DAIM-BD-H-MC

12 September 2006

MEMORANDUM FOR RECORD

SUBJECT: Draft Focused Feasibility Study, Small Weapons Repair Shop, Parcel 66(7), November 2002

1. Subject draft document will not be finalized by the U.S. Army. It is maintained in the Administrative Record and Information Repositories to provide information collected by the Army prior to implementation of the Environmental Services Cooperative Agreement (ESCA) between the Army and the Anniston-Calhoun County Fort McClellan Development Joint Powers Authority (JPA) executed on 15 September 2003, and as modified on 30 September 2005. The JPA will complete environmental services and achieve site closeout in accordance with the requirements of the ESCA.

2. Point of contact for this action is Lisa Holstein, Transition Force, Fort McClellan, AL, at 256-848-7455.

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November 4, 2002

IT-MC-CK05-0671
Project No. 774645

Mr. Lee Douglas Coker
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Contract: **Contract No. DACA21-96-D-0018/CK05**
Fort McClellan, Alabama

Subject: **Draft Focused Feasibility Study, Small Weapons Repair Shop, Parcel 66(7)**

Dear Mr. Coker:

I am enclosing one copy of the *Draft Focused Feasibility Study, Small Weapons Repair Shop, Parcel 66(7).* The FFS was developed based on information collected during remedial investigation activities at Parcel 66(7) and provides a basis for a remedy selection consistent with the Army's intent to transfer the site to the public domain for future industrial reuse. Please review the document and provide either a letter of concurrence or written comments with suggested changes.

At your request, I have distributed copies of this document as indicated below. If you have questions, or need further information, please contact me at (770) 663-1429 or Steve Moran at (865) 694-7361.

Sincerely,

Stephen D. Moran for

Jeanne A. Yacoub, P.E.
Project Manager

Attachments

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Doyle Brittain, EPA Region 4 (3 copies)
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Miki Schneider, JPA (1 copy)

Draft

Focused Feasibility Study
Small Weapons Repair Shop, Parcel 66(7)

Fort McClellan
Calhoun County, Alabama

Prepared for:

U.S. Army Corps of Engineers, Mobile District
109 St. Joseph Street
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Task Order CK05
Contract No. DACA21-96-D-0018
IT Project No. 774645

November 2002

Revision 0

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Executive Summary

In accordance with Contract Number DACA21-96-D-0018, Task Order CK10, IT Corporation completed a focused feasibility study (FFS) for the Small Weapons Repair Shop, Parcel 66(7), at Fort McClellan (FTMC) in Calhoun County, Alabama. This FFS is based on information collected during remedial investigation (RI) activities at Parcel 66(7) and provides a basis for a remedy selection consistent with the Army's intent to transfer the site to the public domain for future industrial reuse. The FFS was prepared in accordance with U.S. Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers guidance.

Parcel 66(7) is located in the central portion of the Main Post at the intersection of Waverly Road and Freemont Road at FTMC. Two buildings (Buildings 335 and 336) are located within the Parcel 66(7) boundary. Building 335 formerly housed the Small Weapons Repair Shop, where weapons used for training exercises were stored, disassembled, and cleaned using various solvents (including trichloroethene [TCE]). Building 336, located just east of Building 335, is presently empty, but previously housed a small boiler plant.

RI activities were conducted at Parcel 66(7) to determine the nature and extent of contamination and to identify chemicals that pose an unacceptable risk to human health and environment. Five chlorinated volatile organic compounds (VOC) were detected in groundwater at concentrations exceeding human health site-specific screening levels: 1,1-dichloroethene (DCE), 1,2-dichloroethane (DCA), cis-1,2-DCE, TCE, and vinyl chloride. A streamlined human health risk assessment (SRA) and a screening-level ecological risk assessment (SLERA) were performed as part of the RI. The SRA identified the following chemicals of concern (COC) in groundwater: 1,1-DCE, 1,2-DCA, TCE, and vinyl chloride; and concluded that the concentrations of chlorinated solvents detected in groundwater present an unacceptable risk to human health. The SLERA concluded that none of the constituents of potential ecological concern present a threat to terrestrial ecosystems at the site.

Given the nature and extent of contamination identified in the RI, a remedial action objective (RAO) for Parcel 66(7) was established to minimize potential risk to human receptors associated with the ingestion of contaminated groundwater. The RAO may be achieved by reducing the potential for groundwater exposure (using land use controls [LUC]) and/or reducing the COC concentrations to specified remedial goal options (RGO) through an active remedial approach (groundwater treatment).

RGOs are the concentrations for individual chemicals in groundwater above which remediation or control measures would be required. The RGOs for Parcel 66(7) were primarily determined with consideration of the risk to human health. Because groundwater at FTMC could serve as a future source of drinking water, the maximum contaminant levels (MCL) presented in the EPA Safe Drinking Water Act and the Alabama Primary Drinking Water Standards were selected as the RGOs for Parcel 66(7).

The most restrictive MCL for any of the COCs is 0.002 milligrams per liter (mg/L) for vinyl chloride; therefore, a total chlorinated VOC concentration limit of 0.001 mg/L was selected as a conservative basis for determining the horizontal and vertical extent of groundwater requiring remedial action at Parcel 66(7). Based on this level, the total volume of groundwater requiring remedial action at Parcel 66(7) is estimated to be approximately 460,000 gallons.

As described in EPA guidance, the FFS identifies, describes, and screens the following:

- General Response Actions (GRA) – broad classes of remedial actions employed to meet the RAO for contaminated groundwater at Parcel 66(7). GRAs considered for Parcel 66(7) included no action, natural attenuation, LUCs, containment, groundwater extraction, treatment, and discharge.

- Remedial Technologies and Process Options - evaluated for each GRA based on effectiveness, implementability, and cost.

Select remedial technologies and associated process options were carried forward from the initial screening and were used to form the following remedial alternatives for Parcel 66(7):

- ***Alternative 1 – No Action.*** Leaves the contaminated groundwater in place with no additional measures to prevent human or ecological exposure and serves as a baseline for comparison with the other alternatives.

- ***Alternative 2 – Land-Use Controls.*** Imposes physical, legal, or administrative restrictions on the use of, or limits access to, the property to prevent exposure to contaminants above permissible levels. Alternative 2 would also include groundwater monitoring to ensure that the contaminant plume at Parcel 66(7) does not migrate beyond site boundaries.

- ***Alternative 3 – In Situ Chemical Oxidation using Potassium Permanganate and Groundwater Monitoring.*** Entails treatment of contaminated groundwater using potassium permanganate and groundwater monitoring to achieve the RGOs.

These remedial alternatives were then individually evaluated against seven CERCLA criteria to provide a basis for selecting the most appropriate remedial alternative for Parcel 66(7). The seven criteria include overall protection of human health and the environment; compliance with applicable regulations; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume; short-term effectiveness; implementability; and cost.

Based upon the results of the FFS, the recommended remedial alternative for Parcel 66(7) is Alternative 2 – Land-Use Controls. LUCs are recommended at Parcel 66(7) primarily because:

- LUCs would be protective of human health because they would prohibit the use of groundwater at the site.
- LUCs would satisfy the RAO for Parcel 66(7).
- LUCs are easily implemented with no significant short-term risks to worker health and safety or the community.
- Costs associated with LUCs are less than the costs for groundwater treatment.

1.0 Introduction

The U.S. Army has selected Fort McClellan (FTMC), located in Calhoun County, Alabama, for closure by the Base Realignment and Closure (BRAC) Commission under Public Laws 100-526 and 101-510. The 1990 Base Closure Act, Public Law 101-510, established the process by which U.S. Department of Defense (DOD) installations would be closed or realigned. The BRAC Environmental Restoration Program requires investigation and cleanup of federal properties prior to transfer to the public domain. The U.S. Army is conducting environmental studies of the impact of suspected contaminants at parcels at FTMC under the management of the U.S. Army Corps of Engineers (USACE)-Mobile District.

The Small Weapons Repair Shop, Parcel 66(7), was initially investigated as part of the site investigation (SI) conducted for the Former Ordnance Motor Repair Area, Parcel 75(7). Sampling for the SI at Parcel 66(7) was performed as specified in the Former Ordnance Motor Repair Area SI work plan. Based on the analytical results from the SI, additional investigation was deemed necessary; hence, a remedial investigation (RI) was performed at Parcel 66(7). SI field activities were initiated in January 1999 and were completed in March 1999. RI field activities at Parcel 66(7) were initiated in October 2000 and completed in October 2001. The results of the SI and RI were reported in the *Draft Remedial Investigation Report, Small Weapons Repair Shop, Parcel 66(7)* (IT Corporation [IT], 2002).

This draft focused feasibility study (FFS) develops and evaluates remedial alternatives for Parcel 66(7) based on information provided in the SI and RI and provides a basis for a remedy selection consistent with the Army's intent to transfer Parcel 66(7) to the public domain for future industrial reuse. The USACE contracted IT to complete the FFS for the Small Weapons Repair Shop, Parcel 66(7), under Contract Number DACA21-96-D-0018, Task Order CK05. The FFS was prepared in accordance with U.S. Environmental Protection Agency (EPA) and USACE guidance, including *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988).

1.1 Purpose

The purpose of an FFS within the framework of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is to identify, develop, evaluate, and screen remedial alternatives that address contamination at a particular site. Cost-effective and appropriate remedial alternatives may be more apparent for some sites than for others, in which case the EPA allows for a more focused approach toward identification and screening of

remedial technologies and development of remedial alternatives by means of an FFS. This FFS screens remedial technologies and develops remedial alternatives that may be appropriate for addressing groundwater contamination at Parcel 66(7) identified through the SI and RI. Completion of this FFS will also support various decisions under the Installation Restoration Program process to facilitate the transfer of Parcel 66(7) to the public domain.

1.2 Site Background

The following site background information for both FTMC and Parcel 66(7) is drawn from the RI report (IT, 2002).

1.2.1 FTMC Site Description and History

FTMC is a U. S. Army facility under the control of the U. S. Army Training and Doctrine Command that was closed under the BRAC program in September 1999. Located in northeast Alabama, near the city of Anniston in Calhoun County (Figure 1-1), FTMC consisted of three tracts of land: the Main Post, Choccolocco Corridor, and Pelham Range. The majority of development at FTMC is in the northwest area of the Main Post. The City of Anniston is located to the south and west of the Main Post; adjoining the Main Post installation to the east are the Choccolocco Mountains of the Talladega National Forest.

The Main Post, consisting of 18,929 acres, was purchased by the federal government in March 1917 for the construction of a National Guard camp (Camp McClellan). Pistol and rifle ranges were established north of the camp, automatic rifle and machine gun ranges were established southwest of the camp, and artillery firing ranges were established southeast of the camp toward the Choccolocco Mountains. Camp McClellan expanded throughout the 1920s and 1930s. The advent of World War II in the 1940s brought continued growth for the installation. Most notably, the 22,245 acres of Pelham Range were purchased to the west of the Main Post in early 1940 for artillery, tank, and heavy mortar firing. Approximately 4,488 additional acres to the east of the Main Post (Choccolocco Corridor) were leased from the State of Alabama to connect the Main Post to the Talladega National Forest. Choccolocco Corridor was used for various range training activities. The lease was terminated in May 1998.

The post-war period initially brought a decline in operations at FTMC. A decrease in military spending placed the installation on inactive status. However, in 1950 the installation was reinstated to active status because of the Korean Conflict. The U.S. Army Chemical School was established at FTMC in 1951; the large outdoor training areas allowed for specialized chemical training involving chemical warfare protection, decontamination procedures, flame throwers, and the operation of smoke generators. The Base hospital was renovated to specialize in chest diseases. The first

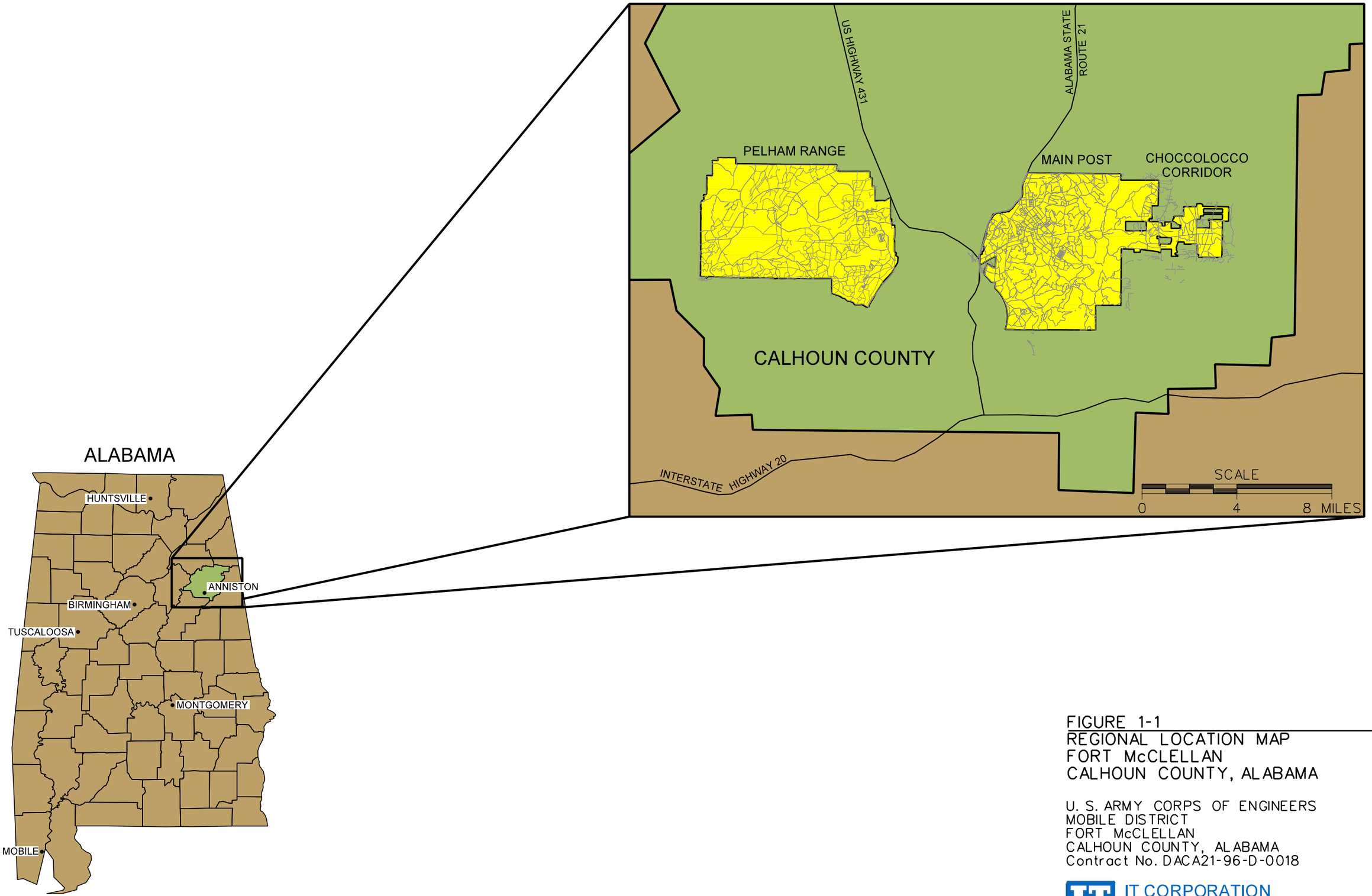

FIGURE 1-1
REGIONAL LOCATION MAP
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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permanent Women's Army Corps (WAC) training facility was established in 1955, although two previous WAC detachments had been established at the installation during the 1940s. Radiological training was conducted in the mid-1950s at Iron Mountain, Alpha Field, and Bromine Field, all located on the Main Post, as well as at Rideout Field on Pelham Range.

The mission of FTMC was changed in 1966, and it became the U.S. Army School/Training Center. An Advanced Individual Training Infantry Brigade was activated in 1966 to meet requirements for the Vietnam War. The brigade was deactivated in 1970 due to continued force reduction in Vietnam.

In 1973, the Chemical Corps School closed, along with the U.S. Army Combat Developments Command Chemical/Biological Radiological Agency. Five years later, in 1978, the WAC was disbanded and the WAC school closed.

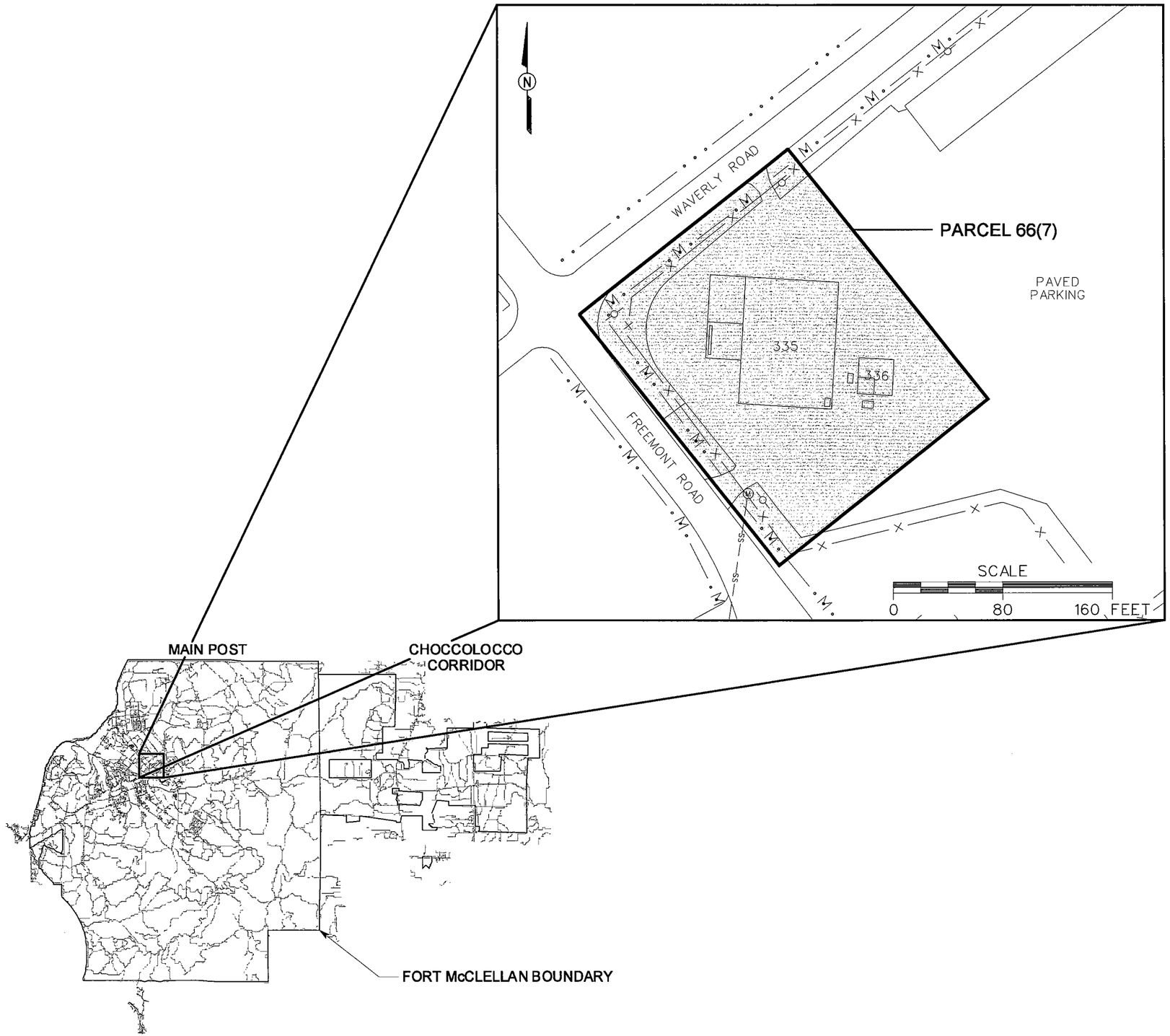
In 1979, the Military Police School was moved to FTMC. In the same year, the U.S. Army Chemical Corps school was re-established, along with a Brigade for Basic Training. U.S. Army Forces Command units, such as D Company, 46th Engineers, were also garrisoned at the post during the 1970s and 1980s.

The mid-1980s brought additional operations to Pelham Range, which is located approximately two miles northwest of Anniston. This area was used for maneuver training and a wide range of activities from small-arms training to tank and artillery training. Pelham Range has also been used for chemical decontamination training and radiological training.

FTMC operations were deactivated and missions completed with the installation closure on September 30, 1999.

