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

August 17, 2022

DAIN-ODB-LO

Mr. Brian Follin
U.S. Environmental Protection Agency
Federal Facilities Section R6
1201 Elm Street, Suite 500
Dallas, TX 75202-2102

Re: Revised Final Record of Decision for LHAAP-47, Plant 3 Area, Solid Rocket Motor Fuel Production, April 2022, Longhorn Army Ammunition Plant, Karnack, Texas

Dear Mr. Follin
Enclosed please find the April 2022 LHAAP-47 Record of Decision (ROD) for your records. This is the final ROD and includes the completed signature page with Army and EPA signatures, and the TCEQ concurrence.

The point of contact for this action is the undersigned. I may be contacted at 571-403-3232, or by email at rose.m.zeiler.ctr@army.mil.

Sincerely,

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

One Enclosure
Copies furnished:

A. Palmie, TCEQ, Austin, TX (1 electronic only)
P. Bruckwicki, Caddo Lake NWR, TX (1 hard copy, 1 CD)
A. Williams, USACE, Tulsa District, OK (1 electronic only)
C. Montoya, USAE, Tulsa District OK (1 electronic only)
L. Sierocinski, USAEC, San Antonio, TX (1 electronic only)
M. Bowlby, USAEC, San Antonio, TX (1 electronic only)

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

August 17, 2022

DAIN-ODB-LO

Ms. April Palmie
Texas Commission on Environmental Quality
Remediation Division
12100 Park 35 Circle, Bldg D
Austin, TX 78753

Re: Revised Final Record of Decision for LHAAP-47, Plant 3 Area, Solid Rocket Motor Fuel Production, April 2022, Longhorn Army Ammunition Plant, Karnack, Texas

Dear Ms. Palmie,

Enclosed please find the April 2022 LHAAP-47 Record of Decision (ROD) for your records. This is the final ROD and includes the completed signature page with Army and EPA signatures, and the TCEQ concurrence.

The point of contact for this action is the undersigned. I may be contacted at 571-403-3232, or by email at rose.m.zeiler.ctr@army.mil.

Sincerely,

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

One Enclosure
Copies furnished:

B. Follin, USEPA Region 6, Dallas, TX (1 electronic only)
P. Bruckwicki, Caddo Lake NWR, TX (1 hard copy, 1 CD)
A. Williams, USACE, Tulsa District, OK (1 electronic only)
C. Montoya, USAE, Tulsa District OK (1 electronic only)
L. Sierocinski, USAEC, San Antonio, TX (1 electronic only)
M. Bowlby, USAEC, San Antonio, TX (1 electronic only)

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

June 23, 2022

Mr. Richard C. Ramsdell
Chief, Base Realignment and Closure Branch
Installations Services-Environmental Division (DAIN-ISE)
Office of the Deputy Chief of Staff, G-9
Suite 1400 Taylor Bldg/NC3
2530 Crystal Drive
Arlington, Virginia 22202

Re: Record of Decision for LHAAP-47, Plant 3 Area, Solid Rocket Motor Fuel Production, Longhorn Army Ammunition Plant Federal Superfund Site TX6213820529
Karnack, Harrison County, Texas

Dear Mr. Ramsdell:

The Texas Commission on Environmental Quality (TCEQ) received the final Record of Decision for LHAAP-47, Plant 3 Area, Solid Rocket Motor Fuel Production, Longhorn Army Ammunition Plant Federal Superfund Site in Karnack, Texas on June 1, 2022. The TCEQ has completed the review of the above referenced document and concurs that the described action is appropriate.

Sincerely,

Toby Baker
Executive Director

cc: Ms. Lisa Price, Acting Director, Superfund and Emergency Management Division, US Environmental Protection Agency, Region 6, 1201 Elm Street, Suite 500, Dallas, TX 75270

Revised Final

Record of Decision

for LHAAP-47,
Plant 3 Area,
Solid Rocket Motor Fuel Production
Longhorn Army Ammunition Plant
Karnack, Texas

April 2022

Prepared For:

U.S. Army Corps of Engineers – Tulsa District

Prepared By:
HDR
9871 S. Meridian Blvd, Suite 400
Englewood, CO 80112

Contract No. W912BV-15-D-0014
Task Order No. W912BV18F0023

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REVISED FINAL

RECORD OF DECISION

FOR

LHAAP-47, PLANT 3 AREA, SOLID ROCKET MOTOR FUEL PRODUCTION

LONGHORN ARMY AMMUNITION PLANT

KARNACK, TEXAS

Prepared For:

U.S. Army Corp of Engineers - Tulsa District

Prepared By:

HDR, Inc.
9871 S. Meridian Blvd, Suite 400
Englewood, CO 80112

Contract No. W912BV-15-D-0014
Task Order No. W912BV18F0023

April 2022

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Appendix A: Public Notice Affidavits

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Acronyms and Abbreviations

amsl	Above mean sea level
ARAR	applicable or relevant and appropriate requirement
BCM	BCM Engineers, Inc.
BEHP	bis(2-ethylhexyl)phthalate
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
Cis-1,2-DCE	Cis-1,2-dichloroethene
COC	contaminant of concern
COPC	chemical of potential concern
COPEC	chemicals of potential ecological concern
CSM	Conceptual Site Model
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
2,4-DNT	2,4-dinitrotoluene
2,6-DNT	2,6-dinitrotoluene
DNAPL	Dense non-aqueous phase liquid
DPT	direct push technology
ECP	Environmental condition of Property
ELCR	excess lifetime carcinogenic risk
EPS	Environmental Protection Systems, Inc.
ERH	Electrical Resistance Heating
ESD	Explanation of Significant Differences
EVO	emulsified vegetable oil
FFA	Federal Facility Agreement
GWP-Ind	groundwater protection for industrial use
GWTP	groundwater treatment plant
HDR	HDR Environmental, Operations and Construction, Inc.
HI	hazard index
HQ	hazard quotient
ISB	in-situ bioremediation
ISTD	In-situ thermal desorption
Jacobs	Jacobs Engineering Group, Inc.
LHAAP	Longhorn Army Ammunition Plant
LTM	long-term monitoring
LUC	Land Use Control
Lynntech	Lynntech, Inc.
MCL	maximum contaminant level
mg/kg	Milligrams per kilogram

mg/L	Milligrams per liter
MNA	monitored natural attenuation
MOA	Memorandum of Agreement
MSC	medium specific concentration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
PCE	tetrachloroethene
PCL	Protective Concentration Level
Plexus	Plexus Scientific Corporation
PSI	Post Screening Investigation
PW	Present Worth
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RfD	reference dose
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
sf	Square foot/feet
Shaw	Shaw Environmental, Inc
STEP	Solutions To Environmental Problems
SVOC	semi-volatile organic compound
TAC	Texas Administrative Code
TCA	trichloroethane
TCDD	tetrachlorodibenzodioxin
TCE	trichloroethylene
TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
TEQ	Total equivalent concentration
2,4,6-TNT	2,4,6-trinitrotoluene
trans-1,2-DCE	Trans-1,2-dichloroethene
TRRP	Texas Risk Reduction Program
U.S.	United States
U. S. C.	United States Code
U.S. Army	U.S. Department of the Army
USACE	U.S. Army Corps of Engineers
USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

VC	vinyl chloride
VOC	volatile organic compound
µg/L	micrograms per liter

1. The Declaration

1.1 Site Name and Location

Longhorn Army Ammunition Plant-47 (LHAAP-47), Plant 3 Area - Solid Rocket Motor Fuel Production, Longhorn Army Ammunition Plant, Karnack, Texas.

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

1.2 Statement of Basis and Purpose

This Record of Decision (ROD) presents the selected remedy for LHAAP-47, Plant 3 Area, located at the 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, 42 United States Code (U.S.C.) §§ 9601 et seq., and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), Code of Federal Regulations (CFR) Title 40 §§300 et seq.

The remedy selection was based on the work completed and documented in the Administrative Record for the site, including the Remedial Investigation (RI) (Jacobs Engineering Group, Inc. [Jacobs], 2002), Baseline Human Health and Screening Ecological Risk Assessment report (Jacobs, 2003), Feasibility Study (FS) (Shaw Environmental, Inc. [Shaw], 2011), Proposed Plan (PP) (AECOM Technical Services, Inc. [AECOM], 2012), Revised PP (HDR, 2021a), Post Screening Investigation (PSI) for LHAAP-47 (HDR, 2019a), PSI No. 2 Addendum Report (HDR, 2021b), and other related documents contained in the Administrative Record for LHAAP-47.

This document is issued by the U.S. Department of the Army (U.S Army), the lead agency for this installation. The U.S. Army, USEPA, and the Texas Water Commission (currently known as the Texas Commission on Environmental Quality [TCEQ]) entered into the Federal Facilities Agreement (FFA) for remedial activities at LHAAP which, became effective on December 30, 1991. The USEPA (Region 6) and the TCEQ are the regulatory agencies providing technical support, project review and comment, and oversight of the LHAAP cleanup program. The USEPA and the U.S Army jointly select the remedy and TCEQ concurs with the selected remedy in this 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 final selected remedy for LHAAP-47 includes excavation of perchlorate impacted soil, and the treatment of contaminated groundwater by in-situ thermal desorption (ISTD), enhanced in-situ bioremediation (ISB), biobarriers, and monitored natural attenuation (MNA). Land use controls (LUCs) will be implemented until soil and groundwater contaminants are reduced to unlimited use and unrestricted exposure concentrations. The LUC's performance objectives consist of land use restrictions to nonresidential and prohibition of potable use of groundwater above cleanup levels until the contaminants of concern (COCs) are at levels that allow for unlimited use and unrestricted exposure.

The final selected remedy for LHAAP-47 protects human health and the environment by preventing perchlorate and trichloroethylene (TCE) in soil from migrating to groundwater, and perchlorate in surface soil from migrating by overland transport (i.e., erosion and storm water flow) into surface water (Goose Prairie Creek that runs through the southwest portion of LHAAP-47 site and then curves back through the southeastern portion of the site); preventing human exposure to unacceptable concentrations of contaminants in groundwater; by returning the groundwater to its potential beneficial use, wherever practicable; and preventing groundwater contaminated with COCs from migrating into nearby surface water (Goose Prairie Creek). Residual TCE Dense Non-aqueous Phase liquid (DNAPL) acting as a source material in shallow and upper intermediate zone groundwater near Building 46A may be considered a principal threat waste.

The human health risk scenario evaluated was based on risk to the hypothetical future maintenance worker. The COCs identified for soil and groundwater are listed below:

- Soil: Perchlorate in soil is a potential residual source for contamination to groundwater and surface water. Perchlorate in soil near Building 25C extends from the surface to approximately 10 feet below ground surface (bgs). TCE in soil is a potential residual source for contamination to groundwater. Perchlorate in soil does not pose a risk to the hypothetical future maintenance worker. Although TCE in soil was not evaluated for risk due to the depth at which it occurs (greater than 10 feet bgs), there is little or no potential for direct human exposure to the contaminated soil.
- Groundwater: The COCs are perchlorate; volatile organic compounds (VOCs) (tetrachloroethene [PCE], trichloroethylene [TCE], cis-1,2-dichloroethene [cis-1,2-DCE], trans-1,2-dichloroethene [trans-1,2-DCE], vinyl chloride [VC]), 1,1-dichloroethene [1,1-DCE], 1,2-dichloroethane [1,2-DCA], acetone, chloroform); explosives (2,4,6- trinitrotoluene [TNT]), 2,4-dinitrotoluene [DNT], 2,6-DNT); semi-volatile organic compounds (SVOCs) (bis(2-ethylhexyl)phthalate [BEHP], pentachlorophenol); and metals (aluminum, antimony, arsenic, cadmium, chromium, cobalt, manganese, nickel, silver, strontium, thallium, tin and vanadium).

Historical surface water sampling prior to the RI and prior to placement of the liner around Building 25C indicated perchlorate had seeped into Goose Prairie Creek at concentrations exceeding cleanup levels. Since installation of the liner, no perchlorate has been detected at concentrations exceeding surface water standards in samples collected from Goose Prairie Creek. As part of the selected remedy, surface water will be monitored only for those chemicals (VOCs and perchlorate) contributing to the primary risk in soil and groundwater to verify that the surface water remains unaffected by potential migration of COCs from soil and groundwater.

The components of the selected remedy are summarized below.

- Excavation of perchlorate-contaminated soil. Approximately, 9,000 cubic yards of perchlorate-contaminated soil as estimated from historical sampling results will be removed from a location near the former Building 25C, along with confirmation sampling and step-out excavation to achieve Remedial Action Objectives (RAOs).

- The residual TCE DNAPL in groundwater and TCE in soil near Building 46A will be treated using ISTD. Electrical Resistance Heating (ERH) technology is the type of ISTD that will be used. An ERH system consisting of subsurface electrodes connected to direct current through the subsurface, with a vapor extraction system to capture the volatilized water and contaminants will be installed within the areas of residual DNAPL. ISB may be implemented following the ISTD treatment if VOC concentrations in groundwater are considered too high to be addressed only through MNA. The soil conditions will be evaluated following ISTD and if required, a contingency remedy developed and implemented to complete soil remediation.
- ISB will be implemented to address COCs in the saturated zone (shallow, and intermediate zone groundwater). ISB will be implemented via two application methods as follows:
    - Area in the 'secondary source' area near Building 46A following ISTD treatment if needed, and additional locations, if necessary, will be treated using ISB via application of substrate in a grid pattern; and
    - Areas near the leading edges of the northern and southern perchlorate and VOC plumes will be treated using ISB via application of substrate in the form of biobarriers. This will be accomplished with closely spaced injections. Multiple applications of substrate may be needed based on effectiveness of the ISB. Bioaugmentation will be performed as necessary.
- MNA will be implemented to monitor reduction/degradation of COCs in groundwater outside of the influence of the ISB treatment areas and to confirm protection of human health and the environment by documenting that contaminated groundwater remains localized with minimal migration and that COCs are being reduced to cleanup levels.
    - Performance objectives will be evaluated after two years of MNA. During those two 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 three 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.
    - If MNA is found to be ineffective, a contingency remedy to enhance MNA will be developed. The contingency remedy would consist of injection of bioremediation amendments to enhance degradation of the groundwater contaminants at selected locations based on data available at the time it is determined MNA is not successful. Development and specific description of the contingency remedy will be presented in a Remedial Design/Remedial Action Work Plan (RD/RAWP).
- LTM to confirm the protection of human health and the environment by documenting the return of the groundwater to the cleanup level (maximum contaminant level [MCL] or, in the absence of federal drinking water standards, the Texas Risk Reduction Program (TRRP) Tier 1 Residential Groundwater Protective Concentration Levels (PCLs), by documenting reduction of the contaminant mass and protection of surface water through containment of the plume.
- Groundwater monitoring will be conducted to evaluate inorganic COCs and other COCs that have either not previously shown exceedances of cleanup levels or have infrequently or only

historically exceeded cleanup levels specified in Table 2-8. The need to continue groundwater monitoring for this purpose will be evaluated at five-year reviews or in some cases after two additional sampling events in which results remain below cleanup levels specified in **Table 2-8**.

- Surface water monitoring to confirm that surface water quality standards for those chemicals (VOCs and perchlorate) contributing to the primary risk in soil and groundwater are not exceeded in Goose Prairie Creek. The surface water quality standards are found in the Texas Administrative Code (TAC) for the TCEQ environmental quality standards at 30 TAC 307.6.(d)(1), or if those standards are not available, the TRRP Tier 1 Residential Groundwater PCLs will be used.
- The LUC's 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 when these 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 ensure 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 LUC Management Plan, Former Longhorn Army Ammunition Plant, Karnack, Texas" and detailed in the LUC RD[1].
- 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 2-8**) 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 RD. 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[2]. The preliminary boundary for the groundwater and land use LUC is shown on **Figure 2-11**. [2]

---

[1] This paragraph is October 31, 2014 Dispute Decision language that is included despite the ROD not being subject to the dispute.

[2,3] Ibid.

- The LUC restricting land use to nonresidential shall be implemented until it is demonstrated that surface and subsurface soil and groundwater COCs are at levels that allow for unlimited use and unrestricted exposure[2].
- The LUC to maintain the integrity of any current or future remedial or monitoring systems will remain in place until the levels of COCs 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 2-8**) in soil and groundwater allow for unlimited use and unrestricted exposure[2].

CERCLA five-year reviews will be performed until the levels of COCs in soil and groundwater allow for unlimited use and unrestricted exposure.

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.[3]

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.[1] Although Army may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the Army shall retain ultimate responsibility for remedy integrity.

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 the 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.[1]

U.S. Army and regulators will consult to determine appropriate enforcement actions should there be a failure of a LUC objective at the site 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. Thus, the implementation of this remedy at LHAAP-47 is independent of any other remedial action at LHAAP to address human health issues. To address ecological risk, LHAAP-47 was grouped with several other sites as part of the Industrial Sub-Area. The Baseline Ecological Risk Assessment (BERA) concluded that no unacceptable risk was present in the Industrial Sub-Area (Shaw, 2007a) and therefore, no further action is needed at LHAAP-47 for the protection of ecological receptors. This management strategy is considered to be endorsed by regulators as evidenced by the regulatory approval of the BERA (Shaw, 2007a) and BERA Addendum (AGEISS, 2014).

The selected remedy at LHAAP-47 is identified in the Proposed Plan (AECOM, 2012) and Revised Proposed Plan (HDR, 2021a) that has been reviewed and approved by the regulatory agencies. The Proposed Plan and Revised Proposed Plan are in the Administrative Record file for LHAAP.

1.5 Statutory Determinations

The final-selected remedy is protective of human health and the environment, complies with Federal and State requirements that are established as applicable or relevant and appropriate requirements (ARARs) for the remedial action, and is cost-effective. In addition, the remedy offers long-term effectiveness through excavation of perchlorate-contaminated soil and the implementation of groundwater ISB, which will reduce or eliminate the potential for contamination migration from soil and groundwater into surface water, ISTD to remediate the TCE in soil and residual TCE DNAPL in groundwater near Building 46A and reduce or eliminate the potential for soil contamination migration to groundwater, and LUCs to minimize the potential risk to the hypothetical future maintenance worker posed by the contaminated groundwater. Furthermore, performance monitoring will document the progress and effectiveness of the final selected remedy. The final selected remedy is easily and immediately implementable. The ISTD, ISB and biobarrier components of the selected remedy satisfy the statutory preference for treatment as a principal treatment element of the remedy.

Because hazardous substances, pollutants, or contaminants may remain at the site above levels that allow for unlimited use and unrestricted exposure, reviews will be conducted every 5 years as required under CERCLA, 42 United States Code (U. S. C.) §121(c), U. S. C. §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 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 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 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 site 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 the COCs and the basis for these levels (Sections 2.7.4 and 2.8).
- How contaminated soil and groundwater constituting principal threats are 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 (PW) 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-47 which documents the final selected remedy. The undersigned is the appropriate approval authority for this decision.

RAMSDELL.RICHARD.C.1161451408 Digitally signed by RAMSDELL.RICHARD.C.1161451408 Date: 2022.06.22 08:33:24 -04'00'

(Name) *(Date)*

Richard C. Ramsdell, Chief
Base Realignment and Closure Branch
Installation Services Directorate, DCS, G-9
Office of the Deputy Chief of Staff
U.S. Army

The United States Environmental Protection Agency approves the selected remedy as provided in the ROD for LHAAP-47.

