing on pre-established grids and transects. The station density enabled rapid reconnaissance while providing sufficient detail to detect relatively small magnetic features (i.e., on the order of 5 to 10 feet or the distance between two stations) and to complement the in-phase data collected during EM surveying. Magnetic measurements were collected at approximately 2,100 stations.

All field data were recorded using a Geometrics G-856AX proton precession magnetometer. The instruments consist of two sensors mounted on an 8-foot pole. The sensors are connected to a unit that displays and stores the data. The instrument measures vertical gradient and total field values to an accuracy and precision of approximately 1 and 0.1 nanoTeslas (nT), respectively. A base station was established at each site to measure diurnal variations during magnetic surveying. Base station data were recorded using the G-856AX instrument with the exception that only one sensor was used to record the total magnetic field. The base station monitored diurnal variations of the total geomagnetic field at 2-minute intervals while the field data were collected. During the course of surveying, the maximum diurnal variation was less than 35 nT. For most surveys, the variation was 10 nT or less, but at several sites (notably the Old Water Hole and Range K), diurnal variations were 20 to 35 nT over the course of the survey. Internal clocks on the base station and field magnetometers were synchronized to facilitate data reduction.

At the beginning of each field day, the operator removed all metallic objects from his person. Readings of vertical gradient and total field were collected at individual stations. The readings, time, and station location were stored internally in the field magnetometer; readings, time, and station identification were recorded in a bound field notebook. The repeatability between data sets was quantified at a site by reoccupying measurement stations at the beginning and end of each survey. The repeatability between all data sets was to within several nT.

The field data were transferred from the magnetometers to computer diskettes using a portable computer at the end of each field day. The raw data were then processed using MAGPAC

(1988) and MAGLOC (1991) software packages. Diurnal variations were removed from the top sensor readings and ASCII files were created after this processing, which were used in profiles and contouring. The bottom or lower sensor values were subtracted from the top or higher sensor values and divided by the distance separating the two sensors, yielding vertical magnetic gradient data. The data were plotted using Grapher for Windows (Golden Software 1993) and Surfer for Windows (Golden Software 1994) software.

3.3.1.3 Arrayed Magnetometer Surveys – Areas T-4, T-24A, and T-38, and Range K

Site areas accessible to GPS mapping and suspected of subsurface burials were investigated using the STOLS™ and STOLS™-adjunct arrayed magnetometer instrumentation. The STOLS™ technology provided an advantage over conventional point or transect-based geophysical surveying in that continuous site mapping could be attained in satellite available areas. The surveys were conducted in February and May 1995 by STOLS™ Search Technologies (a Geo-Centers Company). The STOLS™ unit incorporates an all-terrain vehicle towing an array of nine magnetometers linearly arranged perpendicular to the direction of the survey vehicle movement. Approximately 100,000 magnetometer data points were obtained per acre of survey area at a vehicle speed of approximately 3.5 miles per hour (mph). The STOLS™-adjunct equipment utilizes tandem magnetometers hand-carried across the terrain to map a 3-foot swath at walking speed. The location of each survey array is continuously tracked using multiple receiver, kinematic GPS data. Processing of the acquired data included smoothing, target size classification, and target depth approximation calculations.

The purpose of the STOLS™ surveys was to quantitatively locate buried objects, including munitions, within each site boundary. The STOLS™ was used instead of a single-point magnetometer to ensure that the site area received complete areal coverage because of the discovery of buried ordnance at two of the sites (Area T-24A and Range K). Area T-24A was cleared of surface ordnance and metallic debris by the 142nd Explosive Ordnance Detachment of Fort McClellan. The area within the fence was cleared of trees and brush by facilities personnel from Fort McClellan. The remaining site areas (Area T-4, Area T-38, and Range K) were not surface cleared of trees or brush prior to the surveys. Tree canopy impeded the collection of complete site coverage at Area T-38 and Range K. These areas also were surveyed using conventional single point magnetometry and EM measurements.

The surface vehicle traversed the site area in approximately 10-foot swaths until complete coverage of the target area was obtained. STOLS™-adjunct data were collected along approximately 3-foot swaths. Field data were collected in real time and were spatially referenced using a dual receiver, kinematic, differential global positioning system (DGPS) arrangement with one receiver mounted in the towing vehicle and a second receiver established as a base station over a spatially established control point. Existing surveyed monitoring wells and staked locations were used as base stations and georeference points for the present survey. The magnetometer data were corrected for diurnal variations in the earth's magnetic field strength using data collected from a monitoring magnetometer station established near each site.

The acquired sensor data were processed onsite, or were transmitted electronically for processing at the GeoCenters, Inc. office in Massachusetts, to produce data images for survey quality control and to assess the target distributions in the field. Targets delineated on the data images were modeled by GeoCenters, Inc. using a point source magnetic dipole model for each suspected target. The resulting model match was used to estimate the target's location in three dimensions, and the estimated target orientation and inclination. The target's size (small, medium, or large) was estimated based on the derived magnetic moment. Target location and depth for unsuccessfully modeled targets were estimated using a "full width at half maximum" algorithm, which is a rule-of-thumb estimate that typically produces less accurate depth estimates. Targets that were not isolated (grouped) or were too small for model matching or depth estimates were only located for two-dimensional position.