1.2.2 Parcel 66(7) Site Description and History

Parcel 66(7) is located in the central portion of the Main Post at the intersection of Waverly Road and Freemont Road (Figure 1-2). Two buildings (Buildings 335 and 336) are located within the parcel boundary (Figure 1-3). Building 335 formerly housed the Small Weapons Repair Shop, where weapons, such as the M-16 rifle, were stored after training exercises. The Small Weapons Repair Shop occupied only a small room on the west side of Building 335. Building 336, an inactive boiler plant, is located just east of Building 335 (Figure 1-3). No other information is available concerning dates of operation or past activities at Building 336. Virtually all of Parcel 66(7) and the area immediately surrounding the parcel are covered with asphalt or concrete pavement; only a narrow strip along the northern and western boundary is covered with grass. A



LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- PARCEL BOUNDARY
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FENCE
- UTILITY POLE
- SANITARY SEWER LINE
- MANHOLE

FIGURE 1-2
SITE LOCATION MAP
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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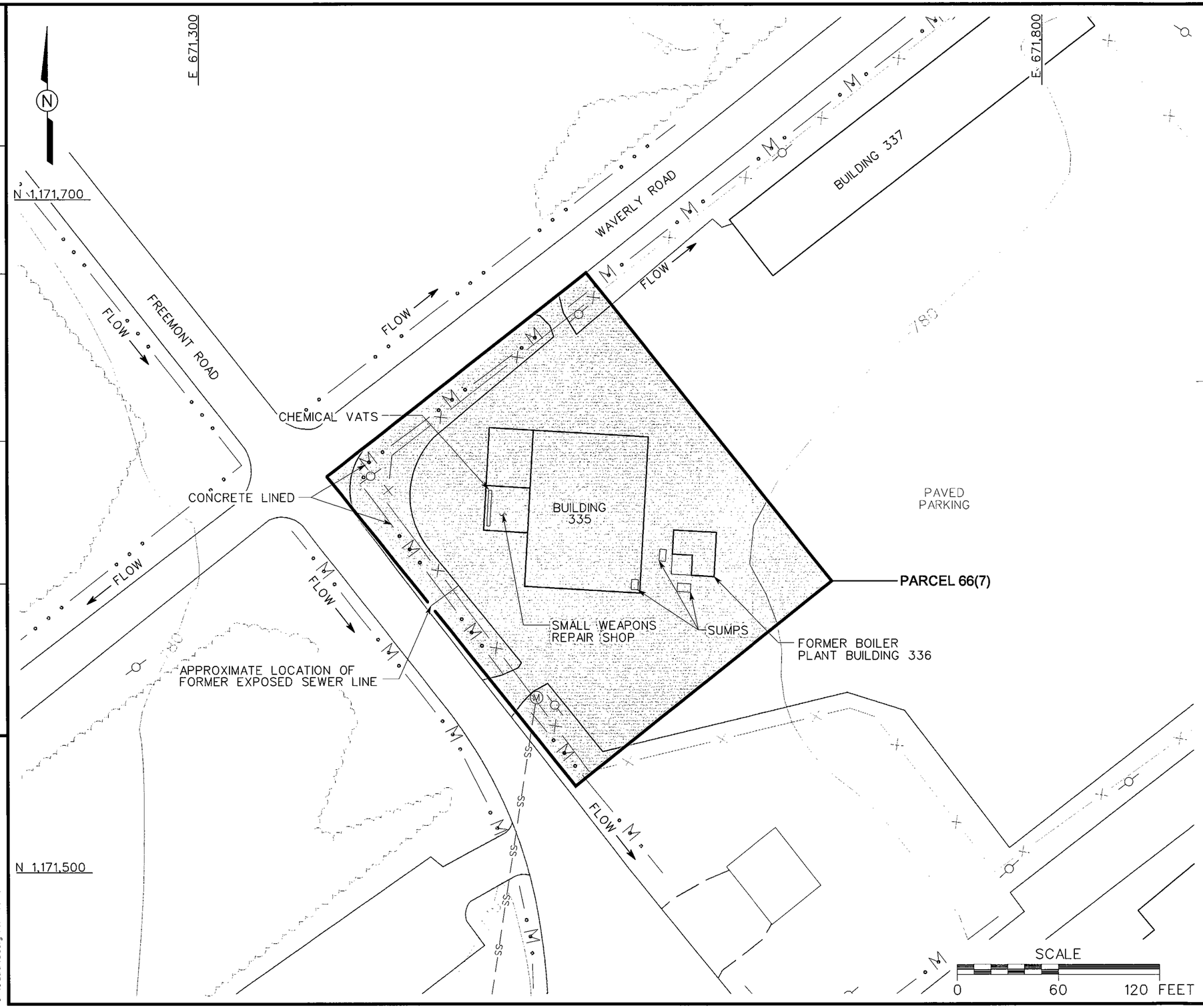

LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 5 FOOT)
- TREES / TREELINE
- PARCEL BOUNDARY
- CULVERT WITH HEADWALL
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FLOW SURFACE WATER FLOW DIRECTION
- FENCE
- UTILITY POLE
- SS SANITARY SEWER LINE
- (M) MANHOLE

FIGURE 1-3
SITE MAP
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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6-foot-high chain-link fence surrounds the entire study area and adjacent parking area. Man-made drainage ditches border the site along Waverly Road to the north and Freemont Road to the west.

In the Small Weapons Repair Shop in Building 335, weapons were disassembled and cleaned using various solutions and solvents, and then were stored until the next exercise. The weapons were brought to the repair shop at Building 335, degreased with 1,1,1-trichloroethane (TCA) in a vapor degreaser, and then stripped with a caustic solution. Bluing/Parkerizing operations were also conducted at the shop. One description of the weapons refinishing activities states that trichloroethene (TCE) was used in the initial step as a degreasing agent for small weapons parts (FTMC, 1985). The vat of TCE used to degrease the parts was typically emptied into drums for disposal. However, the potential existed for the contents of the vat to be discharged to the ground surface outside the building from a drain line at the bottom of the vat. Additional discharges may have occurred from operations conducted in the main part of Building 335 relating to the repair of motorized tanks. Building 335 was maintained by the Alabama National Guard for boiler plant storage, but it is currently empty.

1.3 Summary of Parcel 66(7) Environmental Setting

Physical characteristics of the Parcel 66(7) study area are documented in the RI report, which includes descriptions of site-wide geology, hydrology, hydrogeology, and other regional geographic topics. The following sections detail the site-specific environmental setting.

1.3.1 Physiography and Sensitive Environments

Parcel 66(7) is relatively flat, with an elevation of approximately 780 feet above mean sea level. However, the parcel is located on a topographical divide. The northern portion of the parcel slopes gently to the north, and the southern portion slopes gently to the south. Cane Creek, located approximately 1,300 feet southwest of the parcel, flows to the northwest. Parcel 66(7) is not located within any special interest natural areas, defined as locations where habitat fosters one or more rare, threatened, or endangered species. Parcel 66(7) is not located within a designated wetland area. The closest designated wetlands area is approximately 3,000 feet north of the site, along Cave Creek.

1.3.2 Soils

The soil mapped at Parcel 66(7) is the Rarden silty clay loam. This soil type is found on the uplands and is usually developed from the residuum of shale, fine-grained sandstone, or limestone. The surface soil ranges from dark brown to yellowish brown in color. The subsoil consists of a silt clay to clay that ranges in color from dark brown to yellowish brown. The

runoff and infiltration of this soil type are considered medium. The permeability of this soil is slow, and the capacity for available moisture and organic matter content are low.

1.3.3 Geology

Parcel 66(7) is located within the eroded geologic "window" in the uppermost structural thrust sheet at FTMC. The mapping unit exposed at this parcel is the Mississippian/Ordovician Floyd and Athens Shale, undifferentiated (Figure 1-4). The Floyd Shale consists of thin-bedded, fissile brown to black shale with thin intercalated limestone layers and interbedded sandstone. Athens Shale is comprised of dark gray to black shale and graptolitic shale with localized interbedded dark gray limestone.

Two geologic cross sections were constructed from hollow-stem auger and bedrock coring data collected during the RI at Parcel 66(7). The locations of the geologic cross sections are shown on Figure 1-5, and the cross sections are presented on Figures 1-6 and 1-7. The geologic data collected show that the upper part of the residuum consists of brown to brownish gray to yellowish orange silty clay and clay, with occasional intervals of highly weathered shale. This sequence extends from the ground surface to a depth, in some places, of around 10 to 13 feet below ground surface (bgs). Underlying this interval, and included as residuum, is a variable thickness of highly weathered, light gray to black shale that extends to a maximum depth of approximately 30 feet bgs.

Competent bedrock underlying the residuum consisted of moderately hard, slightly weathered, fractured, dark gray to black shale (Figures 1-6 and 1-7). Some of the fractures in the shale were filled with quartz and/or dolomite. The description of the bedrock encountered during rock coring and drilling activities is consistent with the mapped undifferentiated Floyd and Athens Shale.

1.3.4 Surface Water Hydrology

Parcel 66(7) is located on a local topographical divide and is mostly overlain by asphalt or concrete; only small areas along the northern and western boundaries are covered by grass. Surface runoff from the site collects in man-made ditches located along the northern and western boundaries of the parcel. Runoff from the northern and eastern portions of the parcel collects in a ditch along the northern boundary and eventually empties into Cave Creek. Runoff from the southern and western portions of the parcel collects in a ditch along the western boundary of the parcel and eventually empties into Cane Creek.

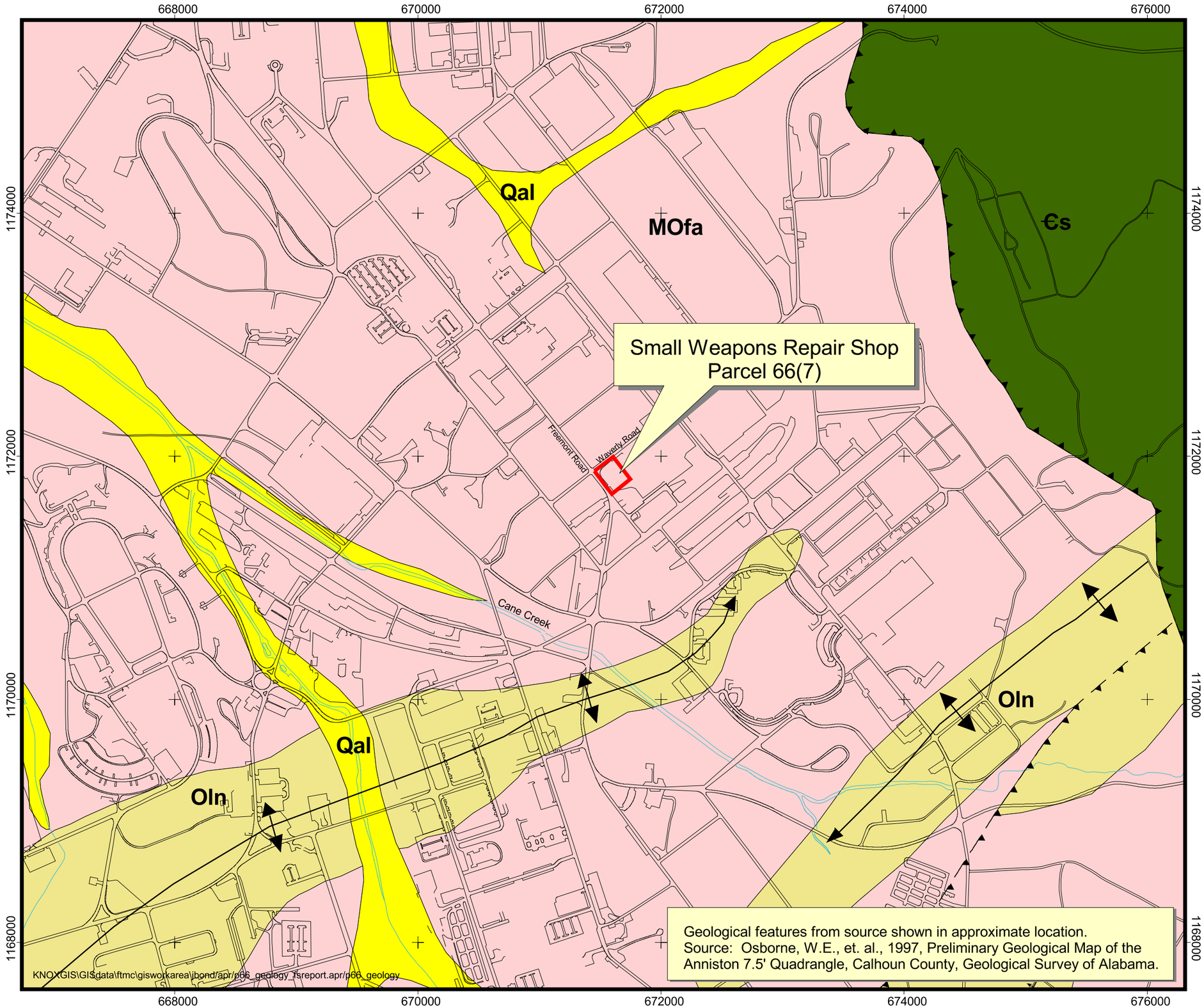

Figure 1-4

Site Geologic Map Small Weapons Repair Shop, Parcel 66(7)

Fort McClellan
Calhoun County, Alabama

Legend

Parcel Boundary

Roads

Streams

Geology

Qal	Quaternary - Alluvium
MOfa	Mississippian/Ordovician - Floyd and Athens Shale, Undifferentiated
Oln	Ordovician - Little Oak and Newala Limestones, Undifferentiated
Ꞓs	Cambrian - Shady Dolomite

Thrust Fault (dashed where inferred; barbs on upper plate)

Plunging Anticline

800 0 800 Feet

NAD 83 State Plane Coordinates

U.S. Army Corps of Engineers
Mobile District

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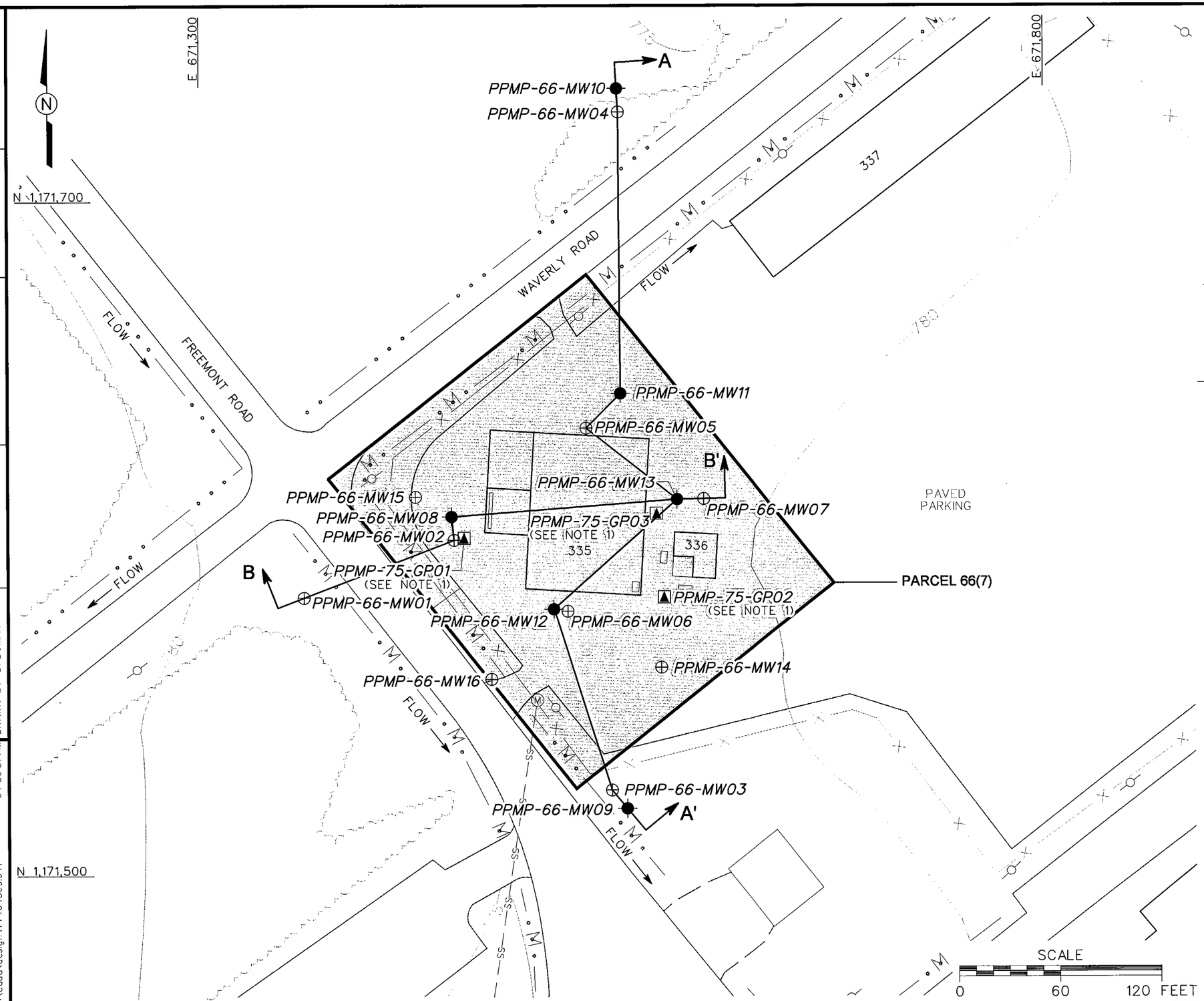

LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 5 FOOT)
- TREES / TREELINE
- PARCEL BOUNDARY
- CULVERT WITH HEADWALL
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FLOW — SURFACE WATER FLOW DIRECTION
- FENCE
- UTILITY POLE
- SS — SANITARY SEWER LINE
- M — MANHOLE
- BEDROCK MONITORING WELL AND GROUNDWATER SAMPLE LOCATION
- RESIDUUM MONITORING WELL AND GROUNDWATER SAMPLE LOCATION
- GROUNDWATER, SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- A A' — CROSS SECTION LOCATION

NOTE:

1. RESIDUUM MONITORING WELL LOCATION.

FIGURE 1-5
CROSS SECTION LOCATION MAP
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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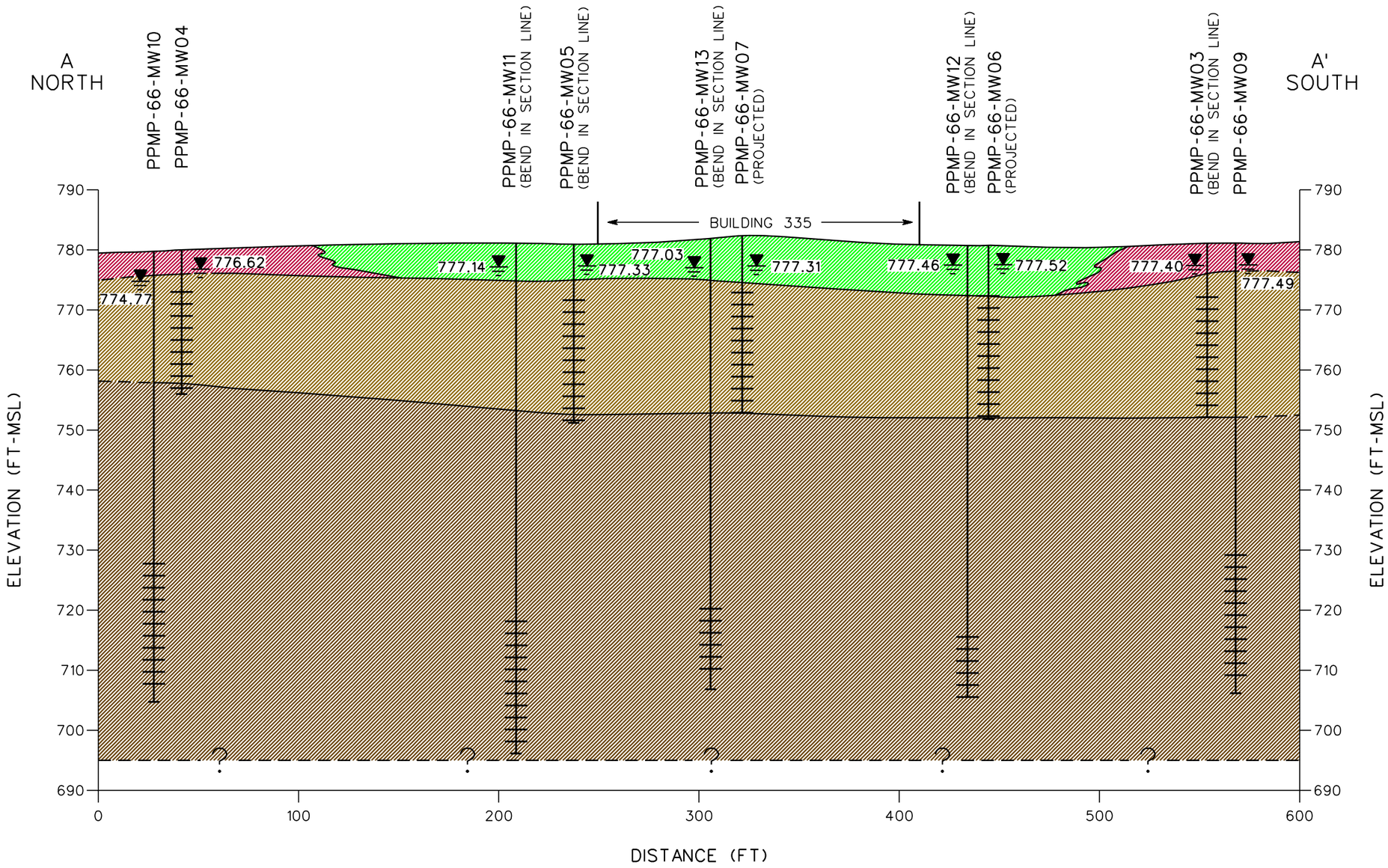

LEGEND

- SCREEN INTERVAL
- WATER TABLE (JANUARY 2002)
- 774.77 GROUNDWATER ELEVATION (FT MSL)
- CONTACT DASHED WHERE INFERRED
- CLAY
- SILTY CLAY
- WEATHERED SHALE
- SHALE

NOTES:

1. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988.
2. DASHED WHERE INFERRED.

HORIZONTAL
0 60 120 FEET

VERTICAL
0 20 40 FEET

FIGURE 1-6
GEOLOGIC CROSS SECTION A-A'
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

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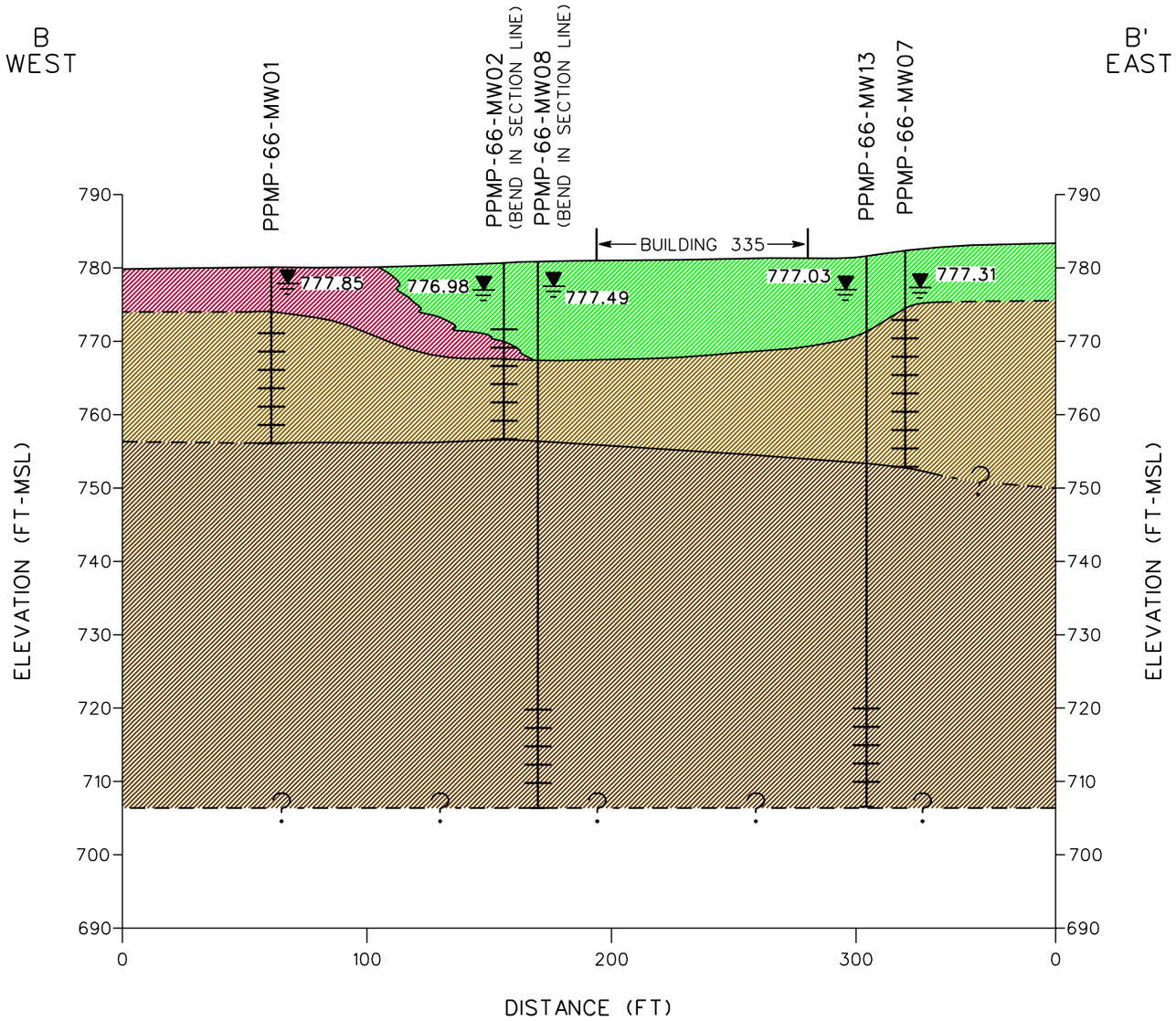

LEGEND

- SCREEN INTERVAL
- WATER TABLE (JANUARY 2002)
- 776.98 GROUNDWATER ELEVATION (FT MSL)
- CONTACT DASHED WHERE INFERRED
- CLAY
- SILTY CLAY
- WEATHERED SHALE
- SHALE

NOTES:

1. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988.
2. DASHED WHERE INFERRED.