LISA PRICE Digitally signed by LISA PRICE Date: 2022.07.19 16:03:09 -05'00'

(Name) *(Date)*

Lisa Price
Acting Director
Superfund and Emergency Management Division
U.S. Environmental Protection Agency
Region 6

2. Decision Summary

2.1 Site Name, Location, and Description

LHAAP-47, Plant 3 Area, Solid Rocket Motor Fuel Production 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 USEPA 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 42 U. S. C. §9620 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, not including LHAAP-47, 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-47 (Plant 3 Area) is located in the north-central portion of LHAAP and covers an area of approximately 275 acres. LHAAP-47 is bounded by LHAAP-46 to the north, Karnack Avenue to the east, Marshall Avenue to the south, and Avenue "P" to the west. LHAAP-6 and LHAAP-7 are within the LHAAP-47 boundary. LHAAP-35B (37) is to the southwest of LHAAP-47, and LHAAP-50 and LHAAP-8 are to its south. **Figure 2-2** shows the site vicinity map.

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. 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.

LHAAP-47 was identified through historical records as Plant 3, producing rocket motors and later pyrotechnic and illumination devices. Construction of Plant 3 began in July 1953 and production of rocket motors began in December 1954. Rocket motor production continued until the early 1980s. Some of the rocket motor production facilities were converted to produce pyrotechnic and illumination devices and were active until approximately 1997. Industrial solid wastes and possibly hazardous wastes, such as parts cleaners and spent solvents, may have been generated by these activities. Fifty waste process sumps and three waste rack sumps were located within LHAAP-47 that are included in LHAAP-35/36 along with sumps from other sites.

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, the U.S. Army Toxic and Hazardous Materials Agency 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).
- In 1982, as part of the LHAAP contamination survey, Environmental Protection Systems, Inc. (EPS) 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. Units requiring further sampling, investigation and corrective action were delineated (USAEHA, 1987).
- In 1988, a preliminary RCRA Facility Assessment was conducted by the U.S. Army (Maley,1988). Waste at the various sites was characterized, but no samples were collected.

The environmental media (soil, groundwater, surface water, sediment, and sump contents) at LHAAP-47 have been the subject of numerous investigations to identify potential contamination, including:

- Pre-RIs (EPS, 1984, BCM Engineers, Inc. (BCM), 1992), and by the U.S. Army Corps of Engineers (USACE) in 1993 (USACE, 1994).
- Phase I, Phase II, and Phase III RIs in 1993, 1995, and 1998 (Jacobs, 2002), and additional RI related investigations in 1996, 1999, 2000, and 2001.
- In November 1999, plastic liner material was placed around Building 25C by the U.S. Army over areas known to contain perchlorate in the soil to prevent migration of perchlorate to Goose Prairie Creek (Shaw, 2011). The extent of the liner is noted in the site-wide perchlorate investigation report written by Solutions To Environmental Problems (STEP, 2005).

- In September 2001 Lynntech, Inc. (Lynntech) collected soil samples at Building 25C and analyzed them for perchlorate. A total of 20 samples were collected from 5 locations over a distance spanning 35 feet (Shaw, 2011).
- A site-wide perchlorate investigation in 2002 (Solutions to Environmental Problems, Inc. (STEP) STEP, 2005), and the Environmental Site Assessment conducted in 2003 (Plexus Scientific Corporation (Plexus) Plexus, 2005).

Several follow-up investigations at LHAAP-47 were performed by USACE to further delineate the extent of contamination identified during the previous sample events. These sample events include:

- A data gaps investigation in the spring and summer of 2004 (Shaw, 2007b); 2006 soil samples for the final evaluation of sumps (Shaw, 2008).
- In 2007 groundwater samples were collected from five wells for natural attenuation evaluation, and from 25 wells for analysis of metals, perchlorate, or VOCs. Additional groundwater samples were collected from 11 wells in 2009. In 2010, soil samples were collected from 28 locations around Building 25C and Building 25D and tested for perchlorate. At that time, groundwater samples were also collected from 26 wells and tested for VOCs, perchlorate, and other parameters (Shaw, 2011).
- The BERA was completed in February 2007 (Shaw, 2007a). The BERA concluded there is no ecological impact in the industrial sub area, which includes LHAAP-47.
- In July 2011, a FS was completed to evaluate remedial alternatives against CERCLA criteria to provide a basis for selecting a preferred alternative in the follow-on Proposed Plan and ROD documents (Shaw, 2011).
- Baseline Ecological Risk Assessment Addendum. After the BERA was completed in 2007, a BERA Addendum was completed (AGEISS, 2014). The results of the re-evaluation indicated that that the replacement data collected during the data gaps investigation confirmed the conclusions of the BERA that there are no ecological impacts within LHAAP-47.
- In December 2015, new plastic liner material was installed to repair exposed liner around Building 25C and emplacement of clean borrow soil to replace the eroded soil cover.
- Post-Screening Investigation (PSI) Report (HDR, 2019a). A PSI at LHAAP-47 was performed to re-assess and update the groundwater contaminant concentrations for the shallow and intermediate groundwater due to old and limited data (i.e., numerous dry shallow wells).
- A PSI Addendum. A Draft Final PSI Addendum (HDR, 2019b) was prepared to present the results of surface water sampling conducted in March and April 2019. The objective of the surface water sampling was to re-assess and update the LHAAP-47 groundwater contribution to surface water in Goose Prairie Creek.
- PSI No. 2 Report (HDR, 2021b). The initial PSI identified concentrations of TCE indicative of residual DNAPL near Building 46A that required additional investigation. The PSI No. 2 was conducted between November 2019 and July 2020 and the results defined the extent of residual TCE DNAPL in Shallow and Upper Intermediate Zone groundwater, and also

identified TCE in unsaturated soil that could be acting as a source for the groundwater contamination (HDR, 2021b). The PSI data was to be used to support revision of the 2013 Draft Final ROD, as necessary. The PSI was conducted at LHAAP-47 between April and September 2018 (HDR, 2019a) and the PSI No. 2 was conducted in November 2019 and April through September 2018, respectively (HDR, 2021b).

Figure 2-3 shows monitoring well locations at LHAAP-47.

2.2.3 History of CERCLA Enforcement Activities

Due to the releases of chemicals from facility operations, the USEPA placed LHAAP on the NPL on August 9, 1990. Activities to remediate contamination associated with the listing of LHAAP as a NPL 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, 42 U. S. C. §9620, FFA for remedial activities at LHAAP. The FFA became effective December 30, 1991.

The FS (Shaw, 2011), presenting an analysis of remedial alternatives for LHAAP-47, was issued in July 2011. The Proposed Plan (AECOM, 2012) was issued in December 2012. A ROD was prepared and completed to the Draft Final version in 2013. Subsequent to the Draft Final ROD, the PSI was completed as described previously (HDR, 2019a and 2021b), followed by a FS Addendum (HDR, 2021c) that identified additional technologies to address the changed groundwater and contaminant conditions near Building 46A. A Revised Proposed Plan (HDR, 2021a) was prepared to supplement the 2012 Proposed Plan. This Revised ROD follows that Proposed Plan and Revised Proposed Plan and precedes the more detailed RD document.

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-47 and other environmental sites at LHAAP. The outreach program has included fact sheets, media interviews, site visits, invitations to attend quarterly RAB meetings, and public meetings consistent with its public participation responsibilities under 40 CFR §113(k)(2)(B), §117(a), and 42. U. S. C. §9621(f)(1)(G) (CERCLA).

The Proposed Plan (AECOM, 2012) and Revised Proposed Plan (HDR, 2021a) for the selection of the remedy for LHAAP-47 was released to the Administrative Record and made available to the public for review and comment on December 21, 2012 and July 7, 2021 respectively. The notice of availability of the Proposed Plan and Revised Proposed Plan and other related documents in the Administrative Record file was published in the *Marshall News Messenger* on December 18, 2012 and July 4, 2021 respectively. The newspaper public notices for the meetings are provided in Appendix A. The public comment period for the Proposed Plan began on January 1, 2013, and ended January 31, 2013. A public meeting was held on January 9, 2013 in a formal format and with a court reporter. The public comment period for the Revised Proposed Plan began on July 7, 2021 and ended August 6, 2021. A public meeting was held on July 21, 2021 in a formal format and with a court reporter. The transcripts for the meetings are 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 at http://www.longhornaap.com/ and locally at the following location:

Location: Marshall Public Library 300 S. Alamo
Marshall, Texas, 75670
Business Hours: Monday - Friday, (9:30 AM – 5:30 PM)

2.4 Scope and Role of Response Action

A plastic liner was placed in 1999 around Building 25C over areas with known perchlorate contaminated soil providing a temporary measure to mitigate soil contaminant migration to surface water and the ground water.

This ROD addresses soil and groundwater contamination and is the final remedy for contamination at the LHAAP-47 site. The final selected remedy at LHAAP-47 will remove the residual soil sources and prevent migration of perchlorate in soil to surface water and groundwater, prevent migration of TCE in soil to groundwater, prevent groundwater contaminated with perchlorate from migrating into surface water, remediate the residual TCE DNAPL in groundwater near Building 46A, and mitigate potential risks associated with exposure of the hypothetical future maintenance worker to contaminated groundwater. The groundwater COCs are perchlorate, VOCs, SVOCs, explosives, and metals. The remedial action will include ISTD, ISB, biobarriers, MNA, LUCs and LTM.

The selected action at LHAAP-47 will prevent potential risks associated with exposure to contaminated groundwater. 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. However, when establishing the RAOs for this response action, the U.S. Army has considered the NCP's expectation to return usable groundwater to its potential beneficial uses wherever practicable in a timeframe that is reasonable given the particular circumstances of the site (40 CFR §300.430(a)(1)(iii)(F)). The U.S. Army 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 milligrams per liter (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-47 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). In the absence of federal drinking water standards, clean-up levels will be based on the Texas Risk Reduction Program (TRRP) Tier 1 Residential Groundwater PCL. For soil, 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 (40 CFR §300.430(a)(1)(iii)(F).

Historical surface water sampling prior to the RI and prior to placement of the liner around Building 25C indicated perchlorate had seeped into Goose Prairie Creek at concentrations exceeding cleanup levels. Since installation of the liner, no COCs from soil or groundwater have seeped into the surface water in Goose Prairie Creek. Because contaminated soil and groundwater has the potential to discharge to Goose Prairie Creek, surface water will be monitored only for those chemicals contributing to the primary risk (VOCs and perchlorate) in soil and groundwater to verify that the surface water remains unaffected by potential migration of COCs from soil and groundwater. Chemical-specific ARARs for surface water consumption are appropriate and relevant because of the potential for discharge to Goose Prairie Creek. The surface water standards in Goose Prairie Creek at LHAAP-47 are the Texas surface water quality standards found at 30 TAC 307.6.(d)(1), or if those standards are not available the TRRP Tier 1 Residential Groundwater PCLs.

The selected remedy will protect human health and the environment. The human receptor evaluated was the hypothetical future maintenance worker. ISTD, ISB, and biobarriers, in conjunction with MNA, will treat/remediate and reduce contaminant mass and lower contaminant concentrations in groundwater. The LUCs to be implemented include groundwater use restrictions and land use restrictions. The LUC restricting the potable use of groundwater above cleanup levels will remain in place until the levels of the COCs in groundwater allow for unlimited use and unrestricted exposure. The LUC restricting land use to nonresidential will remain in place until the levels of the COCs in soil and groundwater allow for unlimited use and unrestricted exposure. The selected remedy will also ensure that the contaminated surface soil and groundwater does not migrate into nearby surface water.

2.5 Site Characteristics

This section of the ROD presents a brief comprehensive overview of LHAAP-47 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, 2002).

2.5.1 Conceptual Site Model

Figure 2-4 illustrates the overall CSM for LHAAP-47. The model presents those pathways that are being considered for remediation. Those pathways that are likely to be incomplete or have negligible impact are not being considered for remediation as discussed below.

There are areas of highly contaminated groundwater at the site, including residual DNAPL near Building 46A, which may have resulted from releases from the former sumps or spills during site operations. All sumps at LHAAP-47 have been either removed or taken out of service and can no longer be a potential source of groundwater contamination. The pathway of leaching of soil contaminants into groundwater is a potential pathway. Perchlorate concentrations in the soil near Building 25C exceed the groundwater protection standard, and soil leaching may have contributed to the perchlorate contamination in the groundwater. The identification of TCE in soil near Building 46A indicates a potential source that may leach to the groundwater and may require remedial action. Metals, SVOCs, and VOCs have been detected in the groundwater at concentrations exceeding their respective MCLs or TRRP Tier 1 Residential Groundwater PCLs for chemicals that do not have USEPA MCLs. However, available data for metals, SVOCs, and VOCs other than TCE do not indicate the presence of associated soil contamination that may leach to the groundwater. Residual groundwater contamination from former sources, the residual TCE DNAPL near Building 46A, and the perchlorate-contaminated soil near Building 25C will be addressed as part of the remedial action.

Risks from exposure to soil were found to be acceptable. Overland surface water flow does not currently appear to be contributing to a migration of contaminants, as the ditch surface water did not contain VOCs, SVOCs, explosives, pesticides, or polychlorinated biphenyls. Likewise, the sediment data show no detections of VOCs, SVOCs, explosives, or pesticides. Some metals were detected in the surface water and sediment at low concentrations that occur naturally. Based on surface water sampling data from the RI and subsequent investigations, no contaminants, including perchlorate, have seeped into Goose Prairie Creek at concentrations exceeding their respective cleanup levels. Historical surface water sampling prior to the RI and prior to placement of the liner around Building 25C indicated perchlorate had seeped into Goose Prairie Creek at concentrations exceeding its cleanup level.

The surface soil to surface water migration pathway and groundwater to surface water migration pathway are considered potentially complete pathways due to the potential for the COCs in soil and groundwater to migrate into surface water.

While the groundwater to surface water migration pathway is not likely complete under current conditions, this pathway could potentially become complete should groundwater elevations rise in the future, as expected. Preventing contaminated groundwater from migrating into surface water is included as a RAO. Surface water monitoring will include only those chemicals contributing to the primary risk (VOCs and perchlorate) in soil and groundwater to determine if there are any exceedances of applicable surface water standards.

The soil to surface water migration pathway is not currently complete because a plastic liner placed as a temporary measure mitigates soil perchlorate migration to surface water. Goose Prairie Creek runs on the south side of LHAAP-47 and the perchlorate contaminated soil may be contributing to detections of perchlorate in surface water. Although perchlorate results for the surface water are below the contact recreational value of 395 micrograms per liter (µg/L) (TCEQ, 2007) and the TRRP Tier 1 Residential Groundwater PCL of 17 µg/L (established monitoring level for perchlorate in surface water), the soil to surface water pathway is considered complete for the purposes of the remedy due to the temporary nature of the plastic liner remedy now in place.

The migration pathway, soil to surface water, is not a likely pathway for the TCE in soil due to the depth of the contamination. Thus, the only soil pathway for TCE in soil near Building 46A considered for remediation is the potential migration to groundwater.

There is no present or projected future use of the groundwater at LHAAP-47. The reasonably anticipated future use of the site is a wildlife refuge. The hypothetical pathway considered for groundwater remediation is potential ingestion by the hypothetical future maintenance worker.

2.5.2 Overview of the Site

LHAAP-47 was identified in historical records as Plant 3 (or Plant 3 Area) and is located within an approximately 275-acre area in the north-central portion of the former plant. The surface features at LHAAP-47 are a mixture of asphalt-paved roads, parking areas, building foundation remnants, old buildings, and overgrown wooded and grassy vegetation-covered areas. The topography in this area is relatively flat with the surface drainage flowing into tributaries of Goose Prairie Creek. Runoff from the site enters Caddo Lake via Goose Prairie Creek.

2.5.3 Geology and Hydrogeology

The subsurface at LHAAP-47 appears to be characterized by layers of silty clay underlain by silty sand to clayey sands. These general soil types repeat throughout the subsurface but vary in thickness and continuity in the shallow and intermediate to deep surface zones, especially in the southern portion of LHAAP-47. Shallow, intermediate, and deep groundwater zones were initially defined during the RI. The shallow (10-35 feet below ground surface [bgs]), intermediate (40-60 feet bgs), and deep (70-95 feet bgs) saturated zones are in the Wilcox Group and are separated by clay layers that extend across the site (Jacobs, 2002). The shallow saturated zone is typically clay to silty clay at the surface underlain by a relatively thin (approximately 3-foot thick) layer of silty to poorly sorted sand that is present across the site. In the east-central portion of the site, the shallow saturated zone is underlain by thick, silty clay that separates the shallow zone from the underlying intermediate saturated zone (Jacobs, 2002).

During the PSI, the Shallow and Intermediate groundwater zones were revised or refined to reflect current conditions. The Shallow Zone currently occurs at depths between approximately 25 ft bgs and 32 ft bgs within the laminated clay/sand unit overlying the clay unit separating the Shallow Zone from the Upper Intermediate Zone. Shallow/Intermediate Zone wells were described in the PSI and have completion depths that generally range between 35 and 55 feet bgs. For development of both groundwater elevation maps and plume maps, Shallow/Intermediate Zone wells were included with Intermediate Zone wells. The Upper Intermediate Zone is the sandy unit underlying the sand-laminated clay Shallow Zone and clay unit separating the two zones.

Historically, monitoring wells with contamination at LHAAP-47 have been classified as being completed in three water bearing zones: Shallow, Shallow/Intermediate and Intermediate. Most shallow wells were dry during the 2019 PSI effort and 40-foot replacement wells were installed. Because the clay separating the Shallow and Intermediate Zones is laterally discontinuous and of varying thickness, some of the PSI wells drilled to replace dry Shallow Zone wells were completed partially in the first sand and into the clay (Shallow Zone) and others were completed partially in the clay separating the Shallow and Intermediate and into the sand of the Intermediate (Upper Intermediate). PSI Shallow Zone wells are located in two isolated areas, near Buildings 46A and 54F. Pre-existing well nomenclature for was not changed in the PSI report.

Wells installed during the PSI were completed to a depth of approximately 40 ft bgs, below the Shallow Zone sand and underlying clay aquitard and into the top of the Intermediate Zone. Wells installed at and/or below these depths are described as being completed in the Upper Intermediate Zone. The intermediate saturated zone is composed of silty sands, sandy clays, and poorly sorted sands that vary in thickness from 5 feet to 20 feet thick. The sand intervals are thickest in the central and southeast portions of LHAAP-47. The intermediate zone is underlain by a thick, silty clay layer overlying the sandy clay of the deep saturated zone (Jacobs, 2002).

Based on November-December 2007 and April 2008 groundwater elevations, the groundwater flow direction in the shallow saturated and intermediate zones below LHAAP-47 was generally to the northeast (Shaw, 2011). Groundwater elevations collected during the PSI confirmed the groundwater flow direction in the shallow saturated zone is to the northeast. Even though many of the historic shallow zone wells were dry, there were a sufficient number of wells with water to confirm the groundwater flow direction but there were too few wells with water present to prepare a potentiometric surface map. LHSMW53 was the only shallow zone well along the southern border of the site with measurable water in the 2019 PSI Report. The other well used to evaluate groundwater contribution to surface water, 08WW01, is located on the other side of Goose Prairie Creek in a different environmental site. See **Figure 2-3** for shallow zone groundwater elevation data for these wells. The groundwater flow direction in the intermediate zone was also found to flow to the northeast (**Figure 2-5**). The groundwater flow direction in the deep zone based on November-

December 2007 groundwater elevations is estimated to be to the north-northeast as shown on **Figure 2-6** (Shaw, 2011).

