4. RESULTS OF FIELD INVESTIGATIONS

The results of the field investigations conducted on the RI sites on Fort McClellan and Pelham Range are provided in the following sections. The field studies have included site-specific geophysical, geological, and hydrogeological measurements and observations, quantitative sampling and analysis of surface soil, subsurface soil, surface water, sediment, and groundwater, and semi-quantitative field screening (Miniature Continuous Air Monitoring System [MINICAMS®])for chemical warfare materials (CWM). Information obtained at the RI sites between March, 1994 and June, 1995 was supplemented by relevant historical information including but not limited to data obtained during separate, ongoing investigations at the Anniston Army Depot (SAIC 1995), information obtained during the previous site investigations at Fort McClellan (SAIC 1993), data obtained during a background metals survey (SAIC 1998), and quarterly landfill monitoring data. The nature and extent of chemical constituents is delineated based on the concentration of inorganic constituents exceeding background concentrations and the presence of organic constituents. Laboratory chemical data quality was assessed by comparing chemical constituent concentrations in environmental samples to quality assurance/quality control (QA/QC) blank samples from the field and laboratory.

4.1 SITE GEOLOGY AND HYDROGEOLOGY

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. The previous site investigations that were concluded in 1993 (SAIC 1993) provide the basis for the remedial investigation. The RI characterizations of the twelve sites incorporate the results obtained from 44 monitoring wells, 44 soil borings, 6 test pit excavations, and geophysical surveys. Supplemental background data for Fort McClellan was obtained in 1997 and is detailed in the *Background Metals Survey Report* (SAIC 1998). Drilling records and well construction diagrams for the wells and borings installed during the RI are provided in Appendix E.

4.1.1 Topographic Mapping and Land Surveying Results

The surface topography on Fort McClellan and Pelham Range was mapped by the U.S. Army Corps of Engineers in 1989 using aerial photography taken over the Post on April 1, 1987. The digital topographic maps (5-foot contour interval, Intergraph™ format) for the area of Fort McClellan and Pelham Range were obtained by Science Applications International Corporation (SAIC) from the U.S. Army Corps of Engineers 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 at 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 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 feet 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 satellite obstructions within 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.

4.1.2 Site Geology

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 and 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. These zones were impenetrable using conventional auger techniques and required alternate drilling methods including air hammer, air rotary, drive casing, and roller bit drilling. In many instances, combinations of these methods were necessary to penetrate to a consistent water-bearing zone. Competent, fractured bedrock (shale/siltstone) was consistently encountered at Landfill #1 and in the vicinity of Area T-24A including background location BK-G06. These locations occur along the flanks of ridges on the Main Post. Weathered limestone was encountered in five of seven borings at Range L on Pelham Range. Based on observations of subsurface conditions (e.g., circulation losses, obstructions, voids) during drilling operations and descriptions of soil and rock core samples, Pelham Range is underlain at depth by variably weathered carbonate bedrock.

The competent bedrock is overlain by silty and clayey residuum derived from the in place weathering of the rock. The effects of weathering have resulted in variable thickness and composition of residuum formation ranging from massive silt and clay soil to transitional horizons of alternating soil and rock intervals (ledges). Residuum derived from weathering of the carbonate bedrock by infiltrating precipitation and groundwater movement comprises the subsurface interval between the ground surface and the top of competent carbonate bedrock on Pelham Range. The residuum on Pelham Range ranges in depth between approximately 23 and in excess of 108 feet below ground surface and consists of relatively homogeneous brown, red, or tan clay with trace proportions of interstitial sand, silt, and weathered rock fragments. Discrete intervals of sand, silt, silty sand or silty gravel were encountered in the residuum, but were generally limited in thickness and lateral extent. The residuum derived from the weathering of shale and siltstone underlying the Main Post ranged between 0.5 and 156 feet thick. Relict chert ledges or boulders may have caused shallow auger refusals in some instances. Subsurface voids were variably encountered in the carbonate bedrock at Range J and Range L on Pelham Range at depths between 47 and 80 feet below ground surface. Subsurface voids ranged from open vugs to cavities to that resulted in core loss or rods dropping within a borehole.

Geotechnical properties (USCS classification, grain size, Atterberg limits, density, soil pH, cation exchange capacity, and laboratory permeability) of soils on the Main Post have been previously investigated by landfill siting studies (ES&E 1981) east of former Landfill #3 and during earlier investigations of Landfills #3 and #4 (USAEHA 1976,1986; SAIC 1993). The geotechnical and geochemical properties of soil samples collected from the residuum horizons are provided in Table 4-1. These data confirm that the site soils are predominantly fine-grained and indicate that the soils are acidic (pH ranging between 4.9 to 6.2 units, averaging 5.2 units) and are typical in their ability to exchange cations with capacity ranging

between 1.8 and 5 milliequivalents per 100 grams of soil with an average of 13.7 meq/100 grams. The measured laboratory hydraulic conductivity ranges between 2.2×10^{-3} cm/sec and 7.15×10^{-8} cm/sec.

The contact between the residuum and the underlying bedrock is gradational in that weathering along the interface has resulted in either an abrupt soil/rock contact, a weathered rock soil profile with distinct rock characteristics, or a transitional contact consisting of alternating rock ledges and soil horizons. Bedrock on Pelham Range consists of Cambro-Ordovician Knox Group limestone, dolomitic limestone, and dolomite. The unweathered bedrock lithology consists primarily of massive, gray to tan, microcrystalline, calcareous dolomite and dolomitic limestone. High angle joints and fractures were common in the obtained core and some core samples were intensely fractured such that accurate core recovery could not be calculated for those intervals.

4.1.3 Site Hydrogeology

Groundwater elevation measurements were obtained on a monthly basis between April, 1994 and June, 1995 by manual measurement in constructed wells at the RI sites. The measured depth to groundwater on the Main Post ranged from 0.0 to 129.87 feet below ground surface and from 0.38 to 72.93 feet on Pelham Range with average depths of 24.2 and 34.1 feet, respectively. Table 4-2 summarizes well construction parameters and monthly groundwater elevations. Because the residual soil comprising the aquifers beneath the site areas is predominantly silt and clay, groundwater at the sites occurs under semi-confined conditions. Artesian conditions were observed on the Main Post at a well location on former Landfill #1 (LF1-G02) and on Pelham Range at well location RL-G02 (Range L). Perched groundwater may occur along less weathered bedrock interfaces including rock ledges and chert boulder horizons.

Groundwater flow across the Main Post generally occurs in a northwesterly direction based on average groundwater elevation measurements from widely spaced monitoring wells (Figure 4-1). Variability in the groundwater flow direction is likely to occur in localized areas of the Main Post dependent on local topography, proximity to surface water bodies, and subsurface geology and structure. Groundwater flow on Pelham Range is known only in the immediate vicinity of the RI sites because of the large areal extent of Pelham Range, the extensive topographic variability, and the scarcity of groundwater monitoring points over the entirety of the range. The measured groundwater elevations ranged between 677.1 and 1,043.2 feet above mean sea level on the Main Post and between 546.0 and 668.6 feet above mean sea level at the RI sites on Pelham Range. Localized groundwater flow at the RI sites is described in subsequent sections. Field hydraulic conductivity values were estimated by slug testing at 16 wells on the RI sites from the Main Post and Pelham Range. The hydraulic conductivity values ranged between 1.05×10^{-5} cm/sec and 3.27×10^{-4} cm/sec with an average error of less than 10 percent. The estimated values for each well are summarized in Table 4-3 and data plots for each test are provided in Appendix E.

The installed groundwater monitoring wells generally produced less than 1 gallon per minute (gpm) to 6 gpm during well development, however, shallow well productivity was highly variable and typically produced less than 1 pgm. Groundwater parameters obtained during sampling consisted of temperature, pH, and conductivity measurements. Groundwater pH ranged from 4.9 to 9.4 pH units on the Main Post and between 6.3 and 9.6 units on Pelham Range. The average groundwater pH on the Main Post was slightly acidic at 6.9 units and the average pH on Pelham Range was basic, consistent with the carbonate geology, at 8.1 units. Groundwater conductivity on the Main Post ranged between 19 and 14,100 umhos/cm, averaging 1,037 umhos/cm. Groundwater conductivity on Pelham ranged from 22 to 409 umhos/cm, averaging 231 umhos/cm. The conductivity values measured on Pelham Range are consistent with regional measurements (see section 2.5), however, the measured values on the Main Post

were higher than the regional averages. The average groundwater temperature in the Fort McClellan area was 62.4° F which is consistent with previously reported regional measurements (59.7° F).

4.1.3.1 Area T-24A – Hydrogeology

Area T-24A is located southeast of the cantonment area on the Main Post in the foothills of the Choccoloco Mountains. The south branch of Cane Creek is located west of the site and flows northward. Monitoring wells at Area T-24A were installed using air rotary drilling because of the extensive bedrock that was encountered at shallow depth beneath the site. The groundwater flow across Area T-24A was estimated for the three monitoring wells (T24A-G01 to T24A-G03) that were installed to triangulate the fenced area. Monitoring well depths range between 30 feet BLS at well T24A-G03 to 100 feet BLS at well T24A-G01. The groundwater elevation (Table 4-4) across the site ranged from 970.1 to 1021.9 feet above mean sea level between July, 1994 and June, 1995 with northwesterly flow toward an adjacent stream tributary west of the site (Figure 4-2). The calculated average horizontal hydraulic gradient (0.132 ft/ft) is steep but is consistent with the movement of groundwater through fine-grained, fractured, shale or siltstone bedrock. A slug test at well T24A-G03 estimated the hydraulic conductivity in the shale/siltstone at 3.04×10^{-4} cm/sec.

4.1.3.2 Area T38 – Hydrogeology

Area T-38 is located along a topographic ridge (Reservoir Ridge) located east of the cantonment area on the Main Post. The hydrogeologic conditions underlying Area T-38 were evaluated by installing 4 wells (T38-G05 to T38-G08) to monitor potential source areas within the fenced enclosure. Well T38-G09 was installed west of the site as an upgradient well. Boring depths for the monitoring well installations ranged between 67 and 156 feet BLS. Drilling was continued until sufficient groundwater for monitoring purposes was encountered.

Groundwater elevation measurements were obtained at Area T-38 (Table 4-5) between May, 1994 and June, 1995 and ranged between 913.3 to 944.2 feet msl. Groundwater was encountered at the site at depths between 45 feet to 128 feet BLS. The aquifer underlying Area T-38 consists of sandy clay to clayey sand residuum with weathered sandstone boulders and ledges. Unweathered bedrock was not encountered at the site. Groundwater flow across Area T-38 was calculated by triangulation between four of the five installed monitoring wells at the site (Figure 4-3). Based on wells T38-G05, T38-G06, T38-G07, and T38-G08, groundwater flow is to the northeast under an average horizontal hydraulic gradient of 0.056 ft/ft. Interpretation of the groundwater flow direction at this site is complicated by the addition of well T38-G09 which was installed as an upgradient well. Based on subsequent groundwater elevation measurements at well T38-G09, the well is apparently on the downgradient side of a groundwater divide that may be located between wells T38-G07 and T38-G09. The occurrence of a divide along the crest of the topographic ridge (Reservoir Ridge) underlying Area T-38 is not unexpected, however, its precise location along the ridge is not determined.

4.1.3.3 Range J – Hydrogeology

Range J is located north of Cane Creek on the central portion of Pelham Range. The fenced enclosure is on a partially wooded hilltop located north of a east-west trending topographic high. Ephemeral streams flow towards Cane Creek north and south of the study area. Groundwater monitoring wells RJ-G05, RJ-G06, and RJ-G07 were installed during the RI study to triangulate the fenced enclosure at Range J. Groundwater elevation measurements were obtained at the site between January, 1995 and June, 1995 and ranged between 572.6 to 575.1 feet msl (Table 4-6). Groundwater depth at the site ranged between 49.6 feet to 65.5 feet BLS. The aquifer underlying Range J consists of sandy clay to

clayey sand residuum to a depth of approximately 58 to 65 feet BLS overlying calcareous sandstone and sandy limestone. Groundwater flow at Range J was directed to the southeast across the fenced area under a hydraulic gradient between 0.00045 to 0.0013 feet/foot between February, 1995 and April, 1995. The direction of groundwater flow at Range J is shown on Figure 4-4. The wells produced between 1.5 to 5 gallons per minute during well development and approximately 3,600 gallons of water were produced at well RJ-G06 to recover water lost to the formation during drilling. The hydraulic conductivity of the sandy clay residuum and calcareous sandstone (60 to 70 feet BLS) that is monitored at well RJ-G07 was measured at 3.89×10^{-4} cm/sec.

4.1.3.4 Range L – Hydrogeology

Range L (Lima Pond) is located on the northwestern corner of Pelham Range to the west of northeast-southwest trending ridge. Groundwater monitoring wells RL-G01 to RL-G07 were installed around the pond area at Range L during the RI study. The aquifer underlying the site consists of clayey sand to sandy clay residuum with chert ledges and boulders overlying fractured limestone bedrock at depths between 24 feet and 50 feet BLS. The residuum ranged between 47.3 to 50 feet thick in the three eastern wells (RL-G01, RL-G05, and RL-G06) and thinned in the wells located west of the pond area. Approximately 25 feet of silty and clayey sand and gravel was encountered in boring RL-G06. Monitoring wells at the site were predominantly screened in the residuum or near the residuum/bedrock contact. Groundwater elevation measurements were obtained at the site between August 1994 and June, 1995 and ranged between 552.2 to 584.8 feet msl (Table 4-7). Groundwater depth at the site ranged between artesian conditions variably occurring at well RL-G02 to 26.7 feet BLS.

The groundwater flow direction at Range L is influenced by the mounded topography and the subsurface materials encountered in the vicinity of Lima Pond. Groundwater flow east and west of the pond is directed to the west-northwest under an average horizontal hydraulic gradient of 0.103 ft/ft (Figure 4-5). The steepness of the observed hydraulic gradient may be attributed to the fine-grained silt and clay comprising the residuum underlying the site area. Well RL-G03 is partially screened in residuum and weathered limestone. Measured groundwater elevations south of the pond at well RL-G03 combined with the presence of higher hydraulic conductivity sand and gravel at well RL-G06 act to re-direct groundwater movement to the north and east in the immediate pond area. An area along the alignment between wells RL-G05 and RL-G06 may act as a drain on the east end of the pond because of the presence of higher hydraulic conductivity sand and gravel. The pond is dependent on precipitation for recharge. Hydraulic conductivity measurements were obtained at well RL-G02 (2.05×10^{-4} cm/sec) and well RL-G03 (1.5×10^{-5} cm/sec).

4.1.3.5 Landfill #1 – Hydrogeology

Former Landfill #1 is located on the Main Post southeast of the officer's housing area on Avery Drive. The site occupies the hillside between Avery Drive and 16th Street on Wygant Hill. A tributary to Remount Creek is located southeast of the study area and flows to the northeast towards the main creek. Four groundwater monitoring wells (LF1-G01 to LF1-G04) were installed around the revised boundary at Landfill #1 during the RI study. The boring depths ranged between 16 to 41.5 feet BLS and all borings encountered weathered shale at depths between 7 to 10 feet BLS. Monitoring well LF1-G01 was installed in the Officer's Housing Area north (upgradient) of the landfill and encountered 10 feet of silt and clay soil overlying weathered shale. Monitoring wells LF1-G02 and LF1-G03 were drilled southeast of the landfill and encountered weathered shale between 9 and 12 feet BLS. Monitoring well LF1-G04 was installed southwest of the landfill adjacent to a stream tributary and encountered weathered shale at 7 feet BLS. Three of the wells (LF1-G01, LF1-G03, and LF1-G04) monitor shallow intervals within the

weathered shale underlying the landfill. Monitoring well LF1-G02 monitors the clay residuum and the upper portion of the weathered shale.

Groundwater flow at Landfill #1 is consistently to the southeast toward a stream tributary east of the site (Figure 4-6). The groundwater elevation in the wells ranged between 737.1 and 775.6 feet above mean sea level between May, 1994 and April, 1995 (Table 4-8). Groundwater depth ranged between 0 and 29.3 feet BLS. The inferred flow direction is strongly influenced by the steep topographic gradient present at the site. The calculated average horizontal hydraulic gradient across the site area is 0.0461 ft/ft in the weathered shale underlying the landfill. Well LF1-G02 installed downgradient of the site has periodically shown flowing artesian conditions and routinely has a near-surface groundwater level. Hydraulic conductivity measurements were obtained in downgradient wells LF1-G02 (3.27×10^{-4} cm/sec) and LF1-G03 (4.08×10^{-5} cm/sec).

4.1.3.6 Landfill #2 – Hydrogeology

Landfill #2 is located on the Main Post at the southern termination of Cemetery Hill and the western termination of Reservoir Ridge. Cave Creek is located east of the site and flows to the west through the gap between the topographic ridges. Three groundwater monitoring wells (LF2-G01 to LF2-G03) were installed to triangulate the boundary of Landfill #2 as determined by field reconnaissance during the SI study (SAIC 1993). The boring depths ranged between 20.5 to 27 feet BLS and silty sand and clay. The boring for monitoring well LF2-MW3 encountered approximately 2.5 feet of fill material consisting of glass, metal, and topsoil debris. Monitoring well LF2-G01 was installed north (upgradient) of the landfill and encountered 15 feet of silty sand and clay soil. Monitoring wells LF2-G02 and LF2-G03 were drilled southwest and southeast of the landfill adjacent to the northern bank of Cave Creek. As determined during the site investigation at Landfill #2 in 1992, groundwater flow across the site is consistently to the southwest toward Cave Creek which flows to the southwest adjacent to the site (Figure 4-7). The horizontal hydraulic gradient ranged from 0.0105 to 0.034 ft/ft between April, 1994 and June, 1995 with an average gradient of 0.0208 ft/ft. The direction of groundwater flow varied to the south-southwest and south-southeast over this time period showing seasonal variability. The groundwater elevation underlying the landfill ranged between elevation 784.8 to 797.8 feet msl between June, 1992 and June, 1995 (Table 4-9) with depth between 3.7 feet and 20.6 feet BLS. A hydraulic conductivity measurement was obtained in downgradient well LF2-G02 (2.89×10^{-5} cm/sec).

4.1.3.7 Landfill #3 – Hydrogeology

Landfill #3 is located near the northwestern corner of the Main Post adjacent to U.S. highway #21. The site is located within the floodplain for Cave Creek and its tributary. Groundwater monitoring wells OLF-G01 to OLF-G05 were installed at Landfill #3 by USAEHA in 1986. Wells OLF-G01, OLF-G04, and OLF-G05 were installed around the western (downgradient) perimeter of the landfill, well OLF-G02 was installed along the southern boundary, and well OLF-G03 was installed at the northeastern landfill corner. These initial wells were drilled to between 50.3 and 60.5 feet BLS and were installed with 30 foot, field-expedient screen lengths presumably because to of low aquifer productivity. Monitoring wells OLF-G06 to OLF-G08 were installed around the western perimeter of the landfill during the 1993 SI study with the purpose to monitor downgradient gaps between the existing well network. Wells OLF-G09 and OLF-G10 were installed to supplement monitoring locations north and south of the landfill. Wells OLF-G11 and OLF-G13 were installed during the RI study as additional upgradient well placements and were supplemented by existing Landfill #4 well MW1-94. The remaining wells (OLF-G12, OLF-G15 to OLF-G19) were installed to monitor groundwater quality at the Post perimeter fence and off Post in the direction of groundwater flow. Boring depths for the SI and RI well placements ranged between 16 feet to 87 feet BLS.

Groundwater movement across Landfill #3 occurs in a northwesterly direction from Landfill #4 in the direction of the City of Weaver (Figure 4-8). The groundwater elevation ranged between 677.1 to 734.8 feet msl between April, 1994 and June, 1995 with an average depth of 28.5 feet BLS (Table 4-10). The hydraulic gradient at the site was approximately 0.04 ft/ft between April and June, 1995. The average hydraulic conductivity based on testing in five wells at the site is 4.61×10^{-5} cm/sec, ranging between 1.05×10^{-5} cm/sec and 2.48×10^{-4} cm/sec. Hydraulic conductivity measurements were obtained at wells OLF-G07 (2.48×10^{-4} cm/sec), OLF-G09 (1.07×10^{-4} cm/sec), OLF-G10 (1.05×10^{-5} cm/sec), OLF-G11 (7.12×10^{-5} cm/sec), and OLF-G15 (1.05×10^{-5} cm/sec).

4.1.3.8 Old Water Hole – Hydrogeology

Three groundwater monitoring wells (OWH-G01 to OWH-G03) were installed to triangulate the Old Water Hole site. The triangulation wells were supplemented with two additional wells (OWH-G04 and OWH-G05) to monitor groundwater quality downgradient of the suspected burial site. Boring depths for the monitoring well installations ranged between 95.5 and 108 feet BLS. Drilling was continued until sufficient groundwater for monitoring purposes was encountered. The aquifer underlying the Old Water Hole consists of sandy clay to clayey sand residuum with weathered limestone fragments. Unweathered bedrock was not encountered at the site.

Groundwater elevation measurements were obtained at Old Water Hole (Table 4-11) between March, 1995 and June, 1995 and ranged between 595.54 to 626.38 feet msl. Groundwater was encountered at the site at depths between 30.8 feet (OWH-G03) and 72.93 feet (OWH-G05) BLS. The groundwater flow direction across the site is to the northeast (Figure 4-9) under a horizontal hydraulic gradient that ranged between 0.00725 to 0.0105 ft/ft. Hydraulic conductivity measurements were obtained at well OWH-G04 (1.305×10^{-4} cm/sec) and well OWH-G05 (1.851×10^{-4} cm/sec).

4.2 DATA QUALITY ASSESSMENT

A comprehensive quality assurance/quality control (QA/QC) program was followed during the Fort McClellan RI to ensure that analytical results and the decisions based on these results are representative of the environmental conditions at Fort McClellan. Documents utilized during the QC evaluation of the data included the *U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) Quality Assurance Program, PAM 11-41* (January 1990), QC requirements contained within the guidelines and specifications presented in the Quality Assurance Project Plan (SAIC 1994), the *Installation Restoration Data Management Information System (IRDMIS), Volume II Data Dictionary,* Potomac Research Institute (PRI,1995), the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) *Statement of Work for Inorganics Analysis*, the EPA CLP *Statement of Work for Organics Analysis,* and the EPA *Laboratory Data Validation Functional Guidelines for Evaluating Organics and Inorganics Analysis* (1988). Tables 4-12a and 4-12b summarize the total number of individual chemical analyses completed during the RI, including field and selected laboratory QC samples. Data validation worksheets are provided in Appendix F.

4.2.1 Data Quality Objectives

A comparison of the RI analytical results to project data quality objectives (DQOs) as defined in the QAPP formed the basis for evaluating the quality of the analytical data. As described in the QAPP, analytical data must be of a known and acceptable quality in order to be used to evaluate contamination at Fort McClellan. The DQOs are qualitative and quantitative indicators of data quality and were established during the initial scoping process to guide the implementation of the field sampling and

laboratory analyses for the RI. Data verification and validation of 30 percent of the laboratory-produced analytical data packages ensured that the analytical laboratories, DataChem Laboratories (DCL) and Environmental Science & Engineering (ES&E), performed at an acceptable level of quality.

Field activities affecting precision and accuracy were controlled by strict adherence to approved standard operating procedures (SOPs) and documentation of the field tasks. Field logbooks noted exceptions to the procedures and chain-of-custody records tracked sample shipments and receipt of these shipments by DCL and ES&E. These protocols mitigated the potential for cross-contamination due to sample handling practices or inadequate equipment decontamination. Indicators used to assess both field and laboratory data quality include precision, accuracy, representativeness, comparability, and completeness (PARCC). The DQOs for the PARCC parameters are summarized in Appendix F.

4.2.2 Laboratory Quality Control Assessment

All environmental (soil and water) samples and field QC blanks (trip blanks and equipment rinsates) collected during the RI at Fort McClellan were analyzed using USAEC methods from the following references:

- *USAEC Class 1, 1A, and 1B Performance Demonstrated Methods* (VOC, SVOC, organochlorine pesticides/PCBs, explosives, chemical agent breakdown products, thiodiglycol, hexachlorobenzene, hexachlorocyclopentadiene, metals, and cyanide).
- Test Methods For Evaluating Solid Waste, Physical/Chemical Methods, SW846 (vinyl chloride, PCP, PAHs, antimony, chromium, thallium)
- Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, 1983 with additions (BOD).

During the review and evaluation process, 30 percent of the analytical data generated using USAEC methods and 100 percent of the analytical data generated using EPA methods were subject to a systematic and rigorous technical process by examining all analytical QC results and laboratory documentation, following the appropriate guidelines for laboratory data validation. The purpose of this section is to provide an assessment of the QA/QC results from the RI to confirm that the data used in this report meet the DQOs established for this investigation. Both quantitative measures and qualitative assessments will be presented to characterize these data as having sufficient quality to satisfy these objectives. The primary intent of this assessment is to illustrate that data originating from the RI can withstand scientific scrutiny, are technically defensible, and are of a known and acceptable precision and accuracy.

Each data point was assessed to determine whether the value was considered usable (i.e., no IRDMIS flag code) or usable but outside QC criteria. IRDMIS flag codes applied by DCL, ES&E, and SAIC are contained in the comprehensive data presentation tables in Appendix G. All IRDMIS flags applied by SAIC for the validated data are summarized in the data summary tables presented within the RI report text. All IRDMIS qualifiers as applied by the USAEC chemist are defined at the bottom of each table presenting analytical data.

The following IRDMIS flags and qualifiers were applied to the data by SAIC, DCL, ES&E, or USAEC:

- 9-Non-demonstrated/validated method performed for USAEC
- B-Analyte found in the method blank or QC blank as well as the sample

- C-Analysis was confirmed
- D-Duplicate analysis
- F-Field filtered sample
- I-Interferences in sample make quantitation and/or identification suspect
- J-Value is estimated
- K-Reported results are affected by interferences or high background
- P-Results less than reporting limit but greater than instrument detection limit
- Q-Sample interference obscured peak of interest
- U-Second column analysis did not confirm result.

IRDMIS Data Qualifiers (USAEC-applied):

- ?-Control chart not yet approved by USAEC
- I-The low spike recovery is high
- J-The low spike recovery is low
- M-The high spike recovery is high
- N-The high spike recovery is low
- O-Low spike recoveries excessively different
- R-Data is rejected.

For the purposes of the RI, non-target, tentatively identified compounds (TICs) that could not be directly attributed to laboratory method blank or field QC blank interference were used to indicate contamination resulting from past use at the applicable site. All TIC concentrations were added together and reported in the Section 4 data summary tables and the Appendix G data presentation tables as a single estimated value. The number of individual compounds detected is shown in parentheses adjacent to the cumulative concentration.

To ensure maximum confidence in chemical identification and detection levels, the CRL was used for reporting all of the target chemicals analyzed by USAEC methods. The CRL is the lowest sample concentration that may be reported. The CRL is associated with the entire method and reflects all sample preparation and measurement steps. The method CRL is higher than the instrument detection limit (IDL). The CRLs were determined from a comparison of found versus actual concentrations for spiked standard matrix samples and calculated according to the USATHAMA reporting limit program with a 95 percent confidence limit. The method detection limit (MDL) was used as a minimum level for reporting all of the target chemicals analyzed by the EPA SW846 methods. The MDL is defined as the minimum concentration of a chemical that can be measured and reported with 99 percent confidence that value is above zero. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

Based on assessments of holding times, GC/MS tuning and mass calibration results, initial instrument calibration results, daily calibration standard results, internal standard summaries, surrogate recoveries, method blank results, and matrix spike/matrix duplicate (MS/MSD) results, analytical laboratory performance was determined to have met established performance and calibration criteria. The detailed results of the QC assessments of the analytical laboratories are provided in Appendix F (Section F.3).

4.2.3 Field Quality Control Assessment

During all phases of the RI sampling program, QC samples were collected to gauge the impacts from various components of field activities. Approximately 23 percent of the samples collected during

the program were QC samples obtained to determine the degree of cross-contamination, ensure successful decontamination procedures, or determine the effects of media heterogeneity on results. One hundred and eleven trip blanks, 42 equipment rinsates, and 27 field duplicates were collected and analyzed using the same laboratory techniques as those used to analyze the environmental samples. Trip blanks and equipment rinsates provide a measure of various sources of external contamination, decontamination efficiency, and any other potential error that can be introduced from sources other than the sample.

4.2.3.1 Trip Blanks

Eighty-five trip blanks were collected and analyzed for VOCs using USAEC Method UM21. Analytical results show that chloroform was detected in one trip blank (i.e., T38-S10 [SAICTB17]) at a concentration greater than the CRL. Methylene chloride, a common laboratory contaminant, was found in 22 trip blanks, with an average concentration of 10.4 µg/L. The presence of chloroform and methylene chloride is not considered to be representative of environmental conditions at Fort McClellan, since these VOCs were not detected in the associated environmental samples. All VOC data were reviewed for potential bias introduced from trip blanks.

4.2.3.2 Source Water Samples

The source water samples provided information on the water used to decontaminate the sample collection devices. Duplicate source water samples were collected from the water source from the Main Post and Pelham Range and analyzed for all analyses scheduled for environmental samples. Cadmium, methylene chlorine, chloroform, and 1,3,5-trinitrobenzene were detected in the water source from the Main Post (Reilly Lake). Barium, beryllium, iron, potassium, magnesium, manganese, sodium, and zinc were detected in the water source from Pelham Range (Rideout Hall). These results were used to assess the suitability of the nonchlorinated potable source waters for use as decontamination rinse water.

4.2.3.3 Equipment Rinsate Blanks

Equipment rinsate blanks provide a measure of the cumulative contamination derived from field sampling equipment usage, transit, and storage. Table 4-13 summarizes the concentrations of the compounds and elements detected in the equipment blanks collected during the RI. Organic compounds were not detected in the associated field samples, indicating that their presence is not the result of incomplete decontamination procedures. Since these compounds were not detected in the associated environmental samples, IRDMIS flag codes were not applied to the data.

Common inorganic elements such as cadmium, calcium, potassium, iron, and sodium were detected several times, but at much lower concentrations than would be expected in naturally occurring water. Arsenic was observed in one equipment rinsate (LF1-D01 [SAICRB30]) at a concentration of 4.72 µg/L. The source of this metal is considered site related, since arsenic also was detected in the associated environmental samples. The anomalous equipment rinsate was collected on June 9, 1994. The IRDMIS flag code (i.e., "G") was applied to one arsenic and three calcium and zinc concentrations detected in soil samples collected from LF1. The flagged results indicate that these concentrations are considered high bias, since the concentrations in the environmental samples did not exceed five times that detected in the associated equipment rinsate.

4.2.3.4 Field Duplicates

One duplicate environmental sample was collected for every 10 environmental samples, as required by the QAPP and USATHAMA PAM 11-41. Duplicate sample pairs were collected to assess the variability in the laboratory analyses due to environmental media. Table 4-14 provides a summary, by medium and analyte, of the RPD values for field duplicates by site. Seventy-one soil and 8 duplicate samples, in addition to 144 water and 11 duplicate samples were collected and analyzed. Specific control limits for field duplicates were established predominantly because of the natural heterogeneity typically observed in environmental media. Field RPD values were calculated for compounds and elements detected in concentrations greater than the CRLs or detection limits in both replicate pair samples or in one sample. Average RPDs were calculated based on the analyte or compound detected in at least two field duplicate pairs.

4.2.4 Assessment Summary

Approximately 330 samples were collected and analyzed during the Fort McClellan RI study, resulting in an analytical data base of more than 3,200 analyses. Laboratory and field performance has been assessed using established criteria and the overall quality of the analytical data is determined to be acceptable for the study purposes. Limitations affecting data interpretation and usage are summarized below:

- Low level boron, calcium, and zinc detects in specific samples are highly suspect and should be considered potential false positives due to possible cross contamination.
- Nondetected BOD values in specific samples are considered low bias due to exceeded holding times.

Low concentrations of bis(2-ethylhexyl)phthalate, methylene chloride, chloroform, and other phthalates were sporadically detected in some of the environmental samples, and only a few compounds were detected in associated blank (method, rinsate, or trip) samples. This disparity may be the result of only quantitatively assessing 30% of the available analytical data. These compounds had a limited presence, were randomly distributed, and are common laboratory contaminants (EPA 1988) and are not representative of site conditions.

This section provides an overview of the approach used to interpret analytical data from samples collected to evaluate groundwater, soil, surface water, and sediment during the RI/BRA. This process includes steps used to select chemicals of potential concern (COPCs) for use in the assessing the nature and extent of environmental contamination. The COPCs are defined as chemicals that are potentially site-related (exceed background) and that are present at concentrations that may impact human or ecological health. For the delineation of the nature and extent of chemical contamination, concentrations that are reported below the QAPP detection limits (in accordance with U.S. Army protocols) are regarded as non-detections. These concentrations are conservatively retained for risk assessment purposes.

4.3 DATA AGGREGATION

Analytical data from Fort McClellan were aggregated for evaluation by study area. The study areas are segregated from each other on the Main Post and Pelham Range but are contiguous with Post properties not evaluated under the RI. Site evaluations were conducted for each sampled medium, including surface soil, subsurface soil, sediment, surface water, and groundwater. Validated SI and RI analytical results were used in the assessments of the Fort McClellan study areas. During the validation

process, data were qualified based on the results of the quality assurance/quality control (QA/QC) samples (e.g., laboratory and field blanks).

The validation methods and results are described in Appendix I. Data found to be unsuitable by the data validation (i.e., data qualifier is "R") were excluded from use in site evaluations. Data found to be unsuitable because of elevated detection level were flagged as rejected.

4.4 BACKGROUND SAMPLING

Inorganic constituents (metals) occurring in natural environmental media (surface and subsurface soil, surface water, sediments, and groundwater) are regarded as "background" concentrations that are characteristic of non-mission related conditions to the extent that site activities have not adversely impacted these media. The background concentrations are typically used during the assessment of site-related contamination (including risk estimates) to ensure that naturally occurring and non-site related constituents are not unnecessarily carried forward through the assessments. Organic compounds are typically regarded as site related because many of these chemicals do not readily occur in nature. However, some compounds such as polynuclear aromatic hydrocarbons and pesticides are comparatively widespread in their usage and are sometimes considered anthropogenic background. A comprehensive background data set is necessary to ensure that indigenous constituents are exempted from study area assessments and that site decisions are not driven by background concentrations in the vicinity of Fort McClellan.

Background data for Fort McClellan and Pelham Range were initially obtained during the SI and RI studies (SAIC 1993,1995) conducted at the Post and at the adjacent Anniston Army Depot (SAIC 1996) between 1991 and 1996. However, because of enhancements in laboratory analytical detection limits and methods over time, changes in chemical concentrations that are of regulatory concern, and insufficient numbers of background samples for the purposes of statistical evaluation, additional background sampling was necessary to complete the data assessments for the ongoing and future investigations on the Post. Supplemental background sampling has been completed (SAIC 1998) on the Main Post and Pelham Range to establish statistically robust background concentrations for Target Analyte List (TAL) metals in environmental media (surface water, sediment, surface soil, subsurface soil, groundwater) to be used during the Base Realignment and Closure (BRAC) environmental process. Field sampling was conducted in accordance with the Final *Background Metals Survey Work Plan* (SAIC 1997) as approved by the Fort McClellan BRAC Cleanup Team (BCT). Additional background surface soil, subsurface soil, surface water, and sediment samples were obtained from 25 locations on the Main Post and 25 locations on Pelham Range as shown on Figures 4-10 and 4-11. Groundwater samples were obtained from 16 locations on the Main Post and 13 locations on (and around) Pelham Range.

4.4.1 Background Sampling Rationale

The principal background sampling objective was to obtain a statistically robust number of samples within five environmental media (groundwater, surface water, sediment, surface soil, and subsurface soil) on Fort McClellan and Pelham Range from locations that are sufficiently distributed to obtain spatial coverage over the entirety of the Main Post and Pelham Range. The number of samples per medium (25) was established by the BCT and these samples were distributed over the site areas to avoid known or obvious training areas or activities. Sampling within the cantonment (developed) area on the Main Post was recommended by the BCT on the basis that areas of limited historical military usage within the cantonment could be representative of background conditions. Because the cantonment area is prioritized as surplus, background samples from within the area were regarded as desirable by the BCT

based on the high potential for re-development in this area. The Main Post is surrounded by developed land on three sides and adjoins the Talladega National Forest to the east. Military training has historically occurred within the leased forest property and the surrounding private property is residentially and commercially developed, therefore background sampling was conducted within the Post perimeter with emphasis in the lightly-utilized mountainous areas surrounding the cantonment.