HORIZONTAL

0 60 120 FEET

VERTICAL

0 20 40 FEET

FIGURE 1-7
GEOLOGIC CROSS SECTION B-B'
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

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1.3.5 Hydrogeology

The following sections describe the results of groundwater elevation data collected and slug testing completed at Parcel 66(7).

1.3.5.1 Groundwater Flow

Static groundwater levels were measured in the permanent residuum and bedrock monitoring wells at Parcel 66(7) and the surrounding area in January 2002. Regional groundwater flow across the area of the Main Post that includes Parcel 66(7) is from east to west. Groundwater flow across the area appears to be influenced by a topographic high located to the west of the site that has created a local groundwater divide in the vicinity of Parcel 66(7) (Figure 1-8). This interpretation is based on the January 2002 groundwater elevations from residuum monitoring wells and on topography.

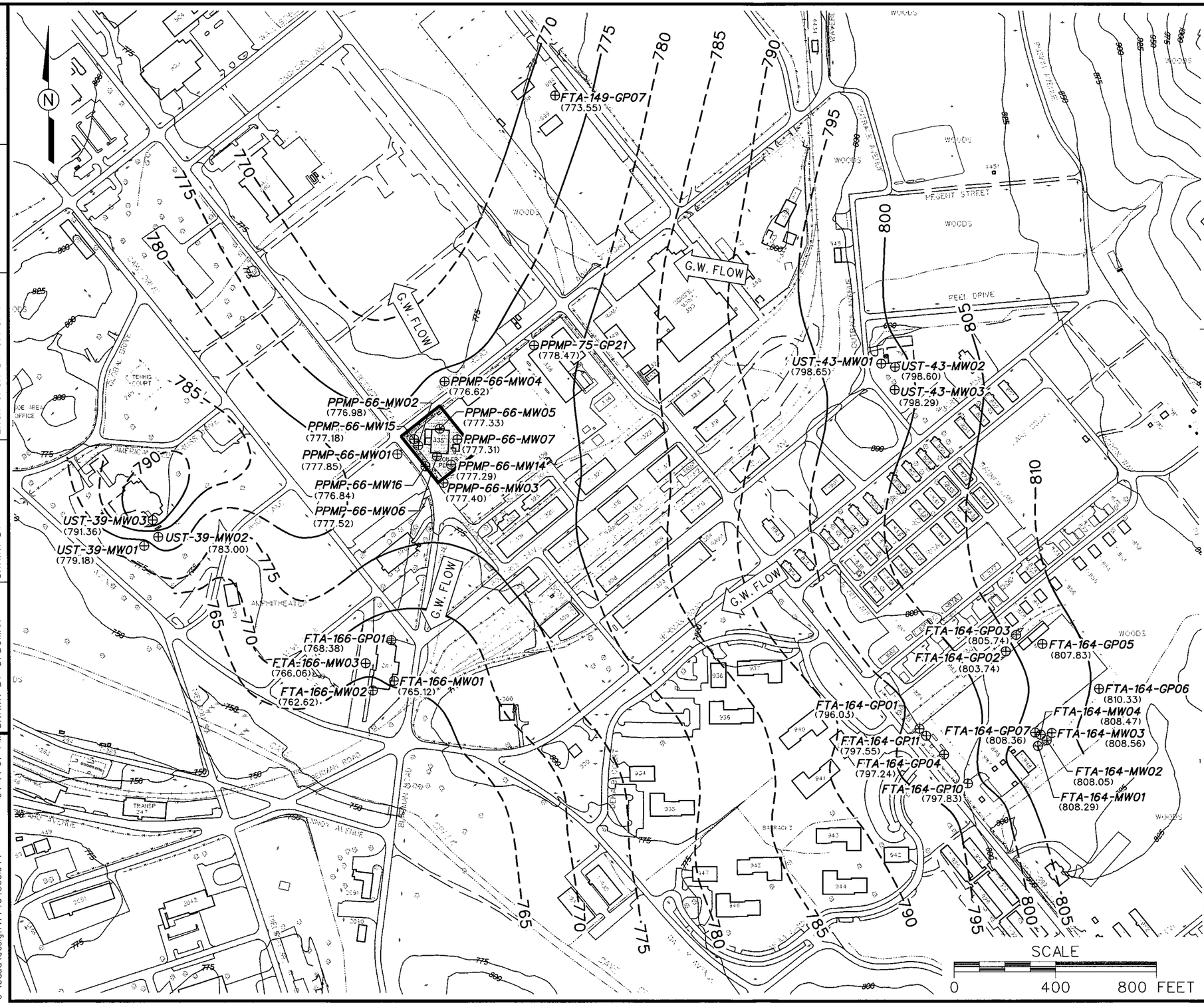
Groundwater elevation maps for Parcel 66(7) were constructed for the residuum and bedrock water-bearing zones (Figures 1-9 and 1-10, respectively). In the residuum, the axis of a groundwater divide is located just to the west of Building 335. Groundwater flow in the northern portion of the site is to the north towards Cave Creek; groundwater flow in the southwestern part of the parcel is to the south towards Cane Creek (Figures 1-8 and 1-9). Based on the January 2002 groundwater elevation data, groundwater flow in the bedrock water-bearing zone (Figure 1-10) is similar to the groundwater flow regime in the residuum water-bearing zone. The position of the divide in the deeper bedrock aquifer, however, has shifted slightly to the east.

1.3.5.2 Aquifer Characteristics

The horizontal hydraulic gradients of the residuum and bedrock water-bearing zones are low, indicating a relatively flat water table. Arithmetic mean values of less than 0.01 foot per foot (ft/ft) in the residuum and only slightly more than 0.01 ft/ft in the bedrock were obtained from the January 2002 data.

The vertical hydraulic gradients calculated from the January 2002 groundwater elevation data are minimal, indicating either weak upward flow (- values) or downward flow (+ values). The varying positive and negative hydraulic conductivity values suggest semiconfined conditions across Parcel 66(7). Although downward gradients are indicated in well clusters within the area of suspected contamination, the values are considered weak and ranged from 0.00147 ft/ft to 0.0075 ft/ft.

Hydraulic conductivity was calculated from both rising and falling head slug tests conducted in six wells at Parcel 66(7). Hydraulic conductivity values for residuum wells ranged from



LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 25 FOOT)
- (776) GROUNDWATER ELEVATION CONTOUR
- (777.33) GROUNDWATER ELEVATION (FT MSL) (JANUARY 2002)
- G.W. FLOW GROUNDWATER FLOW DIRECTION
- PARCEL BOUNDARY
- CULVERT WITH HEADWALL
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FENCE
- UTILITY POLE
- RESIDUUM MONITORING WELL LOCATION

FIGURE 1-8
GROUNDWATER ELEVATION MAP
RESIDUUM MONITORING WELLS
JANUARY 2002
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7) AND ADJACENT AREAS

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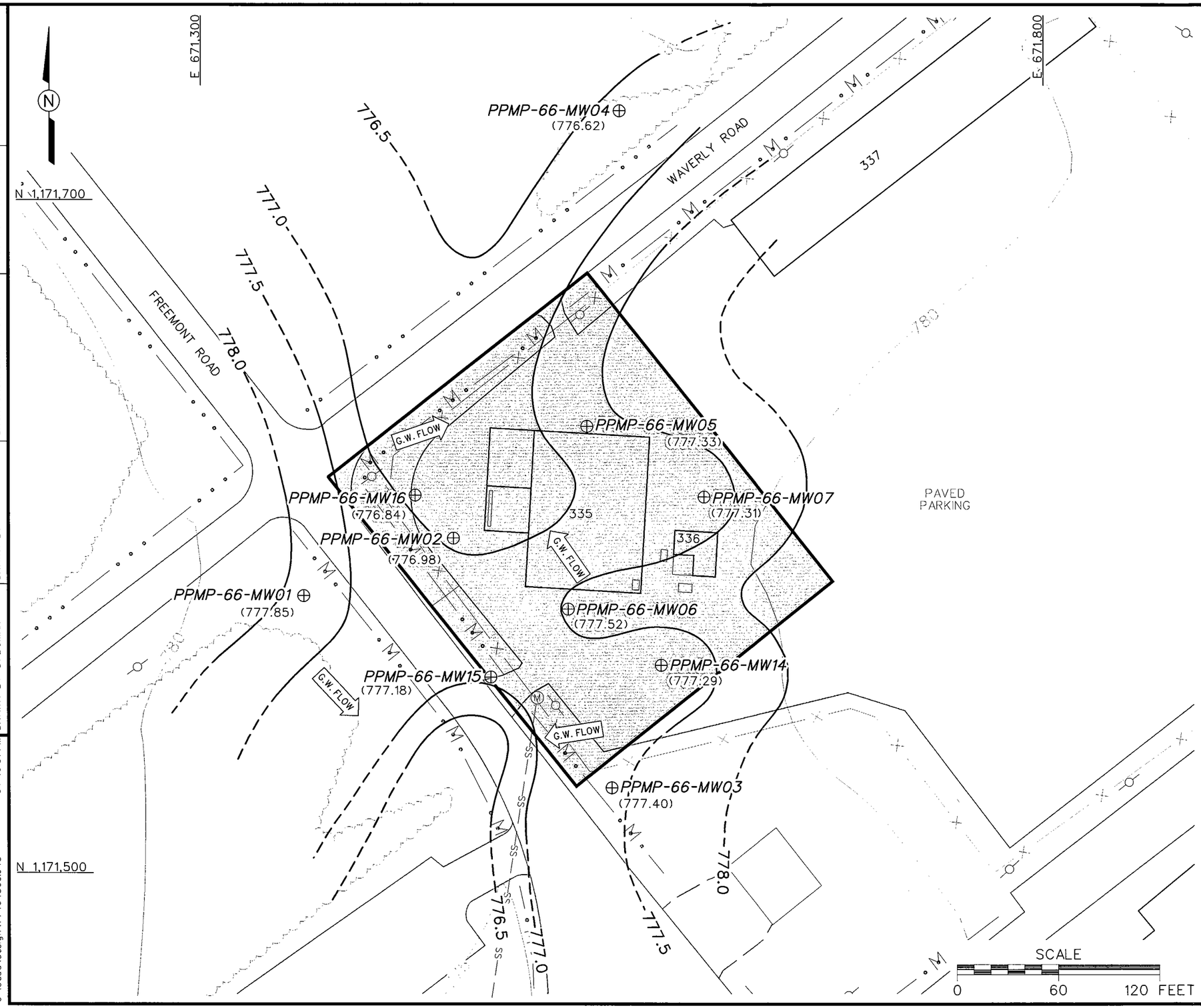

LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 5 FOOT)
- GROUNDWATER ELEVATION CONTOUR (DASHED WHERE INFERRED)
- (777.33) GROUNDWATER ELEVATION (FT MSL) (JANUARY 2002)
- G.W. FLOW GROUNDWATER FLOW DIRECTION
- TREES / TREELINE
- PARCEL BOUNDARY
- CULVERT WITH HEADWALL
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FENCE
- UTILITY POLE
- SS SANITARY SEWER LINE
- M MANHOLE
- RESIDUUM MONITORING WELL LOCATION

SCALE
0 60 120 FEET

FIGURE 1-9
GROUNDWATER ELEVATION MAP
RESIDUUM MONITORING WELLS
JANUARY 2002
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

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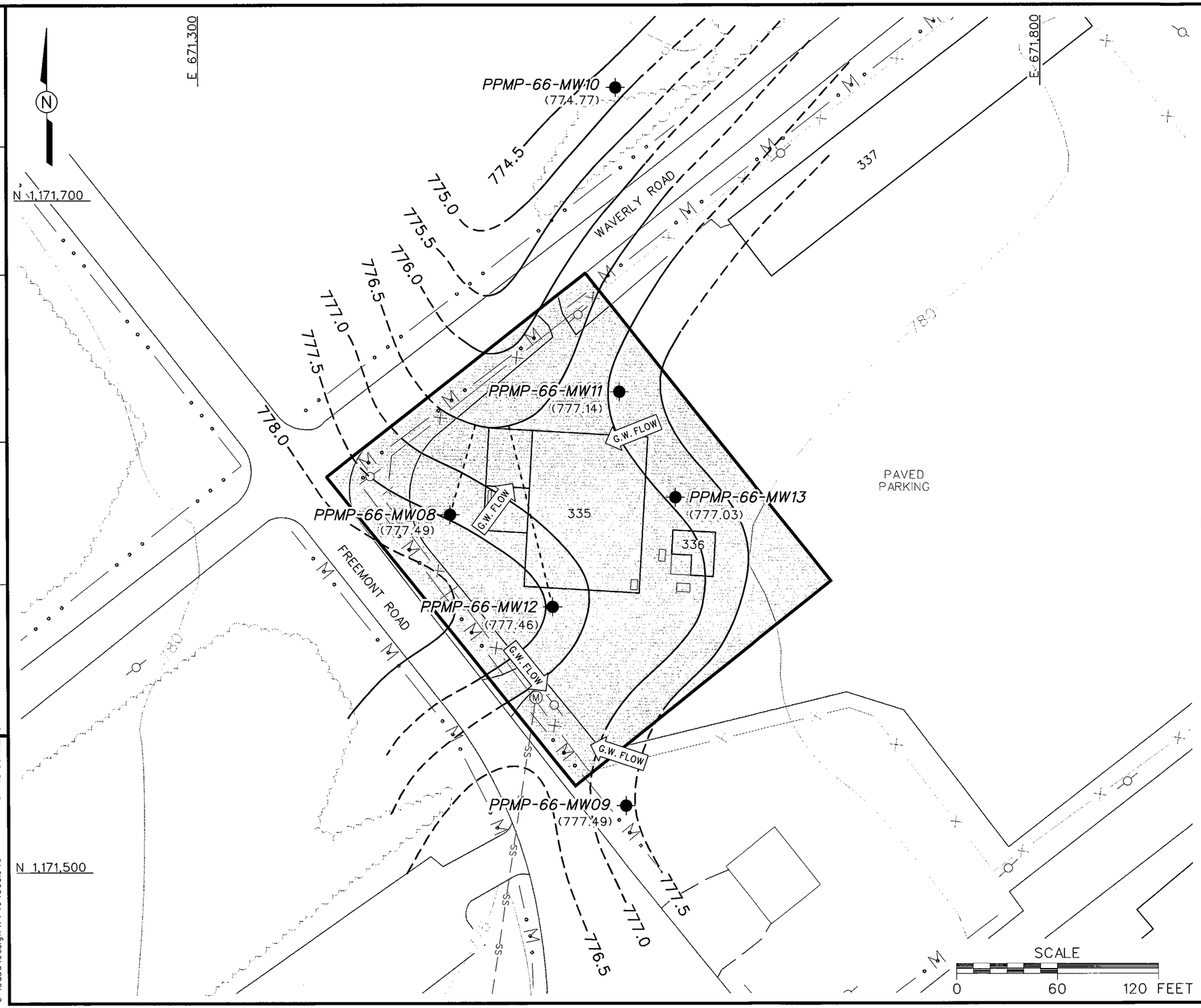

LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 5 FOOT)
- GROUNDWATER ELEVATION CONTOUR (DASHED WHERE INFERRED)
- (777.03) GROUNDWATER ELEVATION (FT MSL) (JANUARY 2002)
- G.W. FLOW GROUNDWATER FLOW DIRECTION
- TREES / TREELINE
- PARCEL BOUNDARY
- CULVERT WITH HEADWALL
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FENCE
- UTILITY POLE
- SS SANITARY SEWER LINE
- M MANHOLE
- BEDROCK MONITORING WELL LOCATION
- LINE OF TRANSECT FOR HORIZONTAL HYDRAULIC GRADIENTS

FIGURE 1-10
GROUNDWATER ELEVATION MAP
BEDROCK MONITORING WELLS
JANUARY 2002
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

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approximately 0.01 feet per day (ft/day) to 0.92 ft/day, with a geometric mean of 0.07 ft/day. For the bedrock wells, conductivity values ranged from approximately 0.03 ft/day to 0.30 ft/day, with a geometric mean of 0.09 ft/day. The average linear velocity was calculated for groundwater flow in the residuum and bedrock. Arithmetic mean horizontal hydraulic gradients and geometric mean hydraulic conductivity values were used. Effective porosities were estimated at 30 percent for the residuum and 15 percent for the bedrock. Based on these parameters, groundwater flow velocities were calculated to be approximately 0.0022 ft/day for the residuum and 0.0078 ft/day for the bedrock.

1.4 Summary of Previous Investigations

Three investigations have been completed at Parcel 66(7). An environmental baseline survey (EBS) was conducted to document current environmental conditions of all FTMC property (Environmental Science and Engineering, Inc. [ESE], 1998). Parcel 66(7) was originally investigated as part of the SI conducted for the Former Ordnance Motor Repair Area, Parcel 75(7). The SI determined that contamination was present at Parcel 66(7); therefore, an RI was conducted. The results of the SI sampling at Parcel 66(7) were documented in the RI report for Parcel 66(7). The purpose of the RI was to determine the nature and extent of contamination at Parcel 66(7) and to identify chemicals that pose an unacceptable risk to human health and environment. A brief summary of the results of the EBS and SI/RI is provided in the following sections.

1.4.1 Environmental Baseline Survey

An EBS was completed to document current environmental conditions of all FTMC property. The study identified sites that, based on available information, do not have a history of contamination and comply with DOD guidelines for fast-track cleanup at closing installations.

The EBS also provided a baseline picture of FTMC properties by identifying and categorizing the properties by seven criteria.

1. Areas where no storage, release, or disposal of hazardous substances or petroleum products has occurred (including no migration of these substances from adjacent areas)

2. Areas where only release or disposal of petroleum products has occurred

3. Areas where release, disposal, and/or migration of hazardous substances has occurred, but at concentrations that do not require a removal or remedial response

4. Areas where release, disposal, and/or migration of hazardous substances has occurred, and all removal or remedial actions to protect human health and the environment have been taken

5. Areas where release, disposal, and/or migration of hazardous substances has occurred, and removal or remedial actions are underway, but all required remedial actions have not yet been taken

6. Areas where release, disposal, and/or migration of hazardous substances has occurred, but required actions have not yet been implemented

7. Areas that are not evaluated or require additional evaluation.

The EBS was conducted in accordance with protocols of the Community Environmental Response Facilitation Act (CERFA) (Public Law 102-426) and DOD policy regarding contamination assessment. Record searches and reviews were performed on all reasonably available documents from FTMC, the Alabama Department of Environmental Management (ADEM), EPA Region 4, and Calhoun County, as well as a database search of CERCLA-regulated substances, petroleum products, and facilities regulated under the Resource Conservation and Recovery Act. Available historical maps and aerial photographs were reviewed to document historical land uses. Personal and telephone interviews of past and present FTMC employees and military personnel were conducted. In addition, visual site inspections were conducted to verify conditions of specific property parcels.

The Small Weapons Repair Shop, Parcel 66(7), was identified as a Category 7 CERFA site in the EBS. Category 7 CERFA parcels are areas that have not been evaluated and/or that require additional evaluation to determine their environmental condition.

1.4.2 Site Investigation and Remedial Investigation

In accordance with Contract Number DACA21-96-D-0018, Task Orders CK05 and CK10, IT completed SI and RI activities at Parcel 66(7). The SI determined that contamination was present at Parcel 66(7); therefore, the RI was conducted to evaluate the nature and extent of the contamination and to assess future risks to human health and the environment.

Parcel 66(7) was originally investigated as a part of the SI for the Former Ordnance Motor Repair Area, Parcel 75(7). The results from the SI indicated that organic chemicals (1,1-dichloroethene [DCE], cis-1,2-DCE, and vinyl chloride [VC]) were present in the groundwater at Parcel 66(7) and that additional investigation was warranted. These chemicals are believed to be associated with chlorinated solvents used during the cleaning of weapons at the Small Weapons

Repair Shop and/or activities conducted in association with the repair of tanks in the main part of Building 335.

The SI and RI at Parcel 66(7) consisted of the sampling and analysis of three surface soil samples, three subsurface soil samples, and nineteen groundwater samples. A total of nineteen groundwater monitoring wells, including three temporary wells, ten permanent residuum wells, and six permanent bedrock wells, were installed at the site to facilitate groundwater sample collection and to provide site-specific geological and hydrogeological characterization. The samples collected during the SI were analyzed for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals, polychlorinated biphenyls (PCB), pesticides, and herbicides. Groundwater samples collected during the RI were analyzed for VOCs only.

Based on the results of the RI, further sampling of the groundwater for VOCs and natural attenuation parameters at Parcel 66(7) was recommended. A FFS was also recommended to screen remedial technologies and process options for groundwater remedial alternatives.

1.4.2.1 Nature and Extent of Contamination in Soil

During the RI, three surface soil samples and three subsurface soil samples were collected for chemical analysis from beneath the asphalt cover at Parcel 66(7).

