DEPARTMENT OF THE ARMY
LONGHORN ARMY AMMUNITION PLANT
POST OFFICE BOX 220
RATCLIFF, AR 72951

September 19, 2016

DAIM-ODB-LO

Mr. Rich Mayer
US Environmental Protection Agency
Federal Facilities Section R6
1445 Ross Avenue
Dallas, TX 75202-2733

Re: Final Record of Decision, LHAAP-17, Burning Ground No. 2/Flashing Area, Group 2, Longhorn Army Ammunition Plant, Karnack, Texas, August 2016

Dear Mr. Mayer,

The above-referenced document is being transmitted to you for your records. The Draft Final document was previously prepared and submitted by Shaw Environmental, Inc. (Shaw) on behalf of the Army as part of Shaw's performance based contract for the facility on September 29, 2011. The Final document has been updated by Army to address the EPA Administrator's decision resolving the dispute in a letter dated October 31, 2014.

The point of contact for this action is the undersigned. I may be contacted at 479-635-0110, or by email at rose.zeiler@us.army.mil.

Sincerely,

Rose M. Zeiler, Ph.D.
Longhorn AAP Site Manager

Copies furnished:
A. Palmie, TCEQ, Austin, TX
P. Bruckwicki, Caddo Lake NWR, TX
R. Smith, USACE, Tulsa District, OK
A. Williams, USACE, Tulsa District, OK
N. Smith, USAEC, San Antonio, TX
D. Richmann, AECOM – San Antonio, TX (for project files)

DEPARTMENT OF THE ARMY
LONGHORN ARMY AMMUNITION PLANT
POST OFFICE BOX 220
RATCLIFF, AR 72951

September 19, 2016

DAIM-ODB-LO

Ms. April Palmie
Texas Commission on Environmental Quality Superfund Section, MC-136
12100 Park 35 Circle, Bldg D
Austin, TX 78753

Re: Final Record of Decision, LHAAP-17, Burning Ground No. 2/Flashing Area, Group 2, Longhorn Army Ammunition Plant, Karnack, Texas, August 2016

Dear Ms. Palmie,

The above-referenced document is being transmitted to you for your records. The Draft Final document was previously prepared and submitted by Shaw Environmental, Inc. (Shaw) on behalf of the Army as part of Shaw's performance based contract for the facility on September 29, 2011. The Final document has been updated by Army to address the EPA Administrator's decision resolving the dispute in a letter dated October 31, 2014.

The point of contact for this action is the undersigned. I may be contacted at 479-635-0110, or by email at rose.zeiler@us.army.mil.

Sincerely,

Rose M. Zeiler

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Longhorn AAP Site Manager

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R. Mayer, USEPA Region 6, Dallas, TX
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R. Smith, USACE, Tulsa District, OK
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20775142

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

September 6, 2016

Mr. Thomas E. Lederle
Chief, ACSIM BRAC Division
2530 Crystal Drive, Room 5000
Taylor Bldg./NC3
Arlington, Virginia 22202

Re: Record of Decision for LHAAP-17, Burning Ground No. 2/Flashing Area
Longhorn Army Ammunition Plant Superfund Site TX6213820529
Karnack, Harrison County, Texas

Dear Mr. Lederle:

The Texas Commission on Environmental Quality (TCEQ) received the final Record of Decision (ROD) for the LHAAP-17, Burning Ground No. 2/Flashing Area, at the Longhorn Army Ammunition Plant Federal Superfund Site in Karnack, Texas on August 16, 2016. The TCEQ has completed the review of the above referenced document and concurs that the response action described in the ROD is the most appropriate remedy for LHAAP-17.

Sincerely,

Richard A. Hyde, P.E.
Executive Director

cc: Mr. Carl Edlund, P.E., Director, Superfund Division, U.S. Environmental Protection Agency, Region 6

FINAL

RECORD OF DECISION
LHAAP-17, BURNING GROUND NO. 2/FLASHING AREA, GROUP 2
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

ON THE LINE

Prepared for

U.S. Army Corps of Engineers
Tulsa District
1645 South 101st East Avenue
Tulsa, Oklahoma

Prepared by

Shaw Environmental, Inc.
1401 Enclave Parkway, Suite 250
Houston, Texas 77077

Contract No. W912QR-04-D-0027, Task Order No. DS02
Shaw Project No. 117591

August 2016

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Glossary of Terms

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Acronyms and Abbreviations

µg/L	micrograms per liter
ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
DCA	Dichloroethane
DCE	Dichloroethene
DNT	Dinitrotoluene
DPT	direct-push technology
EcoPRG	ecological preliminary remediation goal
ECP	environmental condition of property
EEQ	ecological effects quotient
EPC	exposure point concentration
ESD	Explanation of Significant Differences
FFA	Federal Facility Agreement
FS	feasibility study
ft^2	square feet
GWP-Ind	TCEQ soil MSC for industrial use based on groundwater protection
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
HRC®	Hydrogen Release Compound®
IRIS	Integrated Risk InformationSystem
Jacobs	Jacobs Engineering Group
LHAAP	Longhorn Army Ammunition Plant
LTM	long-term monitoring
LUC	land use control
MCL	maximum contaminant level
mg/kg	milligrams per kilogram (parts per million [ppm] – soil analyses)
mg/kg-day	milligrams per kilogram per day
MNA	monitored natural attenuation
MOA	memorandum of agreement
MSC	medium-specific concentration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

Acronyms and Abbreviations *(continued)*

NOAEL	no-observed adverse effect level
NPL	National Priorities List
O&M	operation and maintenance
PEC	Planteco Environmental Consultants, LLC
PCL	Protective Concentration Level
Plexus	Plexus Scientific Corporation
RAB	Restoration Advisory Board
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RFA	RCRA Facility Assessment
RfD	reference dose
RI	remedial investigation
ROD	record of decision
RRS	Risk Reduction Standards
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
Shaw	Shaw Environmental, Inc.
STEP	Solutions to Environmental Problems, Inc.
SVOC	semivolatile organic compound
TAC	Texas Administrative Code
TCDD	tetrachlorodibenzo-p-dioxin
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TEC	toxicity equivalence concentration
TNT	Trinitrotoluene
TRRP	Texas Risk Reduction Program
TRV	toxicity reference level
U.S. Army	U.S. Department of the Army
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USC	U.S. Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VC	vinyl chloride
VOC	volatile organic compound

1.0 The Declaration

1.1 Site Name and Location

LHAAP-17, Burning Ground No. 2/Flashing Area, Group 2

Longhorn Army Ammunition Plant
Karnack, Texas

Comprehensive Environmental Response, Compensation, and Liability Information System, U.S. Environmental Protection Agency (USEPA) Identification Number: TX6213820529.

1.2 Statement of Basis and Purpose

This decision document presents the selected remedy for LHAAP-17, Burning Ground No. 2/Flashing Area, located at the Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. The remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Code of Federal Regulations (CFR) Title 40 §300.

The remedy selection was based on the Administrative Record for the site, including the remedial investigation (RI) (Jacobs Engineering Group, Inc. [Jacobs], 2001), baseline human health risk assessment (BHHRA) report (Jacobs, 2002), installation-wide baseline ecological risk assessment (BERA) report (Shaw Environmental, Inc. [Shaw], 2007a), feasibility study (FS) (Shaw, 2010), and Proposed Plan (U.S. Department of the Army [U.S. Army], 2010).

The U.S. Army is the lead agency for the environmental response actions at LHAAP. The U.S. Army, USEPA, and the Texas Water Commission (currently known as the TCEQ) entered into the FFA for remedial activities at LHAAP which became effective on December 30, 1991. The U.S. Army is acting in partnership with the USEPA Region 6 and the Texas Commission on Environmental Quality (TCEQ), the regulatory agencies providing technical support, project review and comment, and oversight of the U.S. Army cleanup program. The USEPA and the U.S. Army jointly select the remedy and TCEQ concurs with the selected remedy in this Record of Decision (ROD).

1.3 Assessment of the Site

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment.

1.4 Description of the Selected Remedy

The selected remedy for LHAAP-17 protects human health and the environment by preventing human and ecological receptors from exposure to contaminated soil and contaminated groundwater. The human health scenarios evaluated were based on the hypothetical future maintenance worker. In the soil, chemicals of concern (COCs) are explosives (2,4,6-trinitrotoluene [TNT], 2,4-dinitrotoluene [DNT], 2,6-DNT) and perchlorate (potential soil COC based on groundwater concentrations); and chemicals of potential ecological concern (COPECs) are explosives (2,4,6-TNT, 2,4-DNT, 2,6-DNT); dioxins (2,3,7,8-tetrachlorodibenzo-p-dioxin [TCDD] toxicity equivalence concentration [TEC]); and barium. In the shallow groundwater zone, the COCs are perchlorate and volatile organic compounds (VOCs) (1,2-dichloroethane [DCA], 1,1-dichloroethene [DCE], cis-1,2-DCE, trichloroethene [TCE], and vinyl chloride [VC]). In the intermediate groundwater zone, the COCs are TCE and its daughter products (DCE and VC). The contaminated soil has been identified as a principal threat material. The components of the selected remedy are summarized below:

- Contaminated soil removal with off-site disposal to protect the hypothetical future maintenance worker and ecological receptors and to eliminate the soil-to-groundwater pathway.
- Extraction and treatment of groundwater until the trigger level of 20,000 micrograms per liter (µg/L) of perchlorate is reached. The trigger level in this ROD is an interim cleanup level. Upon reaching the trigger level, the remedial action will transition from the initial measure of groundwater extraction to the primary remedy of monitored natural attenuation (MNA). Reduction of the perchlorate concentration to the trigger level is anticipated to expedite MNA.
  - If the 20,000 µg/L of perchlorate level is not reached after approximately 1.5 years, a contingency remedy of in situ bioremediation will be implemented to reduce the perchlorate levels more quickly so the conditions become amenable for TCE to attenuate naturally.
- MNA to confirm protection of human health and the environment by documenting that the contaminated groundwater remains localized with minimal migration and that contaminant concentrations are being reduced to cleanup levels.
  - Performance objectives will be evaluated after 2 years of MNA. During those 2 years, monitoring will be quarterly. If MNA is found to be ineffective, a contingency remedy to enhance MNA will be implemented. If MNA is found to be effective, it will be continued, and long-term monitoring (LTM) will be semiannual for 3 years. In subsequent years, LTM will be annual until the next five-year review and annually thereafter until recommended otherwise by the five-year review. The monitoring and reporting associated with this remedy will be used to track the effectiveness of MNA and will continue until recommended otherwise at the five-year review.

- The LUC objectives include maintaining the integrity of any current or future remedial or monitoring systems, and preventing the use of groundwater contaminated above cleanup levels as a potable water source. The groundwater treatment and MNA remedial components include a groundwater monitoring system that will be used to characterize the condition of the groundwater during the period the groundwater remedy is in place until the groundwater remediation goals are achieved, and to demonstrate achievement of the groundwater remediation goals when the groundwater remedy is complete. As a part of this groundwater remedy, the Army will maintain the remedial and monitoring systems associated with the groundwater remedies until these components of the remedy are no longer needed to achieve cleanup levels, and cleanup levels have been achieved. During the period of operation of the groundwater remedy, if any of the elements of the remedial and groundwater monitoring systems are damaged, destroyed, or become ineffective, they will be repaired or replaced with suitable components to assure that the remedial and groundwater monitoring systems are able to provide data of the quality necessary to determine the progress of and eventual completion of this component of the remedy. The actions to be taken to implement these LUC objectives and requirements will be provided through modifying the "Comprehensive Land Use Control (LUC) Management Plan, Former Longhorn Army Ammunition Plant, Karnack, Texas" and detailed in the LUC RD.

- The LUC for prohibition of groundwater use (except for monitoring and testing) shall be implemented and shall remain in place at the Site until the COCs (i.e. including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soil and groundwater remaining at the site are reduced below levels that would support unlimited use and unrestricted exposure. A LUC RD will be finalized as the land use component of the Remedial Design. Within 21 days of the issuance of the ROD, the Army will propose deadlines for completion of the RD Work Plan, RD and Remedial Action Work Plan. The documents will be prepared and submitted to the EPA and the TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. The long-term groundwater and surface water monitoring and MNA performance monitoring plan will also be presented in the RD. The recordation notification for the Site which will be filed with Harrison County, will include a description of the LUCs. The preliminary boundary for the groundwater LUC is shown on Figure 2-5.

- The LUC restricting land use to nonresidential shall be implemented until it is demonstrated that surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure.

    - The LUC to maintain the integrity of any current or future remedial or monitoring systems will remain in place until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met. The

LUC to prohibit groundwater use (except for environmental monitoring and testing) as a potable source will remain in place until the levels of COCs (i.e., all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soil and groundwater allow for unlimited use and unrestricted exposure.

- CERCLA five-year reviews until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soil and groundwater allow for unlimited use and unrestricted exposure.

Based on a preliminary natural attenuation evaluation and groundwater modeling, cleanup levels are expected to be met through natural attenuation in approximately 117 years (Shaw, 2010). Specifically, TCE should attenuate to its maximum contaminant level (MCL) in approximately 117 years, 1,2-DCA in 10 years, and perchlorate in 15 years without groundwater extraction and treatment. With groundwater extraction and treatment, cleanup times should be reduced. Considering the lithologic variability, particularly the lateral and vertical change from sand to clay, the time to achieve cleanup levels may vary. In the course of the remedy, the additional monitoring results will allow more accurate time estimates.

The groundwater flow rates are within the normal range for the formation material at the site. Thus, no adverse impact is expected to the surface water during the time it would take natural attenuation to reduce contaminant concentrations to cleanup levels.

A LUC Remedial Design (RD) will be finalized as the land use component of the Remedial Design. Within 21 days of the issuance of the ROD, the Army will propose deadlines for completion of the RD Work Plan, RD, and Remedial Action Work Plan. The documents will be prepared and submitted to EPA and TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. The long-term groundwater and surface water monitoring and MNA performance monitoring plan will also be presented in the RD.

The Army will implement, maintain, monitor, report on and enforce land use controls at Army-owned property. The Army shall perform those actions related to land use control activities described in this ROD and in the Remedial Design for the ROD. For portions of the Site subject to land use controls that are not owned by the Army, the Army will monitor and report on the implementation, maintenance, and enforcement of land use controls, and coordinate with federal, state, and local governments and owners and occupants of properties subject to land use controls. The Army will provide notice of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. The Army will send these notices to the federal, state and local governments involved at this site and the owners and occupants of the properties subject to those use restrictions and land use controls. The Army shall provide the initial notice within 90 days of ROD signature. The frequency of subsequent notifications will be described in the Remedial Design for the ROD. The Army remains responsible for ensuring that the remedy remains protective of human health and the environment. The Army will fulfill its responsibility and obligations under CERCLA and the NCP as it implements, maintains, and reviews the selected remedy.

Upon transfer of Army-owned property, the Army will provide written notice of the land use controls to the transferee of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. Within 15 days of transfer, the Army shall provide EPA and TCEQ with written notice of the division of implementation, maintenance, and enforcement responsibilities unless such information has already been provided in the LUC RD. The LUC RD will address the procedures to be used by the Army and the transferee to document compliance with the LUCs described in this ROD. In the event property is transferred out of Federal control, the land use controls relating to property and groundwater restrictions shall be recorded in the deed and shall be enforceable by the United States and the state of Texas.

U.S. Army and regulators will consult to determine appropriate enforcement actions should there be a failure of a LUC objective at these sites after they have been transferred.

The management strategy at LHAAP is to approach each site separately to address human health issues and to approach the sites by sub-area to address ecological risk (Shaw, 2007a). Thus, the implementation of this remedy at LHAAP-17 is independent of any other remedial action at LHAAP to address human health issues. To address ecological risk, LHAAP-17 was grouped with several other sites as part of the Waste Sub-Area. The final COPECs in soil that require remedial action in the Waste Sub-Area are barium, 2,4-DNT, 2,6-DNT, 2,4,6-TNT, and dioxins (Shaw, 2010). The remedial actions at LHAAP-17 will be sufficient to remove ecological risks for the sub-area. This management strategy is considered to be endorsed by regulators as evidenced by the regulatory approval of the BERA (Shaw, 2007a).

1.5 Statutory Determinations

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, and is cost-effective. In addition, the remedy offers long-term effectiveness through excavation of soil and the implementation of LUCs, which will minimize the potential risk to the hypothetical future maintenance worker posed by the contaminated soil and groundwater. Furthermore, evaluation of MNA including routine monitoring of the attenuation until cleanup levels are met would document the effectiveness of the selected remedy. The selected remedy is easily and immediately implementable and has a moderate cost compared to the other alternatives considered for LHAAP-17 with the exception of Alternative 1 (No Action).

The groundwater extraction component of the selected remedy satisfies the statutory preference for treatment as a principal treatment element of the remedy. The MNA component does not address the statutory preference for treatment to the maximum extent practicable; MNA is a passive remedial action using natural processes.

The selected remedy would reduce the toxicity, mobility, or volume of contaminants in the groundwater through active and passive remedial actions. There is no known principal threat material or contaminant source in the LHAAP-17 groundwater.

Because hazardous substances, pollutants, or contaminants will remain at the site above levels that allow for unlimited use and unrestricted exposure, a five-year review will be conducted every 5 years to ensure protection of human health and the environment under CERCLA §121(c), U.S. Code (USC) Title 42 §9621(c). In accordance with Texas Administrative Code (TAC) Title 30 §335.566, a notification will be recorded in Harrison County records restricting land use to nonresidential until it is demonstrated that surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure; that a prohibition of groundwater use (except for environmental monitoring and testing) as a potable source will remain in place until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soil and groundwater allow for unlimited use and unrestricted exposure; and, that the integrity of any current or future remedial or monitoring systems will remain in place until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table-2-10) in groundwater are met. Although the U.S. Army may later pass these procedural responsibilities to the transferee by property transfer agreement, the U.S. Army shall retain ultimate responsibility for remedy integrity per the FFA and CERCLA §121.

1.6 ROD Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record for this site.

- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater as identified in the baseline risk assessment and ROD (**Section 2.6**).
- Potential land and groundwater use that will be available at the sites as a result of the selected remedy (**Section 2.6**).
- COCs and their concentrations (**Section 2.7**).
- Baseline risk represented by the COCs (**Section 2.7**).

- Cleanup levels established for COCs and the basis for these levels (**Sections 2.7.3** and **2.8**).
- Absence of source materials constituting principal threats that need to be addressed at this site (**Section 2.11**).
- Key factor(s) that led to selecting the remedy (**Section 2.12**).
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (**Section 2.12**).

1.7 Authorizing Signatures

As the lead agency, the U.S. Army issues this ROD for LHAAP-17 which documents the final selected remedy. The undersigned is the appropriate approval authority for this decision.

Thomas E. Lederle 16 Aug 2016
(*Name*) (*Date*)
Thomas E. Lederle
Division Chief
Base Realignment and Closure Division
Assistant Chief of Staff for Installation Management
U.S. Army

The United States Environmental Protection Agency approves the selected remedy as provided in the ROD for LHAAP-17.

C E Edlund 09/13/16
(*Name*) (*Date*)
Carl E. Edlund, P.E.
Director
Superfund Division
U.S. Environmental Protection Agency
Region 6

2.0 Decision Summary

2.1 Site Name, Location, and Description

LHAAP-17, Burning Ground No. 2/Flashing Area, Group 2

Longhorn Army Ammunition Plant
Karnack, Texas

Comprehensive Environmental Response, Compensation, and Liability Information System USEPA Identification Number: TX6213820529

Lead Agency: U.S. Army, Department of Defense
Support Agencies: USEPA Region 6, TCEQ

Source of Cleanup Money: U.S. Army, Department of Defense
Site Type: Industrial Facility

The former LHAAP is an inactive, government-owned, formerly contractor operated and maintained, Department of Defense facility located in central east Texas (see **Figure 2-1**) in the northeast corner of Harrison County. LHAAP is approximately 14 miles northeast of Marshall, Texas, and approximately 40 miles west of Shreveport, Louisiana. The former U.S. Army installation occupied 8,416 acres between State Highway 43 at Karnack, Texas, and the southwestern shore of Caddo Lake. The facility can be accessed via State Highways 43 and 134.

LHAAP was placed on the Superfund National Priorities List (NPL) on August 9, 1990. Activities to remediate contamination began in 1990. After its listing on the NPL, the U.S. Army, the USEPA, and the Texas Water Commission (currently known as the TCEQ) entered into a CERCLA §120 FFA for remedial activities at LHAAP. The FFA became effective December 30, 1991. LHAAP operated until 1997 when it was placed on inactive status and classified by the U.S. Army Armament, Munitions, and Chemical Command as excess property. The majority of LHAAP has been transferred by the U.S. Army to the U.S. Fish and Wildlife Service (USFWS) for management as the Caddo Lake National Wildlife Refuge.

LHAAP-17, known as the Burning Ground No. 2/Flashing Area, is a 3.9-acre site located within a heavily wooded section in the southeastern portion of LHAAP (**Figure 2-2**). The site has two 185-feet by 305-feet cleared areas, separated by a gravel access road. The site is covered with grass and scattered brush, has been graded above the surrounding terrain, and is relatively flat.

2.2 Site History and Enforcement Activities

2.2.1 History of Site Activities

LHAAP was established in December 1941 with the primary mission of manufacturing TNT. Production of TNT began at Plant 1 in October 1942 and continued through World War II until August 1945, when the facility was placed on standby status until February 1952. In 1952, the LHAAP facility was reactivated with the opening of Plant 2, where pyrotechnic ammunition, such as photoflash bombs, simulators, hand signals, and tracers for 40 millimeter ammunition, were produced until 1956.

In December 1954, a third facility, Plant 3, began production of solid-fuel rocket motors for tactical missiles. Rocket motor production at Plant 3 continued to be the primary operation at LHAAP until 1965 when Plant 2 was reactivated for the production of pyrotechnic and illuminating ammunition. In the years following the Vietnam conflict, LHAAP continued to produce flares and other basic pyrotechnic or illuminating items for the U.S. Department of Defense inventory. From September 1988 to May 1991, LHAAP was also used for the static firing and elimination of Pershing I and II rocket motors in compliance with the Intermediate-Range Nuclear Force Treaty in effect between the United States and the former Union of Soviet Socialist Republics. LHAAP operated until 1997 when it was placed on inactive status and classified by the U.S. Army Armament, Munitions, and Chemical Command as excess property.

LHAAP-17 was used as a burning ground from 1959 through 1980 (Plexus Scientific Corporation [Plexus], 2005). Bulk TNT, photo flash powder, and reject material from Universal Match Corporation operations were burned at LHAAP-17. In 1959, the materials removed from the former TNT Production Area (LHAAP-29) and the former TNT Waste Disposal Plant (LHAAP-32) during demolition were burned and/or flashed at LHAAP-17. The site was used as a flashing area to decontaminate recoverable metal byproducts until 1980, when it became inactive. Burning trenches were located around the inside perimeter of the previously fenced area and within the open area on the western boundary of the site. As each trench filled with ash, it was covered and a new trench was dug. The waste residues were reportedly removed from the trenches in 1984, and the site was allowed to revegetate (Jacobs, 2002).

2.2.2 History of Investigative Activities

As part of the Installation Restoration Program, the U.S. Army began an environmental investigation in 1976 at LHAAP followed by installation wide assessments/investigations that included the following:

- In 1980, U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) conducted a record search to assess the impact of the LHAAP installation activities including usage, storage, treatment, and disposal of toxic and hazardous materials on the environment, and defined conditions that may have adversely affected human health and the environment (USATHAMA, 1980).

- Contamination Survey – In 1982, as part of the LHAAP contamination survey, Environmental Protection Systems collected six groundwater samples for laboratory analyses. Subsequently in 1987, as part of the Resource Conservation and Recovery Act (RCRA) permit application process, and as a continuation of the contamination survey, U.S. Army Environmental Hygiene Agency (USAEHA) identified, described, and evaluated all solid waste management units at LHAAP (USAEHA, 1987). Units requiring further sampling, investigation, and corrective action were delineated.

- RCRA Facility Assessment (RFA) – In 1988, a preliminary RFA was conducted by the U.S. Army (Maley, 1988). Waste at the various sites was characterized, but no samples were collected.

Several investigations to determine the nature and extent of contamination in the soil, groundwater, surface water, and sediments at LHAAP-17 were conducted and are listed below. Samples were analyzed for VOCs, semivolatile organic compounds (SVOCs), metals, explosive compounds, perchlorate, pesticides, polychlorinated biphenyls, and/or dioxins/furans, depending on the focus of the investigation. For some of the earlier investigations, LHAAP sites were organized into groups, and LHAAP-17 was included in Group 2. The group designation was de-emphasized as the complexities of the individual sites became greater. The following summarizes the investigations at LHAAP-17:

- **Multi-phase investigation of Group 2 sites**: Between 1982 and 1998 numerous investigations were conducted in a phased approach by Jacobs, U.S. Army Corps of Engineers (USACE), and Environmental Protection System. Activities included installation of monitoring wells and analysis of groundwater, surface water, soil, and sediment samples. The results are documented in the RI for Group 2 sites (Jacobs, 2001). **Figures 2-3** and **2-4** show the sample locations at LHAAP-17 for soil and surface water/sediment, respectively. **Figures 2-5** and **2-6** show the well locations for the shallow and intermediate groundwater zones, respectively.

- **Plant-wide perchlorate investigation**: The groundwater investigation was conducted by Solutions to Environmental Problems, Inc. (STEP) from 2000 through 2002 (STEP, 2005).

- **Baseline Human Health Risk Assessment**: The BHHRA (Jacobs, 2002) used data from the investigations conducted through 2001, including the plant-wide perchlorate investigation results up to that time. The report concluded that the soil and groundwater at LHAAP-17 both posed unacceptable carcinogenic risk and non-carcinogenic hazard to the hypothetical future maintenance worker.

- **Environmental Site Assessment**: Media investigated in 2003 included soil and groundwater (Plexus, 2005), although no sampling was conducted at LHAAP-17 for this assessment.

- **Perchlorate treatability demonstration**: The study was conducted by Planteco Environmental Consultants, LLC (PEC) in 2003 and 2004 to demonstrate that perchlorate concentrations in soil can be reduced by soil composting. Organic amendments were added to a 1-acre area in the western portion of LHAAP-17, where the highest concentrations of perchlorate-contaminated soil were located. Decreased concentrations for perchlorate and explosive compounds were observed in the soil, as well as for perchlorate in groundwater (PEC, 2004).

- **Baseline Ecological Risk Assessment**: The BERA (Shaw, 2007a) identified COPECs for the Waste Sub-Area, which includes LHAAP-17. COPECs for the sub-area are addressed in the remedial actions for LHAAP-17. The evaluation was based on environmental investigations from 1993 to 2006.

- **Data gaps**: Additional investigations were conducted by Shaw in 2004 after the BHHRA was finalized to further delineate the extent of groundwater contamination identified during previous sampling events. The results of the 2004 investigation were presented in the *Data Gaps Investigation* (Shaw, 2007b).

- **Feasibility Study**: The FS (Shaw, 2010) was based on the available results from previous investigations. In addition, it included the natural attenuation evaluation based on sampling results from 2009, 2007, and earlier.

2.2.3 History of CERCLA Enforcement Activities

Due to the releases of chemicals from facility operations, the USEPA placed LHAAP on the Superfund NPL on August 9, 1990. Activities to remediate contamination associated with the listing of LHAAP as a Superfund site began in 1990. After the listing on the NPL, the U.S. Army, the USEPA, and the Texas Water Commission (currently known as the TCEQ) entered into a CERCLA §120 FFA for remedial activities at LHAAP. The FFA became effective December 30, 1991.

LHAAP-17 was one of the originally listed NPL sites in the FFA. The FS for LHAAP-17 (Shaw, 2010) was issued in April 2010, and the Proposed Plan (U.S. Army, 2010) was issued in May 2010. This ROD follows that Proposed Plan and precedes the more detailed RD.

2.3 Community Participation

The U.S. Army, USEPA, TCEQ and the LHAAP Restoration Advisory Board (RAB) have provided public outreach to the surrounding community concerning LHAAP-17 and other environmental sites at LHAAP. The outreach program has included fact sheets, media interviews, site visits, invitations to attend quarterly RAB and regulatory review meetings, and public meetings consistent with its public participation responsibilities under Sections 113(k)(2)(B), 117(a), and 121(f)(1)(G) of CERCLA.

The Final Proposed Plan (U.S. Army, 2010) for the selection of the remedy for LHAAP-17 was released to the Administrative Record and made available to the public for review and comment on May 26, 2010. A media release was sent to radio stations KETK, KMSS, KSLA, and KTBS on May 26, 2010. The notice of availability of the Proposed Plan and other related documents in the Administrative Record file was published in *The Shreveport Times* and the *Marshall News Messenger* on May 27, 2010. The newspaper and media notices for the meeting are provided in **Appendix A**. The public comment period for the Proposed Plan began on June 10, 2010 and ended July 10, 2010. A public meeting was held on June 29, 2010 in a formal format and with a court reporter. The transcript for the meeting is part of the Administrative Record. The significant comments (oral or written) are addressed in the Responsiveness Summary, which is included in this ROD as **Section 3.0**.

The Administrative Record may be found locally at the information repository maintained at the following location:

Location:	Marshall Public Library 300 S. Alamo Marshall, Texas 75670
Business Hours:	Monday – Thursday 10:00 a.m. – 8:00 p.m. Friday – Saturday 10:00 a.m. – 5:00 p.m.

2.4 Scope and Role of Response Action

The selected action at LHAAP-17 will prevent potential risks associated with exposure to contaminated groundwater. Although groundwater at LHAAP is not currently being used as drinking water, nor may it be used in the future based on its reasonably anticipated use as a national wildlife refuge, when establishing the remedial action objectives (RAOs) for this response action, the U.S. Army has considered the NCP's expectation to return usable groundwaters to their potential beneficial uses wherever practicable and has also considered the State of Texas designation of all groundwater as potential drinking water, unless otherwise classified, and consistent with 30 TAC 335.563(h)(1) [background total dissolved solids (TDS) content less than or equal to 10,000 mg/L and that occurs within a geologic zone that is sufficiently permeable to transmit water to a pumping well in usable quantities]. The U.S. Army intends to return the contaminated shallow and intermediate groundwater zones at LHAAP-17 to their potential beneficial uses, which for the purposes of this ROD is considered to be attainment of the Safe Drinking Water Act (SDWA) MCLs to the extent practicable, and consistent with 40 CFR §300.430(e)(2)(i)(B&C). For perchlorate, in the absence of federal drinking water standards, clean-up levels will be based on Texas Risk Reduction Program (TRRP) Tier 1 Groundwater Residential Protective Concentration Level (PCL). The TCEQ soil medium-specific concentration (MSC) for industrial use based on groundwater protection (GWP-Ind) is used in accordance with 30 TAC 335.559(g)(2). If a return to potential beneficial uses is not practicable, the NCP expectation is to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.

The selected remedial action will also ensure containment of the plume to prevent potential impact to surface water. The potential exists for contaminated shallow groundwater to migrate to Harrison Bayou.

In addition, the selected action will include groundwater monitoring to demonstrate that the plume is not migrating at levels that present a potential impact to surface water bodies and to verify that contaminant levels are being reduced to cleanup levels.

2.5 Site Characteristics

This section of the ROD presents a brief comprehensive overview of the LHAAP-17 site characteristics with respect to the conceptual site model (CSM), physical site features, known or suspected sources of contamination, types of contamination, and affected media. Known or potential routes of contaminant migration are also discussed. Detailed information about the site characteristics can be found in the RI (Jacobs, 2001).

2.5.1 Conceptual Site Model

Figure 2-7 illustrates the human health conceptual site model for LHAAP-17. The model presents the human health pathways that may impact a hypothetical future maintenance worker and are being considered for remediation. Those pathways that are likely to be incomplete or have negligible impact are not being considered for remediation. **Figure 2-8** illustrates the ecological conceptual model for LHAAP-17, which is similar to the one presented for human health in terms of the origin and fate and transport mechanisms of the contaminants present at the site. However, only exposure pathways and routes associated with soil are relevant for ecological risk assessment.

Explosive compound releases resulting from the burning of explosive type materials removed from the TNT Production Area and the TNT Waste Disposal Plant are the suspected contamination sources at LHAAP-17. Residual contamination as a result of deposition, spills, and runoff of contamination on the surface poses potential risk to the hypothetical future maintenance worker.

Contamination in the form of VOCs and perchlorate is present in groundwater at LHAAP-17 and poses potential risk to the hypothetical future maintenance worker. Perchlorate and VOC concentrations have been detected consistently throughout the shallow groundwater zone. Two VOCs (1,1-DCE and 1,2-DCA) are found only in the shallow groundwater zone. TCE has been detected in both the shallow and intermediate zones. The horizontal extent of contamination in the shallow and intermediate groundwater zones has been defined as presented in **Figures 2-9** and **2-10**, respectively.