3.3.2 MINICAMS® Field Screening (USATEU)

This section describes the equipment and procedures used to screen samples for CWM. Field screening for CWM was conducted by USATEU at sites suspected of CWM training or disposal activities, including Areas T-4, T-5, T-24A, and T-38; the D&I Area; Range J; Range K; Range L; and the Old Water Hole. Onsite field screening of surface and subsurface soil samples was conducted by USATEU using two Type 2000 (CMS Research™ Corporation) MINICAMS® to analyze for chemical and nerve agents (HD, GB, and VX). The MINICAMS® were calibrated and operated daily by USATEU according to their standard operating procedure (SOP) and manufacturer's instructions.

Procedures for the analysis of samples collected for field screening are relatively nonstandardized. However, because conventional analytical laboratories are not equipped or licensed to handle chemical surety materials, the need for field analyses for CWM is essential for containing surety materials at their point of origin. While the potential for encountering surety materials was relatively low based on the age of the sites, the need to semi-quantitatively screen samples onsite was important for minimizing risks to site and laboratory personnel. Since these types of analyses cannot be completed by conventional laboratories, the field data for CWM will be used in the baseline risk assessment. Tabulated MINICAMS® data are provided in Appendix B.

The MINICAMS® is an automatic air monitoring system that collects compounds on a solid sorbent trap and thermally desorbs them into a capillary gas chromatography column for separation. The compounds are detected using a sulfur-sensitive, flame photometric detector. MINICAMS® sample locations were determined using a systematic (triangular grid) sampling scheme combined with biased sampling of known training localities. The MINICAMS® units were operated by two USATEU teams according to their SOP. The MINICAMS® units obtain a time weighted average (TWA) concentration by analyzing vapors produced by thermal desorption from a soil sample. The thermal desorption was effected by heating each sample to approximately 70°F in a controlled environment. The MINICAMS® unit is calibrated to respond to 0.0001 mg/m^3 GB, 0.00001 mg/m^3 VX, and 0.003 mg/m^3 HD as a time-weighted average (TWA). The TWA concentrations for HD, GB, and VX are established by the Surgeon General of the United States and are shown below:

Agent	TWA* (mg/m^3)	TWA* (ng/L)	MINICAMS® Detection Limit* (ng/L)
HD	.003	3	1
GB	.0001	0.1	.005
VX	.00001	0.01	.005

* Data provided by CMS Research Corporation (1993, written communication).

The MINICAMS® system is normally set up to report concentrations in relative units. For example, if a concentration of 0.003 mg/m^3 of HD is detected by the MINICAMS®, it is reported as 1.00 TWA. If a concentration of 0.00001 mg/m^3 of VX is detected, it is reported as 1.00 TWA. Thus, the TWA reading has the same significance no matter which agent is being detected. The TWA reading reported for a given agent may be converted to mg/m^3 simply by multiplying the reported TWA reading by the definition given above. For example, a reading of 0.5 TWA for GB corresponds to 0.00005 mg/m^3.

Ideally, the unit will report a concentration reading of 1.00 TWA each time the proper quantity of agent is injected into the MINICAMS® after calibration. The alarm level for the MINICAMS® is set to correspond to a 95 percent confidence level, which would sound an alarm if the instrument was challenged with the equivalent of 1.00 TWA of agent. Statistical studies have shown that an alarm level of 0.80 TWA is a suitable setpoint for the MINICAMS® to achieve a 95 percent confidence level. A 1.00 TWA challenge of the MINICAMS® will result in a concentration reading greater than or equal to 0.80, 95 percent of the time, resulting in an alarm.

The following procedure was used to analyze soil samples using a MINICAMS® unit at Fort McClellan:

- Prior to initiating field work each day the MINICAMS® units were calibrated by the USATEU using dilute standards obtained from the Anniston Army Depot (ANAD). The standards for the chemical agents were obtained by the USATEU each working morning and were returned to ANAD at the end of each working day. The calibration standard consisted of a solution containing 0.15 ng/µL GB, 0.015 ng/µL VX, and 1.7 ng/µL HD which was injected into the MINICAMS® units. Calibration records were maintained by the USATEU and are provided in Appendix B.
- Approximately 50 grams of soil were collected with a decontaminated stainless steel spoon, trowel, or hand auger; deposited into a stainless steel bowl; homogenized; and placed in a glass jar. Upon retrieval of a split-spoon sample, the soil in the tip of the sampler was removed with a stainless steel spoon and placed in a glass jar.
- The soil sample was placed in the heater box (uncapped) and heated to the required minimum temperature of 70°F. Evolved vapors were collected through Teflon® tubing attached to the heater box and were introduced directly into the MINICAMS® unit. Once the MINICAMS® reported the sample clear of CWM, the soil sample was removed, disposed of onsite, and the results logged by USATEU. Each sample was equilibrated in the heater box at the same temperature, for the same duration, and with approximately equal volume in each soil sample container.
- USATEU also conducted continuous air monitoring with the MINICAMS® units during intrusive activities (i.e., drilling and trenching). The heater lines were placed as close to the borehole or test pit as conditions allowed. The soil vapors released by the intrusive activity were purged through the heater lines, adsorbed onto the trap, and desorbed into the column of the MINICAMS®. The results of each cycle were logged by USATEU.