4.4.1.1 Number and Location of Background Samples

The number of additional samples necessary to produce a statistically robust background data set for the Main Post was estimated using existing analytical data from the Fort McClellan RI and procedures outlined in *Guidance for Data Useability in Risk Assessment* (EPA 1992a) and *Guidance for Planning for Data Collection in Support of Environmental Decision-Making Using the Data Quality Objectives Process* (EPA 1993c). The approach used to evaluate the proposed sample size is based on defining an acceptable level of statistical confidence (probability of avoiding a false positive) and power (probability of avoiding a false negative). Benchmarks for statistical confidence (80%) and power (90%) have been established by EPA (1992). At a given level of confidence and power the number of samples that would be required to detect a difference in concentration between site samples and the background reference data set can be estimated. The Minimum Detectable Relative Difference (MDRD) is the minimum difference (expressed as a percentage) necessary to demonstrate a statistically significant difference between the data sets. The EPA (1992) recommends that MDRDs of 10 to 20 percent are appropriate targets for sampling efforts. Based on this analysis, between 4 and 35 (average 16) multimedia samples would be needed to achieve an MDRD of 15%. The calculation supports the BCT-mandated sample size of 25 samples per medium.

The locations for the collection of the additional background samples (Figures 4-10 and 4-11) were selected to obtain spatial coverage of land area and surface water bodies that have not been affected (or have been minimally affected) by training activities on both Main Post and Pelham Range. Because it is not possible to state unequivocally that areas on the Main Post or Pelham Range have not been impacted by previous training activity, sample locations were selected surrounding the developed portion of the Main Post because of the reduced history of military training in these areas. Sample locations were also sited in less disturbed areas within the cantonment area. The sediment and surface water sample locations were selected to obtain samples near the headwater portions of mapped streams upgradient from the developed Post area and from major surface water bodies on the Post. As recommended by the BCT, sediment samples were obtained from areas of deposition within a streambed, with emphasis on the collection of fine-grained sediments, to the extent that they were available within the streams. Surface water and sediment sampling was conducted in accordance with Sections 10 and 11 of the EISOPQAM (EPA 1996). Surface soil samples were obtained from the interval 0.0 to 1.0 feet below land surface (BLS) and subsurface soil samples were composited over the interval between 1.0 feet and 10.0 feet BLS as directed by the BCT. Soil sampling was conducted in accordance with Section 12 of the EISOPQAM (EPA 1996b).

Background groundwater samples were obtained from 10 existing wells on the Main Post including wells BK-G03 (Reilly Lake well), MW-5-94 (BK-G04 at Landfill #4), LF1-G01, LF2-G01, T24A-G03, BK-G06, four upgradient UST wells within the cantonment area (MW1-G01, MW2-G02, MW4-G01, MW5-G01), and six new well placements (BK-YAHOU, BK-G07, BK-G08, BK-G09, and BK-G10, BK-G11). Proposed well MW2-1 at UST site #2 could not be located for sampling and was replaced by well MW2-2 from the same site. Background groundwater on Pelham Range was obtained from two existing City of Weaver wells (CW-G01, CW-G02), existing Army wells at Rideout Hall (GW-P8802), the SOT Testing Area (GW-P8607), the SOT Administrative Area (GW-P8203), and Range 57 (GW-P8415), two designated background locations for Anniston Army Depot (LDLF-4,

Williams well), two upgradient wells from Range L (RL-G01) and the Old Water Hole (OWH-G02) sites, and three newly installed well placements (GW-BKPR01, GW-BKPR02, GW-BKPR03). Groundwater samples from potable water supply wells were obtained in accordance with Section 8 of the EISOPQAM (EPA 1996). The McCullers well (background for AAD) was not sampled during the 1997 sampling round because the well was found to be in a state of disrepair.

4.4.2 Background Chemical Analysis Program

Environmental samples collected during the background sampling were analyzed for Target Analyte List (TAL) metals (including speciated chromium) in all media and including common anion (SO_4, HCO_3, Cl, Br, F, CO_3, NO_3, PO_4) analyses in groundwater, using USEPA SW-846 analytical methods. Analyses for mercury were conducted using cold vapor atomic absorption (CVAA) and analyses for antimony, arsenic, lead, selenium, and thallium were analyzed by graphite furnace atomic absorption (GFAA). Hexavalent chromium analyses were conducted on 20% of the samples from each medium. The results of the laboratory analyses for background metals constituents are provided in the Final Background Metals Survey report (SAIC 1998).

4.4.3 Calculation of Background Summary Statistics

The arithmetic mean for each TAL metal was calculated using the laboratory data incorporated into the overall database. The results of duplicate samples collected to evaluate field precision were averaged with the duplicated sample prior to inclusion in the calculation of the arithmetic mean and standard deviation. Non-detected values were used at one-half of the analytical detection level in the calculation of the arithmetic mean and standard deviation. A background threshold established as twice the arithmetic mean was calculated for each TAL metal. Outlier concentrations identified by USEPA (T. Simon written communication 1998) were excluded from the calculation of the mean.

The analytical results obtained during the supplemental background metals survey were combined with the useable historical data to comprise the overall background data set for Fort McClellan. Outlier values within the surface water and sediment data sets were identified by USEPA Region IV using probability plots constructed for each surface water and sediment analyte (T. Simon, written communication 5/28/98). The probability plots were constructed by calculating a percentile for each datum and expressing the percentile as a z-score plotted against each logarithmically transformed data value. A resulting straight-line plot is indicative of a single statistical distribution. Outlier values from the straight line distribution were excluded from the calculation of the mean concentration. Summary statistics, including the twice the mean background threshold were calculated for each medium from the composited data obtained from Pelham Range and Main Post. The summary statistics for the composited background data are provided in Tables 4-15 to 4-19.

4.5 NATURE AND EXTENT OF CHEMICAL CONSTITUENTS

The nature and extent of chemical constituents attributable to the RI sites was assessed using field soil screening (MINICAMS®) analyses and soil, groundwater, surface water, and sediment sampling and analysis. In determining the extent of environmental contamination, the laboratory analytical data for each site was compared statistically to background concentrations. Detected concentrations in field and laboratory blank (trip, method) samples were evaluated to identify compounds associated with ambient field, sampling, and laboratory conditions. These compounds are not generally attributable to environmental conditions at a specific site. Geologic, hydrogeologic, and geophysical methods were used to characterize the subsurface conditions at the RI sites.

4.5.1 MINICAMS® Screening

Field screening for chemical warfare agent (GB, VX, and HD) was conducted by USATEU on surface and subsurface soil at Areas T-4, T-5, T-24A, and T-38, Old Water Hole, D&I area, Range J, Range K, and Range L. Field protocols for MINICAMS® screening are described in Section 3.3.2. A total of 365 samples were analyzed for HD, VX, or GB agents. Surface screening of shallow (0 to 5 feet BLS) soils was conducted at the sites and subsurface screening was conducted to depths of 20 feet below ground surface at each monitoring well and soil boring location. Based on the results of the MINICAMS® analyses, chemical warfare agent was not detected above the 0.8 TWA in any screened samples from the RI sites on the Main Post or Pelham Range.

4.5.2 Site 1 – Area T-4 (Biological Simulant Test Area)

Area T-4 was investigated by MINICAMS® screening for HD, GB, and VX agents, soil sampling for CWM breakdown products, and magnetometer surveying over a site area that was located based on historical records and site photography. Groundwater was not evaluated at Area T-4 because of the predominantly surface usage of the property and the absence of any pre-existing structures on the site. Surface topography at the site ranges from 860 feet above mean sea level (msl) to approximately 880 feet above msl sloping to the north and west toward Summerall Gate Road (Figure 4-12). A 1973 U.S. Army photograph (see 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. Surface evidence of the former training area was not observed. The study area has been extensively re-arranged and consists of a central clearing within substantially wooded terrain. Comparison of the historical photography with the site topographic map suggests that the concrete marker may have been located in the southwestern quadrant of the identified site boundary. Because the precise locations and nature of training activities previously conducted at Area T-4 are not documented or evident, the site was non-intrusively investigated using MINICAMS® and geophysical (magnetometer) measurements to guide shallow soil sampling.

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 extensive periods of time (Osterhout 1988) and are 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 similarly used to simulate the airborne dispersal of biological agents in the environment. 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) or irrigation fluids. Decontamination of the biological simulants is achieved using a 0.5 percent sodium hypochlorite solution or DS2.

Field investigation for biological simulants was not conducted at Area T-4 because of the uncertainty associated with the quantities used and dispersal modes of the simulants during training, the extensive physical rearrangement of the study area, and the projected DOD ownership of the property at the time of the RI study. The study area soils were evaluated solely for the presence of CWM and CWM breakdown products. The study area soils and groundwater have not been fully evaluated for the presence of chemical constituents that may be associated with the use of decontamination solutions or that may be pertinent to BRAC property transfer issues. The MINICAMS® screening, soil sample, and geophysical survey locations at Area T-4 are shown on Figure 4-12.

4.5.2.1 Area T-4 – Geophysical Survey Results

Based on historical photography at Area T-4 depicting a concrete monument in a disturbed area, a geophysical survey incorporating tandem magnetometers was completed over the entirety of the documented area of T-4 (USATHAMA 1977) in May, 1995. Staked location T4-10 was used as a GPS reference station during the survey. The results of a target analysis for T-4 are summarized in Table 4-20. Approximately 50 subsurface targets were identified at Area T-4 based on the tandem magnetometer survey. The targets ranged between 0.0 feet and 8.8 feet in depth (estimated) and indicate that metallic debris is present at the site. The nature of the identified targets (i.e., ordnance, steel fragments, drums, building materials, old fence) is not known. Several areas within the site boundary were inaccessible because of tree clusters and could not be surveyed using the GPS method. The locations of the identified targets are shown on Figure 4-12. The spatial distribution of the mapped anomalies is indicative of strewn metallic debris scattered within and beyond the site boundaries.

4.5.2.2 Area T-4 – MINICAMS Screening Results

MINICAMS® screening was conducted by USATEU on soil samples that were obtained from 10 locations on Area T-4 during the RI study. The sample locations were distributed across the study area because of the lack of visible site features attributable to the former training activities at the site. The soil samples were collected by USATEU from 0.5 feet BLS and were analyzed for HD, GB, and VX CWM. The chemical agents were not detected above the 0.8 TWA (instrumental baseline) in any of the screened samples (Table 4-21).

4.5.2.3 Area T-4 – Soil Analytical Results

Four surface soil (T4-S01 to T4-S04) samples were collected across Area T-4 (see Figure 4-12) for analysis of HD and VX breakdown products. The sample locations were selected to obtain analyses at 3 downgradient locations and one uphill (T4-S04) location. Samples were not obtained from the estimated location of a former training monument at the site because the monument was removed by previous site re-working. Overall, CWM (HD, VX) degradation products were not detected in the surface soil at Area T-4 (Table 4-22).

4.5.3 Site 2 – Area T-5 (Toxic Hazards Detection and Decontamination Training Area)

Area T-5 is the Toxic Hazards Detection and Decontamination Training Area located between Sunset Hill and Howitzer Hill. 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. Decontamination of the residual agent on site soils was likely completed by adding either STB, HTH, 10% sodium hydroxide solution, and/or DS2 depending on the chemical agent used for training. 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. The locations of suspected

or potential chemical warfare agent training sites are shown in Figure 4-13. Training ordnance was observed on the site in 1991 and during the conduct of sampling in 1994. 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.

Field investigations at Area T-5 were conducted under the premise that CWM training at the site was surface-oriented, with controlled usage of limited quantities of agent and decontaminants. The property was to remain under DOD control at the time of the study. As a result, groundwater investigations were not conducted at the site. Previous environmental field investigation at Area T-5 consisted of U.S. Army sampling and analysis for CWM in 1972 and 1973, MINICAMS® screening of shallow (9 to 76 inches BLS) soil samples (T5-S01 to T5-S04) from high-probability, former training locations (SAIC 1993), and laboratory analysis of downgradient surface water (T5-W01) and sediment samples (T5-D01) for CWM degradation products (SAIC 1993). Historical documentation for the site, including training location sketches, ground-level photography, and historical soil sampling (SAIC 1993), were used to identify additional screening and sampling locations across the site. Four additional downgradient soil samples (T5-S05 to T5-S08), upstream (T5-W02) and downstream (T5-W03) surface water samples, and upstream (T5-D02) and downstream (T5-D03) sediment samples were collected at the site during the RI study. The samples were analyzed for VOCs, SVOCs, pesticides/PCBs, explosives compounds, metals, and HD, GB, and VX breakdown products. Additional MINICAMS® screening for HD, GB, and VX CWM was conducted by USATEU at 44 locations across Area T-5 during the RI. Sampling locations from the SI and RI studies are shown on Figure 4-13.

4.5.3.1 Area T-5 – MINICAMS® Soil Screening

Soil MINICAMS® screening from high-probability locations during the 1993 SI study was conducted for the presence of chemical warfare agents (HD, GB, and VX) at Area T-5 (Table 4-23). The field screening did not detect these compounds above 0.8 TWA (instrumental baseline) at the former training area (USATEU 1992, SAIC 1993).

Additional MINICAMS® soil screening was conducted by USATEU on 62 samples that were obtained from 44 locations on Area T-5 during the RI study (Table 4-24). The initial 26 sample locations were selected to obtain spatial coverage (approximately 200 foot centers) across the entire study area. The remaining samples were obtained to supplement previous sampling at the locations of historical training activity and to fill gaps in the overall site coverage. The soil samples were obtained by USATEU from 0.5 to 2.0 feet BLS and were analyzed for HD, GB, and VX agents. The chemical agents were not detected above the 0.8 TWA (instrumental baseline) in any of the screened samples.

4.5.3.2 Area T-5 – Soil Analytical Results

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). Eight biased surface and shallow subsurface soil samples (T5-S01 to T5-S04) were obtained from Area T-5 during the SI (SAIC 1993) to depths of approximately 1 foot and 5 feet below grade at each location. Four additional soil samples (T5-S05 to T5-S08) were collected from Area T-5 during the RI (see Figure 4-13) to enhance coverage of the site. The supplemental locations were selected based on MINICAMS® screening data, the locations of historical training sites on the property, and the locations of previous soil sample analyses (SAIC 1993). Soil samples from Area T-5 were analyzed for CWM breakdown products. The results of the laboratory analyses for CWM breakdown products in soil at

Area T-5 are provided in Table 4-25. Breakdown products that are potentially associated with degradation or decontamination of CWM were not detected in the site soil at Area T-5.

4.5.3.3 Area T-5 – Sediment Analytical Results

Three sediment samples (T5-D01 to T5-D03) were collected upstream and downstream of Area T-5 during the SI and RI studies. The samples were obtained from a stream tributary that flows east of the study area. The SI and RI samples were analyzed for HD, GB, and VX breakdown products and the additional RI samples were analyzed for VOC, SVOC, pesticide, PCB, explosive compounds, and metals. The results of the laboratory analyses of sediment at Area T-5 are provided in Table 4-26.

Concentrations of benzyl alcohol (0.056 to 0.074 µg/g) and di-n-butyl phthalate (1.8 to 5.4 µg/g) were detected in the upstream (T5-D02) and downstream (T5-D03) sediment samples. The detected concentrations decreased in the downstream sample. The samples also contained concentrations of unidentified semi-volatile compounds (0.5 to 3 µg/g). The aggregate concentrations (3 to 9.2 µg/g) of unidentified SVOCs similarly decreased in the downstream sample. Concentrations of cadmium (2.37 µg/g), copper (58.6 µg/g), lead (260 µg/g), and zinc (111 µg/g) exceeded background concentrations in upstream sample T5-D02.

4.5.3.4 Area T-5 – Surface Water Analytical Results

Two surface water samples (T5-W02, T5-W03) were collected from a stream flowing along the eastern boundary of Area T-5 (see Figure 4-13) during the RI study. An additional sample (T5-W01) was analyzed for CWM breakdown products from the site in 1992 (SAIC 1993). Sample T5-W03 was collected from an upstream location, and sample T5-W02 was collected from a downstream location. The RI samples were analyzed for VOCs, SVOC, pesticides, PCBs, explosive compounds, metals, and HD, GB, and VX breakdown products (Table 4-27). The surface water samples at Area T-5 contained concentrations of an unidentified semi-volatile compound (6 µg/g) in both the upstream and downstream samples. Inorganic constituents were detected at concentrations below the background surface water values.

4.5.4 Site 3 – Area T-24A (Former EOD Training Area)

Area T-24A is a 1.5-acre former explosive ordnance disposal (EOD) training area located within Range 24A south of Holloway Hill 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 1040 feet to 1012 feet above mean sea level. 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). An inventory of training aids requiring decontamination in April 1973 included 183 105-mm 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, chained-link fence with a single, locked access gate.

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) training 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 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 (Karen 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 (Karen 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).

Initial field sampling (SAIC 1993) at Area T-24A focused on potential high priority locations with emphasis on the identification of residual CWM or CWM breakdown products. Subsequent sampling during the RI was conducted under the premise that EOD training at the site was confined to the fenced enclosure and emphasized intrusive investigations in the vicinity of an identified training marker (Base "E"). Based on information obtained during the intrusive investigations, a STOLS™ survey was conducted to non-intrusively delineate potential buried ordnance over the entirety of the site area. Four soil samples were collected from two biased locations (T24A-S01, T24A-S02) within the fenced enclosure during the SI study (SAIC 1993). The SI samples were analyzed for GB and HD breakdown products. Three additional soil samples (T24A-S03 to T24A-S05) were collected during the RI study from excavated trenches within former training pits in the fenced area. Soils within the interior of the fenced enclosure were screened (MINICAMS®) for CWM during the SI and RI studies. In addition to screening of samples to be submitted for laboratory analyses, 9 samples (T24A-1 to T24A-9) were collected over the entire fenced area for CWM screening. Electromagnetic (EM-31) surveying was conducted during the SI study as a means of ordnance avoidance. A more extensive magnetometer investigation (STOLS™) was conducted during the RI study to quantitatively locate former training areas containing buried ordnance or metallic debris within the fenced perimeter. Groundwater at Area T-24A was evaluated by installing 3 monitoring wells (T24A-G01 to T24A-G03) into the shale and siltstone bedrock underlying the study area. Two rounds of groundwater sampling and analysis were conducted at the site. Surface water (T24A-W01, T24A-W02), and sediment (T24A-D01, T24A-D02) samples were obtained downgradient of the fenced area during the SI and RI studies. The trench, monitoring well, and sample locations are shown on Figure 4-14.

4.5.4.1 Area T-24A – MINICAMS Soil Screening

Soil MINICAMS® screening was conducted by USATEU during the 1993 SI study to support sampling at locations within the fenced enclosure that were identified with a high probability of detecting residual CWM (Table 4-28). Screening was conducted on collected samples for the presence of chemical warfare agents (HD, GB, and VX) at Area T-24A. The field screening did not detect these compounds above 0.8 TWA (instrumental baseline) at the former training area (USATEU 1992, SAIC 1993).

Additional MINICAMS® soil screening was conducted by USATEU at Area T-24A on 9 soil samples that were obtained over Area T-24A during the RI study. Seven samples were analyzed from trench excavations (T24A-T1-1 to T24A-T1-7) in the vicinity of concrete marker "E" within the fenced enclosure. The soil samples were obtained by USATEU from 0.5 to 5.5 feet BLS and were analyzed for HD, GB, and VX CWM. Chemical warfare agents were not detected above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of RI MINICAMS® screening on soil samples from Area T-24A are shown in Table 4-29.

4.5.4.2 Area T-24A – Intrusive Investigations

Trenching was conducted in the vicinity of a suspected burn pit on Area T-24A to obtain soil samples for laboratory analysis and to investigate the characteristics of the former training materials potentially burned and buried at the site. Trenching and sampling activities were conducted by USATEU personnel using an Army SEETrac with a backhoe attachment as described in Section 3.4.3. SAIC personnel selected sample locations and provided technical direction for USATEU personnel. The excavated burn pit sloped downward toward the eastern portion of the site, and contained black discolored soil and debris including charred wood, nails, and gas can handles. Trenching was continued until the bottom of the pit was visually identified. Excavation in the pit vicinity generally extended to depths of 4 to 6 feet BGS until moderately weathered bedrock was encountered. Excavated soils at the site exhibited discoloration and, in some instances, a hydrocarbon (diesel) odor. An unidentified blue-green, granular material was encountered in trench #1 to a depth of 3 feet BLS. The excavated soils were containerized for disposal as hazardous waste by Fort McClellan.

The most significant site features identified in the pit area was the unearthing of two fused 105-mm rounds and a 155-mm round and a burster tube located approximately 30 feet west of concrete monument "E" (see Figure 4-14). Four 4.2" mortar rounds and a possible mine were located approximately 33 feet northwest of monument "E". A liquid-filled 105-mm round and two UID smoke rounds were analyzed on site for the presence of chemical agent by Idaho National Engineering Laboratory (INEL) personnel using Portable Isotopic Neutron Spectroscopy (PINS) testing. The liquid-filled round was determined to have traces of explosive compounds and no chemical agent. The smoke rounds contained no explosives or chemical agent (Col P. Hoffman memoranda May, June 1994). The rounds were disposed of by the 142 EOD at Fort McClellan. Trenching was discontinued following the discovery of ordnance at the site.

4.5.4.3 Area T-24A – Geophysical Results

Area T-24A was investigated non-intrusively during the SI (SAIC 1993) and RI studies using electromagnetic (EM-31) and magnetometer (STOLS™) measurements in support of field sampling at the site. Electromagnetic (EM-31) measurements were obtained at Area T-24A during the 1993 SI study in support of soil sampling at locations (T24A-S01 and T24A-S02) in the northwestern portion of the site. The EM measurements identified an anomalous area at sample location T24A-S01 that was associated with a piece of buried metal debris. Prior to conducting geophysical surveying at Area T-24A during the RI study, the entire fenced area was cleared of trees and brush and was swept for surface ordnance by Fort McClellan EOD personnel. Metallic debris and exploded metal shards including small tanks and canisters were removed from the site by Fort McClellan. Continuous arrayed magnetometer (STOLS™) measurements were obtained over the entire site area (Figure 4-15) and were geopositioned using coordinates from adjacent monitoring wells. A total of 204 subsurface targets were delineated by the STOLS™ survey at Area T-24A. Four large magnetometer anomalies associated with former training pit areas were delineated by the survey as indicated on the figure. In addition, numerous smaller anomalies were mapped across the site area. The STOLS™ survey further delineated an area of buried ordnance that was discovered during intrusive trenching by USATEU within the fenced enclosure. Mapped circular anomalies around the perimeter of the site are associated with the chain link fence surrounding the area. Small, localized mapped anomalies may be associated with buried shrapnel, drums, ordnance, or other metallic debris. The quantified anomalies ranged in depth between 0 feet to 15.0 feet (target 121) below ground surface with an average depth of 2.25 feet. Very large anomalies at targets 61, 93, 121, 176, and 179 are associated either with single, massive magnetic burials or clusters of smaller burials. A summary of quantified anomalies identified by the STOLS™ survey is provided on Figure 4-15.

4.5.4.4 Area T-24A – Soil Analytical Results

Three soil samples (T24A-SO3, T24A-SO4, T24A-SO5) were collected as part of the test pit excavation activities conducted at Area T-24A during the RI field effort in a manner to provide chemical data on the soils within and below the disposal pits (see Figure 4-14). Sample T24A-SO3 was collected to determine the magnitude of contamination within the pit. Samples T24A-SO4 and T24A-SO5 were collected at locations believed to be beneath the pit bottom based on observed green discoloration of the soil and the lack of any debris. Soil samples were analyzed for VOC, SVOC, pesticides/PCBs, explosives, metals, and CWM breakdown products (Table 4-30). Two locations were previously sampled (SAIC 1993) for the presence of chemical agent breakdown products. Chemical agent breakdown products were not detected at these locations to a depth of five feet BGS.

Semi-volatile compounds were detected in the excavation samples at Area T-24A and included anthracene (3.7 to 10 µg/g), 2-methylnaphthalene (7.6 to 50 µg/g), fluorene (2 µg/g), and phenanthrene (3 to 30 µg/g). Concentrations of explosives compounds (nitroglycerine [1.05 to 2.32 µg/g], HMX [5.8 µg/g], and RDX [2.01 µg/g]) were reported in sample T24A-S03, however, the results were unconfirmed by a second (GC) column analysis and are affected by laboratory matrix interference. The excavated soil samples also contained aggregated concentrations of non-target, unidentified volatile (11.4 to 59.7 µg/g) and semi-volatile (149.8 to 1,470 µg/g) compounds. The detection of hydrocarbons, semi-volatiles, and possible explosives in the soil samples obtained from the training pits is consistent with the prior site usage as a detonation and open burning area.

Concentrations of inorganic constituents that exceed background levels in the soil at Area T-24A include aluminum (14,900 to 27,300 µg/g) antimony (1.69 to 29.1 µg/g), cadmium (2.38 to 3.91 µg/g), cobalt (17.7 to 18.7 µg/g), copper (20.9 to 198 µg/g), iron (53,200 µg/g), lead (200 to 220 µg/g), nickel (14.5 to 17 µg/g), and zinc (45.7 to 458 µg/g). The elevated metals were detected in soil samples (T24A-S03 to T24A-S05) that were excavated from a former training pit location within the fenced enclosure.

4.5.4.5 Area T-24A – Surface Water Analytical Results

One surface water (T24A-W02) sample was collected from Cane Creek at a location immediately downstream from Area T-24A (see Figure 4-14) and was analyzed for VOCs, SVOCs, explosives, metals, and HD and GB breakdown products. The sample contained background metals concentrations. The sample did not detect any of the target organic compounds, however, a non-target, unidentified volatile compound was detected at 8 µg/L. The analytical results for detected parameters in surface water are summarized in Table 4-31. Previous surface water sample T24A-W01 (SAIC 1993) did not detect the presence of CWM breakdown products.

4.5.4.6 Area T-24A – Sediment Analytical Results

Sediment sample T24A-D01 was obtained during the 1993 SI study did not detect the presence of HD or GB breakdown products. One sediment (T24A-D02) sample was collected from Cane Creek at a location immediately downstream from Area T-24A during the RI study (see Figure 4-14). The sample was analyzed for VOCs, SVOCs, explosives, metals, and HD and GB breakdown products. An isolated concentration of benzyl alcohol (0.062 µg/g) was detected in the sample in addition to an aggregate concentration (17.8 µg/g) of unidentified semi-volatile compounds. Inorganic concentrations of aluminum (9,810 µg/g), barium (130 µg/g), and iron (50,400 µg/g) exceeded background in sample T24A-D02. The analytical results for the detected parameters in sediment are summarized in Table 4-32.

4.5.4.7 Area T-24A – Groundwater Analytical Results

Three groundwater monitoring wells (T-24A-G01, T24A-G02, T24A-G03) were located at Area T-24A during the RI to triangulate (see Figure 4-14) the perimeter of the fenced site. Two rounds of groundwater samples were collected and analyzed for VOCs, SVOCs, pesticides, PCBs, explosives, metals, and HD, GB, and VX breakdown products (Table 4-33). Upgradient well T24A-G03 was also sampled during the 1997 background sampling study (SAIC 1998).

Volatile organic constituents that were detected in groundwater underlying Area T-24A consisted of concentrations of benzene (100 to 200 µg/L) that were detected in downgradient well T24A-G01. Isolated concentrations of non-target volatile compounds (3 to 30 µg/L) were detected in wells T24A-G01 and T24A-G03. Concentrations of the semi-volatile compounds bis(2-ethylhexyl) phthalate (12 to 19 µg/L), hexachlorobenzene (0.133 µg/L), pentachlorophenol (1.3 to 2 µg/L), and phenol (57 µg/L) were not consistently detected between sampling events. An isolated concentration of benzo(b)fluoranthene (0.0866 µg/L) was detected at comparable concentrations in the associated blank samples. Groundwater underlying Area T-24A contained a confirmed concentration of the pesticide α-BHC (0.00424 µg/L). Concentrations of semi-volatile, non-target constituents were detected upgradient and downgradient of Area T-24A and ranged between 4 to 100 µg/L. The greatest aggregate concentration (119 µg/L) of unidentified (non-target) semi-volatile compounds was detected at well T24A-G01.

Non-nutrient, inorganic constituents that were detected at concentrations exceeding background values included aluminum (4,190 µg/L), beryllium (1.49 to 1.63 µg/L), iron (8,650 to 23,300 µg/L), lead (12.2 µg/L), and manganese (1,100 to 1,690 µg/L). Groundwater pH at Area T-24A ranged between 6.4 to 7.6 pH units with an average pH of 7.0. The groundwater conductivity ranged between 73 to 1,860 µS/cm with an average groundwater conductivity of 422 µS/cm.

4.5.5 Site 4 – Area T-38 (Technical Escort Reaction Area)

Area T-38 (Technical Escort Reaction Area, formerly Old Toxic Agent Yard) is located on the Main Post along the crest of Reservoir Ridge. 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 was also 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 on site (Buildings 4452, 4453), were used for demonstration purposes, and were 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 was reportedly used to dispose of decontaminants and other hazardous wastes at the site (G. Harvey, written communication 10/7/92). In addition, there is a report (Gary 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). 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. The location of former training areas and sample locations are shown on Figure 4-16.

4.5.5.1 Area T38 – MINICAMS® Screening Results

MINICAMS® screening at Area T-38 was conducted by the USATEU during the SI study (SAIC 1993) to support soil sampling at identified high probability sampling locations. Soil samples that were submitted for laboratory analysis of CWM breakdown products were screened for HD, GB, and VX agent prior to submission to the laboratory. The results of the 1993 screening did not detect chemical agent above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of MINICAMS® screening at high probability locations during the SI study (SAIC 1993) are shown in Table 4-34.

Additional MINICAMS® soil screening was conducted by USATEU at Area T-38 on 72 soil samples that were obtained from 47 locations on Area T-38 during the RI study. Sample locations T38-1 to T38-42 were screened to obtain spatial coverage across the entire study area, to supplement previous sampling at the locations of historical training activity, and to fill gaps in the overall site coverage. The soil samples were obtained by USATEU from 0.5 to 2.0 feet BLS and were analyzed for HD, GB, and VX CWM. Additional screening was conducted on subsurface soil samples from borings T38-S05 to T38-S09 to depths of 15 to 45 feet BLS. Chemical warfare agents were not detected above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of MINICAMS® screening on soil samples from Area T-38 that were obtained during the RI study are shown in Table 4-35.

4.5.5.2 Area T-38 – Geophysical Surveys

Reconnaissance geophysical surveying (EM-31) was conducted during the 1993 SI study (SAIC 1993) to investigate high probability sampling locations in the vicinity of decontamination pad located in the northeastern corner of the site, at the possible location of a chemical sump in the central portion of the site, and at the suspected location of an HD drum burial in the southern portion of the site. The locations of the geophysical transects are shown on Figure 4-16. Electromagnetic anomalies were identified to the west of the northern decontamination pad and in the vicinity of the suspected chemical sump.

Additional geophysical surveys (EM-31, EM-61) were conducted in two sections of Area T-38 (see Figure 4-16) including the reported area of a former sump located in the center and towards the east side of the site, and at the reported sites of a buried drum in the southern portion of the site. The second parcel surveyed is located in the southwest portion of Area T-38 where a grid was established over a gravel pad. The sump area was surveyed using frequency domain electromagnetic (EM-31) and magnetic methods and the drum area was surveyed using time domain electromagnetics (EM-61). In addition to the conventional geophysical surveying, a tandem magnetometer survey (STOLS-adjunct) was conducted over satellite-available portions of the site area. Raw data, profiles, and contour plots for the measured data are provided in Appendix A.

Frequency domain EM (EM-31) and magnetic gradiometer data were collected at 10-foot intervals along each established grid line over the larger grid area and EM61 data were collected at 5 foot intervals over a 35 by 70 foot gridded area. Measurement stations were interpolated between staked positions along each transect. The profiled FDEM data from the sump area detected anomalous responses that are attributed to cultural features such as the perimeter and interior fences, bleachers, buried rail lines, and surface enclosures. However, an anomalous area (Figure 4-16) thought to

correspond with a buried target was observed in the horizontal and vertical mode data and can be seen on lines 20 through 50 (especially 40 and 50) between approximately 50 to 100 feet. The response was stronger in the horizontal mode data implying a shallow source.

Time domain (EM-61) electromagnetic measurements (TDEM) data were obtained from the drum area grid on the southeast side of T-38. These anomalies correspond to above ground storage facilities (open protection sheds). Two anomalous areas associated with open-faced protection sheds located on the two ends of the gridded area may indicate buried metallic material based on the TDEM channel 2 data responses and the calculated differentials. Random, reconnaissance data were obtained in the area surrounding the drum search grid area. Localized anomalous areas were identified by the TDEM measurements and their approximate locations are shown in Figure 4-17. Magnetometer data collected over the potential sump area identified dipolar, total field anomalies that cannot be associated with cultural features, and therefore may be caused by buried ferromagnetic material. The linearity observed in many of the magnetic anomalies is associated with the fence surrounding the site.

Portable STOLS™ Survey – Area T-38—Tandem magnetometer surveying was conducted at Area T-38 to augment the conventional point-source and transect-based geophysical measurements. The additional survey was an attempt to resolve site features of a smaller size than the established geophysical survey grids at the site. Although the survey could not obtain continuous coverage of the site area because of reduced satellite visibility caused by the tree canopy, measurements were obtained in areas of interest at the site (Figure 4-17). A total of 153 subsurface targets were identified by the tandem magnetometer survey. Estimated depths for the quantified anomalies ranged between surficial to 10.4 feet (anomaly 42) BGS with an average target depth of approximately 3 feet BGS. Anomaly 42 is the first target mapped immediately west of a concrete pad located in the northeastern corner of the site. Anomalies 45 to 48 are associated with the concrete pad. Several anomalies (127 to 136, 149 to 153) were identified in the approximate area of the reported sump. Sources for the remaining anomalies are generally undetermined and are associated with unknown subsurface site features possibly including buried railroad tracks, subsurface utilities, or storage tanks.

4.5.5.3 Area T-38 – Soil Analytical Results

Seven soil samples were obtained from 4 locations (T38-S01 to T38-S04) on Area T-38 during the SI study (SAIC 1993). The samples were collected from suspected locations with a high probability for the detection of residual CWM. Soil samples from these areas were collected and field-screened (MINICAMS®) by USATEU for the presence of residual HD, GB, and VX agents. Representative samples were laboratory analyzed for CWM breakdown products. Four subsurface soil samples were collected from three locations (borings T38-S06, T38-S09, T38-S10) within Area T-38 (see Figure 4-16) during the RI study. Samples were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives, metals, and HD, GB, and VX breakdown products. All subsurface samples were screened by the USATEU for the presence of CWM prior to submission to the laboratory. Analytical results for soil samples from Area T-38 are provided in Table 4-36.

Semi-volatile constituents that were detected in soil at Area T-38 consisted of concentrations of unidentified, non-target compounds ranging in concentration between 0.3 to 3 µg/g. A confirmed concentration of the pesticide 4,4′-DDE (0.00353 µg/g) was detected at boring T38-S09. The non-target and target organic constituents were predominantly detected at boring T38-S09 located west of the fenced enclosure at Area T-38.

Inorganics constituents that exceeded background concentrations in surface and subsurface soil samples at Area T-38 included aluminum (15,500 to 74,000 µg/g), arsenic (18.7 µg/g), beryllium (0.81 to

4.39 µg/g), chromium (40.1 to 150 µg/g), cobalt (37.5 µg/g), copper (15.3 to 61.7 µg/g), iron (37,900 to 180,000 µg/g), lead (84 µg/g), mercury (0.266 µg/g), nickel (12.2 to 107 µg/g), vanadium (61.6 to 186 µg/g), and zinc (55.1 to 230 µg/g).

4.5.5.4 Area T-38 – Groundwater Analytical Results

Five groundwater monitoring wells (T38-G05 to T38-G09) were installed at Area T-38 (see Figure 4-16). Initially, four wells were installed and sampled during July 1994 and February 1995, however, an additional well (T38-G09) was subsequently installed as an upgradient well because organic constituents were detected in from all of the four initial well installations. Groundwater sampling at Area T-38 was conducted in July, 1994 and February, 1995. Groundwater samples were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives, metals, and HD, GB, and VX breakdown products (Table 4-37).