The base (bottom) of Goose Prairie Creek near the Site 47 southern border was measured at approximately 185 feet above mean sea level (amsl) during the PSI Addendum field investigation performed in March 2019 (HDR, 2019b). Groundwater elevations recorded at nearby monitoring wells (i.e., 08WW01 and LHSMW53) identified that groundwater was higher than the creek bottom and was likely contributing to surface water flow. Moving farther east along Goose Prairie Creek toward Caddo Lake and away from Site 47, a comparison of measurements taken of the creek bottom and nearby monitoring wells found groundwater elevations to be lower than the creek bottom elevations and not contributing to surface water flow.

Previous investigations found that shallow zone groundwater elevations (based on wells LHSMW54 and 47WW34) near the Goose Prairie Creek at Site 47 were between 175 and 180 feet amsl. The groundwater flow was generally towards Goose Prairie Creek; however, under drought conditions that occurred at that time, the groundwater elevations were several feet below the base of the creek bed. Under these previous low groundwater conditions, the interaction between surface water and groundwater at the site was that surface water would infiltrate through the vadose zone into the groundwater when water was present in Goose Prairie Creek (Shaw, 2011). In December 1998 and March 2002, groundwater elevations were higher than the Goose Prairie Creek bed (Shaw, 2011). Thus, the possibility exists that groundwater elevations can rise in the future and groundwater can discharge into the Goose Prairie Creek.

2.5.4 Sampling Events

Various sampling events were conducted at LHAAP-47 since 1993 to assess contamination. Testing for perchlorate began in 2000. The sampling included installation and sampling of surface water, groundwater monitoring wells and sampling of the soil at various depths and locations. The sampling events are summarized in **Table 2-1**.

Table 2-1. Summary of Sampling Events at LHAAP-47

Pre-Phase I (Jacobs, 2002)
EPS, 1984 • EPS installed 1 monitoring well and collected a groundwater sample.
Phases I-III (Jacobs, 2002)
USACE, Phase I 1993 • Collected sump content sample for laboratory analysis • Completed borings at sump locations and collected soil samples
USACE, Phase II 1994 • Collected soil samples from monitoring well locations and from ditch and drainage ways • Installed monitoring wells and collected groundwater samples from each well
USACE, Pre-Phase III 1996 • Determined locations for Phase III monitoring wells by delineating plume using site characterization and analysis penetrometer system (8 locations)
Jacobs, Phase III 1998 • Collected soil samples at waste process sump locations • Collected surface water and sediment samples • Collected soil samples from locations • Installed monitoring wells and collected groundwater samples from the new and existing wells

Table 2-1 Summary of Sampling Events at LHAAP-47 cont'd

Remedial Investigation (Jacobs, 2002)
• USACE collected 2 rounds of groundwater samples in 1996 (Jacobs, 2002) • In 1999 and 2000, collected soil samples for perchlorate and total petroleum hydrocarbons (Jacobs, 2002) • In 2000, installed and sampled 4 new monitoring wells and collected groundwater samples from existing wells (Jacobs, 2002) • In 2001, collected groundwater samples for perchlorate (Jacobs, 2002) • In 2001, collected soil samples for perchlorate investigation (Lynntech, 2001) • In 2002, collected soil samples as part of the perchlorate investigation (STEP, 2005) • In 2003, collected groundwater and soil samples at two locations as part of the Phase II Environmental Site Assessment (Plexus, 2005) • In 2004, installed 4 monitoring wells and collected groundwater samples for VOC analysis (Shaw, 2007b) • In 2006, collected additional soil samples from select sumps (Shaw, 2007a and 2008) • In 2007, installed 1 monitoring well and collected samples for natural attenuation evaluation and for geochemistry evaluation • In 2008, installed 4 monitoring wells and collected groundwater samples for VOC analysis • In 2009, collected additional groundwater samples for VOC analysis • In 2010, installed 2 monitoring wells and 18 temporary monitoring wells, collected additional groundwater samples for VOC, perchlorate, metals, SVOC, and MNA analysis, and collected additional soil samples for perchlorate analysis
Post-Screening Investigation Report (HDR, 2019a)
• Advancement of 11 direct push technology borings (DPT) into the intermediate zone and collection of groundwater grab samples for a combination of analyses that included VOCs, SVOCs, perchlorate, explosives, and/or metals. • Installation of 24 new or replacement wells and collection of groundwater samples for a combination of analyses that included VOCs, SVOCs, perchlorate, explosives, and/or metals. • Collection of synoptic water level measurements. • Well surveying. • Surveying of select creek bottom locations within Goose Prairie Creek and collection of surface water samples for VOC and perchlorate analyses.
Addendum Post-Screening Investigation (HDR, 2019b)
• Collection of 4 surface water grab samples for a combination of analyses that included VOCs and perchlorate.
• Collection of synoptic groundwater level measurements.
• Survey of Goose Prairie Creek bottom elevations.
• Collection of surface water quality parameters stopped
Post-Screening Investigation No. 2 Report (HDR, 2021b)
• Advancement of 27 DPT borings near Building 46A to depths between 31 and 51 bgs, and collection of 4-6 soil samples per boring for VOC analysis
• Installation of temporary wells at 27 locations near Building 46A. Side-by-side wells were installed and completed in the Shallow and Upper Intermediate Zones at 16 locations, Shallow Zone only wells installed at 11 locations. Groundwater grab samples were collected from each well for VOC analysis.
• Installation of 4 Shallow Zone, 3 Upper Intermediate Zone and 1 Intermediate Zone monitoring wells near Building 46A and collection of samples for VOC analysis.
• Abandonment of monitoring well 47WW25R
• Elevation surveys for all newly installed monitoring wells

2.5.5 Nature and Extent of Contamination

As shown in **Figure 2-7**, perchlorate contaminated soil is located near the former Building 25C and extends to depths of 10 ft with an estimated volume of 9,000 cubic yards. In November 1999 plastic liner material was placed around Building 25C by the U.S. Army over areas known to contain perchlorate in the soil to prevent migration of perchlorate into the Goose Prairie Creek. The primary objective of the liner placement was to mitigate perchlorate runoff to surface water as well as mitigate leaching of perchlorate in soil into groundwater. The liner placement provided a temporary measure to mitigate soil to surface water and soil to groundwater pathways. The liner was repaired in 2015 after a reconnaissance survey identified three areas where the topsoil cover was eroded. One area with exposed liner was repaired with new 16-mil liner and 6 inches of clean imported soil in 2015. The three eroded areas were approximately 1,200 square foot (sf), 400 sf, and 100 sf and were covered and leveled with clean topsoil, seeded with rye grass, and covered with erosion matting (Aaron Williams, personal communication, January 6, 2022).

Perchlorate, VOCs, SVOCs, TNT, 2,4-DNT, 2,6-DNT, and metals are the COCs that exceed the respective MCLs or in the absence of federal drinking water standards, the TRRP Tier 1 Residential Groundwater PCL. Perchlorate and TCE plumes exist in the groundwater at the LHAAP-47 site.

A PSI was conducted between 2018-2020 to determine whether changes to the groundwater and surface water conditions had occurred since 2010 and to evaluate impacts to the 2013 Draft Final ROD prior to signature. Although the conclusions of the FS (Shaw, 2011) were generally confirmed and the groundwater flow directions to the northeast remained relatively unchanged, the PSI reported that most Shallow Zone wells were dry and the locations and concentrations of perchlorate, VOCs, SVOCs, TNT, 2,4-DNT, 2,6-DNT, and metals had changed**.** Although extensive contamination remains at the site, most of the groundwater contamination now occurs within the Intermediate Zone. An extended drought in East Texas, exacerbated by the 1997 cessation of washdown activities (potentially acting as a source of recharge to the perched and shallow groundwater systems), likely caused a large portion of the Shallow Zone to go dry. As a result, the extent of VOC contamination is substantially reduced when compared to the 2010 results reported in the FS.

A significant PSI finding was the discovery of residual TCE DNAPL (assumed when the concentration of TCE is greater than 10,000 µg/L) in Shallow Zone and upper Intermediate Zone groundwater near Building 46A. Three areas of residual DNAPL were defined in the Shallow Zone and one larger area was defined in the Upper Intermediate Zone. The apparent separation of the Shallow Zone residual DNAPL was caused by some of the wells and DPT locations that appeared dry during sampling or did not recharge sufficiently to allow samples to be collected even though the depths were at or greater than 23 ft bgs, the depth assumed to represent the saturated zone. The residual DNAPL lies within the TCE plumes in each zone. In addition, TCE in unsaturated soil exceeding the GWP-Ind MSC of 0.5 mg/kg **(Figure 2-8**) was found near Building 46A, indicating TCE could act as a continuing source of contamination to groundwater. Exceedances ranged from 0.5 to 3.3 mg/kg except for the highest concentration of 16 mg/kg in one boring.

When comparing the PSI plume data to plume data presented in the FS (Shaw 2011), the overall extent of contamination in the Intermediate Zone is similar**.** The extent of the TCE plume in 2010 and that observed in the PSI data are similar, with the main difference being the older data has the plume split into separate northern and southeastern plumes. The highest concentration was noted at 47WW25R (120,000 µg/L). The southern perchlorate plume is bounded to the south by 50WW27, which is a well associated with site LHAAP-50, which lies south of LHAAP-47.

Plumes for TCE daughter products 1,1-DCE, cis-1,2-DCE, and VC generally follow the TCE plumes in shallow and intermediate zone groundwater and are entirely within the maximum extent of TCE.

The other COCs (SVOCs, TNT, 2,4-DNT, 2,6-DNT) in groundwater are isolated and do not indicate a widespread plume of contamination (Shaw, 2011).

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 occurred until the facility was determined to be in excess of the U.S. Army's needs in 1997. The majority of the former footprint of LHAAP is now maintained and operated as the Caddo Lake Wildlife Refuge and is largely accessible to the general public. Portions of LHAAP within the refuge still requiring remediation or maintenance are surrounded by fences and warning signs (except on the border with Caddo Lake) to preclude unlimited public access.

The Caddo National Wildlife Refuge was established in 2000 pursuant to a Memorandum of Agreement (MOA) (U.S. Army, 2004) between the USFWS and the U.S. Army. The reasonably anticipated future use of LHAAP-47 is as part of this national wildlife refuge. This anticipated future use is based on the MOA, the National Wildlife Refuge System Administration Act, the National Wildlife Refuge System Improvement Act of 1997, and other acts, regulations, and executive orders relevant to management of refuge lands. The 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-47. Presently the Caddo Lake National Wildlife Refuge occupies approximately 7,100 acres of the 8,416-acre former installation. In accordance with the National Wildlife Refuge System Administration Act of 1966, 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

Goose Prairie Creek, major drainage system on the LHAAP facility runs through the southwestern portion of LHAAP-47 and then curves back through the southeastern portion of the site. The topography of LHAAP-47 generally slopes to the east with surface drainage flowing to the east-southeast into Goose Prairie Creek, which flows into Caddo Lake. A wetland area is present just north of the intersection of Karnack Avenue and Marshall Avenue and runs along Goose Prairie

Creek toward Caddo Lake. Caddo Lake is a large recreational lake covering 51 square miles with a mean depth of 6 feet. The watershed of the lake encompasses approximately 2,700 square miles. Caddo Lake is used extensively for fishing and boating and provides drinking water supply to multiple cities/towns. The anticipated future uses of surface water 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) under and near LHAAP is currently used as a drinking water source. The drinking water aquifer should not be confused with LHAAP "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 known evidence of 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 (**Figure 2-2**). 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 0.3 miles northwest 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 **(Figure 2-2)**. One well is located at the Fire Station with a total depth of 128 feet and a screened interval from 58 to 128 feet bgs; 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 Caddo Lake National Wildlife Refuge, near the main entrance to LHAAP. These three water supply wells were completed at depths greater than the zone of contamination described at LHAAP-47. 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 national wildlife refuge does not include the use of the groundwater at LHAAP-47 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

This section summarizes the results of the Baseline Human Health and Screening Ecological Risk Assessments conducted for the Group 4 Sites (Jacobs, 2003) which included LHAAP-47 and the BERA (Shaw, 2007a). The assessments provide the basis for taking action and identify the COCs and exposure pathways that need to be addressed by the remedial action. It also addresses the impact of data collected after the Baseline Human Health Risk Assessment (BHHRA), including the PSI investigations conducted in 2018-2020.

2.7.1 Summary of Human Health Risk Assessment

The anticipated future use of the site is as a wildlife refuge; therefore, human health risks were calculated for industrial use by the future maintenance worker (Jacobs, 2003) in accordance with 30 TAC 335. The risk assessment was completed using data from groundwater samples collected through February 2001 and the soil samples through December 2000 (Jacobs, 2003). Since that time, additional groundwater and soil samples have been collected and analyzed. Results from the later investigations did not change the overall outcome of the risk assessment and are discussed in **Section 2.7.2** below.

Soil and groundwater data were used to calculate the aggregate risk values, which were then compared to the USEPA target risk range of 1×10^{-4} to 1×10^{-6} for the excess lifetime carcinogenic risk (ELCR) and to a hazard index (HI) of 1 for non-carcinogenic hazards. If there was no unacceptable risk associated with a medium, and a cleanup level for any contaminants is not exceeded, then that medium is not identified for remediation in this ROD. The CSM associated with the risk assessment was introduced in **Section 2.5.1**, and is presented as **Figure 2-4**.

2.7.1.1 <u>Exposure Assessment</u>

The human health risk and hazard to an on-site trespasser were evaluated under current site conditions for surface soil, surface water, sediment, and fish ingestion, and a hypothetical future maintenance worker was evaluated under an industrial scenario for soil and/or groundwater.

For the on-site trespasser, reasonable exposure pathways evaluated are: incidental ingestion of the surface soil (0 to 0.5 feet bgs), dermal contact with the surface soil, inhalation of particulates, and inhalation of VOCs from the soil (0 to 0.5 feet bgs). The Baseline Human Health Risk Assessment found that for the current trespasser, none of the exposure pathways contributed to carcinogenic risk or non-carcinogenic hazard, thus the current trespasser data is not included in **Tables 2-2 and 2-3** discussed in **Section 2.7.1.2**.

For the hypothetical future maintenance worker, reasonable soil exposure routes evaluated are: incidental ingestion of the surface soil (0 to 5 feet bgs), dermal contact with the surface soil, inhalation of particulates, and inhalation of VOCs from the soil (0 to 5 feet bgs). For groundwater, reasonable exposure pathways for the hypothetical future maintenance worker are ingestion of groundwater, dermal contact while showering with contaminated groundwater, and inhalation of VOCs while showering with contaminated groundwater.

2.7.1.2 <u>Identification of Chemicals of Potential Concern</u>

The human health risk assessment identified chemicals of potential concern (COPCs) for LHAAP-47 and evaluated the carcinogenic risk and non-carcinogenic hazard for each COPC. **Tables 2-2 and 2-3** summarizes the risk assessment data for the COPCs, including maximum detected concentrations, and exposure point concentrations.

2.7.1.3 <u>Toxicity Assessment</u>

The carcinogenic and non-carcinogenic toxicity assessments from the BHHRA are summarized in **Tables 2-4** and **2-5**, respectively. The toxicity data assumes that exposure will be chronic to be conservative. Sources for the data include the USEPA's Integrated Risk Information System, 2001, which is a database of human health effects that may result from exposure to various substances; and Health Effects Assessment Summary Tables (Jacobs, 2003).

2.7.1.4 Risk Characterization

Characterization of the carcinogenic risk and non-carcinogenic hazard are summarized in **Table 2-6.**

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. These risks are probabilities that usually are expressed in scientific notation. An ELCR 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 ELCR, because it will be in addition to the risks of cancer that individuals face from other causes such as smoking or exposure to too much sunlight. USEPA's generally acceptable risk range for site related exposures is 1×10^{-4} to 1×10^{-6}.

Non carcinogenic health effects are evaluated by calculating hazard quotients (HQs) and HIs. This is accomplished by comparing the EDIs of the COPCs, which are averaged over the period of exposure, to chemical and route-specific reference doses (RfDs). The RfD represents the daily intake of a chemical to which a person can be exposed over the given length of time without any reasonable expectation of adverse non-carcinogenic health effects.

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.

For the hypothetical future maintenance worker, the carcinogenic risk for soil (0-0.5 ft bgs) and groundwater are 1.8×10^{-5} and $7.1\text{x}10^{-3}$, respectively. The non-carcinogenic risk for soil and groundwater are 0.40 and 1,120, respectively (Jacobs, 2003).

2.7.2 Post Risk Assessment Data Evaluation

Since the risk assessment, additional soil and groundwater samples have been collected and analyzed, and the more recent results do not change the conclusions of the risk assessment (Shaw, 2011). Additional groundwater and surface water samples were collected during the PSI. The objective of the PSI data was to re-assess and update the groundwater contaminant concentrations for the shallow and intermediate groundwater due to old data and declining water levels and to evaluate the groundwater to surface water pathway.

The PSI soil and groundwater data collected near Building 46A between 2018 and 2020 showed VOC concentrations higher than previously reported. In particular, the high TCE concentrations discovered in groundwater indicate that the risk levels would also be higher than calculated in the BHHRA, however, the outcome is the same. The depth of TCE soil contamination near Building 46A is 10 ft bgs and greater and indicates there is no potential for direct human exposure. The remedial actions proposed for the site will address all of the groundwater and soil contamination, and additional risk evaluation was not performed.

This sampling is discussed below.

2.7.2.1 Soil

Additional soil samples were collected in September 2001 (Lynntech, 2001), during the perchlorate investigation in 2002 (STEP, 2005), during the sumps investigation in September 2006 (Shaw, 2008), during the BERA in November 2006 (Shaw, 2007a), and during soil sampling in 2010. Most of the additional results were less than the concentrations used in the risk assessment, but arsenic and perchlorate results were higher. The risk associated with the greatest perchlorate concentrations found in soil is less than the allowable HQ of 1 (Shaw, 2011). Similarly, the risk associated with the highest arsenic concentration found in soil is within the acceptable risk range of 10^{-6} to 10^{-4} and does not change the outcome of the human health risk assessment (Jacobs, 2003). The cancer risks and non-cancer hazards posed by soil, fall within the acceptable range.

Perchlorate was detected at a maximum concentration of 350 mg/kg in the soil (Lynntech, 2001). As presented in **Table 2-7**, the TCEQ soil MSC for industrial use based on groundwater protection (GWP-Ind) for perchlorate is 7.2 mg/kg. Based on the concentrations in the groundwater, the maximum concentrations detected in soil, and the GWP-Ind, perchlorate in the soil is a residual source for perchlorate contamination in groundwater. Perchlorate in soil can also be a residual source of surface water contamination by overland transport (i.e., erosion and storm water). The soil to surface water migration pathway is not currently complete due to the plastic liner placed as a temporary measure, which mitigates soil contaminant migration into surface water.