3.4 GEOLOGICAL/GEOTECHNICAL INVESTIGATIONS

Soil samples and rock cores were collected from several of the areas of concern to obtain lithologic and engineering data to characterize the geologic and geotechnical properties of the materials underlying the site areas. The following sections discuss the equipment, methods, and procedures used to acquire geotechnical data in accordance with USAEC and ADEM guidance. EPA Region IV Environmental Compliance Branch Standard Operating Procedures (ECBSOP [EPA 1991]) were consulted during the planning stages for the RI field study. The ECBSOP guidance subsequently was revised in 1996.

3.4.1 Surface Soil Sampling

SAIC and USATEU personnel collected surface soil samples for chemical analysis at Area T-4, Area T-5, Area T-38, Range K, Range L, the Old Water Hole, Landfill #1, Landfill #3, and at background locations. Soil samples were collected from areas suspected of having the highest potential for detection of mission-related constituents, and to obtain areal coverage of the sites. Sample locations were initially screened by USATEU using a MINICAMS® as a requirement of sample collection at locations where the presence of CWM was suspected and to ensure that the samples were free of chemical surety materials. Soil samples also were screened for total volatile organics using a flame ionization detector (FID). Samples were collected using either a hand auger, stainless steel spoon or garden trowel, or a carbon steel split-spoon with stainless steel liners, depending on the depth of the sample and the competence of the substrate. Section 3.4.2 discusses the procedures used to collect split-spoon samples.

Where necessary, the surface layer (0 to 0.5 feet BLS) of organic material or gravel was removed prior to the collection of the surface sample. Samples collected for volatile organics analysis (VOA) were obtained first using a stainless steel sleeve to ensure expedient acquisition of a representative sample. This was accomplished by covering one end of the sleeve with a nominal 4- by 4-inch Teflon® sheet and plastic end cap before placing the open end of the sleeve into the ground. The sleeve was driven into the ground with a hammer. Additional soil was placed in the VOA sample sleeve to compensate for voids and a Teflon® sheet with a plastic end cap was placed over the exposed end. End caps and sheeting that were damaged during sleeve insertion were replaced prior to being wrapped with non-adhesive Teflon® tape. The sleeve then was wrapped in aluminum foil to ensure that the Teflon® tape would not unravel and the sample was placed in a sealable plastic bag. The sealed plastic bag was then placed in an iced-filled cooler with an ambient temperature between 2° and 6°C. The remaining analytical parameters were collected after the VOA sample had been properly containerized and stored. Approximately 1,500 grams of soil were composited in a stainless steel bowl and containerized in 500 mL sample containers for CWM breakdown products and 250 mL containers for semivolatile organic compounds (SVOCs), pesticides/polychlorinated biphenyls (PCBs), explosives, and metals. The container caps were secured and the samples were placed in a cooler with ice.

All soil samples were labeled before shipment to their respective analytical laboratories. The labels were completed with the installation name, project number, location, sample date/time, media type, method matrix, site identification (ID), site type, field sample number, depth, sample technique, analysis, preservative, comments, and collector's initials. Clear tape was used to secure sample container labels to the bottles to prevent inadvertent label removal due to moist or wet conditions occurring during storage or shipment of the samples.

3.4.2 Subsurface Soil/Rock Sampling

Subsurface soil and rock samples were collected for lithologic, geotechnical, and chemical analysis at six sites, including Area T-38, Landfill #1, Landfill #3, the Old Water Hole, Range J, and Range L. Subsurface soil samples also were collected from excavated trenches at Area T-24A, the D&I Area, and Range J. Rock cores were collected from four sites, including Area T-24A, the Old Water Hole, Range L, and Range J. The following sections describe the equipment and procedures used to collect subsurface soil and rock samples during the RI.

Analytical samples for soil chemistry were collected using a 2.5-inch outside diameter (O.D.) by 2-foot long carbon steel split-spoon lined with stainless steel sleeves. Soil samples for VOA were collected and quickly prepared to minimize the air exposure time of the sample. The open ends of the

VOA sleeve were covered with nominal 4- by 4-inch Teflon® sheets. Plastic end caps were used to cover the sheets and were sealed with a non-adhesive Teflon® tape. The sleeve was then wrapped in aluminum foil to ensure that the Teflon® tape would not unravel and placed in a sealable plastic bag to protect the sample. The plastic bag was then placed in an ice-filled cooler with an ambient temperature between 2° and 6°C. The remaining analytical fractions subsequently were collected from a homogenized sample and were prepared in the same manner as the VOA samples.

The soil samples were homogenized by removing the soil from the remaining sleeves into a stainless steel bowl. A stainless steel spoon or trowel was used to composite the sample prior to containerization. The homogenized sample was placed in three 250-mL containers with threaded caps. The container caps were secured, the samples were placed in a sealable plastic bag, and the samples were stored in the cooler. Additional subsurface soil samples were collected in 250-mL jars for MINICAMS® screening during drilling and excavation operations at Area T-24A, the D&I Area, Area T-38, the Old Water Hole, Range J, and Range L.

Soil samples were collected from excavated trenches at Area T24A, the D&I Area, and Range J by USATEU at locations identified by SAIC oversight personnel. Sample locations were distributed to provide chemical data for soil at and below the source. The soil samples were collected at the ground surface from the backhoe bucket. The USATEU samplers collected a 250-mL jar of soil for MINICAMS® screening and immediately proceeded to collect VOA samples. Soil for the VOA samples was collected below the exposed layer of soil in the backhoe bucket and was placed in labeled 40-mL amber vials with Teflon® caps. Approximately 2 pounds of the remaining soil were removed from the backhoe bucket and placed in a stainless steel bowl after the VOA samples were placed in an ice-filled cooler. The soil was composited and placed in 250-mL amber jars for the additional analyses, which generally included SVOCs, pesticides/PCBs, explosives, metals, and chemical agent breakdown products. Analytical samples were sent to the laboratory based on negative (non-detection) MINICAMS® screening results for CWM.