Groundwater underlying Area T-38 is contains predominantly halogenated organic solvents and isolated semi-volatile constituents. Volatile organic compounds detected at the site include acetone (47 to77 µg/L), 1,1,2,2-tetrachloroethane (95 to 2,000 µg/L), trichloroethene (12 to 300 µg/L), 1,2-dichloroethene (31 to 93 µg/L), 1,1,2-trichloroethane (2.1 µg/L), carbon tetrachloride (11 to 53 µg/L), chloroform (6.8 to 9.2 µg/L), tetrachloroethene (13 µg/L). Volatile organic constituents were no detected in well T38-G09 during the 1995 sampling. Semi-volatile organic compounds were detected sporadically in wells T38-G05, T38-G06, and T38-G09 and consisted of bis(2-ethylhexyl) phthalate (11 to 34 µg/L) and isolated concentrations of the PAH compounds benzo(b)fluoranthene (0.247 µg/L), chrysene (0.0509 µg/L), and indeno(1,2,3-cd)pyrene (0.081 µg/g) in well T38-G09. Semi-volatile target compounds were not detected in the downgradient wells, however, aggregated semi-volatile non-target compound concentrations ranged between 12 and 347 µg/L with the highest concentrations detected at wells T38-G05 (305 µg/L) and T38-G09 (347 µg/L). Concentrations of nitroglycerine (2.04 to 3.49 µg/L) and 1,3,5-trinitrobenzene (0.291 µg/L) were detected in monitoring wells T38-G05 to T38-G08 within the fenced enclosure at Area T-38. Concentrations of the chemical breakdown products for HD, GB, and VX agents were not detected in groundwater at Area T-38.

Inorganics constituents that exceeded background concentrations in groundwater samples at Area T-38 included aluminum (2,580 to 2,620 µg/L), barium (241 to 262 µg/L), beryllium (1.72 to 2.84 µg/L), iron (7,290 to 12,800 µg/L), lead (12.8 to 15.2 µg/L), manganese (3,100 to 3,160 µg/L), and zinc (308 to 321 µg/g).

4.5.6 Site 5 – Range K (Agent Training and Shell Tapping Area)

Range K was a 2-acre agent training and shell tapping area located on Pelham Range. The site is located in a valley flanked by northeast-southwest trending topographic ridges. Surface topography ranges between 570 to 610 feet above mean sea level 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. Weathered ordnance, DANC cans, and DS2 cans have been observed 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. A 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. Range K was investigated using MINICAMS® screening, soil sampling and analysis, and geophysical surveying (EM-31, magnetometer). The locations of the sampled and surveyed areas are shown on Figure 4-18.

4.5.6.1 Range K – MINICAMS® Screening Results

MINICAMS® screening for residual CWM (HD, GB, VX) was conducted by USATEU at Range K on 45 surface soil (0.5 feet BLS) samples that were obtained on a grid pattern over the identified range area during the RI study. Additional screening was conducted on four shallow subsurface soil samples (RK-S01 to RK-S04) along a diagonal transect across the site. Chemical warfare agents were not detected above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of MINICAMS® screening on soil samples from Range K that were obtained during the RI study are shown in Table 4-38.

4.5.6.2 Range K – Geophysical Surveys

Time domain electromagnetic and magnetometer measurements were obtained over a gridded area measuring 280 by 400 feet at Range K. The data were collected on mesh centered points along lines 400 feet long at 10-foot station intervals. Measured locations were marked by a wooden stake every 50 feet along a line and measured stations between each stake were interpolated. Four anomalous areas were identified in the contoured EM61 data, suggesting that buried metallic material is present at Range K. In most of these areas, other surficial materials were observed nearby (empty DANC cans, ordnance) suggesting that these materials were used at Range K. The delineated anomalies are associated with partially buried fence posts and sectioned steel drums, that contributed to the instrument response in both EM channel 1 and channel 2. The calculated differential residual indicates that buried material is also present.

Magnetometer data was obtained over the same gridded area as the TDEM data at Range K. The profiles of magnetic data yield similar results to that observed in the TDEM data. Several anomalies exist that are attributed to surficial or buried fencing materials. Anomaly 1 along both Line 0 and Line 20 between approximately 300 to 420 feet (450,300 to 450,420 feet easting) indicates that buried material occurs in this area. Numerous small anomalies exist along the profiles, which in most cases, are associated with surficial material. Anomaly 2 occurs along Line 240 which correlates with fence posts in this area and a TDEM anomaly (see Figure 4-18). Anomalies observed in the total field contour data along the west side of the surveyed area correlate with the potential fence location and are probably caused by buried material associated with a former barbed wire fence. Similar correlations can be made for anomalies along the south side of the plot. The magnetic anomalies correlate with two of the anomalies seen in the TDEM data.

The results of a tandem magnetometer survey at Range K were not comprehensive because of the lack of satellite visibility from the moderately wooded site area. Although the site coverage was poor, fourteen magnetic anomalies were detected across the site (see Figure 4-18). The majority of the detected anomalies were comparatively small and ranged in depth between the surface and approximately 4 feet BGS.

4.5.6.3 Range K – Soil Analytical Results

Limited soil sampling was conducted during the SI study at Range K consisting of a single soil sample (RK-D01) obtained in an small area of ground disturbance. The sample was analyzed for CWM

breakdown products. Four additional soil samples were collected at Range K during the RI (see Figure 4-18) for the analysis of HD breakdown products and explosives compounds. All subsurface samples were screened by the USATEU for the presence of CWM prior to submission to the laboratory. Explosives and chemical agent breakdown products for HD, GB, and VX were not detected at the sampled locations within Range K. The results of laboratory analyses for shallow soil samples from Range K are provided in Table 4-39.

4.5.7 Site 6 – Range J (Chemical Agent Training Area)

Range J was formerly an agent training area located on the north-central portion of Pelham Range (Figure 4-19). 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. A concrete monument dated August 1973 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. The drums are buried within a shallow depression in the northwestern portion of the study area. Site access is controlled by a 6-foot high, chain-link fence with a single, locked access gate.

Range J was investigated during the 1993 SI using non-intrusive geophysical (EM-31) survey transects centered on the drum burial area and the concrete monument. Shallow soil samples (RJ-S0101 to RJ-S0401) were obtained at depths of 1 foot and 5 feet BLS and were screened (MINICAMS®) in the field for HD. The samples were analyzed in the laboratory for HD breakdown products. Additional MINICAMS® screening (RJ-1 to RJ-23) of surface soil, intrusive sampling and analysis of shallow soil (RJ-S05 to RJ-S08), monitoring well drilling and installation (RJ-G05 to RJ-G07), and groundwater sampling and analysis (Figure 4-19) were completed at the site during the RI.

4.5.7.1 Range J – MINICAMS® Screening Results

MINICAMS® screening at Range J was conducted by the USATEU during the SI study (SAIC 1993) to support soil sampling at identified high probability sampling locations. Soil samples that were submitted for laboratory analysis of CWM breakdown products were screened for residual HD agent prior to submission to the laboratory. The results of the 1993 screening did not detect chemical agent above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of MINICAMS® screening at high probability locations during the SI study (SAIC 1993) are shown in Table 4-40.

Additional MINICAMS® soil screening was conducted by USATEU on 50 soil samples that were obtained from locations within the fenced enclosure at Range J during the RI study. Surface sample locations RJ-1 to RJ-23 were screened to obtain spatial coverage across the entire study area, to supplement previous sampling at the locations of historical training activity, and to fill gaps in the overall site coverage. The soil samples were obtained by USATEU from 0.5 feet BLS and were analyzed for HD, GB, and VX CWM. Additional screening was conducted on subsurface soil samples from borings RJ-S05 to RJ-S07 (located outside the fenced enclosure) and from test pits (TP-1 and TP-2) to depths between 1 and 55 feet BLS. Chemical warfare agents were not detected above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of MINICAMS® screening on soil samples from Range J that were obtained during the RI study are shown in Table 4-41.

4.5.7.2 Range J – Geophysical Investigation

Reconnaissance geophysical measurements using the EM-31 instrument were obtained at the locations of shallow (1 to 5 feet BLS) soil sampling conducted within the fenced enclosure at Range J in 1992 (SAIC 1993). The reconnaissance survey identified an in-phase (metallic) anomaly (15 to 60 parts per thousand [ppt]) within the fence approximately 20 to 25 feet southeast of the concrete monument along transect P4. There were no EM-31 anomalies identified in the area adjacent to the concrete marker within the fenced enclosure and this area does not appear disturbed. Several EM anomalies were identified in the vicinity of the drum burial area within the fence and are associated with the metallic drums and debris. The locations of the geophysical transects and the identified anomalies are shown on Figure 4-19.

4.5.7.3 Range J – Intrusive Investigation

Based on the results of the reconnaissance geophysical surveys, the physical observation of drum burials at Range J, and the presence of a concrete training marker within the fenced enclosure at Range J, intrusive test pitting was conducted at Range J. Two test pits (TP-1, TP-2) were excavated to a depth of 5 feet BLS adjacent to the drum burial site and the concrete marker. Materials that were excavated from the test pits consisted predominantly of site soil with no evidences of additional debris or training materials beyond the soil-filled drums visible in the depression at TP-1. Soil samples RJ-S05 to RJ-S08 were obtained from the excavated pits. The test pits were backfilled on completion. MINICAMS® screening for CWM was completed by USATEU on all collected samples and in ambient air in the test pit excavations.

4.5.7.4 Range J – Soil Analytical Results

Seven soil samples were collected from four locations (RJ-S01 to RJ-S04) within the fenced enclosure at Range J during the SI study (SAIC 1993). The samples were obtained by USATEU at depths of 1 foot and 5 feet BLS at locations RJ-S01 to RJ-S03. Samples at location RJ-S01 were collected in the topographically lower northwest corner of the fenced enclosure and samples at location RJ-S03 were collected within the drum and soil-filled depression. One sample (RJ-S0401) was obtained from soil that filled an exposed drum. The final sample location (RJ-S01) was adjacent to the concrete marker. Soil samples obtained during the SI were analyzed in the laboratory for HD breakdown products which included thiodiglycol, organosulfur compounds, and chloroacetic acid. Four subsurface soil samples (RJ-S05 to RJ-S08) were collected during the RI study from within the excavated test pits inside the fence (see Figure 4-19). Samples were analyzed for HD breakdown products. All subsurface samples were screened by the USATEU for the presence of CWM prior to submission to the laboratory. The results of soil sample analyses from Range J are provided on Table 4-42. CWM breakdown products were not detected in any of the four samples collected during the RI. These data are consistent with the results of previous soil analyses (SAIC 1993) conducted at the site.

4.5.7.5 Range J – Groundwater Analytical Results

Three groundwater monitoring wells (RJ-G05, RJ-G06, and RJ-G07) were installed during the RI to triangulate the fenced enclosure at Range J (see Figure 4-19). Samples from the wells were analyzed for CWM breakdown products and volatile organic compounds (Table 4-43).

Organic constituents in groundwater underlying Range J consist of acetone (27 µg/L), carbon tetrachloride (6.6 to 2,000 µg/L), chloroform (14 to 31 µg/L), tetrachloroethene (2 to 3.9 µg/L), trichloroethene (1.4 to 5 µg/L), and 1,1,2,2 tetrachloroethane (1.6 to 4.4 µg/L). These compounds are

likely associated with the use of decontamination solutions in the site area. The maximum concentrations that were observed in the groundwater were largely detected at well RJ-G07 located southwest of the fenced enclosure.

4.5.8 Site 7 – Detection and Identification (D&I) 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 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 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. 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 pit containing the burned materials is identified by concrete monument "F". The former D&I area was investigated by intrusive trenching and soil sampling in the vicinity of concrete monument "F" and geophysical surveying. The site area is heavily wooded and few indicators of former military training are evident at the site. Geophysical surveying in the vicinity of monument "F" consisted of electromagnetic (EM-31) and magnetometer investigations. The trench, sample, and geophysical transect locations are shown on Figure 4-20.

4.5.8.1 D&I Area – MINICAMS® Screening Results

MINICAMS® screening at Range J was conducted by the USATEU during the SI study (SAIC 1993) to support soil sampling at identified high probability sampling locations in the vicinity of marker "F". Soil samples that were submitted for laboratory analysis of CWM breakdown products were screened for residual HD and GB agent prior to submission to the laboratory. The results of the 1993 screening did not detect chemical agent above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of MINICAMS® screening at high probability locations during the SI study (SAIC 1993) are shown in Table 4-44.

Additional MINICAMS® soil screening was conducted by USATEU during the RI study on 21 soil samples that were obtained from gridded locations over the former D&I Area and from samples collected from excavated trenches at marker "F". Surface sample locations DI-1 to DI-13 were screened to obtain spatial coverage across the entire study area, to supplement previous sampling at the locations of historical training activity, and to fill gaps in the overall site coverage. The soil samples were obtained by USATEU from 0.5 feet BLS and were analyzed for HD, GB, and VX CWM. Additional screening was conducted on 8 subsurface soil samples from test pits (TP-1 and TP-2) to depths between 2.5 to 6.5 feet BLS. Chemical warfare agents were not detected above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of RI MINICAMS® screening on soil samples from the D&I Area are shown in Table 4-45.

4.5.8.2 D&I Area – Intrusive Investigation

Intrusive investigation at the D&I Area was conducted in May, 1994. Trenches were excavated by the USATEU adjacent to monument "F" at the study area to investigate training and construction materials that were potentially buried at the site. Perpendicular trench alignments were excavated adjacent to the monument and extending over total lengths of approximately 25 feet. Intrusive trenching

at monument "F" generally encountered quantities of concrete rubble with rebar, wood including burnt wood and painted lumber (2" × 6"), sand, and tar paper. Sections of a 4.5" pipe embedded in concrete were encountered at a depth of 6.5 feet BLS. Training-related materials that were excavated at the D&I Area consisted of glass tube fragments (potentially from an M-18 test kit) and a rubber (chemical) glove. CWM screening of the glove was negative. Water was encountered in the trenched area at a depth of 6.5 to 7 feet BLS.

4.5.8.3 D&I Area – Geophysical Results

Geophysical measurements at the D&I Area were obtained along four transects centered over concrete monument "F" found at the site (Figure 4-20). The 120-foot long lines were arranged in a star pattern, with the four lines designated as Lines 1, 2, 3, and 4. Frequency domain (EM31) electromagnetic and magnetometer measurements were obtained on 10 intervals along each transect. The results of the geophysical investigation are shown in Figure 4-21.

Anomalous FDEM readings were observed at numerous stations in the D&I Area. Anomaly 1 correlates to a central conductivity (quadrature phase) and in-phase high that is centered approximately on concrete monument "F." The response of both conductivity and in-phase signals suggests that metallic material is buried in this area. The relative difference between the size of the anomaly as observed in the horizontal and vertical mode data may be caused by target geometry at depth. Since the vertical dipole mode attains a greater depth of investigation than the horizontal mode, data collected using the two modes may be used qualitatively to estimate the depth to the source target. Based on this comparison, the source of the anomaly may be less than 10 feet deep. In all cases, the in-phase component shows a pattern for Anomaly 1 similar to the conductivity or quadrature component, implying that Anomaly 1 is associated with metallic material since the in-phase component is particularly sensitive to metallic material.

Anomalies 2 and 3 are observed in vertical mode conductivity data in the south and southwest portions of the survey area. The source of the anomaly is interpreted to be nonmetallic since the in-phase response in this area was not observed to be anomalous. The anomaly source is estimated to be deeper than the investigation depth for the horizontal mode (about 10 feet) since no response is noted in the horizontal mode data. Targets that could result in such a response may include buried nonmetallic material such as unreinforced concrete or other refuse, surface or subsurface lithologic variations, or contaminants migrating in the subsurface. A surface source for the anomalies was not observed at the site.

A single, dipolar magnetic anomaly was observed in the magnetic and vertical magnetic gradient data. The anomaly pattern is characteristic of an anomaly arising from the induced magnetization of a buried ferromagnetic target in the northern hemisphere, with a relative positive anomaly component oriented to the south and a relative negative anomaly component oriented to the north. Semi-quantitative calculations using the steepest slope of the anomaly observed on the north-south oriented profile, produced a depth of burial estimate between 10 to 13 feet. The lack of any magnetic anomaly toward the south to southwest portions of the site suggest a lack of ferromagnetic material which agrees with the FDEM interpretation.

4.5.8.4 D&I Area – Soil Analytical Results

Four soil samples were collected from two locations (DIA-S01 to DIA-S02) in the vicinity of concrete marker "F" at the D&I Area during the SI study (SAIC 1993). The samples were obtained by USATEU at depths of 1 foot and 5 feet BLS at locations DIA-S01 and DIA-S02. Samples at location

DIA-S01 were collected adjacent to marker "F" and samples at location DIA-S02 were collected from a disturbed area located approximately 25 feet west of marker "F". Soil samples obtained during the SI were analyzed in the laboratory for HD and GB breakdown products and metals. Four subsurface soil samples (DIA-S03 to DIA-S06) were collected during the RI study from within the excavated test pits inside the fence. Samples were analyzed for HD and GB breakdown products. All subsurface samples were screened by the USATEU for the presence of CWM prior to submission to the laboratory. The results of soil analyses at the D&I Area are provided on Table 4-46.

Chemical warfare agent breakdown products were not detected in the soil samples obtained from the D&I Area in 1992 and 1994. Inorganic constituents that exceed background concentrations in soil samples obtained between 1 and 5 feet BLS included aluminum (18,200 to 38,000 µg/g), arsenic (17.3 to 21.8 µg/g), beryllium (0.936 to 1.62 µg/g), chromium (42.4 µg/g), cobalt (19.4 µg/g), copper (22.1 to 46.2 µg/g), iron (53,700 to 97,000 µg/g), lead (52.1 µg/g), nickel (15.4 to 24.9 µg/g), and zinc (34.4 to 73.6 µg/g).

4.5.9 Site 8 -Range L (Lima Pond)

Range L is a 0.3-acre site reported to have been used to dispose of captured World War II munitions, including chemical munitions. The pond is within a bermed area that is approximately 10 to 15 feet higher topographically than the surrounding wooded terrain. Surface topography at the site generally slopes radially away from the bermed area with an overall topographic slope to the northwest ranging between 560 to 594 feet above msl. 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. The bermed area at Range L was investigated using geophysical surveying and surface water/sediment sampling and analysis. Groundwater monitoring wells were established in the area surrounding the berm to assess potential leakage from the bermed site (Figure 4-22). The presence of surface water at Range L is highly ephemeral and shallow stream channels flow infrequently. Rainwater accumulates within the bermed area and the depth of the water is dependent on the frequency and quantity of precipitation during dry seasons.

4.5.9.1 Range L – Geophysical Survey Results

Reconnaissance magnetometer surveying conducted by USATEU during the 1993 SI study (SAIC 1993) detected concentrations of metallic debris along the perimeter of the pond area at Range L. Quantitative geophysical measurements within the bermed area (FDEM, TDEM, and magnetometer data) were obtained during the RI along transects aligned with the long axis of the pond in an approximately northeast to southwest direction (Figure 4-22). Measurements were obtained along each line at 5-foot intervals starting on the southwest side and increasing towards the northeast. FDEM and magnetic measurements also were obtained at three well drilling locations to ensure that buried materials would not be encountered during drilling. A star pattern was established at each location consisting of four 50-foot-long transects centered on each drilling stake. Raw data and profiles are provided in Appendix A. An anomalous area of broadly increasing conductivity (quadrature and in-phase) in the northwestern corner of the gridded area corresponds to a point where a survey transect approached the berm around the pond. This anomaly may correspond to conductive material that is buried within the berm. The mapped vertical and horizontal mode conductivity (quadrature and in-phase) patterns are characteristic of anomalies that could be associated with a trenched area, however, the measured conductivities are low making depth estimates in the pond area uncertain.

Two anomalous responses were observed in the TDEM data along Line 10 between 65 and 90 feet. These anomalies may be caused by buried metallic material since EM61 channel 1 response was low in this area. An anomalous area of total magnetic field and vertical magnetic gradient measurements was delineated in the northwestern corner of the gridded area (see Figure 4-23). The anomaly is characterized by a broadly decreasing magnetic field to the northwest and a steepening, negative magnetic gradient. The area of the anomaly is approximately coincident with an anomaly identified from the FDEM data. Since the TDEM data did not indicate an anomalous area along lines 40, 50 or 60, the observed FDEM and magnetic anomalies may not be caused by materials buried directly below the lines. The source of these anomalies may be caused by metallic objects embedded in the berm. Additional anomalous areas were not observed in pond area.

4.5.9.2 Range L – Soil Analytical Results

Eleven surface and subsurface soil samples were collected at Range L from the six boring locations (RL-S01 to RL-S05, RL-S08) surrounding the berm area (Figure 4-22). Samples from all locations except RL-S05 were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives compounds, metals, and HD, GB, and VX breakdown products. Samples from boring RL-S05 were analyzed for explosives. The results of soil analyses at Range L are provided on Table 4-47.

Volatile organic compounds were not detected in the soil samples surrounding Range L. Semi-volatile organic compounds that were detected in surface and subsurface soil samples from Range L consisted of benzyl alcohol (0.074 to 0.110 µg/g) and unidentified, non-target compounds (0.4 to 5 µg/g).

Concentrations of pesticides, PCBs, explosives and HD/GB/VX breakdown products were not detected in the soil surrounding the site.

Inorganic constituents that exceed background concentrations in surface soil samples obtained between 0.5 and 1 feet BLS included aluminum (24,100 to 42,100 µg/g), antimony (2.25 µg/g), arsenic (16.1 µg/g), beryllium (1.23 to 1.3 µg/g), chromium (39.6 to 88.4 µg/g), cobalt (14.6 to 93.6 µg/g), copper (23.1 to 50.5 µg/g), iron (43,800 to 80,000 µg/g), lead (52 to 110 µg/g), manganese (5,600 µg/g), mercury (0.0777 µg/g), nickel (13.3 to 166 µg/g), selenium (0.838 to 1.17 µg/g), vanadium (68.1 to 75.8 µg/g), and zinc (56.2 to 230 µg/g). Inorganic constituents that exceed background concentrations in subsurface soil samples (>1 foot BLS) at Range L include aluminum (18,100 to 53,800 µg/g), arsenic (21.9 µg/g), beryllium (0.794 to 2.48 µg/g), cadmium (4.8 to 7.06 µg/g), chromium (55.6 µg/g), cobalt (24.4 to 426 µg/g), copper (20.3 to 78.3 µg/g), iron (47,800 to 66,800 µg/g), lead (46 to 50 µg/g), manganese (1,800 to 9,800 µg/g), mercury (0.0913 to 0.124 µg/g), nickel (43.6 to 304 µg/g), silver (14.9 µg/g), vanadium (68.9 to 95.1 µg/g), and zinc (114 to 330 µg/g).

4.5.9.3 Range L (Lima Pond)– Sediment Analytical Results

Four sediment samples were collected and analyzed from Range L. Two samples (RL-D01, RL-D03) were obtained from within Lima Pond and two samples (RL-D02, RL-D04) were collected from ephemeral stream channels located approximately 400 feet west of the site (Figure 4-22) during a period of flow. Sediment samples from all locations were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives compounds, metals, and HD, GB, and VX breakdown products (Table 4-48).

Volatile and semi-volatile organic target compounds were not detected in any of the sediment samples obtained at Lima Pond. However, an unidentified, non-target volatile compound was detected at RL-D02 (4 µg/g) and 65 semi-volatile, non-target compounds were variably detected (0.4 to 4 µg/g) in each of the sediment samples. The pesticide dieldrin (0.00358 µg/g) was detected in sample RL-D04. Inorganic constituents that exceed background concentrations in sediment samples obtained at Range L

included aluminum (12,900 to 61,500 µg/g), barium (122 to 165 µg/g), beryllium (1.02 to 1.26 µg/g), chromium (48.5 to 80.2 µg/g), cobalt (13.7 to 92.1 µg/g), copper (42.3 to 50.9 µg/g), iron (49,200 µg/g), lead (56 to 64 µg/g), manganese (1,340 µg/g), nickel (16.7 to 176 µg/g), selenium (0.775 to 1.51 µg/g), vanadium (51.6 to 111 µg/g), and zinc (57 to 247 µg/g).

4.5.9.4 Range L – Surface Water Analytical Results

Four surface water samples were collected from the Range L area at the locations indicated on Figure 4-22. Two of the samples (RL-W01, RL-W03) were collected from the pond area and two (RL-W02, RL-W04) were collected from ephemeral stream channels located approximately 400 feet west of the site (Figure 4-22) during a period of flow. The surface water samples were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives compounds, metals, HD, GB, and VX breakdown products, and BOD (Table 4-49).

Organic chemical constituents were not widely detected in surface water within and surrounding Range L. An isolated concentration of 1,1,1-trichloroethane (2.7 µg/L) was detected in sample RL-W02 located west of the pond. Unidentified, non-target semi-volatile compounds were detected in surface water samples RL-W01 (10 µg/L), RL-W02 (5 to 6 µg/L), and RL-W03 (7 to 20 µg/L). Pesticides and explosives were detected in pond samples RL-W01 and RL-W03 and included confirmed concentrations of α-BHC (0.00322 to 0.00328 µg/L) and δ-BHC (0.00673 to 0.00726 µg/L), 2,4,6-trinitrotoluene (0.918 to 2.2 µg/L), 2,4-dinitrotoluene (1.64 to 5.41 µg/L), and 2,6-dinitrotoluene (0.819 to 2.28 µg/L). Chemical agent breakdown products for HD, GB, and VX were not detected in the surface water samples from Range L. Inorganic constituents that exceed background concentrations in the Lima Pond samples RL-W01 and RL-W03 included arsenic (3.12 to 3.15 µg/L) and manganese (950 to 975 µg/L). Biological oxygen demand (BOD) in the pond water samples (RL-W01, RL-W03) was measured at 4 µg/L.

4.5.9.5 Range L – Groundwater Analytical Results

Seven monitoring wells (RL-G01 to RL-G07) were installed around the bermed area at Range L (see Figure 4-22). The analytical parameters for groundwater samples collected from Range L include VOCs, SVOCs, pesticides, PCBs, explosives-related compounds, metals, and HD, GB, and VX breakdown products (see Table 4-50).

Groundwater underlying Range L contains volatile and semi-volatile organic compounds, pesticides, isolated PCBs, explosives compounds and metals. Trichloroethylene (1.1 µg/L) was detected in upgradient well RL-G05 and was not reproduced during discrete sampling events. An unidentified, non-target volatile compound was detected (10 µg/L) in downgradient well RL-G04. Volatile organic constituents were not detected in the other Range L wells suggesting that decontamination solutions were not widely applied at the site. Semi-volatile compounds that were variably detected in Range L groundwater consisted predominantly of PAH compounds including benzo (a)anthracene (0.0359 to 0.119 µg/L), benzo(b)fluoranthene (0.0274 to 0.275 µg/L), chrysene (0.0347 to 0.0792 µg/L), and indeno(1,2,3-cd) pyrene (0.0781 µg/L). Bis(2-ethylhexyl)phthalate was detected in wells RL-G05 (22 µg/L) and RL-G06 (34 µg/L). Unidentified, non-target SVOCs were variably detected in each of the site wells and ranged in concentration between 0.4 to 200 µg/L). The highest aggregate concentration (266 µg/L) of non-target SVOCs occurred at well RL-G07 and the highest single concentration (200 µg/L) was detected at upgradient well RL-G01.

Pesticide concentrations were confirmed in wells RL-G02, RL-G03, RL-G06, and RL-G07 and included δ-BHC (0.00679 µg/L), heptachlor (0.00731 to 0.167 µg/L), heptachlor epoxide (0.0143 to

0.129 µg/L), 4,4'-DDE (0.0244 µg/L), and isodrin (0.12 µg/L). An isolated PCB compound (PCB-1248) was detected (0.525 to 4.74 µg/L) in wells RL-G02, RL-G03, and RL-G07. The explosives compounds RDX (0.615 µg/L) and nitroglycerine (1.78 to 2.49 µg/L) were variably detected in wells RL-G02, RL-G03, and RL-G07. Concentrations of breakdown products for HD, GB, and VX chemical warfare agents were not detected in groundwater at Range L.

Inorganic constituents that exceeded background concentrations were variably detected at wells RL-G01, RL-G02, RL-G03, RL-G05, and RL-G07. The elevated metals included concentrations of aluminum (2,940 to 6,800 µg/L), beryllium (2.17 to 2.41 µg/L), cadmium (2.34 to 6 µg/L), cobalt (37.9 µg/L), iron (7,170 to 20,300 µg/L), lead (9.96 to 10 µg/L), and manganese (1,040 to 5,260 µg/L).

4.5.10 Site 9 – Landfill #1

Landfill #1 was reportedly operated as a Post sanitary landfill between 1945 and 1947. The identified site area covers approximately 11 densely wooded, steeply sloping acres, and is located between 16th Avenue and Avery Drive, adjacent to the floodplain of an unnamed intermittent stream draining into Remount Creek. The site slopes to the southeast toward 16th Avenue. The area above the inferred landfill site has been partially filled and graded to accommodate military housing structures. The RI site boundaries were revised in 1993 based on historical aerial photography. The initial landfill boundary was investigated along seven magnetometer transects between Avery Drive and 16th Avenue during the SI (SAIC 1993) study. The revised area of Landfill #1 was investigated during the RI using surface geophysical methods (EM, magnetometer), soil drilling, monitoring well installation, and groundwater, soil, and surface water/sediment sampling and analysis (Figure 4-24).

4.5.10.1 Landfill #1 – Geophysical Surveys

Magnetometer data that was obtained along seven transects (A to G) at Landfill #1 during the SI (SAIC 1993) identified several anomalies that were indicative of buried metallic objects. The most extensive anomalies were delineated in the southern portion of the study area around the intersection of transects A and B. These anomalies were attributed to ground disturbance and possibly landfilling. Localized anomalies along the SI transects were variably attributed to localized metallic debris, pipes, utilities, and power line interference.

Geophysical measurements (FDEM, magnetometer) were obtained along four transects at Landfill #1, some of which corresponded to points surveyed during a previous study (SAIC 1993) at the site. While establishing lines for the present survey, old stations along these lines were reestablished to ensure that data for the present study were collected at the same stations. Lines A and B were extended and Line H was added to encompass a greater portion of the inferred landfill boundary. The purpose of the additional geophysical measurements at Landfill #1 was to obtain a geophysical signature over the revised landfill area as identified by historical aerial photography and to investigate the extent and content of the landfill. The locations of the survey transects are shown on Figure 4-24. Frequency domain electromagnetic (EM31), magnetometer, and magnetic gradiometer data were collected at 20-foot intervals along these lines.

Landfill #1 boundaries are readily observed in the obtained data profiles. The EM data collected over previously surveyed areas (Lines A, B, and C; SAIC 1993) yielded comparable results to the earlier geophysical surveys. The mapped anomalies consist of conductivity (quadrature phase) increases, with localized in-phase data spikes suggesting that the source(s) of the anomalies is predominantly nonmetallic. Several of the spike-type, in-phase anomalies can be associated with metallic material that was observed on the ground surface. Figure 4-25 shows the contoured transect data as interpreted from

both the horizontal and vertical mode conductivity data. The overall EM signature at Landfill #1 (Figure 4-25 a,b,c) indicates a broad area of disturbance with contoured conductivity values increasing radially towards the center of the site. A linear chain of anomalies trending to the northeast from the southeastern portion of the survey area reflects an artifact of contouring widely separated data values adjacent to 16th Avenue.

Magnetometer measurements at Landfill #1 identified localized anomalies at various locations in both the total field and vertical gradient data suggesting that ferromagnetic material is causing many of the identified magnetic anomalies. This observation is contrary to that observed for the FDEM in-phase data which suggests some material causing the magnetic anomalies is deeper than the FDEM method can investigate. Several of the spike-type anomalies can be associated with metallic material which was observed on the surface. Figure 4-25(d) shows the contoured magnetic response obtained from Landfill #1. In general, the magnetic data identified more localized anomalies over the same area as the FDEM data. The most distinct, steep-gradient, magnetic anomaly was located near the intersection of Lines A and H (508,800E, 1,169,700N).

4.5.10.2 Landfill #1 – Soil Analytical Results

Eight soil samples were analyzed from two depths at each of the four soil boring (LF1-S01 to LF1-S04) locations around the perimeter of the landfill (see Figure 4-24). Soil samples were not obtained from the interior of the landfill during the RI study. Analytical parameters for the soil and sediment samples included VOCs, SVOCs, pesticides, PCBs, explosives compounds, and metals (Table 4-51). Samples ranged in depth between one foot and 12 feet BLS.

Organic constituents in the soil surrounding Landfill #1 consist of PAH compounds that were detected in a shallow (1 foot BLS) sample at downgradient boring LF1-S02 and pesticides in shallow samples at LF1-S02 and LF1-S03. Concentrations of PAH compounds included benzo(a)anthracene (0.17 µg/g), chrysene (0.17 µg/g), fluoranthene (0.19 µg/g), phenanthrene (0.25 µg/g), and pyrene (0.28 µg/g). Unidentified, non-target semi-volatile compounds were detected in each of the soil samples obtained around Landfill #1 at concentrations ranging between 0.4 to 5 µg/g. Pesticides in the shallow soil at boring locations LF1-S02 and LF1-S03 consisted of concentrations of 4,4′-DDD (0.0125 µg/g), 4,4′-DDE (0.00518 to 0.0287 µg/g), and 4,4′-DDT (0.0181 µg/g). Inorganic constituents that exceeded background concentrations in samples collected from the landfill perimeter included concentrations of aluminum (17,600 to 37,800 µg/g), antimony (8.33 µg/g), beryllium (1.39 to 3.16 µg/g), cobalt (18.6 to 27.9 µg/g), copper (21.3 to 53.4 µg/g), iron (52,600 to 80,000 µg/g), nickel (13.9 to 46.9 µg/g), and zinc (34.3 to 154 µg/g).

4.5.10.3 Landfill #1 – Surface Water Analytical Results

Two surface water (LF1-W01, LF1-W02) samples were analyzed from a tributary to Remount Creek that flows northeastward across the southern corner of the landfill site. Upstream (LF1-W01) and downstream (LF1-W02) samples were collected at the locations shown in Figure 4-24. The samples were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives compounds, and metals (Table 4-52).

Organic compounds were sparsely detected in surface water downgradient from Landfill #1. The downstream surface water sample (LF1-W02) contained 1,1,1-trichloroethane (1.5 µg/L), and chlorobenzene (1.9 µg/L). The upstream sample (LF1-W01) contained an isolated concentration of chloroform (9.2 µg/L) and the explosives compound 1,3-dinitrobenzene (0.841 µg/L). Arsenic (4.78 to 5.48 µg/L), barium (101 to 104 µg/L), and zinc (41.5 µg/L) exceeded background concentrations in the surface water predominantly in upstream sample LF1-W01.

4.5.10.4 Landfill #1 – Sediment Analytical Results

Two sediment (LF1-D01, LF1-D02) samples were analyzed from a tributary to Remount Creek that flows northeastward across the southern corner of the landfill site. Upstream and downstream samples were collected at the locations shown in Figure 4-24. The samples were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives-related compounds, and metals (Table 4-53).

Comparatively few organic constituents were detected in the stream sediment either upstream or downstream of the landfill site. Concentrations of benzyl alcohol (0.059 to 0.064 µg/L) and unidentified, non-target semi-volatile compounds (0.6 to 10 µg/L) were detected both upstream and downstream of the landfill. The pesticide compound 4,4-DDT (0.00517 µg/L) was detected in the downstream sediment sample LF1-D02. Aluminum (17,400 µg/L), barium (124 to 247 µg/L), iron (38,600 µg/L), manganese (1,600 µg/L), and nickel (17.5 µg/L) variably exceeded background concentrations in the upstream or downstream samples.

4.5.10.5 Groundwater Sampling Results – Landfill #1

Groundwater quality underlying Landfill #1 was evaluated by installing four monitoring wells (LF1-G01 to LF1-G04) around the perimeter of the site. Monitoring well LF1-G01 was installed as an upgradient well in the housing community along Avery Drive. Monitoring wells LF1-G02, LF1-G03, and LF1-G04 were installed downgradient of the landfill to the south and along 16th Avenue. Groundwater samples from the wells were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives-related compounds, and metals. The results of groundwater analyses from the Landfill #1 wells are provided in Table 4-54.

Laboratory analyses detected isolated VOC concentrations of acetone (14 µg/L), 1,1,1-trichloroethane (1.6 to 2.1 µg/L), methylene chloride (0.45 to 0.49 µg/L), and toluene (0.18 to 0.22 µg/L). The maximum VOC concentrations were generally detected in upgradient well LF1-G01. The semi-volatile compounds bis-(2 ethylhexyl) phthalate (12 to 21 µg/L) and di-N-butyl phthalate (2.7 to 12 µg/L) were detected in wells LF1-G01 to LF1-G03. An isolated concentration of the pesticide β-BHC (0.0348 µg/L) was detected in well LF1-G02. The explosives compounds 1,3-dinitrobenzene (0.57 µg/L) and nitroglycerine (2.25 to 3.27 µg/L) were detected in wells LF1-G01 and LF1-G03

Inorganics constituents that exceeded background concentrations were detected predominantly in groundwater downgradient from Landfill #1 in wells LF1-G02, LF1-G03, and LF1-G04. The elevated metals included concentrations of aluminum (2,870 to 7,070 µg/L), barium (495 to 629 µg/L), beryllium (1.31 to 3.54 µg/g), iron (8,860 to 14,700 µg/g), and manganese (830 to 1,440 µg/L).