Additional soil samples were also collected during the PSI No. 2 field efforts (HDR, 2021b) centered around Building 46A and analyzed for VOCs. The unsaturated soil results (samples collected from less than 23 ft bgs) indicated exceedances of the GWP-Ind MSC for TCE. As described in **Section 2.5.5**, an area of TCE with concentrations exceeding the MSC of 0.5 mg/kg was identified. TCE in soil was not previously identified as a COC at LHAAP-47. Exceedances ranged from 0.5 to 16 mg/kg, with the high concentration of 16 mg/kg reported in DPT-030 (10-11 ft bgs). Risk associated with TCE in soil has not been evaluated, however, there is no potential for exposure to human receptors due to the depth of the contamination. The highest concentration was reported at 10-11 ft bgs, deeper than the 0-2 ft bgs considered for incidental ingestion or dermal contact, or 0-7 ft bgs for inhalation of VOCs assumed for risk assessment (Jacobs, 2003).

2.7.2.2 Groundwater

Based on the human health risk assessment, groundwater at LHAAP-47 poses an unacceptable carcinogenic risk and non-carcinogenic hazard to a hypothetical future maintenance worker at LHAAP under an industrial scenario. Perchlorate and VOCs contributed the majority (97.5%) of the non-carcinogenic hazard and VOCs contributed the majority (99.8%) of the carcinogenic risk.

The perchlorate and VOC plumes presented in the FS (Shaw, 2011) did not overlap. The VOC plume is primarily of TCE, with minor occurrences of PCE, 1,1-DCE, cis-1,2- DCE, and VC. The MCL (TCE) and TRRP Tier 1 Residential Groundwater PCL (perchlorate) were used as the criteria for defining plume boundaries. The most recent perchlorate and VOC concentrations are presented in the PSI and PSI No. 2 reports (HDR, 2019a and HDR, 2021b). Compared with the FS (Shaw, 2011), the spatial extent in the Shallow and Intermediate Zones has changed with the majority of groundwater contamination now occurring within the Intermediate Zone. The extent of groundwater contamination in the Shallow Zone is reduced to small, isolated VOC plumes in the vicinity of LHSMW44 and LHSMW45 and near Building 46A. No perchlorate plumes remain in the Shallow Zone. The results of replacement wells 47WW11R and LHSMW43R in the Intermediate Zone define the presence of an additional small perchlorate plume not present in the 2010 data. The extent of the

VOC plumes in the Intermediate Zone (described in **Section 2.5.3**) observed in the PSI are similar to 2010 results with the exception that the TCE plume is no longer split into separate northern and southeastern plumes. The Upper Intermediate Zone VOC plume identified near Building 46A falls within the extent of the currently defined Intermediate Zone plume. The current extent of the TCE and perchlorate groundwater plumes from the PSI is shown on **Figure 2-9**. The extent of VOCs other than TCE fall within the maximum extent of the TCE plumes.

All groundwater COCs identified in **Table 2-8**, will be included in the groundwater monitoring program. During Five-Year Reviews, the analytical suite will be re-evaluated. COCs that have decreased to concentrations below cleanup levels, or are non-detect, or only detected sporadically below clean-up levels, or consistent with background will be removed from the monitoring program after consultation between the U.S. Army, USEPA, and TCEQ. If after 2 successive sampling events COCs that have not previously shown exceedances of cleanup levels specified in **Table 2-8** continue to show no exceedances, they will be dropped as COCs and no longer be monitored. These COCs include: 1,2-DCA, chloroform, acetone, 2,4,6-TNT, 2,4-DNT, BEHP, cobalt, and manganese. Pentachlorophenol, aluminum, antimony, arsenic, cadmium, chromium, nickel, silver, strontium, thallium, tin and vanadium have been detected infrequently or only in historical samples and may also be considered to be dropped as COCs if no additional exceedances greater than the cleanup levels specified in **Table 2-8** are reported after 2 successive sampling events. A summary of groundwater contamination at LHAAP-47 is presented below.

2.7.2.3 Perchlorate

Perchlorate results from the PSI were compared to the TRRP Tier 1 Residential Groundwater PCL of 17 µg/L. Perchlorate was not detected in the Shallow Zone wells during the PSI. Shallow Zone wells that previously exceeded perchlorate cleanup standards, as reported in the FS, were dry during the PSI in 2018-2020 and no samples could be collected. Of the 21 wells sampled for perchlorate, only four results exceeded the PCL of 17 µg/L. These intermediate zone wells included 47WW11R (824 µg/L) (replacement well), 47WW38 (266 µg/L), LHSMW43R (59 µg/L) (replacement well), and LHSMW60 (33,000 µg/L). These results indicate two small plumes exist in the Intermediate Zone located at the eastern and southern edges of the site.

2.7.2.4 Trichloroethene

Concentrations of TCE in groundwater were compared to the MCL (5 µg/L). The PSI and PSI No. 2 Addendum reported that TCE concentrations exceeded the MCL in 42 monitoring well samples from 29 monitoring wells; 6 shallow, 18 shallow/intermediate and upper intermediate, and 5 intermediate wells.

Two isolated Shallow Zone plumes were identified with concentrations that exceeded the MCL (HDR, 2019a), one near wells (LHSMW44 and LHSMW45) and another near Building 46A (HDR, 2021b). Residual TCE DNAPL is presumed present within the plume near Building 46A where TCE was reported at concentrations up to 57,000 µg/L. TCE concentrations in the Upper Intermediate Zone wells near Building 46A also indicate residual TCE DNAPL with concentrations up to 120,000 µg/L in well 47WW25R. The well was decommissioned and replaced with well 47WW50, which had TCE reported at 471 µg/L. TCE is present at levels greater than the MCL in Intermediate Zone groundwater throughout the site.

2.7.2.5 Tetrachloroethene

Concentrations of PCE in groundwater were compared to the MCL (5 µg/L). Historically, concentrations of PCE exceeding the MCL (5 µg/L) were limited, occurring in co-located wells LHMSW43 and 47WW09 and within the TCE plume. In 2008 a single exceedance of the MCL in 47WW09 was reported at 9.99 µg/L. LHSMW43 was dry and replacement well LHSMW43R was non-detect for PCE. The trend in PCE concentrations in 47WW09 over time has been mixed with no strong increasing or decreasing pattern.

2.7.2.6 1,1-Dichloroethene

Concentrations of 1,1-DCE in groundwater were compared to the MCL (7 µg/L). The PSI reported 1,1-DCE detections in 6 wells exceeding the MCL of 7 µg/L. A single 1,1-DCE detection was reported at 47WW25R (20.8 µg/L), near Building 46A. Another single 1,1-DCE detection was reported at 47WW09 (19.6 µg/L). Finally, a 1,1-DCE plume is present in the southeastern corner of the site, extending out of the site boundary. The maximum concentration in this plume is 176 µg/L in LHSMW56R. 1,1-DCE was detected greater than the MCL in 1 sample collected during the PSI No. 2 effort (47WW48 – 25.4 µg/L).

2.7.2.7 cis-1,2-Dichloroethene

Concentrations of cis-1,2-DCE in groundwater were compared to the MCL (70 µg/L). It is a daughter product of TCE degradation. The cis-1,2-DCE plumes are entirely within the limits of the TCE plumes in each zone. The trends for cis-1,2-DCE concentrations for individual wells over time have been mixed, with some decreasing and some increasing but the extent of the cis-1,2-DCE plumes have consistently been within the limits of the TCE plumes.

The PSI reported cis-1,2-DCE detections in 12 wells exceeding the MCL of 70 µg/L. The maximum cis-1,2-DCE concentration in samples from Shallow Zone well samples was 505 µg/L in 47WW49, and for Intermediate Zone well samples the maximum concentration was 5,260 µg/L in 47WW42.

2.7.2.8 Vinyl Chloride

Concentrations of VC in groundwater were compared to the MCL (2 µg/L). It is a daughter product of TCE degradation. The VC plume is entirely within the limits of the TCE plumes. The trends for VC concentrations in individual wells have been mixed, with some decreasing and some increasing.

The PSI reported that VC was detected in nine wells exceeding the MCL of 2 µg/L. PSI No. 2 results had VC detected greater than the MCL in 2 wells in the Shallow Zone, 6 Upper Intermediate Zone wells, and 1 Intermediate Zone well. The maximum VC concentration was reported at 1,190 µg/L in Upper Intermediate Zone well 47WW42.

2.7.2.9 1,2-Dichloroethane

Concentrations of 1,2-DCA in groundwater were compared to the MCL (5 µg/L). The most recent 1,2-DCA results, including those from the PSI, do not exceed the MCL at any monitoring well. The chemical 1,2-DCA is considered a COC because one sample from 1996 at monitoring well LHSMW48 exceeded the MCL. It is expected that the 1,2-DCA detected was a trace contaminant in the TCE solvent or a minor daughter product of TCE degradation

2.7.2.10 Chloroform

Concentrations of chloroform in groundwater were compared to the MCL for total trihalomethanes (80 µg/L). The most recent chloroform results from the PSI do not exceed the MCL at any monitoring well. The chemical chloroform is considered a COC because one sample from 1998 at monitoring well 47WW20 exceeded the MCL. It is expected that the chloroform from 1998 was a laboratory contaminant and is not likely to be found in the future.

2.7.2.11 Acetone

Concentrations of acetone in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (22,000 µg/L). The historical acetone results show a maximum of 21,000 µg/L in monitoring well LHSMW35 from 1998. The chemical acetone is considered a COC because the Baseline Risk Assessment used more conservative assumptions for assessing acetone risk and calculated an HQ of 8.1. The high concentration reported in the 1998 sample was an anomalous result, possibly due to sample dilution or cross-contamination from laboratory or field blank contamination. A field duplicate was collected for this well sample and the result was 4,400 µg/L. Samples collected from this well during prior and subsequent investigations were either not analyzed for acetone or the results were non-detect. None of the PSI samples reported acetone that exceeded the TRRP Tier 1 Residential Groundwater PCL of 22,000 µg/L. Since there were no detections in the PSI laboratory blanks and some detections in trip blanks, acetone detections were attributed to contamination during transportation.

2.7.2.12 1,1,2-Trichloroethane

Concentrations of 1,1,2-trichloroethane (TCA) in groundwater were compared to the MCL (5 µg/L). The most recent 1,1,2-TCA results from the PSI showed one detection less than the MCL, and previous results are all less than the MCL. The chemical 1,1,2-TCA is not considered a COC because the maximum concentration detected (4.9 µg/L at LHSMW43) is less than the MCL.

2.7.2.13 2,3,7,8-Tetrachlorodibenzodioxin

The total equivalent concentration (TEQ) of 2,3,7,8-tetrachlorodibenzodioxin (TCDD) and its congeners in groundwater were compared to the MCL (3.0×10-5 µg/L). Samples collected in 2010 showed the TEQ for 2,3,7,8-TCDD and its congeners were all less than the MCL. The chemical 2,3,7,8-TCDD is not considered a COC because the maximum TEQ of 2,3,7,8-TCDD and its congeners detected (2.88×10^{-6} µg/L at 47WW01) is less than the MCL. No samples were analyzed for TCDD during the PSI.

2.7.2.14 2,4,6-TNT

Concentrations of 2,4,6-TNT in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (12 µg/L). The most recent 2,4,6-TNT results, including the 2018 PSI, show no detectable TNT. The chemical 2,4,6-TNT is considered a COC because a 1996 sample from monitoring well LHSMW56 showed a 6.8 µg/L 2,4,6-TNT concentration, leading to an HQ of 0.13. It is expected that the 2,4,6-TNT detected in past groundwater samples was transient and is not likely to be found in the future.

2.7.2.15 2,4-Dinitrotoluene

Concentrations of 2,4-DNT in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (1.3 µg/L). 2,4-DNT results from samples collected in 2010 exceeded the TRRP

Tier 1 Residential Groundwater PCL at one monitoring well, 47WW11. This well was dry in August 2010 and in March 2018. The cumulative risk of all cancer risks for chemicals with no MCL is less than 10^{-4}, but the chemical 2,4-DNT is retained as a COC for further sampling and evaluation.

2.7.2.16 2,6-Dinitrotoluene

Concentrations of 2,6-DNT in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (1.3 µg/L). The most recent 2,6-DNT results, from samples collected prior to 2010, exceeded the TRRP Tier 1 Residential Groundwater PCL at one monitoring well, 47WW11. This well was dry in August 2010 and in March 2018. The cumulative risk of all cancer risks for chemicals with no MCL is less than 10^{-4}, but the chemical 2,6-DNT is retained as a COC for further sampling and evaluation.

2.7.2.17 BEHP

Concentrations of bis(2-ethylhexyl)phthalate in groundwater were compared to the MCL (6 µg/L). BEHP was non-detect in 1998 sampling event though the detection limit was 10 µg/L, slightly above the MCL. Exceedances in two of the monitoring wells 47WW13 and 47WW14 in the 2010 sampling event, were identified by the laboratory as method blank or preparation blank contamination. BEHP was non-detect in the seven wells sampled for BEHP in the PSI sampling though the detection limit was between 6.74 and 7.5 µg/L, slightly above the MCL. The chemical BEHP is considered a COC because concentrations exceed the MCL. It is expected that the BEHP detected in groundwater samples may be a sampling contaminant as it has also been detected in associated equipment blanks.

2.7.2.18 Pentachlorophenol

Concentrations of pentachlorophenol in groundwater were compared to the MCL (1 µg/L). The most recent pentachlorophenol results exceeded the MCL at two monitoring wells, LHSMW46R and 47WW09 in 2018. The chemical pentachlorophenol is considered a COC because concentrations exceed the MCL. It is expected that the pentachlorophenol detected in past groundwater samples was transient and are not likely to be found in the future.

2.7.2.19 Aluminum

Concentrations of aluminum in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (24,000 µg/L). The historical aluminum results exceeded the TRRP Tier 1 Residential Groundwater PCL at one monitoring well, 47WW13 in 2007. The chemical aluminum is considered a COC because aluminum concentrations in groundwater led to an HQ of 0.84. It is expected that the aluminum detected in past groundwater samples is related to clay minerals and future sampling with low-flow methods will show lower concentrations since low-flow sampling is frequently utilized to reduce turbidity during sample collection. The 2010 aluminum result at monitoring well 47WW13 was below the TRRP Tier 1 Residential Groundwater PCL. 47WW13 did not recharge sufficiently for sampling during the PSI in 2018. There were no exceedances in the 10 wells sampled for metals during the PSI.

2.7.2.20 Antimony

Concentrations of antimony in groundwater were compared to the MCL (6 µg/L). Antimony results exceeded the MCL at six monitoring wells, 47WW04, 47WW16, 47WW21 in 1998, 47WW22 in 2007 and LHSMW54 and LHSMW57 in 1996. The chemical antimony is considered a COC because concentrations exceed the MCL. The background results from the Shaw 2007 Evaluation of

Perimeter Well Data for Use as Groundwater Background for antimony ranged from 3.55 µg/L to 10.5 µg/L with a 95% upper tolerance limit of 12.2 µg/L for filtered samples which exceeds the MCL. Thus, it is expected that the antimony detected in past groundwater samples may have a natural source. The most recent antimony results from ten wells sampled during the PSI were below the MCL.

2.7.2.21 Arsenic

Concentrations of arsenic in groundwater were compared to the MCL (10 µg/L). The most recent arsenic samples were collected during the PSI. Ten wells were sampled, and arsenic was detected in 9 of the well samples with one MCL exceedance reported in monitoring well 47WW06 (26.2 µg/L). The background results from the Shaw 2007 Evaluation of Perimeter Well Data for Use as Groundwater Background for arsenic ranged from 0.685 µg/L to 62.1 µg/L with a 95% upper tolerance limit of 34.2 µg/L for filtered samples which exceeds the MCL. The background level for arsenic is 34.2 µg/L and the PSI samples did not show any background level exceedances. Thus, it is expected that the arsenic detected in past groundwater samples may have a natural source. Arsenic was identified as a COC in the BHHRA based on the calculated EPC. The BHHRA also notes that some of the risk is due to background.

2.7.2.22 Cadmium

Concentrations of cadmium in groundwater were compared to the MCL (5 µg/L). Cadmium results exceeded the MCL at one monitoring well, LHSMW57, in 1998. Cadmium was not detected in the ten wells sampled during the PSI. LHSMW57 was dry and could not be sampled during the PSI. The chemical cadmium is considered a COC because one sample result from 1998 exceeded the MCL. It is expected that the cadmium detected in past groundwater samples was an isolated occurrence and future sampling with low-flow methods will show lower concentrations since low-flow sampling is frequently utilized to reduce turbidity during sample collection.

2.7.2.23 Chromium

Concentrations of chromium in groundwater were compared to the MCL (100 µg/L). Chromium results for samples collected prior to 2010 exceeded the MCL at 21 monitoring wells. Most of these monitoring wells are shallow, and all are constructed with stainless steel well screens. The chemical chromium is considered a COC because concentrations exceed the MCL. Based on previous observations made at other LHAAP sites (e.g., LHAAP-48 (Y-Area), LHAAP-49) regarding elevated levels of chromium due to potential corrosion of stainless steel well screens, it is believed that chromium, nickel, and vanadium are likely from the stainless steel well materials.

The PSI reported chromium detected in one monitoring well (47WW14) exceeding the MCL of 100 µg/L. 47WW14 has a stainless steel screen, which is a potential source of chromium at this location. Two wells sampled in 2007 and 2010 (47WW13, 47WW22), showed chromium exceedances. Both of these wells were constructed with stainless steel screens, and both were dry during the PSI.

2.7.2.24 Cobalt

Concentrations of cobalt in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (240 µg/L). Cobalt results, including the PSI data, show no concentrations above the TRRP Tier 1 Residential Groundwater PCL. The chemical cobalt is considered a COC because cobalt concentrations in groundwater led to an HQ of 0.15. It is expected that future sampling with low-flow methods will show lower concentrations since low-flow sampling is frequently utilized to reduce turbidity during sample collection.

2.7.2.25 Manganese

Concentrations of manganese in groundwater were compared to the background level and TRRP Tier 1 Residential Groundwater PCL (1,100 µg/L). The site background for manganese is 7,820 µg/L (Shaw, 2007c). The most recent manganese results, and all past results, were below the background level. The chemical manganese is considered a COC because the Baseline Risk Assessment used more conservative assumptions for assessing manganese risk and calculated an HQ of 1.6. It is expected that the manganese detected in past groundwater samples has a natural source and future sampling with low-flow methods will show lower concentrations since low-flow sampling is frequently utilized to reduce turbidity during sample collection. The samples used to establish the groundwater background levels in the 2007 background report were collected using low-flow methods.

2.7.2.26 Nickel

Concentrations of nickel in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (490 µg/L). Historically, nickel results exceeded the TRRP Tier 1 Residential Groundwater PCL at four monitoring wells, 47WW08, 47WW22, LHSMW51 and LHSMW55. All of these monitoring wells are shallow, and all are constructed with stainless steel well screens. The chemical nickel is considered a COC because concentrations exceed the TRRP Tier 1 Residential Groundwater PCL. Based on previous observations made at other LHAAP sites (e.g. LHAAP-48 (Y-Area), LHAAP-49) regarding elevated levels of chromium due to potential corrosion of stainless steel well screens, it is believed that chromium, nickel, and vanadium are likely from the stainless steel well materials.