Rock coring was conducted at four sites, including Area T-24, the Old Water Hole, Range L, and Range J when auger refusal had occurred and characterization of the consolidated material beneath the site was necessary. A total of 74 linear feet of rock core was obtained during the drilling program with an average recovery of 52 percent. Rock cores were obtained using an NX-sized carbon steel core barrel to collect a 2¼-inch diameter rock core that was placed in wooden or cardboard boxes with one core run (10 feet) per box. Information written on the core box included the soil boring ID, date, cored interval, run number, percent recovery, orientation of the core (i.e., the top and bottom of the run), and approximate down pressure. Core samples were described by the SAIC rig geologist to evaluate the sample lithology, presence of primary or secondary porosity, and competence of the rock. Core sample descriptions were recorded by the rig geologist on a field log.

Subsurface soil samples collected from drilled boreholes were obtained in 5-foot or smaller intervals depending on the encountered subsurface materials. Soil and bedrock samples were archived at Building 692 of the Fort McClellan EMO. A total of 486 split-spoon samples were collected during the RI. A representative portion (approximately 8 percent) of the archived samples were analyzed for grain size and Atterberg limits geotechnical testing. The descriptions of the soils found at Fort McClellan sites are discussed in Section 4.4 and the results of geotechnical tests are provided in Appendix C.

3.4.3 Test Pit Excavation

Test pits were excavated at the D&I Area, Area T-24A, and Range J to collect subsurface soil samples for chemical analysis, delineate site source boundaries, and investigate the nature of subsurface burials at the sites. The locations of the trenches at each site were based on markers (concrete base markers) located at the sites, geophysical results, current site conditions (i.e., the presence of drums), historical aerial photography, and documentation of past site activities.

A U.S. Army SEETRAC with a backhoe attachment was used by USATEU to conduct excavation activities with SAIC oversight. USATEU continuously monitored excavation activities using a MINICAMS® due to the history of CWM usage at the sites. Trenches were excavated to delineate former burial sites both horizontally and vertically. Subsurface soil samples were collected for laboratory analysis from trenches based on visual evidence (i.e., soil discoloration, debris). If visual evidence was not sufficient, samples were collected in a manner to provide areal coverage of the excavation site. Samples were obtained to characterize areas of observed soil disturbance, in addition to potentially uncontaminated zones below the disturbed area.

Excavation activities were documented in site logbooks by both SAIC and USATEU personnel. Documentation of site operations included weather conditions, personnel, test pit locations and orientations, MINICAMS® results from screening samples, visual observations (soil discoloration, debris), and any other site conditions that may provide information to characterize the burial site. Trench orientations at Area T-24A were surveyed by a licensed surveyor because of the discovery of buried ordnance at the site. Trench excavations at Range J and the D&I Area were measured based on site feature (fences and surveyed markers).

3.4.4 Monitoring Well Drilling and Installation

Thirty-six groundwater monitoring wells were installed at seven of the RI sites, including Area T-24A (three wells), Area T-38 (five wells), Landfill #1 (four wells), Landfill #3 (eight wells), Range J (three wells), Range L (seven wells), and the Old Water Hole (five wells). Groundwater samples were also collected from three existing (SI) wells on Landfill #2. One well (BK-G06) was installed as a background well upgradient of Area T-24A. Three monitoring wells were installed at Landfill #2 during the 1991 SI study (SAIC 1993). The final well locations, depths, and screened intervals were determined based on encountered field conditions. The monitoring wells were installed to obtain hydrogeologic and hydrochemical information at six of the RI sites that had not been previously drilled and to enhance the information available from Landfill #3.

Because of the variable subsurface conditions encountered around Fort McClellan and Pelham Range, a combination of drilling techniques was used to sample and complete each well. Large diameter (6¼- to 8-inch O.D.) augers were used in combination with air hammer and roller bit drilling methods. Steel casing (6-inch inside diameter [I.D.]) was used particularly on Pelham Range to maintain borehole stability below the water table. Rock cores (NX diameter) were obtained through weathered-unweathered rock layers, ledges, and boulders that were variably encountered at a particular site. Monitoring well drilling, installation, and development were completed by Environmental Exploration Inc., Atlanta, Georgia; Anderson Engineering, Inc., Little Rock, Arkansas; and Christenson-Boyles, Inc., Murfreesboro, Tennessee.

The cleaning of well casings and well screens was conducted in accordance with the USATHAMA (1987) geotechnical requirements and EPA Region IV Environmental Compliance Branch Standard Operating Procedures (ECBSOP 1991). Well casings and screens were pre-cleaned by the vendor to NSF standards and the casings and screens were provided to Fort McClellan in sealed bags. Drilling equipment (e.g., rig, tools, augers, bits), well purging equipment (except submersible pumps), and well screen and casing materials were decontaminated by steam washing the equipment with a laboratory-grade detergent (Alconox®) solution and rinsing materials with water from the approved potable source. The use of Alconox® as opposed to the more "environmentally-friendly", phosphate-free Liquinox® is not thought to have adversely impacted sampling results because the active ingredients in the materials are substantially the same. There was no impact to the environment because all decontamination fluids were collected and disposed of as IDW. Size-compatible, decontaminated equipment was wrapped in plastic for transport to the site to prevent re-contamination of the equipment and materials. Drilling equipment was decontaminated between drilling locations at established stations on the Main Post and Pelham Range.