4.5.11 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. The landfill is located west of the southern tip of Cemetery Hill, between 2nd Avenue and 10th Street. The site is heavily wooded and is located in the floodplain of Cave Creek, which flows south-southeast of the landfill. Shallow weathered bedrock was observed in the creek bed. The *Fort McClellan Final Environmental Baseline Survey* (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" was also 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. Demolition debris (asphalt, concrete, and glass) was exposed at the landfill by road-building operations during the 1992 site investigation (SAIC 1993).

Landfill #2 was preliminarily investigated during the 1993 SI by triangulating the site with three monitoring wells (LF2-G01 to LF2-G03). Well LF2-G01 was installed upgradient of the inferred landfill site and wells LF2-G02 and LF2-G03 were installed downgradient of the site. Well LF2-G03 was installed between the landfill and Cave Creek. Groundwater samples from the wells were analyzed for VOC, SVOC, pesticides/PCBs, CWM breakdown products, explosives, and metals during the SI. Additional groundwater samples from the wells were analyzed for VOC, SVOC, pesticides/PCBs, explosives, and metals during the RI. The site was further investigated during the RI using two, approximately perpendicular reconnaissance geophysical (EM-31, magnetometer) survey transects centered on the inferred landfill site and intersecting existing monitoring wells LF2-G01 (Line 2) and LF2-G03 (Line 1). Surface water and sediment samples were obtained from Cave Creek upgradient (LF2-W01/ LF2-D01) and downgradient (LF2-W02/LF2-D02) of the site area. Groundwater depth measurements were obtained from the site wells on a monthly basis between April 1994 and June 1995. Soil sampling was not conducted at Landfill #2 during the SI or RI study and is identified as a data gap. Sampling locations at Landfill #2 are shown on Figure 4-26.

4.5.11.1 Landfill #2 – Geophysical Survey

Data were collected for reconnaissance purposes along two intersecting transects at Landfill #2 as shown in Figure 4-26. Transect 1 parallels a dirt road leading into the site and lies approximately west-to-east. Measurement stations began at well location LF2-G03 and followed the road toward the northwest, deviating from the road at approximately 500 feet and heading into an open grassy field. Transect 2 crosses transect 1 at approximately 325 feet and trends northwest to southeast, with measurement stations starting at well location LF2-G01, and increasing towards Cave Creek on the southern side of the site. The line terminates at the creek. A barb wire fence is located approximately 40 feet south of the dirt road (at station 200 along Line 2) and is sub-parallel with the road. FDEM and magnetic gradiometer data were collected at 10-foot intervals along these two lines.

The contoured EM data (Figure 4-27) indicates a radially decreasing (outward) conductivity distribution that is characteristic of a disturbed area. In general, confidence in the interpreted contours decreases away from the measured transect data points, however, the acquired data is useful in delineating the areal extent of the landfill site. Interpreted contours to the northeast and southwest of the transect intersection have the lowest degree of confidence.

Magnetometer data was collected along the same two lines as the FDEM data at Landfill #2. Landfill boundaries are readily observed from the profile data (Appendix A). The anomalous measurements are observed in both the total field and vertical gradient data suggesting that ferromagnetic material is causing many of the landfill anomalies. This observation agrees with the FDEM in-phase data obtained over the same area. Several of the spike anomalies can be associated with metallic material (such as well casings) on the ground surface. In general, the magnetic data suggest anomalous regions in the same areas as the FDEM data.

4.5.11.2 Landfill #2 – Surface Water Analytical Results

Two surface water samples were collected from Cave Creek at Former Landfill #2 (see Figure 4-26). One surface water (LF2-W01) sample was collected from an upstream location in the creek and the other sample (LF2-W02) was collected downstream of the site. Laboratory analyses were conducted for VOCs, SVOCs, pesticides, PCBs, metals, and explosives compounds. Organic chemical constituents were not detected in the surface water samples associated with Landfill #2 with the

exception of an isolated concentration of an unidentified, non-target semi-volatile constituent (6 µg/L) in the downstream sample. Inorganic constituents were below background concentrations in the upstream and downstream samples. The surface water results are shown on Table 4-55.

4.5.11.3 Landfill #2 – Sediment Analytical Results

Two sediment samples were collected from Cave Creek at Former Landfill #2 (see Figure 4-26). One sample (LF2-D01) was collected from an upstream location in the creek bed and the other sample (LF2-D02) was collected downstream of the site. Laboratory analysis was conducted for VOCs, SVOCs, pesticides, PCBs, metals, and explosives-related compounds. The analytical results for sediment samples associated with Landfill #2 are shown on Table 4-56.

Organic constituents that were detected in the upstream and the downstream sediment samples consisted of benzyl alcohol (0.066 to 0.078 µg/L) and four unidentified, non-target semi-volatile compounds ranging in concentration between 0.5 and 1 µg/L. Inorganic constituents that exceeded background concentrations were detected in upstream sample LF2-D01 and consisted of chromium (51 µg/L), iron (45,700 µg/L), and selenium (0.722 µg/L).

4.5.11.4 Landfill #2 – Groundwater Analytical Results

Three wells were installed at Former Landfill #2 during the Site Investigation (SI) that was conducted in 1992. These wells were sampled in conjunction with the RI in July 1994 and January 1995 and as part of a quarterly monitoring program implemented by Fort McClellan. Upgradient well LF2-G01 was also incorporated into the background database. The wells are located along the perimeter of the landfill as shown in Figure 4-26. The analytical parameters for the groundwater samples included VOCs, SVOCs, pesticides, PCBs, metals, CWM breakdown products, and explosives compounds (Table 4-57).

Based on the results of four rounds of groundwater analyses from wells surrounding Landfill #2, groundwater underlying the site contains isolated concentrations of volatile and semi-volatile organic compounds. Volatile constituents consisted of acetone (100 µg/L), 4-methyl-2-pentanone (5.4 µg/L), methylene chloride (0.34 to 1.2 µg/L), toluene (0.16 to 0.17 µg/L), and six unidentified, non-target compounds ranging in concentration between 5 and 80 µg/L. Di-N-butyl phthalate (2.7 to 6.2 µg/L) was detected in each of the landfill wells. Non-target, semi-volatile compounds had aggregated concentrations ranging from 41 to 155 µg/L and were detected in all three monitoring wells at the site. Isolated concentrations of the pesticides aldrin (0.0105 µg/L) and δ-BHC (0.004 µg/L) were detected in wells LF2-G01 and LF2-G03. A single concentration of nitroglycerine (2.77 µg/L) was detected in downgradient well LF2-G03. The compound was not detected in an earlier sampling round.

Inorganics constituents that exceeded background concentrations were predominantly detected in groundwater downgradient from Landfill #2 in wells LF2-G02 and LF2-G03. The elevated metals included concentrations of aluminum (3,680 to 4,940 µg/L), beryllium (4.24 to 6.24 µg/L), iron (16,600 to 22,500 µg/L), lead (10.7 to 46.9 µg/L), and manganese (1,330 to 2,080 µg/L).

4.5.12 Site 11 – Landfill #3

Landfill #3 was the Post sanitary landfill in operation between approximately 1946 and 1967 (Figure 4-28). 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. 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 (downgradient) and adjacent to the recently closed sanitary Landfill #4. 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 (Hicks, R. 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.

Preliminary investigation of Landfill #3 was conducted by USAEHA in 1986 by installing groundwater monitoring wells OLF-G01 to OLF-G05 approximately around the western perimeter of the landfill. Groundwater quality around Landfill #3 was further investigated by the installation, sampling, and analysis of 5 additional monitoring wells (OLF-G06 to OLF-G10) during the SI study (SAIC 1993). The SI wells were installed primarily to monitor downgradient gaps between the USAEHA wells. Monitoring wells OLF-G11 to OLF-G13 and OLF-G15 to OLF-G19 were installed during the RI to obtain monitoring data upgradient of the landfill and included the installation of three, downgradient off-post wells (OLF-G12, OLF-G18, OLF-G19). Planned well OLF-G14 was replaced with existing Landfill #4 well MW1-94 and was not installed. Groundwater samples were analyzed for VOC, SVOC, pesticide/PCB, explosives, and metals compounds during the SI and RI studies. Samples from wells OLF-G01 to OLF-G10 were analyzed for CWM breakdown products during the SI study (SAIC 1993).

Surface water and sediment samples were obtained during the RI from ephemeral streams (OLF-W03/D03 to OLF-W05/D05) that flow into the drainage trench that surrounds the north-western perimeter of Landfill #3. Samples were also obtained south of the landfill from Cane Creek (OLF-W01/D01 to OLF-W02/D02) where the stream exits Fort McClellan. Surface water and sediment samples were analyzed for VOC, SVOC, pesticide/PCB, explosives, and metals compounds during the SI and RI studies. Sample OLF-W01/D01 was also analyzed for CWM breakdown products. The locations of the monitoring wells and samples are shown on Figure 4-28.

4.5.12.1 Landfill #3 – Soil Analytical Results

Twelve soil samples were analyzed from eight locations (OLF-S11, OLF-S13, OLF-S16, OLF-S17, OLF-S20, OLF-S21, OLF-S22, and OLF-S23) on and surrounding Landfill #3. The sampling locations are shown on Figure 4-28. All soil samples were analyzed for VOCs, SVOCs, pesticides, PCBs, metals, and explosives compounds (Table 4-58).

Organic constituents that were detected in the surface soil at Landfill #3 consisted of pesticide and PAH compounds. The pesticide compounds 4,4'-DDD (0.00616 µg/g), 4,4'-DDE (0.00408 to 0.0139 µg/g), and chlordane (0.568 µg/g) were detected at locations OLF-S11 and OLF-S21. The semi-volatile PAH compounds benzo(a)anthracene (0.12 to 0.16 µg/g), chrysene (0.083 to 0.091 µg/g), fluoranthene (0.12 to 0.19 µg/g), phenanthrene (0.087 µg/g), and pyrene (0.3 µg/g) were detected at locations OLF-S21 and OLF -S23. Inorganic constituents that exceeded background concentrations in the surface soil at Landfill #3 consisted of aluminum (24,400 to 78,000 µg/g), barium (133 to 198 µg/g), beryllium (0.951 to 2.82 µg/g), chromium (51 to 67.8 µg/g), cobalt (20.8 to 21.3 µg/g), copper (13.8 to 29.5 µg/g), iron (37,700 to 57,400 µg/g), lead (40 to 46 µg/g), manganese (3,700 to 3,900 µg/g), mercury (0.00925 to 0.111 µg/g), nickel (12.7 to 44.4 µg/g), vanadium (62.2 to 93.8 µg/g), and zinc (43.1 to 128 µg/g). The maximum detected metals concentrations were predominantly detected at location OLF-S22.

Concentrations of organic constituents in subsurface samples at Landfill #3 were generally sparse. Benzyl alcohol (0.053 to 0.054 µg/g) was detected at location OLF-S22 and 4,4'-DDE (0.00376 to 0.00448 µg/g) was detected at locations OLF-S11 and OLF-S13. Volatile organic compounds that were detected in the samples consisted exclusively of unidentified, non-target constituents ranging in concentration between 0.7 to 10 µg/g. Unidentified, non-target semi-volatile compounds were detected in the samples at concentrations between 0.3 and 2 µg/g. Inorganics constituents that exceeded background concentrations were variably detected in subsurface soil at Landfill #3. The elevated metals included concentrations of aluminum (19,000 to 51,300 µg/g), beryllium (0.903 to 1.6 µg/g), copper (146 µg/g), nickel (13.4 to 18.4 µg/g), and zinc (43.1µg/g).

4.5.12.2 Landfill #3 – Surface Water Analytical Results

Three surface water samples (OLF-W03 to OLF-W05) were collected from the intermittent stream that enters Landfill #3 along the central portion of the eastern boundary. Two additional surface water samples (OLF-W01, OLF-W02) were collected from Cane Creek where it exits Fort McClellan southwest of Landfill #3. The surface water bodies surrounding the landfill site, with the exception of Cane Creek, are largely ephemeral, stagnant streams that are recharged by precipitation and runoff. The sample locations are shown on Figure 4-28. The surface water samples were analyzed for VOCs, SVOCs, BOD, pesticides, PCBs, metals and explosives compounds (Table 4-59). Sample OLF-W01 was also analyzed for CWM breakdown products.

Organic constituents that were detected in the surface water at Landfill #3 consisted of concentrations of volatile compounds 1,1,1-trichloroethane (1.2 to 6.2 µg/L) and trichloroethene (1.3 µg/L), unidentified, non-target semi-volatile compounds (6 to 30 µg/L), and confirmed concentrations of the pesticides α-BHC (0.00348 µg/L) and γ-BHC (0.00413 µg/L). The organic compounds were detected exclusively in surface water samples OLF-W03 and OLF-W04 located on the northeast corner of the landfill. The concentration of lead (70.8 µg/L) in surface water sample OLF-W05 from the drainage ditch west of the landfill exceeded the background concentration of 9.61 µg/L.

4.5.12.3 Landfill #3 – Sediment Analytical Results

The surface water bodies surrounding the landfill site, with the exception of Cane Creek, are largely ephemeral, stagnant streams that are recharged by precipitation and runoff. Three sediment samples (OLF-D01 to OLF-D03) were collected from the intermittent stream that enters the drainage ditch surrounding Landfill #3 at the northeast corner of the landfill. Two of the samples (OLF-D01, OLF-D02) were collected from Cane Creek where it exits Fort McClellan southwest of Landfill #3. The sample locations are shown on Figure 4-28. The sediment samples were analyzed for VOCs, SVOCs,

pesticides, PCBs, metals and explosives compounds (Table 4-60). Sample OLF-D01 was also analyzed for CWM breakdown products.

Organic constituents that were detected in the sediments associated with Landfill #3 consisted of concentrations of PAH compounds detected in the sample (OLF-D02) from Cane Creek, unidentified, non-target semi-volatile compounds (0.4 to 1 µg/g), and a confirmed concentration of the pesticide 4,4'-DDE (0.00379 µg/g) in sample OLF-D03. The PAH constituents included concentrations of acenaphthylene (0.08 µg/L), benzo(a)anthracene (0.8 µg/g), benzo(b)fluoranthene (0.92 µg/g), benzo(g,h,i)perylene (0.39 µg/g), benzo(k)fluoranthene (0.48 µg/g), chrysene (0.63 µg/g), fluoranthene (0.89 µg/g), phenanthrene (0.23 µg/g), and pyrene (1.2 µg/g).

Inorganics constituents that exceeded background concentrations were detected in sediment sample OLF-D03 on the northeast corner of the landfill. The elevated metals included concentrations of aluminum (60,800 µg/g), barium (158 µg/g), beryllium (1.87 µg/g), chromium (42.2 µg/g), copper (24.9 µg/g), iron (37,500 µg/g), nickel (21 µg/g), vanadium (77.4 µg/g), and zinc (74.3 µg/g).

4.5.12.4 Landfill #3 – Groundwater Analytical Results

Groundwater samples were analyzed for VOC, SVOC, pesticide/PCB, explosives, and metals compounds during the SI and RI studies. Samples from wells OLF-G01 to OLF-G10 were analyzed for CWM breakdown products during the SI study (SAIC 1993). The results of groundwater analyses at Landfill #3 are shown on Table 4-61. The wells were re-sampled by IT Corporation in 1998 during quarterly monitoring.

Organic constituents that were detected in the groundwater consisted of volatile, semi-volatile, pesticide and explosives compounds. Volatile compounds included acetone (22 to 570 µg/L), benzene (0.91 to 2.1 µg/L), carbon disulfide (0.33 to 3 µg/L), chlorobenzene (0.15 to 1.6 µg/L), dichlorobenzene (2.3 µg/L), methylene chloride (0.26 to 4.6 µg/L), pentachlorophenol (1.19 to 52.8 µg/L), tetrachloroethene (0.58 to 4 µg/L), toluene (0.18 to 0.23 µg/L), trichloroethene (0.16 to 100 µg/L), 1,1,1-trichloroethane (2.4 µg/L), 1,1,2,2-tetrachloroethane (22 to 400 µg/L), 1,1,2-trichloroethane (0.93 to 3.1 µg/L), 1,1-dichloroethane (4.2 to 11 µg/L), 1,2-dichloroethene (2.1 to 20 µg/L), 1,4-dichlorobenzene (4.6 µg/L), 4-methyl-2-pentanone (3.9 µg/L), xylene (0.31 µg/L), and vinyl chloride (1.47 to 4.08 µg/L). Elevated VOC concentrations were detected in wells OLF-G10 to OLF-G12.

Semi-volatile compounds that were detected in groundwater surrounding LF3 consisted of benzo(a)anthracene (0.0261 to 0.113 µg/L), benzo(a)pyrene (0.0405 µg/L), benzo(b)fluoranthene (0.195 to 0.399 µg/L), benzo(k)fluoranthene (0.0394 to 0.714 µg/L), bis-(2-ethylhexyl)phthalate (2.6 to 53 µg/L), 4-chloroaniline (1.8 µg/L), chrysene (0.0427 to 0.0429 µg/L), di-n-butyl phthalate (1.9 to 6.9 µg/L), dibenzo(a,h)anthracene (0.0509 to 0.144 µg/L), diethyl phthalate(1.6 µg/L), hexachlorocyclopentadiene (0.481 µg/L), indeno(1,2,3-cd)pyrene (0.0341 to 0.0387 µg/L), and napthalene (1 to 1.4 µg/L). Concentrations of the explosives compound nitroglycerine (1.52 to 1.89 µg/L) were detected in wells OLF-G01, OLF-G11, OLF-G13, and OLF-G15 but were impacted by analytical interferences that obscured the compound making the detections tentative.

Pesticide compounds including 4,4′-DDD (0.0295 µg/L), 4,4′-DDT (0.114 µg/L), aldrin (0.0649 µg/L), dieldrin (0.0298 to 0.249 µg/L), Endosulfan I (0.0045 to 0.272 µg/L), Endosulfan II (0.0244 µg/L), endrin (0.058 to 0.24 µg/L), heptachlor (0.00696 to 0.0969 µg/L), heptachlor epoxide (0.017 µg/L), methoxychlor (1.68 µg/L), α–BHC (0.0036 to 0.231 µg/L), β-BHC (0.054 µg/L), δ-BHC (0.00404 µg/L), and γ-BHC (0.352 µg/L) were detected in groundwater at Landfill #3. An isolated concentration (0.615 µg/L) of the Aroclor compound PCB-1248 was detected in well OLF-G18.

Inorganics that were detected above background concentrations in the groundwater at Landfill #3 included concentrations of aluminum (2,530 to 240,000 µg/L), barium (196 to 775 µg/L), beryllium (1.17 to 20 µg/L), cadmium (7.18 µg/L), cobalt (25.5 to 151 µg/L), copper (39 to 311 µg/L), iron (7,310 to 271,000 µg/L), lead (9.58 to 1,470 µg/L), manganese (833 to 7,430 µg/L), vanadium (31.6 to 390 µg/L), and zinc (359 to 576 µg/L). The maximum concentrations for these metals were detected in well OLF-G02 located south of the landfill and well MW-1 located east (upgradient) of the landfill.

4.5.13 Site 12 – Old Water Hole

The Old Water Hole site is located between New Mt. Sellers Cemetery and the prisoner of war (POW) camp on Pelham Range. The site was reported to have been 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 wooded 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. The Old Water Hole site was investigated using quantitative geophysical (EM31, EM61, magnetometer) measurements, monitoring well drilling and installation, subsurface soil analyses with MINICAMS® screening, and groundwater sampling and analysis. The locations of field measurements are shown on Figure 4-29.

Frequency domain electromagnetic and magnetic gradiometer data were collected at the Old Water Hole site along three 400-foot transects (Lines 1, 2, and 3) that crosscut several linear topographic features surrounding the area of the site. A gridded area over the location of the Old Water Hole site was also surveyed over a 100 by 300 foot area. Spacing between lines and stations on the transects and the gridded area were 10 feet. Figure 4-29 shows the orientation of the transects and the gridded area. Data collection locations along transect lines were marked at every other measurement station with a flagged wood stake. The grid was marked with wooden stakes on 20 foot centers. Readings collected at intermediate lines or stations between stakes were interpolated. The data were collected from the mesh-centered points on the grid, and included FDEM, TDEM (EM61), and magnetic gradiometer data measurements.

Groundwater monitoring wells OWH-G01 to OWH-G03 were drilled at the Old Water Hole site to triangulate the suspected burial location and determine the direction of groundwater flow across the site. Well OLF-G01 was also located north of the main burial site to investigate and monitor a geophysical anomaly in this area. Monitoring wells OWH-G04 and OWH-G05 were subsequently added to monitor downgradient groundwater quality. Monitoring wells at the Old Water Hole were drilled to depths between 95.5 and 108 feet BLS. Soil borings OWH-S06 to OWH-S11 were drilled around the perimeter of the main site depression. Soil samples from the borings were screened (MINICAMS®) by USATEU for the presence of residual HD, GB, and VX CWM.

4.5.13.1 Old Water Hole – MINICAMS® Screening Results

MINICAMS® soil screening for HD, GB, and VX agents was conducted by USATEU during the RI study on 45 soil samples that were obtained from selected grid locations on the site and from samples collected from drilled boreholes (OWH-S01 to OWH-S03, OWH-S06 to OWH-S11) surrounding the site.

Surface sample locations (C-line and D-line) were screened to obtain data within the Old Water Hole depression. The soil samples were obtained by USATEU from 0.5 feet BLS and were screened for HD, GB, and VX CWM. Additional screening was conducted on 40 subsurface soil samples from borings to depths between 1 and 20 feet BLS. Chemical warfare agents were not detected above the 0.8 TWA (instrumental baseline) in any of the screened samples. The results of RI MINICAMS® screening on soil samples from the Old Water Hole are shown in Table 4-62 and in Appendix B.

4.5.13.2 Old Water Hole – Geophysical Survey Results

Interpreted EM anomalies were observed in the horizontal and vertical mode EM31 measurements along the extended transects and the gridded area (Figure 4-30). The observed signals are noisy reducing the repeatability (precision) of the data. A potential source for the noise could be an underground transmission line which parallels the road, west of the site. The horizontal mode data is affected more than the vertical mode data which suggests that fluctuating secondary electric fields due to the transmission line may not propagate deeply enough to affect the vertical mode as much as the horizontal mode measurements (since the horizontal mode investigation depth is shallower than the vertical mode). The noise observed in the vertical mode measurements generally decreased with distance from the transmission line (with Line 3 being the furthest from the potential source of fluctuation). Overall, the contoured EM31 conductivity distribution identified largely localized conductivity anomalies along the linear transects and a broad, elongate pattern of radially decreasing conductivity in the gridded area. The broad nature of the conductivity pattern in the gridded area may indicate an area of more extensive subsurface depression which does not have surface manifestation. Conductivity data in the area of the identified Old Water Hole site did not indicate the presence of a deep burial pit or buried conductive materials.

The gridded area was also surveyed using the single-gate TDEM method (EM 61). The EM61 channel 2 and the calculated differential responses identified several conductivity anomalies across the site. The two most notable anomalies are observed along Line 10 (from 200 to 230 feet) and Line 30 (from 210 to 250 feet). Other smaller anomalies can be seen in the channel 2 data, however, the calculated differential response did not exhibit increases that would be expected for a surface source for the anomaly. The contour plot shows an anomalous region in the northeast corner of the gridded area which corresponds to low or subsided areas within the gridded area. The observed anomalies are located approximately 150 feet north of the identified Old Water Hole site.

Magnetometer data was collected at the Old Water Hole site over the transects and gridded area. Three anomalous areas in the long transect data. The anomalous measurements are found in both the total field and vertical gradient data suggesting that ferromagnetic material is causing the anomalies. This observation is contrary to that observed for the FDEM in-phase response since no anomalies were evident in that data. Ferromagnetic material that would be detected as a source for the anomalies was not observed at the ground surface.

An anomalous area was delineated by the vertical gradient data along Line 2, from approximately 180 to 210 feet. Line 3 shows two areas of anomalous readings in both the total field data and the vertical gradient data: one from about 140 to 175 feet, and another from about 335 feet to the end of the profile line (400 feet). In general the anomalies have moderate magnitudes (total field of approximately 150 nT or less), but still suggest buried material. Since anomalies were not apparent in the FDEM data, it is interpreted that the anomalies could be caused by distributions of ferromagnetic material which are displaced far enough to the side of the line such that it would not have been detected by the FDEM method but still could have caused a magnetic variation.

Magnetic gradiometer measurements were obtained in the gridded area at the Old Water Hole. As seen in profiles of Lines 20 through 90 (Appendix A), a localized anomalous area was identified between approximately 180 and 250 feet. A single, dipolar anomaly is apparent in the northeast side of the grid that suggests an area of buried ferromagnetic material which is exhibiting induced magnetism. Other anomalies, which were apparent on profiles 80 and 90 are not as apparent on either contour plot.

4.5.13.3 Old Water Hole – Soil Analytical Results

Seven soil samples were analyzed from five locations (see Figure 4-29) at the Old Water Hole site. The samples were analyzed for VOCs, SVOCs, pesticides, PCBs, explosives-related compounds, metals, and HD, GB, and VX breakdown products (Table 4-63). The soil samples were obtained from borings (OWH-S01 to OWH-S03) drilled to install monitoring wells to triangulate the Old water hole site and from two borings (OWH-S10 and OWH-S11) drilled downgradient of the suspected burial site. Because none of the soil samples were obtained from borings within the suspected burial site, the samples are representative of soil conditions surrounding the Old Water Hole. All of the soil samples from each boring were screened for residual HD, GB, and VX CWM using MINICAMS®.

The surface soil surrounding the Old Water Hole site contains isolated concentrations of volatile and semi-volatile organic compounds consisting of benzyl alcohol (0.05 to 0.06 µg/g), phenol (1 to 3.5 µg/g), and 42 unidentified, non-target semi-volatile compounds (0.4 to 3 µg/g). Neither CWM, agent breakdown products, or explosives compounds were detected in the soil samples collected at the site. Inorganics constituents that exceeded background concentrations were detected in the surface soil samples at boring location OWH-S02 upgradient of the site and at location OWH-S03 located southeast of the site included concentrations of aluminum (14,400 to 15,000 µg/g), arsenic (15 to 20.8 µg/g), iron (72,000 µg/g), and vanadium (98.4 µg/g). Organic constituents that were detected in subsurface samples from the site area consisted of isolated concentrations of 1,1-trichloroethane (0.28 µg/g), benzyl alcohol (0.063 µg/g), and phenol (1.3 to 1.7 µg/g) in boring OWH-S03. Metals concentrations that exceeded background levels were detected in subsurface soil from borings OWH-S03 and OWH-S10 and included aluminum (16,500 to 24,900 µg/g), arsenic (30.3 to 56 µg/g), beryllium (3.38 µg/g), cobalt (42.4 µg/g), copper (59.2 µg/g), manganese (2,200 µg/g), nickel (54.2 µg/g), vanadium (92.1 µg/g), and zinc (157 µg/g).

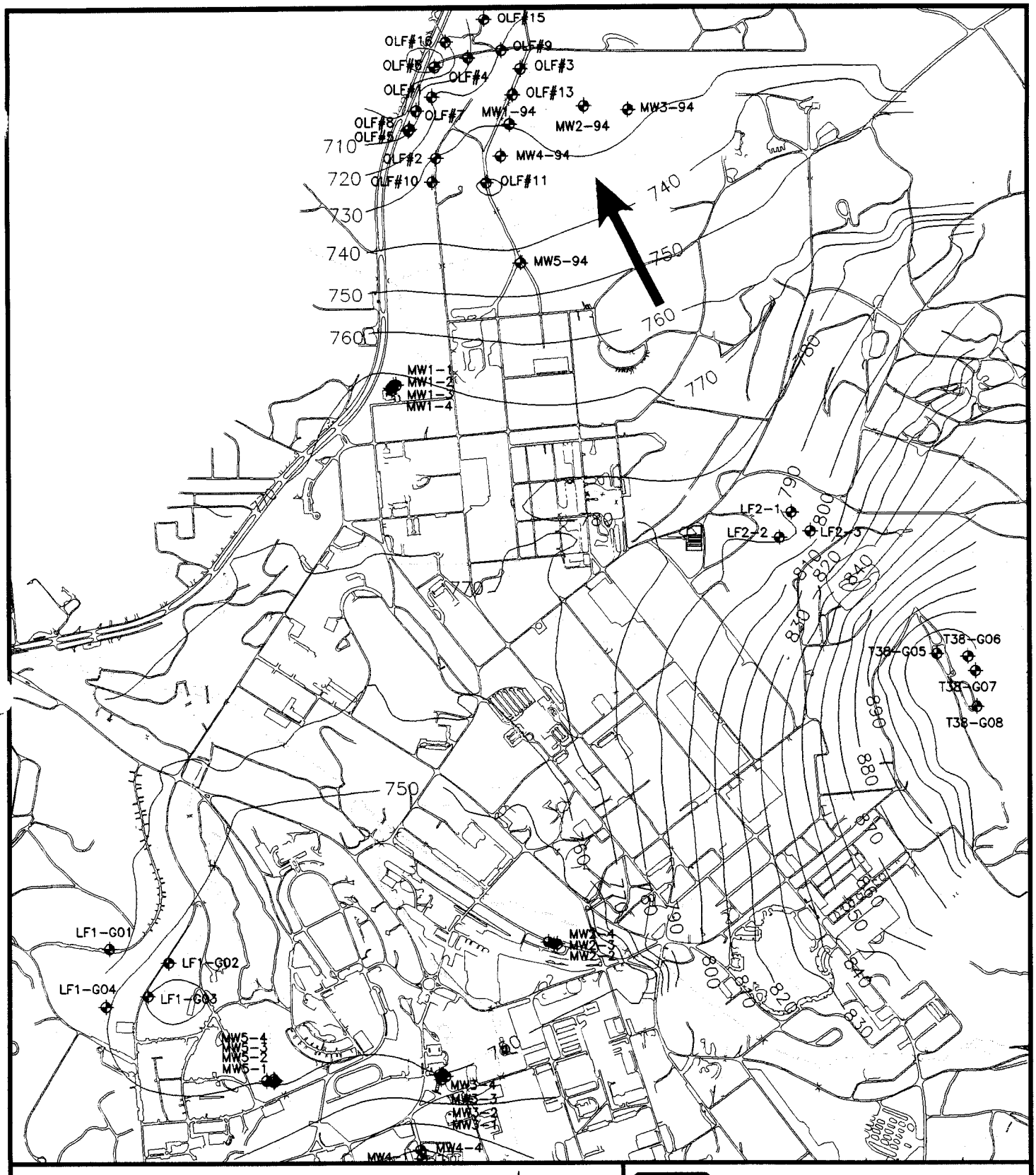
4.5.13.4 Old Water Hole – Groundwater Analytical Results

Five monitoring wells (OWH-G01 to OWH-G05) were installed around the two suspected burial areas at the Old Water Hole. Wells OLF-G01 to OLF-G03 were installed to triangulate the main suspected burial site and well OLF-G04 and OLF-G05 were installed downgradient of the site. The parameters analyzed for included VOCs, SVOCs, pesticides, PCBs, explosives, metals, and HD, GB, and VX breakdown products (Table 4-64). Well OLF-G01 was located to monitor the vicinity of a geophysical anomaly north of the main suspected surface depression

Organic constituents that were detected in groundwater underlying the Old Water Hole site consisted of semi-volatile and pesticide compounds with isolated explosives and PCB compounds. Semi-volatile constituents that were detected included bis(2-ethylhexyl)phthalate (12 to 21 µg/L), benzo(a)anthracene (0.0212 to 0.0581 µg/L), benzo(b)fluoranthene (0.159 to 0.378 µg/L), benzo(k)fluoranthene (0.0262 µg/L), chrysene (0.021 to 0.0572 µg/L), dibenzo(a,h)anthracene (0.0504 to 0.104 µg/L), indeno(1,2,3-cd)pyrene (0.0662 to 0.133 µg/L), and 38 unidentified, non-target compounds (4 to 500 µg/L). Benzo(b)fluoranthene was also detected in laboratory method blank samples and is attributed to laboratory contamination. Trace pesticide concentrations were predominantly undetected by second column analyses with the exception of Endosulfan I (0.0158 to 0.024 µg/L), Endosulfan sulfate

(0.0038 µg/L), aldrin (0.0149 to 0.0317 µg/L), a-BHC (0.0113 µg/L), isodrin (0.0125 µg/L), heptachlor (0.00732 to 0.0401 µg/L), and 4,4'-DDE (0.00438 µg/L). These detected compounds were not detected in earlier sampling rounds. Isolated PCB-1248 concentrations were detected at upgradient well OWH-G02 (0.0499 µg/L) and at downgradient well OWH-G05 (0.447 µg/L). Reported explosives results for groundwater at the Old Water Hole are qualified by sample interference in the analytical laboratory. Concentrations of RDX (0.578 to 1.08 µg/L), and nitroglycerine (2.39 µg/L) were variably detected in wells OWH-G01, OWH-G02, and OWH-G05. Thiodiglycol (242 µg/L) reported in well OWH-G02 (2/95) was determined to be a laboratory-induced concentration resulting from an unpurged GC column (ES&E, personal communication 1995). Subsequent sampling of the well (5/95) did not detect thiodiglycol.

Inorganic constituents that exceeded background concentrations were detected at upgradient well location OWH-G02 and at downgradient well OWH-G04. The inorganic constituents consisted of concentrations of aluminum (2,850 to 9,600 µg/L), barium (252 µg/L), beryllium (1.17 µg/L), cobalt (48.4 µg/L), iron (7,620 µg/L), lead (11.4 to 12.4 µg/L), and manganese (2,110 µg/L).