47WW08 and 47WW22 were dry during the 2018 PSI and LHSMW51 and LHSMW55 were not included in the PSI effort. The PSI reported that nickel was detected in one of the ten wells sampled for metals (47WW09) at 529 µg/L, exceeding the TRRP Tier 1 Residential Groundwater PCL of 490 µg/L. 47WW09 was constructed with a stainless steel well screen.

2.7.2.27 Silver

Concentrations of silver in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (120 µg/L). Silver results, from 10 wells sampled during the 2018 PSI did not show any detected silver. Silver exceeded the TRRP Tier 1 Residential Groundwater PCL at one monitoring well, LHSMW51 in1998 (LHSMW51 was not included in PSI effort). The chemical silver is considered a COC because concentrations exceeded the TRRP Tier 1 Residential Groundwater PCL in a past groundwater sample. It is expected that the silver detected in past groundwater samples is anomalous and future sampling with low-flow methods will show lower concentrations since low-flow sampling is frequently utilized to reduce turbidity during sample collection.

2.7.2.28 Strontium

Concentrations of strontium in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (15,000 µg/L). The most recent strontium results, from the 2018 PSI, show concentrations above the TRRP Tier 1 Residential Groundwater PCL. Previous results included a single exceedance (19,000 µg/L) in a sample collected from 47WW17 during the RI. The chemical strontium is considered a COC because strontium concentrations in groundwater led to an HQ of 0.31. It is expected that future sampling with low-flow methods will show lower concentrations since low-flow sampling is frequently utilized to reduce turbidity during sample collection.

2.7.2.29 Thallium

Concentrations of thallium in groundwater were compared to the MCL (2 µg/L). The most recent thallium results, from 10 wells sampled during the 2018 PSI did not show any MCL exceedances. Thallium exceeded the MCL at one well, 47WW07, in 2007 (47WW07 was not included in PSI effort). The chemical thallium is considered a COC because previous concentrations exceed the MCL. It is expected that the thallium detected in past groundwater samples is related to sampling technique and that future sampling with low-flow methods will show lower concentrations since low-flow sampling is frequently utilized to reduce turbidity during sample collection.

2.7.2.30 Tin

Concentrations of tin in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (15,000 µg/L). Previous tin results exceeded the TRRP Tier 1 Residential Groundwater PCL at one well, 47WW02. The chemical tin is considered a COC because the tin concentration in one RI sample exceeded the TRRP Tier 1 Residential Groundwater PCL. It is expected that the tin detected in past groundwater samples is anomalous and that future sampling with low- flow methods will show lower concentrations since low-flow sampling is frequently utilized to reduce turbidity during sample collection.

Tin was detected in the sample from one well, 47WW41, at a concentration of 439 µg/L during the PSI investigation. The detected result is below the tin TRRP Tier 1 Residential Groundwater PCL of 15,000 µg/L. 47WW02 was not included in the PSI.

2.7.2.31 Vanadium

Concentrations of vanadium in groundwater were compared to the TRRP Tier 1 Residential Groundwater PCL (44 µg/L). Vanadium results, including the 2018 PSI, exceeded the TRRP Tier 1 Residential Groundwater PCL at one monitoring well, 47WW22 in 2007 (47WW22 was dry during the 2018 PSI). The chemical vanadium is considered a COC because concentrations exceed the TRRP Tier 1 Residential Groundwater PCL. Based on previous observations made at other LHAAP sites (e.g., LHAAP-48 (Y-Area), LHAAP-49) regarding elevated levels of chromium due to potential corrosion of stainless steel well screens, it is believed that chromium, nickel, and vanadium are likely from the stainless steel well materials.

2.7.3 Contaminant of Concern Summary

Groundwater contaminants (COPCs) with a HQ greater than 0.1 are listed in **Table 2-2**. Groundwater contaminants with carcinogenic risk greater than 1×10^{-6} are listed in **Table 2-3**. As above, MCLs were used for the evaluation. **Tables 2-2** and **2-3** also summarize the justifications for which of the COPCs should be classified as COCs. Many of the COCs have MCLs, which are the cleanup levels. For COCs that do not have an MCL, the TRRP Tier 1 Residential Groundwater PCLs were used for evaluation. **Table 2-8** presents the final list of COCs, along with cleanup levels. The COCs for the LHAAP-47 groundwater are nine VOCs (TCE, VC, 1,1-DCE, acetone, chloroform, PCE, 1,2-DCA, cis-1,2-DCE and trans-1,2-DCE), perchlorate, two SVOCs (pentachlorophenol and BEHP), thirteen metals (Aluminum, Antimony, Arsenic, Cadmium, Chromium, Cobalt, Manganese, Nickel, Silver, Strontium, Thallium, Tin and Vanadium) and three explosives (2,4,6-TNT, 2,4-DNT and 2,6-DNT) due to their contribution to risk and exceedance of the MCL or TRRP Tier 1 Residential Groundwater PCL. Even though 2,3,7,8-TCDD, and 1,1,2-TCA indicate risk above 1×10^{-6}, the maximum concentrations are below the MCL, and they are not identified as COCs. Explosives 2,4-DNT and 2,6-DNT indicate risk above 1×10^{-6}, but the combined indicated risk is below 1×10^{-4}.

There are no COCs identified for surface water. Surface water monitoring will be performed to monitor the groundwater to surface water migration pathway. Monitoring levels have been identified for surface water based on the list of COCs in groundwater. These levels are presented in **Table 2-9**.

2.7.4 Summary of Ecological Risk Assessment

The ecological risk for LHAAP-47 was assessed as part of the installation-wide BERA (Shaw, 2007a) and BERA Addendum (AGEISS, 2014). For the BERA, the entire Installation was divided into three large sub-areas (i.e., the Industrial Sub-Area, Waste Sub-Area, and Low Impact Sub-Area) for the terrestrial evaluation. The individual sites at LHAAP were grouped into one of these sub-areas, which were delineated based on commonalities of historical use, habitat type, and spatial proximity to each other. The conclusions regarding the potential for chemicals detected at individual sites to adversely affect the environment must be made in the context of the overall conclusions of the sub-area in which the site falls. LHAAP-47 lies within the Industrial Sub-Area. The BERA concluded that no unacceptable risk was present in the Industrial Sub-Area (Shaw, 2007a) and therefore, no further action is needed at LHAAP-47 for the protection of ecological receptors.

After the BERA was completed in 2007, additional data review determined that some explosives results used in the BERA were invalid. Additional samples were collected during a data gaps investigation to replace the invalid results and the results were combined with the previously reported useable data and data from samples collected following completion of the BERA to re-evaluate the ecological risks. The results were reported in the BERA Addendum (AGEISS, 2014). The results of the re-evaluation indicated that that the replacement data collected during the data gaps investigation confirmed the conclusions of the BERA that no explosives compounds in soil should be identified as COPECs in the industrial sub-area. These results do not change the determination that the soil contamination at LHAAP-47 does not pose an unacceptable risk (as defined in the BERA for Industrial Sub-Areas) to ecological receptors.

2.7.5 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. **Table 2-7** and **2-8** present the COCs and their cleanup levels for soil and groundwater. Monitoring levels have been identified for surface water based on the list of COCs in groundwater and are presented in **Table 2-9**. Actions for the soil are necessary to address the migration pathways of perchlorate and TCE in soil into groundwater and perchlorate into surface water.

As it concerns the contaminated groundwater at LHAAP-47, a SDWA MCL has been identified for each of the COCs with the exception of perchlorate, acetone, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, aluminum, cobalt, manganese, strontium, tin, vanadium, nickel and silver. For those COCs and by-product (i.e., daughter) contaminants that have an MCL, the MCL constitutes the groundwater cleanup level to be attained. In the absence of federal drinking water standards, clean-up levels will be based on TRRP Tier 1 Residential Groundwater PCLs. With respect to the surface water that could be impacted by contaminated groundwater, the Texas Surface Water Quality Standards, or if Texas Surface Water Quality Standards are not available, the TRRP Tier 1 Residential Groundwater PCLs constitute the surface water standards to be met at the site for the COCs and by-product (i.e., daughter) contaminants to confirm that the remedial action objective (RAO) for groundwater to surface water migration is achieved.

2.8 Remedial Action Objectives

The RAOs for LHAAP-47, 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:

- Protect future maintenance workers by preventing exposure to unacceptable levels of contaminants in groundwater via the groundwater ingestion pathway;
- Prevent perchlorate in soil from migrating to groundwater and surface water and prevent TCE in soil from migrating to groundwater;
- Prevent groundwater contaminated with perchlorate from migrating into nearby surface water;
- Return of groundwater to its potential beneficial use, wherever practicable, within a reasonable time period given the particular site circumstances (40 CFR §300.430(a)(1)(iii)(F)).

The above RAO recognizes USEPA's policy to return all groundwater to beneficial uses based on the 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 ((40 CFR § 300.430(a)(1)(iii)(F)).

Per these RAOs, and consistent with the NCP, groundwater will be returned to its beneficial use, wherever practicable. In the absence of federal drinking water standards, the groundwater clean-up level at the Site is the TRRP Tier 1 Residential Groundwater PCL and is protective of human health and the environment.

2.9 Description of Alternatives

The 2012 Proposed Plan identified Alternative 2 as the preferred alternative. This alternative used a combination of ISB, Biobarriers, MNA with LTM, soil excavation and LUCs to achieve the RAOs. With the discovery of TCE residual DNAPL and TCE in soil near Building 46A during the 2018-2020 PSI, evaluation of additional treatment technologies was required because the 2011 FS that supported the Proposed Plan did not include technologies necessary to address the TCE source areas. The FS Addendum (HDR, 2021c) evaluated additional treatment technologies and re-evaluated technologies already identified for Alternative 2 to specifically address the residual TCE DNAPL and TCE in unsaturated soil near Building 46A. The Revised Proposed Plan (HDR, Inc. 2021a) identifies Alternative 2 modified to include the ERH ISTD technology as the preferred alternative. Alternatives 3 and 4 were also modified to include ERH ISTD.

Four alternatives (including No Further Action) have been evaluated. 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 Common Remedy Components

Except for the No Action alternative, the other remedial alternatives have the following common components: excavation of perchlorate-contaminated soil, ISB, MNA, LUCs, LTM, and Five-Year Reviews.

2.9.1.1 Excavation of Perchlorate-Impacted Soil

Perchlorate–impacted soil extends to depths of 10 feet with an estimated volume of 9,000 cubic yards exceeding the GWP-Ind. Excavated soil will be sampled and tested to determine if it is a characteristic hazardous waste prior to transportation and disposal. Prior to excavation of soil, the plastic liner located on top of the perchlorate-impacted soil will be removed and disposed of appropriately. Excavation and disposal of the impacted soil will result in eliminating the potential continuing source for perchlorate impacts to groundwater and surface water. Confirmation sampling from the excavation area will be performed to verify that soil with perchlorate impacts exceeding the GWP-Ind value is removed. The excavation area will be backfilled with clean fill material and the surface will be restored.

2.9.1.2 In-Situ Bioremediation

ISB encourages growth and reproduction of indigenous microorganisms to enhance biodegradation of organic constituents in the saturated groundwater zone. The microbiological processes are used to degrade or transform contaminants to ultimately less toxic or non-toxic forms. A substrate will be injected in the areas with high contaminant concentrations via injection points or wells. The selection of specific substrate will be determined during the RD phase. Bioaugmentation, which involves introduction of microbial culture in the aquifer capable of degrading targeted organic constituents in the subsurface environment, may be implemented during ISB, if necessary. Prior to bioaugmentation, the aquifer material (soil) and groundwater in the proposed ISB area(s) will be tested to determine if the necessary microbes are indigenously present in the aquifer in adequate population count to stimulate ISB. Bioaugmentation with the appropriate culture will be performed only if the indigenous microbes are not present and it is determined that the microbial culture to be added will not be detrimental to the characteristics of the aquifer.

2.9.1.3 In-Situ Thermal Desorption

Removal of residual DNAPL via thermal treatment and extraction will remove at least 99.9% according to the thermal treatment vendors, even within low permeability zones. In addition, rebound effects are expected to be negligible as long as target temperatures are achieved and maintained throughout the contaminated zone for the prescribed timeframe. Thermal treatment also heats the overlying soil to a lesser degree, which will be anticipated to promote more rapid biodegradation of COCs in soil hot spots overlying the areas of residual DNAPL. Thermal treatment also enhances mobilization of organic matter from the aquifer matrix to groundwater, which will enhance biodegradation of the COCs. The higher ambient soil temperature imposed by the thermal treatment process during startup and cool down periods will increase hydrolysis.

An ERH system consists of subsurface electrodes connected to direct current through the subsurface, and a vapor extraction system to capture the volatilized water and contaminants. In some cases, groundwater extraction is also used to lower the water table within the treatment zone during initial stages of treatment (prior to temperatures exceeding the boiling point of subsurface water) or to provide hydraulic control. Electrodes can be installed using several different drilling or direct-push techniques, including angled or horizontal methods.

ERH electrodes will be installed to treat the areas of residual TCE DNAPL identified in the Shallow and Upper Intermediate Zones near Building 46A. The heating of overlying soil is also anticipated to treat or increase biodegradation of TCE. Following completion of the ERH treatment, if soil contamination is still present at concentrations exceeding cleanup levels, a contingent remedy will be developed.

2.9.1.4 Monitored Natural Attenuation

MNA is a passive remedial technology that relies upon naturally occurring physical, chemical, and biological processes to reduce the mass and concentrations of groundwater COCs under favorable conditions over time along with groundwater monitoring to demonstrate how MNA is working.

MNA is effective when source releases have been addressed (such as by removal of soil impacted with perchlorate), and when plume is stable when there is a source or if the plume is shrinking, and it can be demonstrated that natural attenuation mechanisms are occurring. An MNA evaluation for LHAAP-47 site demonstrated that natural attenuation is occurring and is effectively controlling COCs in the shallow and intermediate groundwater zones outside of the well field area (Shaw, 2011). As described in Appendix A of the FS (Shaw, 2011), historical perchlorate and VOC data and geochemical indicators were evaluated for the groundwater at LHAAP-47 to determine if MNA can be used as a feasible remedy for chlorinated solvents and perchlorate present in the groundwater. The MNA evaluation concluded that reductions in concentrations of perchlorate, TCE, and other VOCs demonstrate that natural attenuation is occurring in the groundwater at LHAAP-47. Even though natural attenuation may not be currently active in some individual monitoring wells (rising or mixed TCE concentrations at 47WW09, 47WW25, LHSMW45, and LHSMW56), by evaluating the trends at monitoring wells with some of the highest TCE concentrations, it has been demonstrated that attenuation is occurring. Reduction of COC concentrations is occurring by reductive dechlorination at some locations, but is also occurring through other natural attenuation processes including dispersion, dilution, and sorption as shown by reduction of concentration with distance. Thus, this evaluation concludes natural attenuation is occurring at LHAAP-47. The time period required for natural attenuation is long (estimated up to 185 years), but the affected groundwater is not in use, and is not expected to be used in the future over that time period.

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. Under MNA, regular monitoring will be conducted throughout the program to confirm that natural attenuation is progressing towards RAOs. If MNA is not found to be effective in areas outside of direct active treatment, additional ISB treatment in those areas will be implemented. Evaluation of any additional ISB treatment outside of the current target treatment areas will be determined based on the ISB and MNA performance evaluation. MNA is recommended in each of the active remedial alternatives for areas with lower COC concentrations because it has been demonstrated historically to reduce contaminant concentrations at LHAAP-47.

Since the time to achieve the clean-up objectives is longer for MNA than areas planned for active treatment, the time to achieve the clean-up objectives is the same in each active alternative.

MNA performance monitoring will be conducted quarterly for the first two 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, total organic carbon, and ferrous iron (field).

2.9.1.5 LUCs

LUCs are any restriction or control, arising from the need to protect human health and the environment, that limits the use of and/or exposure to any portion of that property, including water resources.

LUCs performance objectives as part of the remedial alternatives (except the No Action alternative) are:

- LUC performance objective to restrict land use to nonresidential use until it is demonstrated that the COCs in soil and groundwater are at levels that allow for unlimited use and unrestricted exposure.
- LUC performance objective to prohibit potable use of groundwater above the cleanup levels until it is demonstrated that the COCs in groundwater are at levels that allow for unlimited use and unrestricted exposure.

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 in groundwater are met; to restrict land use to nonresidential until it is demonstrated that the surface and subsurface soil and groundwater COCs 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 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. Although Army may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the Army shall retain ultimate responsibility for remedy integrity.

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 LHAAP-47, an Environmental Condition of Property (ECP) document will be prepared and the Environmental Protection Provisions from the ECP will be attached to the letter of transfer. The ECP would include the LUCs as part of the Environmental Protection Provisions. The property will 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.

2.9.1.6 Long-Term Monitoring

LTM is the monitoring conducted after a remedy is selected and implemented, and is used to evaluate the progress and degree to which a remedial action achieves its objectives. Alternatives 2 through 4 at the LHAAP-47 site include long-term groundwater monitoring activities. LTM would include monitoring of a select number of groundwater wells to evaluate contaminant migration and ensure that the groundwater COC plume continues to degrade in a manner to achieve attainment of the groundwater cleanup levels.

The LTM will be performed quarterly for the first two years, followed by semi-annual monitoring for three years, and then annually until the next Five-Year Review and annually thereafter until recommended otherwise by the Five-Year Review and with concurrence from EPA and TCEQ.

2.9.2 Description of Alternatives

2.9.2.1 Alternative 1- No Further 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 will be left "as is," without implementing any additional containment, removal, treatment, or other mitigating actions. No other actions will be implemented to reduce existing or potential future exposure to human and ecological receptors.

There are no costs associated with the No Action alternative.

Estimated Total Direct Capital Cost: $0

Estimated Total O&M Cost: $0

Cost Estimate Duration: NA

Estimated Total PW Cost: $0

2.9.2.2 Alternative 2 – Excavation, ISTD, ISB, Biobarriers, MNA, LTM, and LUCs

The Revised Proposed Plan identifies the Modified Alternative 2 as the preferred alternative. This alternative uses a combination of ISB, ISTD, Biobarriers, MNA with LTM, soil excavation and LUCs to achieve the RAOs. Perchlorate contaminated soil will be excavated as described under common elements in **Section 2.9.1**.

The residual TCE DNAPL in groundwater and TCE in soil near Building 46A will be treated using ISTD. ERH technology will be used. An ERH system consisting of subsurface electrodes connected to direct current through the subsurface, with a vapor extraction system to capture the volatilized water and contaminants will be installed within the areas of DNAPL. ISB may be implemented following the ISTD treatment if VOC concentrations in groundwater are considered too high to be addressed only through MNA. The soil conditions will be evaluated following ISTD and if required, a contingency remedy to treat soil hot spots (for example, excavation or enhanced soil vapor extraction) will be developed and implemented to complete soil remediation.

ISB will be completed by injecting the selected substrate in a grid pattern into the secondary source area in the vicinity of wells which have identified VOCs at concentrations greater than 1,000 µg/L and/or perchlorate at concentrations greater than 20,000 µg/L and, if needed, near Building 46A following ISTD treatment.