In surface soil samples, several metals were detected at concentrations exceeding residential human health site-specific screening levels (SSSL), ecological screening values (ESV), and background screening values. The SSSLs and ESVs were developed by IT as part of the human health and ecological risk evaluations associated with site investigations being performed under the BRAC Environmental Restoration Program at FTMC. The SSSLs, ESVs, and polynuclear aromatic hydrocarbon (PAH) background screening values are presented in the *Final Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000). An integrated statistical and geochemical evaluation concluded, however, that the elevated metals concentrations most likely result from the preferential enrichment of samples with iron or manganese oxides that naturally concentrate specific trace elements. The study concluded that the metals are naturally occurring. A similar conclusion was reached for metals that exceeded SSSLs in subsurface soil samples.

VOCs were detected in surface and subsurface soil samples but at concentrations below SSSLs and/or ESVs. Several SVOCs, all of which were PAH compounds, were detected in one surface soil sample at concentrations exceeding SSSLs and/or ESVs. In subsurface soils, no SVOCs were detected above SSSLs. The occurrence of PAH compounds in the one surface soil sample

is believed to be directly related to the asphalt surface covering Parcel 66(7). One pesticide (endrin) was detected in one surface soil sample above its ESV; pesticides were not detected in the subsurface soil samples. Endrin has an adsorption coefficient similar to PAH compounds, and its presence in one surface soil sample beneath the asphalt cover at the site is not considered to pose a risk to human health or the environment.

1.4.2.2 Nature and Extent of Contamination in Groundwater

During the RI, nineteen groundwater samples were collected for chemical analysis at Parcel 66(7). Based on the evaluation of the soil and groundwater data, the most likely fate and transport pathway for groundwater contamination is the leaching of organic contaminants within subsurface soils and movement to the residuum aquifer system.

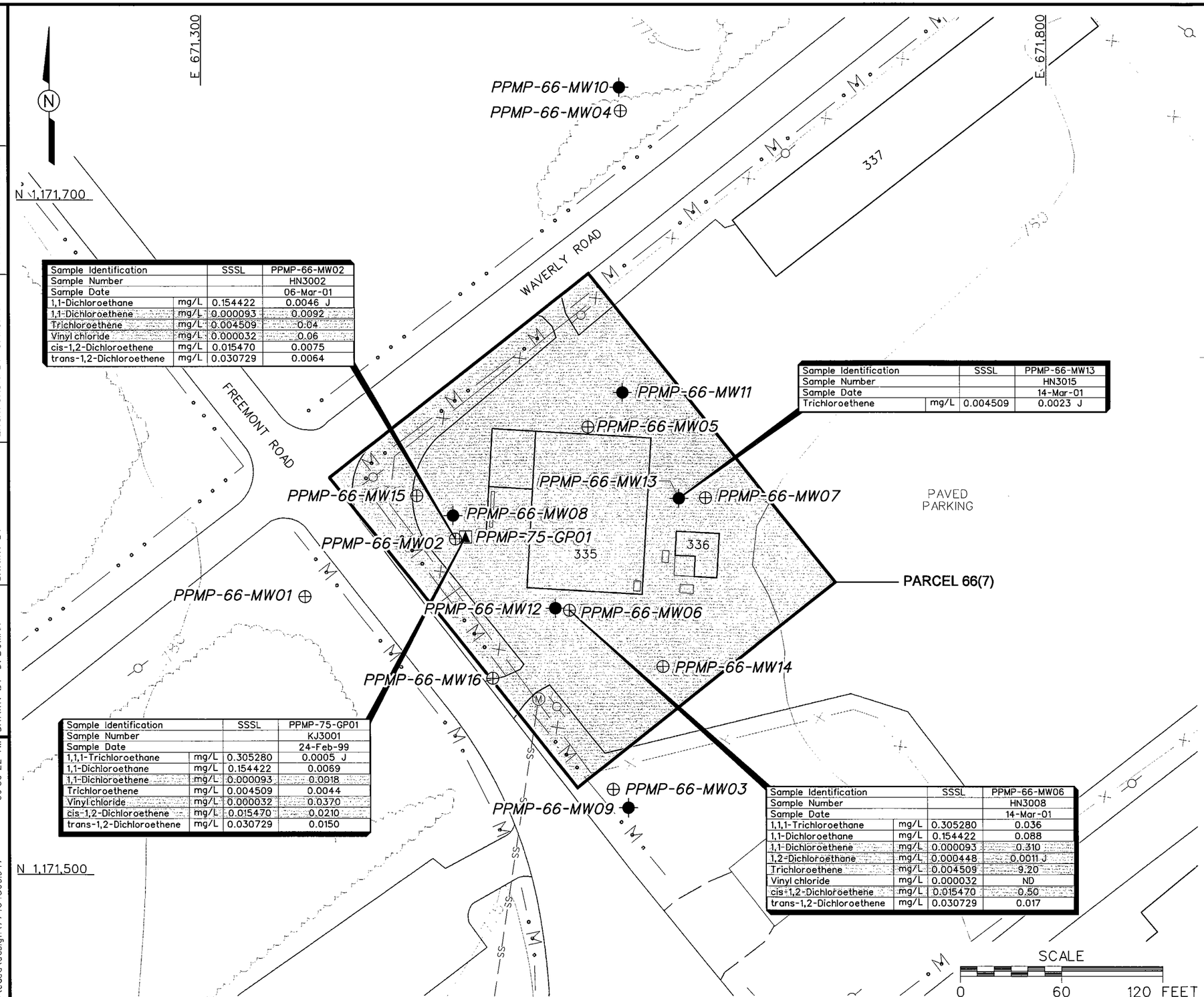
Although iron and manganese were detected in two groundwater samples at concentrations exceeding SSSLs and background concentrations, an integrated statistical and geochemical evaluation of the data concluded that the metals are most likely naturally occurring. However, an elevated manganese concentration in the groundwater sample from monitoring well PPMP-75-GP01 may have been caused by reductive dissolution, which is a secondary effect of the VOC contamination in groundwater at that location.

All nineteen groundwater samples were analyzed for VOCs. A total of twelve VOCs were detected in ten of the samples. VOC concentrations in the ten groundwater samples ranged from 0.00033 to 9.2 milligrams per liter (mg/L).

The concentrations of five chlorinated VOCs exceeded their respective SSSLs as follows:

- 1,1-DCE (0.0018 to 0.31 mg/L) in three wells (PPMP-66-MW02, PPMP-66-MW06, and PPMP-75-GP01)
- 1,2-Dichloroethane (DCA) (0.0011 mg/L) in one well (PPMP-66-MW06)
- cis-1,2-DCE (0.05 and 0.021 mg/L) in two wells (PPMP-66-MW06 and PPMP-75-GP01)
- TCE (0.04 and 9.2 mg/L) in two wells (PPMP-66-MW02 and PPMP-66-MW06)
- VC (0.06 and 0.037 mg/L) in two wells (PPMP-66-MW02 and PPMP-75-GP01).

Figure 1-11 shows the location and concentrations of chlorinated VOCs detected in groundwater at Parcel 66(7). Figure 1-12 is an isopleth map showing the horizontal extent of total chlorinated



Sample Identification		SSSL	PPMP-66-MW02
Sample Number			HN3002
Sample Date			06-Mar-01
1,1-Dichloroethane	mg/L	0.154422	0.0046 J
1,1-Dichloroethene	mg/L	0.000093	0.0092
Trichloroethene	mg/L	0.004509	0.04
Vinyl chloride	mg/L	0.000032	0.06
cis-1,2-Dichloroethene	mg/L	0.015470	0.0075
trans-1,2-Dichloroethene	mg/L	0.030729	0.0064

Sample Identification		SSSL	PPMP-66-MW13
Sample Number			HN3015
Sample Date			14-Mar-01
Trichloroethene	mg/L	0.004509	0.0023 J

Sample Identification		SSSL	PPMP-75-GP01
Sample Number			KJ3001
Sample Date			24-Feb-99
1,1,1-Trichloroethane	mg/L	0.305280	0.0005 J
1,1-Dichloroethane	mg/L	0.154422	0.0069
1,1-Dichloroethene	mg/L	0.000093	0.0018
Trichloroethene	mg/L	0.004509	0.0044
Vinyl chloride	mg/L	0.000032	0.0370
cis-1,2-Dichloroethene	mg/L	0.015470	0.0210
trans-1,2-Dichloroethene	mg/L	0.030729	0.0150

Sample Identification		SSSL	PPMP-66-MW06
Sample Number			HN3008
Sample Date			14-Mar-01
1,1,1-Trichloroethane	mg/L	0.305280	0.036
1,1-Dichloroethane	mg/L	0.154422	0.088
1,1-Dichloroethene	mg/L	0.000093	0.310
1,2-Dichloroethane	mg/L	0.000448	0.0011 J
Trichloroethene	mg/L	0.004509	9.20
Vinyl chloride	mg/L	0.000032	ND
cis-1,2-Dichloroethene	mg/L	0.015470	0.50
trans-1,2-Dichloroethene	mg/L	0.030729	0.017

LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 5 FOOT)
- TREES / TREELINE
- PARCEL BOUNDARY
- CULVERT WITH HEADWALL
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FENCE
- UTILITY POLE
- SS — SANITARY SEWER LINE
- (M) MANHOLE
- BEDROCK MONITORING WELL LOCATION
- RESIDUUM MONITORING WELL LOCATION
- GROUNDWATER, SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- J ESTIMATED CONCENTRATION
- SSSL SITE-SPECIFIC SCREENING LEVEL
- VOC VOLATILE ORGANIC COMPOUND
- mg/L MILLIGRAMS PER LITER
- ND NOT DETECTED
- CONCENTRATION EXCEEDS SSSL

NOTE:

1. EXCLUDES COMMON LABORATORY CONTAMINANTS CHLOROFORM AND METHYLENE CHLORIDE.

FIGURE 1-11
CHLORINATED VOCs DETECTED IN GROUNDWATER
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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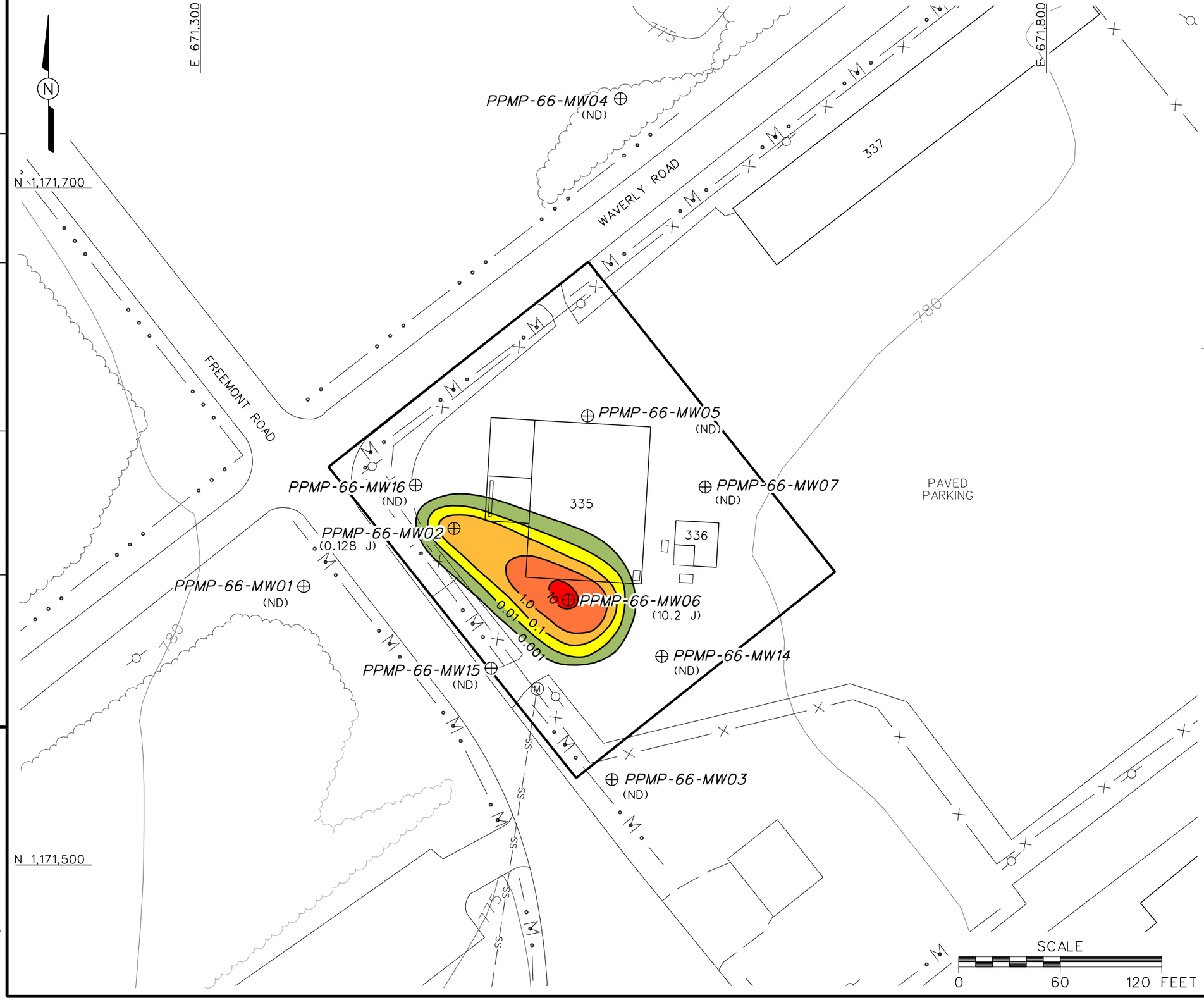

LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 5 FOOT)
- TREES / TREELINE
- PARCEL BOUNDARY
- CULVERT WITH HEADWALL
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FENCE
- UTILITY POLE
- SANITARY SEWER LINE
- MANHOLE
- RESIDUUM MONITORING WELL LOCATION
- 10.0 TOTAL CHLORINATED VOC CONCENTRATION (mg/L)
- (0.20) CONCENTRATION IN MILLIGRAMS PER LITER (mg/L)
- (ND) NOT DETECTED
- J ESTIMATED CONCENTRATION

NOTE:

1. TOTAL CHLORINATED VOC CONCENTRATION EXCLUDES COMMON LABORATORY CONTAMINANTS CHLOROFORM AND METHYLENE CHLORIDE.

FIGURE 1-12
TOTAL CHLORINATED VOCs
IN RESIDUUM GROUNDWATER ZONE
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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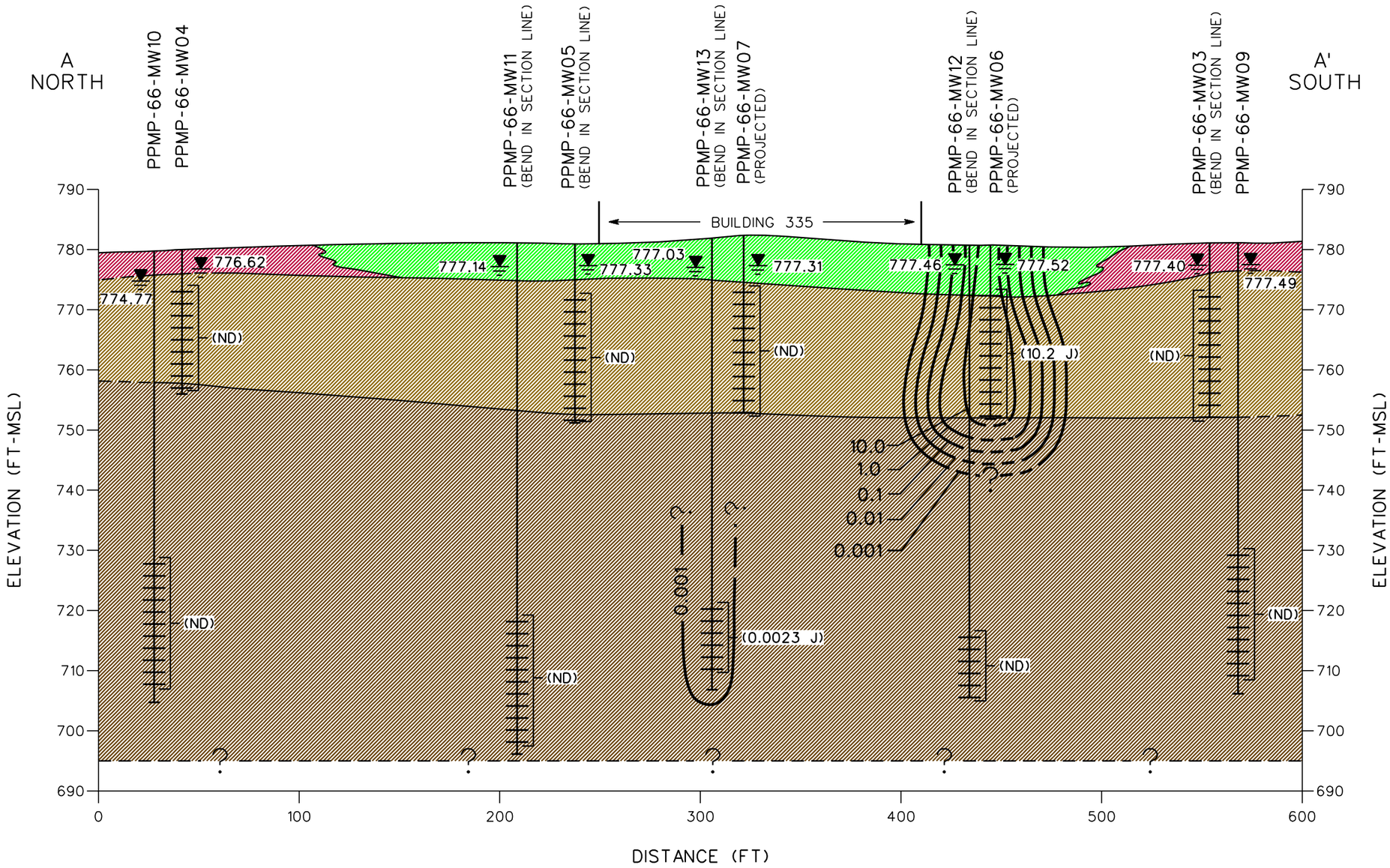
VOCs in the residuum groundwater zone. The vertical extent of these contaminants in groundwater is restricted to the interval of weathered shale comprising the lower part of the residuum. Figures 1-13 and 1-14 present cross-sectional views of the distribution of total chlorinated VOCs in relation to the subsurface geology. Contamination is verified as not present in the deeper competent bedrock. The horizontal extent of contamination is defined.

The rate and potential distance of contaminant migration were estimated for both the residuum and bedrock. The maximum solute transport rates for vinyl chloride were calculated to be 0.56 feet per year in the residuum and 0.65 feet per year in the bedrock. These values suggest that, over a 50-year period, movement of contaminants beyond the parcel boundary is not likely to occur.

1.5 Human Health/Ecological Risks

A streamlined human health risk assessment (SRA) was performed to determine the potential risk to human health from exposure to environmental media at Parcel 66(7). Three receptor scenarios were evaluated in the SRA: resident, groundskeeper, and construction worker. Chemicals of potential concern (COPC) included five VOCs in groundwater (1,1-DCE, 1,2-DCA, cis-1,2-DCE, TCE, and VC) and four PAH compounds in soils. The SRA concluded that the concentrations of chlorinated solvents detected in groundwater present an unacceptable risk to human health. This risk is not realized unless the groundwater is developed as a potable water source. The PAHs in soils were consistent with anthropogenic background, and it was concluded that they do not represent a significant site-related risk to human health.

A screening-level ecological risk assessment (SLERA) was performed to determine the potential risk to ecological receptors from exposure to environmental media at Parcel 66(7). The SLERA identified six metals, four PAH compounds, and one pesticide (endrin) as constituents of potential ecological concern in surface soil. The arithmetic mean concentrations of these constituents, however, were less than their respective background threshold values and/or ESVs. Further, statistical and geochemical evaluations of the metals results indicated that they were all naturally occurring. The PAHs in surface soil were attributed to asphalt pavement at the site rather than mission-related Army activities. The SLERA concluded that none of the constituents of potential ecological presents a threat to terrestrial ecosystems at the site.



LEGEND

	SCREEN INTERVAL
	WATER TABLE (JANUARY 2002)
774.77	GROUNDWATER ELEVATION (FT MSL)
	CONTACT DASHED WHERE INFERRED
0.1	TOTAL CHLORINATED VOCs CONCENTRATION (mg/L) (DASHED WHERE INFERRED)
(10.2)	CONCENTRATION IN MILLIGRAMS PER LITER (mg/L)
(ND)	NOT DETECTED
J	ESTIMATED CONCENTRATION
	CLAY
	SILTY CLAY
	WEATHERED SHALE
	SHALE

NOTES:

1. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988.
2. DASHED WHERE INFERRED.
3. TOTAL CHLORINATED VOC CONCENTRATION EXCLUDES COMMON LABORATORY CONTAMINANTS CHLOROFORM AND METHYLENE CHLORIDE.