LEGEND:

- .....BUILDINGS
- .....ASPHALT ROADS
- .....STREAM OR TRIBUTARY
- .....GROUNDWATER ELEVATION (SAIC 1995)
- ..... APPROXIMATE GROUNDWATER FLOW DIRECTION (JUNE 1994)

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

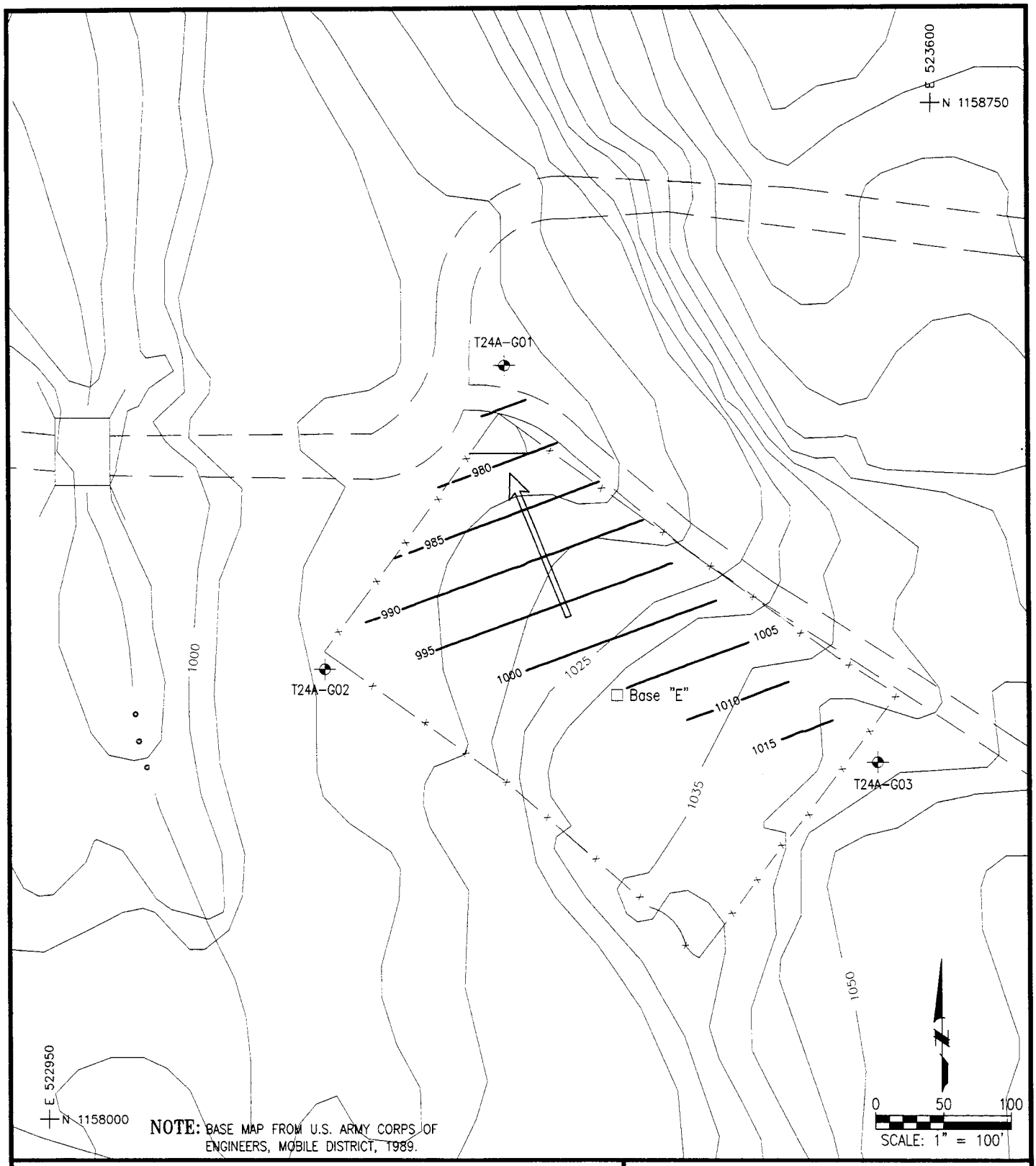
0 800 1600

SCALE: 1" = 1600'

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

GROUNDWATER FLOW MAP
MAIN POST
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-1	01-0827-07-6520-012	FTMC\98-FIG4-1	Oct. 1998



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

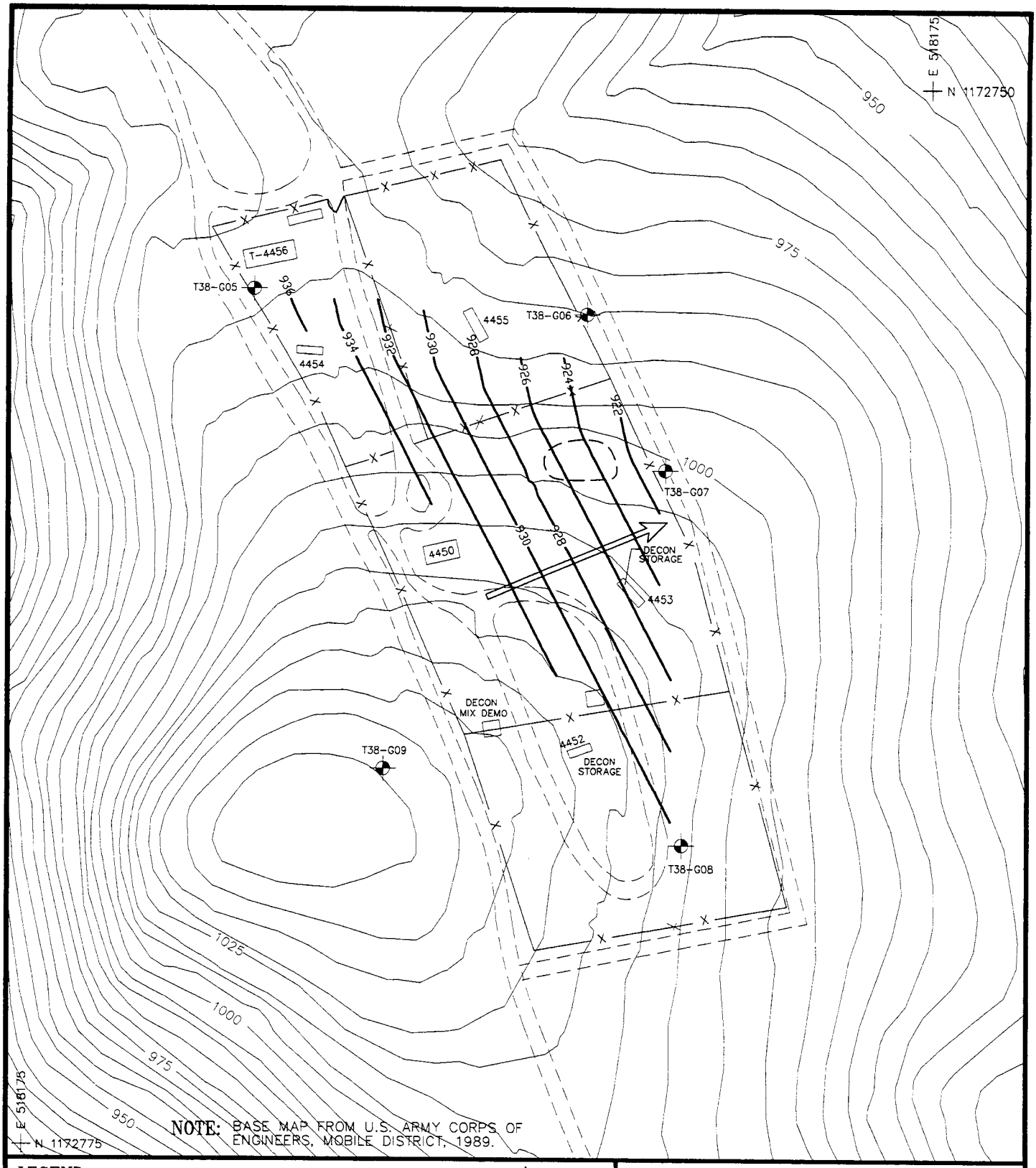
LEGEND:

- BUILDINGS
- ASPHALT ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=5 ft)
- 1000 GROUNDWATER ELEVATION
- GROUNDWATER FLOW DIRECTION
- MONITORING WELL

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

AREA T-24A
GROUNDWATER FLOW MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-2	01-0827-03-6520-012	FTMC\98-FIG4-2	Dec. 1998



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

LEGEND:

- BUILDINGS
- GRAVEL ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=5 ft)
- GROUNDWATER ELEVATION (SAIC, 1995)
- APPROXIMATE SUMP LOCATION
- GROUNDWATER FLOW DIRECTION
- MONITORING WELL

N

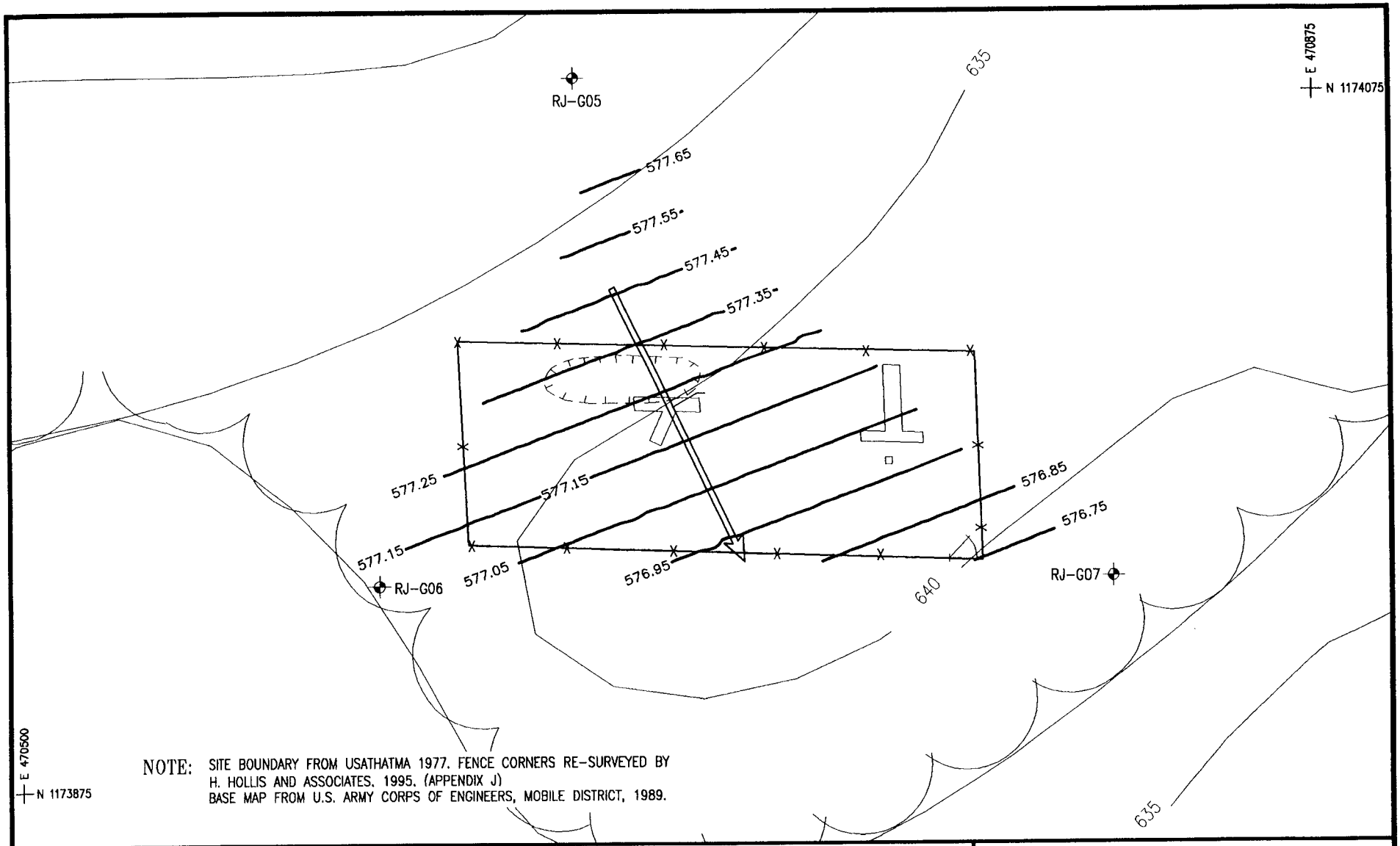
0 50 100 150

SCALE: 1" = 150'

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

AREA T-38
GROUNDWATER FLOW MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-3	01-0827-03-6520-012	FTMC\98-FIG4-3	Dec. 1998



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.

LEGEND:

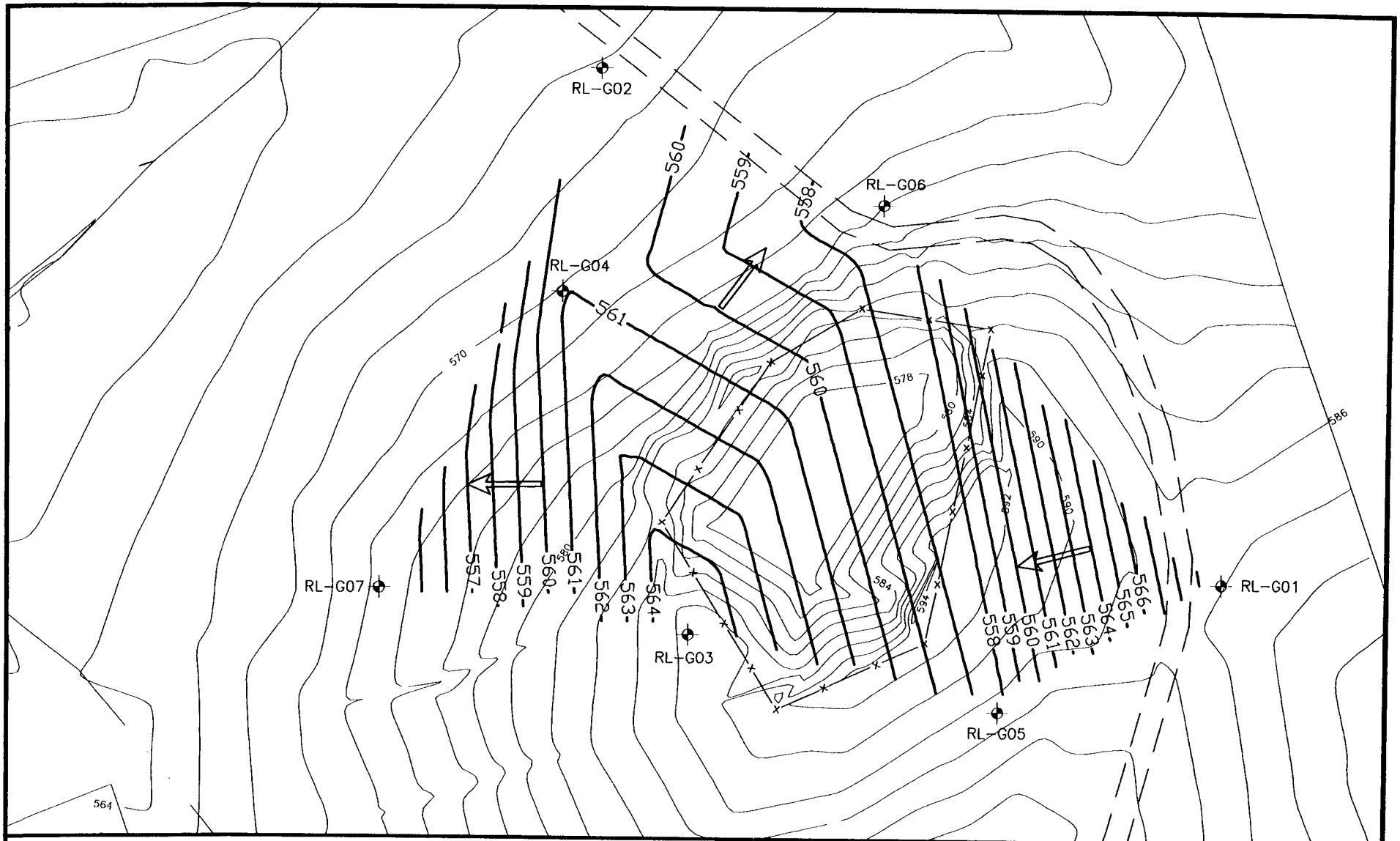
- FENCE LINE
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- TRENCH LOCATION
- 576.05 GROUNDWATER ELEVATION (SAIC, 1995)
- MONITORING WELL
- GROUNDWATER FLOW DIRECTION
- DRUM DISPOSAL PIT
- CONCRETE MONUMENT

0 20 40
SCALE: 1" = 40'

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

RANGE J
GROUNDWATER FLOW MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-4	01-0827-03-6520-012	FTMC\98-FIG4-4	Dec. 1998



LEGEND:

- GRAVEL ROADS
- FENCE LINE
- 620 TOPOGRAPHIC CONTOUR (CI=25 ft.)
- TOPOGRAPHIC CONTOUR (CI=5 ft.)
- INTERMITTENT STREAM
- GROUNDWATER ELEVATION (SAIC, 1995)
- MONITORING WELL (SAIC 1994-95)
- GROUNDWATER FLOW DIRECTION

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

N

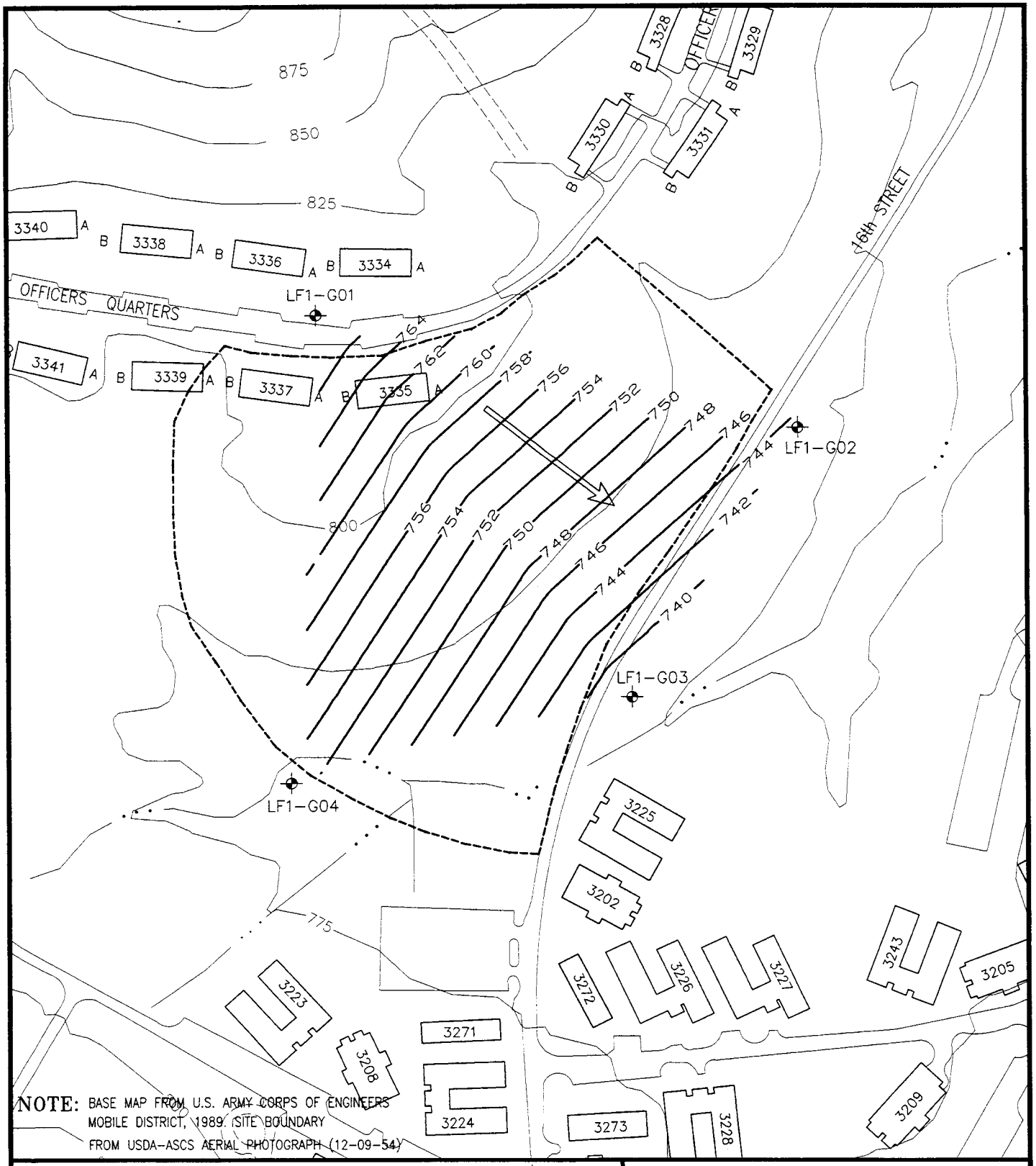
0 30 60

SCALE: 1" = 60'

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

RANGE L
GROUNDWATER FLOW MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-5	01-0827-03-6520-012	FTMC\98-FIG4-5	Dec. 1998



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

LEGEND:

- SITE BOUNDARY
- ASPHALT ROADS
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- GROUNDWATER ELEVATION (SAIC, 1995)
- SITE BOUNDARY
- GROUNDWATER FLOW DIRECTION

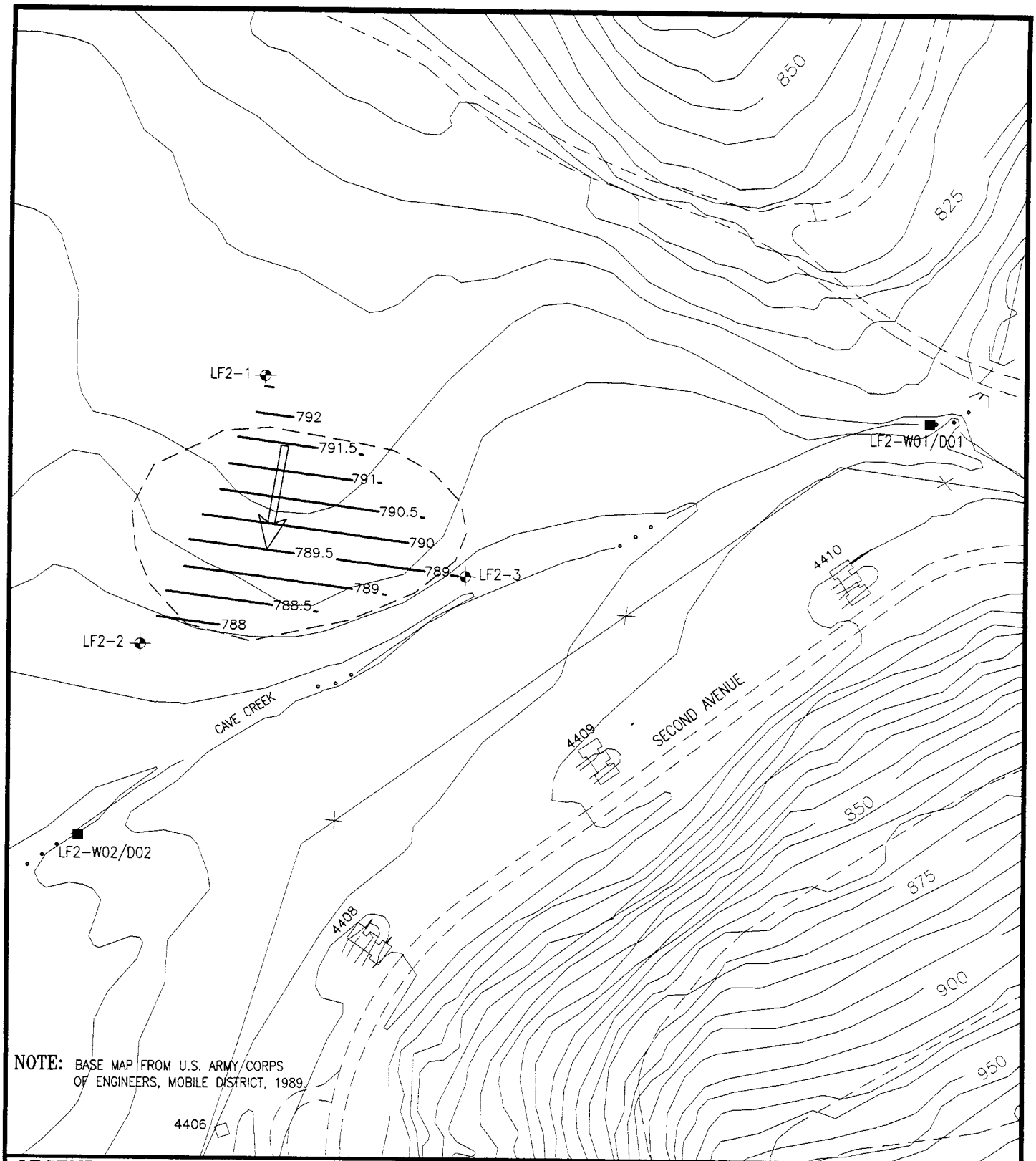
0 100 200 300

SCALE: 1" = 300'

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

LANDFILL #1
GROUNDWATER FLOW MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-6	01-0827-03-6520-012	FTMC\98-FIG4-6	Dec. 1998



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

LEGEND:

- GRAVEL ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- GROUNDWATER ELEVATION (SAIC, 1995)
- MONITORING WELL
- GROUNDWATER FLOW DIRECTION

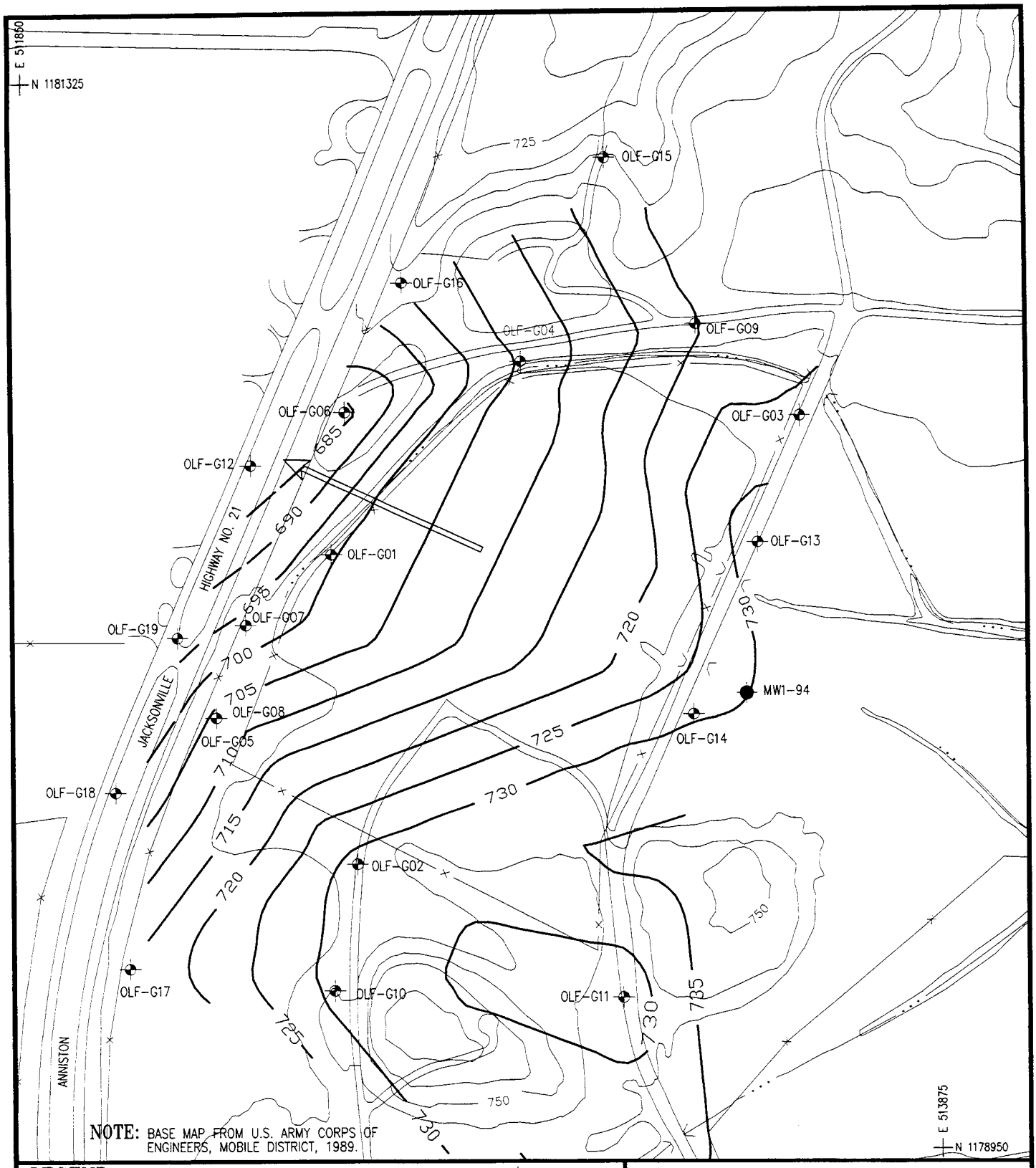
0 50 100 150

SCALE: 1" = 150'

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

LANDFILL #2
GROUNDWATER FLOW MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-7	01-0827-03-6520-012	FTMC\98-FIG4-7	Dec. 1998



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

LEGEND:

- ASPHALT ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- GROUNDWATER ELEVATION (SAIC, 1995)
- GROUNDWATER FLOW DIRECTION
- MONITORING WELL
- MONITORING WELL

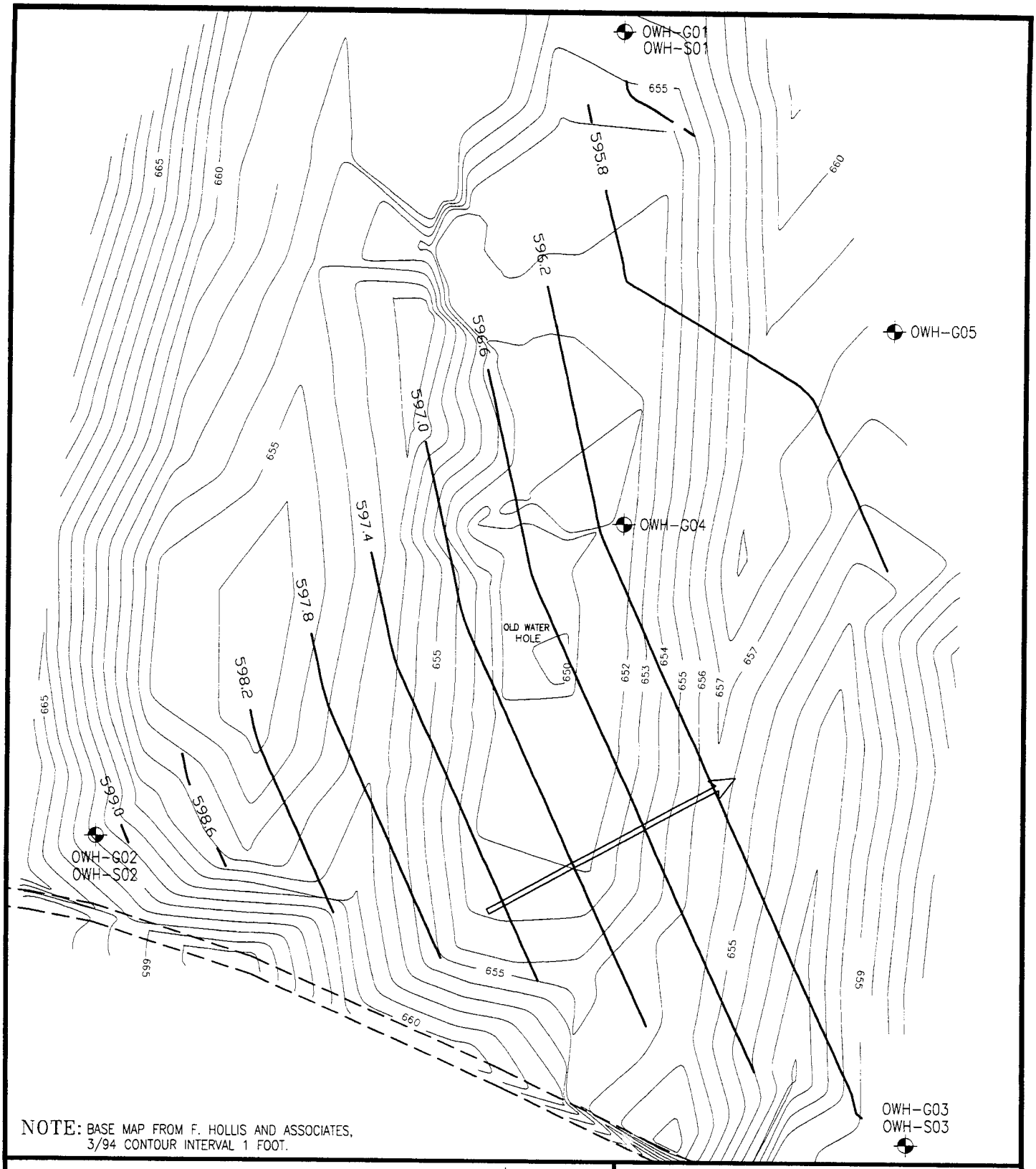
0 100 200 300

SCALE: 1" = 300'

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

LANDFILL #3
GROUNDWATER FLOW MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-8	01-0827-03-6520-012	FTMC\98-FIG4-8	Dec. 1998



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

LEGEND:

- GRAVEL ROADS
- 855 TOPOGRAPHIC CONTOUR (CI=5 ft)
- TOPOGRAPHIC CONTOUR (CI=1 ft)
- GROUNDWATER ELEVATION (SAIC, 1995)
- MONITORING WELL
- GROUNDWATER FLOW DIRECTION

0 30 60

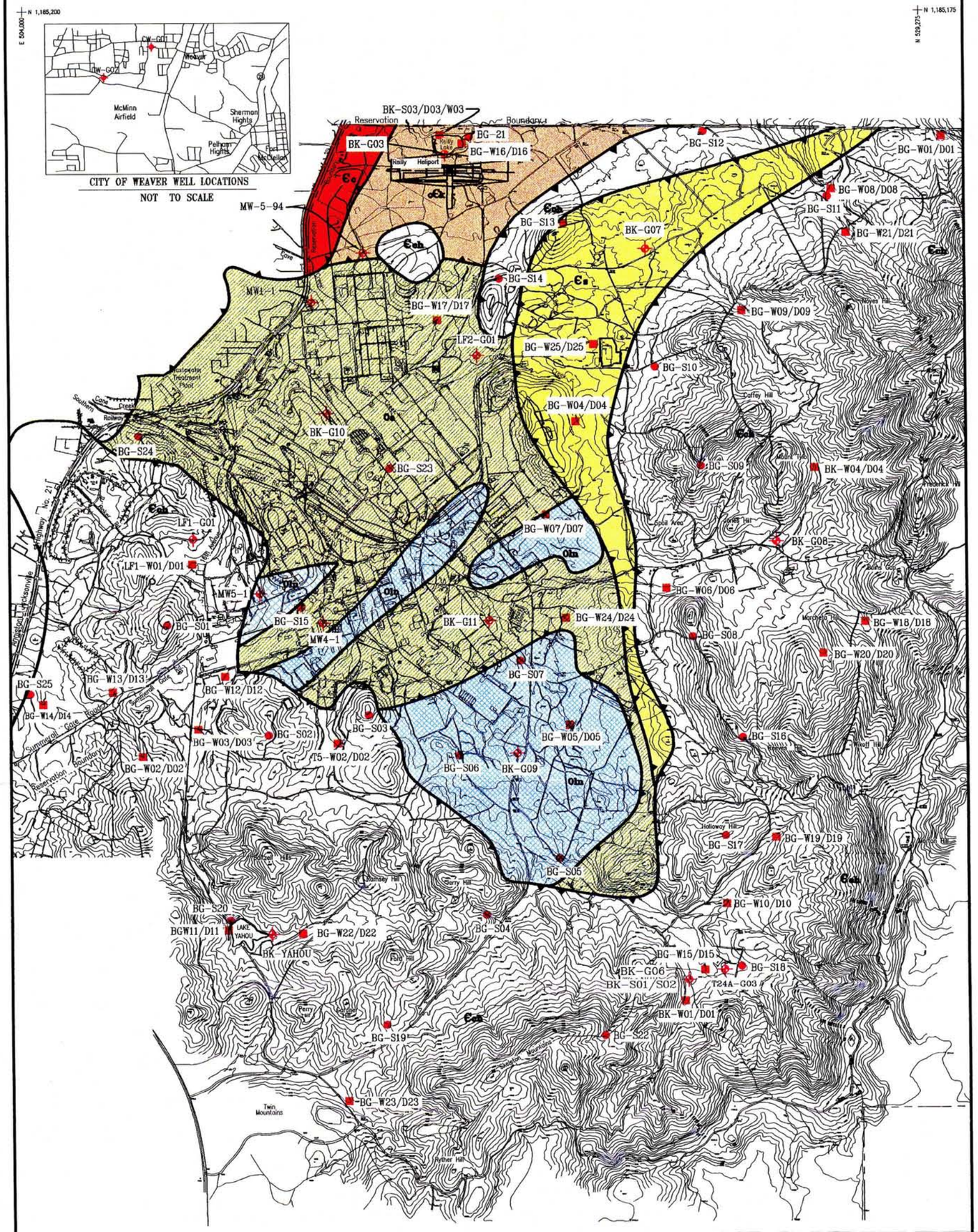
SCALE: 1" = 60'

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

OLD WATER HOLE GROUNDWATER FLOW MAP

FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-9	01-0827-03-6520-012	FTMC\98-FIG4-9	Dec. 1998



LEGEND:

- PRIMARY AND SECONDARY ROADS
- BUILDINGS
- STREAM & TRIBUTARY
- FENCE
- RAILROAD
- PROPERTY BOUNDARY
- TOPOGRAPHIC CONTOUR (25 ft. INTERVAL)
- BG-S22 ... SOIL BORING LOCATION
- BG-W10/D10 ... SURFACE WATER/SEDIMENT SAMPLE LOCATION
- BK-YAHOU ... MONITORING WELL LOCATION
- GEOLOGIC CONTACT
- THRUST FAULT
- Ca ... ATHENS SHALE
- Obn ... LITTLE OAK AND NEWALA LIMESTONE, UNDIFFERENTIATED
- Ok ... KNOX GROUP, UNDIFFERENTIATED
- Cs ... SHADY DOLOMITE
- Ech ... CHILHOWEE GROUP, UNDIFFERENTIATED
- Kc ... CONASAUGA FORMATION
- + ... ALABAMA STATE PLANE GRID

NOTES:

1. Geologic contacts from Osborn and Szabo, Geologic Survey of Alabama Circular 117 plate 1, 1983.
2. Base map from U.S. Army Corps of Engineers, Mobile District, 1989.