Decontamination of submersible pumps and tubing included circulating an Alconox® solution through the pump with a potable water rinse. Sampling and well development equipment (i.e., bailers, core sampler, hand auger, split-spoon samplers) coming in direct contact with the sample media were decontaminated using the procedure listed below (ECBSOP Section B.8.3):

- Scrub the equipment with a solution of laboratory-grade detergent (Alconox®) using a brush
- Rinse the equipment with potable water
- Rinse equipment with American Society for Testing and Materials (ASTM) water
- Rinse equipment with isopropanol and air dry
- Rinse with ASTM water again, air dry, and wrap in aluminum foil.

Decontamination rinsate from soil sampling activities was collected and containerized pending the results of chemical analyses at the respective sites. Generated decontamination waste streams were generally segregated by site to reduce potential disposal costs associated with contaminated, composite decontamination wastes from an individual site. All generated waste streams were subjected to toxicity characteristics leaching procedure (TCLP) testing.

3.4.4.1 Well Construction and Development

Well construction was initiated following the sampling of each borehole to the completion depth. Prior to insertion in the borehole, well casings and well screens were decontaminated by steam cleaning, scrubbing with Alconox® solution, and rinsing with potable water. Variations from the standard well construction were documented in field logbooks and implemented after verbal discussions with USAEC or their geotechnical representatives. Drilling, well construction logs, and well development records for each installed boring and monitoring well are provided in Appendix D.

Well development was initiated at all newly installed monitoring wells 48 hours after the placement of the internal mortar collar in accordance with USAEC protocols. The wells were developed using a variety of methods, including hand pump, submersible pump, bailing, and pneumatic pump, depending on the well productivity. The wells were developed by removing a minimum of five times the volume of standing water in the well, including the saturated annulus. Additional water volumes equivalent to five times the volume of drilling fluid losses to the borehole were removed as part of the well development. Specific conductivity, pH, and temperature measurements were obtained periodically during the well development process. Stabilization of these parameters were utilized, in addition to produced groundwater volumes, as criteria for determining development completion. Groundwater clarity was qualitatively observed and documented during development. A sample of groundwater from the developed well was archived onsite. The developed water was containerized and stored onsite pending analytical testing. Parameters measured during well development are summarized in Table D-1 (Appendix D).

3.4.5 Geotechnical Testing

Soil and sediment samples were collected from boreholes and surface sampling locations for the determination of grain size (ASTM D422, sieve, and hydrometer) and Atterberg limits (ASTM D4318). Geotechnical properties were determined for 37 samples and the resulting data are provided in Appendix C. Testing was completed by Willmer Engineering of Atlanta, Georgia.

3.5 GROUNDWATER INVESTIGATIONS

Groundwater samples were collected at Fort McClellan from monitoring wells installed at the RI sites. Two rounds of groundwater samples were collected at each RI site where wells were installed. A third round of samples (initial quarterly monitoring round) was obtained from wells at Landfill #3. Table 3-2 summarizes the laboratory analytical parameters for each site. Groundwater (including potable water) samples were collected for chemical analysis from Area T-24A; Area T-38; Range J; Range L; the Old Water Hole; and Landfills #1, #2, and #3 at Fort McClellan during the RI field work. Potable water samples were obtained from non-chlorinated water sources on the Main Post (Reilly Lake well) and Pelham Range (Building 8801). Additional groundwater samples were obtained as background samples from 30 wells installed on the Main Post, Pelham Range, Anniston Army Depot, and in the city of Weaver (SAIC 1998).

3.5.1 Groundwater Sampling

Prior to collection of groundwater samples and at least 2 weeks after well development, each well was purged in accordance with the following procedures:

- The depth to the water level and well bottom from the top of the well riser was measured, measurements in the logbook were recorded, and purge volumes were calculated.
- The purging device (pump or bailer) was lowered until it was approximately 1 foot from the well bottom. The pump intake was raised during purging to withdraw water from the entire water column.
- Water was begun to be removed; initial pH, specific conductance, and temperature measurements were collected; and readings were recorded in the logbook.
- An average discharge rate was determined and was recorded in the logbook. Purging continued until five volumes of water (ECBSOP Section 4.9.3.1, EPA 1991) in the well had been removed.
- pH, specific conductance, and temperature were measured at regular intervals (each well volume) proportional to the total volume of water removed. A minimum of two more readings were collected while purging.
- If the well went dry but recovered 90 percent of its initial level within 1 hour, the required five volumes (ECBSOP Section 4.9.3.1, EPA 1991) were purged before sampling. After collecting analytical samples, a final sample was collected for pH, temperature, and specific conductance measurements and the results were recorded in the logbook. If the well was slow to recover, the well was purged, allowed to recover to 75 percent of its initial level before it was purged again, and subsequently sampled. In this case, initial and final pH, temperature, and specific conductance readings were measured as a minimum.