The soil and groundwater at LHAAP-17 may pose a risk for the hypothetical future maintenance worker, and the soil may pose a risk for ecological receptors. Thus the pathways considered for remediation include soil, soil to groundwater, and future industrial groundwater use. Analytical results showing soil contamination are presented in **Figure 2-11**.

2.5.2 Overview of the Site

The site boundary of LHAAP-17 comprises approximately 3.9 acres in the southern portion of LHAAP. The surface features include two 185-feet by 305-feet cleared areas, separated by a gravel access road. The site is covered with grass and scattered brush and has been graded above the surrounding terrain. The topography is relatively flat. Surface drainage flows to ditches along the eastern and western boundaries of the site and then to Harrison Bayou, which is located to the west of LHAAP-17. The entire site is within the 100-year floodplain of the bayou. There are no surface water bodies located on the site.

2.5.3 Geology and Hydrogeology

The local geology at LHAAP-17 consists of silty, clayey and sandy units of the Wilcox Group. The uppermost unit consists predominantly of silty clay to clay extending to depths ranging from 5 to 30 feet. Underlying this layer is a gray to light brown, fine grained silty sandy unit interbedded with silty clay to clay lenses. The clay layers act as an aquitard separating the shallow zone from the intermediate zone. A thick, fine to medium grained sand layer was encountered in boring 17WW05 from 50 to 151 feet in depth without encountering the silty clay lenses. The sand layer was underlain by a dense, dark gray clayey shale.

Figures 2-5 and **2-6** illustrate the groundwater elevations in the shallow zone and intermediate zone, respectively. With the exception of monitoring wells 17WW05 and 17WW16 that were completed in the deep zone, the remainder of the monitoring wells at the site have been completed in the shallow and intermediate saturated zones. The depth of the shallow groundwater zone generally ranges from 18 to 35 feet below ground surface (bgs). The intermediate zone is less defined, but its depth has been measured to approximately 55 feet bgs. The deep groundwater zone extends to a depth of approximately 151 feet bgs. The predominant groundwater flow in the shallow and intermediate zones is generally to the northwest towards Harrison Bayou. Based on historical groundwater flows, the direction can vary more to the west or more to the north. The groundwater elevation between the shallow and intermediate zones is less than 0.1 feet at paired wells, and no distinct vertical gradient is present. The expectation is that the shallow and intermediate zone groundwater contours will be the same. However, due to different data point locations and accepted contouring protocols, slightly different contour lines were produced, but result in the same flow direction. Additional data collected during the RD phase will refine the hydrogeological conditions at the site.

2.5.4 Sampling Strategy

Several sampling events were conducted at LHAAP-17 from 1982 to 2009, as outlined in **Section 2.2.2** on site investigations. In the early investigations, soil samples were collected from throughout the site to determine the areas of contamination. Subsequent investigations focused on the areas where contamination was found, performing additional soil, groundwater, and sediment sampling, and installing monitoring wells to delineate the contamination. Samples were analyzed for various analytes including VOCs, SVOCs, metals, explosives, perchlorate, pesticides, and dioxins/furans. In the area of the contaminant plume, groundwater samples were also analyzed for indicators of conditions that promote natural attenuation (biodegradation), such as dissolved oxygen, conductance, pH, oxidation-reduction potential, sulfide, methane, and chloride.

2.5.5 Nature and Extent of Contamination

Contamination was found in the soil and groundwater (shallow and intermediate zones). The COCs are toxic and carcinogenic. Principal threat waste material is present in the contaminated soil at LHAAP-17.

The COCs and COPECs for LHAAP-17 for the various media are identified below:

- Soil COCs and COPECs are explosives (2,4,6-TNT, 2,4-DNT, 2,6-DNT), dioxins (2,3,7,8-TCDD TEC), perchlorate (potential soil COC based on groundwater concentrations), and barium.

- Shallow zone groundwater COCs are perchlorate and VOCs (1,2-DCA, 1,1-DCE, cis-1,2-DCE, TCE and VC).

- Intermediate zone groundwater COCs are TCE and its daughter products (DCE and VC).

Figure 2-12 shows the approximate areas of contaminated soil that are proposed to be removed for ecological and human health risk mitigation. The maximum 2,4,6-TNT in the soil is 10,000 milligrams per kilogram (mg/kg). Other explosives, 2,4-DNT and 2,6-DNT, have maximum concentrations of 4,000 mg/kg and an estimated concentration of 27 mg/kg, respectively. Additionally, perchlorate has been detected in the soil at a maximum concentration of 7.11 mg/kg. The concentrations of 2,3,7,8-TCDD TEC and barium affecting ecological receptors are 1.9×10^{-4} mg/kg and 20,500 mg/kg, respectively.

The shallow zone plumes for perchlorate and VOCs is shown on **Figure 2-9**. The perchlorate plume, which largely encloses the VOCs plumes, has a lateral extent of approximately 160,000 square feet (ft^2), and a vertical extent of approximately 15 ft. Assuming a total porosity of 0.25, the calculated volume of contaminated groundwater is 4,500,000 gallons. The highest concentration of perchlorate detected was 160,000 µg/L at well 17WW02. The highest concentration of TCE detected in the shallow groundwater was 6,090 µg/L at well 17WW01. Other VOCs detected in the shallow groundwater are 1,2-DCA at an estimated concentration of 35.8 J µg/L and 1,1-DCE at 70 µg/L, also at 17WW01. The daughter product cis-1,2-DCE had a maximum detection of 107 µg/L. The daughter product VC has been nondetect.

The intermediate zone plume for TCE is shown on **Figure 2-10**. In this zone, the lateral extent of contamination is approximately 1,094 ft^2, and the vertical extent is approximately 27 ft. Assuming a total porosity of 0.25, the calculated volume of contaminated groundwater is 55,000 gallons. The highest concentration of TCE detected was 10.8 µg/L at 17WW17. Other COCs identified for the intermediate groundwater zone are degradation daughter products of TCE that have been nondetect or have not been detected above their MCLs. The intermediate zone does not have a perchlorate plume.

2.6 Current and Potential Future Land and Resource Uses

2.6.1 Current and Future Land Uses

LHAAP is located near the unincorporated community of Karnack, Texas. Karnack is a rural community with a population of 775 people. The incorporated community of Uncertain, Texas, population 205, is located to the northeast of LHAAP on the edge of Caddo Lake and is a resort area and an access point to Caddo Lake. The industries in the surrounding area consist of agriculture, timber, oil and natural gas production, and recreation.

LHAAP has been an industrial facility since 1942. Production activities and associated waste management activities continued until the facility was determined to be in excess of the U.S. Army's needs in 1997. The plant area has been relatively dormant since that time. LHAAP is surrounded by a fence (except on the border with Caddo Lake), and current security measures at the LHAAP preclude unlimited public access to areas within the fence. The fence now represents the National Wildlife Refuge boundary. Approved access for hunters is very limited.

The reasonably anticipated future use of LHAAP-17 is as part of a national wildlife refuge. This anticipated future use is based on a Memorandum of Agreement (MOA) (U.S. Army, 2004) between the USFWS and the U.S. Army. That MOA documents the transfer process of the LHAAP acreage to USFWS to become the Caddo Lake National Wildlife Refuge and will be used to facilitate a future transfer of LHAAP-17. Presently the Caddo Lake National Wildlife Refuge occupies approximately 7,000 acres of the 8,416-acre former installation. In accordance with the National Wildlife Refuge System Administration Act of 1966 and its amendments (16 USC 668dd), the land will remain as a national wildlife refuge unless there is a change brought about by an act of Congress, or the land is part of an exchange authorized by the Secretary of the Interior.

2.6.2 Current and Future Surface Water Uses

Streams on LHAAP currently support wildlife and aquatic life. While humans may have limited access to some streams during annual hunts, there is no routine human use of streams on LHAAP. The streams do not carry adequate numbers and size of fish to support either sport or subsistence fishing. During the summer months, the streams cease flowing and/or dry up. The streams flow into Caddo Lake. Caddo Lake is a large recreational area that covers 51 square miles and has a mean depth of 6 feet. The watershed of the lake encompasses approximately 2,700 square miles. It is used extensively for fishing and boating. Caddo Lake is a drinking water supply for multiple cities in Louisiana including Vivian, Oil City, Mooringsport, South Shore, Blanchard, Shreveport, and Bossier City.

The anticipated future uses of the streams and lake are the same as the current uses.

2.6.3 Current and Future Groundwater Uses

Groundwater in the drinking water aquifer (250-430 feet bgs) near LHAAP is currently used as a drinking water source. The drinking water aquifer should not be confused with the deep zone groundwater, which extends only to a depth of approximately 151 feet bgs. The deep zone groundwater and the drinking water aquifer are distinct from each other and there is no connectivity between the contaminated zone and the drinking water aquifer. There are five active water supply wells near LHAAP that are completed in the drinking water aquifer. One well is located in and owned by Caddo Lake State Park. The well is completed to a depth of 315 feet bgs and has been in use since 1935. A second well owned by the Karnack Water Supply Corporation services the town of Karnack and is located approximately 2 miles southeast of town. This well is completed to approximately 430 feet bgs and has been in use since 1942. The Caddo Lake Water Supply Corporation has three wells located both north and northwest of LHAAP. These wells are identified as Caddo Lake Water Supply Corporation Wells 1, 2, and 3, and all are hydraulically upgradient of LHAAP (Jacobs, 2002). These wells are completed deeper than the deepest zone of contamination at LHAAP. Because of this and the large distance between these wells and LHAAP, water removal from these wells is not expected to affect groundwater flow at the site. In addition, there are several livestock and domestic wells located in the vicinity of LHAAP with depths averaging approximately 250 feet bgs.

Three water supply wells are located within the boundary of LHAAP itself. One well is located at the Fire Station; the second well is located approximately 0.35 miles southwest of the Fire Station. The third well is located north of the USFWS administration building for the Caddo Lake National Wildlife Refuge, near the main entrance to LHAAP. The distances from these water supply wells to LHAAP-17 are approximately 2.2 miles, 2.1 miles, and 2.6 miles, respectively. The three water supply wells were completed at a depth much greater than the zone of contamination described at LHAAP-17. Two additional wells previously supplied water to the installation, but these have been plugged and abandoned. None of these three wells are currently used for drinking water at LHAAP, although they may supply water for non-potable uses.

Although the anticipated future use of the facility as a wildlife refuge does not include the use of the groundwater at LHAAP-17 as a drinking water source, the State of Texas designates all groundwater as potential drinking water, unless otherwise classified, and consistent with 30 TAC 335.563(h)(1). To be conservative, a hypothetical industrial use scenario was evaluated for risk. The future industrial scenario for LHAAP assumes limited use of groundwater as a drinking water source.

2.7 Summary of Site Risks

The BHHRA and BERA estimate the risks posed by the site if no action were taken. These assessments provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the remedial action.

2.7.1 Summary of Human Health Risk Assessment

This section is based on the conclusions presented in the *Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 2 Sites* (Jacobs, 2002), in the *Data Gaps Investigations* (Shaw, 2007b), and in additional data collected in preparation of the *Final Feasibility Study, LHAAP-17* (Shaw, 2010). The risk assessment used data from the investigations conducted through 1998 and the plant-wide perchlorate investigation conducted in 2000. Results from the later investigations through 2009 did not change the overall outcome of the risk assessment. During the risk assessment, soil and groundwater data were used to calculate the aggregate risk, which was then compared to the USEPA target risk range of 1×10^{-4} to 1×10^{-6} for the excess lifetime carcinogenic risk and to a hazard index (HI) of 1 for non-carcinogenic hazards. If there is no unacceptable risk associated with a medium, and a cleanup level is not exceeded, then the medium is not identified in this ROD for remediation. The CSM that is associated with the risk assessment was introduced in **Section 2.5.1**, and is presented as **Figure 2-7**.

2.7.1.1 Identification of Chemicals of Potential Concern

The BHHRA identified chemicals of potential concern (COPCs) for LHAAP-17 and evaluated the carcinogenic risk and non-carcinogenic hazard for each. **Table 2-1** summarizes the risk assessment data for the COPCs, including minimum and maximum detected concentrations, frequency of detection, and exposure point concentrations (EPCs). Analytical results for various congeners of dioxins and furans are expressed as 2,3,7,8-TCDD TEC.

2.7.1.2 Exposure Assessment

The Jacobs risk assessment (Jacobs, 2002) presented the human health risks and hazards to a hypothetical future maintenance worker under an industrial scenario for soil and groundwater.

For soil, reasonable exposure pathways according to the CSM are: incidental ingestion of the surface soil (0 to 2 feet bgs), dermal contact with the surface soil, inhalation of particulates, and inhalation of VOCs from the soil (0 to 7 feet bgs). The BHHRA found VOC levels in the soil at 0 to 7 feet bgs to be non-detect; this exposure pathway did not add to carcinogenic risk or non-carcinogenic hazard, thus inhalation of VOCs from the soil (0 to 7 ft bgs) was not included in **Table 2-1**.

For groundwater, reasonable exposure pathways are ingestion of groundwater, dermal contact while showering with contaminated groundwater, and inhalation of VOCs while showering with contaminated groundwater.

2.7.1.3 Toxicity Assessment

The carcinogenic and non-carcinogenic toxicity assessments from the BHHRA are summarized in **Tables 2-2** and **2-3**, respectively. The toxicity data assumes that exposure would be chronic to be conservative. Sources for the data include the Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST).

2.7.1.4 Risk Characterization

Characterization of the carcinogenic risk and non-carcinogenic hazard are summarized in **Tables 2-4** and **2-5**, respectively. For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime carcinogenic risk is calculated from the following equation:

$$\text{Risk} = \text{CDI} \times \text{SF}$$

where: risk = unitless probability of an individual developing cancer
CDI = chronic daily intake averaged over 70 years, expressed as milligrams per kilogram per day (mg/kg-day)
SF = slope factor, expressed as $(\text{mg/kg-day})^{-1}$

These risks are probabilities that usually are expressed in scientific notation. An excess lifetime carcinogenic risk of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime carcinogenic risk" because it would be in addition to the risks of cancer that individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. USEPA's generally acceptable risk range for site-related exposures is 1×10^{-4} to 1×10^{-6}.

The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ < 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non-carcinogenic effects from that chemical are unlikely. The HI is generated by adding the HQs for all COCs that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI < 1 indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic non-carcinogenic effects from all contaminants are unlikely. An HI > 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-carcinogenic HQ = CDI/RfD

Where: CDI = chronic daily intake
RfD = reference dose

Chronic daily intake (CDI) and RfD are expressed in the same units and represent the same exposure period (e.g. chronic, subchronic, or short-term).

The carcinogenic risks for soil and groundwater are 1.4×10^{-3} and 1.6×10^{-3}, respectively (Jacobs, 2002). The HIs for soil and groundwater are 37 and 3,500, respectively. The carcinogenic risks and non-carcinogenic hazards for both soil and groundwater are unacceptable; therefore, the remedial action acts on both the soil and groundwater. Chemicals with a HQ greater than one in groundwater include perchlorate, TCE, and 1,2-DCA, and those in the soil include 2,4,6-TNT and 2,4-DNT. Perchlorate was the single most significant contributor to the HI in groundwater; its HQ of 3,500 eclipses the contributions from other chemicals. Chemicals with a risk greater than 1×10^{-4} in groundwater include TCE, 1,1-DCE, and 1,2-DCA, and those in soil include 2,4-DNT, 2,4,6-TNT, and 2,6-DNT.

The BHHRA included an uncertainty analysis which identified factors that would cause values used in the risk assessment to be over or underestimated. The analysis concluded that the risks and HIs are overestimated, making the BHHRA a conservative evaluation. The analysis listed seven factors that would lead to overestimations, three that would lead to underestimations, and five that could lead to either over or underestimations.

2.7.1.5 Evaluation of COPCs

To further evaluate the occurrence of COPCs, a data gap investigation was conducted (Shaw, 2007b) and additional investigations were conducted when preparing the FS (Shaw, 2010). While these investigations did not change the overall outcome of the earlier BHHRA, they determined what COCs needed to be targeted by the remedial action.

Tables 2-6 and **2-7** list chemicals in the soil that have a carcinogenic risk greater than 1×10^{-6} and those with an HQ greater than 0.1 for the hypothetical maintenance worker. **Tables 2-8** and **2-9** list the chemicals in groundwater that exceed those values for the carcinogenic risk and HQ, respectively. These tables also summarize the justifications for which of the COPCs should be classified as COCs. COPCs in soil were identified as COCs when they posed a carcinogenic risk above the acceptable range (risk greater than 1×10^{-4}) or when their HQ was greater than 1.0. COPCs in groundwater were identified as COCs when they posed a carcinogenic risk above the acceptable range (risk greater than 1×10^{-4}), when their HQ was greater than 1.0, or when the EPC was above the MCL or in the absence of federal drinking water standards, the Texas Risk Reduction Program (TRRP) Tier 1 Groundwater Residential Protective Concentration Level (PCL) . Recent data obtained after the BHRRA investigations was used when possible. **Table 2-10** presents the final list of COCs, along with cleanup levels.

2.7.2 Summary of Ecological Risk Assessment

The *Final Installation-Wide Baseline Ecological Risk Assessment* (Shaw, 2007a) evaluated potential hazards to ecological resources at LHAAP by conducting a screening evaluation to identify initial COPECs in the individual sub-areas and watersheds. The potential of these COPECs to adversely affect communities was evaluated for: (1) organisms that have direct contact with the COPECs (e.g., plants and earthworms growing and living in contaminated soil); and (2) organisms that may be exposed to the chemicals via food chain pathways (e.g., ingestion of an earthworm living in the contaminated soil by a shrew). Potential impacts to invertebrate and plant communities were evaluated by comparing COPEC concentrations to benchmark values available from multiple literature sources. For the food chain exposure assessment, a number of measurement receptors were selected as representative species for the various trophic levels in the food web that could be at risk from contaminants in site media. The measurement receptors that were selected and used in the food chain evaluation included the following:

- Deer Mouse
- Short-Tailed Shrew
- Raccoon
- Modified Raccoon (as a surrogate for the Louisiana Black Bear)
- Red Fox
- Townsend's Big-Eared Bat
- Bank Swallow

- Belted Kingfisher
- American Woodcock
- Red-Tailed Hawk
- Aquatic Life (benthic invertebrates)

A food chain model was developed and used to estimate the total dose for each measurement receptor based on species-specific considerations such as diet, body weight, ingestion rates, etc., using conservative exposure estimates. Ecological hazard estimates were developed based on exposure to all media including soil in a particular sub-area and surface water and sediment from any watersheds present in the sub-areas. Two different soil depths were used for modeling exposure to ecological receptors: surface soil (0 to 0.5 foot) and total soil (0 to 3 feet). Each receptor was assumed to be exposed to one of the two depths based on its life history characteristics (e.g., burrowing animals were assumed to be exposed to total soil). Bioaccumulation of chemicals up the food chain was initially estimated using uptake factors obtained from available literature, and then refined using site-specific data obtained during the BERA. **Figure 2-8** presents the ecological conceptual model, which lays out the exposure pathways for selected species.

Ecological effects quotients (EEQ) were developed for each of the measurement receptors. EEQs are similar to HQs for human health, and are calculated by dividing the total dose that the receptor is exposed to by the toxicity reference value (TRV), which is based on a no-observed adverse effect level (NOAEL) or the lowest-observed adverse effect level concentration. If the EEQ exceeds 1 for a receptor (based on the NOAEL TRV), then that chemical is considered to have a realistic potential to cause adverse ecological impacts, and is identified as a final COPEC that should be addressed either through remediation or further investigation. As discussed in the BERA, there are several important uncertainties associated with the assumptions used in the EEQ process, and it should be noted that EEQs greater than 1 do not necessarily mean that ecological impacts have occurred, or are occurring.

Several sub-areas were established within LHAAP for the BERA. LHAAP-17 falls within the Waste Sub-Area. The final COPECs in soil that require remedial action in the Waste Sub-Area are barium, 2,4-DNT, 2,6-DNT, 2,4,6-TNT, and dioxin (2,3,7,8-TCDD TEC) because of their potential to cause adverse impacts to one or more ecological receptors. These COPECs pose a potential risk to ecological receptors due to the direct contact with soil and indirect (i.e., dietary) exposure routes. In support of the LHAAP-17 FS, an analysis was performed to determine what sample locations require remediation to meet the ecological preliminary remediation goals (EcoPRGs) developed in the BERA for the final COPECs (Shaw, 2007a) as shown on **Table 2-11**. An excel spreadsheet analysis was performed by ranking the detected concentrations of each final COPEC in the Waste Sub-Area and iteratively re-calculating the 95% upper confidence limit (UCL) on the mean after removing concentrations until the 95%

UCL for the Waste Sub-Area was lower than the EcoPRG. (Note: as discussed in the BERA, the EcoPRG is not a "not to exceed" value for all concentrations; rather, it is a conservative estimate of the average concentration that results in no adverse effects, and as such is equivalent to the 95% UCL of chemical concentrations, rather than to individual sample concentrations.) The order of chemical concentrations was altered to preferentially remove LHAAP-17 samples in order to reduce the ecological risk in the Waste-Sub Area. It is assumed that the locations associated with these concentrations will be remediated. The outcome of the analysis is included on **Table 2-11** and the locations that need to be remediated for ecological risk are shown on **Figure 2-12**.

2.7.3 Basis of Action

The remedial action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment. Actions for the groundwater are necessary to address the potential for human health risks in the unlikely event there is an attempt to use groundwater as a potable water source. Actions for soil are necessary to address human health risk including the pathway from soil to groundwater and ecological risks. **Tables 2-10** and **2-11** present the COCs and COPECs, respectively. **Table 2-10** includes cleanup levels for both soil and groundwater with groundwater COCs for the shallow zone and the intermediate zone listed separately. **Table 2-10** includes cleanup levels for daughter products of TCE, even when they are not COCs based on the risk assessment due to their low detections.

A Safe Drinking Water Act MCL has been determined for each of the groundwater COCs except for perchlorate. For the chemicals with an MCL that has been determined, the MCL is used as the cleanup level. In the absence of federal drinking water standards, clean-up levels will be based on TRRP Tier 1 Groundwater Residential PCLs.

2.8 Remedial Action Objectives

The RAOs for LHAAP-17, which address contamination associated with the media at the site and take into account the future uses of LHAAP surface waters, land, and groundwater, are:

- Protection of human health by preventing human exposure to the contaminated groundwater and contaminated soil;
- Protection of human health by preventing further potential degradation of groundwater from contaminated soil;
- Protection of ecological receptors by preventing exposure to the contaminated soil;
- Protection of human health and the environment by preventing contaminated groundwater from migrating into nearby surface water; and

- Return of groundwater to its potential beneficial uses as drinking water, wherever practicable.

The above RAO recognizes USEPA's policy to return all groundwater to beneficial uses, based on the non-binding programmatic expectation in the NCP, and is consistent with the NCP regulations requiring the lead agency, the U.S. Army in this case, to establish RAOs specifying contaminants and media of concern, potential exposure pathways, and remediation goals.

Per the ROD's RAOs, and consistent with the NCP, groundwater will be returned to its beneficial uses as drinking water. The groundwater cleanup level for perchlorate at the Site is the TRRP PCL residential groundwater cleanup level, 17 ug/L, and is protective of human health and the environment.

2.9 Description of Alternatives

Four alternatives (including No Action) are proposed. This section introduces the remedy components, identifies the common elements and distinguishing features of each alternative, and describes the expected outcomes of each.

2.9.1 Description of Remedy Components

Alternative 1 – No Action

As required by the NCP, the no action alternative provides a comparative baseline against which the action alternatives can be evaluated. Under this alternative, groundwater would be left "as is" without implementing any additional monitoring, containment, removal, treatment, or other mitigating actions. No actions would be implemented to reduce existing or potential future exposure to human and ecological receptors, although natural attenuation would be ongoing.

Estimated Capital Present Worth Cost: $0
Estimated O&M Present Worth Cost: $0
Cost Estimate Duration: --
Estimated Present Worth Cost: $0

Alternative 2 – Excavation and Off-site Disposal for Soil; MNA and LUCs

The major components of this alternative include the following.

- Excavation and off-site disposal of impacted soil from LHAAP-17 to protect human and ecological receptors, and to eliminate the potential soil-to-groundwater pathway
- MNA to return shallow and intermediate zone groundwater to its potential beneficial use, wherever practicable
- Performance objectives to evaluate the MNA remedy performance after 2 years

- A contingency remedy to reach the RAOs if MNA is found to be ineffective
- LTM semiannually for 3 years, annually until the next five-year review, then annually until recommended otherwise at the five-year review to evaluate remedy performance and determine if plume conditions remain constant, improve, or worsen. Monitoring will continue until five-year review demonstrate that cleanup levels are reached
- The LUCs' performance objectives are to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met.

Estimated Capital Present Worth Cost: $1,600,000
Estimated O&M Present Worth Cost: $600,000
Cost Estimate Duration: 30 years
Estimated Present Worth Cost: $2,200,000

Alternative 3 – Excavation and Off-site Disposal of Soil; In Situ Bioremediation; MNA and LUCs

The major components of this alternative include the following:

- Excavation and off-site disposal of impacted soil from LHAAP-17 to protect human and ecological receptors, and to eliminate the potential soil-to-groundwater pathway
- In situ bioremediation in the shallow zone groundwater to target perchlorate contaminated groundwater, which leads to favorable conditions for MNA of TCE
- MNA with LTM in the shallow zone (after in situ bioremediation) to reduce groundwater contamination, particularly TCE and daughter products, to cleanup levels
- MNA with LTM in the intermediate zone to reduce groundwater contamination to cleanup levels
- The LUCs' performance objectives are to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and

contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met.

Estimated Capital Present Worth Cost: $2,200,000
Estimated O&M Present Worth Cost: $700,000
Cost Estimate Duration: 30 years
Estimated Present Worth Cost: $2,900,000

Alternative 4 – Excavation and Off-site Disposal of Soil; Groundwater Extraction; MNA and LUCs

The major components of this alternative include the following:

- Excavation and off-site disposal of impacted soil from LHAAP-17 to protect human and ecological receptors, and to eliminate the potential soil-to-groundwater pathway
- Groundwater extraction in the shallow zone until perchlorate levels are reduced to 20,000 µg/L to make conditions favorable for MNA of TCE
- A contingency remedy of in situ bioremediation in the shallow zone followed by MNA in the event that groundwater extraction cannot reduce perchlorate levels to 20,000 µg/L in the estimated 1.5-year pumping period
- MNA with LTM to reduce groundwater contamination to cleanup levels in the shallow zone (following groundwater extraction) and in the intermediate zone
- The LUCs' performance objectives are to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met.

Estimated Capital Present Worth Cost: $1,800,000
Estimated O&M Present Worth Cost: $600,000
Cost Estimate Duration: 30 years
Estimated Present Worth Cost: $2,400,000

2.9.2 Common Elements and Distinguishing Features of Each Alternative

Common Elements of Alternative 2, 3, and 4

Common elements of Alternatives 2, 3, and 4 are described below.

Soil Excavation – Soil contamination would be excavated at LHAAP-17 under Alternatives 2, 3 and 4 to prevent human and ecological receptors from exposure to contaminants in the soil and to eliminate the soil-to-groundwater pathway. Disposal would be at a RCRA Subtitle D-permitted landfill.

MNA – MNA is a passive remedial action that relies on natural biological, chemical, and physical processes to reduce the mass and concentrations of groundwater COCs under favorable conditions. The natural attenuation evaluation indicates that MNA is a feasible technology for the groundwater at LHAAP-17 (Shaw, 2010). Monitoring activities associated with MNA would confirm the protection of human health and the environment by documenting the return of the groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of the contaminant mass and protection of surface water through containment of the plume. In Alternative 2, contaminant reduction would occur by MNA alone in both the shallow and intermediate zones. In Alternative 3, in situ bioremediation would reduce perchlorate in the shallow zone and condition the shallow zone for MNA of TCE. The treatment in the intermediate zone would be MNA alone. In Alternative 4, groundwater recovery would reduce perchlorate in the shallow zone to 20,000 µg/L, after which MNA would take over and reduce perchlorate and VOCs to cleanup levels. The treatment in the intermediate zone would be MNA alone.

MNA performance monitoring will be conducted quarterly for the first 2 years. After eight quarterly sampling events, MNA effectiveness will be evaluated. The analytical program will consist of VOCs, including chlorinated compounds and degradation products, methane, ethene, and ethane. Initially, the following geochemical parameters will also be included in the analytical program: dissolved oxygen (field), redox potential (field), sulfate, nitrate, nitrites, alkalinity, total organic carbon, and ferrous iron (field).

- ***LUCs*** – LUCs would be implemented to support the RAOs. The LUC for groundwater would prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health and ensure that there is no withdrawal or use of groundwater beneath the sites for anything other than environmental monitoring and testing. The LUC to prohibit groundwater use (except for environmental testing and monitoring) as a potable source would remain until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met.

In addition, within 90 days of signature of this ROD, the Army shall request the Texas Department of Licensing and Regulation to notify well drillers of groundwater use prohibitions based on a preliminary LUC boundary. A LUC Remedial Design (RD) will be finalized as the land use component of the Remedial Design. Within 21 days of the issuance of the ROD, the Army will propose deadlines for completion of the RD Work Plan, RD, and Remedial Action Work Plan. The documents will be prepared and submitted to EPA and TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. The long-term groundwater and surface water monitoring and MNA performance monitoring will also be presented in the RD. Consistent with the dates presented for these documents, the U.S. Army shall: 1) request the Texas Department of Licensing and Regulation to notify well drillers of the final boundary of groundwater use prohibitions; and 2) notify the Harrison County Courthouse of the LUCs to include a map showing the areas of groundwater and nonresidential use restrictions, and the monitoring system at the site, in accordance with 30 TAC 335.565.

The Army will implement, maintain, monitor, report on and enforce land use controls at Army-owned property. The Army shall perform those actions related to land use control activities described in this ROD and in the Remedial Design for the ROD. For portions of the Site subject to land use controls that are not owned by the Army, the Army will monitor and report on the implementation, maintenance, and enforcement of land use controls, and coordinate with federal, state, and local governments and owners and occupants of properties subject to land use controls. The Army will provide notice of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. The Army will send these notices to the federal, state and local governments involved at this site and the owners and occupants of the properties subject to those use restrictions and land use controls. The Army shall provide the initial notice within 90 days of ROD signature. The frequency of subsequent notifications will be described in the Remedial Design for the ROD. The Army remains responsible for ensuring that the remedy remains protective of human health and the environment. The Army will fulfill its responsibility and obligations under CERCLA and the NCP as it implements, maintains, and reviews the selected remedy.

Upon transfer of Army-owned property, the Army will provide written notice of the land use controls to the transferee of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. Within 15 days of transfer, the Army shall provide EPA and TCEQ with written notice of the division of implementation, maintenance, and enforcement responsibilities unless such information has already been provided in the LUC RD. The LUC RD will address the procedures to be used by the Army and the transferee to document compliance with the LUCs described in this ROD. In the event property is transferred out of Federal control, the land use controls relating to property and groundwater restrictions shall be recorded in the deed and shall be enforceable by the United States and the state of Texas.

To transfer this property (LHAAP-17), an Environmental Condition of Property (ECP) document would be prepared and the Environmental Protection Provisions from the ECP would be attached to the letter of transfer. The ECP would include the LUCs as part of the Environmental Protection Provisions. The property would be transferred subject to the LUCs identified in the ECP. These restrictions would prohibit or restrict property uses that might result in exposure to the contaminated groundwater (e.g., drilling restrictions) or soil (e.g., residential land use prohibition).

The U.S. Army and regulators will consult to determine appropriate enforcement actions should there be a failure of a LUC objective at these sites after they have been transferred.

Inspection/Long-Term Groundwater Monitoring – Alternatives 2, 3, and 4 include inspection and long-term groundwater monitoring activities. Monitoring would be continued as required to evaluate the effectiveness of the remedy, to demonstrate compliance with applicable or relevant and appropriate requirements (ARARs) and RAOs, and to support five-year reviews.

Distinguishing Features of Alternatives 3 and 4

The distinguishing feature of Alternative 3 and 4 compared to Alternative 2 is the inclusion of in situ bioremediation or groundwater extraction. These actions are described below.

In situ bioremediation – The components of this action include:

- **Performing a treatability study.** A number of environmental conditions can slow or stop the biodegradation process. Therefore, prior to initiation of a bioremediation project, a specific microbial enhancement study and general hydrogeologic investigation will be required for the site. These studies are necessary to identify the types and amounts of substances required to stimulate optimum contaminant degradation and specify geologic and geochemistry information for project design. Some of the parameters that are important to consider include the biodegradability, phase-distribution, leaching potential, and chemical reactivity of the contaminants; the mix of contaminants in the plume; soil type and properties; pH; salinity; competing electron acceptors (e.g., sulfates, nitrates); the presence of adequate microbial populations; the presence of adequate microbial populations; and the presence or absence of inhibitory substances.

- **Retrofitting existing wells for injection.** Chlorinated solvents and perchlorate often require circulation of nutrients and other growth-stimulating additives/materials specific to the contaminants' metabolic degradation process. The wells will be used to inject these materials to accelerate microbial degradation of the plumes. It is anticipated that the material will be injected quarterly for one year, and that the injection will occur in the shallow zone at approximately 15 feet bgs.