STATE PLANE GRID

0 1000 2000 3000 6000

SCALE: 1" = 3000'

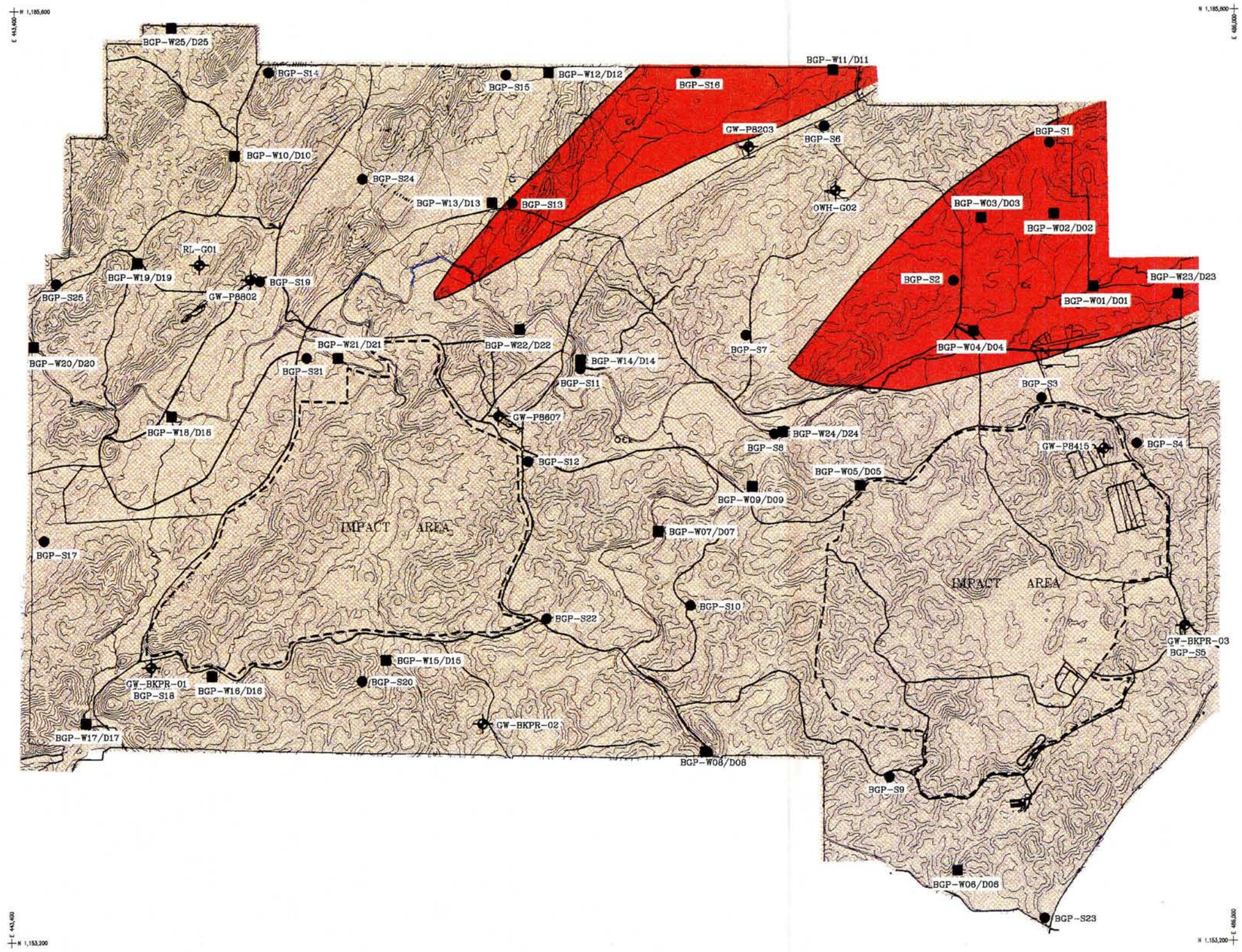
U.S. ARMY
CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE, ALABAMA

REV.	DRAWN BY:	CHKD. BY:	DATE:
0	A.S.J.	C. MANIKAS	July, 1998
1	A.S.J.	C. MANIKAS	Dec.1998

BACKGROUND SAMPLE LOCATIONS
MAIN POST
FORT McCLELLAN, ALABAMA

XREFERENCES	PLOT FILES
S7025\XREF\MC01PN, MC01TG, MC02PN, MC02TG, MC03PN, MC03TG, MC04PN, MC04TG, MC05PN, MC05TG, MC06PN, MC06TG, MC07PN, MC07TG, MC08PN, MC08TG, MC09PN, MC09TG	

FIGURE NO.	CAD FILE #
4-10	FTMC\A01_MWL-BB.DWG



LEGEND:

- PRIMARY ROADS
- SECONDARY ROADS
- BUILDINGS
- STREAM & TRIBUTARY
- FENCE
- RAILROAD
- IMPACT AREA
- TOPOGRAPHIC CONTOUR (25 ft. INTERVAL)
- TOPOGRAPHIC CONTOUR (5 ft. INTERVAL)
- BG-S22 MONITORING WELL LOCATION
- BG-W10/D10 SURFACE WATER/SEDIMENT SAMPLE LOCATION
- BK-YAHOU SOIL BORING LOCATION
- GEOLOGIC CONTACT
- Ock KNOX GROUP, UNDIFFERENTIATED
- Cc CONASAUGA FORMATION
- ALABAMA STATE PLANE GRID

NOTES:

1. Geologic contacts from Osborn and Szabo, Geologic Survey of Alabama Circular 117 plate 1, 1983.
2. Base map from U.S. Army Corps of Engineers, Mobile District, 1989.

AL. STATE PLANE GRID

0 3500 7000

SCALE: 1" = 3500'

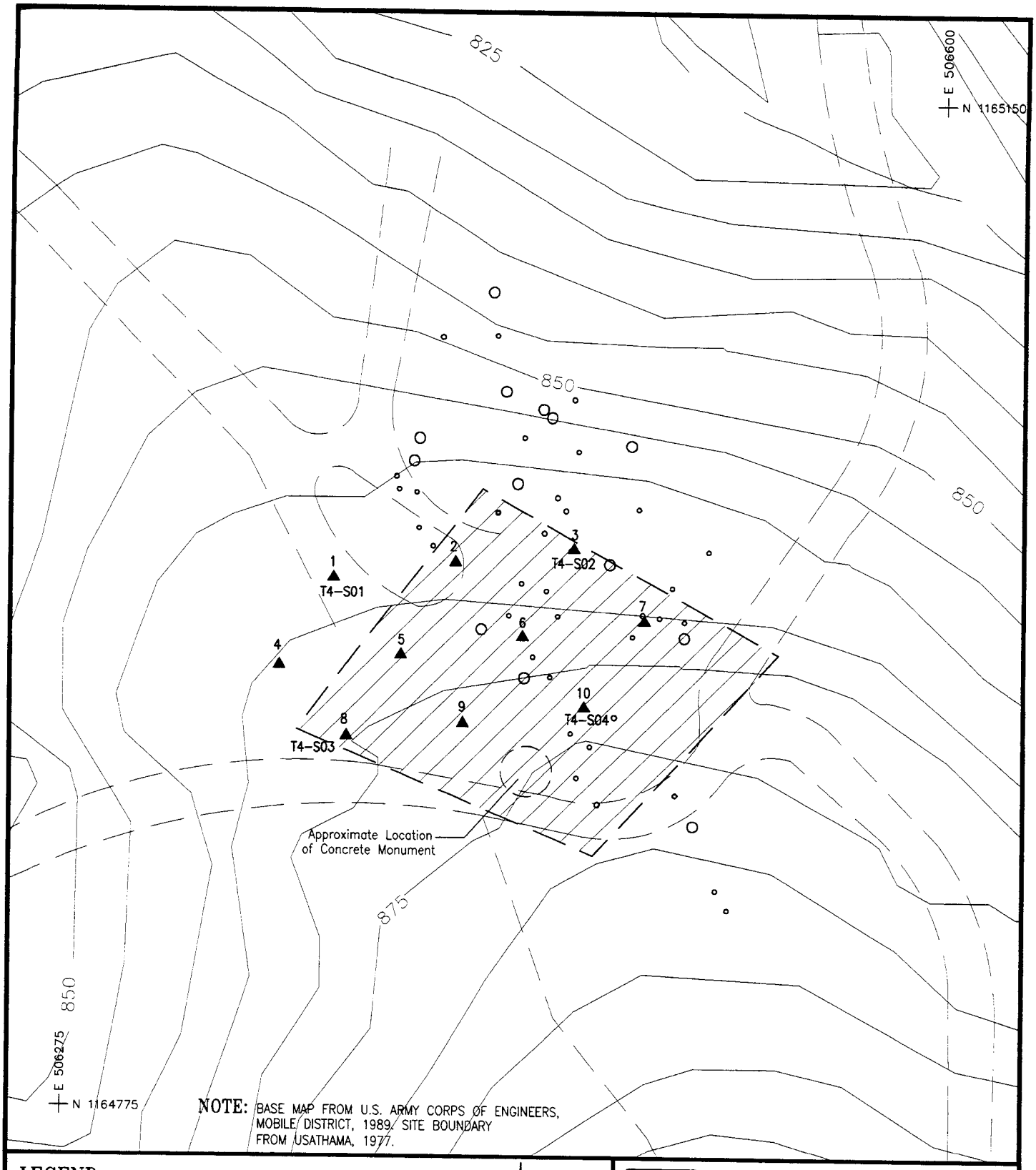
U.S. ARMY
CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE, ALABAMA

BACKGROUND SAMPLE LOCATIONS
PELHAM RANGE
FT. McLELLAN, ALABAMA

REV.	DRAWN BY:	CHKD. BY:	DATE:
0	ASJ	C.MANIKAS	JAN.1998

XREFERENCES	PLOT FILES
97029\XREF\XR_GS1, XR_GS2A XR_GS3, XR_GS4, XR_GS5, XR_GS6, XR_GS7, XR_GS8, XR_GS9, XR_GS10, XR_GS11, XR_GS12, XR_GS13	97029\PLOT\879GSALL.PLT

FIGURE NO.	CAD FILE #
4-11	FTMC/879GSAA-BB



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

LEGEND:

- BUILDINGS
- ASPHALT ROADS
- BOUNDARY
- TOPOGRAPHIC CONTOUR (CI=5 ft.)
- 850 TOPOGRAPHIC CONTOUR (CI=25 ft.)
- MAGNETOMETER ANOMALY
- ▲ MINICAMS SCREENING LOCATION WITH SOIL SAMPLE

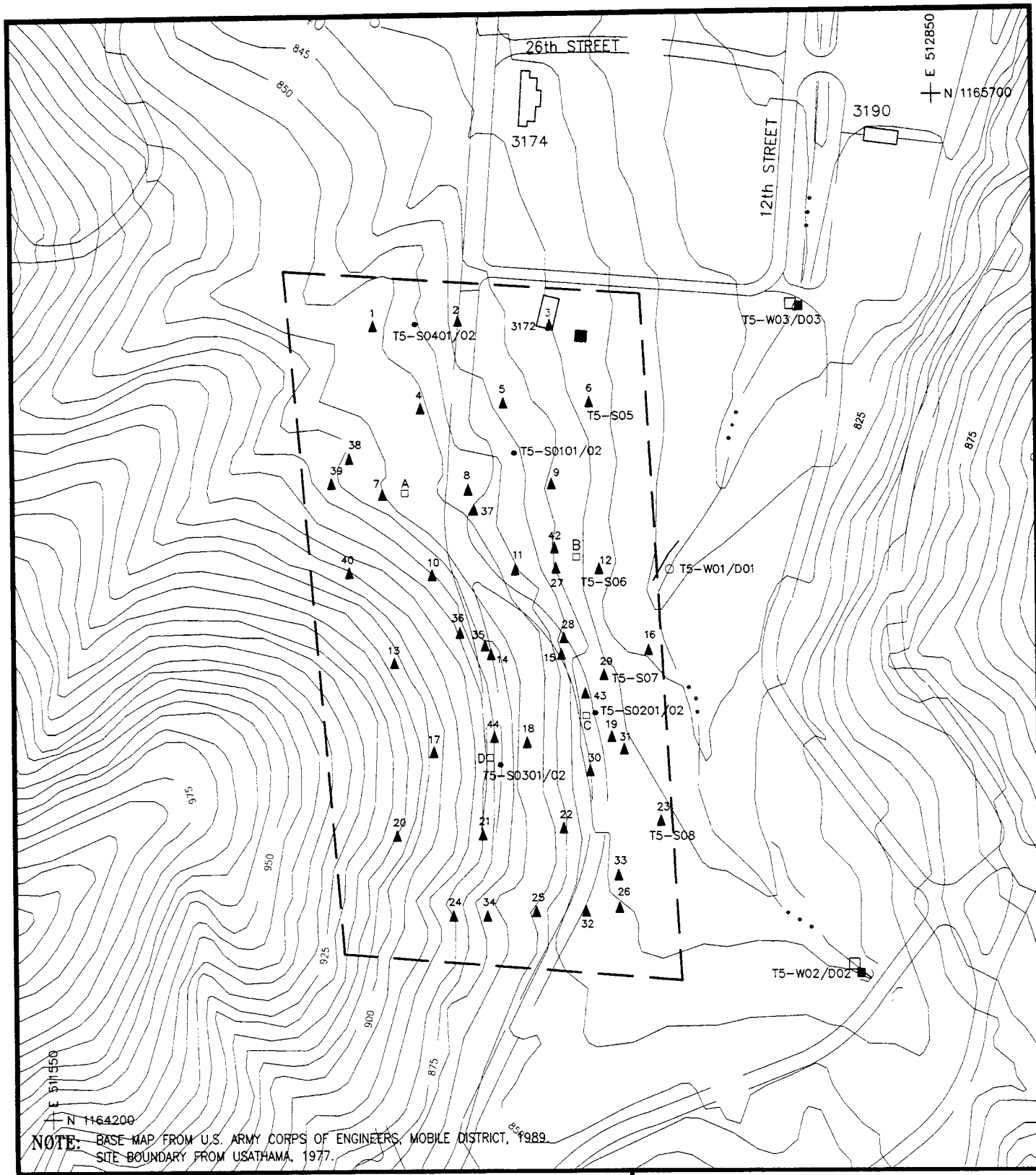
0 25 50

SCALE: 1" = 50'

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

AREA T-4
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-12	01-0827-03-6520-012	FTMC\98-FIG4-12	Dec. 1998



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

LEGEND:

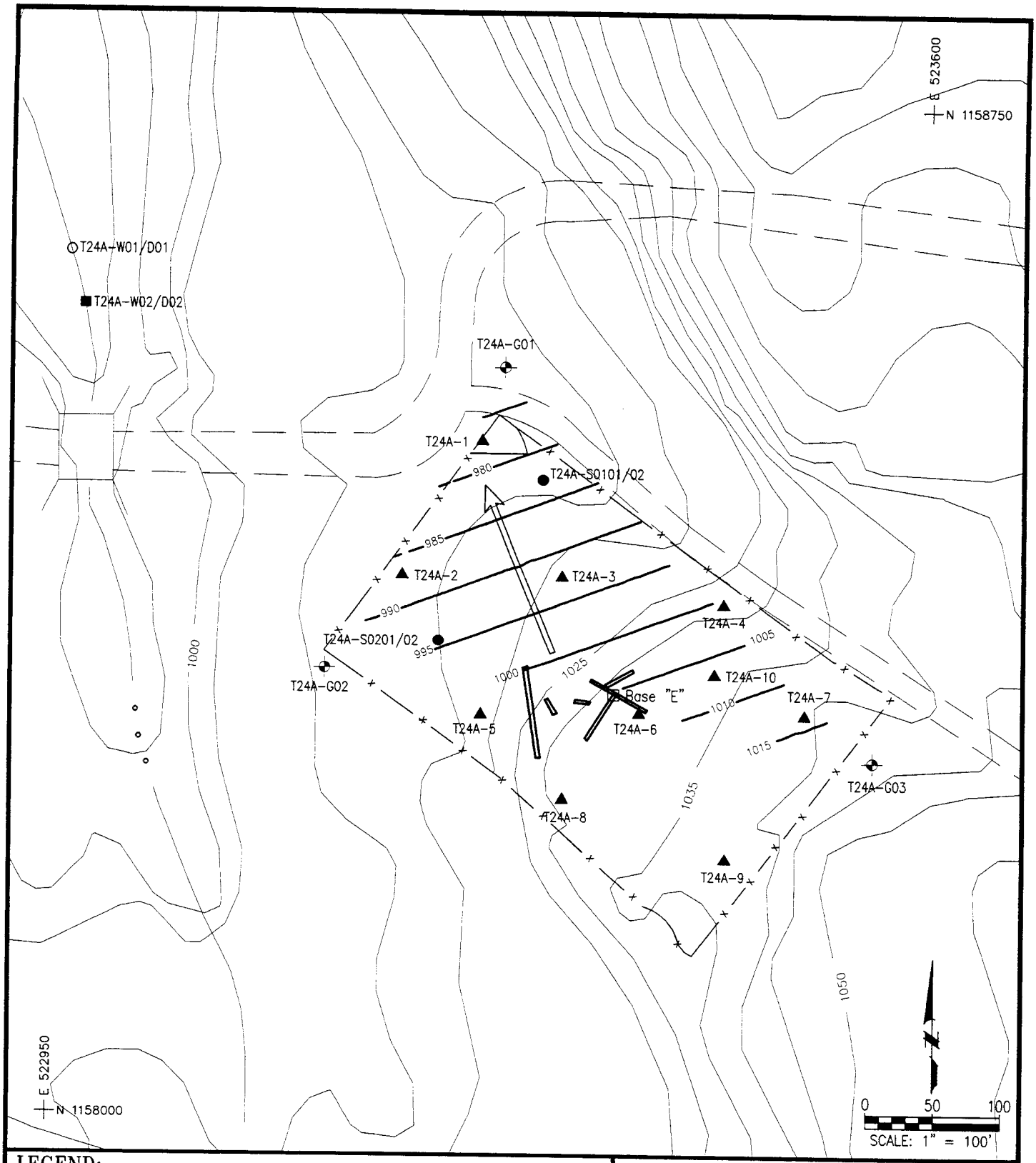
- BUILDINGS
- ASPHALT ROADS
- STREAM OR TRIBUTARY
- 825 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- CONCRETE MONUMENT
- 25 / T5-S07 MINICAMS SCREENING LOCATION
- SI SW/SEDIMENT SAMPLE LOCATION (SAIC, 1992)
- SI SOIL SAMPLE LOCATION (SAIC, 1992)
- RI SURFACE WATER/SEDIMENT SAMPLE

0 100 200
SCALE: 1" = 200'

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

AREA T-5
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-13	01-0827-07-6520-012	FTMC\98-FIG4-13	Dec.1998



LEGEND:

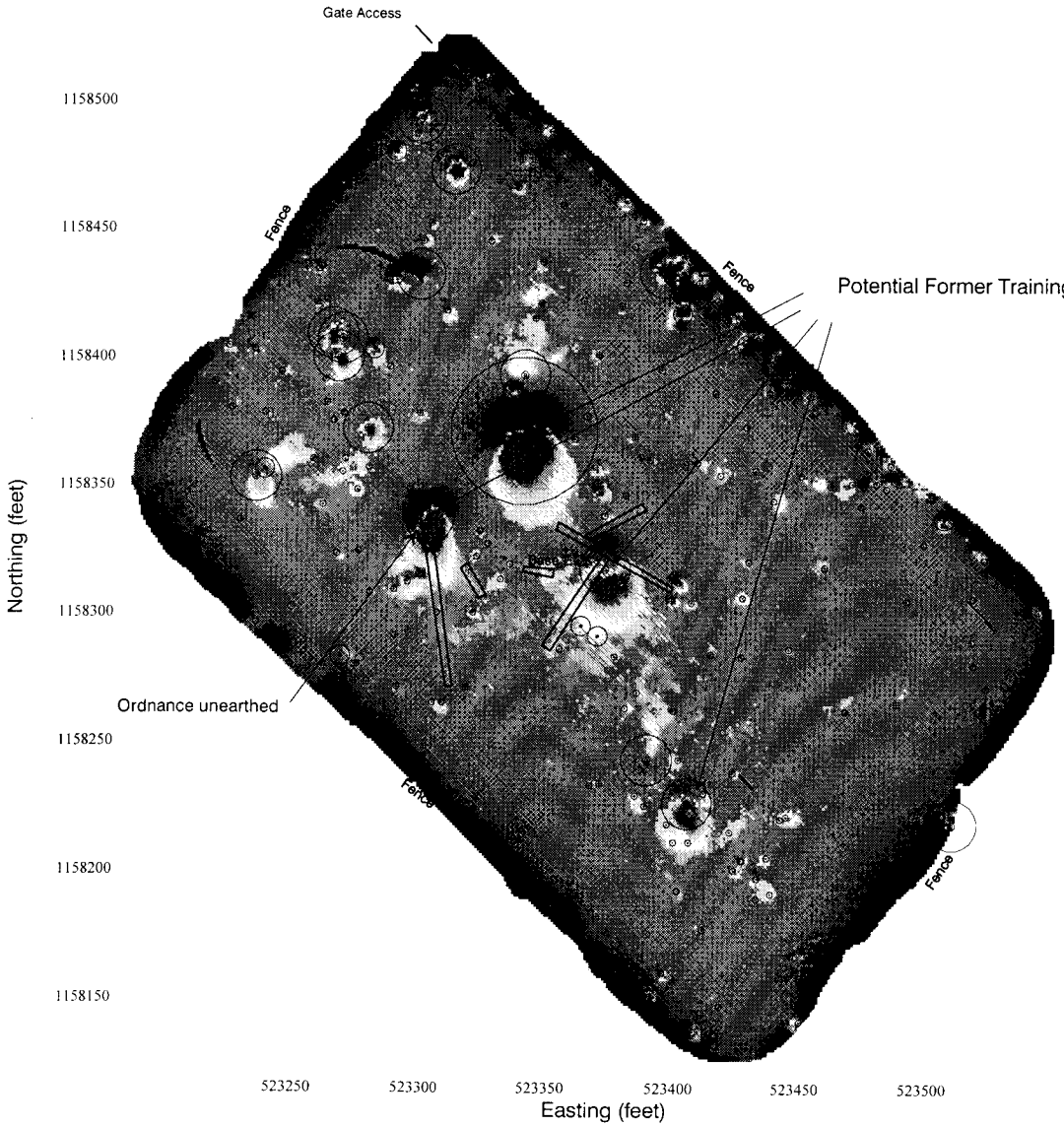
- BUILDINGS
- ASPHALT ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- MONUMENT
- TRENCH LOCATION
- SI SW/SEDIMENT SAMPLE LOCATION (SAIC,1992)
- MINICAMS SCREENING LOCATION
- RI SW / SEDIMENT SAMPLE (SAIC, 1995)
- MONITORING WELL
- SI SOIL SAMPLE LOCATION (SAIC,1992)
- GROUNDWATER FLOW DIRECTION

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
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-14	01-0827-03-6520-012	FTMC\98-FIG4-14	Dec. 1998



Target	Easting	Northing	Depth (meters)
1	523305.5	1158265	0.3
2	523309.4	1158265	0.6
3	523279.5	1158273	0.7
4	523291.4	1158271	0.6
5	523269	1158283	1.3
6	523250	1158302	0.2
7	523267.5	1158323	0.4
8	523296.4	1158312	0.3
9	523300	1158315	0.5
10	523275.4	1158348	0.4
11	523258	1158360	0.7
12	523280	1158357	0.6
13	523279.4	1158372	1
14	523270.5	1158360	0.5
15	523269.5	1158355	0.5
16	523235.9	1158353	1.4
17	523245.5	1158394	0.5
18	523225.2	1158404	0.3
19	523285.9	1158375	0.4
20	523269.8	1158378	0.4
21	523263.3	1158382	0.6
22	523281.7	1158403	0.6
23	523267.6	1158400	1
24	523261.9	1158342	1.1
25	523262.6	1158391	1.2
26	523310.7	1158418	0.6
27	523265.3	1158409	1.1
28	523269.2	1158407	
29	523263	1158422	0.6
30	523259.7	1158434	0.4
31	523303.8	1158452	0.4
32	523300.6	1158445	0.4
33	523289.7	1158432	1
34	523299.8	1158432	1
35	523289.7	1158480	0.8
36	523298	1158487	0.6
37	523299.6	1158493	1.2
38	523313.4	1158473	0.8
39	523308.5	1158479	0.5
40	523305.8	1158477	0.6
41	523303.6	1158503	
42	523432.2	1158127	0.4
43	523419	1158130	0.2
44	523409.2	1158137	0.4
45	523402	1158143	0.2
46	523392.1	1158150	0.1
47	523391.5	1158152	0.2
48	523396.7	1158160	0.5
49	523427.7	1158204	0.3
50	523424.7	1158200	0.5
51	523434.3	1158197	0.8
52	523437.9	1158205	0.4
53	523445.5	1158221	0.6
54	523443.2	1158220	0.4
55	523412.6	1158230	0.6
56	523402.4	1158192	1.4
57	523423.1	1158215	1
58	523385.7	1158229	1
60	523389.3	1158225	1
61	523406	1158226	2.6
62	523398.1	1158218	1.1
63	523406.7	1158211	1.2
64	523400.7	1158211	1.5
65	523402.4	1158243	0.7
66	523371.8	1158234	0.4
67	523367.9	1158233	0.3
68	523419.7	1158147	0.2
69	523451.6	1158141	0.5
70	523448	1158167	0.8
71	523452.6	1158169	0.4
72	523371.1	1158182	0.2
73	523381.4	1158263	0.6
74	523400.2	1158262	0.9
75	523319	1158271	0.5
76	523321.7	1158300	0.4
77	523332.5	1158313	0.6
78	523336.2	1158319	0.5
79	523323	1158322	0.6
80	523324.3	1158332	0.6
81	523327.6	1158327	0.5
82	523355.8	1158286	1
83	523377.2	1158283	2.1
84	523370.6	1158291	2.3
85	523364.1	1158295	2.3
86	523407.1	1158304	0.8
87	523427.5	1158306	0.8
88	523429.9	1158320	0.9
89	523407.1	1158304	0.9
90	523401.9	1158312	0.5
91	523398.3	1158306	0.4
92	523357.9	1158321	0.8
93	523373.3	1158317	4.1
94	523373	1158338	0.5
95	523381.2	1158346	0.5
96	523384.6	1158369	0.3
97	523361.2	1158368	0.5
98	523365.8	1158377	0.2
99	523336.6	1158387	0.4
100	523446.2	1158286	0.8
101	523394.8	1158395	0.2
102	523436.8	1158344	1.3
103	523428.6	1158373	0.8
104	523427.2	1158283	0.9
105	523415	1158284	1
106	523437.8	1158386	0.2
107	523396.8	1158361	
108	523489.1	1158351	
109	523370.2	1158401	1.3
110	523390.5	1158360	0.8
111	523409.2	1158359	1
112	523418.4	1158354	0.7
113	523432.5	1158356	1
114	523450.6	1158354	0.8
115	523462.1	1158350	0.9
116	523454	1158365	0.2
117	523447.7	1158393	0.2
118	523440.8	1158400	0.2
119	523460.1	1158318	0.8
120	523416.2	1158386	0.3
121	523341.5	1158393	4.6
122	523345.5	1158415	0.3
123	523380.7	1158429	0.7
124	523364.3	1158422	0.6
125	523338.4	1158466	0.6
126	523339.7	1158477	0.7
127	523344.6	1158477	0.3
128	523348.2	1158437	0.7
129	523327.8	1158445	0.7
130	523330.8	1158469	1.4
131	523402.7	1158417	
132	523387	1158453	0.7
134	523380.8	1158461	0.5
135	523372.6	1158466	0.2
136	523321.7	1158508	0.2
137	523327.3	1158509	0.2
138	523409.3	1158429	0.4
139	523416.9	1158422	0.2
140	523425.1	1158415	0.2
141	523432.6	1158407	0.2
142	523428.3	1158405	0.6
143	523395.8	1158433	-1.8
144	523384	1158443	0.2
145	523351.5	1158488	0
146	523333.8	1158502	0.2
147	523510.6	1158218	0.7
148	523468.6	1158262	1.1
150	523488.6	1158265	0.2
151	523518.6	1158280	0.2
152	523517.9	1158289	0.4
153	523492.3	1158305	1.2
154	523498.9	1158327	0.7
155	523544.2	1158301	0.4
156	523526.6	1158312	0.2
157	523522.6	1158321	0.4
158	523506.8	1158337	0.1
159	523474.3	1158342	1.3
160	523484.2	1158349	0.2
161	523480.2	1158361	0.3
162	523470.7	1158351	0.7
163	523476.9	1158364	0.2
164	523472	1158374	0.1
165	523290	1158336	0.2
166	523276	1158324	1.5
167	523295.7	1158293	0.8
168	523288	1158396	0.8
169	523239.2	1158356	1.3
170	523290.7	1158291	0.3
171	523259.1	1158421	1
172	523319	1158486	0.2
173	523379.1	1158420	0.8
174	523356.1	1158459	0.2
175	523347.8	1158421	1.2
176	523341.2	1158371	
177	523390	1158243	
178	523485.8	1158358	
179	523304	1158337	2.2
180	523219.6	1158390	
181	523275.6	1158280	0.2
182	523299.8	1158378	0.9
183	523412.5	1158177	0.4
184	523518.3	1158306	0.2
185	523523.5	1158271	0.2
186	523504.7	1158227	
187	523375	1158176	
188	523368.8	1158175	
189	523286.1	1158265	
190	523249.6	1158280	
191	523262.1	1158280	
192	523236.2	1158296	
193	523214.8	1158328	
194	523213.9	1158322	
195	523307.2	1158300	0.8
196	523290.1	1158309	0.4
197	523280.6	1158308	0.8
198	523226.5	1158360	0.2
199	523239.3	1158378	0.9
200	523235	1158403	
201	523386	1158269	1.4
202	523424.1	1158238	0.6
203	523433.9	1158189	0.8

N

SCALE
(Feet)
0 25 50 75 100

LEGEND
- Excavated trench area
- Mapped target location
- Concrete monument (Base E)

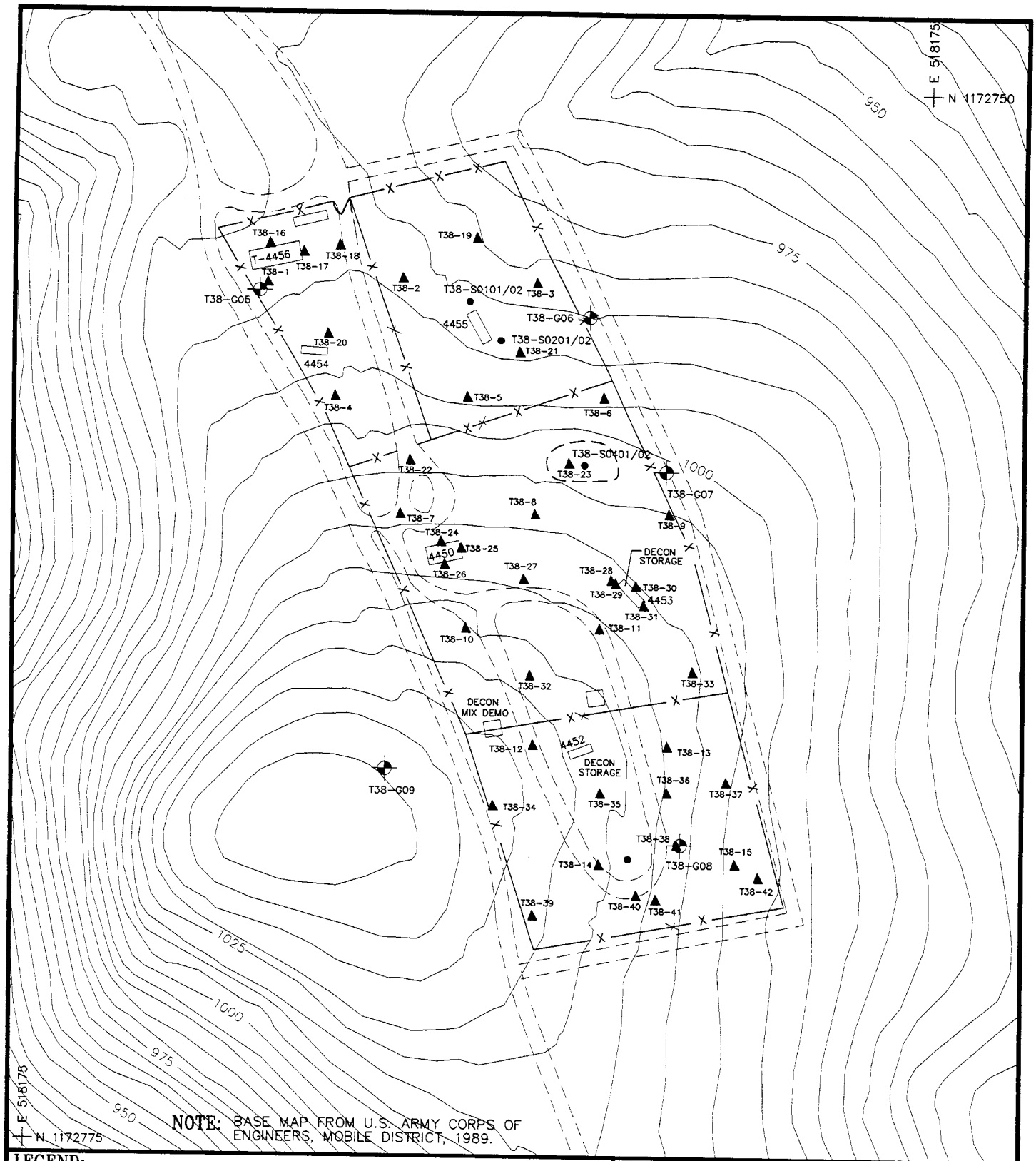
STOLS survey conducted by GeoCenters, Inc., 3/18/95.
Grid coordinates in Alabama state plane (NAD27) system (east)

U.S. Army Corps of Engineers
Mobile, Alabama

AREA T-24A GEOPHYSICAL SURVEY RESULTS

Fort McClellan RI/FS, Anniston, Alabama

Figure:	Project:	File:	Date:
4-15	01-0827-03-6520-012	FIG4-15.SRF	04/13/95



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

LEGEND:

- BUILDINGS
- GRAVEL ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- APPROXIMATE SUMP LOCATION
- SI SOIL SAMPLE LOCATIONS (SAIC, 1992)
- MINICAMS SCREENING LOCATION
- MONITORING WELL

N

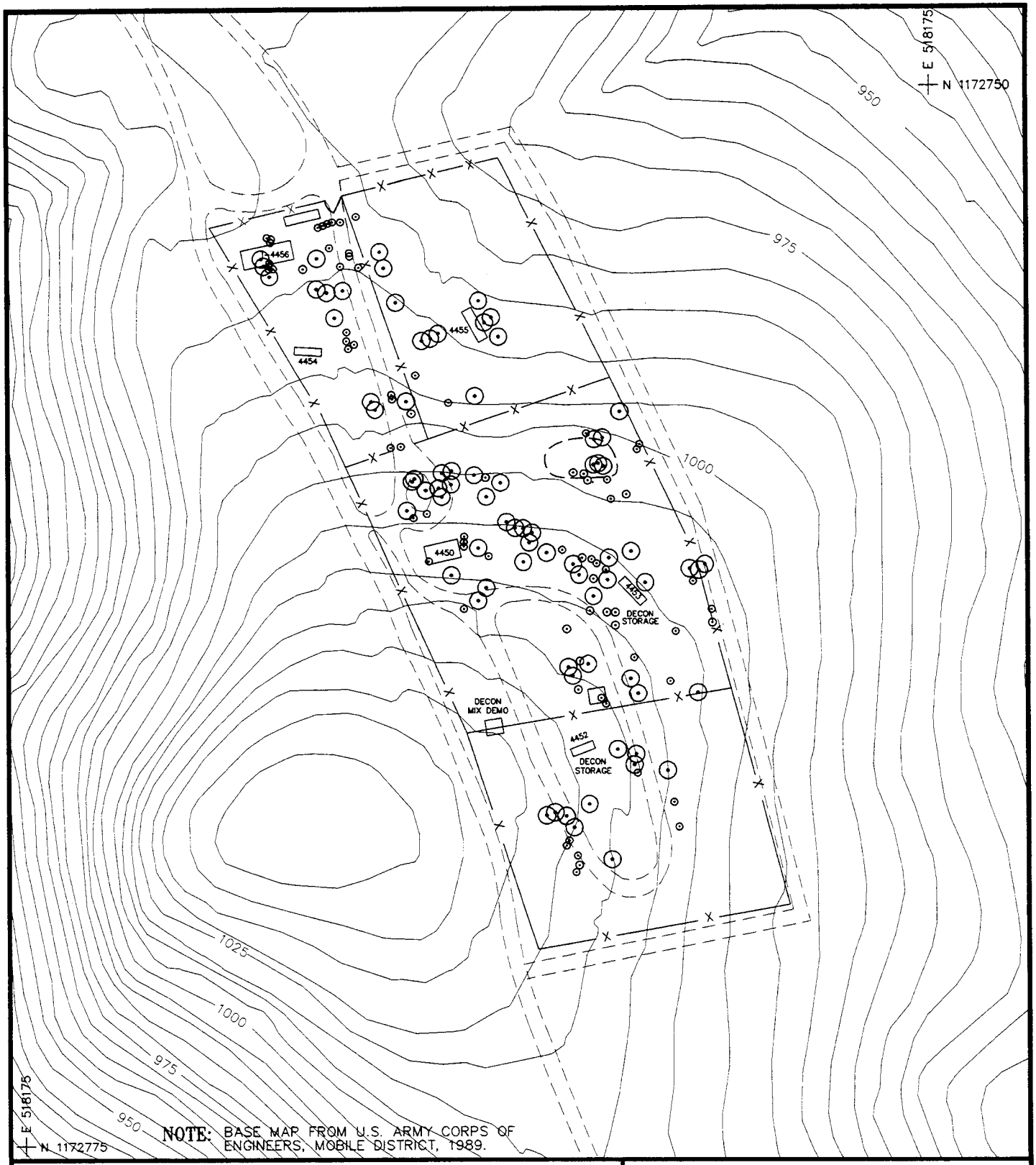
0 50 100 150

SCALE: 1" = 150'