Biobarriers are a variant of ISB and consist of ISB injection points arranged in a closely-spaced linear fashion to form a linear treatment zone. Biobarriers will treat groundwater contaminated with perchlorate and VOCs as the groundwater flows through the treatment zone, as opposed to direct injection into areas of high contaminant concentration. Biobarriers will be installed near the northern and southern perchlorate and VOC plumes, and at the southern edge of the perchlorate plumes near Goose Prairie Creek. Bioaugmentation, which consists of introduction of microbial cultures capable of degrading the organic constituents in the subsurface environment, will be performed if necessary.

MNA will be implemented to monitor continued reduction/degradation of COCs (VOCs, SVOCs, perchlorate, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, and identified metals) in the treatment areas after completion of ISB treatment and also to monitor reduction/degradation of COCs in groundwater outside of the influence of the ISB treatment areas. LTM and LUCs will be implemented as described in the common elements section (Section 2.9.1).

Preliminary estimates indicate that the groundwater will require 30 years in the treated areas, and more than 100 years to attain cleanup levels in non-treated areas based upon MNA duration for areas of the plume with lower COC concentrations (Shaw, 2011). The timeframes for this alternative are difficult to estimate due to the thin discontinuous nature of the more permeable lenses which facilitate treatment. If MNA is not found to be effective in areas outside of direct active treatment, additional treatment using ISB will be performed in these areas. The need for additional treatment using ISB will be determined based on ISB and MNA performance evaluation. For the purposes of alternative evaluation, the duration of this alternative is estimated to be approximately 30 years. Actual time to achieve RAOs is likely to be longer than this estimate. The monitoring parameters will include VOCs, SVOCs, TNT, 2,4-DNT, 2,6--DNT, and metals (those that may be mobilized by ISB).

The estimated PW costs for this Alternative are based on two years of quarterly monitoring followed by three years of semiannual monitoring; annual monitoring thereafter until the next Five-Year Review; and thereafter once every five years.

Estimated Total Direct Capital Cost: $7.16 million

Estimated Total O&M Cost: $3.09 million

Cost Estimate Duration: 30 years

Estimated Total Cost: $10.25 million

Estimated Total PW Cost: $9.33 million

2.9.2.3 Alternative 3 – Excavation, ISTD, Re-circulating ISB, MNA, LTM, LUCs

This alternative uses a combination of ISTD, ISB with groundwater re-circulation, MNA with LTM, soil excavation and LUCs to achieve the RAOs. Perchlorate contaminated soil will be excavated as described under common elements in **Section 2.9.1**. ISB along with groundwater re-circulation, ISTD, MNA, and LTM will be used to address COCs in site groundwater.

ISTD would be implemented as described in Alternative 2.

For the ISB, the selected substrate will be injected in a grid pattern into the secondary source areas near monitoring wells 47WW25 and LHSMW56. Bioaugmentation will be performed as necessary to introduce the appropriate kind of microbial culture into the subsurface environment.

Re-circulation zones will be established in target areas that have elevated COCs to enhance their degradation rates. Groundwater is extracted from downgradient wells in a target area, mixed with microbes and a carbon source and then reinjected in upgradient wells in a re-circulating process. The re-circulation component is expected to increase effectiveness of bioremediation by increased mixing and improving contact between contaminants and injected substrate and microbes, leading to accelerated achievement of clean-up objectives in re-circulation areas.

LTM and LUCs will be implemented as described in the common elements section (**Section 2.9.1**).

Preliminary estimates indicate that the groundwater will require 30 years in the treated areas, and more than 100 years to attain cleanup levels in non-treated areas based upon MNA duration for areas of the plume with lower COC concentrations (Shaw, 2011). The timeframes for this alternative are difficult to estimate due to the thin discontinuous nature of the more permeable lenses which facilitate treatment. If MNA is not found to be effective in areas outside of direct active treatment, additional treatment using ISB will be performed in these areas. The need for additional treatment using ISB will be determined based on ISB and MNA performance evaluation. For the purposes of alternative evaluation, the duration of this alternative is estimated to be approximately 30 years. Actual time to achieve RAOs is likely to be longer than this estimate.

The estimated PW costs for this Alternative are based on two years of quarterly monitoring followed by three years of semiannual monitoring; annual monitoring thereafter until the next Five-Year Review; and once every five years for the next 30 years.

The O&M of the re-circulation component will include periodic inspections of the system for leaks from pipelines, tanks, pumps, or equipment and is anticipated to last for five years or less.

Estimated Total Direct Capital Cost: $10.28 million

Estimated Total O&M Cost: $3.09 million

Estimated Total Cost: $13.36 million

Estimated Total PW Cost: $12.6 million

Cost Estimate Duration: 30 years

2.9.2.4 Alternative 4 – Excavation, ISTD, Pump and Treat, ISB, MNA, LTM and LUCs

This alternative uses a combination of ISTD, pump and treat technology, ISB, MNA with LTM, soil excavation and LUCs to achieve the RAOs. Perchlorate contaminated soil will be excavated as described under common elements in **Section 2.9.1**.

ISTD would be implemented as described in Alternative 2.

A pump and treat system will target groundwater in areas with highest COC concentrations and MNA will be implemented in areas outside the pump and treat zones until COCs (VOCs, SVOCs, perchlorate, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, and identified metals) attain respective cleanup levels. Areas in the vicinity of wells with high COC concentrations, but which have insufficient groundwater yield for effective pumping and treatment will be treated via ISB.

Pump and treat is a technology in which contaminated groundwater is extracted via a network of groundwater extraction wells and treated above-grade to remove or neutralize the contaminants. Pump and treat at LHAAP-47 site will consist of extraction wells in target areas with high COC concentrations and sufficient yield available for effective pumping. Extracted groundwater will be transported and treated at the existing groundwater treatment plant (GWTP) at Burning Ground No. 3. The treated effluent will be required to meet applicable discharge criteria.

ISB will be applied in target areas that have high COC concentrations but have insufficient groundwater yield for effective pumping operation. Three target areas were identified in the 2011 FS (LHSMW43, LHSMW56, and 47WW25). However, specific locations for ISB will be identified based on current conditions during the RD.

LTM and LUCs will be implemented as described under common elements in **Section 2.9.1.**

Preliminary estimates indicate that the groundwater will require 30 years in the treated areas, and more than 100 years to attain cleanup levels in non-treated areas based upon MNA duration for areas of the plume with lower COC concentrations (Shaw, 2011). The timeframes for this alternative are difficult to estimate due to the thin discontinuous nature of the more permeable lenses which facilitate treatment. If MNA is not found to be effective in areas outside of direct active treatment, additional treatment using ISB will be performed in these areas. The need for additional treatment using ISB will be determined based on ISB and MNA performance evaluation. For the purposes of alternative evaluation, the duration of this alternative is estimated to be approximately 30 years. Actual time to achieve RAOs is likely to be longer than this estimate.

The estimated PW costs for this Alternative are based on two years of quarterly monitoring followed by three years of semiannual monitoring; annual monitoring thereafter until the next Five-Year Review; and once every five years thereafter for thirty years.

O&M of the pump and treat system will include periodic inspections of the system for leaks from pipelines, tanks, pumps, or equipment. Maintenance for pumps and equipment is assumed to be done once every 10 years.

Estimated Total Direct Capital Cost: $7.24 million

Estimated Total O&M Cost: $8.07million

Cost Estimate Duration: 30 years

Estimated Total Cost: $15.32 million

Estimated Total PW Cost: $12.95 million

2.9.2.5 Distinguishing Features of Action Alternatives

Alternative 2

The distinguishing features of Alternative 2 are the inclusion of an in situ enhanced bioremediation by direct injection in grid or biobarrier configuration.

In-Situ Bioremediation

The ISB target treatment areas including the secondary source area via direct push injections are targeted in the vicinity of wells which have identified VOCs at greater than 1,000 µg/L and perchlorate at greater than 20,000 µg/L. ISB will be used to treat groundwater near Building 46A following the ERH implementation if VOC concentrations greater than 1,000 µg/L remain. This technology uses a substrate and, if necessary, a bioaugmentation culture to create conditions favorable for reductive dechlorination. Substrate may include a wide variety of carbon sources: sugars (molasses), alcohols (methanol, ethanol), volatile acids (acetate, lactate), or wastes (food processing, manure). Additional direct injection events in the secondary source area may be conducted as necessary, as well as possibly other areas. Injection points will be installed using DPT at an approximate spacing of 20 feet between points. It is anticipated that the substrate will be injected once, and that the injection would occur in the contaminated interval at approximately 30 feet bgs.

Biobarriers

Biobarriers will be used to treat other targeted areas within the plume. Biobarriers are expected to provide treatment and thus prevent down gradient migration of COCs. Biobarriers will be installed by closely spaced injection points in the shallow and intermediate zones near the leading edges of the northern and southern plumes to mitigate the risk of contaminant migration into Goose Prairie Creek. For biobarrier application, the carbon source chosen would require longevity, such as emulsified vegetable oil (EVO) or a proprietary mix. The biobarriers are assumed to be installed in the first year, then follow-up injections will be administered as necessary to ensure that the conditions conducive to ISB are maintained.

Alternative 3

The distinguishing feature of Alternative 3 is the implementation of ISB using direct injection and via re-circulation of the groundwater (injected with the substrate solution).

In-Situ Bioremediation

This is same as discussed under Alternative 2.

Re-circulating ISB

Re-circulation zones will be established in target treatment areas which have elevated COCs. Extraction and injection wells will be used to re-circulate groundwater in these zones. The re-circulation component is expected to accelerate bioremediation by increased mixing and improving contact between contaminants and injected substrate and microbes.

Alternative 4

The distinguishing feature of Alternative 4 is the inclusion of a pump and treat system in addition to ISB as the active treatment technology.

The pump and treat system will consist of extraction wells in target areas with high COC concentrations and sufficient yield available for effective pumping. Extracted groundwater will be transported and treated at the existing GWTP at Burning Ground No. 3. The treated effluent is required to meet applicable discharge criteria.

2.9.3 Expected Outcomes of Each Alternative

Alternative 1 would allow the site to remain a potential hazard to human receptors due to the potential ingestion of contaminated groundwater; and to the environment due to overland transport of contaminants to surface water in Goose Prairie Creek and groundwater discharge to Goose Prairie Creek in the event groundwater elevations return to pre-drought elevations. Alternatives 2 through 4 all provide treatment or removal of the contaminated soil and groundwater to meet COC cleanup levels that will be protective of human receptors and the environment. The three action alternatives therefore have very similar outcomes of preventing exposure to contaminated groundwater by utilizing either in-situ or ex-situ technologies, or both, in combination with LUCs. Alternatives 2 through 4 use ERH to treat residual TCE DNAPL and other VOCs near Building 46A. Alternatives 2 and 3 rely solely on ISB technology to treat other areas with highest COC concentrations. Alternative 4 relies primarily on groundwater extraction and takes advantage of an existing treatment system at LHAAP. All three action alternatives would also be protective of the surface waters of Goose Prairie Creek though a variety of treatment approaches.

The similar outcomes include restoration of the contaminated groundwater by attainment, to the extent practicable, of the SDWA MCLs for those COCs and by-product (i.e., daughter) contaminants that have an MCL, consistent with 40 CFR §300.430(e)(2)(i)(B&C). In the absence of federal drinking water standards, the cleanup levels for perchlorate, acetone, explosives, and seven metals will be based on the TRRP Tier 1 Residential Groundwater PCLs (**Table 2-8**). In addition, the LTM associated with Alternatives 2 through 4 would confirm the protection of human health and the environment by documenting the return of groundwater to its potential beneficial use as a drinking water supply, by documenting reduction of 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 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 in groundwater are met.

2.10 Summary of Comparative Analysis of Alternatives

Nine criteria identified in 40 CFR §300.430(e)(9)(iii) are used to evaluate the different remediation alternatives individually and against each other in order 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 2-10** 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 is the primary objective of a remedial action. The No Action Alternative will not achieve the RAOs and does not protect human health or the environment because no remedial activities will be conducted and no LUCs will be maintained. Therefore, LHAAP-47 contamination would present the potential for unacceptable risks to human health and the environment through ingestion of groundwater. The other three alternatives, collectively referred to as the action alternatives, are expected to achieve the RAOs for LHAAP-47 site. Alternatives 2, 3, and 4 include removal of the soil that may act as a continuing source of perchlorate contamination to groundwater and ISTD to actively treat residual TCE DNAPL in groundwater near Building 46A. Active treatment in Alternative 2 is performed solely in the subsurface environment. Impacted groundwater is brought to the surface in Alternative 3 and Alternative 4 which has the potential for human exposure. Alternatives 2, 3, and 4 all provide overall protection of human health and the environment. LUCs for groundwater would protect human health by preventing potable use of contaminated groundwater above cleanup levels until the levels of COCs allow for unlimited use and exposure.

2.10.2 Compliance with ARARs

CERCLA, 42 U. S. C. §9621(d) and 40 CFR §300.430(f)(1)(ii)(B) require 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 42 U. S. C. §9621(d)(4). The ARARs that pertain to this ROD are discussed in **Section 2.13.2**.

Alternative 1 does not comply with chemical-specific ARARs as no remedial action or measure will be implemented. Location and action-specific ARARs do not apply to Alternative 1 since no remedial activities will be conducted. Alternatives 2, 3, and 4 are expected to comply with chemical-specific, 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.

Alternative 1 would not be effective in the long-term because no contaminant removal or treatment will take place and no active measures will be implemented to control risks posed by the contaminated site. Alternatives 2, 3, and 4 all offer a similar level of long-term effectiveness and permanence provided the underlying technologies (ISTD, ISB and pump and treat technology) are effective. Alternatives 2 through 4 use ERH to treat the residual TCE DNAPL. Alternatives 2 and 3 primarily rely upon ISB and its effectiveness and longevity is dependent upon the substrate used and microbial processes. Alternative 4 has the additional benefit of providing some level of hydraulic control of the plume via groundwater pumping, provided that conditions are favorable for such a system. In Alternative 4, the extracted groundwater will be treated and discharged to the existing GWTP. Alternatives 2, 3, and 4 all may require contingency remedies once remedies are in place and have been monitored over a period of time. Alternatives 2, 3, and 4 also rely upon LUCs for long-term protection of human health and the environment.

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 does not include treatment and would not result in a reduction of toxicity, mobility, or volume of contaminants except through natural attenuation processes, although the progress will be unmonitored and undocumented.

The soil excavation component of Alternatives 2, 3, and 4 provides a reduction in volume and mobility because perchlorate is removed from the site and placed in a permitted disposal facility. Reduction in toxicity and volume of perchlorate at the site will be achieved, but overall reduction will depend upon any treatment processes that may be applied by the disposal facility.

The ISTD component of Alternatives 2, 3, and 4 provides a reduction of toxicity, mobility, and volume of residual TCE DNAPL in the area around building 46A. ISTD is projected to reduce concentrations by up to 99%. ISTD is a very robust technology for treatment of VOCs, even if present as DNAPL, and minimal technical concerns exist that will hinder its implementation. The boiling point of TCE is 87 °C and since ERH will heat the groundwater to 100 °C, the TCE will volatilize readily. In addition, TCE tends to break down rapidly at these elevated temperatures. TCE breakdown products have lower boiling points and will volatilize and be captured by soil vapor extraction and subsequently destroyed in the emission control system.

Alternatives 2 and 3 offer a similar degree of reduction of toxicity, mobility, and volume of groundwater contaminants through treatment in areas with VOCs at concentrations greater than 1,000 µg/L and/or perchlorate at concentrations greater than 20,000 µg/L. Alternative 2 is designed to treat groundwater via ISTD and direct injection bioremediation and installation of biobarriers.

Alternative 3 is designed to treat groundwater via a combination of ISTD, direct injection and re-circulation bioremediation. The degree of reduction in toxicity, mobility or volume in alternatives 2 and 3 will depend upon how quickly the microbes use the substrate and degrade the COCs.

A similar degree of reduction of toxicity, mobility, and volume of contaminated groundwater will be achieved by Alternative 4 in areas with VOCs at concentrations greater than 1,000 µg/L and/or perchlorate at concentrations greater than 20,000 µg/L through a combination of ISTD, extraction and in-situ treatment. The volume of contaminants in site groundwater will be reduced via extraction and mobility will be reduced by to the extent hydraulic control is achieved. Toxicity of the extracted groundwater will be reduced by subsequent treatment in the GWTP at Burning Ground No. 3. Alternative 4 also reduces toxicity, mobility, and volume through in-situ treatment via direct injection ISB of secondary source areas lacking sufficient permeability for implementation of the pump-and-treat technology, and MNA of the remaining areas of groundwater contamination.

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 of the remedy.

Alternative 1 does not involve any remedial actions; therefore, no short-term risks to workers, the community, or the environment would exist.

Alternatives 2, 3, and 4 involve utilization of excavation, drilling and construction equipment and also pose operational safety hazards to on-site workers. The implementation of Alternatives 2, 3, and 4 will require more time than Alternative 1 due to pre-design activities and RD. For Alternatives 2, 3, and 4, vegetation clearing throughout the well field and vicinity near Building 46A will be required to install heater and monitoring wells and surface equipment required for the ISTD process. The implementation of proper engineering controls will minimize the risk of environmental impacts.

Alternative 3 involves some level of O&M due to the re-circulation component, but the re-circulation component is expected to improve degradation rates significantly over direct injection bioremediation alone, thus reducing the duration of this alternative.

Alternative 4 is construction and O&M intensive due to the pump and treat component, thereby providing greater potential for short-term physical safety risks to on-site workers or visitors.

Through LUCs and engineered controls (e.g., administrative controls, and dust suppression), the three action alternatives will be protective of the community during implementation. By planning the construction, excavation, and transportation activities in accordance with industry and OSHA codes and requirements, risks from contaminant exposure and construction operations will be controlled to acceptable levels. Appropriate personal protective equipment will be required for remediation workers.

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.

Administratively, all of the alternatives are implementable. Under Alternative 1, no remedial action will be taken. Therefore, there will be no difficulties or uncertainties with implementation.

Alternatives 2, 3, and 4 can easily be implemented from a technical standpoint as all equipment, materials, and services required are readily available. The excavation, MNA, LTM, and LUCs portions of Alternatives 2, 3, and 4 are all equivalent, so the primary differences in implementability result from differences in the active treatment of groundwater in these alternatives. The equipment and materials required to implement ISTD are generally commercially available, although some parts may be covered under patents. All equipment, services and materials are readily available to conduct the activities for this technology. The LHAAP GWTP is already operational and can be used to dispose of any extracted groundwater associated with the ISTD implementation. Alternatives 2, 3, and 4, require some vegetation removal to allow installation of the ERH electrodes, and provision of power will be required for the duration of the ERH operation.

The U.S. Army will meet substantive requirements for underground injection control and obtain TCEQ approval for the active alternatives (Alternatives 2, 3, and 4) prior to implementation of the ISB and groundwater re-circulation component.

Among active alternatives, Alternative 2 is the easiest to implement. Biobarriers and direct injection bioremediation may be implemented with minimal studies or testing. No permanent piping will be necessary.

Alternative 3 requires provision of power and piping for the groundwater re-circulation component and design and testing of wells and control systems may be necessary.