- **Injecting nutrients into the subsurface at a predetermined location.** Bacteria present in the groundwater can use chlorinated solvents as electron acceptors. Electron donors may include a wide variety of nutrients: sugars (molasses), alcohols (methanol, ethanol), volatile acids (acetate, lactate), and/or wastes (food processing, manure). The COCs at LHAAP-17 can degrade under anaerobic conditions, but microorganisms, mechanisms, and redox requirements differ. Based on results of a treatability study, appropriate nutrients and other materials will be injected into the subsurface. For this FS, it is assumed that a Hydrogen Release Compound® (HRC®), a sticky gel, will best degrade the COCs at LHAAP-17. HRC® is a polyacetate compound especially formulated for the slow release of lactate into water. The HRC® compound is typically heated to reduce its viscosity and injected with a high viscosity fluid pump. In addition to the application of HRC®, degradation of the 1,1-DCE to vinyl chloride may require the addition of a bacterial consortium. The plume will be gridded with direct-push technology (DPT) injection sites through which the various materials would be injected. For costing purposes in this FS, it is assumed that application would include 10 DPT injection points at approximately 15 feet bgs to cover the groundwater plume.

- **Sampling wells to monitor effectiveness.** Monitoring for contaminants will be performed to assess the effectiveness of the treatment. Anticipated remediation times may be short with appropriate contact of the contaminant and the injected materials. Assuming first order anaerobic degradation rates and reasonable half-lives for the COCs, the COCs could be reduced to their respective levels amenable to MNA remediation in approximately two years. Additional monitoring in the treatment zone is recommended for one to three years after reduction of the COCs to the remediation levels. Since there is considerable uncertainty about achieving sufficient contact between the contaminated groundwater and the injected material, the groundwater in the treatment zone will continue to be monitored for the maximum recommended period, three years, after reduction of the COCs to the preliminary remediation goals.

Groundwater Extraction – The components of this action include:

- **Pre-Design Study.** This action in the shallow groundwater zone will begin with a pre-design study. A pump test will be conducted and hydrogeologic parameters will be measured to better design the system. During the design activities, extraction trenches will also be evaluated. Groundwater flow will be modeled to set performance evaluation parameters and to assess the likely time required for remediation.

- **Construction.** The shallow zone groundwater contamination at LHAAP-17 consists of a VOC plume and an overlapping perchlorate plume. The contamination occurs in the shallow groundwater zone where a sufficient number of groundwater monitoring wells are located throughout the site. To remediate the contaminated groundwater, it is estimated that sufficient flow can be attained by converting three of the existing monitoring wells in the shallow zone into extraction wells to extract the contaminated groundwater from the aquifers. Final number of wells and their placement will be determined in the design. A new piping system will be constructed to transport the water to the groundwater treatment plant at LHAAP-18/24.

- **Performance Monitoring.** During extraction, samples will be collected from the extraction wells to monitor the effectiveness of the action. Monthly sampling will be conducted for approximately six months during startup and initial operation of the extraction system. After six months, monitoring will be reduced to quarterly for approximately 1 year or until pumping ceases. If perchlorate concentrations have not been reduced to levels at or below 20,000 µg/L, a contingency action will be initiated pending lead agency and regulatory approval. If the 20,000 µg/L trigger value has been obtained, then MNA will be implemented.

- **Water Treatment/Surface Water Discharge.** The extracted groundwater from LHAAP-17 will be treated at the LHAAP groundwater treatment plant, which was originally built to treat groundwater containing VOCs and metals extracted from other LHAAP sites. The plant uses air stripping, carbon adsorption, and catalytic oxidation. Perchlorate treatment using a fluidized bed reactor was added in April 2001 to the treatment plant. **Figure 2-13** shows a simplified flow diagram of the primary treatment components in the existing plant. The extracted water from LHAAP-17 will be discharged from the piping into the existing 300,000-gallon equalization tank. This tank receives water from other LHAAP sites which is stored in this tank until treatment. After the water is treated, the effluent will be discharged in accordance with plant procedures to surface water. The plant presently operates at a fraction of its maximum capacity of 1 to 1.5 million gallons of water per month. The original groundwater treatment plant components have adequate capacity to accommodate the increase in volume that will be introduced to the system when the contaminated groundwater is transported through the piping system from LHAAP-17 to the plant. The system capacity is limited by effluent storage and discharge rate, and this concern was addressed. Recent mitigating measures include the replacement of the reinjection pipeline to increase the pipe diameter to 4-inches, and the installation of a sprinkler system. The capacity issue will be revaluated as necessary during the remedial action.

- **Extraction System.** Operation and maintenance will include groundwater extraction system maintenance, groundwater treatment plant operations, and environmental media monitoring. In approximately 1.5 years, the extraction wells are anticipated to remove the highest concentrations of VOCs and perchlorate from the groundwater at LHAAP-17, thus reducing the contaminant mass to make conditions favorable for MNA. During the groundwater extraction operations, the extraction wells will require regular maintenance to prevent fouling of well screens, and the extraction pumps will require routine maintenance and may also require replacement. Cleaning of the pipelines, refurbishing pumps and other maintenance activities will be needed on the groundwater collection and transport system during full-scale operation. O&M costs will include the addition of chemicals, power, and labor; equipment cleaning, tank cleaning, general system maintenance, and replacement; and regulatory monitoring and reporting. O&M activities will also be conducted at the LHAAP plant location as part of the routine plant O&M activities.

2.9.3 Expected Outcomes of Each Alternative

Alternative 1 would allow the site to remain a hazard to human and ecological receptors, since it simply leaves the site as is. Alternatives 2, 3, and 4 all provide the same outcome to mitigate exposure to human and ecological receptors by excavation and off-site disposal of the contaminated soil. Soil excavation would also eliminate the soil-to-groundwater pathway, preventing further potential degradation of groundwater from contaminated soil. Alternatives 3 and 4 have very similar outcomes though they use different treatment processes, and the main difference is that Alternative 4 takes advantage of the existing groundwater treatment plant. Alternative 2 also has the same outcome as Alternatives 3 and 4, but without the benefit of active treatment. Based on the natural attenuation evaluation (Shaw, 2010), cleanup levels should be achieved by MNA alone (Alternative 2) in approximately 117 years (117 years for TCE, and 15 years for perchlorate). Alternatives 3 and 4 would achieve cleanup levels in less time through active treatment. The similar outcomes are considered to be attainment of the SDWA MCLs to the extent practicable, and consistent with 40 CFR §300.430(e)(2)(i)(B&C). For perchlorate, in the absence of federal drinking water standards, the cleanup level will be based on the TRRP Tier 1 Groundwater Residential PCL. In addition, the monitoring activities associated with MNA would confirm the protection of human health and the environment by documenting the return of the groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of the contaminant mass and protection of surface water through containment of the plume. The LUC to prohibit groundwater use (except for environmental testing and monitoring) as a potable source until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure; and to maintain the integrity of any current or future remedial or monitoring systems until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met.

2.10 Summary of Comparative Analysis of Alternatives

Nine criteria identified in the NCP §300.430(e)(9)(iii) are used to evaluate the different remediation alternatives individually and against each other to select a remedy. This section profiles the relative performance of each alternative against the nine criteria, noting how it compares to the other options under consideration. The nine evaluation criteria are discussed below. **Table 2-12** summarizes the comparative analysis of the alternatives.

2.10.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

The four alternatives provide varying levels of human health protection. Alternative 1, no action, does not confirm achievement of the RAO for the return of groundwater to its potential beneficial use because there is no monitoring involved. Alternative 1 also provides the least protection of all the alternatives; it provides no reduction in risks to human health or the environment because no measures would be implemented to eliminate the pathway for human exposure to soil or to the groundwater contamination and potential groundwater impacts to Harrison Bayou would not be addressed. Additionally, the soil pathway for ecological receptors would not be addressed.

Alternatives 2, 3, and 4 all satisfy the RAOs for LHAAP-17. Alternatives 2, 3, and 4 would remove the contaminated soil and provide confirmation that human health and the environment will be protected because the monitoring will be conducted to confirm that MNA is returning the contaminated shallow and intermediate groundwater zones at LHAAP-17 to their potential beneficial uses as a drinking water, wherever practicable, and to document that the plumes are contained and prevented from impacting surface water at levels that could present a risk to human health and the environment. Furthermore, the LUC for groundwater would protect human health by preventing access to the contaminated groundwater until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soils and groundwater allow for unlimited use and unrestricted exposure.

2.10.2 Compliance with ARARs

Section 121(d) of CERCLA and 40 CFR §300.430(f)(1)(ii)(B) requires that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations, which are collectively referred to as “ARARs”, unless such ARARs are waived under CERCLA Section 121(d)(4). The ARARs that pertain to this ROD are discussed in **Section 2.13.2**.

Because contaminated groundwater has the potential to flow into Harrison Bayou which flows to Caddo Lake, a drinking water supply, chemical-specific ARARs for surface water consumption are appropriate and relevant. Specifically, Texas surface water quality standards are set forth in 30 TAC 307.6(d)(1) for TCE (5 μg/L), 1,2-DCA (5 μg/L), 1,1-DCE (7 μg/L), and VC (2 μg/L) for LHAAP-17. These standards are equivalent to the MCLs. In the absence of a federal drinking water standard, the perchlorate clean-up level will be based on TRRP Tier 1 Groundwater Residential PCL.

Alternative 1 does not comply with chemical-specific ARARs because no additional remedial action would be implemented. Alternatives 2, 3, and 4 comply with all chemical-specific ARARs for soil because the contaminated soil above the chemical-specific ARAR will be removed. Alternatives 2, 3, and 4 comply with all chemical-specific ARARs for groundwater because they will return the contaminated shallow and intermediate groundwater zones at LHAAP-17 to their potential beneficial use as drinking water, wherever practicable, which for the purposes of this ROD is considered to be attainment of the relevant and appropriate cleanup levels (SDWA MCLs) to the extent practicable, and consistent with 40 CFR 300.430(e)(2)(i)(B&C). If a return to potential beneficial uses is not practicable, these alternatives would still meet the NCP expectation to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction. Alternative 2 complies with surface water ARARs because natural attenuation would reduce the contaminant concentrations in groundwater to the cleanup levels prior to flowing into surface water. Alternatives 3 and 4 also comply with surface water chemical specific ARARs because active remedial processes will reduce contaminant levels in groundwater to levels below water quality standards prior to flowing into surface water.

Location-specific and action-specific ARARs would not apply to Alternative 1 since no remedial activities would be conducted. Alternatives 2, 3, and 4 comply with all location-specific and action-specific ARARs.

2.10.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation, and the adequacy and reliability of controls.

For Alternative 1, contaminant removal would occur by natural attenuation processes, but the long-term effectiveness and permanence would be unknown because of the absence of monitoring. No measures would be implemented to control exposure risks posed by contaminated site groundwater. Alternative 1 would also have no effectiveness and permanence with regards to the contaminated soil, since no soil removal would be conducted.

Alternative 2 would provide a moderate degree of long-term effectiveness by removing the source soils and providing restoration of the groundwater by MNA. LUC would be required for groundwater for the protection of human health exposure.

Alternatives 3 and 4 would also provide a moderate degree of long-term effectiveness by removing the source soils and providing better long-term effectiveness by achieving cleanup levels in the shallow zone in a shorter time as compared to Alternative 2. Alternatives 3 and 4 would significantly reduce initial groundwater contaminant concentrations and thereafter rely on natural attenuation and LUCs until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soils and groundwater allow for unlimited use and unrestricted exposure. Monitoring activities associated with MNA would confirm the protection of human health and the environment by documenting the return of the groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of the contaminant mass and protection of surface water through containment of the plume.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternative 1 has the potential to reduce the mass and concentration of contaminants through natural attenuation processes, although the progress would be unmonitored and undocumented. Alternative 2 would use MNA to permanently reduce the mass and concentration of contaminants through natural processes and; therefore, the toxicity, mobility, and volume of the contaminants. Alternatives 3 and 4 would use in situ bioremediation or groundwater extraction, followed by MNA, to achieve the same reductions in contamination that are expected from Alternative 2. MNA is a passive remedial action, and bioremediation and groundwater extraction are active treatment processes.

Biological activity would generate daughter products that may temporarily increase toxicity or mobility of the contaminant plume. Alternatives 2, 3, and 4 include monitoring so that daughter products would be quantified, documented, and evaluated. The same biological activities would also consume the daughter products, and it is anticipated that these concentrations would be reduced to levels below their associated cleanup levels to return groundwater to its potential beneficial use, wherever practicable.

For Alternative 3, achievement of cleanup levels in groundwater would be expedited by implementing in situ bioremediation in areas of highest contaminant concentrations. Monitoring for contaminants would be performed to assess the effectiveness of the treatment. It is also anticipated that COCs would remain in the plume outside the treated areas and continue to attenuate to cleanup levels over time.

Achievement of cleanup goals would also be expedited for Alternative 4 by implementing pumping and treatment of the contaminated groundwater to reduce perchlorate concentrations throughout the plume.

The soil excavation in Alternatives 2, 3, and 4 would reduce mobility because perchlorate would be removed from the site and placed in a permitted disposal facility. Toxicity and volume would not be reduced by the excavation portion of the alternatives as the form and quantity of the perchlorate would not be altered.

2.10.5 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternative 1 would not involve any remedial measures; therefore, no short-term risk to workers, the community, or the environment would exist. The activities associated with Alternatives 2, 3, and 4 would be protective to the surrounding community from short-term risks except for minimal potential short-term risks during transport (possible accident when soil is transported off site) of perchlorate and explosive contaminated soil.

Alternatives 2, 3, and 4 would involve potential short-term risks to workers associated with exposure to contaminated groundwater from monitoring and/or operation of drilling/construction equipment, and with exposure to contaminated soil during excavation work.

Alternative 3 would have short-term risks to remediation workers associated with exposure while performing in situ bioremediation activities, including handling of additives/materials.

Alternatives 2, 3, and 4 include the LUCs as elements of their remedies and would provide almost immediate protection from the contaminated groundwater by prohibiting groundwater use except for environmental monitoring and testing through LUC implementation. The time period to achieve groundwater cleanup levels is the most significant difference between Alternative 1 versus Alternatives 2, 3, and 4. Alternatives 3 and 4 are expected to take less time to achieve RAOs.

Alternative 4 would have short-term risks to the workers associated with exposure during increased operations at the LHAAP groundwater treatment system, which include chemical handling (caustic acids) and operation of a high-temperature catalytic oxidizer. The implementation of Alternatives 3 and 4 would require more time than Alternative 2.

2.10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Under Alternative 1, no remedial action would be taken. Therefore, no difficulties or uncertainties would be associated with its implementation. For Alternatives 2, 3, and 4, soil excavation would require extensive coordination between excavation, sampling, transportation and disposal. The U.S. Army would be responsible for long-term maintenance and enforcement of the LUCs, long-term evaluation of MNA, long-term sampling, and long-term maintenance and operation of sampling equipment. For groundwater, Alternatives 3 and 4 are technically implementable, although less so than Alternative 2 because of the uncertainties associated with hydrogeologic conditions. Those conditions may impact the ability of in situ bioremediation or groundwater extraction to lower perchlorate concentrations quickly to levels that would be more amenable to MNA of TCE.

Alternative 3 would involve the use of in situ bioremediation, which requires specialized expertise to design and construct the in situ bioremediation treatment elements. A groundwater treatment system currently exists at LHAAP and is easily accessible to the site; therefore, groundwater extraction for Alternative 4 technically would be readily implementable.

Administratively, all of the alternatives are implementable.

2.10.7 Cost

Cost estimates are used in the CERCLA process to eliminate those remedial alternatives that are significantly more expensive than competing alternatives without offering commensurate increases in performance or overall protection of human health or the environment. The cost estimates developed are preliminary estimates with an intended accuracy range of –30 to +50 percent. Final costs will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final scope, final schedule, final engineering design, and other variables.

The cost estimates include capital costs (including fixed-price remedial construction) and long-term O&M costs (post-remediation). Overall present worth costs are developed for each alternative assuming a discount rate of 2.8 percent. The duration used for the estimates is a 30-year period.

The progression of present worth costs from the least expensive alternative to the most expensive alternative is as follows: Alternative 1, Alternative 2, Alternative 4, and Alternative 3. No costs are associated with Alternative 1 because no remedial activities would be conducted.

Alternative 2 has the lowest present worth and capital costs of the active remedial alternatives as no active remediation of groundwater would be implemented. Alternative 3 has the highest present worth and capital costs primarily due to the activities associated with the injection phase of in situ bioremediation. Alternative 4 may at first glance be expected to have the highest capital cost because it requires groundwater extraction and treatment. However, the presence of the existing groundwater treatment system at LHAAP greatly reduces the costs associated with Alternative 4. Compared to the selected alternative (Alternative 4), the total present worth cost of Alternative 2 is 9% less and Alternative 3 is 24% more. The capital present worth cost of Alternative 2 is 12% less and Alternative 3 is 25% more.

2.10.8 State/Support Agency Acceptance

The USEPA and TCEQ have reviewed the Proposed Plan, which presented Alternative 4 as the preferred alternative. Comments received from the USEPA and TCEQ during the Proposed Plan development have been incorporated. Both agencies concur with the selected remedial action.

2.10.9 Community Acceptance

Community acceptance is an important consideration in the final evaluation of the selected remedy. One set of written public comments was received during the 30-day public comment period; there were no verbal comments from the June 29, 2010 public meeting. The topics of the comments included: the trigger level for ending pump and treat, effectiveness of MNA, time required to achieve cleanup levels, and the absence of perchlorate from the COC list for the intermediate zone groundwater. Comment responses were provided and incorporated into the ROD, including clarification of the role of pump and treat in the overall remedial action, explanation of why perchlorate is only associated with the shallow zone, and reiteration of the contingency actions. The written comments received and their responses are presented in the Responsiveness Summary (**Section 3.0**).

2.11 Principal Threat Wastes

The principal threat waste at LHAAP-17 is soil contamination. The perchlorate-contaminated soil is a source material due to high concentrations of contaminants that are mobile (i.e., soil to groundwater). The perchlorate concentrations in soil are near the GWP-Ind, and perchlorate is identified as a potential soil COC because of perchlorate contaminated groundwater. Thus, perchlorate-contaminated soil is considered a principal threat waste.

2.12 The Selected Remedy

2.12.1 Summary of Rationale for the Selected Remedy

Alternative 4 (excavation and off-site disposal of soil; groundwater extraction, MNA, and LUCs) is the preferred alternative for LHAAP-17 and is consistent with the intended future use of the site as a national wildlife refuge. This alternative would satisfy the RAOs for the site through the following:

- Contaminated soil removal with off-site disposal will protect the hypothetical future maintenance worker and ecological receptors and eliminate the soil-to-groundwater pathway;
- Extraction and treatment of groundwater until the trigger level of 20,000 µg/L of perchlorate is reached will expedite MNA;
- MNA was selected as one component of the remedy based on available groundwater evidence as presented in the Addendum to the FS (Shaw, 2010). A tiered approach using three lines of evidence was used to examine the occurrence of natural attenuation. The first line of evidence evaluated reductions in COC concentrations over time and with distance, the second line of evidence evaluated geochemical indicators, while the third line of evidence entailed estimation of natural attenuation rates. In the shallow groundwater zone, historical analytical trends indicate the occurrence of perchlorate biodegradation, but perchlorate still exists in high levels at some areas, and increased at 17WW11. The perchlorate concentrations at 17WW11 are small compared to perchlorate concentrations within the rest of the plume and would be expected to attenuate quickly once perchlorate degradation restarts in this area. Natural attenuation is effectively controlling the TCE plume migration along the flow direction and the TCE plume is stable. The increasing ratio of cis- and trans-1,2-DCE isomer suggests the occurrence of reductive dechlorination of TCE; meanwhile the elevated concentrations of TCE and stabilized 1,1-DCE and 1,2-DCA suggest that chlorinated solvents cannot achieve complete dechlorination under current conditions. In the intermediate groundwater zone, the TCE plume exists at a single well (17WW17), is stable, and has a decreasing concentration trend. Geochemical indicators in the shallow, intermediate, and deep groundwater zones present evidence that geochemical conditions are adequate for reductive dechlorination. Low DO, intermediate ORP, and low nitrate values suggest that the groundwater conditions are anaerobic and nitrate-reducing, which are favorable for perchlorate and TCE reduction. Elevated sulfate concentrations and low TOC concentrations may be limiting factors for biodegradation. Following perchlorate depletion, the subsurface conditions may become reducing enough for complete reductive dechlorination. Thus, natural attenuation was considered feasible for a portion of the site, but not as a sole remedy for the entire site. MNA, together with the groundwater extraction, will ultimately restore the groundwater to attain groundwater cleanup standards/levels; this is anticipated to be completed in approximately 117 years. This approximate timeframe to achieve cleanup levels is considered reasonable based on the anticipated future land use of the site as a national wildlife refuge and the fact that there is no current or anticipated future use of groundwater as a drinking water supply. Thus, MNA is an appropriate component of the remedy for those regions outside the influence of the active remedy because it will protect human health and the environment and will document that further reductive dechlorination is occurring within the groundwater plume and that contaminant concentrations are being reduced to attain groundwater standards/levels;

The LUC to prohibit groundwater use (except for environmental testing and monitoring) as a potable source will be implemented to ensure protection of human health by preventing exposure to groundwater until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met. The LUC restricting land use to nonresidential will be implemented until it is demonstrated that the surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure. The LUC to maintain the integrity of any current or future remedial or monitoring systems will be implemented until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met.

- If the 20,000 µg/L of perchlorate level is not reached after approximately 1.5 years, the contingency remedy of in situ bioremediation described in Alternative 3 will be implemented to reduce the perchlorate levels more quickly so the conditions become amenable for TCE to attenuate naturally. The monitoring and reporting associated with MNA would continue until the cleanup levels are achieved.

By extracting contaminated groundwater, Alternative 4 intends to lower the highest concentrations of perchlorate in groundwater to levels more amenable to natural attenuation. The extracted contaminated groundwater would be conveyed to the existing on-site groundwater treatment plant for treatment. The groundwater plume is contaminated with both TCE and high concentrations of perchlorate that tend to inhibit degradation of the TCE. Removal of the perchlorate down to a concentration of 20,000 µg/L by extraction is expected to accelerate the TCE degradation by MNA. Once reduced to 20,000 µg/L, the performance of natural attenuation would be evaluated by 2 years of monitoring using data acquired from the eight quarters and from the historical sampling events of the prior 10 years. The performance objectives for groundwater remediation will be included in the RD. If it is found that the performance objectives are not met, a contingency remedy of in situ bioremediation (see Alternative 3 description for basic elements) would be implemented.

Five-year reviews will be performed to document that the remedy remains protective of human health and the environment.

The selected alternative offers a high degree of long-term effectiveness, can be easily and immediately implemented, and costs less than the other most comparable alternative, Alternative 3.

The U.S. Army believes the selected alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the CERCLA §121(b) criteria used to evaluate remedial alternatives. The selected alternative will: 1) be protective of human health and the environment; 2) comply with ARARs; 3) be cost-effective; 4) utilize a permanent solution; and 5) utilize an active treatment as a principal element. The selected remedy addresses the statutory preference for treatment to the maximum extent possible.

The U.S. Army will present details of the soil excavation plan, groundwater extraction plan, LUC implementation plan, groundwater monitoring plan, and MNA remedy implementation in the RD for LHAAP-17.

2.12.2 Description of the Selected Remedy

The selected remedy, Alternative 4, was outlined in **Section 2.9**; that description is expanded in the following discussion. The major components of the remedy and the contingency remedies include:

- ***Soil Excavation.*** The excavation will remove explosives, barium, and dioxin contamination for off-site disposal at a RCRA Subtitle D-permitted landfill. This action will achieve the following: 1) removal of soil that is a direct risk to the hypothetical future maintenance worker, thereby protecting human health by preventing inhalation, ingestion, and dermal contact with the COCs; 2) removal of contaminated soil that is a potential source of contaminant migration to groundwater; and 3) removal of soil posing a risk to ecological receptors. The cleanup levels are presented in **Table 2-10**. The treatability demonstration study by PEC may have reduced the contaminants to the preliminary cleanup level. To verify the remaining levels of contamination and to further delineate areas of excavation for design purposes, a limited soil sampling will be conducted during the remedial design phase. The approximate excavation locations are highlighted on **Figure 2-12**. The removal of soil contamination will be verified by collecting confirmation samples from the walls and floors of the excavation area and submitting them for laboratory analysis for the COCs of interest. Clean borrow soil will be used as needed to backfill the excavations so they can be graded for proper drainage.

- ***Groundwater extraction.*** The desired outcome is to reduce perchlorate concentrations in the groundwater to 20,000 µg/L or lower during an operational period of 1.5 years. At these levels, it is anticipated that conditions will be favorable for MNA to take over to reduce contaminants to the cleanup levels. This component is described in **Section 2.9.2**. **Figure 2-13** presents a process flow diagram for the treatment process. The groundwater treatment plant is located at LHAAP-18/24.

- ***Contingency remedy if groundwater extraction does not reduce perchlorate levels to 20,000 µg/L in the 1.5 year extraction timeframe.*** The contingency remedy would implement in situ bioremediation. The area and the elements of the contingency remedy would be selected based on the entire data set available. The elements of an in situ bioremediation remedy are described in **Section 2.9.2**. If a contingency remedy is implemented, it will be documented in an Explanation of Significant Differences (ESD).

- ***MNA to return groundwater to its potential beneficial use, wherever practicable.*** MNA begins following groundwater extraction activities. Historic data suggest that natural attenuation of COCs is occurring at the site; however, additional data collection is necessary to fully evaluate natural attenuation. Monitoring wells will be sampled for eight consecutive quarters to evaluate and confirm the occurrence of natural attenuation in conjunction with historical data. Data from the eight quarterly events will be combined with historic data to evaluate the effectiveness of various natural physical, chemical, and biological processes in reducing contaminant concentrations.

- ***Performance objectives to evaluate the MNA remedy performance after 2 years.*** Each of the general performance objectives must be met as indicated below. If the criteria are not met to illustrate that MNA is an effective remedy, the contingency action would be initiated. If MNA is effective, a baseline will be established from the data to this point in time. Specific evaluation criteria will be developed in the RD. The MNA evaluation will be based on the USEPA lines of evidence (USEPA, 1999) and the anaerobic screening (USEPA, 1998) as follows:

- MNA potential based on evaluation biodegradation screening scores using USEPA guidance.

- Plume stability (i.e., the plume concentrations are decreasing in the majority of performance wells, and the plume is not expanding in area as demonstrated with compliance wells).

- MNA Process Evaluation demonstrated based on an attenuation rate calculated with empirical performance monitoring data, and MNA Process Demonstration based on the presence of daughter products and bacterial culture counts.

- ***A contingency remedy involving in situ bioremediation to reach the RAOs if MNA is found to be ineffective.*** The contingency remedy will use elements of in situ bioremediation from Alternative 3 to address the ineffective aspects of MNA. The area and the elements of the contingency remedy would be selected based on the entire data set available. If the contingency remedy is implemented, it will be documented in an ESD.

- ***Initiate LTM.*** If MNA is determined to be effective, monitoring will be conducted to evaluate the remedy performance and determine if the plume conditions remain constant, improve or worsen after the baseline is established. LTM will be implemented at a frequency of semiannual for 3 years, then annually until the next five-year review. The performance monitoring plan will be developed in the RD and will be based on USEPA guidance (USEPA, 2004).

- Continue LTM annually thereafter until recommended otherwise by the five-year review to evaluate remedy performance and determine if plume conditions remain constant, improve, or worsen. The baseline of the plume for future five-year reviews will be established as part of the MNA evaluation program. The initial LTM plan will be developed during RD.

- ***Land Use Control.*** The LUC objectives include maintaining the integrity of any current or future remedial or monitoring systems, and preventing the use of groundwater contaminated above cleanup levels as a potable water source. The groundwater treatment and MNA remedial components include a groundwater monitoring system that will be used to characterize the condition of the groundwater during the period the groundwater remedy is in place until the groundwater remediation goals are achieved, and to demonstrate achievement of the groundwater remediation goals when the groundwater remedy is complete. As a part of this groundwater remedy, the Army will maintain the remedial and monitoring systems associated with the groundwater remedies until these components of the remedy are no longer needed to achieve cleanup levels, and cleanup levels have been achieved. During the period of operation of the groundwater remedy, if any of the elements of the remedial and groundwater monitoring systems are damaged, destroyed, or become ineffective, they will be repaired or replaced with suitable components to assure that the remedial and groundwater monitoring systems are able to provide data of the quality necessary to determine the progress of and eventual completion of this component of the remedy. The actions to be taken to implement these LUC objectives and requirements will be provided through modifying the "Comprehensive Land Use Control (LUC) Management Plan, Former Longhorn Army Ammunition Plant, Karnack, Texas" and detailed in the LUC RD.

- The LUC for prohibition of groundwater use (except for monitoring and testing) shall be implemented and shall remain in place at the Site until the COCs (i.e. including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soil and groundwater remaining at the site are reduced below levels that would support unlimited use and unrestricted exposure. A LUC RD will be finalized as the land use component of the Remedial Design. Within 21 days of the issuance of the ROD, the Army will propose deadlines for completion of the RD Work Plan, RD and Remedial Action Work Plan. The documents will be prepared and submitted to the EPA and the TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. The long-term groundwater and surface water monitoring and MNA performance monitoring plan will also be presented in the RD. The recordation notification for the Site which will be filed with Harrison County, will include a description of the LUCs. The preliminary boundary for the groundwater LUC is shown on Figure 2-5.

- The LUC restricting land use to nonresidential shall be implemented until it is demonstrated that surface and subsurface soil and groundwater COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) are at levels that allow for unlimited use and unrestricted exposure.

- The LUC to maintain the integrity of any current or future remedial or monitoring systems will remain in place until the levels of COCs (i.e., including all hazardous substances, pollutants and contaminants found at the Site at cleanup levels as listed in Table 2-10) in groundwater are met. The LUC to prohibit groundwater use (except for environmental monitoring and testing) as a potable source will remain in place until the levels of COCs (i.e., all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soil and groundwater allow for unlimited use and unrestricted exposure.

The Army will implement, maintain, monitor, report on and enforce land use controls at Army-owned property. The Army shall perform those actions related to land use control activities described in this ROD and in the Remedial Design for the ROD. For portions of the Site subject to land use controls that are not owned by the Army, the Army will monitor and report on the implementation, maintenance, and enforcement of land use controls, and coordinate with federal, state, and local governments and owners and occupants of properties subject to land use controls. The Army will provide notice of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. The Army will send these notices to the federal, state and local governments involved at this site and the owners and occupants of the properties subject to those use restrictions and land use controls. The Army shall provide the initial notice within 90 days of ROD signature. The frequency of subsequent notifications will be described in the Remedial Design for the ROD. The Army remains responsible for ensuring that the remedy remains protective of human health and the environment. The Army will fulfill its responsibility and obligations under CERCLA and the NCP as it implements, maintains, and reviews the selected remedy.

Upon transfer of Army-owned property, the Army will provide written notice of the land use controls to the transferee of the groundwater and soil (surface and subsurface) contamination and any land use restrictions referenced in the ROD. Within 15 days of transfer, the Army shall provide EPA and TCEQ with written notice of the division of implementation, maintenance, and enforcement responsibilities unless such information has already been provided in the LUC RD. The LUC RD will address the procedures to be used by the Army and the transferee to document compliance with the LUCs described in this ROD. In the event property is transferred out of Federal control, the land use controls relating to property and groundwater restrictions shall be recorded in the deed and shall be enforceable by the United States and the state of Texas.

LUC implementation and maintenance actions would be described in the RD for LHAAP-17. The LUCs would be included in the property transfer documents and a recordation of the area of groundwater prohibition would be filed in the Harrison County Courthouse. The LUC for groundwater will prevent human exposure to groundwater contaminated with chlorinated solvents and perchlorate through the prohibition of groundwater use. In addition, within 90 days of signature of this ROD, the Army shall request the Texas Department of Licensing and Regulation to notify well drillers of groundwater use prohibitions based on a preliminary LUC boundary. A LUC Remedial Design (RD) will be finalized as the land use component of the

Remedial Design. Within 21 days of the issuance of the ROD, the Army will propose deadlines for completion of the RD Work Plan, RD, and Remedial Action Work Plan. The documents will be prepared and submitted to EPA and TCEQ pursuant to the FFA. The LUC RD will contain implementation and maintenance actions, including periodic inspections. The long-term groundwater and surface water monitoring and monitored natural attenuation (MNA) performance monitoring plan will also be presented in the remedial design (RD). Consistent with the dates presented for these documents, the U.S. Army shall: 1) request the Texas Department of Licensing and Regulation to notify well drillers of groundwater use prohibitions; and 2) notify the Harrison County Courthouse of the LUC to include a map showing the areas of groundwater use prohibition at the site, in accordance with 30 TAC 335.565.