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

AREA T-38
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-16	01-0827-03-6520-012	FTMC\98-FIG4-16	Dec. 1998



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

LEGEND:

- BUILDINGS
- GRAVEL ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- APPROXIMATE SUMP LOCATION
- DETECTED MAGNETOMETER (STOLS) TARGETS (GEOCENTERS, INC. 1995)

N

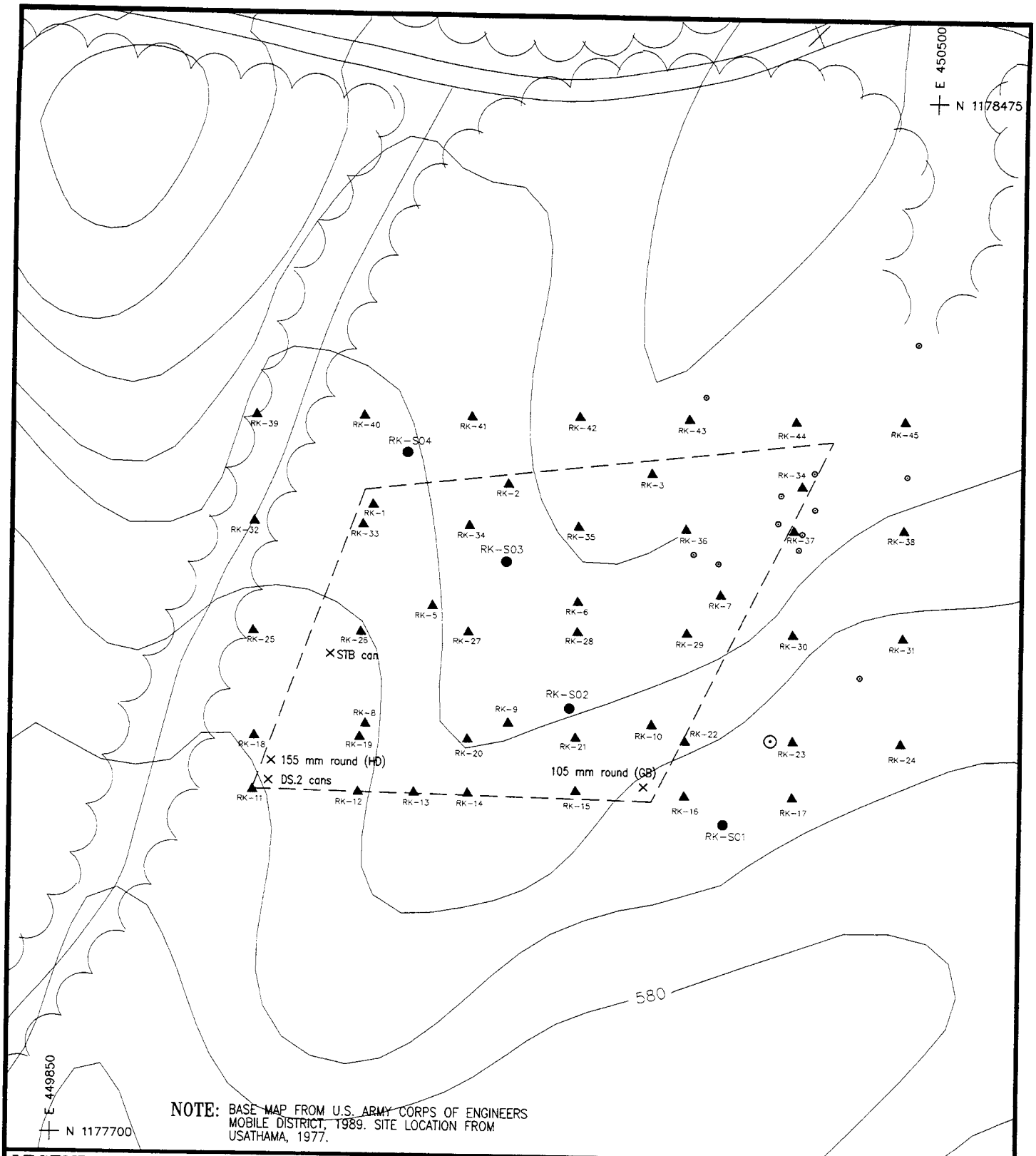
0 50 100 150

SCALE: 1" = 150'

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

AREA T-38
GEOPHYSICAL SURVEY RESULTS
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-17	01-0827-03-6520-012	FTMC\98-FIG4-17	Dec. 1998



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

LEGEND:

- BUILDINGS
- ASPHALT ROADS
- BOUNDARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- TREE LINE
- SURFACE DEBRIS (USAEC 1992)
- MINICAMS SCREENING LOCATION
- STOLS MAGNETOMETER TARGET (GEOCENTERS, INC. 1995)
- SOIL SAMPLE (SAIC, 1995)

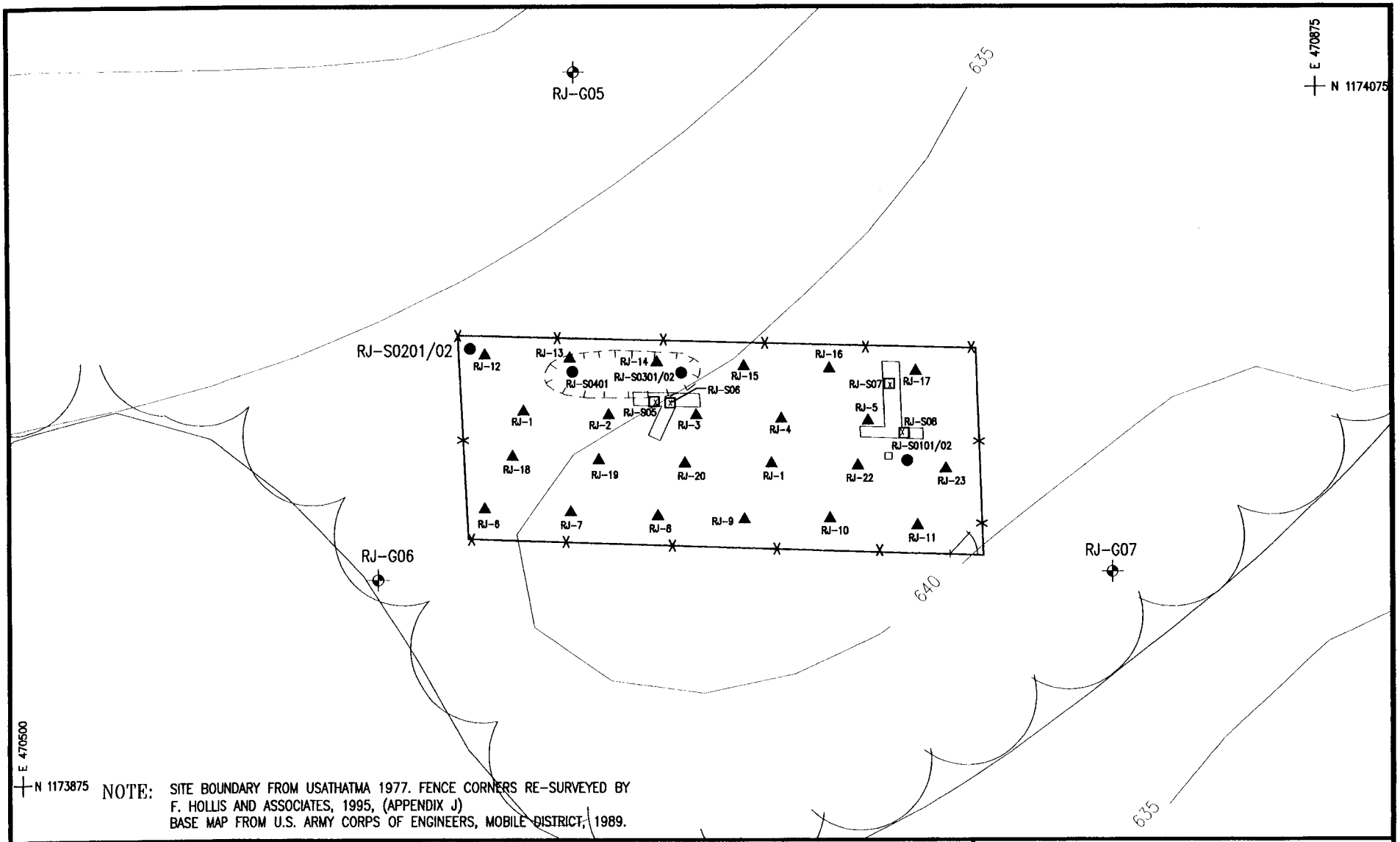
0 50 100

SCALE: 1" = 100'

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

RANGE K
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-18	01-0827-03-6520-012	FTMC\98-FIG4-18	Dec. 1998



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

LEGEND:

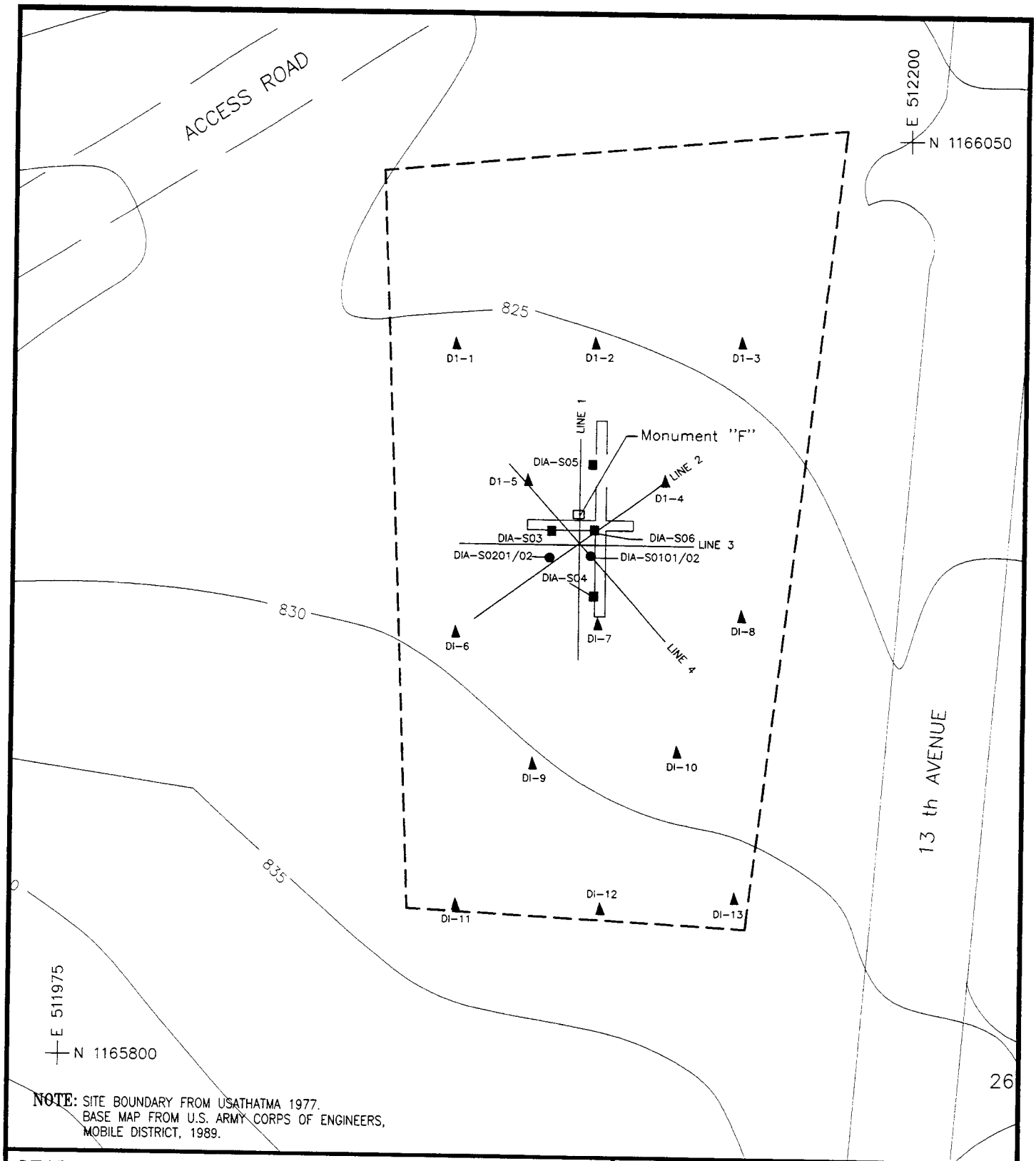
- FENCE LINE
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- DRUM DISPOSAL PIT
- CONCRETE MONUMENT
- RI SAMPLE (SAIC 1995)
- MINICAMS SCREENING LOCATION
- MONITORING WELL (SAIC, 1995)
- SI SAMPLE LOCATION
- TRENCH LOCATION

0 20 40
SCALE: 1" = 40'

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
4-19	01-0827-03-6520-012	FTMC\98-FIG4-19	Dec. 1998



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

LEGEND:

- ASPHALT ROADS
- GRAVEL ROADS
- BOUNDARY
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- CONCRETE MONUMENT F
- MINICAMS SCREENING LOCATION
- SI SOIL SAMPLE LOCATION (SAIC 1992)
- RI SOIL SAMPLE (SAIC, 1994)
- GEOPHYSICAL TRANSECT (SAIC, 1994)

N

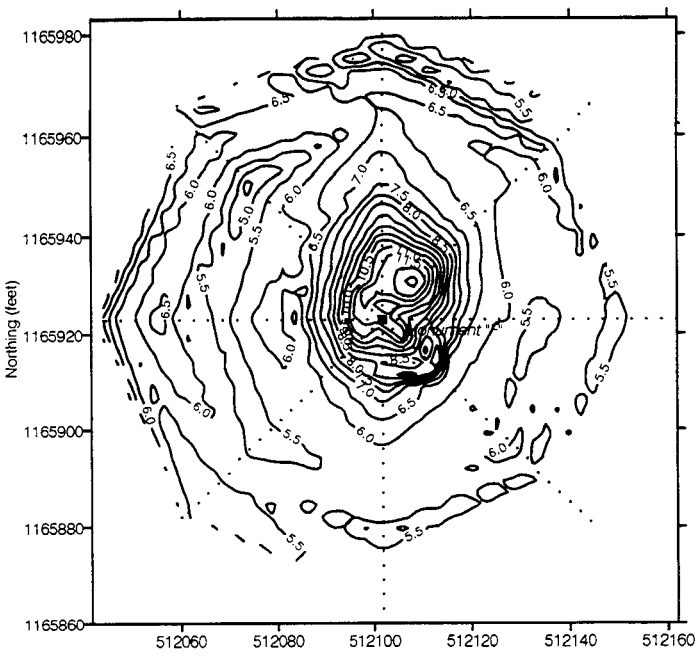
0 20 40

SCALE: 1" = 40'

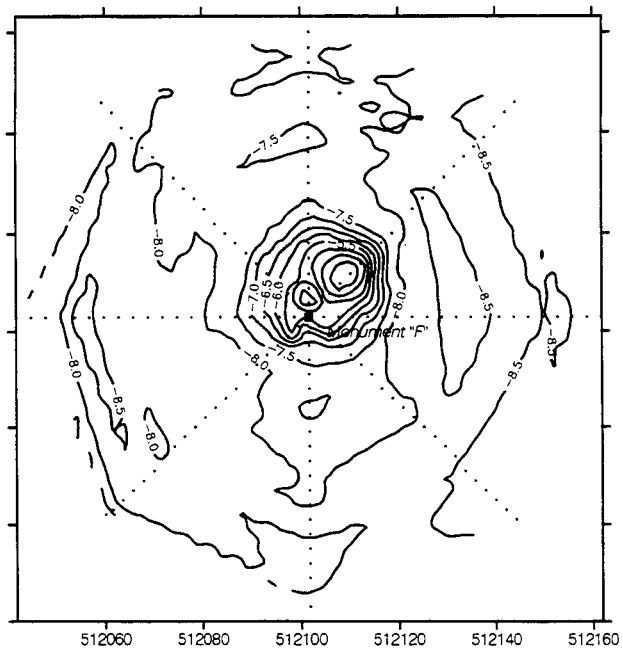
U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

D AND I AREA
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

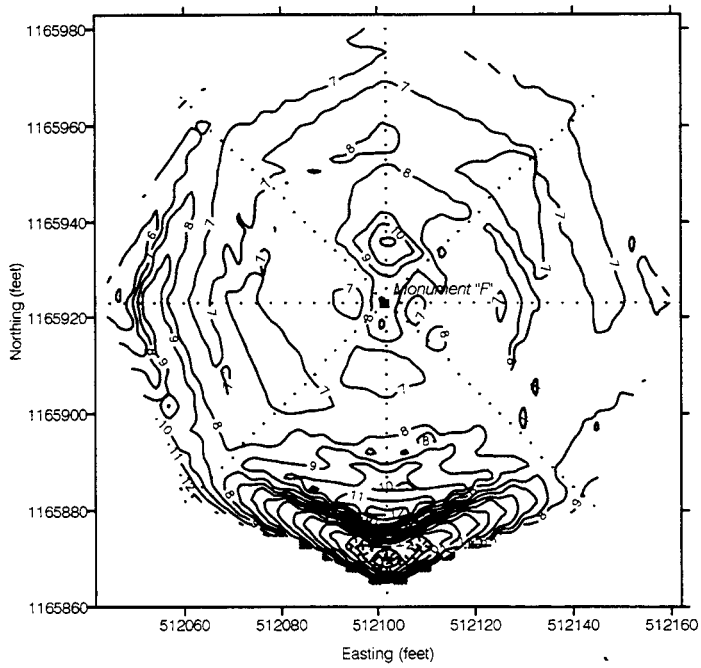
Figure No.	Project No.	File Name	Date
4-20	01-0827-03-6520-012	FTMC\98-FIG4-20	Dec. 1998



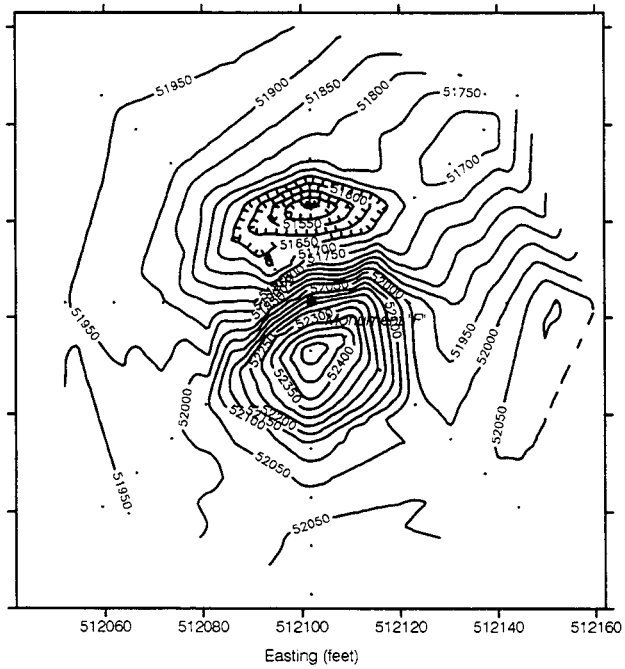
Horizontal Mode EM Conductivity



Horizontal Mode In-Phase Conductivity



Vertical Mode EM Conductivity



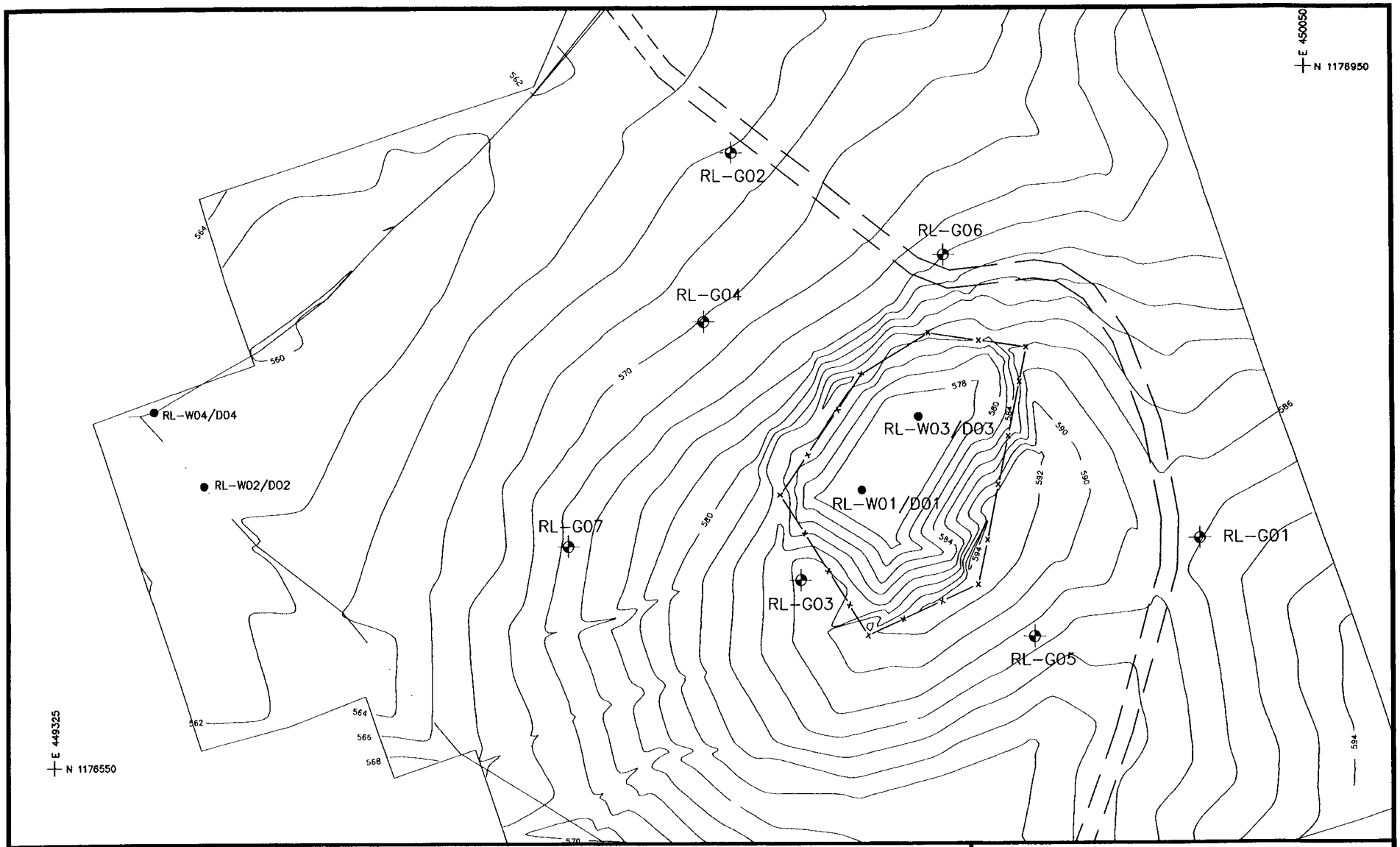
Total Field Magnetometer Data

EM-31 vertical and horizontal mode conductivity data.
Magnetometer data obtained using Geometrics G-856-AX instrument.

U.S. Army Corps of Engineers
Mobile, Alabama

Geophysical Survey Data
Detection and Identification Area
Fort McClellan RI/FS, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
4-21	01-0827-03-6520-012	FIG4_21.SRF	03-15-95	SAIC-McLean



LEGEND:

- GRAVEL ROADS
- FENCE LINE
- 620 TOPOGRAPHIC CONTOUR (CI=25 ft.)
- TOPOGRAPHIC CONTOUR (CI=5 ft.)
- INTERMITTENT STREAM
- RI SURFACE/SEDIMENT SAMPLE LOCATION
- MONITORING WELL

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

N

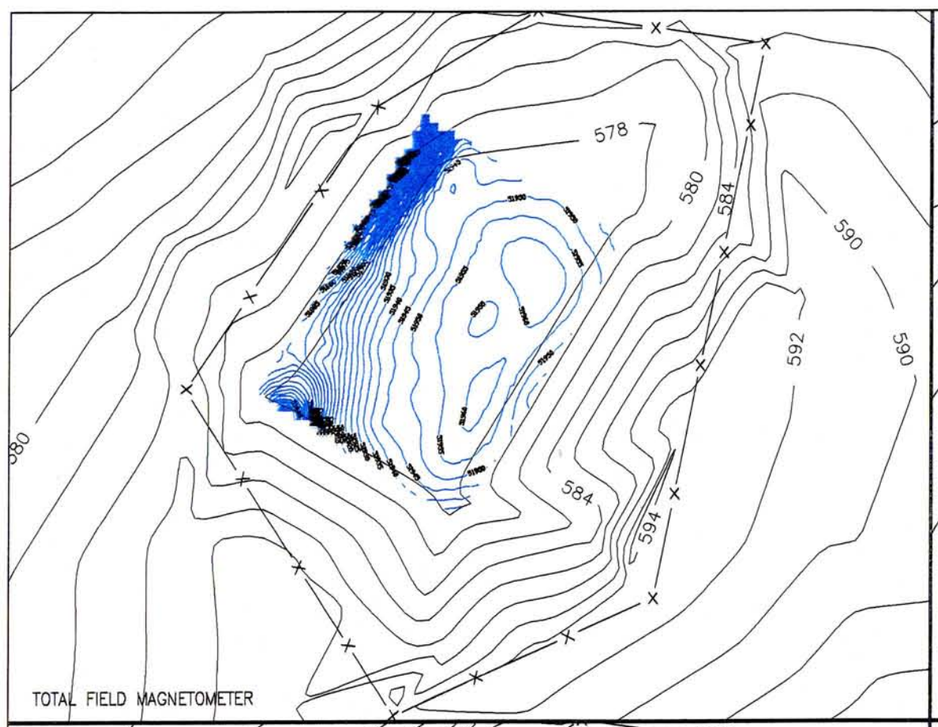
0 40 80

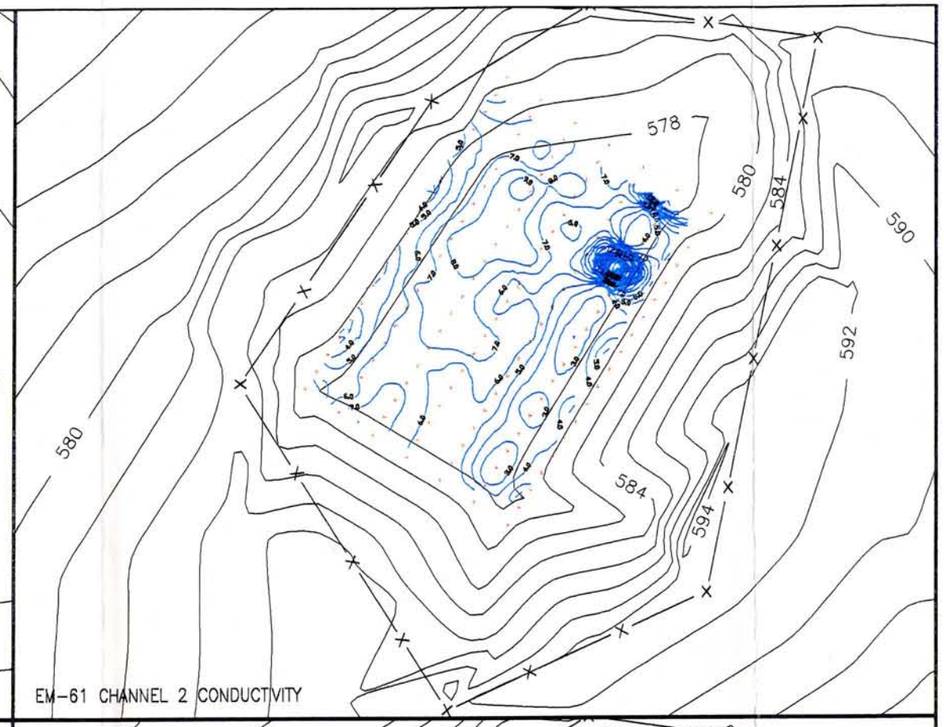
SCALE: 1" = 80'

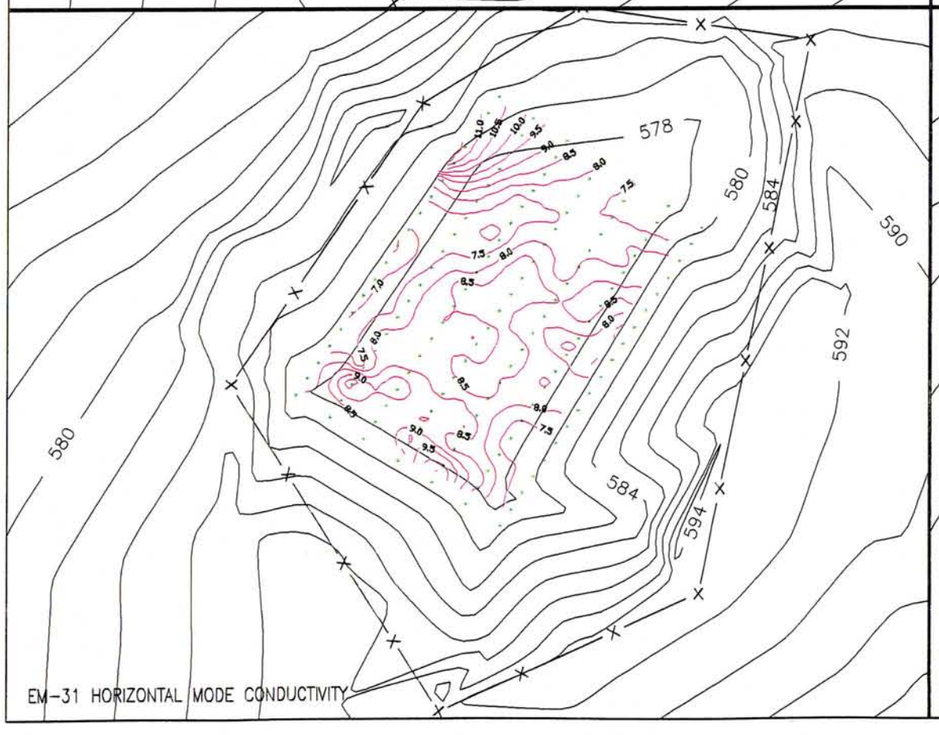
U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

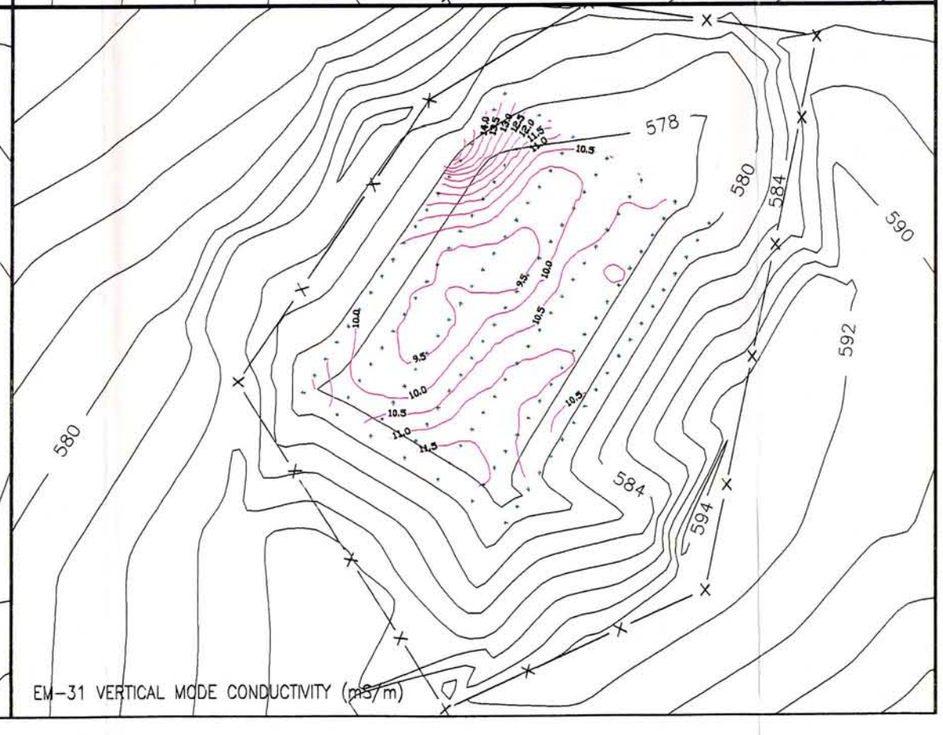
RANGE L
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-22	01-0827-03-6520-012	FTMC\98-FIG4-22	Dec. 1998









LEGEND:

FENCE LINE

620 TOPOGRAPHIC CONTOUR (CI=2 ft.)

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

N

0 20 40 80

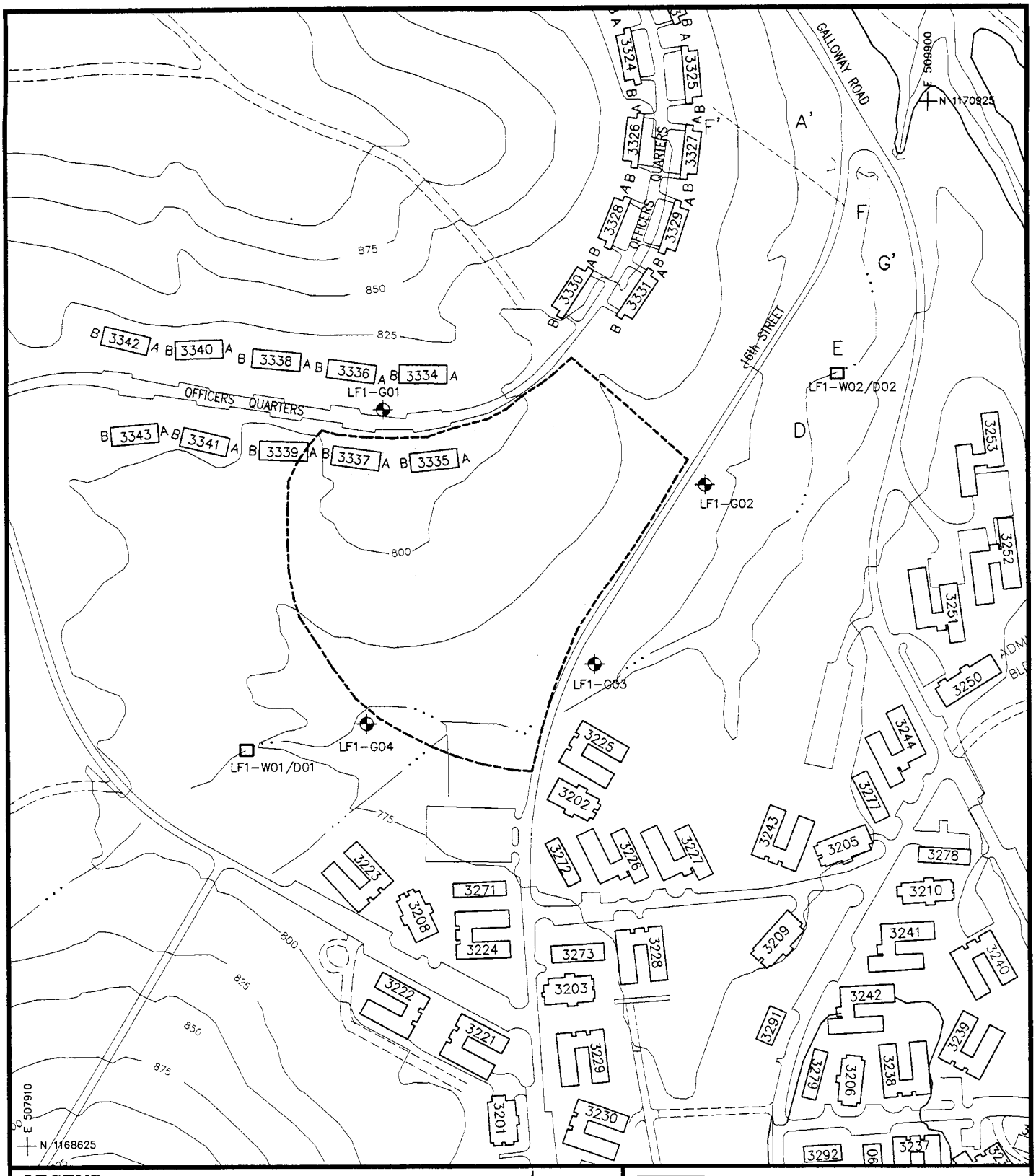
SCALE: 1" = 40'