Purging was accomplished using submersible pumps or Teflon® bailers, depending on the well productivity. A well volume consists of the standing column of water in the screened interval and riser pipe as well as the calculated volume of water in the sand pack. Measured depths to groundwater were used to calculate the height of standing water in the well, and therefore, the volume of standing water in each well and the purge volume. Purge volume inside the well was calculated using the following equation:

$$V1 = \Pi(r^2) \times h \times 7.48$$

where:

V	=	volume of water in well (gal)
r	=	well radius (ft)
h	=	height of standing water column (ft).

The volume of water in the sand pack to be purged was calculated using the equation:

$$V2 = \Pi(R^{2-}r^2) \times h \times 0.3 \times 7.48$$

where:

V	=	volume of water in the sand pack (gal)
R	=	radius of the sand pack (ft)
r	=	radius of the well casing (ft)
h	=	height of water in the sand pack (ft)
porosity	=	0.30.

The single well purge volume ($V_1 + V_2$) was calculated for each well using the well casing and annular liquid volume estimates. The potable water source wells with in service pumping equipment on Fort McClellan and in the city of Weaver were purged for 15 to 30 minutes at a rapid rate (ECBSOP Section 4.9.3.4, EPA 1991). Parameters, including temperature, pH, and specific conductivity, were monitored during purging and after the sample had been collected. Well purge water was containerized at each well pending the results of chemical analysis of the well water or TCLP analysis.

Groundwater samples were collected from the well as soon after purging as there was a sufficient volume of water in the well for the intended analyses. Groundwater was obtained using disposable point-source, bottom-filling polyethylene bailers and was used to triple rinse each sample container (USATHAMA 1990). Preserved volatile organics vials were not triple rinsed prior to sampling because of the presence of preservative in the bottles. After the bottles had been rinsed properly, a groundwater sample was collected and dispensed directly into the appropriately labeled sample bottles. A portion of the collected sample was used to measure the final temperature, pH, and specific conductance. Groundwater clarity was qualitatively observed and documented during well purging and sampling.

3.5.2 City of Weaver

SAIC obtained groundwater samples from the city of Weaver municipal supply wells #1 and #3 in July 1994 and February 1995. The wells produce groundwater from a carbonate bedrock aquifer at depths between 150 and 350 feet BLS. The two wells were sampled prior to chlorination to determine if low-concentration groundwater constituents that were detected at Landfill #3 east of the city of Weaver has impacted water quality in the municipal wells. The data also were used to establish a baseline chemical analysis for the water supply. Groundwater samples from the municipal wells were analyzed for volatile organic compounds (VOCs) and SVOCs, metals, pesticides/PCBs, and explosives. A representative from the city of Weaver accompanied the sampling crew to each pump house and turned on the tap. After disconnecting the chlorination system, each well was purged for a minimum of 20 minutes prior to sampling by opening the tap and discharging the water into the stormwater drain located in the floor of the pump house. Groundwater samples were collected by filling the containers directly from the flowing tap. The city of Weaver wells were re-sampled for metals during the background metals survey (SAIC 1998).

3.5.3 Private Wells

A private well located approximately 300 feet west of Landfill #3 was sampled in August 1995. The well had been inactive for an extended period of time (since the early 1970's) and was not in use as a primary drinking water source. Approximately 120 feet of corroded pump tubing and a submersible pump were removed from the well by a licensed water well contractor under arrangement with the homeowner prior to the sampling attempt. A depth measurement made during sampling indicated a total depth of 90 feet, suggesting that approximately 30 feet of the open well had potentially collapsed during removal of the pump and tubing. Approximately 3 feet of standing water was encountered in the open well bore.

3.6 SURFACE WATER/SEDIMENT SAMPLING

Surface water and sediment were sampled during the RI to assess water and sediment quality in stream reaches adjacent to or potentially impacted by the areas of concern. Results from the analyses of these samples were used to assess risks to human health and the environment. Sediment and surface water samples were collected from Area T-5, Area T-24A, Landfill #1, Landfill #2, Landfill #3, Range L, and at 50 background locations (SAIC 1998) on the Main Post and Pelham Range. All sediment samples were collected using a decontaminated stainless steel spoon or trowel and were placed directly into glass sample containers. All surface water samples were collected by directly submerging the sample bottles into the surface water body consistent with ECBSOP Section 4.8.3.2 (EPA 1991). This protocol was implemented to reduce the potential for cross-contamination between sample locations. All samples were collected, preserved in the field, and shipped to the analytical laboratory in accordance with the requirements established in the QAPP (SAIC 1994c).

3.7 HYDROGEOLOGICAL INVESTIGATIONS

Hydrogeological investigations were conducted at RI sites where groundwater monitoring wells were installed and incorporated existing wells installed by Fort McClellan. RI sites with installed monitoring wells include Area T-24A, Area T-38, Landfill #1, Landfill #2, Landfill #3, the Old Water Hole, Range L, and Range J. Existing wells at Landfill #4, near the Women's Army Corps (WAC) museum, and at underground storage tank (UST) locations near Buildings 263, 2109, 3176, and 3299, also were periodically monitored. Hydrogeological investigations during the RI included monthly groundwater elevation measurements and slug testing of 16 of the installed RI wells. Data obtained from measurements and testing in monitoring wells on Fort McClellan and Pelham Range are provided in Appendix E.