Monitoring activities associated with the LUC would be undertaken to ensure that groundwater is not being used. Long-term operational requirements under this alternative would include maintenance of the LUCs. Groundwater monitoring will demonstrate no migration of the plume and the eventual reduction of contaminants to levels below cleanup levels. The need for continued groundwater monitoring will be evaluated every 5 years during the reviews. Sampling frequency and analytical requirements will be presented as an appendix to the RD for LHAAP-17.

2.12.3 Cost Estimate for the Selected Remedy

Table 2-13 presents the present worth analysis of the cost for the selected remedy, Alternative 4. The information in the table is based on the best available information regarding the anticipated scope of the remedial alternative. The quantities used in the estimate are for estimating purposes only. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record, an ESD, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within -30 to +50 percent of the actual project cost.

The total project present worth cost of this alternative is approximately $2,347,000, using a discount rate of 2.8%. The capital cost is estimated at $1,763,000. The total O&M present value cost is estimated at approximately $584,000. The O&M cost includes evaluation of MNA, maintenance of the LUCs, and LTM through Year 30. The LTM would support the required CERCLA five-year reviews.

2.12.4 Expected Outcomes of Selected Remedy

The purpose of this response action is to attain the RAOs stated in **Section 2.8** of this document. **Table 2-10** and **2-11** present the cleanup levels for COCs and COPECs, respectively. The cleanup levels for the COCs in the groundwater are the Federal Safe Drinking Water Act MCLs, or in the absence of federal drinking water standards, clean-up levels will be based on TRRP Tier

1 Groundwater Residential PCLs. The cleanup level for the COCs in the soil is the GWP-Ind. The cleanup level for the COPECs in the soil is the EcoPRGs.

The expected outcome of the selected remedy is that contaminants in soil and groundwater will be reduced to the cleanup levels. Achievement of the cleanup levels (**Tables 2-10** and **2-11**) is anticipated to be completed in less than 117 years; how much less depends on the success of the active remediation. This approximate timeframe to achieve cleanup levels is considered reasonable for the anticipated future land use as a national wildlife refuge. The LUC for the maintenance of the monitoring system will be maintained until the groundwater cleanup levels are achieved. The LUCs for soil and groundwater will be maintained until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) allow for unlimited use and unrestricted exposure. In the short-term (prior to the groundwater achieving cleanup levels), the site will be made part of a national wildlife refuge operated by USFWS, and will continue as such in the long-term (after the groundwater achieves cleanup levels).

In addition, the monitoring activities associated with MNA would confirm the protection of human health and the environment by documenting the return of the groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of the contaminant mass, and protection of surface water through containment of the plume. The LUC for groundwater will prohibit the use of the site's groundwater except for environmental monitoring and testing.

As part of the evaluation of MNA, attenuation rates are computed and evaluated in accordance with the USEPA guidance material (USEPA, 1998). Time-dependent attenuation rate constants and estimated in-well cleanup times are determined based on COC concentration data over time from individual wells assuming first order degradation kinetics. Attenuation rates are calculated for the monitoring wells with the highest concentrations for which the available data allow such a calculation. Attenuation rates are based on the following formula from the USEPA guidance (USEPA, 1998):

$$C = C_o e^{-kt}$$

where:
- C = concentration at time t
- C_o = initial concentration
- k = attenuation rate constant (first order reaction)

2.13 Statutory Determinations

Under CERCLA §121 and the NCP, the U.S. Army must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the selected remedy meets the statutory requirements.

2.13.1 Protection of Human Health and the Environment

The selected remedy, Alternative 4, will achieve the RAOs for LHAAP-17. For the protection of human health, the remedial action would remove soil that exceeds the cleanup levels, and it would eventually achieve the destruction of the COCs present in the groundwater plumes at LHAAP-17. Continued maintenance of the LUC for groundwater would prevent human access and exposure to groundwater that poses an unacceptable risk to human health, until COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soils and groundwater have sufficiently degraded to levels that allow for unlimited use and unrestricted exposure. At LHAAP-17, the evaluation of historical groundwater contaminant trends indicates that natural attenuation processes are occurring at the site. This remedy provides adequate confirmation that human health and the environment are protected because monitoring would be conducted to document the effectiveness of MNA. The monitoring activities associated with MNA will ensure that COCs and by-product (daughter) contaminants in groundwater do not flow to surface water bodies at such levels that ARARs are exceeded. The LUCs for soil and groundwater will be maintained until the levels of COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) in soil and groundwater allow for unlimited use and unrestricted exposure.

For the protection of ecological receptors, the remedial action would remove soil at select areas (in addition to those areas excavated for the protection of human health) to address ecological risks. The outcome of the removal is that the soil in the Waste Sub-Area, which includes LHAAP-17, will satisfy the EcoPRGs.

There are no short-term threats associated with the selected remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from the selected remedy.

2.13.2 Compliance with ARARs

The selected remedy complies with all ARARs. The ARARs are presented below and in **Table 2-14**.

Chemical-Specific ARARs

- **Soil**: Since there are no federally promulgated chemical-specific ARARs for soil (e.g., perchlorate), the ROD applies the State of Texas promulgated cleanup standards under

30 TAC 335, Subchapter S, which are used as the chemical-specific ARARs for this site. It is anticipated that removal of contaminated soils above the Texas standard will prevent any future contamination of the groundwater from soil at the site.

- **Surface water**: Section 121(d)(2) of CERCLA states that every remedial action shall require a level of control which at least attains surface water quality criteria established under Sections 304 or 303 of the Clean Water Act of 1972. Therefore, surface water quality criteria are ARARs if there is a remedial action that affects surface water, and measures will be implemented during construction to prevent off-site migration of contaminants to surface waters. In the event of remedy failure resulting in or potentially resulting in a release to surface water, 40 CFR §§ 122, 125, 129, and 130 – 131 and 30 TAC 307.1, 307.2, 307.3, 307.4, 307.5(a) and (b), 307.6, 307.7, 307.8 and 307.9 are considered potential future ARARs.

- **Groundwater**: Cleanup levels are presented in **Table 2-10**. LHAAP is being addressed using the Risk Reduction Standards (RRS) (30 TAC 335.551 through 335.569). The RRS were provided to ensure adequate protection of human health and the environment from potential exposure to contaminants associated with releases from solid waste management facilities or other areas. There are three sets of RRS that provide cleanup levels ranging from closure/remediation to site background (RRS 1) to closure/remediation with controls (RRS 3). A baseline risk assessment under RRS 3 was completed for LHAAP-17 which identified COCs in groundwater that potentially pose carcinogenic risk and hazard to the hypothetical future maintenance worker. These identified COCs, with the exception of perchlorate, have MCLs. Thus, the cleanup goal for groundwater will be the MCLs which meet health-based standards and criteria. In the absence of federal drinking water standards, clean-up levels will be based on TRRP Tier 1 Groundwater Residential PCLs. This alternative will return the contaminated shallow and intermediate groundwater zones at LHAAP-17 to their potential beneficial use as drinking water, wherever practicable, which for the purposes of this ROD is considered to be attainment of the relevant and appropriate SDWA MCLs, and consistent with 40 CFR 300.430(e)(2)(i)(B&C). If a return to potential beneficial uses is not practicable, this alternative would still meet the NCP expectation to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.

Location-Specific ARARs

- **Floodplain management**: LHAAP-17 includes areas classified as part of a floodplain.

- **Wetlands**: The USACE has not made a determination that jurisdictional wetlands exist at LHAAP-17, and none are identified on the USFWS database; therefore, protection of wetlands is not considered a potential location-specific ARAR for this site.

Action-Specific ARARs

The selected remedy has potential action-specific ARARs related to the following activities: site preparation, construction, and excavation activities; waste generation, characterization, management, storage, and disposal activities; well construction; and water treatment.

- **Site preparation, construction, and excavation activities**: Certain on-site preparation, construction, and/or excavation activities will be necessary under all remediation actions to prepare the site for remediation, including the soil-moving or site-grading activities. Control of fugitive emissions and storm water runoff during implementation of these activities will be required. Airborne particulate matter resulting from construction or excavation activities is subject to the fugitive dust and opacity limits listed in 30 TAC 111, Subchapter A. No person may cause, suffer, allow, or permit visible emissions from any source to exceed an opacity of 30 percent for any 6-minute period (30 TAC 111.111[a]). Reasonable precautions must also be taken to achieve maximum control of dust to the extent practicable, including the application of water or suitable chemicals or the complete covering of materials (30 TAC 111.143 and 30 TAC 111.145). Texas has also promulgated general nuisance rules for air contaminants mandating that no person shall discharge from any source whatsoever one or more air contaminants, or combinations thereof, in such concentration and of such duration as are or may tend to be injurious to or to adversely affect human health or welfare, animal life, vegetation, or property, or as to interfere with the normal use and enjoyment of animal life, vegetation, or property (30 TAC 101.4). Storm water discharges from construction activities that disturb equal to or greater than one acre of land must comply with the substantive requirements of a USEPA National Pollutant Discharge Elimination System general permit (40 CFR 122.26; 30 TAC 205, Subchapter A; and 30 TAC 308.121), depending on the amount of acreage disturbed. Substantive requirements include implementation of good construction management techniques; phasing of large construction projects; minimal clearing; and sediment, erosion, structural, and vegetative controls to mitigate runoff and ensure that discharges meet required parameters.

- **Waste and disposal activities**: The processes of monitoring, intercepting, or treating contaminated groundwater may generate a variety of primary and secondary waste streams (e.g., soil, personal protective equipment, and dewatering and decontamination fluids). These waste streams are expected to be non-hazardous waste. All solid waste (defined as any solid, liquid, semisolid, or contained gaseous material intended for discard [40 CFR 261.2]) generated during remedial activities must be appropriately characterized to determine whether it contains RCRA hazardous waste (40 CFR 262.11; 30 TAC 335.62; 30 TAC 335.503[a][4]; 30 TAC 335.504). All wastes must be managed, stored, treated (if necessary), and disposed in accordance with the ARARs for waste management listed in **Table 2-14** for the particular type of waste stream or contaminants in the waste.

- **Well construction**: The remedial action may involve the placement, use, or eventual plugging and abandonment of some type of groundwater monitoring, injection, and/or extraction wells, either for in situ treatment or extraction of the contaminated groundwater or for LTM of the groundwater. Available standards for well construction and plugging/abandonment would provide ARARs for such actions and include 30 TAC 331, Subchapters A, C, and H. Texas has promulgated technical requirements in Chapter 76 of Title 16 of the TAC applicable to construction, operation, and plugging/abandonment of water wells. In particular, 16 TAC 76.1000 (*Locations and Standards of Completion for Wells*), 16 TAC 76.1002 (*Standards for Wells Producing Undesirable Water or Constituents*) (LHAAP-17 contaminated groundwater could be considered "undesirable water" defined pursuant to Section 76.10[36] as "water that is injurious to human health and the environment or water that can cause pollution to land or other waters"), 16 TAC 76.1004 (*Standards for Capping and Plugging of Wells and Plugging Wells that Penetrate Undesirable Water or Constituent Zones*), and 16 TAC 76.1008 (*Pump Installation*) may provide ARARs for the placement, construction, and eventual plugging/abandonment of groundwater injection or extraction wells or the placement and long-term operation of groundwater monitoring wells for proposed groundwater remedial strategies.

- **Water treatment**: Contaminated groundwater and wastewaters collected during well drilling or decontamination activities could be transported to the groundwater treatment plant at LHAAP-18/24 for processing, and would subsequently be discharged in compliance with the effluent limits for that plant. Such waters would be characterized, as required, before transport and managed accordingly in compliance with requirements for the type of waste contaminating the water. To assure compliance with the groundwater treatment plant's discharge limits, the incoming water must meet the waste acceptance criteria for the facility. On-site wastewater treatment units (as defined in 40 CFR 260.10) that are part of a wastewater treatment facility that is subject to regulation under Section 402 or Section 307(b) of the Clean Water Act of 1972 are not subject to RCRA Subtitle C hazardous waste management standards (40 CFR 270.1[c][2][v]; 40 CFR 264.1[g][6]; 30 TAC 335.42[d][1]). The USEPA has clarified that this exemption applies to all tanks, conveyance systems, and ancillary equipment, including piping and transfer trucks, associated with the wastewater treatment unit (Federal Register Title 53, 34079, September 2, 1988).

2.13.3 Cost-Effectiveness

The progression of present worth costs from the least expensive alternative to the most expensive alternative is as follows (provided that no contingencies are implemented): Alternative 1, Alternative 2, Alternative 4, and Alternative 3. No costs are associated with Alternative 1 because no remedial activities would be conducted. Alternative 2 has the lowest present worth and capital costs of the remediation alternatives (Alternatives 2 through 4). The present worth costs for Alternative 2 is lower than that of Alternatives 3 and 4, as it does not involve injections for bioremediation or construction for a groundwater extraction system. Compared to the selected alternative (Alternative 4), the total present worth cost of Alternative 2 is 9% less and Alternative 3 is 24% more. The capital present worth cost of Alternative 2 is 12% less and Alternative 3 is 25% more. **Table 2-13** is the cost estimate summary table for the selected remedy.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

The U.S. Army has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. Soil excavation would remove impacted soils and groundwater extraction and treatment would irreversibly reduce groundwater contaminant concentrations in the treated portions of the groundwater plume. When perchlorate is reduced to 20,000 µg/L, groundwater extraction will be discontinued and MNA will reduce groundwater contaminants to cleanup levels. Natural biodegradation is an irreversible treatment process that would reduce the mass and concentration of contaminants.

Alternative 4 would significantly reduce groundwater contaminant concentrations and achieve cleanup levels although the actual potential effectiveness will be controlled by the nature of the permeable water-bearing zones and the distribution and presence of COCs remaining in the groundwater in the untreated areas. The selected remedy would provide reduction in toxicity, mobility, and volume of the groundwater contaminants via active treatment. Alternative 4 would take less time to achieve remediation goals than Alternative 2 provided subsurface conditions for groundwater extraction are favorable.

Alternative 4 would provide almost immediate protection because the LUCs would be implemented quickly. Maintenance of this control would be required until COCs (i.e., including all hazardous substances, pollutants, and contaminants found at the Site at cleanup levels as listed in Table 2-10) and by-product (daughter) contaminant concentrations in soil and groundwater allow for unlimited use and unrestricted exposure.

2.13.5 Preference for Treatment as a Principal Element

The selected remedy would reduce the toxicity, mobility, or volume of contaminants in the groundwater through an active remedial process. By utilizing groundwater extraction as a significant portion of the remedy, the statutory preference for remedies that employ treatment as a principal element is satisfied. There is principal threat material in the soil at LHAAP-17. The contaminated soil that is principal threat source material will be excavated to remove the contaminated material from the site. Based on the waste characteristics, the material will be disposed at an approved landfill.

2.13.6 Five-Year Review Requirements

Section 121(c) of CERCLA and NCP §300.430(f)(5)(iii)(C) provide the statutory and legal bases for conducting five-year reviews. Because this remedy will result in contaminants that remain on site above levels that allow unlimited use and unrestricted exposure, a review will be conducted at least every five years to confirm that the remedy continues to provide adequate protection of human health and the environment.

2.14 Significant Changes from the Proposed Plan

The Proposed Plan for LHAAP-17 was released for public comments on May 26, 2010. The Proposed Plan identified Alternative 4 as the Preferred Alternative for groundwater remediation. The U.S. Army reviewed all written comments during the public comment period (there were no verbal comments). After careful consideration of the comments, it was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

Table 2-1
Summary of Chemicals of Concern and Medium Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical	Concentration Detected[1] (mg/L)		Frequency of Detection	Exposure Point Concentration (mg/L)	Statistical Measure
		Minimum	Maximum			
Ingestion, inhalation, dermal contact	***Dioxin/Furan***					
	2,3,7,8-TCDD TEC	1.84E-09	3.54E-09	---	3.54E-09	maximum
	Metals					
	Aluminum	5.00E-01	8.10E+00	11/17	8.10E+00	maximum
	Antimony	5.00E-03	1.30E-02	6/28	1.30E-02	maximum
	Cadmium	9.00E-04	9.00E-04	1/28	9.00E-04	maximum
	Chromium	1.00E-02	1.80E-01	15/28	1.80E-01	maximum
	Lead	3.00E-03	1.00E-02	14/28	1.00E-02	maximum
	Manganese	4.90E-02	3.49E+00	17/17	3.49E+00	maximum
	Nickel	4.00E-02	2.10E-01	7/28	2.10E-01	maximum
	Silver	1.00E-02	1.00E-02	1/28	1.00E-02	maximum
	Strontium	1.40E-01	3.20E+00	17/17	3.20E+00	maximum
	Thallium	1.70E-03	4.30E-03	16/28	4.30E-03	maximum
	Non-Metallic Anion					
	Perchlorate	1.0E-02	3.2E+02	21/31	3.20E+02	maximum
	Semi-Volatile Organics					
	2,4-Dinitrotoluene	---	---	0/7	3.80E-03	maximum
	2,6-Dinitrotoluene	---	---	0/7	3.80E-03	maximum
	Volatile Organics					
	1,1-Dichloroethene	3.70E-03	5.10E-02	7/28	5.10E-02	maximum
	1,2-Dichloroethane	4.90E-03	6.30E-02	8/28	6.30E-02	maximum
	Methylene chloride	1.10E-03	3.20E-03	4/28	3.20E-03	maximum
	Trichloroethene	2.90E-03	5.32E+00	13/28	5.32E+00	maximum
	Dioxin/Furan					
	2,3,7,8-TCDD TEC	1.28E-06	2.14E-04	---	2.14E-04	maximum
	Explosive					
	2,4,6-Trinitrotoluene	4.30E-01	8.40E+03	9/29	8.40E+03	maximum
	2-Amino-4,6-dinitrotoluene	5.10E-01	1.60E+01	5/29	1.60E+01	maximum
	4-Amino-2,6-dinitrotoluene	4.90E-01	4.80E+00	4/20	4.80E+00	maximum

Table 2-1 (*continued*)
Summary of Chemicals of Concern and Medium Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Soil
Exposure Medium: Soil (0 to 2 feet below ground surface)

Exposure Point	Chemical	Concentration Detected[1] (mg/kg)		Frequency of Detection	Exposure Point Concentration (mg/kg)	Statistical Measure
		Minimum	Maximum			
Ingestion, inhalation, dermal contact	***Metals***					
	Antimony	1.36E+00	2.51E+00	9/30	2.51E+00	maximum
	Barium	4.70E+01	2.05E+04	47/47	1.16E+03	95% UCL
	Cadmium	6.80E-01	7.33E+00	11/47	7.33E+00	maximum
	Lead	4.77E+00	5.97E+02	47/47	9.34E+01	95% UCL
	Thallium	4.80E+00	4.80E+00	1/47	4.80E+00	maximum
	Non-Metallic Anion					
	Perchlorate	3.56E-02	6.16E-01	4/4	6.16E-01	maximum
	Semi-Volatile Organics					
	2,4-Dinitrotoluene	1.90E+00	7.10E+03	4/18	2.60E+03	95% UCL
	2,6-Dinitrotoluene	1.80E+00	7.60E+02	5/18	3.18E+02	95% UCL
	Hexachlorobenzene	2.80E-01	2.80E-01	1/18	2.80E-01	maximum

Notes:
[1] Minimum/maximum detected concentration above the reporting limit

For groundwater, the maximum detected concentrations were used to estimate the exposure point concentration.
For soil, the 95% UCL values were used to estimate the exposure point concentration if the concentration exceeded the average and was below the maximum detected; otherwise, the maximum detected concentration was used to estimate the exposure point concentration.

---: No information available
95% UCL: 95% upper confidence level of the mean
mg/kg: milligrams per kilogram
mg/L: milligrams per liter
TCDD: tetrachlorodibenzo-p-dioxin
TEC: toxicity equivalence concentration

References:
Jacobs Engineering Group, Inc. (Jacobs), 2002, *Baseline Human Health and Screening Ecological Risk Assessment for the Group 2 Sites (Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Oak Ridge, TN, August.

Summary of Chemicals of Potential Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of potential concern (COPCs) and exposure point concentration (EPC) for each (i.e. the concentration used to estimate the exposure and risk from each COPC). The table includes the range of concentrations detected for each COPC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the EPC, and the statistical measure upon which the EPC was based. The COPCs listed are the ones that were quantitatively evaluated for carcinogenic risk and non-carcinogenic hazard in the Baseline Human Health Risk Assessment (Jacobs, 2002).

Table 2-2
Carcinogenic Toxicity Data Summary

Pathway: Ingestion, Dermal Contact

Chemical of Concern	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Dermal Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight of Evidence/ Carcinogen Guideline Description	Source/Date
Dioxin/Furans				
2,3,7,8-TCDD TEC	1.50E+05	3.00E+05	not classified	USEPA-HEAST, 1997
Explosives				
2,4,6-Trinitrotoluene	3.00E-02	5.00E-02	C	USEPA-IRIS, 2001
2-Amino-4,6-dinitrotoluene	1.00E-02	2.00E-02	not classified	TCEQ, 2001
4-Amino-2,6-dinitrotoluene	1.00E-02	2.00E-02	not classified	TCEQ, 2001
Metals				
Aluminum	NTV	NTV	not classified	---
Antimony	NTV	NTV	not classified	---
Barium	NC	NC	D	TCEQ, 2001
Cadmium (Water)	NTV	NTV	B1	TCEQ, 2001
Chromium (Total)	NC	NC	not classified	---
Lead	NTV	NTV	not classified	---
Manganese (Non-diet)	NC	NC	D	TCEQ, 2001
Nickel	NTV	NTV	A	TCEQ, 2001
Silver	NC	NC	D	TCEQ, 2001
Strontium	NTV	NTV	not classified	---
Thallium	NC	NC	not classified	---
Non-Metallic Anions				
Perchlorate	NTV	NTV	not classified	---
Semivolatile Organics				
2,4-Dinitrotoluene	6.80E-01	8.00E-01	B2	USEPA-IRIS, 2001
2,6-Dinitrotoluene	6.80E-01	8.00E-01	B2	USEPA-IRIS, 2001
Hexachlorobenzene	1.60E+00	3.20E+00	B2	USEPA-IRIS, 2001
Volatile Organics				
1,1-Dichloroethene	6.00E-01	6.00E-01	C	USEPA-IRIS, 2001
1,2-Dichloroethane	9.10E-02	9.10E-02	B2	USEPA-IRIS, 2001
Methylene chloride	7.50E-03	7.89E-03	B2	USEPA-IRIS, 2001
Trichloroethene	1.10E-02	1.10E-02	B2	USEPA-NCEA, 2001

Table 2-2 (*continued*)
Carcinogenic Toxicity Data Summary

Pathway: Inhalation

Chemical of Concern	Unit Risk Factor $(mg/m^3)^{-1}$	Weight of Evidence/ Carcinogen Guideline Description	Source/Date
Dioxin/Furans			
2,3,7,8-TCDD TEC	3.30E+04	Not Classified	USEPA-HEAST, 1997
Explosives			
2,4,6-Trinitrotoluene	NTV	C	TCEQ, 2001
2-Amino-4,6-dinitrotoluene	NTV	Not Classified	---
4-Amino-2,6-dinitrotoluene	NTV	Not Classified	---
Metals			
Aluminum	NTV	Not Classified	---
Antimony	NTV	Not Classified	---
Barium	NC	D	TCEQ, 2001
Cadmium (Water)	1.80E+00	B1	USEPA-IRIS, 2001
Chromium (Total)	NC	Not Classified	---
Lead	NTV	Not Classified	---
Manganese (Non-diet)	NC	D	TCEQ, 2001
Nickel	4.80E-01	A	USEPA-IRIS, 2001
Silver	NC	D	TCEQ, 2001
Strontium	NTV	Not Classified	---
Thallium	NC	Not Classified	---
Non-Metallic Anions			
Perchlorate	NTV	Not Classified	---
Semivolatile Organics			
2,4-Dinitrotoluene	NTV	B2	TCEQ, 2001
2,6-Dinitrotoluene	NTV	B2	TCEQ, 2001
Hexachlorobenzene	4.60E-01	B2	USEPA-IRIS, 2001
Volatile Organics			
1,1-Dichloroethene	5.00E-02	C	USEPA-IRIS, 2001
1,2-Dichloroethane	2.60E-02	B2	USEPA-IRIS, 2001
Methylene chloride	4.70E-04	B2	USEPA-IRIS, 2001
Trichloroethene	1.70E-03	B2	USEPA-NCEA, 2001

Table 2-2 (*continued*)
Carcinogenic Toxicity Data Summary

Notes

--- : No information available
mg/kg-day: milligrams per kilogram per day
mg/m^3: milligrams per cubic meter
NC: Chemical not classified as a carcinogen
NTV: no toxicity value available
TCDD: tetrachlorodibenzo-p-dioxin
TEC: toxicity equivalence concentration

Weight of Evidence/Carcinogen Guideline Description:
A - Human carcinogen
B1 - Probable human carcinogen – Indicates that limited human data are available
B2 - Probable human carcinogen – Indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen

References

Jacobs Engineering Group, Inc. (Jacobs), 2002, *Baseline Human Health and Screening Ecological Risk Assessment for the Group 2 Sites (Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake)*, Longhorn Army Ammunition Plant, Karnack, Texas, Final, Oak Ridge, TN, August.

Texas Commission on Environmental Quality (TCEQ), 2001, Update to 1998 Consistency Memorandum. Toxicity Factors Table, 15 March 2001.

U.S. Environmental Protection Agency (USEPA), 1993, *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*, Office of Research and Development, EPA/600/$-93/089, July 1993.

USEPA-HEAST, 1997, Human Health Effects Summary Tables (HEAST). FY-1995, Annual, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/r-95-036.

USEPA-IRIS, 2001. Integrated Risk Information System (IRIS). United States Environmental Protection Agency Online Database for Toxicity Information on Hazardous Chemicals, 2001.

USEPA-NCEA, 2001, USEPA Region 3 Risk-Based Concentration Tables (5/8/2001). Referenced values from National Center for Environmental Assessment (NCEA).

Summary of Toxicity Assessment

The table provides carcinogenic risk information which is relevant to the contaminants of potential concern in soil and ground water. The list of chemicals of concern presented here are the ones that were quantitatively evaluated for carcinogenic risk and non-carcinogenic hazard in the Baseline Human Health Risk Assessment (Jacobs, 2002).

Table 2-3
Non-Carcinogenic Toxicity Data Summary

Pathway: Ingestion, Dermal Contact

Chemical of Concern	Chronic/ Subchronic	Oral RfD Value (mg/kg-day)	Dermal RfD (mg/kg-day)	Target Endpoint	Combined Uncertainty/ Modifying Factors	Source/Date
Dioxin/Furans						
2,3,7,8-TCDD TEC	chronic	NTV	NTV	NA	NA	---
Explosives						
2,4,6-Trinitrotoluene	chronic	5.00E-04	3.00E-04	Liver effects	1000/1	USEPA-IRIS, 2001
2-Amino-4,6-dinitrotoluene	chronic	1.67E-04	8.33E-05	NA	NA	TCEQ, 2001
4-Amino-2,6-dinitrotoluene	chronic	1.67E-04	8.33E-05	NA	NA	TCEQ, 2001
Metals						
Aluminum	chronic	1.00E+00	1.00E-01	NA	NA	USEPA-NCEA, 2001
Antimony	chronic	4.00E-04	6.00E-05	Longevity, blood glucose, and cholesterol	1000/1	USEPA-IRIS, 2001
Barium	chronic	7.00E-02	4.90E-03	Increased kidney weight	3/1	USEPA-IRIS, 2001
Cadmium (Water)	chronic	5.00E-04	1.25E-05	Proteinuria	10/1	USEPA-IRIS, 2001
Chromium (Total)	chronic	1.50E+00	1.95E-02	No effects observed	100/10	USEPA-IRIS, 2001
Lead	chronic	NTV	NTV	NA	NA	---
Manganese (Non-diet)	chronic	4.70E-02	2.82E-03	Central nervous system effects	1/1	USEPA-IRIS, 2001
Nickel	chronic	2.00E-02	8.00E-04	Decreased Body Weight	300/1	USEPA-IRIS, 2001
Silver	chronic	5.00E-03	2.00E-04	Argyria	3/1	USEPA-IRIS, 2001
Strontium	chronic	6.00E-01	1.20E-01	Rachitic bone	300/1	USEPA-IRIS, 2001
Thallium	chronic	8.00E-05	8.00E-05	Blood	3000/1	USEPA-IRIS, 2001[d]
Non-Metallic Anions						
Perchlorate	chronic	9.00E-04	9.00E-04	NA	NA	USEPA, 1998
Semivolatile Organics						
2,4-Dinitrotoluene	chronic	2.00E-03	1.70E-03	Central nervous system effects	100/1	USEPA-IRIS, 2001
2,6-Dinitrotoluene	chronic	1.00E-03	8.50E-04	Central nervous system effects	3000/1	USEPA-HEAST, 1997
Hexachlorobenzene	chronic	8.00E-04	4.00E-04	Liver effects	100/1	USEPA-IRIS, 2001
Volatile Organics						
1,1-Dichloroethene	chronic	9.00E-03	9.00E-03	Hepatic lesions	1000/1	USEPA-IRIS, 2001
1,2-Dichloroethane	chronic	3.00E-02	3.00E-02	NA	NA	USEPA-NCEA, 2001
Methylene chloride	chronic	6.00E-02	5.70E-02	Liver toxicity	100/1	USEPA-IRIS, 2001
Trichloroethene	chronic	6.00E-03	6.00E-03	NA	NA	USEPA-NCEA, 2001

Table 2-3 (*continued*)
Non-Carcinogenic Toxicity Data Summary

Pathway: Inhalation

Chemical of Concern	Chronic/ Subchronic	Inhalation RfC (mg/m^3)	Target Endpoint	Combined Uncertainty/ Modifying Factors	Source/Date
Dioxin/Furans					
2,3,7,8-TCDD TEC	chronic	NTV	---	---	---
Explosives					
2,4,6-Trinitrotoluene	chronic	0.0001	NA	NA	TCEQ, 2001
2-Amino-4,6-dinitrotoluene	chronic	0.0001	NA	NA	TCEQ, 2001
4-Amino-2,6-dinitrotoluene	chronic	0.0001	NA	NA	TCEQ, 2001
Metals					
Aluminum	chronic	0.0035	NA	NA	USEPA-NCEA, 2001
Antimony	chronic	0.0005	Pulmonary toxicity, chronic interstitial inflammation	300/1	USEPA-IRIS, 2001
Barium	chronic	0.00049	Fetus, developmental effects	1000/1	USEPA-HEAST, 1997
Cadmium (Water)	chronic	0.0002	NA	NA	USEPA-NCEA, 2001
Chromium (Total)	chronic	0.0001	NA	NA	TCEQ, 2001
Lead	chronic	NTV	---	---	---
Manganese (Non-diet)	chronic	0.00005	Impairment of neurobehavioral function	1000/1	USEPA-IRIS, 2001
Nickel	chronic	0.0002	Respiratory effects	NA	ATSDR, 1997
Silver	chronic	0.00001	NA	NA	TCEQ, 2001
Strontium	chronic	NTV	---	---	---
Thallium	chronic	0.0001	NA	NA	TCEQ, 2001
Non-Metallic Anions					
Perchlorate	chronic	NTV	---	---	---
Semivolatile Organics					
2,4-Dinitrotoluene	chronic	0.00015	NA	NA	TCEQ, 2001
2,6-Dinitrotoluene	chronic	0.00015	NA	NA	TCEQ, 2001
Hexachlorobenzene	chronic	NTV	---	---	---
Volatile Organics					
1,1-Dichloroethene	chronic	NTV	---	---	---
1,2-Dichloroethane	chronic	0.005	NA	NA	USEPA-NCEA, 2001
Methylene chloride	chronic	3	Liver toxicity	100/1	USEPA-HEAST, 1997
Trichloroethene	chronic	NTV	---	---	---

Table 2-3 (*continued*)
Non-Carcinogenic Toxicity Data Summary

Notes

---: No information for a compound with no toxicity value (NTV)
IRIS: Integrated Risk Information System, USEPA
mg/kg-day: milligrams per kilogram per day
mg/m³: milligrams per cubic meter
NA: Information not available
NTV: No toxicity value available
RfC: Reference concentration
RfD: Reference dose
TCDD: tetrachlorodibenzo-p-diozin
TEC: toxicity equivalence concentration

References

Agency for Toxic Substances and Disease Registry (ATSDR), 1997, Minimal Risk Levels (MRLs) for Hazardous Substances.

Jacobs Engineering Group, Inc. (Jacobs), 2002, *Baseline Human Health and Screening Ecological Risk Assessment for the Group 2 Sites (Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake)*, Longhorn Army Ammunition Plant, Karnack, Texas, Final, Oak Ridge, TN, August.

Texas Commission on Environmental Quality (TCEQ), 2001. Update to 1998 Consistency Memorandum. Toxicity Factors Table, 15 March, 2001.