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

GEOPHYSICAL SURVEY RESULTS-RANGE L SAMPLE LOCATION MAP

FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-23	01-0827-03-6520-012	FTMC\98-FIG4-22-A	Jan. 1999



LEGEND:

- SITE BOUNDARY
- ASPHALT ROADS
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- SURFACE WATER/SEDIMENT SAMPLE (SAIC, 1994)
- MONITORING WELL

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

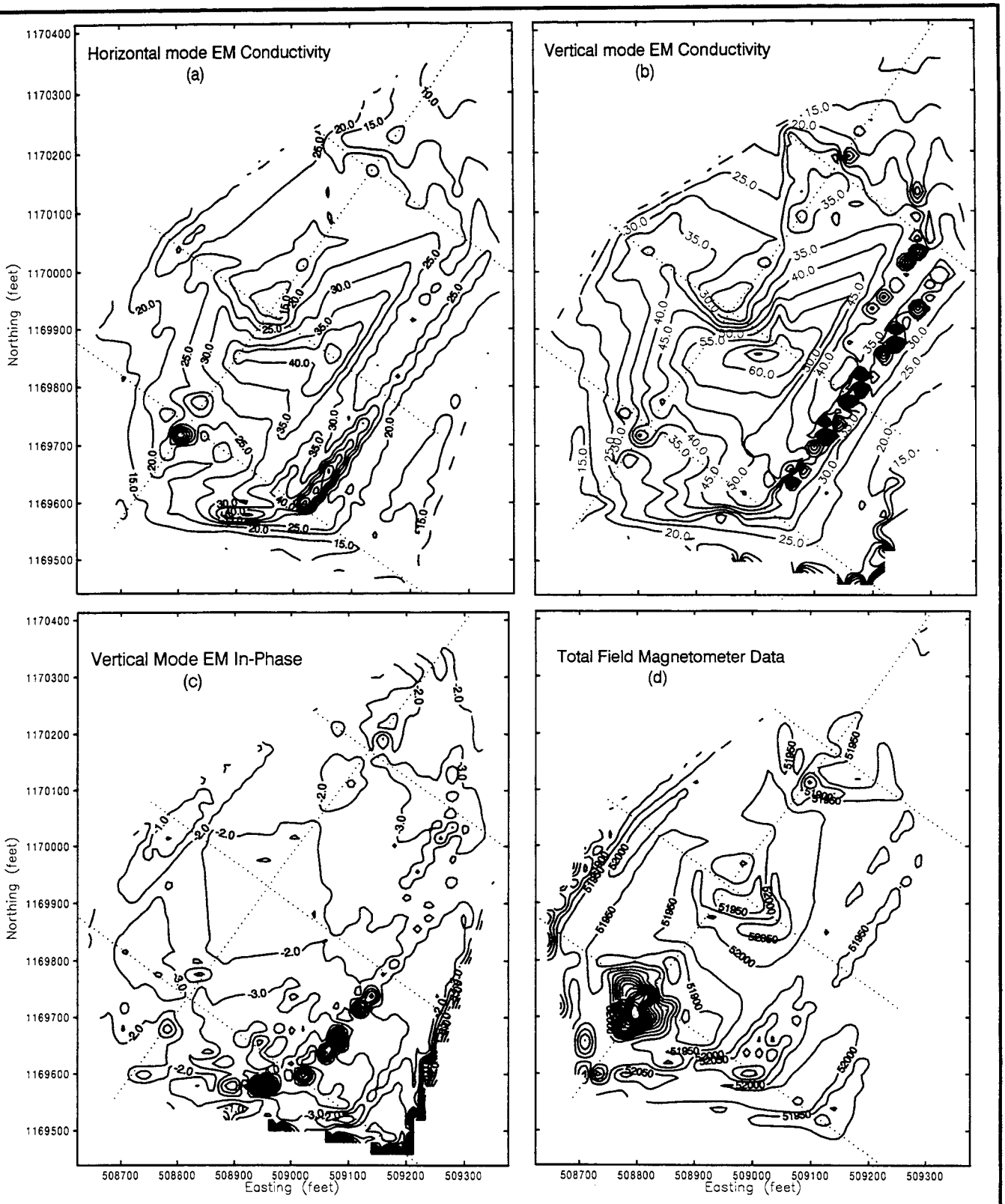
0 100 200 300

SCALE: 1" = 300'

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

LANDFILL #1
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-24	01-0827-03-6520-012	FTMC\98-FIG4-24	Dec. 1998

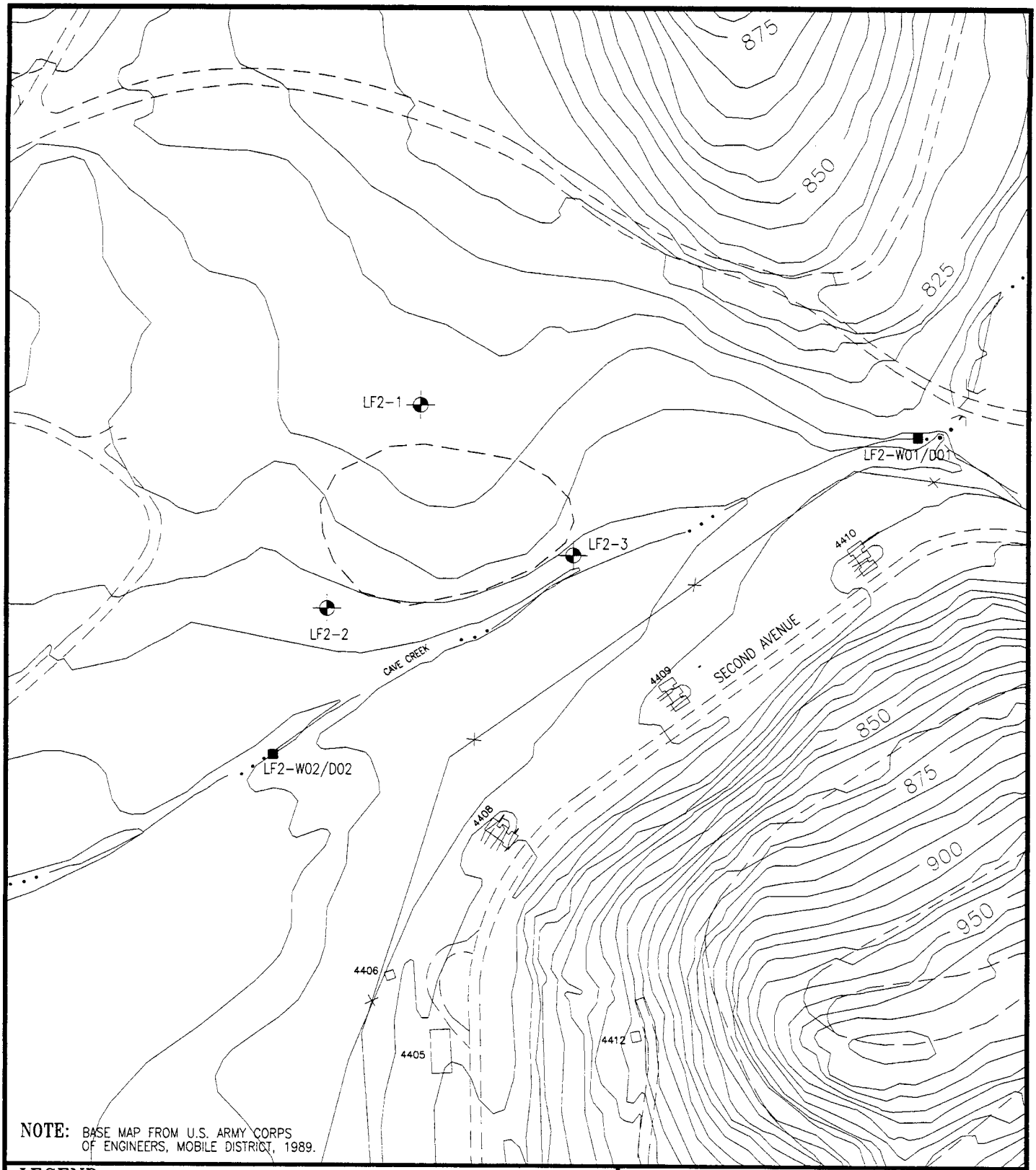


N

U.S. Army Corps of Engineers
Mobile, Alabama

LANDFILL #1 GEOPHYSICAL SURVEY RESULTS
Fort McClellan RI/FS, Anniston, Alabama

File:	Project:	File:	Date:
4-25	01-0827-03-6520-012	FIG4-25.SRF	03/05/95



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

LEGEND:

- GRAVEL ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- SURFACE WATER / SEDIMENT SAMPLE (SAIC, 1994)
- MONITORING WELL (SAIC, 1992)

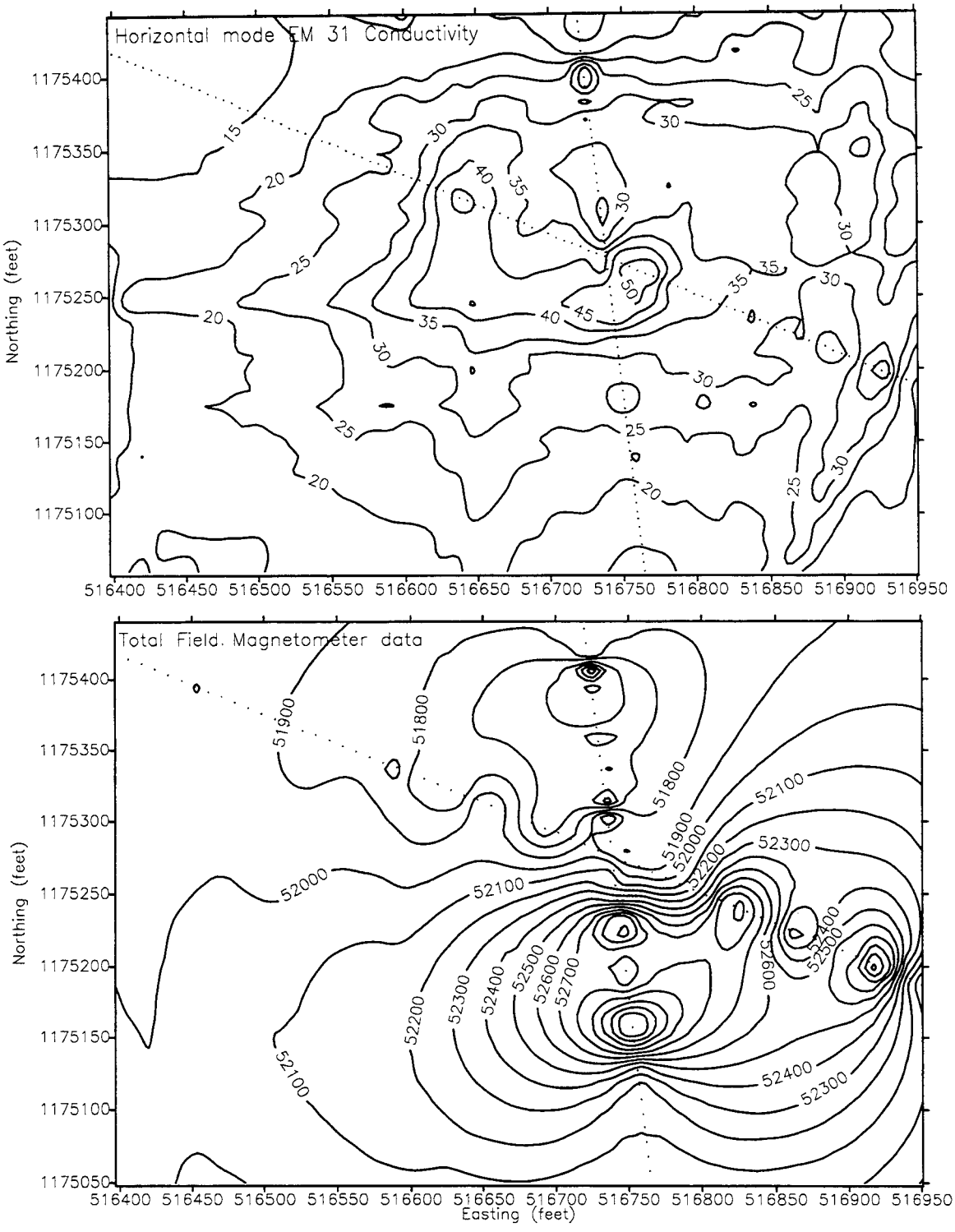
0 100 200

SCALE: 1" = 200'

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

LANDFILL #2
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

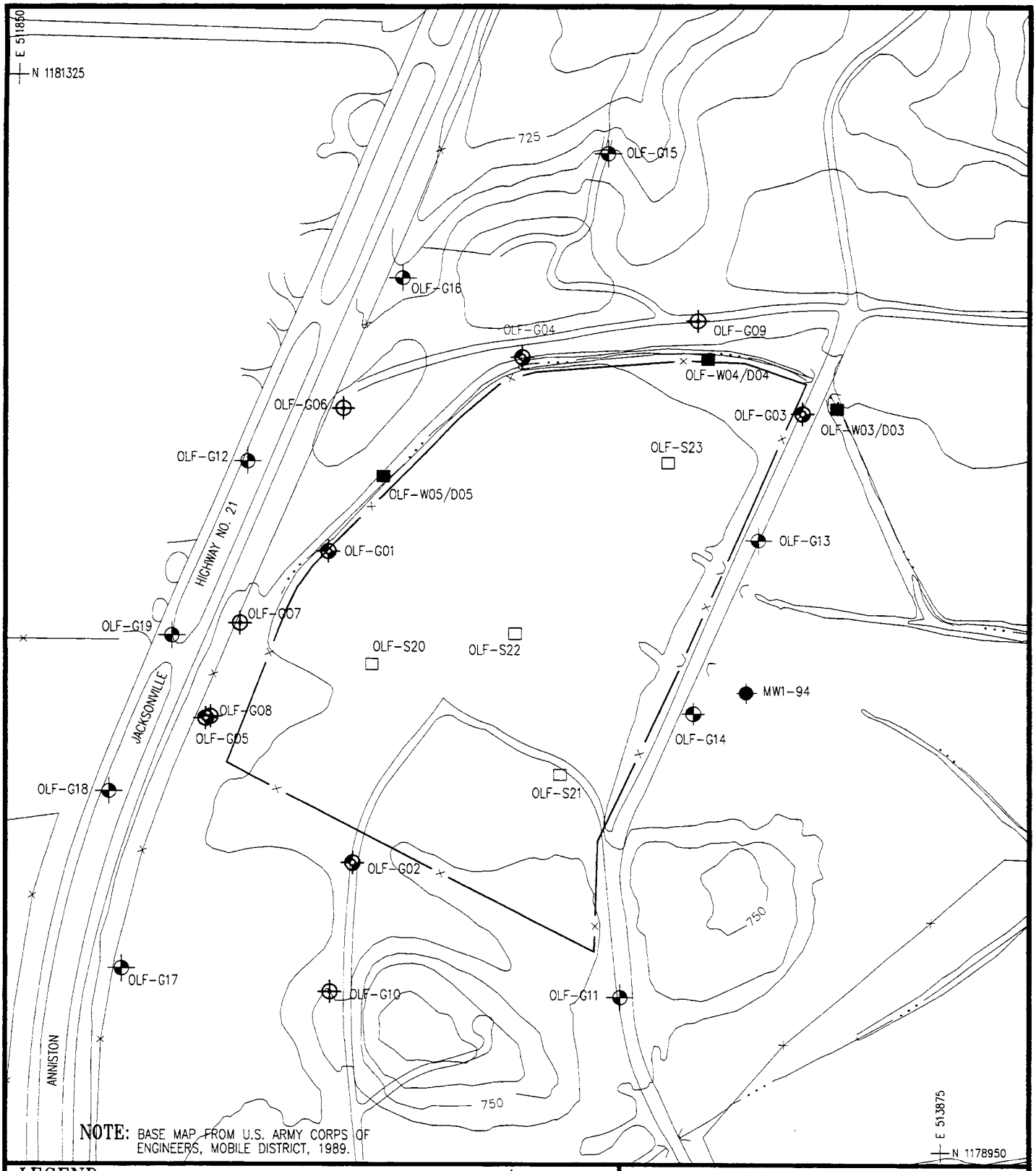
Figure No.	Project No.	File Name	Date
4-26	01-0827-03-6520-012	FTMC\98-FIG4-26	Dec. 1998



U.S. Army Corps of Engineers
Mobile, Alabama

LANDFILL #2 GEOPHYSICAL SURVEY RESULTS
Fort McClellan RI/FS, Anniston, Alabama

Figure:	Project:	File:	Date:
4-27	01-0827-03-6520-012	LF2_GEOP.SRF	03/16/95



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

LEGEND:

- ASPHALT ROADS
- FENCE LINE
- STREAM OR TRIBUTARY
- 855 TOPOGRAPHIC CONTOUR (CI=25 ft)
- TOPOGRAPHIC CONTOUR (CI=5 ft)
- RI WELL LOCATION (SAIC, 1995)
- SI WELL LOCATION (SAIC, 1992)
- USAEHA WELL LOC. (USAEHA 1986)
- SURFACE SOIL SAMPLE (SAIC, 1995)
- SURFACE WATER/ SEDIMENT SAMPLE (SAIC, 1995)
- LANDFILL #4 MONITORING WELL (EEG 1993)

N

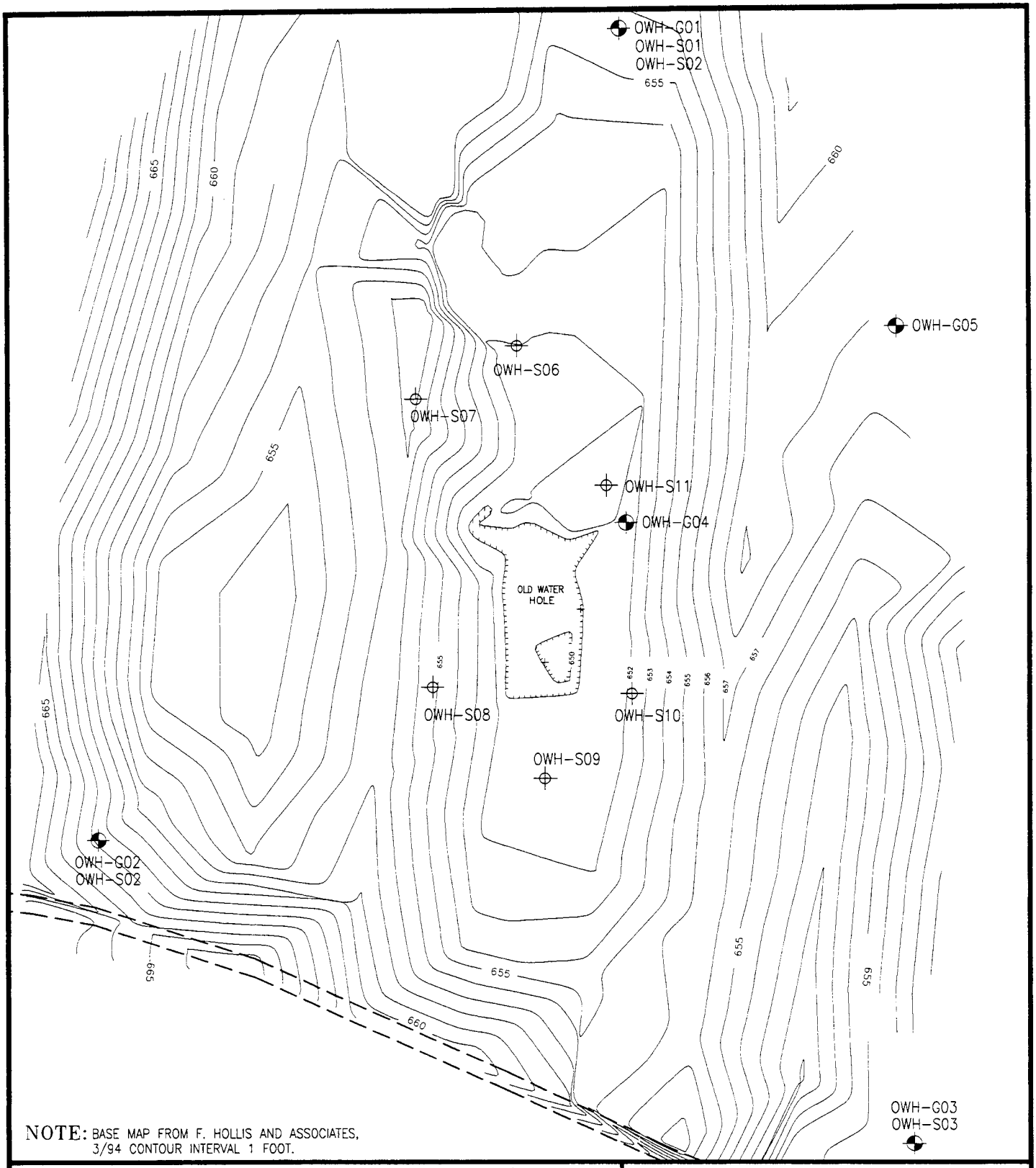
0 100 200 300

SCALE: 1" = 300'

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

LANDFILL #3
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-28	01-0827-03-6520-012	FTMC\98-FIG4-28	Dec. 1998



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

LEGEND:

- GRAVEL ROADS
- 855 ..... TOPOGRAPHIC CONTOUR (CI=5 ft)
- ..... TOPOGRAPHIC CONTOUR (CI=1 ft)
- ..... SOIL BORING (SAIC, 1995)
- ..... MONITORING WELL (SAIC, 1995)

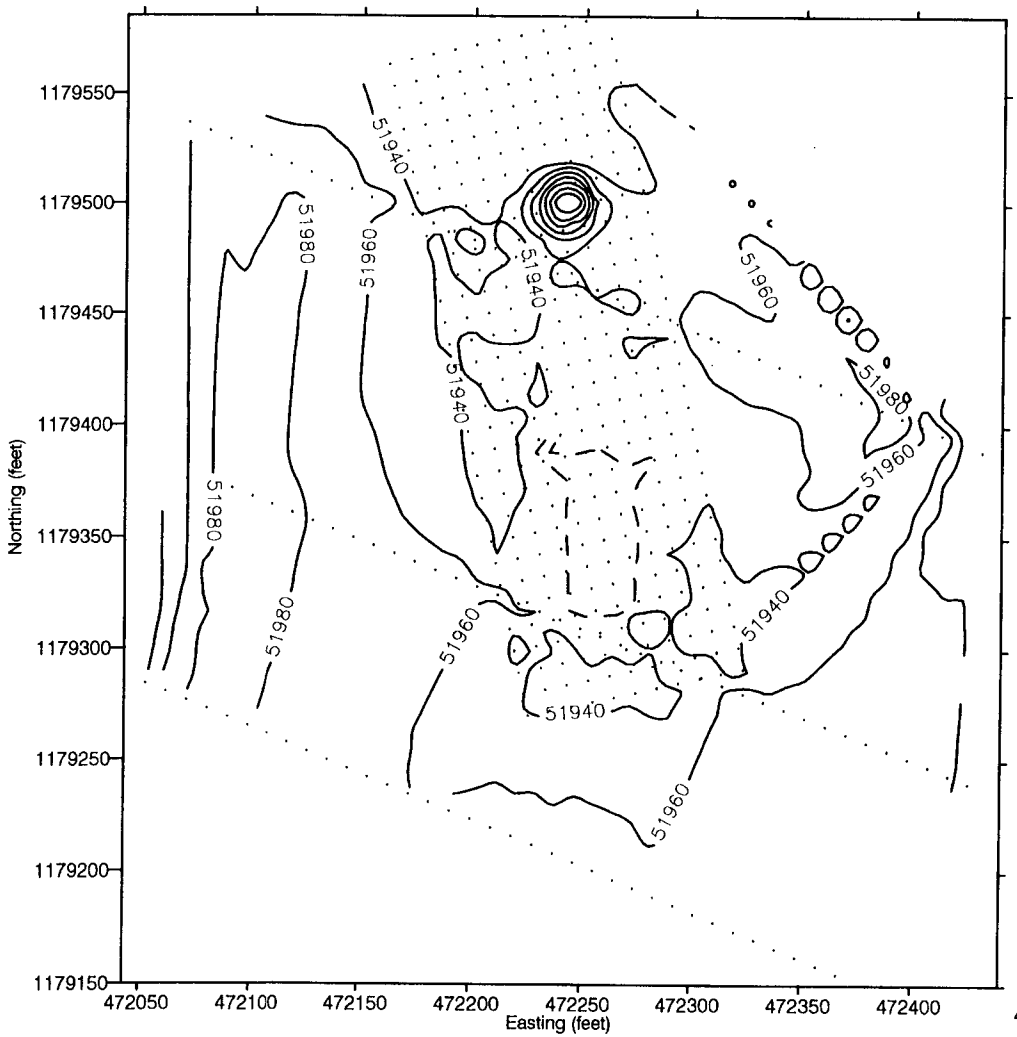
0 30 60

SCALE: 1" = 60'

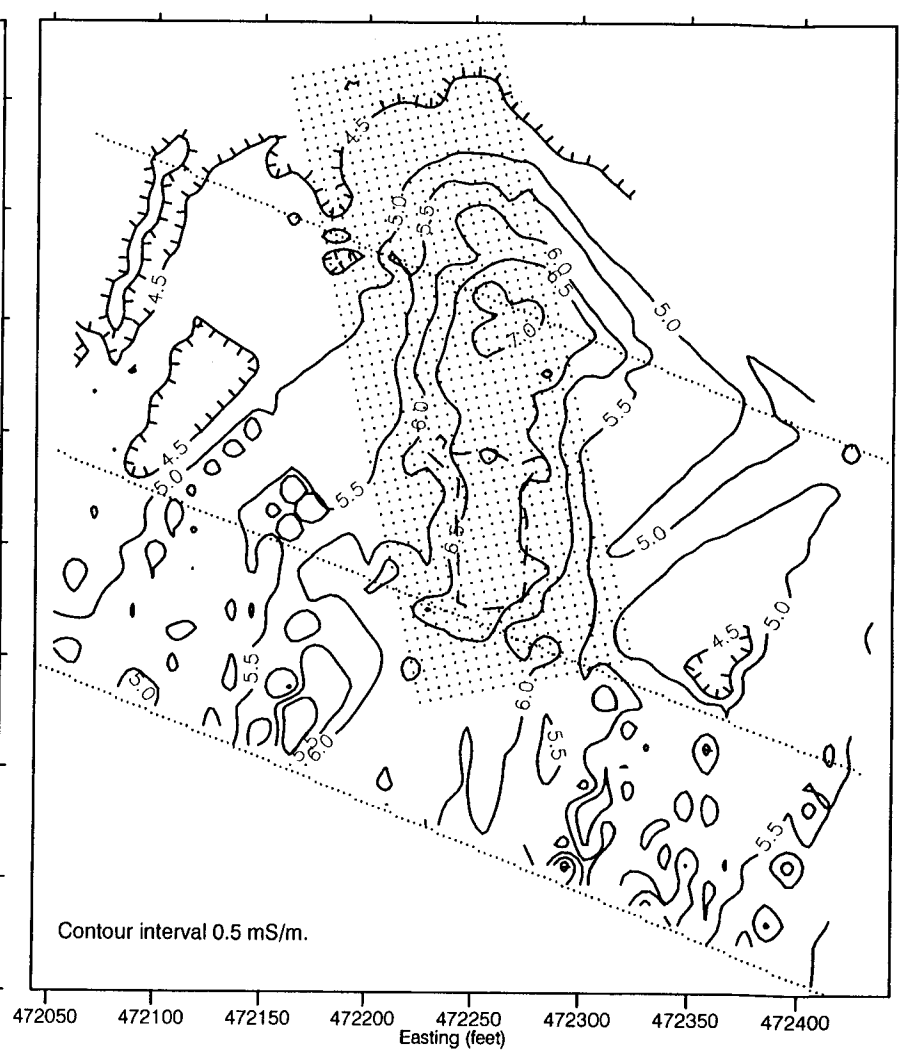
U.S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
MOBILE ALABAMA

OLD WATER HOLE
SAMPLE LOCATION MAP
FORT McLELLAN, ALABAMA

Figure No.	Project No.	File Name	Date
4-29	01-0827-03-6520-012	FTMC\98-FIG4-29	Dec. 1998



Total Field Magnetometer Data



Vertical Mode EM-31 Conductivity (mS/m)

Grid and transect data coordinates surveyed by F. Hollis and Associates (1994).

N

U.S. Army Corps of Engineers
Mobile, Alabama

OLD WATER HOLE GEOPHYSICAL SURVEY RESULTS

Fort McClellan RI/FS, Anniston, Alabama

Figure:	Project:	File Name:	Date:	Production:
4-30	01-0827-03-6520-012	4-30.SRF	03-17-95	SAIC-McLean

Table 4-1. Geotechnical Soil Properties- Previous Investigations
Fort McClellan, Alabama

Boring	Investigator	Site	Depth (feet)	USCS Classificatior	Liquid Limit	Plasticity Index	Plastic Limit	Soil pH	CEC (meq/100 g)	Density	Hydraulic Conductivity (cm/sec)
1	USAEHA, 1976[1]	Landfill #4	22	ML	40	8	32	--	--	--	1.1E-04
1	USAEHA, 1976	Landfill #4	27	ML	28	4	24	--	--	--	2.4E-06
2	USAEHA, 1976	Landfill #4	25	ML	42	15	27	--	--	1.62	2.3E-05
2	USAEHA, 1976	Landfill #4	37	SC	34	12	22	--	--	1.55/1.64	3.3E-05
3	USAEHA, 1976	Landfill #4	15	SM-SC	21	5	16	--	--	--	--
3	USAEHA, 1976	Landfill #4	31	ML/CL	40	17	23	--	--	--	--
4	USAEHA, 1976	Landfill #4	20	ML	48	18	30	--	--	1.54	1.0E-08
4	USAEHA, 1976	Landfill #4	32	ML	37	7	30	--	--	1.56	4.2E-07
4	USAEHA, 1976	Landfill #4	50	SM	36	10	26	--	--	1.66	6.4E-04
5	USAEHA, 1976	Landfill #4	10	SM-SC	28	7	21	--	--	--	--
5	USAEHA, 1976	Landfill #4	15	MH	56	22	34	--	--	1.45	3.9E-08
5	USAEHA, 1976	Landfill #4	29	ML	36	6	30	--	--	1.55	1.9E-07
Bag	USAEHA, 1976	Landfill #4	30-32	ML	33	7	26	--	--	--	--
Bag	USAEHA, 1976	Landfill #4	7-10	SM	32	7	25	--	--	--	--
Bag	USAEHA, 1976	Landfill #4	18	SM	59	23	36	--	--	--	--
Bag	USAEHA, 1976	Landfill #4	103	SM-SC	22	6	16	--	--	--	--
Bag	USAEHA, 1976	Landfill #4	0	ML	46	11	35	--	--	1.63	2.8E-08
FM-1	ES&E, 1981[2]	Siting	3-5	--	--	--	--	--	--	--	2.2E-03
FM-1	ES&E, 1981	Siting	11-13	--	--	--	--	--	--	--	7.0E-05
FM-2	ES&E, 1981	Siting	0-2	--	--	--	--	--	--	--	1.1E-05
FM-2	ES&E, 1981	Siting	3-5	--	--	--	--	--	--	--	6.4E-05
FM-2	ES&E, 1981	Siting	7-8	--	--	--	--	--	--	--	8.1E-04
FM-3	ES&E, 1981	Siting	17	--	--	--	--	--	--	--	3.0E-06
FM-4	ES&E, 1981	Siting	0-2	--	--	--	--	--	--	--	9.3E-04
FM-5	ES&E, 1981	Siting	5-7	--	--	--	--	--	--	--	8.6E-06
FM-6	ES&E, 1981	Siting	5-6.5	CL	44	25	19	--	--	--	--
FM-6	ES&E, 1981	Siting	7-9	--	--	--	--	--	--	--	8.0E-07
FM-6	ES&E, 1981	Siting	10-11.5	SC	44	23	21	--	--	--	--
FM-7	ES&E, 1981	Siting	5-6.5	CL	31	17	14	--	--	--	--
FM-7	ES&E, 1981	Siting	7-9	--	--	--	--	--	--	--	1.4E-07
FM-7	ES&E, 1981	Siting	10-11.5	CL	33	18	15	5.2	3.5	--	--
FM-7	ES&E, 1981	Siting	15-16.5	CL	45	20	25	5.2	3.5	--	--
FM-7	ES&E, 1981	Siting	20-21.5	CH	55	28	27	--	--	--	--
FM-7	ES&E, 1981	Siting	25-26.5	CL	44	19	25	5.2	5.0	--	--
FM-7	ES&E, 1981	Siting	30-31.5	CL-CH	50	30	20	5.2	5.0	--	--
FM-7	ES&E, 1981	Siting	32-34	--	--	--	--	--	--	--	1.2E-07
FM-7	ES&E, 1981	Siting	35-36.5	CH	55	35	20	5.2	5.0	--	--
FM-7	ES&E, 1981	Siting	40-41.5	CL	49	29	20	6.2	5.0	--	--
FM-7	ES&E, 1981	Siting	45-46.5	CL	31	14	17	6.2	5.0	--	--
FM-8	ES&E, 1981	Siting	5-6.5	SC	37	18	19	5.2	1.8	--	--
FM-8	ES&E, 1981	Siting	10-11.5	MH	55	22	33	5.2	1.8	--	--
FM-8	ES&E, 1981	Siting	15-16.5	CH	53	35	18	--	--	--	2.0E-07
FM-8	ES&E, 1981	Siting	20-21.5	CH	68	42	26	5.4	3.5	--	--
FM-8	ES&E, 1981	Siting	25-26.5	CH	57	33	24	5.4	3.5	--	--
FM-8	ES&E, 1981	Siting	30-31.5	CL-CH	50	27	23	5.4	3.5	--	--
FM-8	ES&E, 1981	Siting	35-36.5	CL	47	27	20	5.6	4.3	--	--
FM-8	ES&E, 1981	Siting	40-41.5	CL	41	21	20	5.6	4.3	--	--
FM-9	ES&E, 1981	Siting	5-6.5	CL	33	18	15	4.9	4.8	--	--
FM-9	ES&E, 1981	Siting	10-11.5	CL	28	13	15	4.9	4.8	--	--
FM-9	ES&E, 1981	Siting	15-16.5	SC	35	14	21	--	--	--	--
FM-9	ES&E, 1981	Siting	20-21.5	CL-CH	50	29	21	--	--	--	--
FM-9	ES&E, 1981	Siting	25-26.5	CH	65	34	31	5.3	3.9	--	--
FM-9	ES&E, 1981	Siting	30-31.5	CL	46	20	26	5.3	3.9	--	--
FM-9	ES&E, 1981	Siting	35-36.5	MH	62	29	33	5.3	3.9	--	--
FM-9	ES&E, 1981	Siting	40-41.5	CL	46	20	26	--	--	--	--
FM-9	ES&E, 1981	Siting	45-46.5	CH	60	30	30	--	--	--	--
FM-9	ES&E, 1981	Siting	50-51.5	CL-CH	50	28	22	6.0	4.1	--	--
FM-9	ES&E, 1981	Siting	55-56.5	MH	51	20	31	6.0	4.1	--	--
FM-9	ES&E, 1981	Siting	60-61.5	CL	35	15	20	--	--	--	--
FM-10	ES&E, 1981	Siting	0	ML	44	16	28	5.3	1.9	--	--
FM-10	ES&E, 1981	Siting	3.5-5	ML	29	6	23	5.3	1.9	--	--
FM-10	ES&E, 1981	Siting	10-11.5	CL	41	19	22	--	--	--	--
FM-10	ES&E, 1981	Siting	19-20.5	CH	62	37	25	5.4	2.5	--	--
FM-10	ES&E, 1981	Siting	24-25.5	CL	46	19	27	--	--	--	--
FM-10	ES&E, 1981	Siting	29-29.5	CL	--	--	--	--	--	--	--
FM-10	ES&E, 1981	Siting	34-35.5	CL	43	22	21	--	--	--	--