3.7.1 Groundwater Elevation Measurements

Groundwater elevation measurements were obtained monthly at each installed RI well location. In addition, groundwater elevation measurements were obtained periodically from existing UST wells located on Fort McClellan and from existing wells on Landfill #4. Measured groundwater depths were referenced in all instances to the surveyed top of the PVC well casing. Groundwater elevation was calculated by subtracting the measured depths from the top of the casing elevation. Groundwater elevation monitoring data are provided in Section 4 and Table E-1 (Appendix E).

3.7.2 Slug Testing

During the Fort McClellan RI, aquifer slug tests were conducted on 16 groundwater monitoring wells from 8 of the RI sites (Area T-38, Area T-24A, Landfill #1, Landfill #2, Landfill #3, the Old Water Hole, Range L, and Range J). The tests were conducted to determine the hydraulic conductivity of the screened aquifer. The slug test measures the rate of recovery of the water level inside a well after a known volume of water is added or removed. At Fort McClellan, the rising head slug test was performed in which groundwater was removed by pumping, and the rate that the water level returned toward the static level was recorded using an automatic data recording instrument. The following section outlines the field procedures used to perform and analyze the aquifer slug tests. The equipment used to perform the rising-head slug test consisted of an automatic data recording instrument (Hermit™ Environmental Data Logger, In-Situ, Inc., Model SE 1000B) with a pressure transducer, water level indicator, measuring tape, Grundfos™ submersible pump with tubing, and a gas-powered generator.

3.7.2.1 Slug Test Field Procedures

Prior to initiating each slug test, the initial water level and total depth of the monitoring well were measured to the nearest 0.01 foot and were recorded in the field notebook. The Hermit data logger was calibrated according to manufacturer's instructions for slug tests with a logarithmic time scale in minutes and hours, and draw-down in feet. A pressure transducer and cable were lowered into the well so that the transducer was located between 0.5 and 2 feet from the bottom of the well. The transducer did not touch the bottom of the well, but was low enough so that sufficient water was above it to perform a complete slug test. A decontaminated submersible pump and tubing was lowered into the well so that it was located approximately 1 foot above the transducer. The water in the well was allowed to stabilize prior to initiating the slug test.

The Hermit™ data logger was set to the ready mode (per manual instructions) with a reference value of zero. Some of the tests were run with reference values equal to manually obtained depth-to-water (DTW) readings. Entering a depth reference value allowed the field crew to see the DTW readings throughout the slug test. Those tests with depth reference values had to be normalized to the initial water level before they could be analyzed. Prior to initiating the well purging, field personnel recorded the data logger test number and corresponding well number, and diagrammed the well set-up in a field notebook.

Water in each well was purged into 55-gallon drums until the water level was at the approximate depth of the pump intake. Before shutting off the pump, the water level was tagged, which allowed confirmation of the location of the pump within the well. The pump was turned off and the well was allowed to partially recharge so that water from the sand pack could flow into the well. This step was not followed for all wells tested, but it ensured that the recharge rate seen was due to the surrounding formation characteristics and not just the water flowing into the well from the sand pack. The pump was re-started to remove the recharged water. Simultaneously, the pump was turned off and the Hermit™ data logger was turned on to begin collecting recharge data. The data logger recorded until the water level rose to more than 90 percent of the initial static water level. To keep track of the recharge, depths were hand-tagged with the water level indicator, taking care to just touch the surface with the probe. The Hermit™ data logger automatically recorded the time and draw-down values. After reaching 90 percent recharge, the Hermit™ recorder was stopped and the testing equipment was removed from the well. The downhole equipment then was decontaminated according to the protocols established for the project.

3.7.2.2 Slug Test Data Analysis

Groundwater head (feet) and time data obtained during each slug test were retrieved from the data logger following each test and were stored on computer diskettes for later processing. After normalizing the head (h) data to the initial head valve (H_o), the data were analyzed using curve matching techniques in the Aqtesolv® software package (Geraghty and Miller 1989). An initial curve match was obtained using automatic, non-linear curve matching and the curves were adjusted manually. The data were analyzed using the Cooper et al. (1973) analytical method. Assumptions associated with the application of this analytical solution include:

- Aquifer has infinite areal extent
- Aquifer is homogeneous, isotropic, and of uniform thickness
- Aquifer potentiometric surface is initially horizontal
- Aquifer is confined
- Well storage is negligible
- Water slug is removed/added instantaneously
- Flow to the well is horizontal.

Data plots for each test with the curve match overlain are provided in Appendix E.

3.8 ECOLOGICAL INVESTIGATIONS

Field work to support ecological risk assessment of the RI sites was conducted in September 1994. The field study included an inspection of each RI site by SAIC ecologists to characterize the habitats associated with each area. Field observations were recorded for each site for use in developing realistic estimates of target populations in the risk evaluation.

3.9 INVESTIGATION-DERIVED WASTE MANAGEMENT

Soil and water generated during drilling, decontamination, well purging and development, and sampling activities at Fort McClellan and Pelham Range were containerized in drums and aboveground storage tanks (ASTs) pending laboratory analysis. Soil materials that were determined by laboratory analysis to be uncontaminated were thinly spread in the vicinity of the boring from which the soils were recovered. Groundwater produced during drilling, decontamination, well installation, well development, and well purging was containerized in drums or storage tanks pending analysis. Collected groundwater was generally segregated by well or was composited in 1,300-gallon storage tanks by site.