U.S. Environmental Protection Agency (USEPA), 1998. *Perchlorate Environmental Contamination Toxicological Review and Risk Characterization based on Emergency Information*, Review Draft, Office of Research and Development. NCEA-1-0503, 31 December, 1998.

USEPA-HEAST, 1997. Health Effects Summary Table (HEAST). FY 1995, Annual Office of Emergency and Remedial Response. Washington, D.C. EPA/340/R-95-036.

USEPA-IRIS, 2001. Integrated Risk Information System (IRIS). United States Environmental Protection Agency Online Database for Toxicity Information on Hazardous Chemicals, 2001.

USEPA-NCEA, 2001. USEPA Region 3 Risk-Based Concentration Tables (5/8/2001). Referenced values from National Center for Environmental Assessment (NCEA).

Summary of Toxicity Assessment

This table provides non-carcinogenic risk information relevant to the contaminants of concern in both soil and ground water. The list of chemicals of potential concern presented here are the ones that were quantitatively evaluated for carcinogenic risk and non-carcinogenic hazard in the Baseline Human Health Risk Assessment (Jacobs, 2002). The uncertainty factor and modifying factor are used in the development of a references dose. The uncertainty factor adjusts results from dose-response studies in animals to make them applicable to humans. The modifying factor is used to account for uncertainties in the available toxicity data from which the reference dose is derived. In the risk assessment, the reference doses and concentrations were for the chronic case, to be conservative.

Table 2-4
Risk Characterization Summary – Carcinogens

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogen Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Ingestion or exposure through showering	***Dioxin/Furan***				
			2,3,7,8-TCDD TEC	1.9E-06	NE	1.5E-05	1.7E-05
			Explosive				
			2,4,6-Trinitrotoluene	ND	ND	ND	NA
			2-Amino-4,6-dinitrotoluene	ND	ND	ND	NA
			4-Amino-2,6-dinitrotoluene	ND	ND	ND	NA
			Metals				
			Aluminum	NTV	NE	NE (Kp<=0.01)	NA
			Antimony	NTV	NE	NE (Kp<=0.01)	NA
			Barium	ND	ND	ND	NA
			Cadmium	NTV	NE	NE (Kp<=0.01)	NA
			Chromium	NC	NE	NE (Kp<=0.01)	NA
			Lead	NTV	NE	NE (Kp<=0.01)	NA
			Manganese	NC	NE	NE (Kp<=0.01)	NA
			Nickel	NTV	NE	NE (Kp<=0.01)	NA
			Silver	NC	NE	NE (Kp<=0.01)	NA
			Strontium	NTV	NE	NE (Kp<=0.01)	NA
			Thallium	NC	NE	NE (Kp<=0.01)	NA
			Non-Metallic Anion				
			Perchlorate	NTV	NE	NE (Kp<=0.01)	NA
			Semi-Volatile Organics				
			2,4-Dinitrotoluene	9.0E-06	NE	NE (Kp<=0.01)	9.0E-06
			2,6-Dinitrotoluene	9.0E-06	NE	NE (Kp<=0.01)	9.0E-06
			Hexachlorobenzene	ND	ND	ND	NA
			Volatile Organics				
			1,1-Dichloroethene	1.1E-04	1.6E-04	1.4E-04	4.1E-04
			1,2-Dichloroethane	2.0E-05	1.0E-04	9.2E-06	1.3E-04
			Methylene chloride	8.4E-08	9.2E-08	NE (Kp<=0.01)	1.8E-07
			Trichloroethene	2.0E-04	5.5E-04	2.7E-04	1.0E-03
						Groundwater risk total =	1.6E-03

Table 2-4 (*continued*)
Risk Characterization Summary – Carcinogens

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogen Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil (0 to 2 feet)	Soil and particulates	Incidental Ingestion, inhalation of particulates, and dermal contact	***Dioxin/Furan***				
			2,3,7,8-TCDD TEC	1.1E-05	3.7E-10	4.3E-06	1.6E-05
			Explosive				
			2,4,6-Trinitrotoluene	8.8E-05	NTV	9.4E-05	1.8E-04
			2-Amino-4,6-dinitrotoluene	5.6E-08	NTV	7.2E-08	1.3E-07
			4-Amino-2,6-dinitrotoluene	1.7E-08	NTV	2.1E-08	3.8E-08
			Metals				
			Aluminum	ND	ND	ND	NA
			Antimony	NTV	NTV	NTV	NA
			Barium	NC	NC	NC	NA
			Cadmium	NTV	7.0E-10	NTV	7.0E-10
			Chromium	ND	ND	ND	NA
			Lead	NTV	NTV	NTV	NA
			Manganese	ND	ND	ND	NA
			Nickel	ND	ND	ND	NA
			Silver	ND	ND	ND	NA
			Strontium	ND	ND	ND	NA
			Thallium	NC	NC	NC	NA
			Non-Metallic Anion				
			Perchlorate	NTV	NTV	NTV	NA
			Semi-Volatile Organics				
			2,4-Dinitrotoluene	6.2E-04	NTV	4.7E-04	1.1E-03
			2,6-Dinitrotoluene	7.6E-05	NTV	5.7E-05	1.3E-04
			Hexachlorobenzene	1.6E-07	6.8E-12	2.0E-07	3.6E-07
			Volatile Organics				
			1,1-Dichloroethene	ND	ND	ND	NA
			1,2-Dichloroethane	ND	ND	ND	NA
			Methylene chloride	ND	ND	ND	NA
			Trichloroethene	ND	ND	ND	NA
						Soil risk total =	1.4E-03
						Total risk (soil and groundwater) =	3.0E-03

Table 2-4 (*continued*)
Risk Characterization Summary – Carcinogens

Notes

Kp	Dermal permeability coefficient
NA	Not applicable
NC	Not classified as a carcinogen
ND	Not detected in associated media or not selected as a chemical of potential concern
NE	Not evaluated through this exposure pathway. Chemical is not identified as volatile.
NE(Kp<=0.01)	Based on USEPA Region 6 guidance, chemicals of potential concern with a Kp<=0.01 were not evaluated for dermal contact while showering (USEPA, 1995)
NTV	No toxicity value available
TCDD	Tetrachlorodibenzo-p-dioxin
TEC	Toxicity equivalence concentration

References

U.S. Environmental Protection Agency (USEPA), 1989, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)*, EPA/540/1-89/002, December.

USEPA, *Supplemental Region VI Risk Assessment Guidance, May 5, 1995*.

Summary of Risk Characterization

The table provides risk estimates for the significant routes of exposure at LHAAP-17. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of a hypothetical future maintenance worker's exposure to soil and groundwater, as well as the toxicity of the chemicals of concern. The total risk from exposure to contaminated soil and groundwater at this site is estimated to be 3.0×10^{-3}. A risk below 1×10^{-4} is generally considered to be acceptable (USEPA, 1989). The soil risk and the groundwater risk are unacceptable.

Table 2-5
Risk Characterization Summary – Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Target Endpoint	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Ingestion or exposure through showering	***Dioxin/Furan***					
			2,3,7,8-TCDD TEC	NA	NTV	NE	NTV	NA
			Explosive					
			2,4,6-Trinitrotoluene	Liver effects	ND	ND	ND	NA
			2-Amino-4,6-dinitrotoluene	NA	ND	ND	ND	NA
			4-Amino-2,6-dinitrotoluene	NA	ND	ND	ND	NA
			Metals					
			Aluminum	NA	7.9E-02	NE	NE (Kp<=0.01)	7.9E-02
			Antimony	Longevity, blood glucose, and cholesterol	3.2E-01	NE	NE (Kp<=0.01)	3.2E-01
			Barium	Increased kidney weight	ND	ND	ND	NA
			Cadmium	Proteinuria	1.8E-02	NE	NE (Kp<=0.01)	1.8E-02
			Chromium	No effects observed	1.2E-03	NE	NE (Kp<=0.01)	1.2E-03
			Lead	NA	NTV	NE	NE (Kp<=0.01)	NA
			Manganese	Central nervous system effects	7.3E-01	NE	NE (Kp<=0.01)	7.3E-01
			Nickel	Decreased Body Weight	1.0E-01	NE	NE (Kp<=0.01)	1.0E-01
			Silver	Argyria	2.0E-02	NE	NE (Kp<=0.01)	2.0E-02
			Strontium	Rachitic bone	5.2E-02	NE	NE (Kp<=0.01)	5.2E-02
			Thallium	Blood	5.3E-01	NE	NE (Kp<=0.01)	5.3E-01
			Non-Metallic Anion					
			Perchlorate	NA	3.5E+03	NE	NE (Kp<=0.01)	3.5E+03
			Semi-Volatile Organics					
			2,4-Dinitrotoluene	Central nervous system effects	1.9E-02	NE	NE (Kp<=0.01)	1.9E-02
			2,6-Dinitrotoluene	Central nervous system effects	3.7E-02	NE	NE (Kp<=0.01)	3.7E-02
			Hexachlorobenzene	Liver effects	ND	ND	ND	NA
			Volatile Organics					
			1,1-Dichloroethene	Hepatic lesions	5.5E-02	NTV	7.4E-02	1.3E-01
			1,2-Dichloroethane	NA	2.1E-02	2.2E+00	9.5E-03	2.2E+00
			Methylene chloride	Liver toxicity	5.2E-04	1.8E-04	NE (Kp<=0.01)	7.0E-04
			Trichloroethene	NA	8.7E+00	NTV	1.2E+01	2.0E+01
							Groundwater Hazard Index Total =	3.5E+03

Table 2-5 (*continued*)
Risk Characterization Summary – Non-Carcinogens

Scenario Timeframe: Future
Receptor Population: Maintenance Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Target Endpoint	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil (0 to 2 feet)	Soil and particulates	Incidental ingestion, inhalation of particulates, dermal contact	***Dioxin/Furan***					
			2,3,7,8-TCDD TEC	NA	NTV	NTV	NTV	NA
			Explosive					
			2,4,6-Trinitrotoluene	Liver effects	1.6E+01	1.2E-02	1.8E+01	3.4E+01
			2-Amino-4,6-dinitrotoluene	NA	9.4E-02	2.4E-05	1.2E-01	2.1E-01
			4-Amino-2,6-dinitrotoluene	NA	2.8E-02	7.1E-06	3.6E-02	6.4E-02
			Metals					
			Aluminum	NA	ND	ND	ND	NA
			Antimony	Longevity, blood glucose, and cholesterol	6.1E-03	7.4E-07	2.6E-03	8.8E-03
			Barium	Increased kidney weight	1.6E-02	3.5E-04	1.5E-02	3.1E-02
			Cadmium	Proteinuria	7.2E-03	5.4E-06	1.8E-03	9.0E-03
			Chromium	Proteinuria	ND	ND	ND	NA
			Lead	Gastrointestinal	NTV	NTV	NTV	NA
			Manganese	NA	ND	ND	ND	NA
			Nickel	Decreased Body Weight	ND	ND	ND	NA
			Silver	Argyria	ND	ND	ND	NA
			Strontium	Rachitic bone	ND	ND	ND	NA
			Thallium	Blood	5.9E-02	7.1E-06	3.8E-03	6.2E-02
			Non-Metallic Anion					
			Perchlorate	NA	6.7E-04	NTV	4.3E-05	7.1E-04
			Semi-Volatile Organics					
			2,4-Dinitrotoluene	Central nervous system effects	1.3E+00	2.6E-03	9.6E-01	2.2E+00
			2,6-Dinitrotoluene	Central nervous system effects	3.1E-01	3.1E-04	2.3E-01	5.5E-01
			Hexachlorobenzene	Liver effects	3.4E-04	NTV	4.4E-04	7.8E-04
			Volatile Organics					
			1,1-Dichloroethene	Hepatic lesions	ND	ND	ND	NA
			1,2-Dichloroethane	NA	ND	ND	ND	NA
			Methylene chloride	Decreased hematocrit and hemoglobin in the blood	ND	ND	ND	NA
			Trichloroethene	Liver and kidney effects	ND	ND	ND	NA
							Soil Hazard Index Total =	3.7E+01
							Hazard Index Total (soil and groundwater) =	3.5E+03

Table 2-5 (*continued*)
Risk Characterization Summary – Non-Carcinogens

Notes

Kp	Dermal permeability coefficient
NA	Not applicable
ND	Not detected in associated media or not selected as a chemical of potential concern
NE	Not evaluated through this exposure pathway. Chemical is not identified as a volatile.
NE (Kp<=0.01)	Based on USEPA Region 6 guidance, chemicals of potential concern with a Kp<=0.01 were not evaluated for dermal contact while showering (USEPA, 1995)
NTV	No toxicity value
TCDD	Tetrachlorodibenzo-p-dioxin
TEC	Toxicity equivalence concentration

References

U.S. Environmental Protection Agency (USEPA), 1989, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)*, EPA/540/1-89/002, December.

USEPA, *Supplemental Region 6 Risk Assessment Guidance*, May 5, 1995.

Summary of Risk Characterization

The table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure for LHAAP-17. The Risk Assessment Guidance for Superfund (USEPA, 1989) states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse non-carcinogenic effects. The estimated HI for groundwater is 3,500 and for soil is 37. Both values are unacceptable and indicate that the potential for adverse non-carcinogenic effects could occur from exposure to contaminants in those mediums.

Table 2-6
Chemicals with Carcinogenic Risk Greater than 1×10^{-6} in Soil

Chemical	Baseline Risk Assessment			Retained as COC ?
	Carcinogenic Risk in Soil [a]	EPC (mg/kg)	Soil Sample Location (Depth)	
2,4-Dinitrotuluene	1.1×10^{-3}	2602[b]	*	Yes, 1
2,4,6-Trinitrotoluene	1.8×10^{-4}	8400	17SS22 [c] (0-2 feet)	Yes, 1
2,6-Dinitrotoluene	1.3×10^{-4}	318 [b]	*	Yes, 1
2,3,7,8-TCDD TEC	1.6×10^{-5}	2.14×10^{-4}[d]	17SD12[e] (0.00 feet)	No, 2

Notes and Abbreviations:

1. *Identified as chemical of concern (COC) since carcinogenic risk is above the acceptable range*
2 *Excluded since risk is within the acceptable range and the chemical is not a COC for groundwater*

[a] *Carcinogenic risk from Baseline Risk Assessment Table C-29 (Jacobs, 2002)*
[b] *95 percent upper confidence limit (UCL) used as EPC.*
[c] *From Baseline Risk Assessment Table 3-64.*
[d] *Toxic equivalents used in developing the EPC.*
[e] *From Baseline Risk Assessment Table 3-19.*
* *No specific location, EPC calculated as 95 percent UCL as noted in the Baseline Risk Assessment Report Table 3-64*

COC chemical of concern
EPC Exposure Point Concentration from Baseline Risk Assessment (Jacobs, 2002)
mg/kg milligrams per kilogram
TCDD tetrachlorodibenzo-p-dioxin
TEC toxicity equivalence concentration

Table 2-7
Chemicals with Hazard Quotient Greater than 0.1 in Soil

Chemical	Baseline Risk Assessment			Retained as COC ?
	Soil Hazard Quotient [a]	EPC (mg/kg)	Soil Sample Location (Depth)	
2,4,6-Trinitrotoluene	34	8400	17SS22 [b] (0-0.5 ft)	Yes, 1
2,4-Dinitrotoluene	2.2	2602[c]	*	Yes, 1
2,6-Dinitrotoluene	0.55	318 [c]	*	No, 2
2-Amino-4,6-dinitrotoluene	0.21	16	17SB03 (0-2 feet)	No, 2

Notes and Abbreviations:

1. *Identified as COC since Hazard Quotient is greater than 1.0.*
2. *Not identified as COC since HQ is less than 1.0*

[a] *HQ from Baseline Risk Assessment Table C-26 (Jacobs, 2002)*
[b] *From Baseline Risk Assessment Table 3-64*
[c] *95 percent upper confidence limit (UCL) used as the EPC*
* *No specific location, EPC calculated as 95 percent UCL as noted in the Baseline Risk Assessment Report Table 3-64 (Jacobs, 2002)*

COC chemical of concern
EPC Exposure Point Concentration from Baseline Risk Assessment (Jacobs, 2002)
HQ hazard quotient
mg/kg milligrams per kilogram.

Table 2-8
Chemicals with Carcinogenic Risk Greater than 1×10^{-6} in Groundwater

Chemical	Baseline Risk Assessment			Data Since Risk Assessment		
	Carcinogenic Risk in Ground-water [a]	EPC (µg/L)	Well	Maximum [b] (µg/L)	Well	Adjusted Risk
Trichloroethene	1×10^{-3}	5,320	17WW01	6090	17WW01	1.1×10^{-3}
1,1-Dichloroethene	4.1×10^{-4}	51	17WW01	70	17WW01	5.6×10^{-4}
1,2-Dichloroethane	1.3×10^{-4}	63	17WW01	35.8 J	17WW01	7.4×10^{-5}
2,3,7,8-TCDD TEC	1.7×10^{-5}	3.5×10^{-6} [c]	17WW13	–	–	–
2,4-Dinitrotuluene	9×10^{-6}	3.8	17WW02	ND	17WW02	–
2,6-Dinitrotoluene	9×10^{-6}	3.8	17WW02	ND	17WW02	–

Chemical	Comparison Levels		Retained as COC?
	MCL (µg/L)	TRRP Tier 1 Groundwater Residential PCLs (µg/L)	
Trichloroethene	5	5	Yes, 1
1,1-Dichloroethene	7	7	Yes, 1
1,2-Dichloroethane	5	5	Yes, 1
2,3,7,8-TCDD TEC	3×10^{-5}	3×10^{-5}	No, 2
2,4-Dinitrotuluene	–	1.3	No, 3
2,6-Dinitrotoluene	–	1.3	No, 3

Notes and Abbreviations:

No adjusted risk was calculated for 2,3,7,8-TCDD TEC, 2,4-dinitrotoluene, and 2,6-dinitrotoluene because no data was collected since the risk assessment for 2,3,7,8-TCDD TEC, and concentrations since the risk assessment have been ND for 2,4-dinitrotoluene and 2,6-dinitrotoluene.
No MCL available for 2,4-dinitrotoluene and 2,6-dinitrotoluene.

1. *Identified as COC because most recent maximum concentration is above the MCL*
2. *Excluded because the EPC and more recent results are below the MCL*
3. *Excluded because more recent results are below the TRRP Tier 1 Groundwater Residential PCL*

[a] *From Baseline Risk Assessment Table C-29 (Jacobs, 2002)*
[b] *Maximum data from the latest sampling event*
[c] *Toxic equivalents were used in developing the EPC*

–	*not applicable*
µg/L	*micrograms per liter*
COC	*chemical of concern*
EPC	*exposure point concentration*
J	*estimated concentration*
MCL	*Safe Drinking Water Act maximum contaminant level*
ND	*nondetect*
PCL	*Protective Concentration Limit*
TCDD	*tetrachlorodibenzo-p-dioxin*
TEC	*toxicity equivalence concentration*
TRRP	*Texas Risk Reduction Program*

Table 2-9
Chemicals with Hazard Quotient Greater than 0.1 in Groundwater

Chemical	Baseline Risk Assessment			Data Since Risk Assessment		
	Hazard Quotient Groundwater [a]	EPC (µg/L)	Well	Maximum [b] (µg/L)	Well	Adjusted Hazard Quotient
Perchlorate	3500	320,000	17WW06	74,000 160,000	17WW06 17WW02	809 1750
Trichloroethene	20	5,320	17WW01	5,970	17WW01	22.9
1,2-Dichloroethane	2.2	63	17WW01	44.9	17WW01	1.3
Manganese	0.73	3490	17WW01	–	–	–
Thallium	0.59	4.3	17WW13	ND (0.05)	17WW13	–
Antimony	0.32	13	17WW02	ND (0.25)	17WW02	–
1,1-Dichloroethene	0.13	51	17WW01	70	17WW01	0.2

Chemical	Comparison Levels		Retained as COC?
	MCL (µg/L)	TRRP Tier 1 Groundwater Residential PCLs (µg/L)	
Perchlorate	—	17	Yes, 1
Trichloroethene	5	5	Yes, 2
1,2-Dichloroethane	5	5	Yes, 2
Manganese	—	1,100	No, 3
Thallium	2	2	No, 4
Antimony	6	6	No, 4
1,1-Dichloroethene	7	7	Yes, 2

Notes and Abbreviations:

1. *Identified as a COC because HQ >1*
2. *Identified as COC because EPC is above the MCL.*
3. *Excluded because EPC is below the* 95% UTL value for Manganese of 7,820 µg/L from Final Evaluation of Perimeter Well Data for Use as Groundwater Background (Shaw, 2007) *and HQ is <1.0*
4. *Excluded because more recent data results are below the MCL*

[a] *From Baseline Risk Assessment Table C-29 (Jacobs, 2002)*
[b] *Maximum data from the latest sampling event*

—	*not applicable*
COC	*chemical of concern*
EPC	*exposure point concentration*
HQ	*hazard quotient*
MCL	*Safe Drinking Water Act maximum contaminant level*
PCL	*Protective Concentration Limit*
TRRP	*Texas Risk Reduction Program*
µg/L	*micrograms per liter*

Table 2-10
Cleanup Levels for Human Health Risk

Medium	Chemical of Concern	Cleanup Level
Shallow zone groundwater		**MCL (µg/L)**
	1,1-Dichloroethene	7
	1,2-Dichloroethane	5
	cis-1,2-Dichloroethene	70
	Trichloroethene	5
	Vinyl chloride	2
		Texas Residential Groundwater PCL (µg/L)
	Perchlorate	17
		MCL (µg/L)
Intermediate zone groundwater	cis-1,2-Dichloroethene	70
	Trichloroethene	5
	Vinyl chloride	2
Soil		**GWP-Ind (mg/kg)**
	2,4,6-Trinitrotoluene	5.1
	2,4-Dinitrotoluene	0.042
	2,6-Dinitrotoluene	0.042
	Perchlorate	7.2

Notes and Abbreviations:

GWP-Ind *Texas Commission on Environmental Quality soil medium specific concentration for industrial use based on groundwater protection*
MCL *Safe Drinking Water Act maximum contaminant level*
mg/kg *milligrams per kilogram*
PCL *Protective Concentration Level*
TRRP *Texas Risk Reduction Program*
µg/L micrograms per liter

Table 2-11
Cleanup Levels for Ecological Risk in Soil (EcoPRGs)

Chemical	SS EcoPRG [a] (mg/kg)	TS EcoPRG [a] (mg/kg)	Depth [b]	Sample Location
Barium	222	—	0 - 0.5'	17SS22, 17SD04, 17SD07, 17SD08, 17SD11
	—	520	0 - 3'	17SD07
2,4-Dinitrotoluene	—	12	0 - 3'	17SB02
2,6-Dinitrotoluene	2.7	6.8	0 - 3'	17SB02
2,4,6-Trinitrotoluene	—	4.7	0 - 3'	17SS22, 17SS23, 17SB06
2,3,7,8-TCDD TEC	4×10^{-6}	4×10^{-6}	0 - 3'	17SD12

Notes and Abbreviations:

[a] *From Baseline Ecological Risk Assessment Table 16-1 (Shaw, 2007b)*
[b] *Depth and locations of remedial action for Waste Sub-Area*

EcoPRG ecological preliminary remediation goal
mg/kg milligrams per kilogram
SS surface soil from 0-0.5 feet (applicable to deer mouse)
TCDD tetrachlorodibenzo-p-dioxin
TEC toxicity equivalence concentration
TS total soil from 0-3 feet (applicable to short-tailed shrew)

Table 2-12
Comparative Analysis of Alternatives

Comparative Analysis of Alternatives Criteria	Alternative 1 No Action	Alternative 2 Excavation and Off-site Disposal of Soil; MNA and LUC for Groundwater	Alternative 3 Excavation and Off-site Disposal of Soil; In Situ Bioremediation; MNA and LUC for Groundwater	Alternative 4 Excavation and Off-site Disposal of Soil; Groundwater Extraction; MNA and LUC for Groundwater
Overall protection of human health and the environment	No protection. Does not achieve RAOs.	Achieves RAOs. Protection of human health and environment provided by excavation and maintenance of LUC. Excavation would remove soil above cleanup levels. Monitored natural attenuation activities would demonstrate that degradation of plume is occurring in groundwater.	Achieves RAOs. Protection of human health and environment provided by excavation of soil, bioremediation of shallow zone groundwater, and MNA of intermediate zone groundwater. Groundwater monitoring will continue until remainder of plumes degrade to cleanup levels and LUC will remain in place until the levels of COCs allow for unlimited use and unrestricted exposure.	Achieves RAOs. Protection of human health and environment provided by excavation of soil, extraction of shallow zone groundwater, and MNA of intermediate zone groundwater. Groundwater monitoring will continue until remainder of plumes degrade to cleanup levels and LUC will remain in place until the levels of COCs allow for unlimited use and unrestricted exposure.
Compliance with ARARs	No compliance with chemical-specific ARARs.	Complies with ARARs.	Complies with ARARs.	Complies with ARARs.
Long-term effectiveness and permanence	Not effective for soil. Natural attenuation would occur, but its progress would be unverified by monitoring. No evaluation of natural attenuation's long-term effectiveness and permanence.	Excavation would have a permanent effect of removing contaminants from the soil. MNA would verify permanent reduction of contaminant levels in the groundwater over time. LUC would be effective and reliable so long as it is maintained until the levels of COCs allow for unlimited use and unrestricted exposure.	Excavation would have a permanent effect of removing contaminants from the soil. Bioremediation would permanently convert contaminants to harmless compounds (chlorinated solvents also generate temporary daughter products). A treatability study may be required. Long-term monitoring would verify permanent reduction of contaminant levels in the groundwater over time. LUC would be effective and reliable so long as it is maintained until the levels of COCs allow for unlimited use and unrestricted exposure.	Excavation would have a permanent effect of removing contaminants from the soil. Groundwater extraction would permanently remove contaminants from groundwater which is treated at the groundwater treatment plant. Long-term monitoring would verify permanent reduction of contaminant levels in the groundwater over time. LUC would be effective and reliable so long as it is maintained until the levels of COCs allow for unlimited use and unrestricted exposure.

Table 2-12 *(continued)*
Comparative Analysis of Alternatives

Comparative Analysis of Alternatives Criteria	Alternative 1 No Action	Alternative 2 Excavation and Off-site Disposal of Soil; MNA and LUC for Groundwater	Alternative 3 Excavation and Off-site Disposal of Soil; In Situ Bioremediation; MNA and LUC for Groundwater	Alternative 4 Excavation and Off-site Disposal of Soil; Groundwater Extraction; MNA and LUC for Groundwater
Reduction of toxicity, mobility, or volume through treatment	No active reduction.	Soil contaminants removed and disposed of without treatment. No active reduction in groundwater.	Soil contaminants removed and disposed of without treatment. Shallow zone groundwater contaminants would be treated through in situ bioremediation in the areas of highest contamination. No active reduction in intermediate zone groundwater.	Soil contaminants removed and disposed of without treatment. Shallow zone groundwater contaminants would be extracted and treated at the groundwater treatment plant. No active reduction in intermediate zone groundwater.
Short-term effectiveness	No short-term impacts.	Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection.	Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection.	Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection.
Implementability	Inherently implementable.	Readily implemented.	Implementable, but uncertainty exists in the effectiveness and time required to reduce contaminants to cleanup levels. Specialized knowledge required for implementation.	Implementable, but uncertainty exists in the effectiveness and time required to reduce contaminants to cleanup levels. Specialized knowledge required for implementation.
Cost • Capital present worth • O&M present worth • Total present worth	 $0 $0 $0	 $1,600,000 $600,000 $2,200,000	 $2,200,000 $700,000 $2,900,000	 $1,800,000 $600,000 $2,400,000
State acceptance	Not acceptable	Not acceptable	Acceptable	Acceptable
Community acceptance	Responded to comments			

Notes and Abbreviations:

ARAR	applicable or relevant and appropriate requirement
COC	chemical of concern
LUC	land use control
MNA	monitored natural attenuation
O&M	operation and maintenance
RAO	remedial action objective

Table 2-13
Remediation Cost Table
Selected Remedy (Alternative 4)
Present Worth Analysis

				Operation & Maintenance Costs			Present Value (NPV)		
Year	FY	Capital Costs		Long-Term Monitoring	Groundwater Extraction	Total	Discount Rate	Capital	O&M
							2.8%		
1	2016	$1,766,292		$27,225	$225,123	$252,349	**NPV**	**$1,766,292**	**$607,421**
2	2017			87,882	112,562	200,444			
3	2018	0		46,823		46,823		**Total NPV**	**$2,373,713**
4	2019	0		39,535		39,535			
5	2020			79,988		79,988			
6	2021	0		27,458		27,458			
7	2022	0		15,462		15,462			
8	2023	0		15,462		15,462			
9	2024	0		15,462		15,462			
10	2025			63,216		63,216			
11	2026					0			
12	2027					0			
13	2028					0			
14	2029					0			
15	2030			66,496		66,496			
16	2031					0			
17	2032					0			
18	2033					0			
19	2034					0			
20	2035			66,496		66,496			
21	2036					0			
22	2037					0			
23	2038					0			
24	2039					0			
25	2040			66,496		66,496			
26	2041					0			
27	2042					0			
28	2043					0			
29	2044					0			
30	2045			66,496		66,496			
		$1,766,292		$684,498	$337,685	$1,022,183			

Table 2-13 *(continued)*
Remediation Cost Table
Selected Remedy (Alternative 4)

Notes:

MNA	monitored natural attenuation
NPV	net present value
O&M	operation & maintenance
VOC	volatile organic compounds

Major assumptions are as described below. Quantities and assumptions are for cost estimating purposes only.

Capital costs include: excavation evaluation, excavation and disposal activities, flow tests, engineering support, and construction management. The soil is assumed to be classified as nonhazardous for disposal purposes.

O&M costs for groundwater extraction are based on having 3 extraction wells.

Monitoring costs are based on the assumption that sampling is conducted at 5 shallow zone wells and 3 intermediate zone wells, with one quality control sample in each zone. In the shallow zone, monitoring begins 6 months into Year 2 when groundwater extraction ends and MNA begins. The sampling frequency is quarterly for 2 years, then semiannual for 3 years, then annual for Years 7 through 10, and finally every five years (Years 15, 20, 25, and 30). Analysis of the shallow zone groundwater is for VOCs and perchlorate. In the intermediate zone, monitoring begins at the start of Year 1 when MNA begins. The sampling frequency is quarterly for 2 years (Years 1 and 2), then semiannual for 3 years (Years 3 through 5), then annual for Years 6 through 10, and finally every five years (Years 15, 20, 25, and 30). Analysis of the intermediate zone groundwater is for VOCs.

The discount rate of 2.8% is based on the Office of Management and Budget Circular No. A-94, January 2008.

Costs have been escalated to bring FY08 dollars to FY13 dollars using escalation rate of 1.0776 and escalated to bring FY13 dollars to FY16 dollars using escalation rate of 1.0421

Table 2-14
Description of ARARs for Selected Remedy

Citation	Activity or Prerequisite/Status	Requirement
Soil		
TCEQ Texas Risk Reduction Rules 30 TAC 335.558 and 335.559(g)(2)	Ensures adequate protection of human health and the environment from potential exposure to contaminants associated with releases – **relevant and appropriate** for remediation of contaminated soil for cross-media contamination pathways such as soil to groundwater and for hypothetical future maintenance workers.	Near surface (i.e., 0-2 feet bgs) non-residential (industrial) soils shall conform to the non-residential soil MSCs (SAI-Ind) based upon worker ingestion of soil, inhalation of particulates and volatiles and the non-residential soil-to-groundwater cross media protection concentration. The concentration of contamination in soil shall not exceed the non-residential soil-to-groundwater protection MSC (GWP-Ind). See **Table 2-10** for specific numeric criteria.
Groundwater		
Federal Safe Drinking Water Act MCLs/Non-Zero MCLGs 40 CFR 141	Applicable to drinking water for a public water system—**relevant and appropriate** for water that could potentially be used for human consumption.	Must not exceed MCLs/non-zero MCLGs for water designated as a current or potential source of drinking water. See **Table 2-10** for specific numeric criteria.
Floodplain		
Requirements for Hazardous Waste Facilities in Floodplains Resource Conservation and Recovery Act (RCRA) 40 CFR 264.18(b)	If excavated soil is found to constitute RCRA hazardous waste, these requirements are **relevant and appropriate** since LHAAP-17 is located within a 100-year floodplain. However, it is not anticipated that the excavated soil will be classified as hazardous.	A hazardous waste treatment, storage, or disposal facility used for remediation waste and located in the 100-year floodplain must be designed, constructed operated, and maintained to prevent washout of such waste by a 100-year flood unless owner/operator show that procedures are in effect to remove waste safely before flood water can reach the facility.