HORIZONTAL

0 60 120 FEET

VERTICAL

0 20 40 FEET

FIGURE 1-13
TOTAL CHLORINATED VOCs
GEOLOGIC CROSS SECTION A-A'
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

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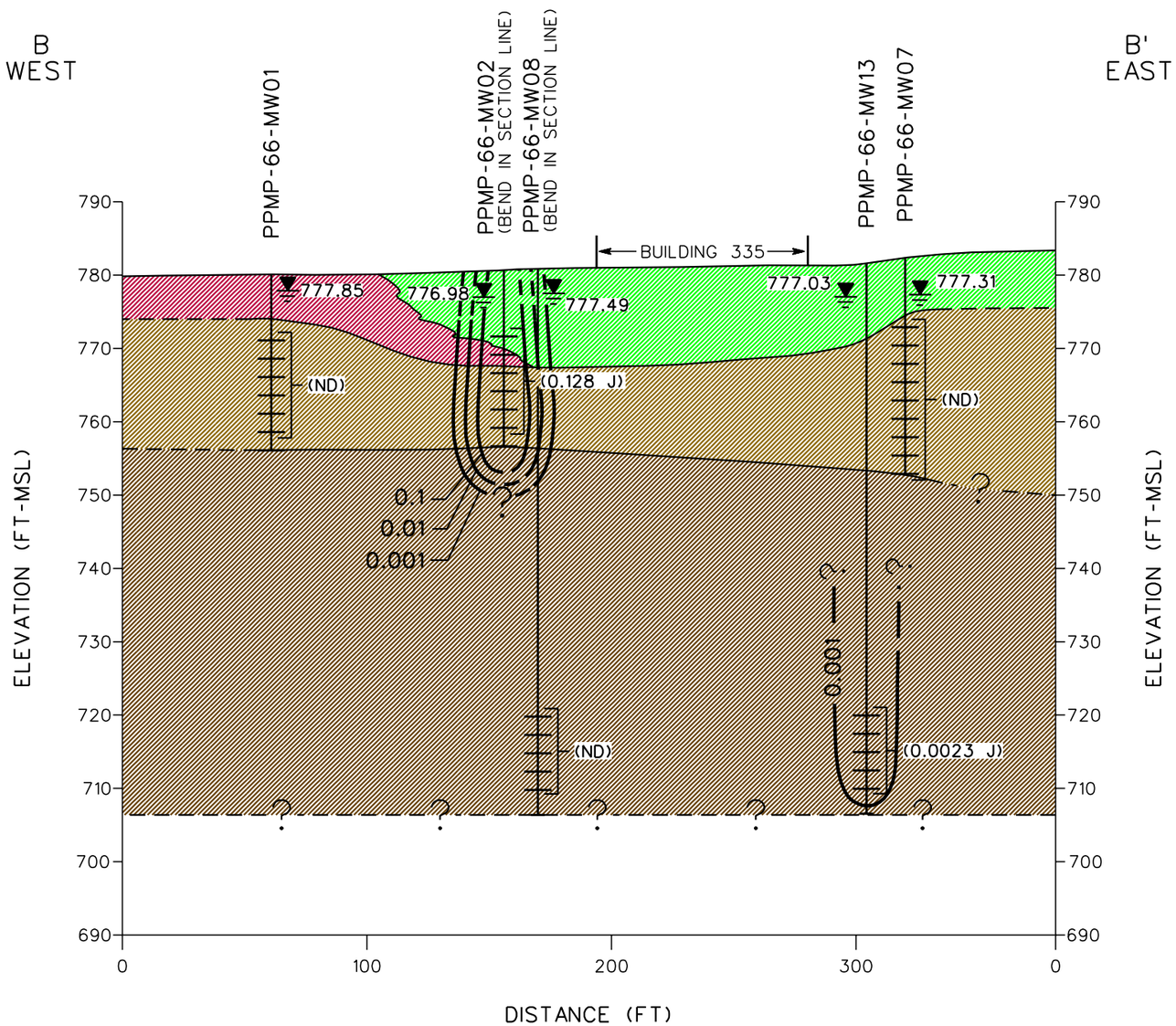

LEGEND

	SCREEN INTERVAL
	WATER TABLE (JANUARY 2002)
776.98	GROUNDWATER ELEVATION (FT MSL)
· — ? — —	CONTACT DASHED WHERE INFERRED
0.1	TOTAL CHLORINATED VOCs CONCENTRATION (mg/L) (DASHED WHERE INFERRED)
(0.128 J)	CONCENTRATION IN MILLIGRAMS PER LITER (mg/L)
(ND)	NOT DETECTED
J	ESTIMATED CONCENTRATION
	CLAY
	SILTY CLAY
	WEATHERED SHALE
	SHALE

NOTES:

1. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988.
2. DASHED WHERE INFERRED.
3. TOTAL CHLORINATED VOC CONCENTRATION EXCLUDES COMMON LABORATORY CONTAMINANTS CHLOROFORM AND METHYLENE CHLORIDE.

HORIZONTAL

0 60 120 FEET

VERTICAL

0 20 40 FEET

FIGURE 1-14
TOTAL CHLORINATED VOCs
GEOLOGIC CROSS SECTION B-B'
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

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1.6 Report Organization

This FFS report is organized as follows:

- ***Chapter 1.0 – Introduction.*** This chapter states the purpose of the FFS, describes site background, summarizes previous investigations, and details human health/ecological risks.

- ***Chapter 2.0 – Identification of the Remedial Action Objective and Remedial Goal Options.*** This chapter defines the remedial action objective and describes applicable or relevant and appropriate requirements and remedial goal options.

- ***Chapter 3.0 – Identification and Screening of Remedial Technologies.*** This chapter identifies areas requiring remedial action and discusses potential remedial technologies and process options with respect to effectiveness, implementability, and cost.

- ***Chapter 4.0 – Development and Detailed Analysis of Remedial Alternatives.*** This chapter combines process options to form remedial alternatives and evaluates remedial alternatives against seven CERCLA criteria.

- ***Chapter 5.0 – Comparative Analysis of Alternatives.*** This chapter evaluates the relative performance of each alternative with respect to the seven CERCLA criteria.

- ***Chapter 6.0 – Recommended Remedial Alternative.*** This chapter provides the rationale for selecting a remedial alternative.

- ***Chapter 7.0 – References.*** This chapter lists the references cited in this FFS report.

2.0 Identification of the Remedial Action Objective and Remedial Goal Options

2.1 Remedial Action Objective

This section presents the remedial action objective (RAO) for Parcel 66(7) at FTMC. CERCLA and the National Contingency Plan (NCP) present the procedures for deriving the RAOs used at all Superfund sites. Although FTMC is not currently on the Superfund list and is not proposed for inclusion, the CERCLA guidance was used as a basis for this FFS. RAOs refer to the statutory requirements that should be addressed for all of the remedial actions for a given site. These objectives are usually as specific as possible without unduly limiting the range of alternatives that can be developed for a detailed feasibility evaluation. RAOs include goals for protecting human health and the environment that are specific to each of the potentially affected environmental media.

An SRA was performed in the RI to determine the threat to human health from exposure to environmental media at Parcel 66(7). Three receptor scenarios were evaluated: groundskeeper, construction worker, and resident. The estimates of total incremental lifetime cancer risk (ILCR) for the groundskeeper and resident are above the risk management range (1E-6 to 1E-4), and the hazard index (HI) estimates exceeded 1 (the threshold level for the occurrence of adverse noncancer effects) for all three receptor scenarios for groundwater. The data clearly show, however, that chlorinated VOCs in groundwater are the risk drivers and are responsible for cancer and noncancer risks exceeding acceptable or threshold levels and that soil did not present a significant site-related risk to human health.

Per the SRA, the chemicals of concern (COC) in groundwater include 1,1-DCE, 1,2-DCA, TCE, and VC. The SRA concluded that these chlorinated compounds in groundwater present an unacceptable risk to human health.

A SLERA was also conducted during the RI activities. The results of the SLERA revealed that none of the constituents in surface soil presents an unacceptable risk to terrestrial ecosystems at FTMC; therefore, the RAO will not include a reference to the overall protection of the environment.

The RAO for Parcel 66(7) is to minimize the potential risk to human receptors associated with the ingestion of groundwater containing elevated COC concentrations, so that the Army can release the site for its intended industrial reuse. This RAO can be achieved by reducing the potential for groundwater exposure (e.g., through the use of land-use controls) and/or reducing the COC

concentrations to specified remediation goal options (RGO) through an active remedial approach (e.g., in situ chemical oxidation).

2.2 Applicable or Relevant and Appropriate Requirements

CERCLA specifies that remedial actions for the cleanup of hazardous substances must comply with applicable or relevant and appropriate requirements (ARAR) or standards under Federal or more stringent state environmental laws regarding to the hazardous substance or particular circumstances at a site. The assumption that human health and the environment are protected is inherent in the interpretation of the ARARs.

2.2.1 Applicable Requirements

The NCP defines "applicable" requirements as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site" (EPA, 1991). In addition to laws, ARARs may be regulations or guidance promulgated by federal or state agencies. Only promulgated state standards that are identified by a state and are equally or more stringent than federal requirements may be applicable.

2.2.2 Relevant and Appropriate Requirements

The NCP defines "relevant and appropriate" requirements as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility citing laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site." As for "applicable" requirements, the NCP provides that only those promulgated state requirements that are equally or more stringent than corresponding federal requirements may be relevant and appropriate.

2.2.3 To Be Considered Requirements

To be considered (TBC) requirements pertain to federal and state criteria, advisories, guidelines, or proposed standards that are not generally enforceable but are advisory; TBCs do not have the status of potential ARARs. Guidance documents or advisories "to be considered" in determining the necessary level of cleanup for protection of human health or the environment may be used where no specific ARARs exist for a chemical or situation or where such ARARs are not sufficient to be protective.

2.2.4 Identification of ARARs

EPA identifies three basic types of ARARs: chemical-specific, action-specific, and location-specific.

2.2.4.1 Chemical-Specific ARARs

Chemical-specific ARARs provide protective site cleanup levels or a basis for calculating cleanup levels for COCs in designated media. Chemical-specific ARARs are also used to determine treatment and disposal requirements for a particular remedial activity and to assess the effectiveness of a remedial alternative.

Chemical-specific standards for the COCs identified in Section 2.3 have been established under several federal statutes, including the Safe Drinking Water Act, the Clean Water Act, and the Clean Air Act. Table 2-1 details the potential chemical-specific ARARs for groundwater at the site. Table 2-2 lists the Safe Drinking Water Act drinking water standards and the ambient water quality criteria for the COCs identified in Section 2.3. As noted in this table, the Alabama drinking water standards are the same as the federal standards.

2.2.4.2 Location-Specific ARARs

A remedial action alternative may be restricted or precluded by federal, state, or facility laws based on its location within a site or its immediate environment. Location-specific ARARs are designed to protect the local area from potentially damaging remedial actions. For example, altering the habitat of an endangered species to construct a treatment facility may jeopardize the survivability of the species. Table 2-3 identifies the federal and state laws that contain promulgated standards, requirements, criteria, or limitations that will be considered location-specific ARARs for this FFS.

2.2.4.3 Action-Specific ARARs

Action-specific ARARs are promulgated state or federal laws that set controls or restrictions on activities related to the management of hazardous materials or pollutants. Table 2-4 lists the potential federal and state action-specific ARARs for groundwater at Parcel 66(7). Each action-specific ARAR may not apply to all remedial technologies and process options; therefore, a description of the applicable remedial technology and/or process option is included in the comments section of the table.

Table 2-1

Potential Federal and State Chemical-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, Or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
Federal			
Safe Drinking Water Act (SDWA), 40 USC Section 300 - National Primary Drinking Water Standards - 40 CFR Part 141	Applicable to the use of public water systems. Establishes maximum contaminant levels (MCL), monitoring requirements, and treatment techniques.	Applicable	Applicable because groundwater is a potential source of drinking water at Fort McClellan.
SDWA, 40 USC Section 300 – Maximum Contaminant Level Goals (MCLG), 40 CFR 143	Establishes drinking water quality goals set at levels of no known or anticipated adverse health effects.	To Be Considered	Proposed MCLGs for organic and inorganic contaminants are to be considered for contaminants with no federal and state MCLs.
Clean Water Act, 33 USC Sections 1351-1376 – Water Quality Criteria, 40 CFR Part 131	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Relevant and Appropriate	The ambient water quality criteria for organic contaminants are relevant and appropriate if the discharge to surface water process option is selected.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601 et. Seq.	Provides for response to hazardous substances released into the environment and the cleanup of inactive hazardous waste disposal sites.	Relevant and Appropriate	Even though Fort McClellan is not currently on the Superfund list and is not proposed for inclusion, the CERCLA guidance was used as a basis for this focused feasibility study.
Clean Air Act, 40 USC 1857 - National Primary and Secondary Ambient Air Quality Standards, 40 CFR Part 50	Set primary and secondary air standards at levels to protect public health and welfare.	Applicable	Applicable if remedial technologies or process options incorporating vapor-producing treatment components (e.g., in situ or ex situ air stripping) are selected.
Clean Air Act, 40 USC. 1857 - National Emissions Standards for Hazardous Air Pollutants, 40 CFR Part 61	Provides emissions standards for hazardous air pollutants for which no ambient air quality standards exist.	Applicable	Applicable if remedial technologies incorporating vapor-producing components are selected.
Occupational Safety and Health Act, 29 CFR 1910 Part 120	Provides safety rules for handling specific chemicals for site workers during remedial activities.	Applicable	Applicable to all remedial actions conducted at Fort McClellan sites.

Table 2-1

Potential Federal and State Chemical-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, Or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
State			
Alabama Primary Drinking Water Quality Standards, ADEM 335-7-2	Establishes standards for public water supply systems for households.	Applicable	Applicable because groundwater is a potential source of drinking water at Fort McClellan.
Alabama Secondary Drinking Water Quality Standards, ADEM 335-7-3	Establishes standards for public water supply systems for households.	To Be Considered	Proposed MCLGs for organic and inorganic contaminants are to be considered for contaminants with no federal and state MCLs.
Alabama Ambient Air Quality Standards, ADEM 335-3-1-.03	Establishes applicability of federal primary and secondary air quality standards defined in 40 CFR Part 50 to the State of Alabama.	Applicable	Applicable if remedial technologies incorporating vapor-producing treatment components are selected.

ADEM – Alabama Department of Environmental Management.
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act.
CFR – Code of Federal Regulations.
MCL – Maximum contaminant level.
MCLG – Maximum contaminant level goal.
SDWA – Safe Drinking Water Act.
USC – United States Code.

Table 2-2

Potential Chemical-Specific ARARs and TBCs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Chemical	ARARs and TBCs				
	Federal Drinking Water Standards[a]		Alabama Drinking Water Standard[b]	Ambient Water Quality Criteria (WQC) for Protection of Human Health[c]	
	MCL	MCLG		WQC for Aquatic Organisms and Drinking Water	WQC for Aquatic Organisms Alone
1,1-DCE	0.007	0.007	0.007	0.000057	0.0032
1,2-DCA	0.005	0	0.005	0.00038	0.099
cis-1,2-DCE[d]	0.070	0.070	0.070	NA	NA
TCE	0.005	0	0.005	0.0027	0.081
Vinyl chloride	0.002	0	0.002	0.002	0.525

All values given in milligrams per liter (mg/L).

[a] EPA, 2000, *Drinking Water Standards and Health Advisories* – based on adult lifetime cancer risk

[b] Alabama primary drinking water standards and secondary maximum contaminant levels are identical to Federal standards for these contaminants.

[c] Federal Ambient Water Quality Criteria for the Protection of Human Health and Freshwater Organisms. Required by the CWA, Section 304(a). Source: EPA National Recommended Water Quality Criteria, 63 FR 68354, December 10, 1998

ARAR - Applicable or relevant and appropriate requirement.

MCL - Maximum contaminant level.

MCLG - Maximum contaminant level goal.

NA - Not available.

TBC - To be considered.

WQC – Water quality criteria.

Table 2-3

Potential Federal and State Location-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
Federal			
Safe Drinking Water Act – 40 CFR 149	Sole-source drinking water aquifer designation.	Not Applicable	Parcel 66(7) is not located over a sole-source aquifer.
Floodplain Management – 40 CFR 6.302(b) Executive Order 11988	Federal agencies proposing actions to be located in a floodplain must first evaluate the potential adverse effects those actions might have on the natural and beneficial values served by the floodplain.	Not Applicable	Parcel 66(7) is not located in a floodplain.
Floodplain Management – Resource Conservation and Recovery Act (RCRA); **Resource Conservation and Recovery Act Location Standards,** 42 USC Section 6901, 40 CFR 264.18(b)	Requires treatment, storage, or disposal facilities (TSDF) facilities to be designated, constructed, operated and maintained to avoid washout on a 100-year floodplain.	Not Applicable	Parcel 66(7) is not located in a floodplain.
Protection of Wetlands – 40 CFR 6.302(a) Executive Order 11990	Federal agencies are directed to avoid construction located in wetlands unless the agency head finds: (1) no practical alternative to such construction, and (2) the proposed action includes all practical measures to minimize harm to wetlands which might results from such use.	Not Applicable	Parcel 66(7) is not located in proximity of wetlands. Construction activities are not expected to affect the wetlands located to the northeast, southeast, and to the west.

Table 2-3

Potential Federal and State Location-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
Endangered Species Act 16 USC 1531 50 CFR 200 & 402	Requires Federal agencies to ensure that actions are not likely to threaten the continued existence of endangered/threatened species or adversely modify or destroy the critical habitats of such species.	Applicable	Endangered and threatened species have not been identified in this area; however, the Gray Bat (*Myotis grisescens*), Blue Shiner (*Cyprinella caerulea*), Mohr's Barbara Buttons (*Marshallia mohrii*), and Tennessee Yellow-eyed Gras (*Xyris tennesseensis*) have been found in other portions of Fort McClellan. Historically, the Red-cockaded Woodpecker (*Picoides borealis*) has also been observed at Fort McClellan but has not been recorded since 1968. There are no state-protected species. Another candidate species (present within the Mountain Longleaf Community complex) includes the Applachian Cottontail (*Syivilagus obscurus*). Applicable if endangered/threatened species are encountered at Parcel 66(7).
Fish and Wildlife Coordination Act - 16 USC 661-666 33 CFR 320-330	Sets forth procedures for consultation between regulatory agencies to consider wildlife conservation. Requires any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service.	Applicable	Applicable if the discharge to surface water process option is retained.
Wild and Scenic Rivers Act, 16 U.S.C. 1274, 40 CFR 6.302(e)	Restricts activities within areas affecting national wild, scenic, or recreational rivers.	Applicable	Applicable if the discharge to surface water process option is selected and Cave Creek is identified as a wild, scenic, or study river or stream tributary on the National Rivers Inventory.
Presence of archaeological resources, 43 CFR 7.4(a), 40 CFR 7.5(b)(1), 43CFR 10.4(c), 43 CFR 10.4(d)	Restricts excavating, removing, damaging, or otherwise altering or defacing such resources unless by permit or exception. Protects any such archaeological resources, if discovered. Restricts activities in the area of discovery and requires a reasonable effort be made to protect the objects discovered. Requires consultation with the Indian tribe likely to be affiliated with the objects to determine further disposition per 40 CFR 10.5(b).	Not Applicable	Based on the facility-wide Phase I survey performed, there are no known archaeological or historic resources at Parcel 66(7) or surrounding areas.
National Archaeological and Historical Preservation Act (16 USC Section 469); 35 CFR Part 65	Requires action be taken to recover and preserve artifacts.	Not Applicable	Based on the facility-wide Phase I survey performed, there are no known archaeological or historic resources at Parcel 66(7) or surrounding areas.

Table 2-3

Potential Federal and State Location-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
American Indian Religious Freedom Act, 42 USC 1996	Requires activities in the area of discovery to be stopped and affected work to be suspended until a compliance strategy is approved.	Not Applicable	Based on the facility-wide Phase I survey performed, there are no known archaeological or historic resources at Parcel 66(7) or surrounding areas.
State			
Alabama Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, ADEM 335-14-5-.02, Hazardous Waste Program	Establishes location standards for facilities located in 100-year floodplains. Forbids placement of any non-containerized or bulk liquid hazardous waste within any salt dome/salt bed, underground mine or cave.	Applicable	Although Parcel 66(7) is not located in a floodplain, Fort McClellan is underlain by dolomite and limestone which are subject to cave formation and sinkhole development. If the ex-situ treatment process options are selected, extracted groundwater may be classified as bulk liquid hazardous waste due to elevated concentrations of hazardous constituents (e.g., TCE).
Alabama Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, ADEM 335-14-6, Hazardous Waste Program	Prohibits placement of any hazardous waste in a salt dome, salt bed formation, underground mine, or cave.	Applicable	Fort McClellan is underlain by dolomite and limestone which are subject to cave formation and sinkhole development. If the ex-situ treatment process options are selected, hazardous waste may be generated (e.g., extracted groundwater, spent activated carbon).
Alabama Permit Requirements for Solid Waste Disposal, ADEM 335-13-4-.01, Water Quality Program	Establishes siting standards for disposal facilities in floodplains. Facilities must comply with wildlife, endangered or threatened species, and critical habitat regulations under the Alabama Water Pollution Control Act and related Federal Standards	Not Applicable	Parcel 66(7) is not located in a floodplain.
Alabama Water Quality Criteria, ADEM 335-6-10, Water Quality Program	Requires any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service. Establishes antidegradation policy based on water use classifications and potentially impacted wildlife, fish, and aquatic life	Applicable	Applicable if the discharge to surface water process option is selected.

Table 2-4

Potential Federal and State Action-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
Federal			
Identification and Listing of Hazardous Waste and Sampling and Analysis procedures, 40 CFR Part 261, 40 CFR 136, App. A (SW-846 sampling methods)	Specifies requirements for identifying hazardous wastes under the Resource Conservation and Recovery Act (RCRA). Establishes analytical requirements for testing and evaluating solid, hazardous, and water wastes.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated (e.g., extracted groundwater, spent activated carbon).
Standards Applicable to Generators of Hazardous Waste, 40 CFR Part 262	Establishes standards for generators of hazardous waste under RCRA. Specifies requirements for hazardous waste packaging, labeling, manifesting, record keeping, and accumulation time.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated (e.g., extracted groundwater, spent activated carbon).
Standards Applicable to Transporters of Hazardous Waste, 40 CFR Part 263	Establishes standards for transporters of hazardous waste under RCRA.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). Hazardous waste generated must be transported for disposal.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264	Establishes minimum national standards that define the acceptable management of hazardous waste for owners and operators of facilities that treat, store, or dispose of hazardous waste under RCRA.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). The ex situ treatment facility may be identified as a hazardous waste treatment and storage facility.
Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 265	Establishes minimum national standards that define the acceptable management of hazardous waste during the period of interim status and until certification of the final closure under RCRA.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). The ex situ treatment facility may be identified as a hazardous waste treatment and storage facility.

Table 2-4

Potential Federal and State Action-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
Land Disposal Restrictions, 40 CFR 268	Identifies hazardous wastes that are restricted from land disposal.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). The ex situ treatment facility may be identified as a hazardous waste treatment and storage facility.
U.S. Department of Transportation (DOT) Hazardous Materials Transportation Regulations, 49 CFR 171-173 and 177-180	Establishes classification, packaging, and labeling requirements for shipments of hazardous materials.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). Hazardous waste generated must be transported for disposal.
Occupational Safety and Health Act (OSHA), 29 U.S.C. ss. 651-678	Regulates worker health and safety.	Applicable	Applicable to all remedial activities.
EPA Region 4 Standard Operating Procedures (SOP)	Requires monitoring and extraction wells to be constructed and abandoned in accordance with EPA Region 4 SOPs, May 1996.	Applicable	Applicable if monitoring or extraction wells are installed.
Safe Drinking Water Act (SDWA), 40 U.S.C. Section 300 – National Primary Drinking Water Standards - 40 CFR Part 141	Applicable to the use of public water systems. Establishes maximum contaminant level, monitoring requirements, and treatment techniques.	Applicable	Applicable if discharge to surface water process option is selected.
Safe Drinking Water Act (SDWA), 40 U.S.C. Section 300 – Maximum Contaminant Level Goals, 40 CFR 143	Establishes drinking water quality goals set at levels of no known or anticipated adverse health effects.	To Be Considered	Proposed MCLGs for organic and inorganic contaminants are to be considered for contaminants with no federal and state MCLs.
Discharge to Offsite Surface Water, 40 CFR 122.26, 122.41, and 122.48	Requires that the selected remedial action must establish a standard of control to maintain surface water quality.	Applicable	Applicable if discharge to surface water process option is selected.
Superfund Amendments and Reauthorization Act (SARA), 42 U.S.C. Section 9801 et. Seq.	Requires the discharge to comply with Federal water quality criteria.	Applicable	Applicable if discharge to surface water process option is selected.