Alternative 4 is the most difficult to implement, involving construction and operation of a groundwater extraction system which will require provision of power and piping, as well as design and testing of wells and control system. The collection tank and pipeline to the existing GWTP will require additional construction and modifications and improvements to the existing GWTP and control system, in addition to more O&M costs for equipment repair, maintenance and potential replacement over the remedy duration.

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). PW costs were developed for each alternative assuming a discount rate of 2.8 percent. No costs are associated with Alternative 1 because no remedial activities will be conducted. Of the action alternatives, Alternative 2 is the least expensive, followed by Alternative 3, and then Alternative 4, which is the most expensive alternative. The PW costs for the alternatives are summarized below.

Alternative 1 Total PW Cost: $0

Alternative 2 Total PW Cost: $9.33 million

Alternative 3 Total PW Cost: $12.6 million

Alternative 4 Total PW Cost: $12.95 million

2.10.8 State/Support Agency Acceptance

The USEPA and TCEQ have reviewed the Proposed Plan and the Revised Proposed Plan, which presented Alternative 2 and the Modified Alternative 2 respectively, as the preferred alternative. Comments received from the USEPA and TCEQ during the Proposed Plan and Revised 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. Public comments were received during the 30-day public comment periods for the Proposed Plan and Revised Proposed Plan, respectively, and during the January 9, 2013 and July 21, 2021 public meetings. The topics of the comments for the January 2013 public meeting and comment period included: time to complete, evidence of natural attenuation occurrence, MNA effectiveness, estimation of natural attenuation rates, hydraulic conductivity estimation, metal remediation, perchlorate cleanup standard, and surface water modeling. The topics of comments for the July 2021 meeting and comment period included: time to complete, evidence of natural attenuation occurrence, MNA effectiveness, estimation of natural attenuation rates, hydraulic conductivity estimation, metal remediation, perchlorate cleanup standard, surface water modeling, prior implementation of thermal technologies, schedule for remedial implementation, power source for the thermal technology, treatment temperature for the technology, presence of arsenic in groundwater, and need for re-evaluation of background levels.

The written comments received, and their responses are presented in the Responsiveness Summary (**Section 3.0**).

2.11 Principal Threat Wastes

Perchlorate contaminated soil is considered as a principal threat waste at the LHAAP-47 site. The perchlorate contaminated soil provides a source for perchlorate impacts to groundwater (via the impacted soil leaching to groundwater pathway) as well as to surface water (via the overland impacted surface soil migration into surface water. The migration pathways are temporarily mitigated with the liner placed on top of the perchlorate impacted soil. An estimated volume of approximately 9,000 cubic yards of perchlorate impacted soil represents the principal threat. The TCE concentrations reported in groundwater near Building 46A are high enough to be considered a highly toxic source material and indicate TCE in the saturated zone in this area is a principal threat waste. The areas of residual DNAPL in groundwater have a combined estimated volume of 237,799 - 532,669 gallons in the Shallow Zone, and one larger area of residual DNAPL in groundwater in the Upper Intermediate Zone has an estimated volume of 261,890 – 586,634 gallons.

2.12 The Selected Remedy

2.12.1 Summary of Rationale for the Selected Remedy

Alternative 2, consisting of excavation of perchlorate impacted soil, ISTD, ISB, biobarriers, MNA, LTM, LUCs and Five Year Reviews is the selected alternative for LHAAP-47 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:

- Excavation of the perchlorate impacted soil and disposal in a permitted landfill will result in the removal of soil that is a potential source of perchlorate contamination to groundwater and surface water. With the removal of this soil, the potential migration of perchlorate from soil to groundwater and surface water will be eliminated and long- term operations/management for impacted soil would not be required.
- Groundwater within the areas of Residual TCE DNAPL near Building 46A will be thermally treated using ERH. This consists of installing an array of electrodes and heating the groundwater to the boiling point. The steam produced from pore-water serves as a medium to carry out volatilized VOCs for capture via SVE and subsequent ex-situ treatment of extracted vapors. The halo-effect of the heating is also expected to treat the TCE in soil overlying the plumes.
- Groundwater will be treated in target areas using ISB. This consists of implementing ISB near target areas and Building 46A following ERH implementation, if necessary. Areas with VOCs greater than 1,000 μg/L or perchlorate greater than 20,000 μg/L are expected to be the target areas.
- Biobarriers will be installed near the leading edges of the northern and southern perchlorate and VOC plumes, and at the southern edge of the perchlorate plume near Goose Prairie Creek to mitigate the risk of contaminant migration into Goose Prairie Creek.
- MNA for areas outside the influence of the active treatment will provide protection of human health and the environment by documenting that further reductive dechlorination is occurring within the groundwater plume and that contaminant concentrations are being reduced to attain surface water and 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 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 2-8**) 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) in groundwater are met.
- Long-term monitoring and reporting would continue until the cleanup levels are achieved in groundwater to confirm protection of human health by preventing exposure to groundwater until cleanup levels are met.

The selected remedy employing treatment will significantly reduce contaminant concentrations. The performance of MNA will be evaluated after completion of quarterly sampling for eight events. If MNA is not found to be effective in areas outside of direct active treatment, additional treatment using ISB will be performed in those area. The need for additional treatment using ISB will be determined based on ISB and MNA performance evaluation.

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

Alternative 2 is readily implementable and has no significant short-term risks to worker health and safety or to the community. The PW cost of Alternative 2 is lower than the other remedial alternatives except for Alternative 1. Based on the information currently available, the U.S. Army believes that the selected alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to 42 U. S. C. §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 permanent solutions; and 5) utilize treatment as a principal element.

The U.S Army will present details of the ISTD, ISB and biobarrier implementation, groundwater and surface water monitoring plan, LUC RD, and the MNA remedy implementation in the RD for LHAAP-47.

2.12.2 Description of the Selected Remedy

The selected remedy, Alternative 2, was outlined in **Section 2.9**; that description is expanded in the following discussion. The remedy may undergo modifications as a result of the RD and construction processes. Modifications of the remedy described in the ROD will be documented using a technical memorandum in the Administrative Record, an Explanation of Significant Differences (ESD), or a ROD amendment.

The major components of the remedy and the contingency remedies include:

- ***ERH (ISTD).*** Use of ERH as a thermal treatment to remediate the areas of residual TCE DNAPL near Building 46A is expected to effectively remediate the groundwater and reduce TCE concentrations by up to 99%. **Figure 2-10** shows the areas of residual TCE DNAPL greater than 10,000 µg/L in the shallow and intermediate zone groundwater targeted for ERH treatment. ERH involves the application of electrical current through the subsurface, resulting in the generation of heat. ERH uses the natural electrical resistance within the subsurface where energy is dissipated through ohmic, or resistive losses. This manner of in-situ heating allows energy to be focused into a specific source zone. When the subsurface temperature is increased to the boiling point of the pore water or the saturated media in the treatment zone, steam is generated. The steam strips contaminants from the aquifer matrix and enables them to be extracted from the subsurface. In addition, contaminants are directly volatilized from unsaturated soil.

  An ERH system consists of subsurface electrodes connected to direct current through the subsurface, and a vapor extraction system to capture the volatilized water and contaminants. In some cases, groundwater extraction is also used to lower the water table within the treatment zone during initial stages of treatment (prior to temperatures exceeding the boiling point of subsurface water) or to provide hydraulic control.

Typically, utility (60 Hertz) electrical power is used with power conversion equipment to regulate voltage or to convert the phase characteristics of the power. Multi-phase heating requires additional space for a transformer (typically mounted on a standard tractor trailer), which can also be designed to include voltage controls. Vapor extraction systems are typically used to remove volatilized water and contaminants from the subsurface. The vapor extraction and aboveground treatment equipment include blowers, condensate removal system, emission control system (refrigerated condenser, thermal/catalytic oxidizer or activated carbon) and associated control equipment. Higher temperature conditions should be considered when designing extraction and monitoring wells and associated equipment for the treatment area. Existing equipment may require modifications or replacement to accommodate these elevated temperature conditions. The design of the electrode field and required supporting technologies will be developed during the RD.

- ***In Situ Bioremediation.*** The desired outcome will be to reduce contaminant mass and lower the contaminant concentrations in hot spots. For the purposes of costing, target areas were assumed to be near monitoring wells 47WW09, 47WW25, 47WW30, 47WW34, LHSMW43, and LHSMW56 with VOCs greater than 1,000 µg/L or near well LHSMW60 where perchlorate is greater than 20,000 µg/L. ISB will be used for any remaining hot spots near Building 46A following ERH implementation. The target areas including the horizontal and vertical target zones will be further refined during the RD phase. Appropriate substrates for in-situ bioremediation of the TCE and perchlorate hot spots will be identified during the RD phase.

  The COCs at LHAAP-47 can degrade under anaerobic conditions under different mechanisms and redox requirements. Therefore, the addition of a carbon source will encourage the growth of microorganisms in the subsurface. A microbial culture will be added, if necessary, to provide microbial species specifically able to degrade TCE and its daughter products to harmless end products. A substrate Injection of the carbon source and bioaugmentation culture into the aquifer will be accomplished utilizing direct push technology. Carbon source includes a wide variety of nutrients: sugars (molasses), alcohols (methanol, ethanol), volatile acids (acetate, lactate), or wastes (food processing, manure). The injection would occur in the contaminated interval, at approximately 30 feet bgs. Additional future injections may occur near well 47WW25 and additional locations, if necessary to support continued remediation in the target area. The number of DPT injection points and the injection volumes, as well as the appropriate substrate, will be finalized in the RD. A substrate specific to perchlorate will be developed and used to treat perchlorate hot spots.

- ***Biobarriers.*** Biobarriers will be installed near the leading edges of the northern and southern perchlorate and VOC plumes, and at the southern edge of the perchlorate plume near Goose Prairie Creek (**Figure 2-10**). Biobarriers will be installed by closely spaced injection points in the shallow and intermediate zones. A substrate will be injected in the target treatment areas via injection points or wells. The selected substrate is expected to enable native microorganisms to create favorable conditions for degradation of the COCs. A bioaugmentation culture may be introduced, if necessary, to the subsurface environment to provide appropriate microbes able to degrade the COCs to non-toxic end products. The biobarriers will be installed in the first year, then follow-up injections will be administered as necessary to ensure that the conditions conducive to biological processes are maintained.

The specific locations for biobarriers, substrate selection and injection frequency will be determined in the RD.

- ***Excavation.*** Perchlorate impacted soil extends to depths of 10 feet with an estimated volume of 9,000 cubic yards based on historical soil sampling exceedances of the GWP-Ind value. The extent of perchlorate-contaminated soil to be removed is shown on **Figure 2-10**. Excavated soil will be sampled to determine if it is a characteristic hazardous waste prior to transportation and disposal. Prior to excavation of perchlorate impacted soil, the plastic liner located on top of the perchlorate impacted soil will be removed and appropriately disposed. Pre-excavation sampling will also be completed to confirm planned extent of excavation based upon the clean-up objectives. Confirmation sampling will be completed along the sidewalls and floor of the excavation, with excavation proceeding until the clean-up objective of the GWP-Ind are achieved. If groundwater intrusion is present in the excavation, water will be managed and disposed of at the GWTP until the excavation reaches 10 feet in depth. If residual contamination exists in soil at this depth it will be addressed under the groundwater remedy for the site. Excavation and disposal of the soil will result in eliminating the potential continuing source for perchlorate impacts to groundwater and surface water. The excavation area will be backfilled with certified clean backfill soil located from an off-site source.
- ***Monitored Natural Attenuation.*** An MNA evaluation for LHAAP-47 site demonstrated that natural attenuation is occurring and is effectively controlling COCs in the shallow and intermediate groundwater zones outside of the well field area (Shaw, 2011). Under MNA, regular monitoring will be conducted throughout the program to confirm that natural attenuation is progressing towards the groundwater cleanup levels. Select wells will be monitored 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. If MNA is not found to be effective in areas outside of direct active treatment, a contingency remedy may be implemented. The contingency remedy will be determined based on aquifer conditions at that time.
- ***Groundwater Monitoring.*** Groundwater monitoring will be conducted to evaluate inorganic COCs and other COCs that have either not previously shown exceedances of cleanup levels or have infrequently or only historically exceeded cleanup levels specified in **Table 2-8**. The need to continue groundwater monitoring for this purpose will be evaluated at five-year reviews or in some cases after two additional sampling events in which results remain below cleanup levels specified in **Table 2-8**.
- ***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 will 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:

- 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.

- ***Additional Treatment using ISB*** *if MNA is found to be ineffective.* If MNA is not found to be effective in areas outside of direct active treatment, additional treatment using ISB will be performed in those areas. The need for additional treatment using ISB will be determined based on ISB and MNA performance evaluation.
- **Initiate LTM.** 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. The performance monitoring plan will be developed in the RD and will be in accordance with USEPA guidance (USEPA, 2004). LTM will be implemented such that it is consistent with USEPA's long-term monitoring criteria, the NCP, and the USEPA's Guidance (Summary of Key Existing USEPA CERCLA Policies for Groundwater Restoration). The number and location of the wells and surface water sample locations in the LTM will be reviewed during the Five-Year Reviews. LTM will be conducted to evaluate contaminant migration, ensure that the COC plume continues to degrade, and to demonstrate compliance with ARARs until groundwater cleanup levels are met. LTM will follow the 2-years of quarterly MNA monitoring, and will consist of semiannual monitoring for three years (through Year 5), and annual monitoring until the next Five-Year Review, when the analytical suite, and number and location of monitoring points will be re-evaluated. Monitoring will continue annually thereafter until recommended otherwise by the Five-Year Review and with concurrence of EPA and TCEQ. Annual reports will be prepared to document the effectiveness of the treatment and provide an evaluation of the effectiveness of the selected remedy until the end of annual monitoring (Year 10). It is assumed that after Year 10, monitoring will be performed once every 5 years with samples analyzed for VOCs and perchlorate only.
- ***Surface Water Monitoring.*** Surface water monitoring will be performed at LHAAP-47 beginning with a baseline sampling prior to excavation and continuing quarterly throughout the first two years to ensure that COCs are not migrating to surface water in Goose Prairie Creek. To the extent feasible, surface water sampling at the site will be performed at times when the groundwater table is believed to be in contact with surface water or during or after precipitation events. Following completion of the MNA evaluation, surface water monitoring locations, frequency, and contaminants included for analysis will be re-evaluated. The monitoring program frequency and duration will be established 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 2-8**) 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 and land use LUC is shown on **Figure 2-11**.
- The LUC restricting land use to nonresidential shall be implemented until it is demonstrated that surface and subsurface soil and groundwater COCs 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 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 2-8**) 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 LUCs that have been transferred out of Army control, the Army will monitor and report on the implementation, maintenance, and enforcement of LUCs, and coordinate with federal, state, and local governments and owners of properties subject to LUCs. 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 will be described in the RD for LHAAP-47. The LUCs will be included in the property transfer documents and a recordation of the area of groundwater prohibition will 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 will 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. Sampling frequency and analytical requirements will be presented as an appendix to the RD for LHAAP-47.

CERCLA Five-Year Reviews will be conducted to evaluate whether the remedy remains protective of human health and the environment. The need for continued groundwater monitoring will be evaluated every 5 years during the reviews. All groundwater COCs identified in **Table 2-8**, will be included in the final remedy groundwater monitoring program. During each Five-Year Review, the analytical suite will be re-evaluated. COCs that have decreased to concentrations below cleanup levels, or are non-detect, or only detected sporadically below clean-up levels, or consistent with background will be removed from the monitoring program after review by the U.S. Army, USEPA, and TCEQ.

2.12.3 Cost Estimate for the Selected Remedy

Table 2-11 presents the PW analysis of the cost for the selected remedy, Alternative 2. 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. Modifications 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 PW cost of this alternative is approximately $9.33 million using a discount rate of 2.8%. The capital cost PW is estimated at $6.76 million. The total O&M present value cost is estimated at approximately $2.56 million. The O&M cost includes LTM associated with the LUCs, and the assessment of ISB performance. The LTM will 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 ROD. The groundwater will be restored to attain groundwater cleanup standards/levels, to the extent practicable. With respect to the COCs and by-product contaminants found in the groundwater at the site, the groundwater cleanup standards/levels include attainment of the SDWA MCL for those COCs and by-product (i.e., daughter) contaminants that have a MCL, to the extent practicable, consistent with 40 CFR §300.430(e)(2)(i)(B & C). In the absence of federal drinking water standards, clean-up levels will be based on TRRP Tier 1 Residential Groundwater PCLs (**Table 2-8**). Surface water monitoring levels for groundwater COCs (**Table 2-9**) are the Texas Surface Water Quality Standards found at 30 TAC 307.6(d)(1), or if a standard is not available, the TRRP Tier 1 Residential Groundwater PCL.

The expected outcome of the selected remedy is that the COCs and their by-products in groundwater will be reduced to attain the SDWA MCLs or TRRP Tier 1 Groundwater Residential PCLs and that groundwater discharging into Goose Prairie Creek will have COC concentrations that do not result in exceedances of the Texas surface water quality standards for the COCs and their byproducts (or TRRP Tier 1 Residential Groundwater PCLs where Texas surface water quality standards are not available). Attainment of the groundwater cleanup standards/levels is anticipated to be completed in approximately 100 years. The site will be made part of a national wildlife refuge operated by USFWS, and will continue in such use for the foreseeable future. This approximate timeframe to achieve cleanup levels is considered reasonable for the anticipated future land use as a national wildlife refuge with no other reasonably anticipated use. When the levels of COCs in soil and groundwater allow for unlimited use and unrestricted exposure, the agency with jurisdiction over the property may petition to remove the LUCs restricting groundwater use and restricting land use to nonresidential, if it so desires.

2.13 Statutory Determinations

Under 42. U. S. C. §9621 and the NCP, the U.S. Army must select remedies that are protective of human health and the environment, comply with ARARs (unless a 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 reduces 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 will achieve the RAOs for LHAAP-47 by protecting human health from exposure to contaminated groundwater, reducing the COCs and their by-products within the groundwater plume to below groundwater cleanup standards/levels, and by maintaining surface water quality in Goose Prairie Creek such that surface water standards/levels for COCs and by-products are not exceeded. LUCs would ascertain that receptors are not exposed to unacceptable levels of contaminated groundwater. The LUCs will be required until the COCs attain levels that allow for unlimited use and unrestricted exposure.

The soil remedial action under this remedy would remove the potential sources of perchlorate migration to groundwater and surface water and TCE to groundwater. The groundwater remedial action would eventually achieve the cleanup levels for COCs present in groundwater. Therefore, the residual site risk after completion of these actions will be within the target risk range for a hypothetical future maintenance worker.

The facility-wide Ecological Baseline Risk Assessment concluded that risks to ecological receptors at the LHAAP-47 (part of the industrial sub area) were within the acceptable risk range (Shaw, 2007a).

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 2-12**.