Table 2-14 *(continued)*
Description of ARARs for Selected Remedy

Citation	Activity or Prerequisite/Status	Requirement
General Site Preparation, Construction, and Excavation Activities		
Opacity Standard 30 TAC 111.111(a)(8)(A)	Fugitive emissions from land-disturbing activities (e.g., excavation, construction)—**applicable**.	Visible emissions shall not be permitted to exceed opacity of 30% for any 6-minute period from any source.
Fugitive Particulate Matter Standard 30 TAC 111.145	Fugitive emissions from land-disturbing activities (e.g., excavation, construction)—**applicable**.	No person may cause, suffer, allow, or permit a structure, road, street, alley or parking area to be constructed, altered, repaired, or demolished, or land to be cleared without taking at least the following precautions to achieve control of dust emissions: • Use of water or of suitable oil or chemicals for control of dust in the demolition of structures, in construction operations, in work performed on a road, street, alley, or parking area, or in the clearing of land; and • Use of adequate methods to prevent airborne particulate matter during sandblasting of structures or similar operations
Storm water Runoff Controls 40 CFR 122.26; 30 TAC 205, Subchapter A; 30 TAC 308.121	Storm water discharges associated with construction activities—**applicable** to disturbances of equal to or greater than 1 acre of land.	Specific to areas of excavation of contaminated soil. Good construction management techniques, phasing of construction projects, minimal clearing, and sediment, erosion, structural, and vegetative controls shall be implemented to mitigate storm water run-on/runoff.
Waste Generation, Management, and Storage		
Characterization of Solid Waste 40 CFR 262.11 30 TAC 335.62 30 TAC 335.504 30 TAC 335.503(a)(4)	Generation of solid waste, as defined in 30 TAC 335.1—**applicable**.	Must determine whether the generated solid waste is RCRA hazardous waste by using prescribed testing methods or applying generator knowledge based on information regarding material or process used. If the waste is determined to be hazardous, it must be managed in accordance with 40 CFR 262–268. After making the hazardous waste determination as required, if the waste is determined to be nonhazardous, the generator shall then classify the waste as Class 1, Class 2, or Class 3 (as defined in Section 335.505 through Section 335.507) using one or more of the methods listed in Section 335.503(a)(4) and Section 335.508 and manage the waste in accordance with the requirements of Chapter 335 of the TAC for industrial solid waste.
Characterization of Hazardous Waste 40 CFR 264.13(a)(1); 40 CFR 268.7 30 TAC 335.504(3) 30 TAC 335.509 30 TAC 335.511	Generation of a RCRA hazardous waste for treatment, storage, or disposal—**applicable** if hazardous waste is generated (e.g., PPE).	Must obtain a detailed chemical and physical analysis of a representative sample of the waste(s) that at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with 40 CFR 264 and 268. Must also determine whether the waste is restricted from land disposal under 40 CFR 268 et seq. by testing in accordance with prescribed methods or use of generator knowledge of waste.

Table 2-14 *(continued)*
Description of ARARs for Selected Remedy

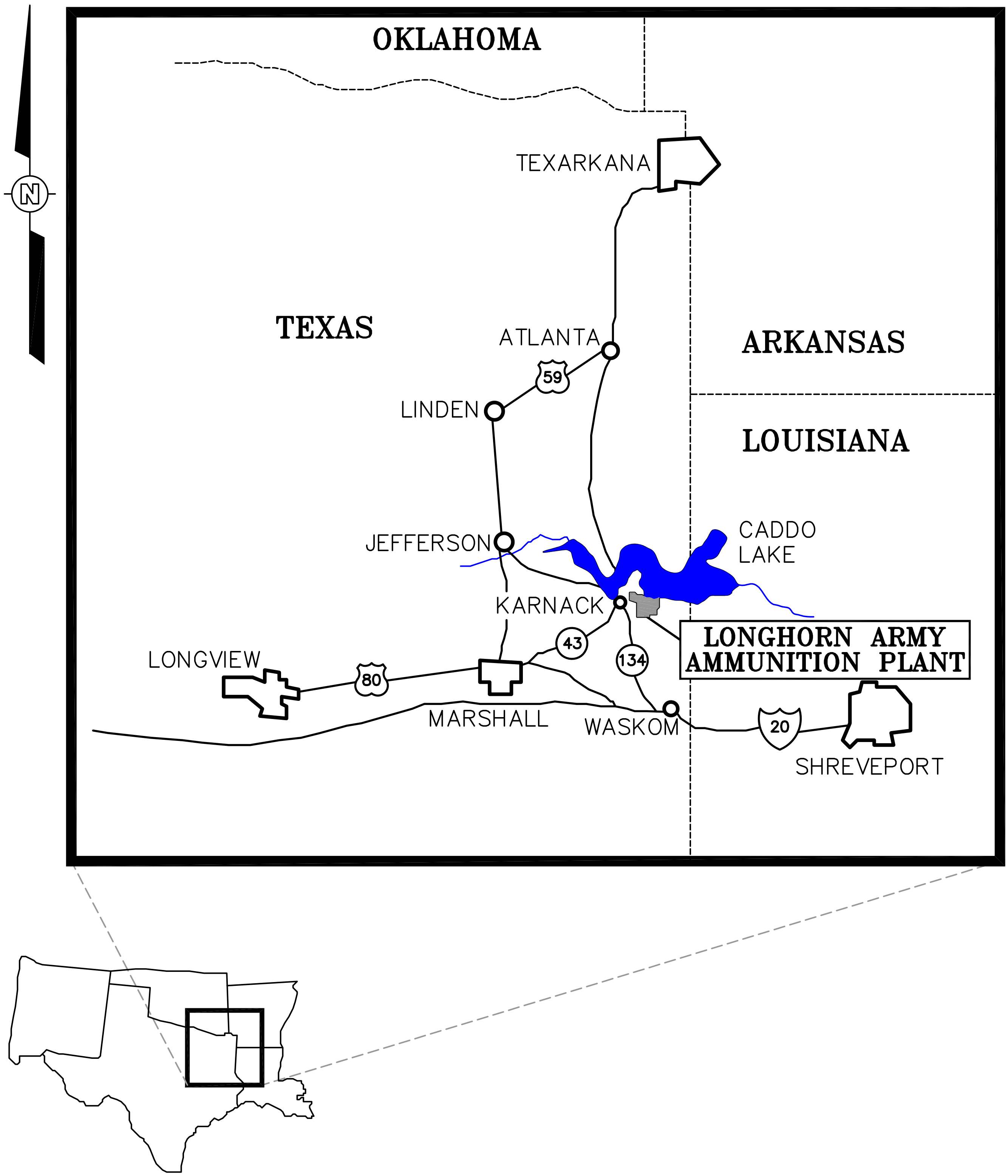
Citation	Activity or Prerequisite/Status	Requirement
Requirements for Temporary Storage of Hazardous Waste in Accumulation Areas 40 CFR 262.34(a) and (c)(1) 30 TAC 335.69(a) and (d)	On-site accumulation of 55 gallons or less of RCRA hazardous waste for 90 days or less at or near the point of generation**—applicable** if hazardous waste is generated (e.g., PPE) and stored in an accumulation area.	Applicable to IDW and other waste. A generator may accumulate hazardous waste at the facility provided that • Waste is placed in containers that comply with 40 CFR 264.171 to 264.173 (Subpart I); and • Container is marked with the words “hazardous waste”; or • Container may be marked with other words that identify the contents.
Requirements for the Use and Management of Containers 40 CFR 264.171–264.173 30 TAC 335.69(e) 30 TAC 335.152(a)(7)	On-site storage/treatment of RCRA hazardous waste in containers for greater than 90 days**—applicable** if hazardous waste is generated (e.g., PPE) and is stored in containers.	Design and operating standards of 40 CFR 264.175(c) and 40 CFR 264.171, 264.172, and 264.173(a) and (b) must be met for the use and management of hazardous waste in containers.
	Wells	
Well Construction Standards—Monitoring or Injection Wells 16 TAC 76.1000	Construction of water wells—**applicable** to construction of new monitoring or injection wells, if needed.	Adhere to substantive requirements. Wells shall be completed in accordance with the technical requirements of Section 76.1000, as appropriate.
Class V Injection Wells 30 TAC 331 Subchapters A, C, and H	Installation, operation, and closure of injection wells for in situ chemical oxidation fall in the category of Class V Injection Wells— **relevant and appropriate**.	Injection wells shall be constructed to the required specifications for isolation casing, surface completion, prevention of commingling, and confinement of undesirable groundwater to its zone of origin. Closure shall be accomplished by removing all of the removable casing and the entire well shall be pressure filled via a tremie pipe with cement from bottom to the land surface, or closure shall be performed by the alternative method for Class V Wells completed in zones of undesirable groundwater. Groundwater concentrations at time of well closure will determine the appropriate method of abandonment.

Table 2-14 *(continued)*
Description of ARARs for Selected Remedy

Citation	Activity or Prerequisite/Status	Requirement
Well Construction Standards—Extraction Wells 16 TAC 76.1000(a) and (c) through (h) 16 TAC 76.1002(a) through (c) 16 TAC 76.1008(a) through (c)	Construction of water wells—**applicable** to construction of extraction (recovery) wells.	Wells shall be completed in accordance with the technical requirements of Section 76.1000, as appropriate. Water wells completed to produce undesirable water shall be cased to prevent the mixing of water or constituent zones. The annular space between the casing and the wall of the borehole shall be pressure grouted with cement or bentonite grout to the land surface. Bentonite grout may not be used if a water zone contains chloride water above 1500 parts per million (ppm) or if hydrocarbons are present. Wells producing undesirable water or constituents shall be completed in such a manner that will not allow undesirable fluids to flow onto the land surface. During installation of a water well pump, installer shall make a reasonable effort to maintain integrity of groundwater and to prevent contamination by elevating the pump column and fittings, or by other means suitable under the circumstances. Pump shall be constructed so that no unprotected openings into the interior of the pump or well casing exist.
Treatment/Disposal		
Disposal of Wastewater (e.g., contaminated groundwater, dewatering fluids, decontamination liquids) 40 CFR 268.1(c)(4)(i) 30 TAC 335.431(c)	RCRA-restricted characteristically hazardous waste intended for disposal—**applicable** if extracted groundwater is determined to be RCRA characteristically hazardous.	Appropriate and relevant in the event of a spill. Disposal is not prohibited if such wastes are managed in a treatment system subject to regulation under Section 402 of the CWA that subsequently discharges to waters of the United States.
Closure		
Standards for Plugging Wells that Penetrate Undesirable Water or Constituent Zones 16 TAC 76.1004(a) through (c)	Plugging and abandonment of wells—**applicable** to plugging and closure of monitoring and/or extraction wells.	If a well is abandoned, all removable casing shall be removed and the entire well pressure filled via a tremie pipe with cement from bottom up to the land surface. In lieu of this procedure, the well shall be pressure-filled via a tremie tube with bentonite grout of a minimum 9.1 lb/gal weight followed by a cement plug extending from land surface to a depth of not less than 2 feet. Undesirable water or constituents or the freshwater zone(s) shall be isolated with cement plugs.

Abbreviations:

ARAR	*applicable or relevant and appropriate requirement*	*MCLG*	*maximum contaminant level goal*
bgs	*below ground surface*	*MSC*	*medium-specific concentration*
CFR	*Code of Federal Regulations*	*%*	*percent*
CWA	*Clean Water Act of 1972*	*PPE*	*personal protective equipment*
FR	*Federal Register*	*ppm*	*part per million*
lb/gal	*pound per gallon*	*RCRA*	*Resource Conservation and Recovery Act of 1976*
LHAAP	*Longhorn Army Ammunition Plant*	*TAC*	*Texas Administrative Code*
MCL	*maximum contaminant level*	*TCEQ*	*Texas Commission on Environmental Quality*



"DRAWING NOT TO SCALE"

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TULSA DISTRICT
TULSA, OKLAHOMA

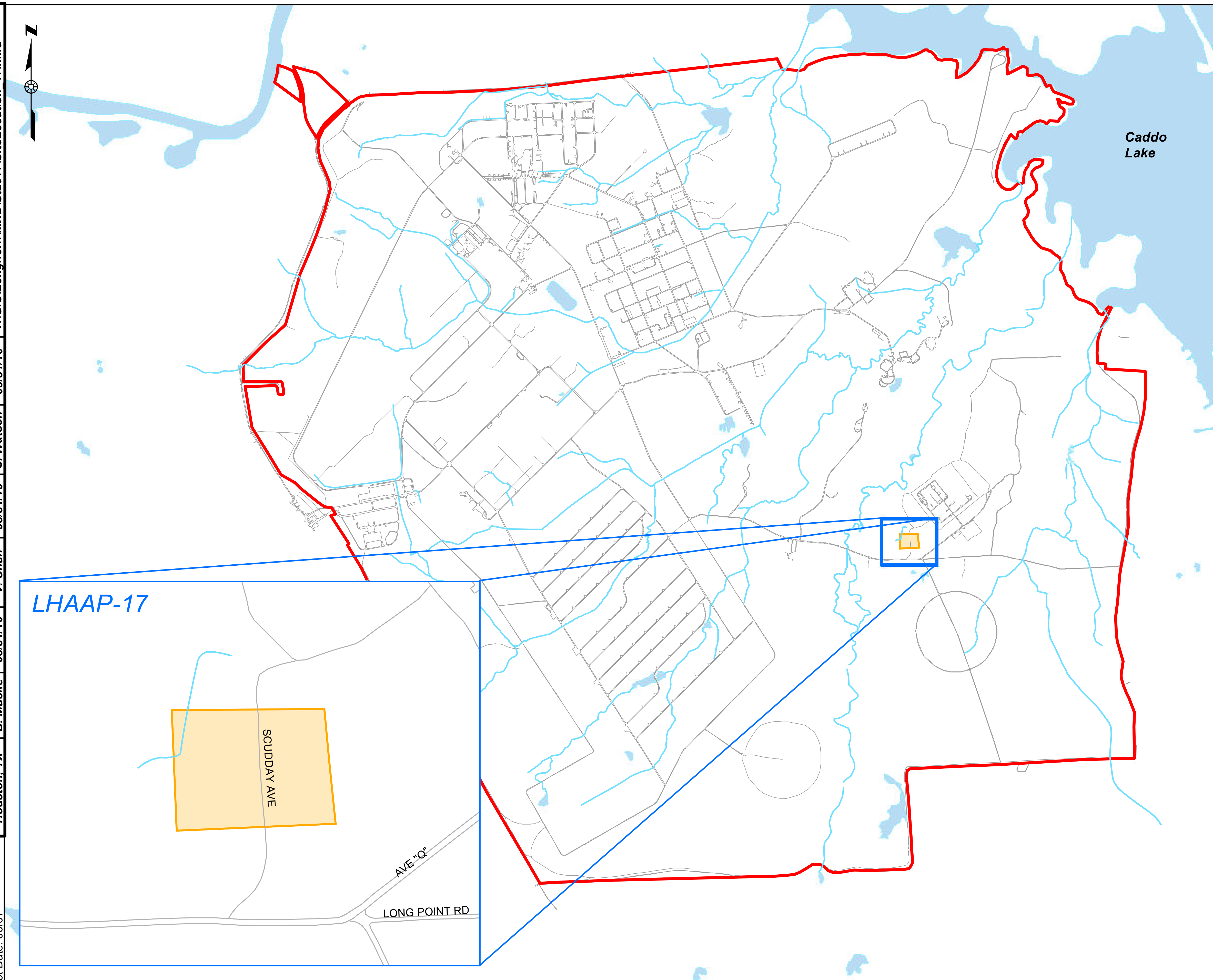
FIGURE 2–1

LHAAP LOCATION MAP

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

IMAGE	X–REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	---	Houston, Texas	L. JONES 12/17/03	G. JONES 10/07/09	P. SRIVASTAV 10/07/09	117591–A55

PLOT DATE: 10/07/09
FORMAT REVISION 3/25/99



Legend

- Stream
- LHAAP Boundary
- Road
- Site
- Lake/Pond

0 1,250 2,500 5,000 Feet

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TULSA, OKLAHOMA

FIGURE 2-2

SITE VICINITY MAP
LHAAP-17, GROUP 2

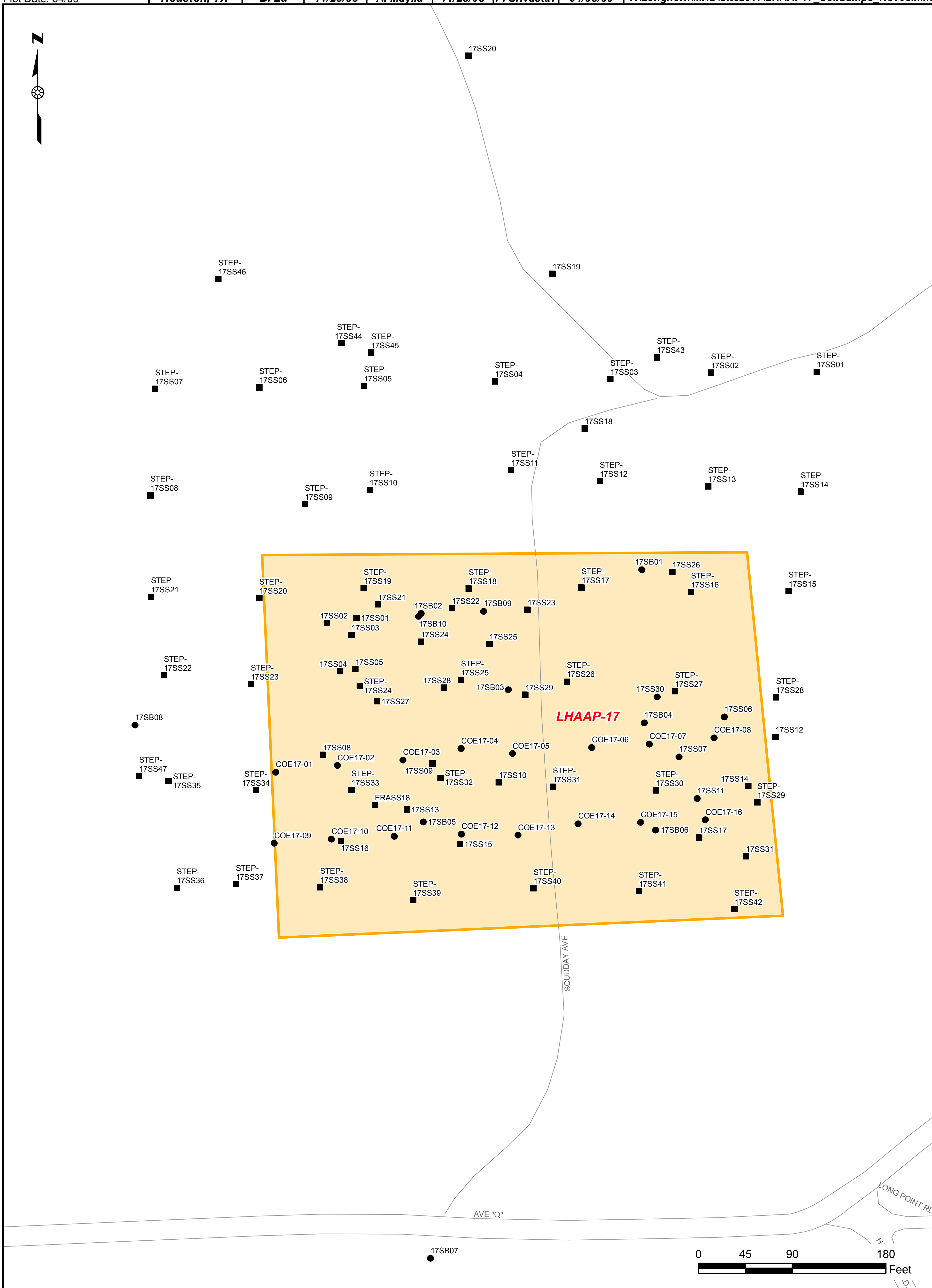
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 08/31/10	V. Chan 08/31/10	S. Watson 08/31/10	T:\GIS\Longhorn\MXD\St2917\SiteLocation_17.mxd

Plot Date: 06/07

OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		FILE PATH
Houston, TX	B. Lu	11/25/08	A. Mayila	11/25/08	P. Srivastav	04/08/09	T:\Longhorn\MXD\Site2917\LHAAP17_SoilSamps_Nov08.mxd

Plot Date: 04/09



LEGEND

- ■ Surface Soil Sample
- ● Soil Boring
- Road
- Stream
- Site

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TULSA, OKLAHOMA

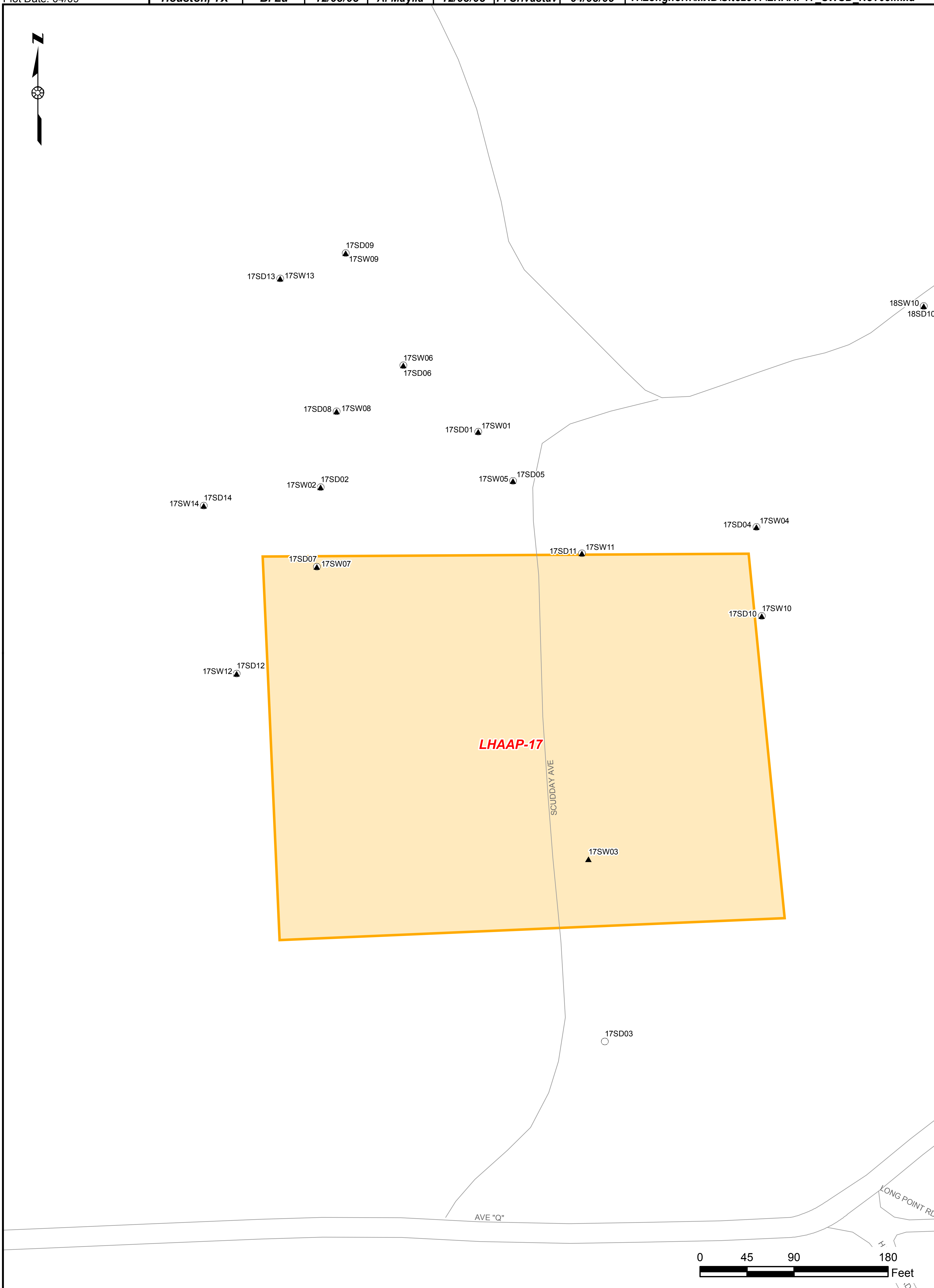
FIGURE 2-3

SOIL SAMPLE LOCATION MAP
LHAAP-17, GROUP 2

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		FILE PATH
Houston, TX	B. Lu	12/03/08	A. Mayila	12/03/08	P. Srivastav	04/08/09	T:\Longhorn\MXD\Site2917\LHAAP17_SWSD_Nov08.mxd

Plot Date: 04/09



LEGEND

- ▲ SWTR
- ○ SED
- Road
- Stream
- Site

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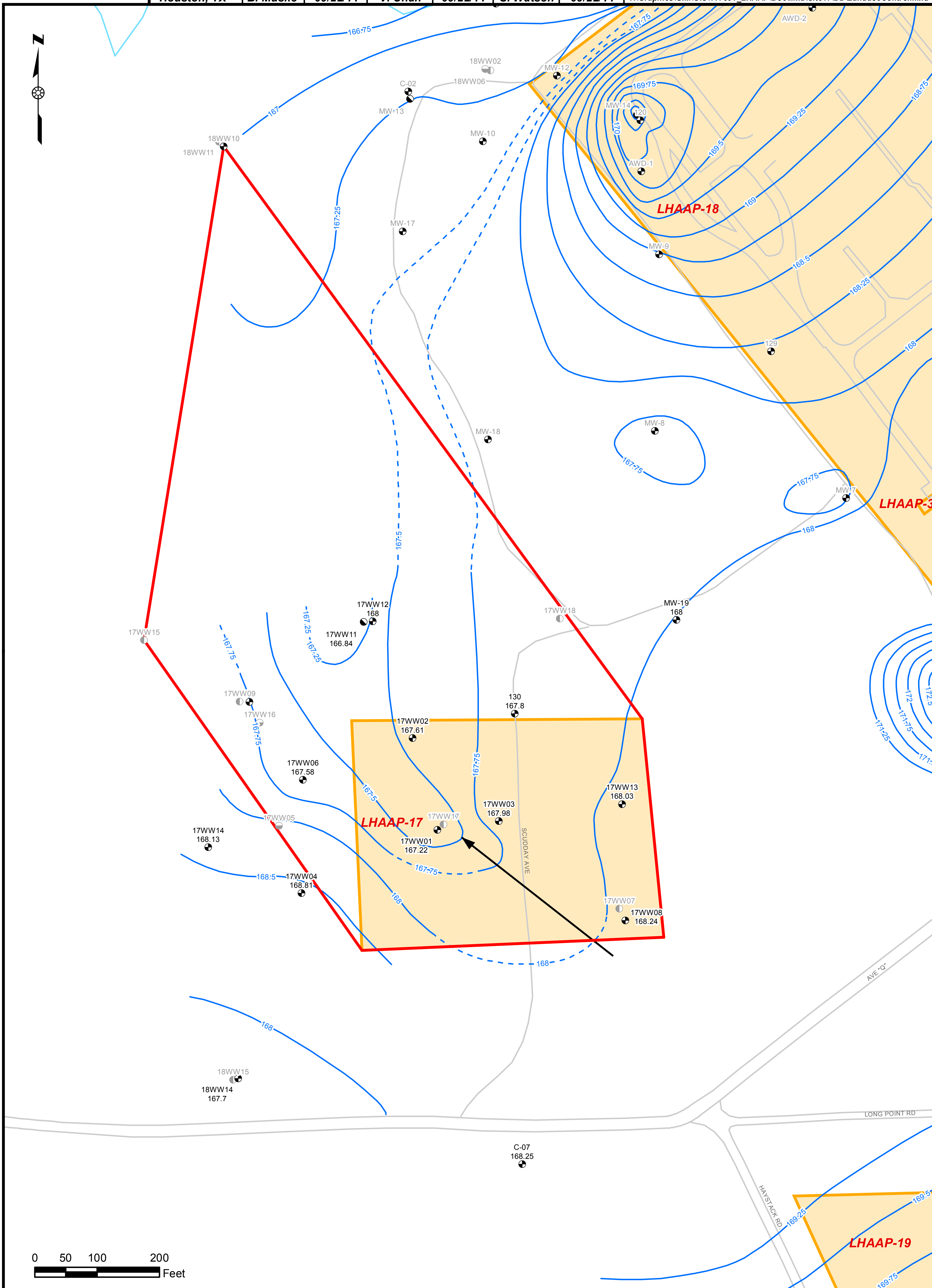
TULSA, OKLAHOMA

FIGURE 2-4

SURFACE WATER AND
SEDIMENT SAMPLE LOCATION MAP
LHAAP-17, GROUP 2

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		FILE PATH
Houston, TX	*B. Muske*	*09/22/11*	*V. Chan*	*09/22/11*	*S. Watson*	*09/22/11*	*T:\Graphics\GIM\GIS\117591_LHAAP\Doc\Mxd\Site17\DD\LanduseControl.mxd*



- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Inferred Shallow Groundwater Elevation Contour
- Shallow Groundwater Elevation Contour
- Shallow Groundwater Flow Direction
- Preliminary Land Use Control Boundary

NOTES:

1. Groundwater elevation contours based on water levels measured on November 14, 2007 at LHAAP-17 and LHAAP-18/24.

2. 17WW12 is considered to be screened in a perched zone.