Table 2-4

Potential Federal and State Action-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
Clean Water Act, 33 U.S.C. Sections 1351-1376 – Best Available Treatment Technology (BATT), 40 CFR 122	Requires use of best available technology economically achievable to control discharge of toxic pollutants to a Publicly Owned Treatment Works (POTW).	Applicable	Applicable if discharge to POTW process option is selected.
Clean Water Act, 33 U.S.C. Sections 1351-1376 – National Pollutant Discharge Elimination System (NPDES) Permit Regulations, 40 CFR 122 Subpart C	Requires use of best available technology economically achievable for toxic pollutants discharged to surface waters. Mandates that the discharge must comply with the EPA-approved Water Quality Management Plan.	Applicable	Applicable if discharge to surface water process option is selected.
Discharge to a Publicly Owned Treatment Works (POTW), 33 USC Section 1317, 40 CFR 403	Establishes list of toxic pollutants and promulgates pretreatment standards for discharge to POTWs.	Applicable	Applicable if the discharge to POTW process option is selected.
Clean Air Act, 40 U.S.C. 1857 – National Primary and Secondary Ambient Air Quality Standards, 40 CFR Part 50	Set primary and secondary air standards at levels to protect public health and welfare.	Applicable	Applicable if remedial technologies incorporating vapor-producing treatment components (e.g., in-situ or ex situ air stripping) are selected.
Clean Air Act, 40 U.S.C. 1857 - National Emissions Standards for Hazardous Air Pollutants, 40 CFR Part 61	Provides emissions standards for hazardous air pollutants for which no ambient air quality standards exist.	Applicable	Applicable if remedial technologies incorporating vapor-producing components are selected.
State			
Alabama Hazardous Waste Management Regulations, ADEM 335-14-1	Establishes standards that define the acceptable management of hazardous waste for owners and operators of facilities that treat, store, or dispose of hazardous waste.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). The ex situ treatment facility may be identified as a hazardous waste treatment and storage facility.

Table 2-4

Potential Federal and State Action-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
Identification and Listing of Hazardous Waste, ADEM 335-14-2	Requirements for identification of hazardous wastes	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated (e.g., extracted groundwater, spent activated carbon).
Alabama Hazardous Waste Generator Regulations, ADEM 335-14-3	Establishes standards for generators of hazardous waste	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon).
Alabama Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, ADEM 335-14-5, ADEM 335-14-6	Standards and requirements for facilities that treat, store, and dispose of hazardous waste	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon).
Alabama Hazardous Waste Management and Minimization Act, Code of Alabama, Title 22, Chapter 30	Establishes a site-wide program to provide for the safe management of hazardous wastes, including hazardous waste generation, transportation, and land disposal.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). Hazardous waste generated must be transported for disposal.
Alabama Land Disposal Restrictions, ADEM 335-14-9	Identifies hazardous wastes that are restricted from land disposal and defines those limited circumstances under which an otherwise restricted waste may continue to be land disposed.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). The hazardous waste would require disposal; therefore, these regulations would be applicable.
Alabama Solid Waste Act, Code of Alabama, Title 22, Chapter 27	Establishes site-wide program to provide for the safe management of non-hazardous wastes.	Applicable	Non-hazardous waste may be generated during monitoring or remedial activities.
Alabama Solid Waste Management Regulations, ADEM 335-13-1 through 335-13-8	Establishes minimum criteria for the processing, recycling, transportation, and disposal of solid wastes and the design, location, and operation of solid waste disposal facilities.	Applicable	Non-hazardous waste may be generated, transported, or disposed as part of monitoring or remedial activities.
Alabama Air Emissions Regulations, ADEM 335-3-4	Provides for a coordinated statewide program of air pollution prevention, abatement, and control.	Applicable	Applicable if remedial technologies incorporating vapor-producing treatment components (e.g., in-situ or ex situ air stripping) are selected.

Table 2-4

Potential Federal and State Action-Specific ARARs for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Standard, Requirement, or Criterion	Requirement	Applicable, Relevant and Appropriate, To Be Considered, Not Applicable	Comments
Alabama NPDES Permit Regulations, ADEM 335- 6-6	Establishes rules and procedures for the administration of an NPDES-type permit system for the state. Establishes standards for permit compliance, system operations and maintenance, monitoring and record keeping, and reporting.	Applicable	Applicable if the discharge to surface water process option is selected.
Alabama Water Quality Criteria and Use Classifications Regulations, ADEM 335-6-10	Establishes water quality criteria and uses for lakes and rivers based on toxicity to aquatic organisms and human health and water use classifications and antidegradation policy.	Applicable	Applicable if the discharge to surface water process option is selected.
Indirect Discharge Permits and Pretreatment Rules, ADEM 335-6-5	Establishes list of toxic pollutants and promulgates pretreatment standards for discharge to POTWs.	Applicable	Applicable if the discharge to POTW process option is selected.
Alabama Closure and Post-Closure Standards, ADEM 335-14-.07 or 335-15-6-.07	Provides standards for closure and post-closure of hazardous waste management facilities that are either RCRA-permitted or classified under interim status.	Applicable	If the ex situ treatment process options are selected, hazardous waste may be generated and stored (e.g., extracted groundwater, spent activated carbon). The ex situ treatment facility may be identified as a hazardous waste treatment and storage facility.
Alabama Wellhead Protection Program, ADEM 335-7-12	Establishes requirements for the closure or abandonment of groundwater monitoring or extraction wells.	Applicable	Upon achieving the remedial action objective, monitoring and/or extraction wells may require abandonment.
Alabama Groundwater and Underground Injection Control (UIC), ADEM 335-6-8	Details the requirements of the Alabama UIC program.	Applicable	Applicable if the discharge to groundwater or in-situ treatment process options are selected.

2.3 Remedial Goal Options

Protection of human health can be achieved by reducing the levels of contaminants in groundwater at Parcel 66(7) to specified RGOs by a remedial action. RGOs are the concentrations for individual chemicals in groundwater above which remediation or control measures would be required. The RGOs for Parcel 66(7) were determined with consideration of the risk to human health and the ARARs that were identified for the site. The ARARs for Parcel 66(7) include federal and State of Alabama regulations and other TBC guidance. The RGOs are provided for groundwater only, as soil was not considered a significant threat to human health or the environment.

The COCs identified in the RI include 1,1-DCE, 1,2-DCA, TCE, and VC. The chemicals selected are those that were determined to have a resident ILCR higher than the maximum risk management value (i.e., greater than 1E-4) and/or a resident HI of more than 1 individually or in combination. Cis-1,2-DCE was not selected as a COC because a target organ analysis revealed the HI to be below the threshold level of 1. However, the maximum detected concentration of cis-1,2-DCE exceeds the chemical-specific ARARs (i.e., EPA maximum contaminant level [MCL]); therefore, the chemical is included as a COC within this FFS. With the exception of 1,2-DCA, the COCs include those contaminants that exceed their respective MCLs in groundwater. Although 1,2-DCA was detected in groundwater at levels below its MCL, it was included as a COC based on the resident cancer risk as described in the RI. As shown in Table 2-5, the RGOs for residuum groundwater at Parcel 66(7) are equivalent to the MCLs. MCLs were selected as the RGOs because the groundwater at Fort McClellan could serve as a potential future source of drinking water. A comparison of the Parcel 66(7) groundwater analytical results to the MCLs is provided on Figure 2-1.

Federal and state cleanup standards exist for all the COCs in groundwater at Parcel 66(7). Federal and state regulations stipulate that risk calculations shall be completed to determine the total cancer risk (ILCR) and noncancer hazard (HI) associated with the COCs at their respective RGO concentrations. This is accomplished with the cancer-based groundwater SSSLs for residential exposure provided in Table L-8 of the RI report, because cancer risk and concentration are linearly related. The cancer-based SSSLs are the concentrations associated with a cancer risk of 1E-6. Therefore, the cancer risk associated with the MCL is calculated by multiplying the RGO by 1E-6 and dividing the result by the SSSL. Calculated ILCRs for the COCs in groundwater are presented in Table 2-6.

The total ILCR for exposure to all COCs in groundwater (except 1,2-DCA) at their respective MCLs is 1.24E-4. This must be summed with the total ILCR of 2.40E-5 for exposure to the

Table 2-5

Remedial Goal Options
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Chemical	Maximum Concentration[a]	MCL[b]	Remedial Goal Option
1,1-DCE	0.310	0.007	0.007
1,2-DCA	0.0011J	0.005	0.005
cis-1,2-DCE	0.5	0.070	0.070
TCE	9.2	0.005	0.005
Vinyl chloride	0.060	0.002	0.002

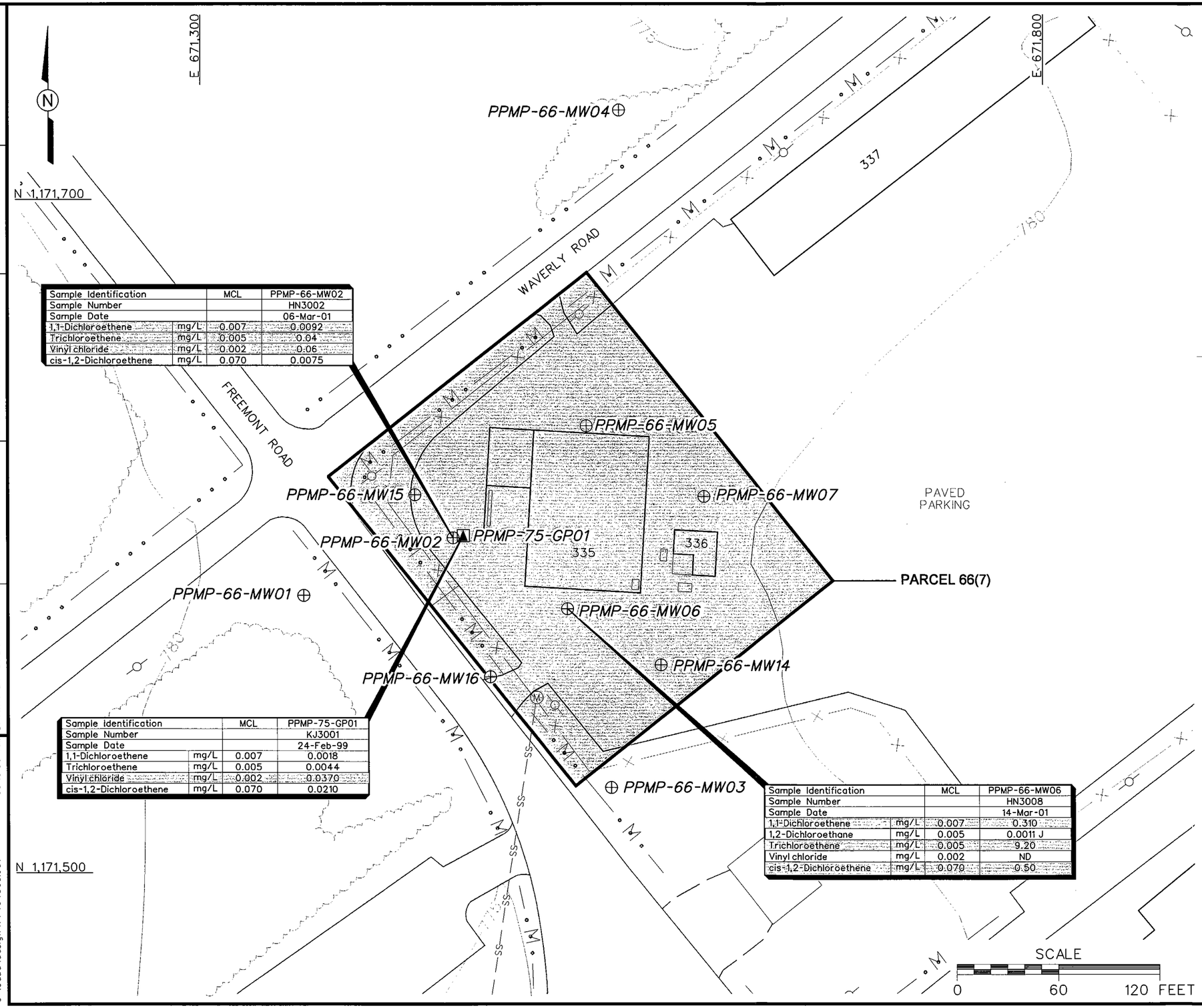
All values given in milligrams per liter (mg/L).

[a] Based on groundwater analytical data from March 2001 sampling event.

[b] EPA, 2000, *Drinking Water Standards and Health Advisories.*

J - Estimated concentration within the error of the instrument.

MCL - Maximum contaminant level.



Sample Identification		MCL	PPMP-66-MW02
Sample Number			HN3002
Sample Date			06-Mar-01
1,1-Dichloroethene	mg/L	0.007	0.0092
Trichloroethene	mg/L	0.005	0.04
Vinyl chloride	mg/L	0.002	0.06
cis-1,2-Dichloroethene	mg/L	0.070	0.0075

Sample Identification		MCL	PPMP-75-GP01
Sample Number			KJ3001
Sample Date			24-Feb-99
1,1-Dichloroethene	mg/L	0.007	0.0018
Trichloroethene	mg/L	0.005	0.0044
Vinyl chloride	mg/L	0.002	0.0370
cis-1,2-Dichloroethene	mg/L	0.070	0.0210

Sample Identification		MCL	PPMP-66-MW06
Sample Number			HN3008
Sample Date			14-Mar-01
1,1-Dichloroethene	mg/L	0.007	0.310
1,2-Dichloroethane	mg/L	0.005	0.0011 J
Trichloroethene	mg/L	0.005	9.20
Vinyl chloride	mg/L	0.002	ND
cis-1,2-Dichloroethene	mg/L	0.070	0.50

LEGEND

- UNIMPROVED ROADS AND PARKING
- PAVED ROADS AND PARKING
- BUILDING
- TOPOGRAPHIC CONTOURS (CONTOUR INTERVAL - 5 FOOT)
- TREES / TREELINE
- PARCEL BOUNDARY
- CULVERT WITH HEADWALL
- SURFACE DRAINAGE / CREEK
- MANMADE SURFACE DRAINAGE FEATURE
- FENCE
- UTILITY POLE
- SANITARY SEWER LINE
- MANHOLE
- RESIDUUM MONITORING WELL LOCATION
- GROUNDWATER, SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- J — ESTIMATED CONCENTRATION
- MCL — MAXIMUM CONTAMINANT LEVEL
- VOC — VOLATILE ORGANIC COMPOUND
- mg/L — MILLIGRAMS PER LITER
- ND — NOT DETECTED
- CONCENTRATION EXCEEDS MCL

FIGURE 2-1
CHEMICALS OF CONCERN IN RESIDUUM GROUNDWATER
SMALL WEAPONS REPAIR SHOP
PARCEL 66(7)

U. S. ARMY CORPS OF ENGINEERS
MOBILE DISTRICT
FORT McCLELLAN
CALHOUN COUNTY, ALABAMA
Contract No. DACA21-96-D-0018

IT CORPORATION
A Member of The IT Group

DWG. NO.: ...\774645es.951 | PROJ. NO.: 774645
INITIATOR: J. MALINO | PROJ. MGR.: J. YACOUB
DRAFT. CHCK. BY: | ENGR. CHCK. BY: S. MORAN
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 10/01/02 | DRAWN BY: D. BOMAR
10/10/02 09:16:56 AM
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Table 2-6

Incremental Lifetime Cancer Risk for Groundwater RGOs
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Chemical	MCL[a] (mg/L)	SSSL[b] (mg/L)	ILCR
1,1-DCE	0.007	9.36E-5	7.48E-5
1,2-DCA	0.0011[c]	4.48E-4	2.46E-6
cis-1,2-DCE	0.070	NA	NA
TCE	0.005	0.00451	1.11E-6
Vinyl chloride	0.002	4.41E-5	4.54E-5
Total ILCR for groundwater			1.24E-4

[a] EPA, 2000, *Drinking Water Standards and Health Advisories.*

[b] Taken from Table L-8 of the RI report.

[c] The maximum detected concentration (MDC) was used because the MCL exceeds the MDC.

ILCR - Incremental lifetime cancer risk.

MCL - Maximum contaminant level.

mg/L - Milligrams per liter.

NA - Not applicable; chemical is a suspected carcinogen.

SSSL - Site-specific screening level based on cancer risk.

COCs in total soil (from Table L-26 of the RI report) to estimate a total ILCR for a resident summed across all site media. A total ILCR of 1.48E-4 is obtained, which, when rounded to one significant figure as per EPA Region 4 guidance, is equivalent to 1E-4. Therefore, the total ILCR for residential exposure to soil and groundwater is within the risk management range if COC concentrations in groundwater are reduced to their respective MCLs.

A similar exercise is used to demonstrate that reducing groundwater COC concentrations to their respective MCLs yields target organ-specific HI values below the threshold of 1. The noncancer-based SSSLs reflect an HI of 0.1. Calculated HIs for the COCs in groundwater are presented in Table 2-7. As shown in the table, the total HI for each target organ for residential exposure to soil and groundwater is below the threshold level of 1 if COC concentrations in groundwater are reduced to their respective MCLs.

Table 2-7

Hazard Indices for Groundwater RGOs
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

Chemical	MCL[a] (mg/L)	SSSL[b] (mg/L)	HI (Liver)[c]	HI (Kidney)[c]	HI (RBC)[c]
1,1-DCE	0.007	0.0136	0.0515	NA	NA
1,2-DCA	0.0011 [d]	0.00488	0.0225	0.0225	NA
cis-1,2-DCE	0.070	0.0155	NA	NA	0.452
TCE	0.005	0.00915	0.0546	0.0546	NA
Vinyl chloride	0.002	0.00464	0.0431	NA	NA
Total ILCR for each target organ			0.171	0.077	0.452

[a] EPA, 2000, *Drinking Water Standards and Health Advisories.*

[b] Taken from Table L-8 of the RI report.

[c] Information for target organ taken from toxicity profiles appended to IT Corporation, 2000, *Final Human Health and Ecological Screening Values and PAH Background Summary Report, Fort McClellan, Calhoun County, Alabama*, August.

[d] The maximum detected concentration (MDC) was used because the MCL exceeds the MDC.

HI - hazard index.

MCL - Maximum contaminant level.

mg/L - Milligrams per liter.

RBC - Red blood cell (erthrocyte).

NA - Not applicable.

SSSL - Site-specific screening level based on noncancer hazard.

3.0 Identification and Screening of Remedial Technologies

3.1 Introduction

This chapter identifies and screens general response actions (GRA), remedial technologies, and process options that may be appropriate for satisfying the RAO for Parcel 66(7). Select GRAs, remedial technologies, or process options will be carried forward after the initial screening and combined to develop remedial alternatives for Parcel 66(7). The steps involved in the screening process in this chapter are defined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988) and include the following:

- Identification of the area and volume of the medium of interest requiring remedial action. The identification shall be consistent with the RAO and the chemical and physical characteristics of the site.

- Development of GRAs for the medium of interest defining particular actions, singularly or in combination, that may be taken to fulfill the RAO for the site.

- Identification and screening of remedial technologies and process options for each GRA based on effectiveness, implementability, and cost.

3.2 Identification of the Area and Volume of the Contaminated Medium Requiring Remedial Action

During the RI, five chlorinated VOCs were detected in groundwater samples from two monitoring wells (PPMP-66-MW06 and PPMP-66-MW02) at concentrations that exceeded their respective SSSLs: 1,1-DCE, 1,2-DCA, cis-1,2-DCE, TCE, and VC. The vertical extent of these contaminants in groundwater is restricted to the interval of weathered shale comprising the lower part of the residuum. Contamination is verified as not present in the deeper competent bedrock. The horizontal extent of contamination is defined.

As discussed in Chapter 2.0 of this report, groundwater COCs exceeding their respective MCLs include 1,1-DCE, cis-1,2-DCE, TCE, and VC. The most restrictive MCL for any of the COCs is 0.002 mg/L for VC; therefore, a total chlorinated VOC concentration limit of 0.001 mg/L was selected as a conservative basis for determining the horizontal and vertical extent of groundwater requiring remedial action at Parcel 66(7).

The horizontal extent of groundwater requiring remedial action based on the 0.001 mg/L total chlorinated VOC isopleth shown on Figure 1-12 equals approximately 8,200 square feet. The vertical depth of groundwater requiring remedial action (the vertical extent of groundwater

exceeding 0.001 mg/L total chlorinated VOCs) equals approximately 25 feet, based on Figure 1-13. The total volume of groundwater requiring remedial action was calculated based on the following equation:

Horizontal area requiring remedial action (8,200 square feet) * Vertical depth requiring remedial action (25 feet) * porosity of residuum (0.30) * 7.48 gallons per cubic foot = 460,020 gallons

Therefore, the volume of groundwater requiring remedial action equals approximately 460,000 gallons.

3.3 Identification of General Response Actions

GRAs are a broad class of remedial actions employed to meet the RAOs for a particular medium. The objective of this section is to identify and describe the GRAs that may satisfy the RAO for contaminated groundwater at Parcel 66(7). Individually, GRAs do not have to meet the RAO. The RAO will be met when the remedial technologies or process options applicable to a given GRA are developed into alternatives.

3.3.1 No Action

The no-action GRA is retained throughout the FFS process as recommended by the NCP. This alternative provides a comparative baseline against which other alternatives can be evaluated. Under this alternative, no remedial action would be conducted. The contaminants are left in place without implementing any containment, removal, treatment, or other mitigating actions. For the no-action alternative, reductions in groundwater contaminant concentrations would not be expected other than those resulting from natural processes. The no-action alternative does not provide for groundwater monitoring, nor does it provide for access control actions taken to reduce the potential for contaminant exposure.

3.3.2 Natural Attenuation

Natural attenuation is the reduction of contaminant concentrations in groundwater resulting from the combined effect of aerobic and anaerobic biodegradation, dispersion, dilution, volatilization, and adsorption. Generally, biodegradation is the most important natural attenuation mechanism and is the only natural process that results in an actual reduction of contaminant mass. This action relies on groundwater monitoring to confirm the effectiveness of the natural attenuation and to quantify the reductions.