Groundwater determined to be uncontaminated by laboratory analysis was either discharged to the ground surface downgradient from the well from which it was produced in accordance with EPA Region IV standard protocols (EPA 1991, Section 4.5.1.2) or was discharged to the sanitary sewer system after obtaining approval from the Anniston Board of Water and Sewers. Groundwater that was determined to contain concentrations of chemicals above regulatory limits was composited in tanks and filtered through a portable carbon absorption unit provided by TIGG Corporation. The water then was discharged to the sanitary sewer system after effluent samples from the carbon unit were determined by laboratory analysis to be uncontaminated. Analytical (TCLP) data obtained for waste samples from the site are provided in Appendix K.

Table 3-1. Summary of Remedial Investigation Activities

Site	Remedial Investigation Activities
Area T-4	•Locate site using historical coordinate information. •MINICAMS screening of surface soil for CWA. •Laboratory analysis of soil samples for CWA breakdown products. •STOLS™-adjunct geophysical survey.
Area T-5	•MINICAMS screening of surface soil for CWA. •Laboratory analysis of soil samples for CWA breakdown products. •Surface water/sediment sampling and analysis
Area T-24A	•MINICAMS screening of surface soil for CWA. •Test pit excavations within fenced area. •STOLS™-geophysical survey within fenced area. •Installed wells T24A-G01,T24A-G02,T24A-G03. • Surface water/sediment sampling and analysis •Excavated soil sampling and laboratory analysis. •Groundwater sampling and analysis (two rounds). •Slug testing
Area T-38	•MINICAMS screening of surface soil for CWA. •EM, magnetometer geophysical surveys. •STOLS™-adjunct geophysical survey. •Installed wells T38-G05,T38-G06,T38-G07, T38-G08, T38-G09. •Drilled soil boring in suspected sump area. •Groundwater sampling and analysis (two rounds). •Slug testing
Range J	• EM-31 geophysical survey. •MINICAMS screening of soil for CWA. •Laboratory analysis of soil samples for CWA breakdown products. •Installed wells RJ-G05 to RJ-G07. •Groundwater sampling and analysis (two rounds).
Range K	• Site reconnaisance for ordnance. •MINICAMS screening of surface soil for CWA. •Laboratory analysis of soil samples for CWA breakdown products. •EM, magnetometer geophysical surveys. •STOLS™-adjunct geophysical survey.
Range L	•EM-31, EM-61; magnetometer geophysical surveys. •Installed wells RL-G01 to RL-G07. •Groundwater sampling and analysis (two rounds). •Surface water/sediment sampling and analysis •Slug testing •Topographic mapping.
Detection and Identification Area	•EM-31, EM-61; magnetometer geophysical surveys. •Test pit excavations near monument "F". •Laboratory analysis of soil samples for CWA breakdown products.
Landfill #1	•Installed wells LF1-G01 to LF1-G04. •Groundwater sampling and analysis (two rounds). •Surface water/sediment sampling and analysis •Slug testing
Landfill #2	•Groundwater sampling and analysis (two rounds). •Surface water/sediment sampling and analysis •Slug testing
Landfill #3	•Installed wells OLF-G11 to OLF-G19 (excluding OLF-G14). •Groundwater sampling and analysis (two rounds). •Surface water/sediment sampling and analysis •Surface soil sampling and analysis. •Slug testing
Old Water Hole	•Installed wells OWH-G01 to OWH-G05. •Groundwater sampling and analysis (two rounds). •Soil sampling and analysis. •Slug testing •Topographic mapping.
Background	•Installed well BK-G06 •Groundwater sampling and analysis (two rounds). •Supplemental Background Sampling Study (SAIC 1998).

Table 3-2. Summary of RI/FS Sampling and Analysis
Fort McClellan, Alabama

	SOIL								WATER								
	Agent Breakdown Products						Pesticides/		Agent Breakdown Products						Pesticides/		
Site	HD	GB	VX	VOC	SVOC	Metals	PCB's	Explosives	HD	GB	VX	VOC	SVOC	Metals	PCB's	Explosives	BOD
T-4	SS	SS	SS														
T-5	SS,SB,SD	SS,SB,SD	SS,SB,SD	SD	SD	SD	SD	SD	SW	SW	SW	SW	SW	SW	SW	SW	SW
T-24A	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	
T-38	SS,SB	SS,SB	SS,SB	SS,SB	SS,SB	SS,SB	SS,SB	SS,SB	GW	GW	GW	GW	GW	GW	GW	GW	
Range J	SS,SB								GW			GW					
Range K	SB,SD	SB,SD	SB,SD					SB,SD									
Range L	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW
Detection & Identification	SS,SB	SS,SB	SS,SB			SS,SB											
Old Water Hole	SS,SB	SS,SB	SS,SB	SS,SB	SS,SB	SS,SB	SS,SB	SS,SB	GW	GW	GW	GW	GW	GW	GW	GW	
Landfill #1	SD			SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW
Landfill #2	SD			SD	SD	SD	SD	SD	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW
Landfill #3	SD	SD	SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW
Background (Historical)	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SS,SB,SD	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW,GW	SW
Background						SS,SB,SD								SW,GW			
Town of Weaver												GW	GW	GW	GW	GW	
Potable Water									GW	GW	GW	GW	GW	GW	GW	GW	
Quarterly LF-3												GW	GW	GW	GW	GW	

SS-Surface soil
SB-Subsurface soil
SD-Sediment
SW-Surface Water
GW-Groundwater