3. LHAAP-18/24 and associated wells are not depicted on this map.

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FIGURE 2-5

GROUNDWATER ELEVATION MAP
(SHALLOW ZONE)
LHAAP-17, GROUP 2

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

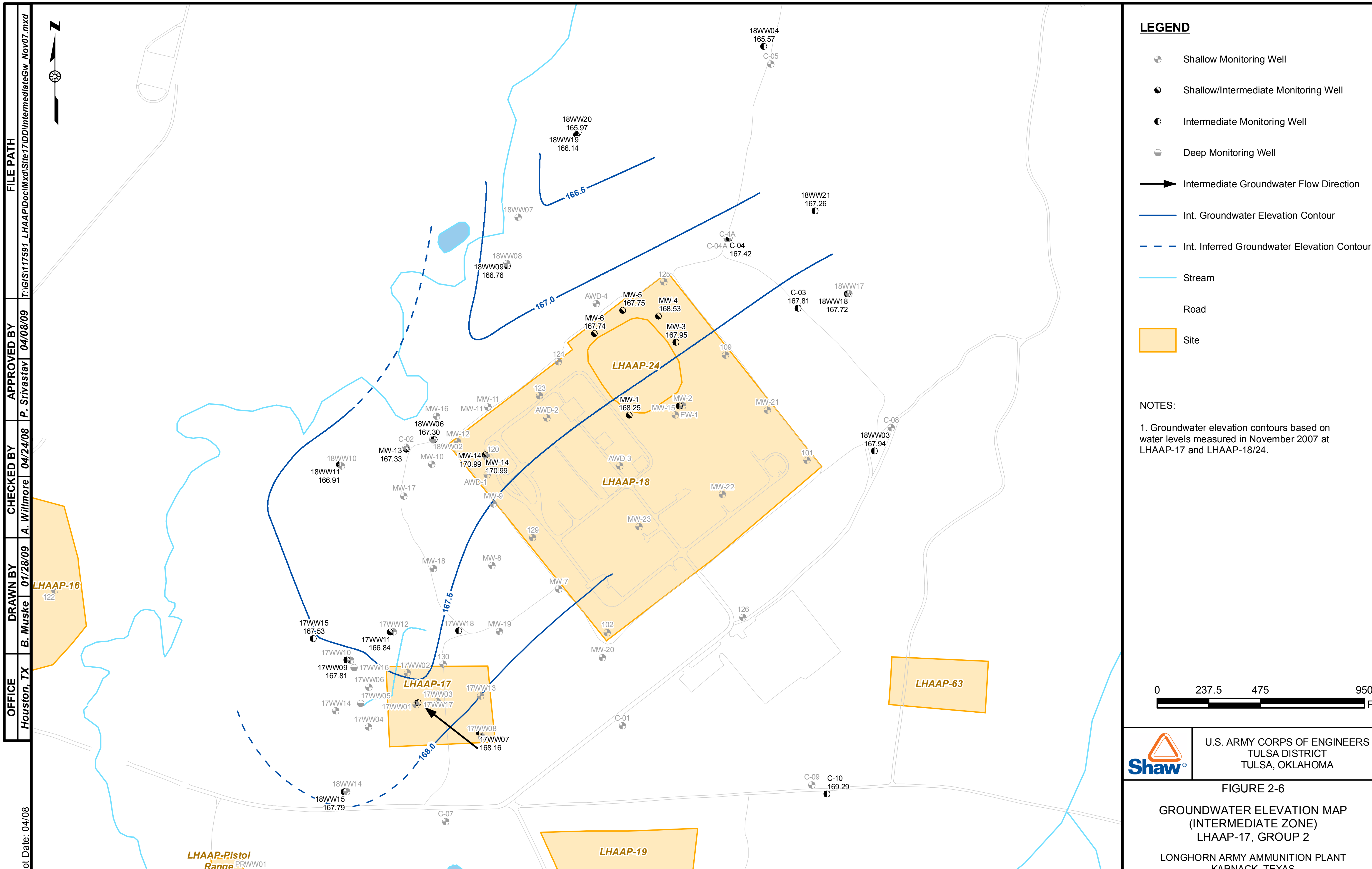

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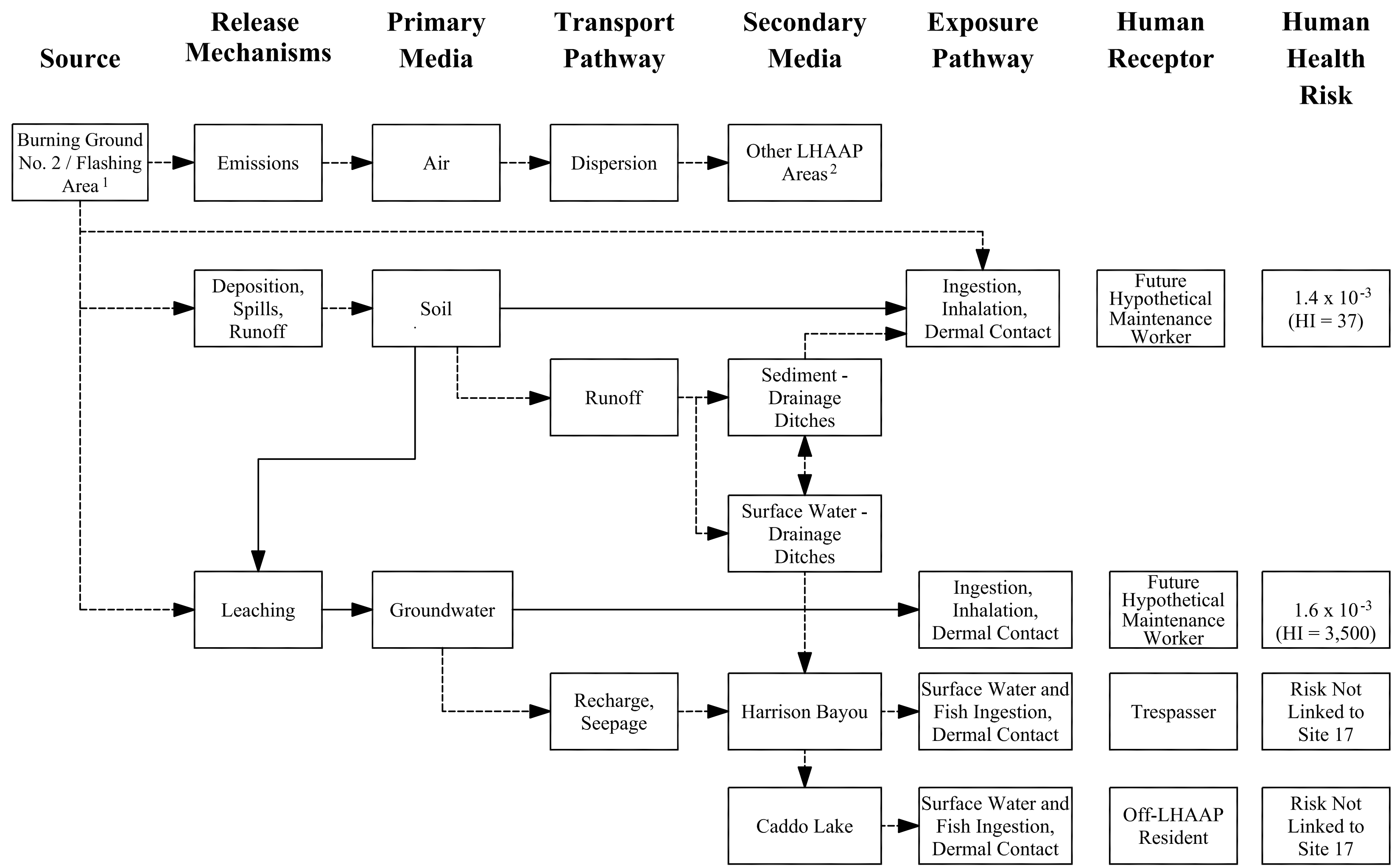
FIGURE 2-6

GROUNDWATER ELEVATION MAP
(INTERMEDIATE ZONE)
LHAAP-17, GROUP 2

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

PLOT DATE: 07/12/10
FORMAT REVISION 5/13/02

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
---	---	Houston, Texas	L. JONES	07/12/10	V. CHAN	07/12/10	P. SRIVASTAV	07/12/10	117591-A72



Pathway considered for remediation

Pathway *not* considered for remediation

Notes:

1. The waste residues were reportedly removed in 1984. Site characterization occurred after removal.

2. Contaminants (e.g., dioxins) dispersed via air emissions to other LHAAP sites are addressed in the CERCLA documentation for those sites. No gross contamination by dioxins has been encountered at Longhorn AAP.

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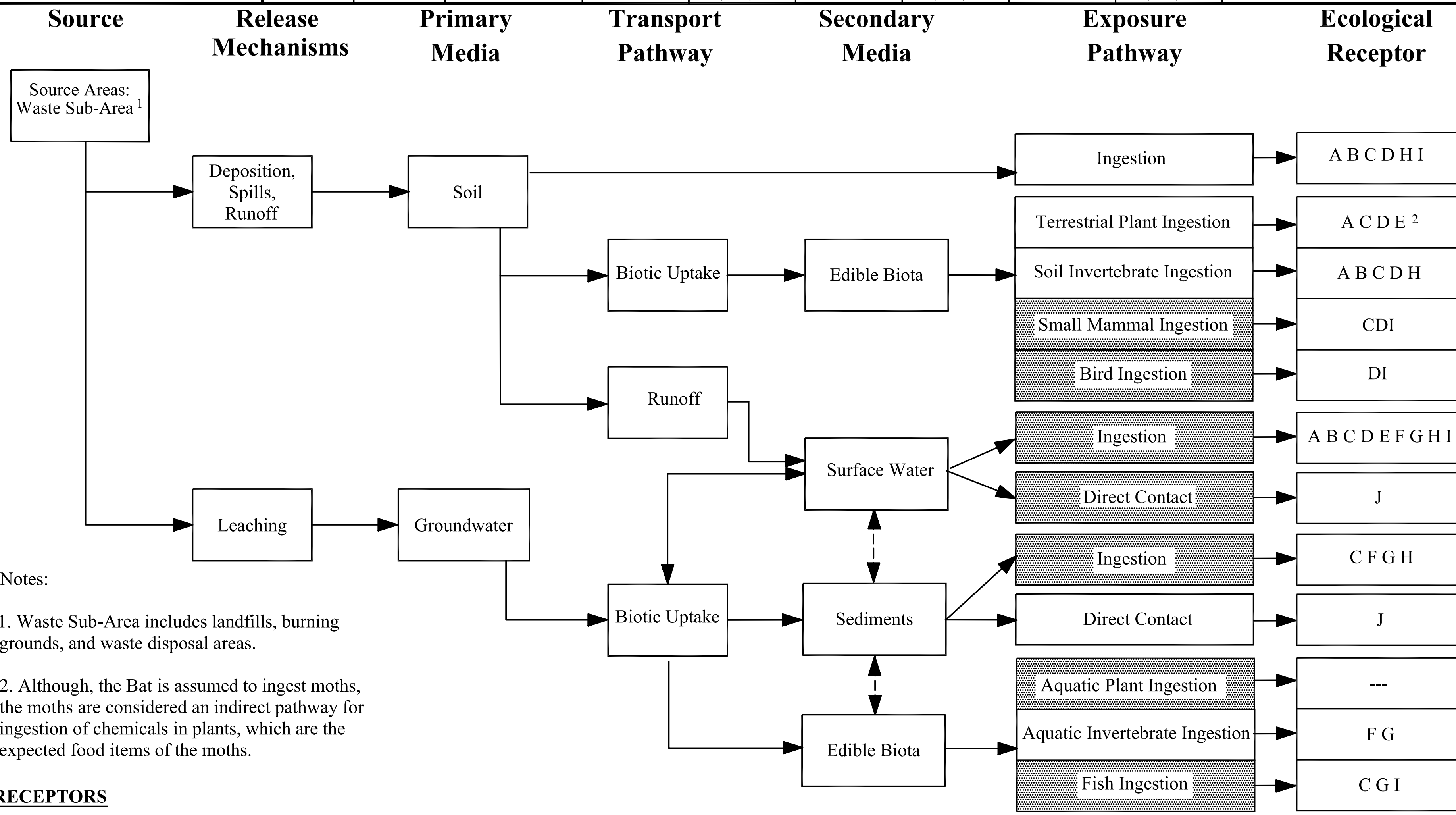
FIGURE 2-7
HUMAN HEALTH CONCEPTUAL SITE MODEL
LHAAP-17, GROUP 2
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

PLOT DATE: 07/12/10
FORMAT REVISION

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
---	---	HOUSTON, TX	L. JONES	07/12/10	S. WATSON	07/12/10	P. SRIVASTAV	07/12/10	117591-A73



Notes:

1. Waste Sub-Area includes landfills, burning grounds, and waste disposal areas.

2. Although, the Bat is assumed to ingest moths, the moths are considered an indirect pathway for ingestion of chemicals in plants, which are the expected food items of the moths.

RECEPTORS

A. Deer Mouse
B. Short-Tailed Shrew
C. Racoon (& Racoon [Louisiana Black Bear])
D. Red Fox
E. Townsend's Big-Eared Bat
F. Bank Swallow
G. Belted Kingfisher
H. American Woodcock
I. Red-Tailed Hawk
J. Aquatic Life (benthic invertebrates)

--- = All receptors exposed to this pathway were determined not to be of concern.

Shaded cells indicate pathways that were not identified as significant, are background related, or were refined via site-specific investigations.

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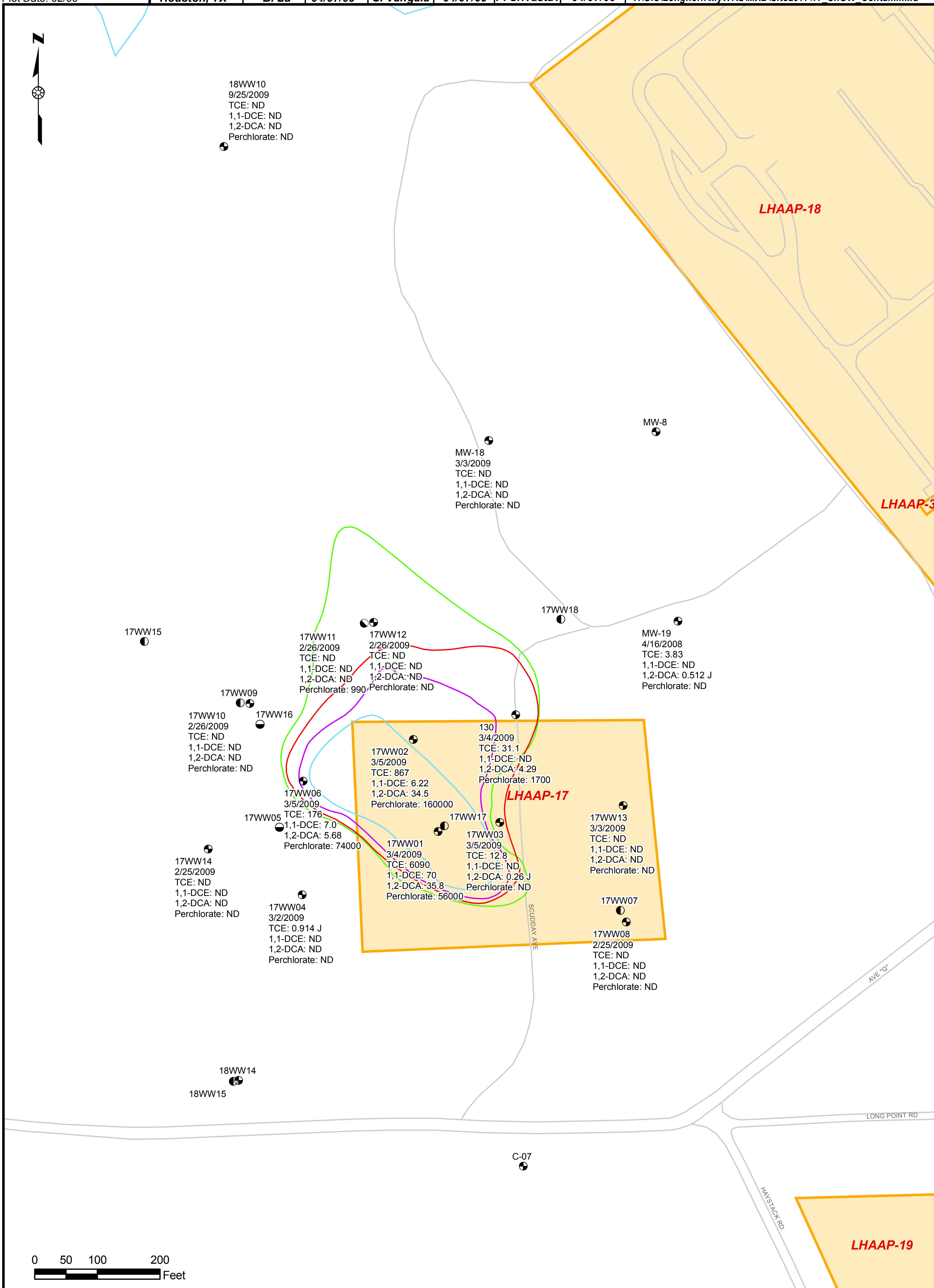
Figure 2-8
Ecological Conceptual Exposure Model LHAAP-17, Group 2
Longhorn Army Ammunition Plant
Karnack, Texas

Plot Date: 02/09

OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		FILE PATH
Houston, TX	B. Lu	04/07/09	S. Vangala	04/07/09	P. Srivastav	04/07/09	T:\GIS\Longhorn\MyWKS\MXD\Site2917\17_ShGW_Contam.mxd



Shallow Monitoring Well	TCE Plume (MCL = 5 µg/L)
Shallow/Intermediate	1,1-DCE Plume (MCL = 7 µg/L)
Intermediate Monitoring	1,2-DCA Plume (MCL = 5 µg/L)
Deep Monitoring Well	Perchlorate Plume (PCL = 17 µg/L)
Stream	
Road	
Site	

NOTES:

1. All concentrations are reported in microgram per liter (µg/L).
2. ND - non detect
3. PCL - TRRP Tier 1 Groundwater Residential PCL
4. MCL - maximum contaminant level
5. TCE - trichloroethene
6. 1,1-DCE - 1,1-dichloroethene
7. 1,2-DCA - 1,2-dichloroethane

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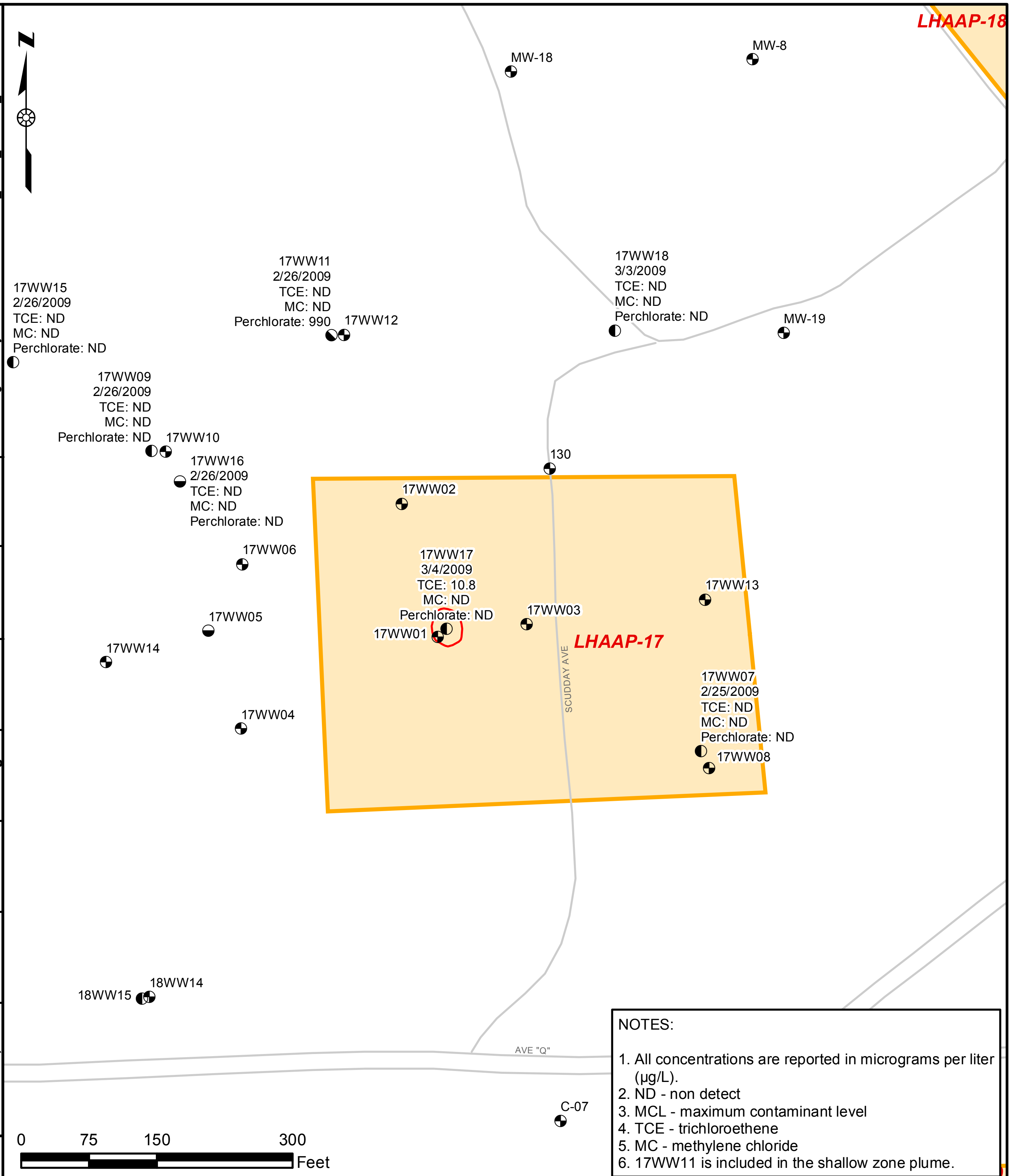
FIGURE 2-9

VOCs AND PERCHLORATE
IN SHALLOW ZONE GROUNDWATER
LHAAP-17, GROUP 2

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS



NOTES:

1. All concentrations are reported in micrograms per liter (µg/L).
2. ND - non detect
3. MCL - maximum contaminant level
4. TCE - trichloroethene
5. MC - methylene chloride
6. 17WW11 is included in the shallow zone plume.

LEGEND

- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Stream
- Road
- Site
- TCE Plume (MCL = 5 µg/L)

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Lu 04/07/09	V. Vangala 04/07/09	P. Srivastav 04/07/09	T:\GIS\Longhorn\MyWKS\MXD\Site29\17\17_InGW_Contam_Mar2009.mxd

Plot Date: 03/09

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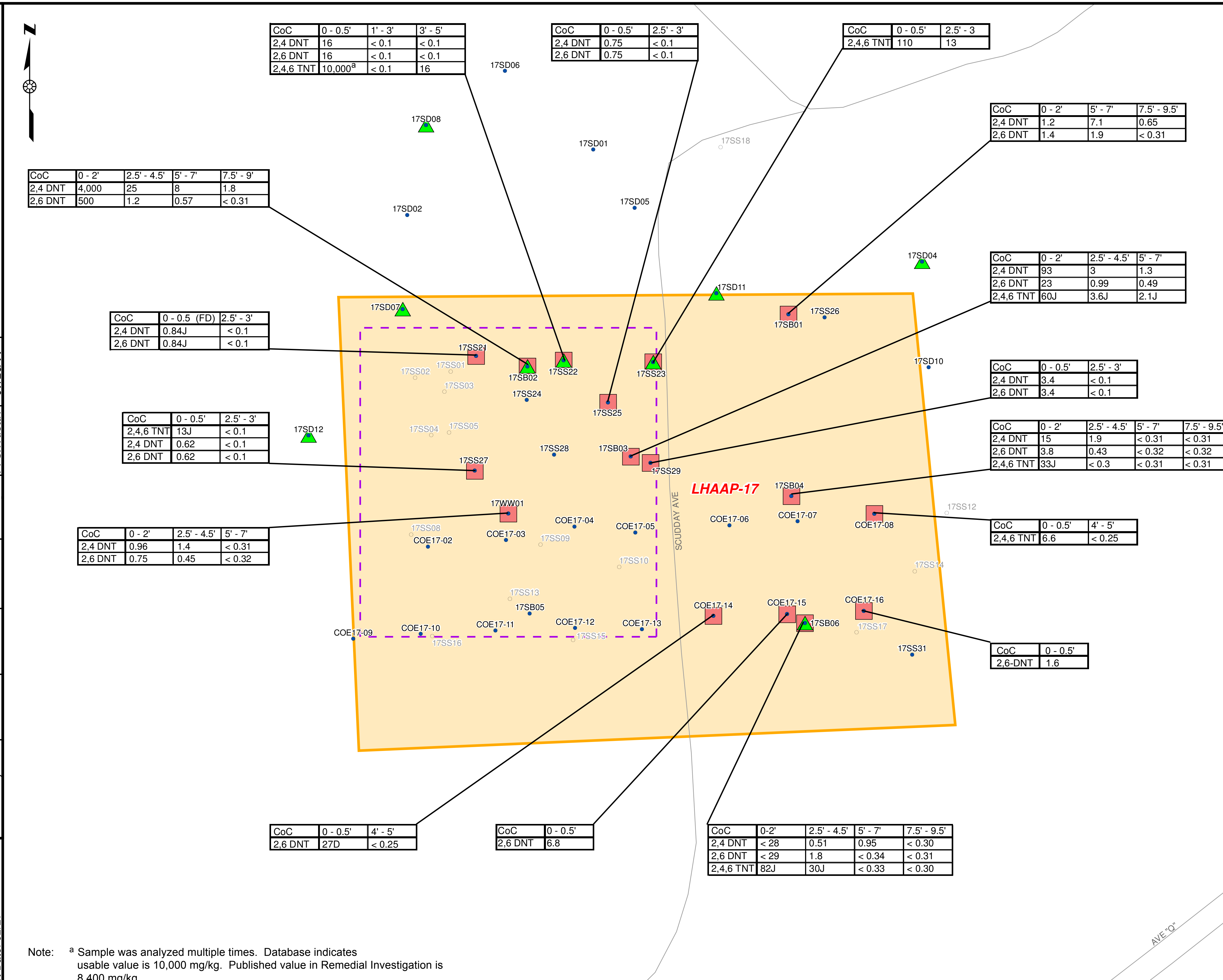
FIGURE 2-10
VOCs AND PERCHLORATE
IN INTERMEDIATE ZONE GROUNDWATER
LHAAP-17, GROUP 2
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS



CoC	0 - 0.5'	1' - 3'	3' - 5'
2,4 DNT	16	< 0.1	< 0.1
2,6 DNT	16	< 0.1	< 0.1
2,4,6 TNT	10,000[a]	< 0.1	16

CoC	0 - 0.5'	2.5' - 3'
2,4 DNT	0.75	< 0.1
2,6 DNT	0.75	< 0.1

CoC	0 - 0.5'	2.5' - 3
2,4,6 TNT	110	13

CoC	0 - 2'	5' - 7'	7.5' - 9.5'
2,4 DNT	1.2	7.1	0.65
2,6 DNT	1.4	1.9	< 0.31

CoC	0 - 2'	2.5' - 4.5'	5' - 7'	7.5' - 9'
2,4 DNT	4,000	25	8	1.8
2,6 DNT	500	1.2	0.57	< 0.31

CoC	0 - 2'	2.5' - 4.5'	5' - 7'
2,4 DNT	93	3	1.3
2,6 DNT	23	0.99	0.49
2,4,6 TNT	60J	3.6J	2.1J

CoC	0 - 0.5 (FD)	2.5' - 3'
2,4 DNT	0.84J	< 0.1
2,6 DNT	0.84J	< 0.1

CoC	0 - 0.5'	2.5' - 3'
2,4 DNT	3.4	< 0.1
2,6 DNT	3.4	< 0.1

CoC	0 - 0.5'	2.5' - 3'
2,4,6 TNT	13J	< 0.1
2,4 DNT	0.62	< 0.1
2,6 DNT	0.62	< 0.1

CoC	0 - 2'	2.5' - 4.5'	5' - 7'	7.5' - 9.5'
2,4 DNT	15	1.9	< 0.31	< 0.31
2,6 DNT	3.8	0.43	< 0.32	< 0.32
2,4,6 TNT	33J	< 0.3	< 0.31	< 0.31

CoC	0 - 2'	2.5' - 4.5'	5' - 7'
2,4 DNT	0.96	1.4	< 0.31
2,6 DNT	0.75	0.45	< 0.32

CoC	0 - 0.5'	4' - 5'
2,4,6 TNT	6.6	< 0.25

CoC	0 - 0.5'
2,6-DNT	1.6

CoC	0 - 0.5'	4' - 5'
2,6 DNT	27D	< 0.25

CoC	0 - 0.5'
2,6 DNT	6.8

CoC	0-2'	2.5' - 4.5'	5' - 7'	7.5' - 9.5'
2,4 DNT	< 28	0.51	0.95	< 0.30
2,6 DNT	< 29	1.8	< 0.34	< 0.31
2,4,6 TNT	82J	30J	< 0.33	< 0.30

Note: [a] Sample was analyzed multiple times. Database indicates usable value is 10,000 mg/kg. Published value in Remedial Investigation is 8,400 mg/kg.

LEGEND

- Sample location with contamination that poses Ecological Risk. See Table 2-11 in this Record of Decision for additional information.
- Sample location with contamination that poses Human Health Risk (for soil to groundwater).
- Soil sample location not posing risk.
- Soil sample deemed unusable by EPA for environmental decisions (Jacobs, 2002).
- Road
- Approximate boundary of treatability demonstration study (PEC, 2004).
- Site

TNT Trinitrotoluene
DNT Dinitrotoluene
CoC Contaminant of Concern

1. Depths are reported in feet below ground surface.

2. Soil sample concentrations in milligrams/kilograms (mg/kg).

GWP-IND

2,4,6 TNT	5.1 mg/kg
2,4 DNT	0.042 mg/kg
2,6 DNT	0.042 mg/kg

References:

Jacobs Engineering Group, Inc. (Jacobs), 2002, Baseline Human Health and Screening Ecological Risk Assessment for the Group 2 Sites (Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas, Final, Oak Ridge, TN, August.

Planteco Environmental Consultants, LLC (PEC), 2004, In Situ Bioremediation of Perchlorate Contaminated Soils and Groundwater at Site-17 (Burning Ground No. 2), Longhorn Army Ammunition Plant, Karnack, Texas, Draft Final, March.

0 40 80 160 Feet

Shaw

U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 2-11

SOIL CONTAMINATION
LHAAP-17, GROUP 2

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

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APPROVED BY P. Srivastav 07/25/11

CHECKED BY S. Watson 07/25/11

DRAWN BY B. Musk0 07/25/11

OFFICE Houston, TX

Plot Date: 02/27

LEGEND

- Sample location with contamination that poses Ecological Risk. See Table 2-11 in this Record of Decision for additional information.
- Sample location with contamination that poses Human Health Risk (for soil to groundwater).
- Soil sample location not posing risk.
- Soil sample deemed unusable by EPA for environmental decisions (Jacobs, 2002).
- Road
- Proposed excavation areas with average depth of 5 feet below ground surface (bgs) for Human Health Risk areas, or with a depth of up to 3 feet bgs for Ecological Risk areas.
- Approximate boundary of treatability demonstration study (PEC, 2004).
- Site

References:

Jacobs Engineering Group, Inc. (Jacobs), 2002, *Baseline Human Health and Screening Ecological Risk Assessment for the Group 2 Sites (Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Oak Ridge, TN, August.

Planteco Environmental Consultants, LLC (PEC), 2004, *In Situ Bioremediation of Perchlorate Contaminated Soils and Groundwater at Site-17 (Burning Ground No. 2), Longhorn Army Ammunition Plant, Karnack, Texas*, Draft Final, March.

0 40 80 160 Feet

U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 2-12

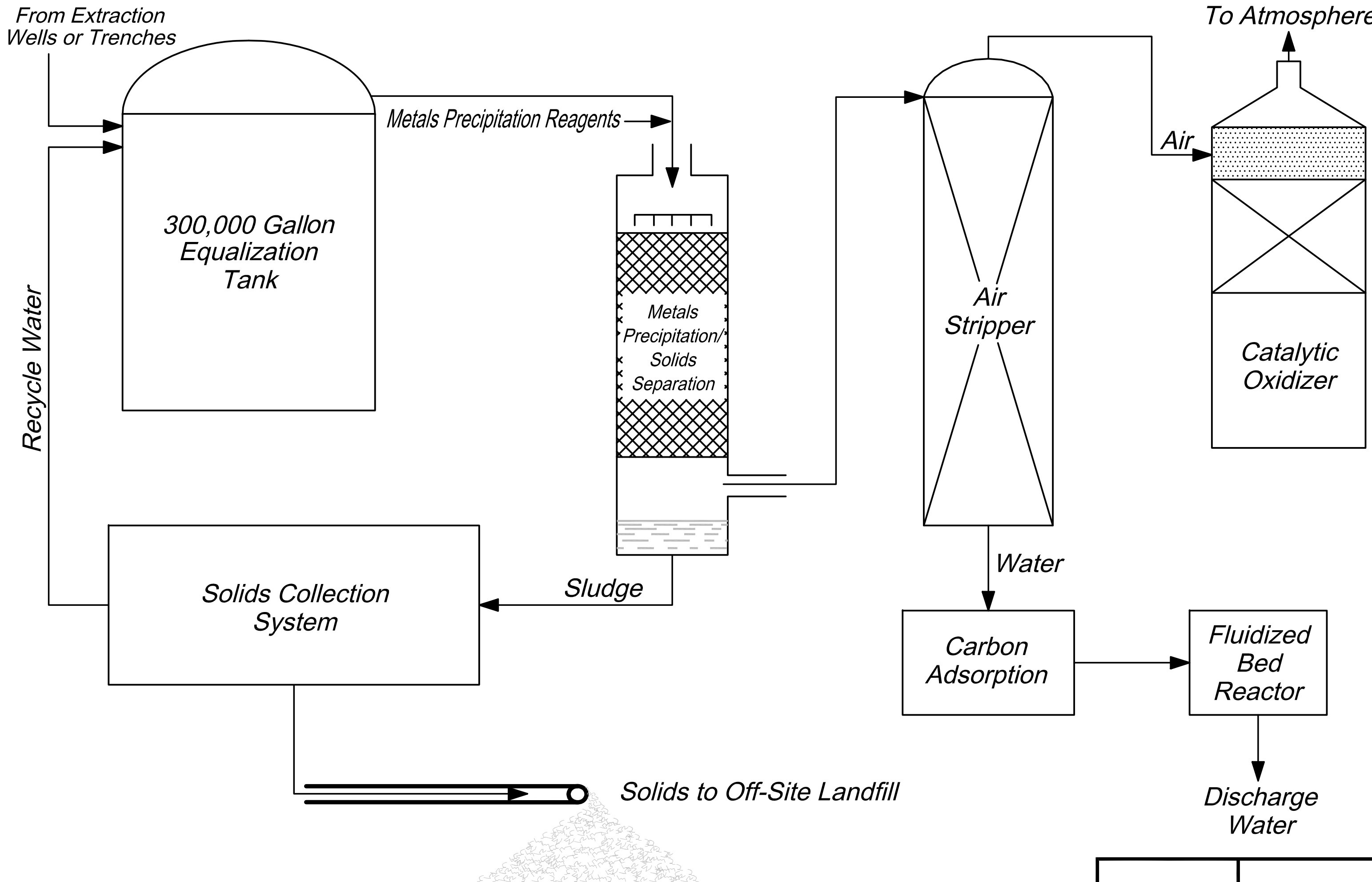
AREAS OF SOIL REMEDIATION
LHAAP-17, GROUP 2

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	FILE PATH
Houston, TX	B. Muske 08/31/10	V. Chan 08/31/10	P. Srivastav 08/31/10	T:\GIS\117591 LHAAP\Doc\Mxd\Site17\ROD\SoilRemediation.mxd

Plot Date: 2/27

PLOT DATE: 07/12/10	IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
FORMAT REVISION 5/13/02	---	---	Houston, Texas	L. JONES	07/12/10	V. CHAN	07/12/10	P. SRIVASTAV	07/12/10	117591-A74



U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 2-13
EXISTING GROUNDWATER TREATMENT PLANT PROCESS
LHAAP-17, GROUP 2
LONGHORN ARMY AMMUNTION PLANT
KARNACK, TEXAS

3.0 Responsiveness Summary

The Responsiveness Summary serves three purposes. First, it provides the U .S. Army, USEPA, and TCEQ with information about community concerns with the preferred alternative at LHAAP-17 as presented in the Proposed Plan. Second, it shows how the public's comments were considered in the decision-making process for selection of the remedy. Third, it provides a formal mechanism for the U.S. Army to respond to public comments.