3.3.3 Land-Use Controls

Land-use controls (LUC) include physical, legal, or administrative restriction mechanisms on groundwater use at the site and may also include monitoring. The legal mechanisms used for LUCs are generally the same as those used for institutional controls as discussed in the NCP. Under this GRA, no remedial action would be taken, and no change in contaminant concentrations in the groundwater would be expected other than those resulting from natural processes.

3.3.4 Containment

Containment reduces the risk to human health or the environment by reducing contaminant mobility. Contaminated media may be contained or isolated using engineering controls such as caps or vertical barriers. Under this GRA, no change in the concentrations of COCs in the groundwater is expected. Containment would be conducted with groundwater monitoring to confirm the effectiveness of restricting the mobility of the COCs in the groundwater.

3.3.5 Groundwater Extraction

Groundwater extraction involves removal of the groundwater from the subsurface. Groundwater extraction remedial technology types include extraction by recovery wells, by recovery trenches, or both. Groundwater extraction is typically combined with treatment for reduction of the COCs to acceptable levels. A decrease in the mobility and concentrations of the COCs in the groundwater is expected with this GRA.

3.3.6 Treatment

Treatment includes biological, physical, and chemical remedial technology types. The remedial technologies could be further separated into ex situ and in situ options. Treatment can be combined with other GRAs (e.g., groundwater extraction) for effective reduction of COC concentrations in groundwater.

3.3.7 Discharge

Discharge includes remedial technology types for extracted groundwater such as groundwater re-injection, discharge to a publicly owned treatment works, and surface water discharge. The GRA also includes air pollution control systems for treatment of extracted vapors produced from air stripping or air sparging/soil vapor extraction (AS/SVE) process options. Discharge can be combined with other GRAs (e.g., extraction/treatment) to provide an effective remedial technology for reduction of COC concentrations in groundwater at Parcel 66(7).

3.4 Identification and Screening of Remedial Technology Types and Process Options

The purpose of this section is to screen potentially applicable remedial technology types and representative process options identified for the GRAs. The term "remedial technology type" refers to general categories of technologies (e.g., chemical treatment), while the term "process option" refers to specific processes within each remedial technology type (e.g., in situ chemical oxidation using potassium permanganate).

The following section describes technology types and process options that may reasonably be considered to meet the RAOs for groundwater at Parcel 66(7). An evaluation of each technology type or process option will follow each description. This evaluation, or screening, will focus on the effectiveness, implementability, and cost of each technology or process option in meeting the RAOs. A summary of GRAs, technology types, process options, and initial screening comments is presented in Table 3-1. The technologies or process options that are retained will ultimately be assembled into remedial alternatives and evaluated in detail in Chapter 4.0.

3.4.1 No Action

There are no remedial technology types associated with the no-action GRA. This GRA provides a baseline against which other remedial technology types are compared.

Effectiveness. The no-action GRA is not an effective remedial alternative because it retains the present level of risk and it does not reduce or eliminate the toxicity, mobility, or volume of the COCs in the groundwater. It is used as a baseline for comparison with other identified technologies.

Implementability. Since there is no remedial action associated with this option, the no-action option is easily implemented.

Cost. There is no cost associated with this option.

Recommendation. The no-action option will be retained as recommended by the NCP.

3.4.2 Monitored Natural Attenuation

The monitored natural attenuation (MNA) remedial technology type is a passive remedial approach that depends on natural processes to degrade and dissipate organic constituents in the groundwater. The groundwater is monitored to quantify the effectiveness of the natural attenuation.

Table 3-1

Identification and Screening of Remedial Technologies for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
No Action	None	None	No remedial action or control measures are associated with the No Action GRA.	Recommended for baseline comparison by the National Contingency Plan (NCP).
Natural Attenuation	Monitored Natural Attenuation (MNA)	Monitored Natural Attenuation	Groundwater monitoring to assess the reduction of the chemicals of concern (COC) in the subsurface through natural processes.	The results of the MNA evaluation indicated the natural degradation of the COCs to maximum contaminant levels (MCL) would not be achieved within a reasonable timeframe.
Land Use Controls (LUC)	Physical mechanisms	Fence/warning sign installation	Installation of fencing and warning signs around Parcel 66(7) to limit property access.	Potentially applicable in combination with other LUC mechanisms and groundwater monitoring.
	Legal mechanisms	Deed/zoning restrictions	Deeds for property in the area of influence would include well installation restrictions.	Potentially applicable in combination with other LUC mechanisms and groundwater monitoring.
	Administrative mechanisms	Notices/site visits	Notices and site visits to serve as a reminder of the LUCs in place and for inspection of the physical mechanisms in place.	Potentially applicable in combination with other LUC mechanisms and groundwater monitoring.
	Monitoring	Groundwater Monitoring	Sampling of groundwater monitoring wells to assess the horizontal and vertical migration of the groundwater contaminant plume.	Potentially applicable in combination with physical, legal and administrative LUC mechanisms.
Containment	Capping	Asphalt	Asphalt cover over contaminated area to prevent exposure and surface water infiltration.	Surface and subsurface soil do not pose risks to human health or environment; therefore, no protective barrier is required.
		Clay cap	Clay cap over contaminated area to prevent exposure and surface water infiltration.	Surface and subsurface soil do not pose risks to human health or environment; therefore, no protective barrier is required.
		Multimedia cap	Multiple layer cap (topsoil, sand or gravel, and synthetic liner or clay) over area to prevent exposure and surface water infiltration.	Surface and subsurface soil do not pose risks to human health or environment; therefore, no protective barrier is required.
	Vertical barriers	Slurry wall	Vertical trench around contaminated area filled with soil-bentonite slurry to limit horizontal migration of contaminants.	Ineffective in reducing toxicity or volume of the contaminants, difficult to implement, and relatively high in cost.
		Grout curtain	Pressure injection of cement, grout, or other fluids into subsurface to limit groundwater flow.	Ineffective in reducing toxicity or volume of the contaminants, difficult to implement, and relatively high in cost.
Groundwater Extraction	Extraction by recovery wells	Extraction by recovery wells	Network of wells containing submersible pumps for extraction of contaminated groundwater.	Ineffective due to the low hydraulic conductivities at the site that will lead to low recovery rates; extracted water requires ex situ treatment and duration for treatment would be lengthy.
	Extraction by recovery trenches	Extraction by recovery trenches	Trench(es) containing submersible pumps for extraction of contaminated groundwater.	The cost would be excessive due to the depth of the plume, the potential requirement for multiple trenches, and the operation and maintenance costs associated with the extraction trenches.

Table 3-1

Identification and Screening of Remedial Technologies for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment	Biological treatment	In situ anaerobic bioremediation	Addition of an electron donor within the subsurface to stimulate indigenous anaerobic microorganisms to biodegrade contaminants.	Treatability study results indicate that this process option was not effective in reductively dechlorinating the chlorinated solvents in Parcel 66(7) groundwater.
		In situ aerobic bioremediation	Increasing the dissolved oxygen concentration in the subsurface to stimulate aerobic microorganisms to degrade contaminants.	Due to the lack of a suitable substrate in the subsurface for co-metabolic degradation of trichloroethene, and the complicating factors associated with delivering an air stream into the subsurface, this process option will not be retained for alternative development.
	Physical treatment	In situ Density-Driven Air Stripping	Air is injected into the bottom of well casing to "strip" VOCs from the groundwater by partitioning into the air stream. The contaminated air stream is extracted and treated above ground.	The process option is neither field-proven nor effective in tight soil formations similar to those at Parcel 66(7).
		Air sparging/soil vapor extraction	Inject air into the subsurface to "strip" or volatilize the contaminants into the vadose zone; soil vapor extraction wells are installed to capture the sparged air from the vadose zone for treatment above ground.	The site-specific geology and hydrogeology do not favor the use of this technology.
	Chemical treatment	Zero-valent iron reactive wall	Large trench installed along the flow path of the groundwater filled with zero-valent iron for abiotic dechlorination of the COCs at Parcel 66(7).	This process option may not be effective due to the low hydraulic gradient at the site which would make the inducement of groundwater flow through the wall difficult.
		In situ chemical oxidation by hydrogen peroxide	Addition of hydrogen peroxide and ferrous iron (as a catalyst) to the groundwater for oxidation of chlorinated solvent contamination.	The requirement for acid addition to the subsurface would have potential ecological effects and chemical handling issues.
		In situ chemical oxidation using potassium permanganate	Addition of potassium permanganate to the groundwater to oxidize chlorinated ethene contamination.	This option is retained because it is an aggressive and proven treatment method. Potassium permanganate is more stable in the subsurface than other oxidants such as hydrogen peroxide and ozone.
		In situ chemical oxidation using ozone	Addition of gaseous ozone to the subsurface for oxidation of chlorinated solvent contaminants.	This process option is costly, and the corrosive and reactive nature of ozone would cause potential safety concerns.

Table 3-1

Identification and Screening of Remedial Technologies for Groundwater
Small Weapons Repair Shop, Parcel 66(7)
Fort McClellan, Calhoun County, Alabama

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Discharge	Groundwater Discharge	Groundwater discharge process options include recharge basins, discharge to an off-site POTW, and discharge to a local stream	Groundwater discharge technology types include groundwater re-injection, publicly owned treatment works (POTW) discharge, and surface water discharge.	The groundwater discharge remedial technology type will not be retained for further consideration due to elimination of the groundwater extraction and ex situ treatment GRAs.
	Air pollution control systems	Common off-gas treatment systems include vapor phase granular activated carbon, thermal oxidizers, catalytic oxidizers, biofilters and internal combustion engines	Treatment of the contaminated off-gas from soil vapor extraction or air stripping activities.	The air pollution control systems remedial technology type will not be retained for further consideration due to the elimination of the air stripping (in situ and ex situ) and air sparging/soil vapor extraction remedial technology types.

Note: Shaded remedial technologies and process options were retained for remedial alternative development; unshaded entries were not retained for further consideration.

Effectiveness. An evaluation of MNA was conducted for Parcel 66(7) to determine whether MNA is a feasible process option for groundwater remediation. A report discussing the results of the MNA evaluation is included as Appendix A of this FFS report. According to the evaluation, MNA was not proven to be effective in reducing the toxicity, mobility, and volume of COCs in the groundwater within a reasonable timeframe due to limited reductive dechlorination in the residuum water-bearing zone. The results of the evaluation indicate that the degradation of the COCs was limited due to the low concentration of naturally occurring total organic carbon, elevated sulfate levels, and lack of sufficient nutrients.

Implementability. MNA would be accomplished using conventional equipment and analytical methods; therefore, it is readily implementable. Existing monitoring wells may be used or additional wells may be installed to collect data from specific areas that do not currently have monitoring wells.

Cost. The cost associated with MNA is expected to be moderate compared to other remedial technology types. The cost is dependent on the sampling frequency, analytical parameters, reporting, MNA modeling, and the depth and number of additional monitoring wells required for effective monitoring.

Recommendation. This option will not be retained for further consideration in developing remedial alternatives. The results of the MNA evaluation indicated that natural degradation of the COCs to MCLs would not be achieved within a reasonable timeframe.

3.4.3 Land-Use Controls

LUCs consist of administrative actions designed to minimize or reduce the potential for exposure to the COCs. The implementation of this technology type is based on the *Department of Defense Guidance on Land Use Controls Associated with Environmental Restoration Activities for Property Planned for Transfer Out of Federal Control* (DOD, 2001). LUCs include physical, legal, and administrative mechanisms used to restrict the use of, or limit access to, property to prevent exposure to contaminants above permissible levels and monitoring. The intent of LUCs is to protect human health and the environment by limiting the type and extent of activity on a site and ensuring the compatibility of land use at active installations with restrictions imposed on the property.

3.4.3.1 Physical Mechanisms

Physical mechanisms include various engineered remedies to contain or reduce contamination and/or physical barriers intended to limit access to property, such as fences or signs. A fence is currently in place surrounding Parcel 66(7) and bordering areas. Additional fencing would be required to limit access to Parcel 66(7) from the southeast and northeast. Warning signs would be posted at Parcel 66(7) to provide notification that groundwater usage in the area is restricted due to contamination and that the installation of potable water wells is prohibited.

Effectiveness. Physical mechanisms would not be effective in reducing the toxicity, mobility, or volume of the COCs. However, these restrictions would be effective in reducing the human health risk by limiting access to the contaminated groundwater.

Implementability. This process option can easily be implemented, as fence and warning signs are commercially available items. This option would limit the potential for future land development at the site.

Cost. The cost of this option is low compared to other process options.

Recommendation. This option will be retained for further consideration in developing remedial alternatives, probably in combination with another technology such as groundwater monitoring.

3.4.3.2 Legal Mechanisms

Legal mechanisms are forms of LUCs that limit land or groundwater use via public advisories and applicable legal restrictions on land or groundwater use. The legal mechanisms may include deed and/or zoning restrictions on groundwater well installation at Parcel 66(7). Deed and zoning restrictions serve to alert concerned parties of the presence of elevated concentrations of contaminants in the groundwater and to restrict land development with regard to groundwater usage.

Effectiveness. Legal mechanisms would not be effective in reducing the toxicity, mobility, or volume of the COCs. The restrictions are only effective in reducing the human health risk by limiting future land development with regard to groundwater usage.

Implementability. This process option can be easily implemented, but maintenance of LUCs may be somewhat difficult due to the potential transfer of Parcel 66(7) to the public domain. This option would also limit the potential for future land development at the site.

Cost. The cost of this option is low compared to other process options.

Recommendation. This option will be retained for further consideration in developing remedial alternatives, probably in combination with another technology such as groundwater monitoring.

3.4.3.3 Administrative Mechanisms

Administrative mechanisms are LUCs that the Army may institute to manage and reduce the risks to human health posed by site contamination at Parcel 66(7). These measures may include internal notices and site inspections to serve as a reminder of the existence of the LUCs; a site approval process to review construction projects and other land-use changes at Parcel 66(7) to ensure that the LUCs are followed; training of site personnel regarding the existence and care of the LUCs; regular inspection and maintenance of the LUCs; and maintenance of an LUC database.

Effectiveness. Administrative mechanisms are not effective in reducing the toxicity, mobility, or volume of the COCs. The restrictions are only effective in potentially reducing the human health risk by site-wide communication of the LUCs at Parcel 66(7).

Implementability. This process option can be easily implemented, but maintenance of this LUC may be somewhat difficult due to the potential transfer of Parcel 66(7) to the public domain. This option would also limit the potential for future land development at the site.

Cost. The cost of this option is low compared to other process options.

Recommendation. This option will be retained for further consideration in developing remedial alternatives, probably in combination with another technology such as groundwater monitoring.

3.4.3.4 Groundwater Monitoring

Existing residuum and bedrock monitoring wells at Parcel 66(7) would be sampled to monitor the groundwater for VOCs. Groundwater monitoring would be conducted to track the potential horizontal and vertical migration of the groundwater contaminant plume. Additionally, groundwater monitoring may be conducted to evaluate COC concentration trends and to determine whether RGOs have been met.

Effectiveness. Groundwater monitoring is not effective in reducing the toxicity, mobility, or volume of the COCs. It may be used to assess the potential horizontal and vertical migration of the groundwater contaminant plume and to monitor groundwater contaminant concentration trends.

Implementability. Groundwater monitoring is easily implemented because the materials and equipment to conduct sampling are readily available.

Cost. The cost of this option is low compared to other process options. The capital costs associated with groundwater monitoring would be low, since residuum and bedrock monitoring wells are already present at Parcel 66(7). Operation and maintenance (O&M) costs for sampling and analysis of the contaminants would also be relatively low.

Recommendation. This option will be retained for further consideration in developing remedial alternatives, possibly in combination with other technologies, such as the physical, legal, and administrative mechanisms associated with LUCs.

3.4.4 Containment

Containment is a remedial action that isolates the contaminated groundwater from the noncontaminated portion of an aquifer. Containment of contaminated groundwater would consist of capping and/or the installation of vertical barriers.

3.4.4.1 Capping

Capping is the process of placing an impermeable cover over the contaminated area to inhibit infiltration of surface water and/or to prevent human contact with soil. Process options associated with the capping remedial technology type may include asphalt caps, clay caps, or multi-media caps. An asphalt cap consists of the placement of a layer of asphalt over the contaminated area at the site. A clay cap consists of the placement of compacted clay with a permeability of 10^{-7} or less over the area of concern. The clay layer is then covered with topsoil and vegetation. A multimedia cap consists of a combination of layers such as topsoil, a drainage layer (sand or gravel), and a low-permeability layer (synthetic liner or clay).

Effectiveness. The capping process options are not effective in reducing the toxicity, mobility, or volume of the COCs. No environmental or human health risk is associated with the surface or subsurface soils per the RI; therefore, a protective cap would not be required to minimize human exposure to surface soil. Furthermore, since contamination is limited to the

saturated zone, potential contaminant migration from the unsaturated zone associated with the infiltration of surface water is not a concern.

Implementability. All capping process options can be easily installed at the site. Asphalt pavement currently overlies the area of groundwater contamination at Parcel 66(7) and minimizes surface water infiltration.

Cost. The cost associated with the capping process options is expected to be low to moderate as compared to other process options. The cost is dependent on the type and quantity of material required for the cap.

Recommendation. The capping remedial technology will not be retained for further consideration in developing remedial alternatives. Based on the recommendations in the RI, the limited contaminant concentrations within the surface and subsurface soil do not pose significant risks to human health or the environment. Since contamination is limited to the saturated zone, capping is not required to prevent contaminant migration from the unsaturated zone.

3.4.4.2 Vertical Barriers

Vertical barriers, or nonpermeable barrier walls, are subsurface walls that limit the horizontal migration of contamination or groundwater flow. Nonpermeable barrier walls are constructed from a nonpermeable substance such as soil-bentonite slurry (slurry wall) or cement grout (grout curtain). Slurry walls are constructed in vertical trenches filled with a mixture of expanding soil-bentonite slurry. During installation, the slurry mixture hydraulically stabilizes the trench walls to prevent collapse. Grout curtains are subsurface layers, which run perpendicular to grade, created in unconsolidated materials by pressure injection. Pressure injection refers to a process whereby cement, grout, or other fluids are injected into a rock or soil mass in situ to reduce horizontal water flow and strengthen the formation. In general, vertical barrier walls are more effective when they are incorporated into an impervious confining clay or competent bedrock layer.

Effectiveness. Vertical barriers are not effective in reducing the toxicity or volume of the COCs in groundwater. Although a vertical barrier would reduce the mobility of the COCs, estimates of contaminant migration rates and distances presented in the RI suggest that significant migration of contaminants beyond the Parcel 66(7) boundary is not likely to occur over time.

Implementability. This remedial technology would require excavation and placement of the barrier to a depth below the elevation of the groundwater contamination and downgradient of the plume. For Parcel 66(7), the installation depth for a vertical barrier to bedrock would exceed 35 feet, and the horizontal length of the barrier may be extensive due to the presence of a groundwater divide at Parcel 66(7).

Cost. The cost associated with vertical barriers is moderate to high compared to other remedial technologies. A major contributor to the cost would excavation of the barrier to the required depth and linear extent to achieve adequate contaminant containment.

Recommendation. The vertical barrier remedial technology will not be retained for remedial alternative development due to its ineffectiveness in reducing the toxicity or volume of the COCs in groundwater, its difficulty of implementation, and its relatively high cost.

3.4.5 Groundwater Extraction

Groundwater extraction techniques involve the passive or active manipulation and management of groundwater to contain or remove a contaminant plume, or adjustment of groundwater levels to prevent the formation of a contaminant plume. The selection of the appropriate extraction technique depends upon the objectives of the remedial action, the depth of contamination, and the hydrologic and geologic characteristics of the aquifer. Extraction techniques are most effective where the contaminated aquifer has a high hydraulic conductivity (or transmissivity). The most commonly used extraction technique is a recovery well system.

3.4.5.1 Extraction by Recovery Wells

This remedial technology type includes extraction of contaminated groundwater from a single recovery well or a series of recovery wells using submersible pumps. Groundwater is extracted through a well screen set at a specific depth interval within a zone of influence to induce radial flow toward the well. The objective of this remedial technology is to achieve hydraulic control of the plume and removal of groundwater contamination.

Effectiveness. The effectiveness of this technology for capturing the contaminant plume at Parcel 66(7) is questionable because of the low hydraulic conductivity and the unpredictability of the groundwater flowpaths within the residuum formation. Therefore, the radius of influence and yield from each recovery well are expected to be minimal. Field pumping tests would be required to determine the site-specific yields, drawdown, pumping rates, and the optimal screen depth interval to achieve maximum contaminant removal.

Implementability. The recovery well network can be installed using commonly applied drilling techniques. Recovery wells may be readily installed by qualified contractors with commercially available equipment and materials. Due to the low hydraulic conductivity of the subsurface, fracturing of the residuum may be required to increase groundwater yield and recovery.

Cost. The cost of extraction by recovery wells is expected to be moderate to high compared to other technology types or process options and would depend upon the number of wells required to maintain adequate hydraulic control of the plume and to achieve contaminant removal. Costs may also be somewhat higher due to O&M requirements and typically longer treatment durations. Additional costs may be incurred if subsurface fracturing is required.

Recommendation. Recovery well extraction will not be retained for remedial alternative development. This technology type may not be effective due to the low hydraulic conductivity at the site. Additionally, the extracted water will require costly treatment prior to discharge. The costs associated with this process option may also increase due to the requirement for system O&M and the potential requirement for subsurface fracturing.

3.4.5.2 Extraction by Recovery Trenches

This technology includes the installation of a subsurface trench/drainage system to allow the interception and collection of large amounts of contaminated groundwater. Contaminated groundwater is extracted from the trench using submersible pumps and then treated ex situ prior to discharge. Recovery trenches essentially function as a consecutive line of recovery wells to effectively lower the groundwater table and contain or remove a contaminated groundwater plume. Key design considerations include the location, depth, and spacing of the trenches; the transmissivity of the aquifer; and the hydraulic design of the collection system. This technology is generally applied to areas with shallow groundwater contamination.

Effectiveness. The effectiveness of this process option is questionable due to the relatively low hydraulic conductivity of the residuum water-bearing zone at Parcel 66(7) and the unpredictability of the groundwater flowpaths within the residuum formation. Furthermore, this process option would be less effective due to the presence of a groundwater divide beneath Parcel 66(7).

Implementability. The installation of recovery trenches would be difficult due to the required depth of the trenches (approximately 35 feet bgs) for proper capture of the groundwater contaminant plume. Furthermore, the presence of the groundwater divide and the low hydraulic

conductivity within the residuum water-bearing zone may require the installation of multiple trenches to capture the contaminant plume.

Cost. The cost of the recovery trench extraction option is expected to be high compared to other process options due to the possibility that multiple trenches may have to be installed. As is the case for the recovery well extraction option, costs for the recovery trench option may be somewhat higher due to O&M requirements and typically longer treatment durations. Ex situ treatment costs for the recovered groundwater would be similar to those for the recovery well extraction option.