The U.S. Army, USEPA, and TCEQ provide information regarding LHAAP-17 through public meetings, the Administrative Record for the facility, and announcements published in the Shreveport Times and Marshall News Messenger newspapers. **Section 2.3** discusses community participation on LHAAP-17, including the dates for the public comment period, the date, location, and time of the public meetings, and the location of the Administrative Record. The following documents related to community involvement were added to the Administrative Record:

- Transcript of the public meeting on June 29, 2010
- Presentation slides from the June 29, 2010 public meeting
- Written questions and comments from the public during the public comment period, and the U.S. Army response to those comments dated December 9, 2010.

3.1 Stakeholder Issues and Lead Agency Responses

This section responds to significant issues raised by stakeholders including the public and community groups that were received in written or verbal form. The figures that the commenter makes reference to were provided by the commenter.

Question/comment: The Army intends to stop pumping and treating groundwater once average perchlorate concentrations are reduced to 20,000 µg/L. According to the Army, high concentrations of perchlorate inhibit the natural attenuation of TCE. However, the Army has not presented any evidence to show that there are significant differences in the attenuation of TCE when the perchlorate concentration is below 20,000 µg/L. In fact, TCE concentrations are increasing at monitor wells 130 and 17WW03, even though perchlorate concentrations at these wells are well below 20,000 µg/L (see figures 1a, 1b, 2a, and 2b on the next page). On the other hand, perchlorate concentrations in monitor well 17WW06 are much higher than 20,000 µg/L, but TCE concentrations are decreasing (see figures 3a and 3b). Thus, there does not appear to be a strong relationship between perchlorate concentrations and the attenuation of TCE. The Army should not rely on a reduction in perchlorate concentrations to result in the attenuation of TCE.

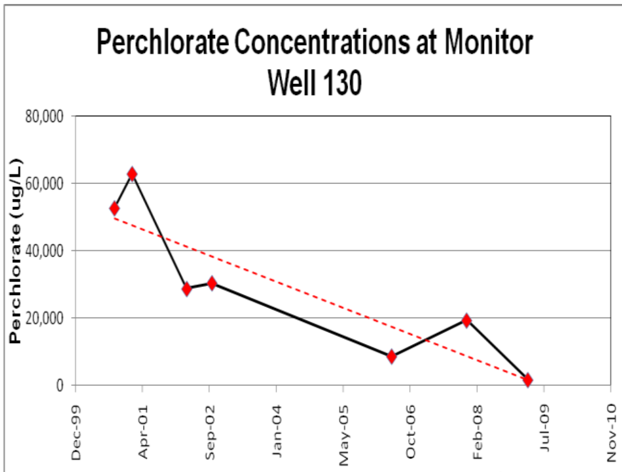


Figure 1a

Data source: United States Army, 2010a, appendix A, table A-1.

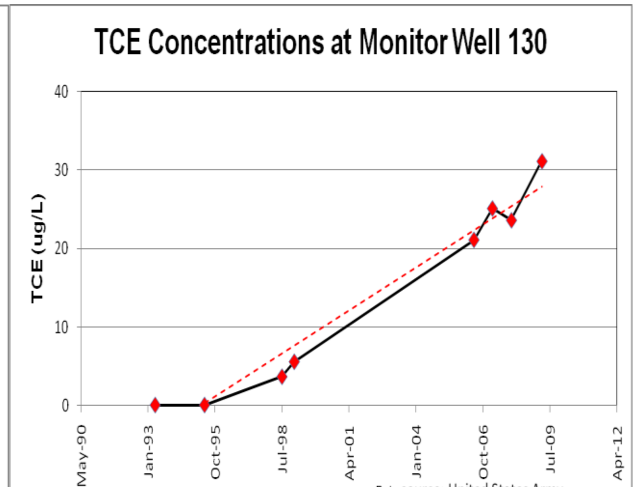


Figure 1b

Data source: United States Army, 2010a, appendix A, table A-1.

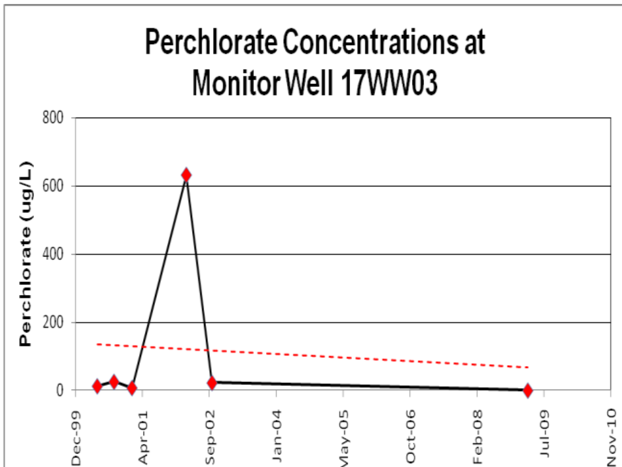


Figure 2a

Data source: United States Army, 2010a, appendix A, table A-1.

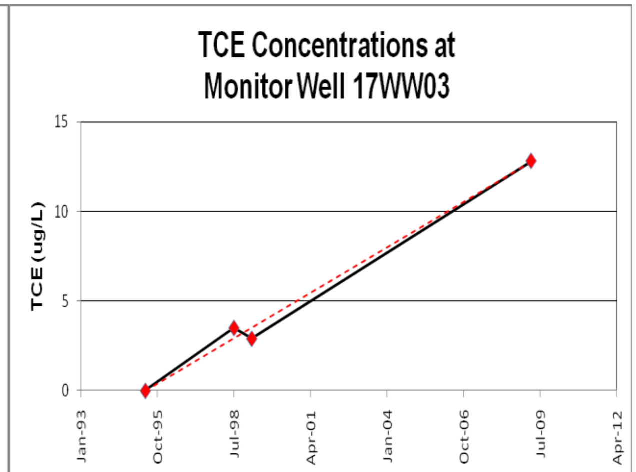


Figure 2b

Data source: United States Army, 2010a, appendix A, table A-1.

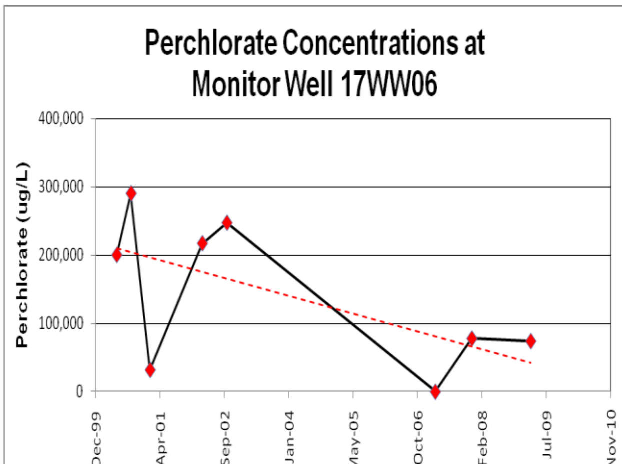


Figure 3a

Data source: United States Army, 2010a, appendix A, table A-1.

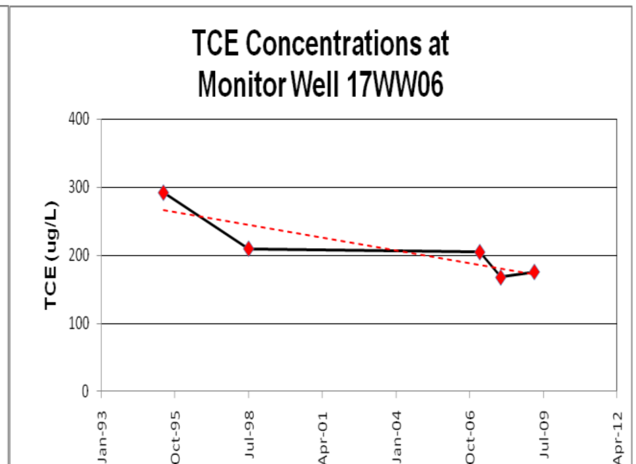


Figure 3b

Data source: United States Army, 2010a, appendix A, table A-1.

Response: Studies of natural attenuation and guidance for implementing MNA presume that biologically assisted attenuation proceeds from the most easily reduced compounds to the ones that are most difficult. Perchlorate is more easily reduced than TCE. The microbes that metabolize perchlorate are ubiquitous in the natural environment, and there appears to be no potential "stalling" at daughter products (which can happen with TCE). The perchlorate concentration of 20,000 µg/L was selected based on data from LHAAP-17 and another site at Longhorn. At LHAAP-17, observation of the subsurface conditions is complicated by the perchlorate contaminated soil which may add perchlorate to the groundwater via percolation. The performance of natural attenuation to meet remedial action objectives will be evaluated after soil removal, groundwater pumping, and eight quarterly sampling events. If it is found that the performance objectives are not being met with natural attenuation, a contingent remedy such as in situ bioremediation would be implemented.

Question/comment: It appears that the Army intends to stop pump and treat once the trigger is reached, regardless of the effect that pump and treat is having on contaminant concentrations. This is not a reasonable approach to contaminant clean-up. The Army should evaluate the effectiveness of pump and treat when the trigger is reached. Then, if it is still having a substantial effect on contaminant concentrations, pump and treat should be continued. The pump and treat system should be operated as long as it is causing significant reductions in contaminant concentrations.

Response: The U.S. Army has chosen to implement pump and treat to reduce the highest contaminant concentrations at LHAAP-17 to make conditions more favorable for MNA. Contaminant removal by pump and treat methods operates with diminishing returns – as concentrations decrease, the mass removal rate also falls. Inevitably, a point is reached at which remediation by pump and treat is no longer cost effective. The pump and treat system in conjunction with the site hydrogeological conditions may also be considered ineffective if the system is incapable of reducing perchlorate concentrations at a rate that would be considered productive. As the wording in the comment implies, "substantial effect" and "significant reductions", there is some amount of interpretation involved in deciding when to turn off the pumps. However, pump and treat is not the primary remedy selected or evaluated for LHAAP-17. It is used to assist the primary remedy of MNA by reducing the highest contaminant concentrations. If the pump and treat does not effectively reduce the highest contaminant concentrations in the reasonable time allowed, a contingency remedy such as in situ bioremediation will be implemented.

Question/comment: TCE samples have been collected from 11 monitor wells in the shallow zone. TCE concentrations have exceeded the 5 µg/L MCL in six of these wells. Of these six wells TCE concentrations are rising in four, and dropping in two (see figures 1b, 2b, 3b, 4, 5, and 6). The table below shows the most recent TCE concentrations found in the six wells.

Clearly, natural attenuation is not acting to reduce TCE concentrations throughout the site. Although the Army claims that high concentrations of perchlorate are inhibiting the attenuation of TCE, this assertion is not supported by the data (see first comment). The Army should reevaluate its reliance on natural attenuation to reduce TCE concentrations at Site 17.

Most Recent TCE Concentrations in Shallow Zone Monitor Wells

Wells with increasing concentrations of TCE		**Wells with decreasing concentrations of TCE**	
Well ID	TCE (µg/L)	Well ID	TCE (µg/L)
130	31.1	17WW04	0.9
17WW01	6090	17WW06	176
17WW02	867		
17WW03	12.8		

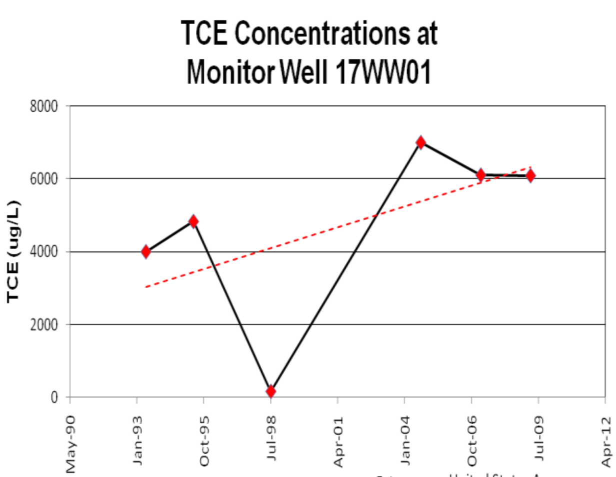


Figure 4 Data source: United States Army, 2010a, appendix A, table A-1.

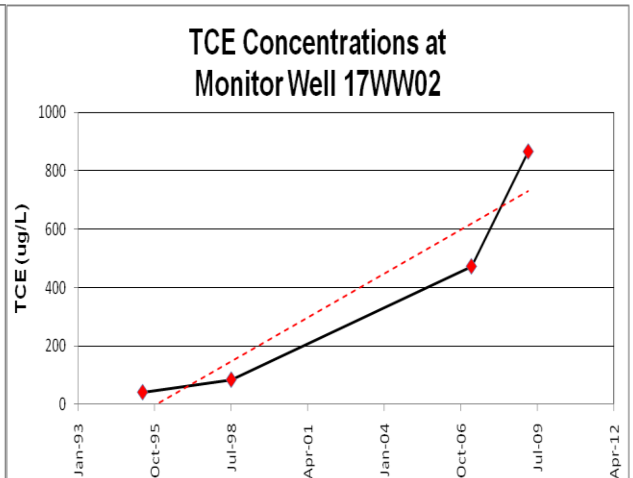


Figure 5 Data source: United States Army, 2010a, appendix A, table A-1.

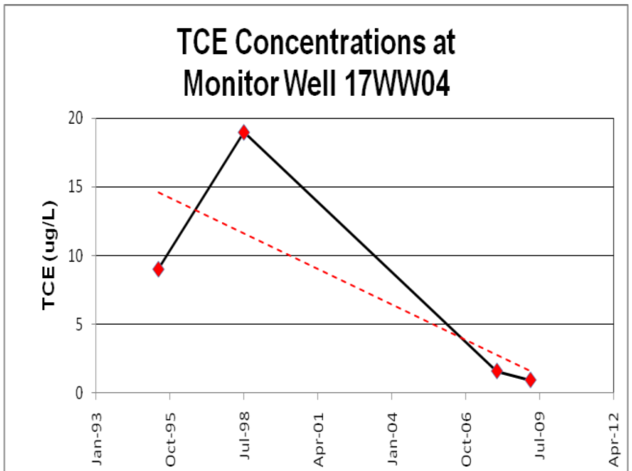


Figure 6 Data source: United States Army, 2010a, appendix A, table A-1.

Response: The most significant increase in TCE concentrations is seen at well 17WW01 between 1998 and 2004. TCE concentrations have declined in this well since 2004. Increases in TCE concentrations at wells 130, 17WW02, and 17WW03 are not as significant and may reflect seasonal variations instead of an overall increase in mass. The groundwater gradient at LHAAP-17 is fairly flat and the diffusion of TCE away from 17WW01 may cause a rise in concentrations in the surrounding wells (i.e., 17WW02 and 17WW03). Even though there are fluctuations in the wells at LHAAP-17, the plume is bounded and there does not appear to be a significant migration of the plume. Additionally, pump and treat will contain the plume and will reduce TCE concentrations (prior to MNA evaluation) as well as the perchlorate.

Under current conditions at LHAAP-17, with the addition of perchlorate from contaminated soil by percolation, natural attenuation cannot be effectively evaluated since the high perchlorate concentrations are inhibiting TCE attenuation. After contaminated soil is removed, groundwater pumping will still disturb natural conditions. It is only after soil is removed and pumping is stopped that an effective MNA evaluation may be made. When that evaluation is complete, and if it is favorable, MNA will continue as the remedy. However, if the evaluation is not favorable, another remedy (e.g., in situ bioremediation) will be implemented to reduce the TCE concentrations.

Question/comment: The Army estimates that natural attenuation will reduce TCE concentrations in the shallow groundwater zone to the clean-up level (5 µg/L) in less than 120 years. It is not reasonable to propose a plan that could require the maintenance of LUCs for a century.

Response: The reasonably anticipated future use of the site is as a wildlife refuge (i.e., Caddo Lake National Wildlife Refuge). Once the property is transferred into the refuge system, the property must be kept as a National Wildlife Refuge unless there is an act of Congress which removes the parcel or the land is exchanged in accordance with the National Wildlife Refuge System Administration Act of 1966 and the National Wildlife Refuge System Act Amendments of 1974. This proposed transfer as a national wildlife refuge, which by its very nature includes physical access and use restrictions, is subject to control and continual inspection by Refuge personnel. Also, the property is intended to remain under ownership and management of a federal government agency. The LUC for groundwater will prohibit access to the groundwater except for environmental testing until cleanup levels are met. Maintenance of the LUC for groundwater use prohibition would require minimal effort and would be reasonable for extended lengths of time. Effectiveness of the LUC will be evaluated as part of the statutory five-year reviews and does not pose additional burden. Additionally, access of groundwater through well installations requires a permit from the Texas Department of Licensing and Regulation or Texas Water District authority. The department will be provided a copy of the county recordation that indicates the location of contaminated groundwater at the site and associated prohibitions.

Question/comment: The clean-up time estimate is based on data from monitor well 17WW06, where TCE concentrations are declining (see figure 3b). However, this estimate does not apply to those portions of Site 17 where TCE concentrations are increasing (see third comment). The Army should provide an estimate of clean-up time for the entire site.

Response: Although there is some uncertainty associated with the cleanup time for the entire site because of the inhibitive effects of perchlorate, the data collected during the two year period of natural attenuation monitoring (post pump and treat) will be used to remove some of the uncertainties associated with the estimate of time to achieve MCLs. The statutory five-year reviews will evaluate the effectiveness of the remedy and estimated durations to reach MCLs and would recommend implementation of other measures if needed.

Question/comment: The Army estimates that natural attenuation will reduce perchlorate concentrations to the clean-up level (17 µg/L) within approximately 15 years. This estimate is based on perchlorate degradation rates (half-lives) calculated for eight monitor wells. However, the Army did not calculate degradation rates for two monitor wells that currently contain high perchlorate concentrations: well 17WW01 (56,000 µg/L) and well 17WW02 (160,000 µg/L). Over the entire period of record, perchlorate concentrations in these two wells have increased, although concentrations in both wells are currently decreasing (see figures 7 and 8). Wells 17WW01 and 17WW02 are important data points that the Army has not accounted for in its estimate. The Army should explain why it did not use data from these wells to estimate the clean-up time for perchlorate at Site 17.

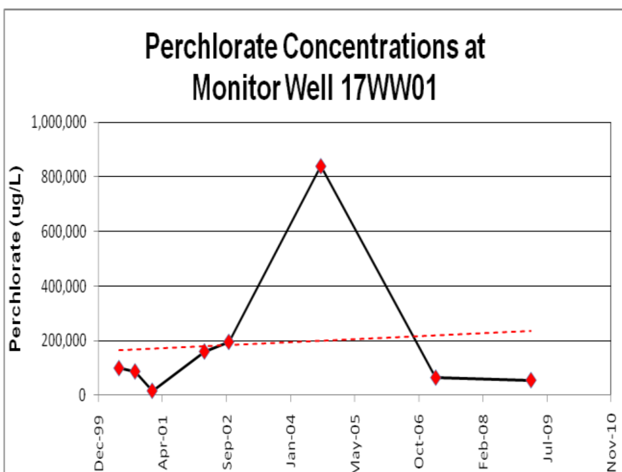


Figure 7 Data source: United States Army, 2010a, appendix A, table A-1.

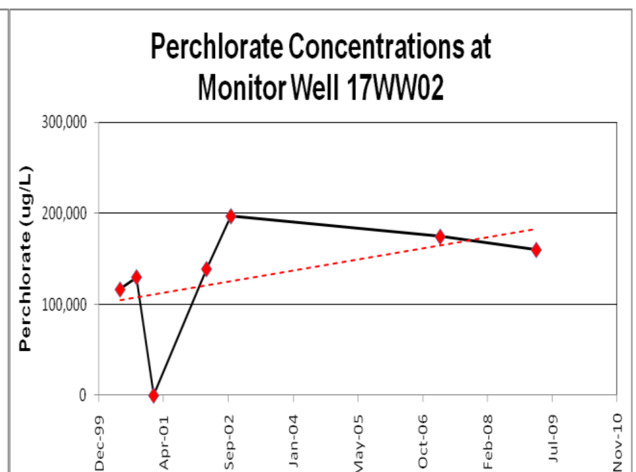


Figure 8 Data source: United States Army, 2010a, appendix A, table A-1.

Response: Data from wells 17WW01 and 17WW02 were not used because those two wells appear to be receiving additional perchlorate as it leaches into groundwater from the overlying contaminated soil. The removal of contaminated soil will end this influx, and the pump and treat activity will reduce perchlorate concentrations in the groundwater at those two wells (to

20,000 µg/L). As the perchlorate concentration at 17WW06 (74,000 µg/L) is significantly higher, the U.S. Army feels that the cleanup time estimated for perchlorate at 17WW06 by MNA provides a reasonable estimate.

Question/comment: The Army does not consider perchlorate to be a COC in the intermediate groundwater zone. However, high concentrations of perchlorate have been detected in intermediate zone monitor well 17WW11. Therefore, perchlorate should be a COC in the intermediate zone.

Response: Well 17WW11 is considered a shallow-intermediate well. There was no distinct clay layer to separate the shallow and intermediate zones. Boring logs for it and surrounding wells were inspected along with groundwater elevations, and it appears to be more reasonably connected with nearby shallow zone monitoring wells than with nearby intermediate zone monitoring wells. As a result, the well 17WW11 has been included with the shallow wells, and within the defined perchlorate plume. Also, perchlorate concentrations were below the detection limit in the intermediate groundwater zone wells (17WW07, 17WW09, 17WW15, and 17WW17).

Question/comment: The Army will present details of the soil excavation plan, the pump and treat system, the groundwater remediation performance objectives, the plan for implementing and evaluating MNA, and the LUC implementation plan, in the RD. However, the RD has not yet been produced. Given its importance, the Army should make the RD available for public review and comment as soon as practicable.

Response: The public will be provided with updates on remedial design and remedial action status through the RAB meeting and any concerns can be addressed through this forum. The RD will include performance objectives, schedule and other design criteria and will follow established regulatory guidance for MNA.

3.2 Technical and Legal Issues

This section is used to expand on technical and legal issues. However, there are no issues of that nature beyond the technical issues already discussed in **Section 3.1**.

4.0 References

Jacobs Engineering Group, Inc. (Jacobs), 2001, *Remedial Investigation Report for the Group 2 Sites Remedial Investigation (Sites 12, 17, 18/24, 29, and 32) at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas*, Final, St. Louis, Missouri, April.

Jacobs, 2002, *Baseline Human Health and Screening Ecological Risk Assessment for the Group 2 Sites (Sites 12, 17, 18/24, 29, 32, 49, Harrison Bayou, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Oak Ridge, Tennessee, August.

Maley, Don, 1988, *Potential Hazardous Waste Site Preliminary Assessment, EPA Form 2070-12*, April.

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Shaw Environmental, Inc. (Shaw), 2007a, *Final Installation-Wide Baseline Ecological Risk Assessment, Longhorn Army Ammunition Plant, Karnack, Texas*, Houston, Texas, *Volume I: Step 3 Report*, January, and *Volume II: Steps 4 through 8*, November.

Shaw, 2007b, *Data Gaps Investigation Report, Longhorn Army Ammunition Plant, Karnack, Texas*, Final, Houston, Texas, April.

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Texas Commission on Environmental Quality (TCEQ), 2006, Updated Examples of Standard No. 2, Appendix II, Medium-Specific Concentrations, March 21.

U.S. Department of the Army (U.S. Army), 2004, *Memorandum of Agreement Between the Department of the Army and the Department of the Interior for the Interagency Transfer of Lands at the Longhorn Army Ammunition Plant for the Caddo Lake National Wildlife Refuge, Harrison County, Texas*, Signed by the Department of the Interior on April 27, 2004 and the U.S. Army on April 29, 2004.

U.S. Army, 2010, *Proposed Plan for LHAAP-17, Burning Ground No. 2/Flashing Area, Group 2, Longhorn Army Ammunition Plant, Karnack, Texas*, Final, May.

U.S. Army Environmental Hygiene Agency (USAEHA), 1987, *Final Groundwater Contamination Survey No. 38-26-0851-89, Evaluation of Solid Waste Management Units, Longhorn Army Ammunition Plant, Karnack, Texas*, May.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), 1980, *Installation Assessment of Longhorn Army Ammunition Plant, Report No. 150*, February.

U.S. Environmental Protection Agency (USEPA), 1998, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*, EPA/600/R-98/128, Wiedemeier, T.H., M.A. Swanson, D.E. Moutoux, E.K. Gordon, J.T. Wilson, B.H. Wilson, D.H. Kampbell, P.E. Haas, R.N. Miller, J.E. Hansen, and F.H. Chapelle, Cincinnati, Ohio.

USEPA, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER Directive 9200.4.-17P, April.

USEPA, 2004, *Performance Monitoring of MNA Remedies for VOCs in Ground Water*, EPA/600/R-04/027, April.

Glossary of Terms

Glossary of Terms

Administrative Record – The body of reports, official correspondence, and other documents that establishes the official record of the analysis, clean up, and final closure of a site.

ARARs – Applicable or relevant and appropriate requirements. Refers to the federal and state requirements that a selected remedy will attain.

Attenuation – The process by which a compound is reduced in concentration over time, through absorption, adsorption, degradation, dilution, and/or transformation.

Characterization – The compilation of available data about the waste site to determine the rate and extent of contaminant migration resulting from the site, and the concentration of any contaminants that may be present.

Chemicals of Concern (COCs) – Those chemicals that significantly contribute to a pathway in an exposure model of a hypothetical receptor (e.g., a child that resides on a site). They exceed either the calculated numerical limit for cumulative site carcinogenic risk (1 in 10,000 exposed individuals) or the calculated numerical limit of 1 for non-carcinogenic effects, a value proposed by the USEPA.

Chemical of Potential Concern (COPCs) – Those chemicals that are identified as a potential threat to human health or the environment and are evaluated further in the baseline risk assessment. COCs are a subset of the COPCs that are identified in the Remedial Investigation/Feasibility Study as needing to be addressed by the response action proposed in the Record of Decision.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – CERCLA was enacted by Congress in 1980 and was amended by the Superfund Amendments and Reauthorization Act in 1986. CERCLA provides federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites and established the Superfund Trust Fund.

Contaminant Plume – A column of contamination with measurable horizontal and vertical dimensions that is suspended and moves with groundwater.

Exposure – Contact of an organism with a chemical or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut) and available for absorption.

Glossary of Terms (continued)

Federal Facility Agreement – A binding legal agreement among USEPA, TCEQ, and U.S. Army that sets the standards and schedules for the comprehensive remediation of Longhorn Army Ammunition Plant.

Groundwater – Underground water that fills pores in soil or openings in rocks to the point of saturation.

Human Health Risk Assessment – A study conducted as part of a remedial investigation to determine the risk posed to human health by site-related chemicals.

Maximum Contaminant Level (MCL) – The maximum contaminant level is the maximum permissible level of a contaminant in a public water system. MCLs are defined in the Code of Federal Regulation (40 CFR 141, National Primary Drinking Water Regulations, which implement portions of the Safe Drinking Water Act). The TCEQ has adopted MCLs as the regulatory cleanup levels for both industrial and residential uses. Any detected compound in the groundwater samples with a MCL was evaluated by comparing it to its associated MCL.

National Priorities List (NPL) – The USEPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. USEPA is required to update the NPL at least once a year. A site must be on the NPL to receive money from the Trust Fund for remedial action.

Organic Compounds – Carbon compounds such as solvents, oils, and pesticides. Most are not readily dissolved in water.

Record of Decision – A legal document presenting the remedial action selected for a site or operable unit. It is based on information and technical analyses generated during the remedial investigation/feasibility study process and consideration of public comments on the proposed plan and community concerns.

Remedial Investigation – A study designed to gather data needed to determine the nature and extent of contamination at a Superfund site.

Resource Conservation and Recovery Act (RCRA) – Gives USEPA the authority to control the generation, transport, treatment, storage, and disposal of hazardous waste. RCRA focuses only on active and future facilities and does not address abandoned or historical sites.

Glossary of Terms (continued)

Responsiveness Summary – A summary of oral and/or written comments received during the proposed plan comment period, including responses to these comments. The responsiveness summary is a key part of a ROD highlighting community concerns.

Proposed Plan – A plan for a site cleanup that proposes a recommended or preferred remedial alternative. The Proposed Plan is available to the public for review and comment. The preferred alternative may change based on public and other stakeholder input.

Superfund Amendments and Reauthorization Act (SARA) – Amended CERCLA in 1986. SARA resulted in more emphasis on permanent remedies for cleaning up hazardous waste sites, increased the focus on human health problems posed by hazardous waste sites, and encouraged greater citizen participation in making decisions on how sites should be cleaned up.

Surface Media – The soil (surface or subsurface), surface water, and sediment present at a site as applicable.

Superfund – The common name used for CERCLA; also referred to as the Trust Fund. The Superfund Program was established to help fund cleanup of hazardous waste sites. It also allows legal action to force those responsible for sites to clean them up.

Appendix A

Public Meeting Newspaper and Media Notices

PUBLIC NOTICE
THE UNITED STATES ARMY INVITES PUBLIC COMMENT ON THE PROPOSED PLAN FOR ENVIRONMENTAL SITE LHAAP-17
LONGHORN ARMY AMMUNITION PLANT, TEXAS
PUBLIC MEETING AT KARNACK COMMUNITY CENTER JUNE 29, 2010

The U.S. Army is the lead agency for environmental response actions at Longhorn Army Ammunition Plant (LHAAP). In partnership with Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency Region 6, the U.S. Army has developed the Proposed Plan for NPL site LHAAP-17. Although the Proposed Plan for LHAAP-17 identifies the preferred remedy for the site, the U.S. Army welcomes the public's review and comments. The public comment period is June 10, 2010 through July 10, 2010. The public meeting will be held on June 29, 2010 at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas. Questions, comments, and responses on the Proposed Plan will be recorded by a court reporter during the public meeting. Copies of the Proposed Plan and supporting documentation are available for public review at the Marshall Public Library, 300 S. Alamo, Marshall, Texas, 75670. A summary of the site, including a discussion of various alternatives that were evaluated, are provided below.

Longhorn Army Ammunition Plant (LHAAP) is an inactive, government-owned, formerly contractor-operated and -maintained industrial facility located in central-east Texas in the northeastern corner of Harrison County. The installation occupies nearly 8,416 acres between State Highway 43 at Karnack, Texas, and the western shore of Caddo Lake. LHAAP was established in December 1941 near the beginning of World War II for the manufacture of trinitrotoluene. Other past industrial operations at the installation included the use of secondary explosives, rocket motor propellants, and various pyrotechnics, such as illuminating and signal flares and ammunition.

LHAAP-17, Burning Ground No. 2/Flashing Area, is located in the west-central portion of LHAAP and covers an area of approximately 3.9 acres. The site was used as a burning ground from 1959 through 1980 and as a flashing area to decontaminate recoverable metal byproducts. Four alternatives were evaluated for addressing the contaminated soil and groundwater at the site: 1) no action; 2) excavation and off-site disposal for soil; monitored natural attenuation (MNA) and land use controls (LUCs) for groundwater; 3) excavation and off-site disposal for soil; in situ bioremediation; MNA and LUCs for groundwater; and 4) excavation and off-site disposal for soil; groundwater extraction, MNA and LUCs for groundwater. Based on available information, the preferred remedy is alternative 4 which would remove contaminated soil from LHAAP-17 with off-site disposal; reduce groundwater contamination throughout the shallow zone groundwater contaminant plume via groundwater extraction; MNA to assure protection of human health and the environment by documenting that the contaminated groundwater remains localized and that contaminant concentrations are being reduced to MCLs; and LUCs to protect human health by preventing human exposure to contaminated groundwater.

For further information or to submit written comments, contact: Dr. Rose M. Zeiler, Longhorn Army Ammunition Plant, P.O. Box 220, Ratcliff, Arkansas, 72951; phone number 479-635-0110 or e-mail rose.zeiler@us.army.mil.

MEDIA RELEASE

The United States Army has prepared a Proposed Plan for the environmental site LHAAP-17, Burning Ground No. 2/Flashing Area, at the Longhorn Army Ammunition Plant. The Proposed Plan is the document that describes LHAAP-17 and its proposed remedies. The Proposed Plan was developed to facilitate public involvement in the remedy selection process.

Copies of the Proposed Plan and other supporting documentation for LHAAP-17 are available for public review at the Marshall Public Library, 300 S. Alamo, Marshall, Texas, 75670. The public comment period is June 10, 2010 through July 10, 2010.

A public meeting will be held on June 29, 2010, from 6:00 to 8:00 p.m. at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas, 75661.

All written public comments on the Proposed Plan must be postmarked on or before July 10, 2010. Written comments may be provided to Dr. Rose M. Zeiler, Longhorn Army Ammunition Plant, P.O. Box 220, Ratcliff, Arkansas, 72951, or e-mailed to rose.zeiler@us.army.mil. E-mailed comments must be submitted by close of business on July 10, 2010.