Recommendation. The recovery trench extraction option will not be retained for remedial alternative development. The cost of this process option would be prohibitively high due to the depth of the groundwater contaminant plume, the potential requirement for multiple trenches, and the requirement for O&M of the system to treat the extracted water.

3.4.6 Treatment

Due to the elimination of the groundwater extraction GRA, only in situ groundwater treatment processes will be considered in the following sections. Ex situ treatment technologies require that the groundwater be extracted prior to treatment; therefore, the technology descriptions for these process options have not been included in this document.

3.4.6.1 Biological Treatment

In situ biological treatment of the groundwater contaminant plume may be achieved by amending the groundwater with organic carbon, nutrients, oxygen, or other substrates to stimulate microbial biodegradation of the contaminants. The amendments would be injected via delivery systems such as injection wells or direct-push technology. The goal of biological treatment is to biodegrade the COCs to innocuous end products such as ethene, ethane, chloride ions, or carbon dioxide.

3.4.6.1.1 In Situ Anaerobic Bioremediation

In situ anaerobic bioremediation entails the addition of an electron donor (i.e., carbon source) within the subsurface to stimulate indigenous anaerobic microorganisms to biodegrade contaminants. The COCs at Parcel 66(7) (TCE, 1,1-DCE, 1,2-DCA, cis-1,2-DCE, and VC) may be degraded under anaerobic conditions via reductive dechlorination where carbon is used as an energy source by the anaerobic microbes in the subsurface and the chlorinated ethenes and ethanes are used as respiratory substrates, or electron acceptors, during metabolism. Chlorine atoms are sequentially removed from the chlorinated contaminant and replaced with hydrogen

atoms. Microbial activity is supported by an external carbon source such as hydrogen releasing compound (HRC), lactate, or molasses. Without an organic carbon source, the dehalogenation reaction ceases and the chlorinated solvents persist in the groundwater. The carbon source is typically injected (either continuously or as a batch delivery) into the groundwater and allowed to diffuse throughout the plume. Groundwater amendment with nutrients (i.e., ammonia and phosphate) may be required to further enhance the in situ anaerobic bioremediation process.

Effectiveness. The effectiveness of enhanced anaerobic biodegradation at Parcel 66(7) was evaluated through a bench-scale treatability study. Lactate and HRC were evaluated for their effectiveness in stimulating the reductive dechlorination of chlorinated ethenes using site soil and groundwater. A report discussing the results of the anaerobic biodegradation treatability study is included as Appendix B of this FFS report. Based on the results of the treatability study, in situ anaerobic bioremediation would not be effective for remediating groundwater at Parcel 66(7). Treatment of groundwater with different carbon sources (HRC and lactate) induced limited reductive dechlorination of TCE and resulted in the accumulation of cis-1,2-DCE with no significant dechlorination beyond cis-1,2-DCE. The results of the treatability test indicate that the subsurface conditions at Parcel 66(7) are not suitable for anaerobic bioremediation due to the lack of microorganisms essential for the complete biodegradation of the COCs to innocuous end products via the reductive dechlorination pathway.

Implementability. HRC and lactate can be delivered with commercially available equipment. Delivery systems include injection rods advanced using direct-push technology and injection wells. Commercial vendors are available to implement the carbon source addition. The installation of groundwater extraction wells may be required for groundwater control and to enhance the distribution of the carbon source throughout the aquifer. Because of the low hydraulic conductivity of the subsurface, fracturing of the residuum may also be required to increase carbon source distribution. The installation of additional monitoring wells may be required to assess the effectiveness of the remedial action. The monitoring wells can be installed with commercially available equipment and materials by a qualified contractor. Pilot testing would be required to help determine scale-up doses and duration for site-wide implementation.

Cost. The overall cost for in situ anaerobic treatment is expected to be moderate compared to other process options due to the limited amount of labor and equipment required for addition of the carbon source. Monitoring and reporting costs would be incurred until treatment goals are achieved.

Recommendation. The in situ anaerobic bioremediation option will not be retained for remedial alternative development. As determined by treatability testing, enhanced anaerobic biodegradation through lactate or HRC addition was not proven to be effective in reductively dechlorinating the COCs at Parcel 66(7).

3.4.6.1.2 In Situ Aerobic Bioremediation

In situ aerobic bioremediation typically entails increasing the dissolved oxygen concentration in the subsurface to stimulate aerobic microorganisms to degrade contaminants. Under aerobic conditions, microorganisms use dissolved oxygen in the groundwater as a respiratory substrate (electron acceptor). With sufficient oxygen, microorganisms will completely oxidize many organic chemicals to carbon dioxide and water. Chlorinated solvents may be biodegraded through several different mechanisms; however, each mechanism has specific requirements and preferences for the type of solvent that can be degraded. One such mechanism is cometabolism. The COCs at the site may be biodegraded via cometabolism under aerobic conditions in the presence of a suitable substrate (e.g., methane, propane, or butane) to stimulate the aerobic microbial populations and generate the enzymes necessary to induce co-metabolic biodegradation. Through a second mechanism, less highly-chlorinated compounds (e.g., DCE and VC) may undergo metabolic oxidation under aerobic conditions, resulting in the formation of carbon dioxide, water, and chloride. In situ aerobic conditions can be induced through the direct injection of an air stream into the aquifer via injection wells, or through the injection of chemicals capable of releasing oxygen such as oxygen-releasing compound or dilute hydrogen peroxide.

Effectiveness. Aerobic degradation of TCE (the COC present at the highest concentration in the Parcel 66[7] groundwater) does not occur under natural conditions because it is a highly oxidized compound. However, the COCs at Parcel 66(7) may degrade via co-metabolic pathways under aerobic conditions in the presence of a suitable substrate (e.g., methane, propane, or butane) to stimulate the microbes and generate the required enzymes. Without a suitable substrate, the co-metabolic degradation of TCE will not proceed under aerobic conditions. Although an innovative technology, aerobic cometabolism of TCE is expected to be effective if sufficient distribution of dissolved oxygen and the gaseous substrate is achieved.

Implementability. In situ aerobic bioremediation would be difficult to implement because of the weathered shale lithology at the site. The microfractures constituting the porosity of the subsurface would limit the effective delivery of an air stream amended with a gaseous substrate. Short-circuiting and low radii of influence would be expected in this type of lithology. In addition, the low hydraulic conductivity at the site would limit the distribution of dissolved

oxygen and in substrate via advective mechanisms, which would further limit the implementability of the technology.

Cost. The overall cost for the treatment system is expected to be moderate to high compared to other process options. Channeling effects during the administration of a gas substrate into the subsurface would increase the number of required injection wells, which would increase capital costs and O&M costs.

Recommendation. The in situ aerobic bioremediation option will not be retained for remedial alternative development. Due to the lack of a suitable substrate for co-metabolic degradation of TCE and the complicating factors associated with delivering an air stream into the subsurface, in situ aerobic bioremediation would not be implementable at Parcel 66(7).

3.4.6.2 Physical Treatment

In situ physical groundwater treatment technologies include density-driven air stripping and AS/SVE. The physical treatment process options depend on the inherent properties of the contaminant (e.g., Henry's Law Constant and solubility) and do not chemically change the contaminant.

3.4.6.2.1 In Situ Density-Driven Air Stripping

The in situ density-driven air stripping process option is designed with a grid of wells screened near the top and bottom of the contaminated groundwater zone. Air is injected into the bottom of the well casing through a drop tube placed within the well casing. The air forms bubbles that flow upward, displacing water and lowering the density of the water column within the well casing. The density reduction creates an upward vertical gradient that draws groundwater in through the lower screen and pushes aerated (stripped) water out through the upper screen. Volatile contaminants are stripped from the water by partitioning into the air stream. The contaminated air stream is extracted using a vacuum blower and treated to remove the chlorinated compounds prior to discharge.

Effectiveness. The in situ density-driven air stripping will not be effective in reducing the concentrations of the COCs in groundwater at Parcel 66(7). The in situ air stripping system is generally ineffective in a tight formation such as the weathered shale present at the site. The microfractures in the subsurface would limit the effectiveness of this technology by reducing the radius of influence of the wells. Chemical precipitates often form during the air stripping process and clog the well screens, thereby limiting groundwater recirculation.

Implementability. A limited number of patented in situ density-driven air stripping systems are commercially available. The selected design must be pilot tested prior to implementation of the full-scale treatment system. In addition, ex situ air pollution abatement controls may be required for the off-gas created by the vacuum blower.

Cost. The cost of installing an in situ density-driven air stripping system is moderate compared to other process options. The cost would depend on the capacity of the compressor and vacuum blower, the number of stripping wells, and the cost of the air pollution control equipment.

Recommendation. This process option will not be retained for detailed analysis. The technology is neither field-proven nor effective in tight soil formations similar to those observed at Parcel 66(7). Additionally, the cost of the air pollution control equipment and associated maintenance could be prohibitive.

3.4.6.2.2 Air Sparging/Soil Vapor Extraction

The in situ AS/SVE process removes dissolved-phase VOC contamination from groundwater. This process uses air as a carrier for the removal of contaminants instead of water as in the conventional pump-and-treat method. Pressurized air is injected via air sparging wells within the contaminated portion of the saturated zone to form bubbles that rise through the aquifer, stripping the dissolved-phase contamination from the groundwater. The contaminants volatilize into the rising air stream and are carried from the saturated zone in gaseous form to the vadose zone. The gaseous emissions are recovered from the vadose zone using an extraction system typically consisting of vapor extraction wells screened within the vadose zone or extraction trenches and a vacuum blower. The extracted vapors are processed through an air pollution abatement system (e.g., granular activated carbon bed or an oxidizer). The pressurized air is generated using a compressor or blower and applied below the contaminated zone in the aquifer via air sparging wells constructed for this purpose and installed with conventional well installation equipment.

Effectiveness. AS/SVE is a proven technology that is widely used to remediate VOC-contaminated groundwater. Used alone or in combination with other technologies, AS/SVE can be used for source area removals, plume control, and the reduction of dissolved-phase contamination. AS/SVE systems have not been proven effective for use in tight geological formations such as those found at Parcel 66(7). Short-circuiting of the injected air stream along preferential flow-paths within the formation would be expected at Parcel 66(7), which would limit the effectiveness of the technology. Furthermore, extraction of vapors would be difficult

due to the low air permeability of the clay soils within the vadose zone and the shallow depth of the residuum groundwater.

Implementability. The air sparging wells, extraction trenches/wells, manifold piping, and process equipment are commercially available and installed using conventional methods. Once installed and operating, the O&M requirements are generally lower than for pump-and-treat systems, because air is generally easier to move and treat than groundwater. A site pilot test would be required prior to design and implementation.

Cost. The cost for air sparging is generally moderate to high compared to other remedial technologies. Capital costs would include installation of the sparging and extraction wells, manifold piping, blower units, and an air pollution control system. O&M costs would be associated with the blower units and pollution control system.

Recommendation. The AS/SVE process option is not retained for remedial alternative development because site-specific geology and hydrogeology do not favor the use of this technology.

3.4.6.3 Chemical Treatment

Chemical treatment includes process options such as in situ chemical reduction using zero-valent iron and in situ chemical oxidation using hydrogen peroxide, ozone, or permanganate. In situ chemical reduction may be achieved through the installation of a zero-valent iron reactive wall perpendicular to groundwater flow. As contaminated groundwater passively flows through the wall, the zero-valent iron will dechlorinate the chlorinated compounds, converting them to innocuous compounds such as ethene. In situ chemical oxidation entails the injection of chemical oxidants into the subsurface to destroy the contaminants by converting them to innocuous compounds such as carbon dioxide, water, and chloride.

3.4.6.3.1 Zero-Valent Iron Reactive Wall

Reactive walls are installed by constructing a large trench across the flowpath of contaminated groundwater and filling the trench with one of a variety of materials (e.g., reactive filings) carefully selected for their ability to remediate specific types of contaminants. Zero-valent iron is an effective fill material for reactive walls to accomplish abiotic dechlorination of the COCs at Parcel 66(7). The zero-valent iron is typically installed as a subsurface reactive wall perpendicular to groundwater flow direction. As groundwater flows through the wall, chlorinated organics are reduced to innocuous compounds through successive dechlorination reactions. The mechanism is believed to involve abiotic reductive dechlorination by monatomic

hydrogen, which is liberated (in low concentrations) during the reaction of water with metallic iron in an anaerobic environment.

Effectiveness. The effectiveness of the zero-valent iron wall is dependent on groundwater flow characteristics, groundwater quality, thickness of the iron barrier, and the reactivity of the iron. The concentrations of contaminants entering the wall must be well characterized such that there is sufficient residence time for the contaminants to be treated prior to leaving the reactive portion of the wall. Inducing groundwater to flow through the wall would be difficult because of the presence of a groundwater divide beneath Parcel 66(7) and the low hydraulic gradient.

A concern associated with the use of zero-valent iron is decreasing iron reactivity over time due to a build-up of corrosion products (iron oxides) or other precipitates (carbonate deposition in alkaline water) on the iron surface. Excess oxygen may oxidize iron, resulting in the formation of iron oxide minerals that clog the formation and reduce the reactivity of the iron surface. Formation clogging and iron reactivity issues are typically solved by replacing the filings. Bench-scale treatability testing would be required to determine the amount of iron necessary to achieve abiotic dechlorination and to quantify the factors influencing contaminant degradation rates and the lifetime of the zero-valent iron.

Implementability. The zero-valent iron wall can be installed using commercially available equipment. The bottom of the zero-valent iron wall would be installed into a confining layer (e.g., bedrock) so that groundwater would flow through the porous reactive medium contained in the wall. The trenching for the wall may be difficult due to the excavation depth to bedrock required to capture the plume (approximately 40 feet bgs). Selecting a location for the zero-valent iron wall that would effectively capture the plume would be difficult due to the presence of the groundwater divide.

Cost. The cost for the zero-valent iron wall is moderate compared to the other process options. O&M costs, primarily associated with periodic groundwater monitoring, would be low after installation of the zero-valent iron wall. Costs could escalate, however, if the zero-valent iron filings need replacement due to a reduction in reactivity over time.

Recommendation. The zero-valent iron wall process option will not be retained for remedial alternative development. The zero-valent iron wall may not be effective due to the low hydraulic gradient at the site, which would make the inducement of groundwater flow through the wall difficult.

3.4.6.3.2 In Situ Chemical Oxidation Using Hydrogen Peroxide

Hydrogen peroxide (H_2O_2) is typically used with ferrous iron (Fe^{2+}) as a catalyst to produce Fenton's Reagent, which yields a highly reactive hydroxyl radical (OH•). The hydroxyl radical breaks the carbon-hydrogen bonds of organic molecules, thereby degrading most organic compounds, including the COCs at Parcel 66(7). The simplified stoichiometric reaction for the degradation of TCE (C_2HCl_3) is given by the following equation:

$$3H_2O_2 + C_2HCl_3 \text{--->} 2CO_2 + 2H_2O + 3HCl$$

The residual hydrogen peroxide decomposes to water and oxygen in the subsurface, and the remaining iron precipitates out of solution. The optimum pH range to facilitate the generation of the hydroxyl radical is between 2 and 4, necessitating the addition of an acid to the subsurface.

The method of delivery of the oxidants may vary. The oxidant is either injected through a series of wells, mixed with the iron catalyst and then injected, or combined with a stabilizer and then injected. Because of its high volatility, hydrogen peroxide is typically mixed with a stabilizer prior to injection.

Effectiveness. Hydrogen peroxide oxidation has been proven effective for remediation of chlorinated compounds in groundwater. The effectiveness of the treatment usually depends on the success of the delivery method.

Implementability. Hydrogen peroxide oxidation is readily implemented using existing technology and qualified vendors. The primary limitation associated with the implementation of this treatment is the ability to deliver the peroxide to the subsurface to maintain efficient contact between the peroxide and the contaminants. Other limitations include handling issues associated with the hazardous nature of the chemicals (peroxide is a class II oxidizer). Special measures may also be required during chemical delivery because of the potential for peroxide to break down to water vapor and oxygen, causing fugitive VOC emissions and pressure buildup in the subsurface.

Cost. The hydrogen peroxide oxidation cost is moderate to high compared to other process options. The cost will depend on the quantity of chemicals required for effective treatment.

Recommendation. This process option will not be retained for remedial alternative development due to safety concerns associated with chemical handling and the potential environmental effects associated with the addition of an acid to the subsurface.

3.4.6.3.3 In Situ Chemical Oxidation Using Ozone

Ozone (O_3) is a strong oxidant capable of oxidizing contaminants directly or through hydroxyl radical formation. The simplified stoichiometric reaction for the degradation of TCE by ozone is given by the following equation:

$$O_3 + H_2O + C_2HCl_3 \text{--->} 2CO_2 + 3HCl$$

As with hydrogen peroxide, in situ oxidation using ozone requires acidic conditions. The ozone is produced on-site and delivered via closely spaced points such as sparging wells.

Effectiveness. Ozone oxidation has proven to be effective in lowering the toxicity and volume of chlorinated compounds in groundwater. The effectiveness of the treatment is dependent on the success of the delivery method.

Implementability. The ozone oxidation process option is not easily implemented because the ozone must be generated on site. Ozone is a criteria air pollutant per the EPA and is very reactive and corrosive to materials. It reacts quickly in the subsurface and does not migrate long distances from the delivery point; therefore, many injection points would be required.

Cost. Since ozone must be generated on site and a large number of injection wells are required for effective delivery, the ozone oxidation cost would be moderate to high compared to other process options.

Recommendation. This process option will not be retained for remedial alternative development due to the high cost associated with the on-site generation of ozone and the corrosive and reactive nature of the oxidant.

3.4.6.3.4 In Situ Chemical Oxidation Using Potassium Permanganate

The permanganate ion (MnO_4^-), delivered either as potassium permanganate ($KMnO_4$) or sodium permanganate ($NaMnO_4$), is a common oxidant widely used in the water treatment industry to remove and precipitate dissolved metals, and in the sewage treatment industry to treat sulfide odors. The permanganate ion reacts with and oxidizes a wide range of common organic compounds relatively quickly and completely. In particular, MnO_4^- reacts rapidly with the nonconjugated (i.e., nonaromatic) double bonds in chlorinated ethenes such as the above-MCL levels of COCs present at Parcel 66(7). Permanganate oxidizes the chlorinated ethenes to carbon

dioxide and chloride ions. The balanced chemical equation for $KMnO_4$ oxidation of TCE (for example) is:

$$4KMnO_4 + 3C_2HCl_3 + 4H_2O \text{--->} 6CO_2 + 4MnO_2 + 4K^+ + 9Cl^- + 11H^+$$

Sodium permanganate is available in liquid form, which is useful for soil remediation, but it is more costly than $KMnO_4$. Therefore, sodium permanganate is excluded from further consideration.

The effectiveness of treatment depends on three factors: 1) the kinetics of the reaction between the permanganate and the contaminants, 2) the contact between the oxidant and the contaminants, and 3) competitive reactions of permanganate with other reduced/oxidizable species. If the contaminants being targeted for in situ chemical oxidation are reactive (e.g., chlorinated ethenes) and if sufficient oxidant has been added to overcome the demand from other reduced species, the limiting factor to the successful application of in situ oxidation is the transport of the oxidant to the contaminated areas and not the reaction itself. The oxidation of contaminants by permanganate is essentially an instantaneous reaction. If the permanganate contacts the contaminant, a reaction will occur. Significant oxidation can be observed in as little as a few hours after addition. By contrast, the time of migration for the permanganate from the delivery point may be on the order of days to weeks, depending on the delivery mechanism.

Effectiveness. In situ chemical oxidation using $KMnO_4$ is expected to be effective in reducing the toxicity and volume of chlorinated ethenes in groundwater at Parcel 66(7). The effectiveness of the treatment in situ is dependent upon the soil and groundwater chemistry (interferents). In situ chemical oxidation using $KMnO_4$ will not treat 1,2-DCA, which is one of the COCs at Parcel 66(7); however, this is not a concern because 1,2-DCA exists in the groundwater at a concentration below its MCL. The oxidation is not compound specific; therefore, interfering compounds in the soil and groundwater could limit the effectiveness of the degradation of the chlorinated ethenes. Soil oxidant demand testing was conducted to estimate the quantity of excess $KMnO_4$ required to treat the groundwater plume (Appendix C). The primary limitation of this process option would be the difficulty associated with dispersing the $KMnO_4$ throughout the groundwater plume, which could be overcome by pneumatically fracturing the residuum prior to $KMnO_4$ injection.

Implementability. $KMnO_4$ is easily injected into the subsurface via injection wells as a liquid or by air injection as a solid. $KMnO_4$ addition is readily implemented using existing technology and qualified vendors. A field pilot test at the site would be required to determine the site-

specific chemical transport properties of the aquifer. Fracturing of the subsurface may be required to ensure adequate $KMnO_4$ dispersion.

Cost. The cost of in situ oxidation using $KMnO_4$ is moderate compared to other process options. The capital cost for permanganate remediation would depend on the quantity of oxidant required to treat the entire plume and the number of injection points needed to adequately distribute the oxidant. O&M costs would be relatively low and would be associated with periodic groundwater monitoring.

Recommendation. This process option will be retained for remedial alternative development. $KMnO_4$ is an aggressive, proven, and effective means of treating the above-MCL levels of COCs in groundwater at Parcel 66(7). Furthermore, $KMnO_4$ is also more stable in the subsurface than other oxidants (e.g., hydrogen peroxide and ozone).

3.4.7 Discharge

3.4.7.1 Groundwater Discharge

Groundwater discharge process options include recharge basins, discharge to an off-site publicly owned treatment works, and discharge to a local stream. The groundwater discharge remedial technology type will not be retained for further consideration because the groundwater extraction and ex situ treatment GRAs have been previously eliminated.

3.4.7.2 Air Pollution Control Systems

Air pollution control remedial technologies would be used for treating the off-gas during air stripping (in situ or ex situ) and AS/SVE process options. Common off-gas treatment systems include vapor-phase granular activated carbon, thermal oxidizers, catalytic oxidizers, biofilters, and internal combustion engines. The air pollution control systems remedial technology type will not be retained for further consideration because the air stripping and AS/SVE process options have been previously eliminated.

3.5 Summary of Process Options and Remedial Alternatives Retained for Remedial Alternative Development

The following groundwater remedial technologies or process options are retained for remedial alternative development:

- No Action

- Land Use Controls
  - Physical Mechanisms
  - Legal Mechanisms
  - Administrative Mechanisms
  - Groundwater Monitoring

- In situ Chemical Oxidation using $KMnO_4$.

Detailed analyses of these remedial alternatives are included in Chapter 4.0.