2.13.2.1 Chemical-Specific ARARs

- **Soil.** Since there are no federally promulgated chemical-specific ARARs for soil, the ROD applies the State of Texas promulgated cleanup standards under 30 TAC 335, Subchapter S, specifically 30 TAC 335.559 (g)(2) which specifies contaminant concentration limits for nonresidential soil and are used as the chemical-specific ARARs for the site soils. The concentrations represent the non-residential soil-to-ground water cross-media protection concentrations that must be met to demonstrate that a contaminant in soil does not pose the potential for a future release of leachate in excess of the groundwater concentration considered to be protective for nonresidential worker exposure. It is anticipated that removal of contaminated soils above the Texas standards will prevent further contamination of the groundwater from soil at the site.
- **Surface Water**. 42 U. S. C. §9621(d)(2) 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 (CWA). Therefore, surface water quality criteria may be 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.(d)(1), 307.7, 307.8 and 307.9 are considered potential future ARARs.

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 COCs that are not listed in Table 2 of 30 TAC §307.6(d)(1), the TRRP Tier 1 Residential Groundwater PCLs for those COCs apply.

- **Groundwater**. Cleanup levels are presented in **Table 2-8**. In the absence of federal drinking water standards, clean-up levels will be based on TRRP Tier 1 Residential Groundwater PCLs. This alternative will return the contaminated shallow and intermediate groundwater zones at LHAAP-47 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.

2.13.2.2 Location-Specific ARARs

This remedy includes activities which may be implemented in close proximity to internationally recognized wetlands and extra precaution will be taken to avoid unduly stressing the ecosystem or sensitive habitat. The remedy does not include any dredging, filling, or other wetlands destruction components. There will not be any impacts to archeological resources or threatened and endangered species. The only other location-specific ARAR is the placement of hazardous waste facilities in floodplains under 40 CFR §264.18(b).

2.13.2.3 Action-Specific ARARs

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

- **Site Preparation, Construction, and Excavation Activities.** Certain on-site preparation, construction, and/or excavation, and vegetation clearing activities will be necessary 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), 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 and 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 nonhazardous 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). If feasible, secondary waste streams generated due to dewatering, well development activities, or from decontamination activities will be sent to the LHAAP-18/24 wastewater treatment facility for further treatment in accordance with applicable regulations. All wastes must be managed, stored, treated (if necessary), and disposed of in accordance with the ARARs for waste management listed in **Table 2-12** 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 provide ARARs for such actions and include 30 TAC 331, Subchapters A and H. Specific provisions 30 TAC §331.9(a); 30 TAC §331.10(a); 30 TAC §331.10(d); 30 TAC §331.21; 30 TAC §331.132(a); 30 TAC §331.132(c); 30 TAC §331.132(d)(1); 30 TAC §331.132(d)(4); 30 TAC §331.133(e) apply. 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-47 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 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 will 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

Alternative 2 has the lowest PW and capital costs of the action alternatives that were evaluated in the FS (Shaw, 2011) and FS Addendum (HDR, 2021c). Alternative 2 utilizes active technologies (ISTD, ISB and biobarriers) combined with MNA; those active technologies lead to much lower monitoring costs in the future, thus giving Alternative 2 a relatively low total present value cost.

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 final 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. ISTD and ISB (if needed) will lower groundwater COC concentrations in the most contaminated portion of the groundwater plumes. Biobarriers or grids will provide additional reduction of COC concentrations in the groundwater through degradation by biological processes. The active biodegradation that occurs as part of the natural attenuation, together with dilution, dispersion and other natural processes has the capability to ultimately reduce the groundwater contaminants to cleanup levels.

Alternative 2 would provide almost immediate protection because the LUCs will be implemented relatively quickly. Maintenance of this control will be required until COC concentrations in groundwater allow for unlimited use and unrestricted exposure.

2.13.5 Preference for Treatment as a Principal Element

The selected remedy satisfies the statutory preference for treatment as a principal element of the remedy. The selected final remedy will reduce the toxicity, mobility, or volume of the COCs in groundwater through the implementation of ERH. ERH will lower COC concentrations in the groundwater plume to meet cleanup level. ISB will be implemented following ERH if needed. ISB will be the primary treatment technology in areas outside of the Building 46A area. The ERH and biological activity in the ISB treatment areas will significantly reduce the overall mass of COCs in the groundwater.

2.13.6 Five-Year Review Requirements

42 U. S. C. § 121(c) and 40 §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 onsite above levels that allow unlimited use and unrestricted exposure, a review will be conducted at least

every 5 years to ascertain 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-47 was released for public comments on December 21, 2012. The Proposed Plan identified Alternative 2 as the Preferred Alternative for groundwater remediation. In 2021, the Proposed Plan was revised to address significant new information obtained during the 2018-2020 PSI. The Revised Proposed Plan incorporated the results of the FS Addendum (HDR, Inc. 2021c) which evaluated additional treatment technologies specific to remediating residual TCE DNAPL. The Revised Proposed Plan was released for public comments on July 7, 2021. The Revised Proposed Plan identified a modified Alternative 2 as the Preferred Alternative for groundwater remediation. The U.S. Army reviewed all written comments during the public comment period and verbal comments during the January 9, 2013 and July 21, 2021 public meetings. After careful consideration of the comments, it was determined that no significant changes to the modified remedy are necessary or appropriate.

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

Chemical	Baseline Risk Assessment			Recent Maximum Result			Comparison Level		Retained as COC?
	EPC (µg/L)	Well	Groundwater Hazard Quotient	Recent Maximum (µg/L)	Date	Well[a]	MCL (µg/L)	TRRP Tier 1 Residential Groundwater PCL (µg/L)	
Perchlorate	82,900	LHSMW60	900	56,600	08/30/10	LHSMW60		17	Yes, 1
Trichloroethene	29,400	LHSMW43	110	13,300 6,240	04/03/09 02/19/09	47WW25 LHSMW43	5		Yes, 2
Chloroform	120	47WW20	69	1.61 JB -	10/09/09 -	47WW35 47WW20	80 [b]		Yes, 2
Thallium	93	LHSMW47	11	4.62 ND	09/13/07 05/18/98	47WW07 LHSMW47	2		Yes, 2
Acetone	21,000	LHSMW35	8.1	12.5 -	10/09/08 -	47WW36 LHSMW35		22000	Yes, 1
Cadmium	200	LHSMW57	3.9	5.07 -	11/29/07 -	47WW22 LHSMW57	5		Yes, 2
Nickel	8,000	LHSMW51	3.9	17,500 -	11/29/07 -	47WW22 LHSMW51		490	Yes, 1
cis-1,2-Dichloroethene	2,090	LHSMW43	2.5	1,440 325	08/04/10 02/19/09	47WW13 LHSMW43	70		Yes, 2
Silver	1,000	LHSMW51	2	ND -	08/04/10 -	47WW13 LHSMW51		120	Yes, 1
Tin	120,000	47WW02	2	Not Tested After Risk Assessment				15000	Yes, 1
Antimony	76	LHSMW60	1.9	7.5 1.62 J	11/29/07 08/30/10	47WW22 LHSMW60	6		Yes, 2
Manganese	7,750	47WW16	1.6	3,280 -	11/29/07 -	47WW22 47WW16		1100	Yes, 1
Aluminum	86,000	LHSMW48	0.84	63,000 -	11/29/07 -	47WW22 LHSMW48		24000	Yes, 1
Strontium	19,000	47WW17	0.31	Not Tested After Risk Assessment				15000	Yes, 1
Chromium	43,000	LHSMW51	0.28	356,000 -	11/29/07 -	47WW22 LHSMW51	100		Yes, 2
Vanadium	130	LHSMW48	0.18	1,820 -	11/29/07 -	47WW22 LHSMW48		44	Yes, 1
Cobalt	311	LHSMW53	0.15	171 80	11/29/07 05/20/98	47WW22 LHSMW53		240	Yes, 1
2,4,6-Trinitrotoluene	6.8	LHSMW56	0.13	Not Tested After Risk Assessment				12	Yes, 1

Notes and Abbreviations:
Lists chemicals with hazard quotient greater than 0.1.
1. Retained as a COC because hazard quotient is greater than 0.1.
2. Retained as a COC because at least 1 result is greater than the MCL.
[a] When 2 wells are listed, the recent maximum was from a different well.
[b] MCL for Total Trihalomethanes used as a surrogate.

μg/L	micrograms per liter
COC	chemical of concern
EPC	exposure point concentration
MCL	maximum contaminant level
PCL	Protective Concentration Level
TCEQ	Texas Commission on Environmental Quality

Source: Shaw 2011, Final Feasibility Study, LHAAP-47, Plant 3, Group 4
TRRP Tier 1 Residential Groundwater PCLs, 4/27/2018 Update

Table 2-3. Chemicals Contributing to Carcinogenic Risk in Groundwater

Chemical	Baseline Risk Assessment			Recent Maximum Result			Comparison Level		Retained as COC?
	EPC (µg/L)	Well	Cancer Risk Groundwater	Recent Maximum (µg/L)	Date	Well [a]	MCL (µg/L)	TRRP Tier 1 Residential Groundwater PCL (µg/L)	
Trichloroethene	29,400	LHSMW43	5.70E-03	13,300 6,240	04/03/09 02/19/09	47WW25 LHSMW43	5		Yes, 1
Vinyl Chloride	127	LHSMW56	7.30E-04	249 14.3	08/04/10 04/03/09	47WW13 LHSMW56	2		Yes, 1
1,1-Dichloroethene	32.2	LHSMW48	2.60E-04	108 2.9	04/03/09 05/19/98	LHSMW56 LHSMW48	7		Yes, 1
Chloroform	120	47WW20	1.80E-04	1.61 JB -	10/09/09 -	47WW35 47WW20	80 [b]		Yes, 1
Tetrachloroethene	168	LHSMW43	1.50E-04	38.4	02/19/09	LHSMW43	5		Yes, 1
2,3,7,8-TCDD	2.88E-06	47WW01	1.40E-05	2.31E-06	11/07/98	47WW01	3.00E-05		No, 2
Pentachlorophenol	7.9	LHSMW47	1.20E-05	Not Tested After Risk Assessment			1		Yes, 1
1,2-Dichloroethane	5.7	LHSMW48	1.20E-05	0.746 ND	02/23/09 05/19/98	47WW34 LHSMW48	5		Yes, 1
2,4-Dinitrotoluene	1.4	47WW11	3.30E-06	Not Tested After Risk Assessment				1.3	Yes, 3
2,6-Dinitrotoluene	1.4	47WW11	3.30E-06	Not Tested After Risk Assessment				1.3	Yes, 3
1,1,2-Trichloroethane	4.9	LHSMW43	1.90E-06	1.8	02/22/09	LHSMW43	5		No, 2
bis(2-Ethylhexyl)phthalate	21	LHSMW45	1.70E-06	Not Tested After Risk Assessment			6		Yes, 1

Notes and Abbreviations:
1. Retained as a COC because at least 1 result exceeded the MCL
2. Excluded as a COC because all results are less than the MCL
3. Retained as a COC because cumulative cancer risk is greater than 1.0×10^{-6}
[a] The recent maximum from the well cited in the BHHRA is shown;
if there was a higher concentration for the chemical from a different well, that value and well are also shown
[b] MCL for Total Trihalomethanes used as a surrogate

µg/L micrograms per liter
COC chemical of concern
EPC exposure point concentration
MCL maximum contaminant level
PCL Protective Concentration Level

Source: Shaw 2011, Final Feasibility Study, LHAAP-47, Plant 3, Group 4
TRRP Tier 1 Residential Groundwater PCLs, 4/27/2018 Update

Table 2-4. Cancer Toxicity Data-Oral Dermal Exposure, Group 4 Risk Assessment**

Chemical of Potential Concern	Oral CSF (mg/kg-day) [1]	Reference	ABSgi * (unitless)	Reference	Dermal CSF (mg/kg-day) [1]	Weight of Evidence/ Cancer Guideline Description	Reference
Trichloroethane	1.1E-02	EPA-NCEA, 2001	1	TCEQ, 1998	1.1E-02	B2	EPA-IRIS, 2001
Vinyl Chloride	1.5E+00	EPA-IRIS, 2001	1	TCEQ, 1998	1.50E+00	A	EPA-IRIS-2001
1,1-Dichloroethene	6.00E-01	EPA-IRIS, 2001	1	TCEQ, 1988	6.00E-01	C	EPA-IRIS-2001
Chloroform	6.10E-03	EPA-IRIS, 2001	0.2	TCEQ, 1988	3.05E-01	B2	EPA-IRIS-2001
Tetrachloroethene	5.2E-02	EPA-NCEA, 2001	1	TCEQ, 1988	5.2E-01	B2	EPA-IRIS-2001
2,3,7,8-TCDD	1.50E+05	EPA-HEAST, 1997	0.5	TCEQ, 1998	3.00E+05	Not Classified	--
Pentachlorophenol	1.2E-01	EPA-IRIS, 2001	0.76	TCEQ, 1988	1.58E-01	B2	EPA-IRIS, 2001
1,2-Dichloroethane	9.10E-02	EPA-IRIS, 2001	1	TCEQ, 1988	9.1E-02	B2	EPA-IRIS, 2001
2,4-Dinitrotoluene	--	--	--	--	--	--	--
2,6-Dinitrotoluene	--	--	--	--	--	--	--
1,1,2-Trichloroethane	5.7E-02	EPA-IRIS, 2001	0.81	TCEQ, 1988	7.04E-02	C	EPA-IRIS, 2001
Bis(2-ethylhexyl)phthalate	1.4E-02	EPA-IRIS, 2001	0.19	TCEQ, 1988	7.37E-02	B2	EPA-IRIS, 2001

EPA-HEAST, 1997 Health Effects Summary Tables (HEAST0. FY-1995. EPA/540/R-95-036.
EPA-IRIS, 2001 Integrated Risk Information System (IRIS). United States Protection Agency Online Database for Toxicity Information on Hazardous Chemicals. 2001. TCEQ, 1998. Consistency Memorandum Attachment C. Office of Waste Management. 23 July 1998

Notes and Abbreviations:
* The dermal RfD was derived by multiplying the Oral Rfd by the ABSgi.
** The human health risk is based on baseline human health risk assessment adopted from 'Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 4 Sites' (Jacobs, 2003)"

ABSgi gastrointestinal absorption factor NA= Information not available
NTV no toxicity value available CSF = cancer slope factor
TCDD tetrachlorodibenzo-p-dioxin
TCEQ Texas Commission on Environmental Quality

Table 2-5. Non-Cancer Toxicity Data-Oral Dermal Exposure, Group 4 Risk Assessment

Chemical of Potential Concern	Oral RfD (mg/kg- day)	Reference	ABSgi * (unitless)	Reference	Dermal RfD (mg/kg- day)	Target Endpoint	Combined Uncertainty/ Modifying Factors	Reference
Perchlorate	9.00E-04	EPA, 1994	1	Health Consultation, 1997	9.00e-04	NA	NA	--
Trichloroethene	6.00E-03	EPA-NCEA, 2001	1	TCEQ, 1998	6.00E-03	NA	NA	--
Chloroform	1.00E-02	EPA-IRIS, 2001	0.2	TCEQ, 1988	2.00E-03	Cyst formation in liver	1000/1	EPA-IRIS, 2001
Thallium	8.00E-05	EPA-IRIS, 2001	1	TCEQ, 1988	8.00E-05	Blood	3000/1	EPA-IRIS, 2001
Acetone	1.00E-01	EPA-IRIS, 2001	0.83	TCEQ, 1988	8.30E-02	Liver and kidney effects	1000/1	EPA-IRIS, 2001
Cadmium	5.00E-04	EPA-IRIS, 2001	0.025	TCEQ, 1988	1.25E-05	Proteinuria	10/1	EPA-IRIS, 2001
Nickel	2.00E-01	EPA-IRIS, 2001	0.04	TCEQ, 1988	8.00E-04	Decreased body weight	300/1	EPA-IRIS, 2001
cis-1,2 Dichloroethene	1.00E-02	EPA-HEAST, 1997	1	TCEQ, 1988	1.00E-02	Decreased hematocrit and hemoglobin in blood	3000/1	EPA-IRIS, 2001
Silver	5.00E-03	EPA-IRIS, 2001	0.04	TCEQ, 1988	2.00E-04	Argyria	3/1	EPA-IRIS, 2001
Tin	6.00E-01	EPA-HEAST, 1997	0.1	TCEQ, 1988	6.00E-02	Liver/kidney	100/1	EPA- HEAST, 199
Antimony	4.00E-04	EPA-IRIS, 2001	0.15	TCEQ, 1988	6.00E-05	Longevity, blood glucose and cholesterol	1000/1	EPA-IRIS, 2001
Manganese	4.70E-04	EPA-IRIS, 2001	0.06	TCEQ, 1988	2.82E-03	Central nervous system	1/1	EPA-IRIS, 2001
Aluminum	1.00E+00	EPA-NCEA, 2001	0.1	TCEQ, 1988	1.00E-01	NA	NA	--
Strontium	6.00E-01	EPA-IRIS, 2001	0.2	TCEQ, 1988	1.2E-01	Rachitic bone	300/1	EPA-IRIS, 2001
Chromium	1.50E+00	EPA-IRIS, 2001	0.013	TCEQ, 1988	1.95E-02	No observed effects	1000/10	EPA-IRIS, 2001
Vanadium	7.00E-03	EPA-HEAST, 1997	0.026	TCEQ, 1988	1.82E-04	NA	NA	--
Cobalt	2.00E-02	EPA-NCEA, 2001	0.8	TCEQ, 1988	1.60E-02	NA	NA	--
2,4,6-trinotrotoluene	5.00E-04	EPA-IRIS, 2001	0.6	TCEQ, 1998	3.00E-04	Liver effects	1000/1	EPA-IRIS, 2001

Notes and Abbreviations:
EPA, 1998. Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization Based on Emerging Information, Review Draft, Office of research and Development, NCEA-1-0503, 31 December 1998.
EPA-IRIS, 2001 Integrated Risk Information System (IRIS). United States Protection Agency Online Database for Toxicity Information on Hazardous Chemicals. 2001. EPA-NCEA, 2001. EPA Region III Risk-Based Concentration Tables (5/8/2001). Referenced values from National center for Environmental Assessment.
Health Consultation, 1997. Health Consultation, Perchlorate Contamination in the Citizens Utilities Suburban and Security Park Water Service Areas. Aerojet General Corporation. February 1997.
TCEQ, 1998. Consistency Memorandum Attachment C. Office of Waste Management. 23 July 1998
* The dermal RfD was derived by multiplying the Oral Rfd by the ABSgi.

ABSgi gastrointestinal absorption factor
NA Information not available
NTV no toxicity value available
RfD Reference Dose

Table 2-6. Summary of Carcinogenic Risks and Non-Carcinogenic Hazard at LHAAP-47

Scenario	Total Hazard Index	Total Cancer Risk
Risks from Soil		
Future Maintenance Worker (0 to 0.5 feet bgs)	0.40	1.82×10^{-5}
Future Maintenance Worker (0 to 2 feet bgs)	0.46	1.77×10^{-5}
Risks from Groundwater		
Future Maintenance Worker	1,120	7.07×10^{-3}
Combined Risks- Soil and Groundwater		
Future Maintenance Worker (0 to 0.5 feet bgs)	1,120	7.09×10^{-3}
Future Maintenance Worker (0 to 2 feet bgs)	1,120	7.09×10^{-3}

Notes and Abbreviations:
bgs = below ground surface

Source: Jacobs, 2003. Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 4 Sites (Sites 04, 08, 35A, 35B, 35C, 46, 47, 48, 50, 60, 67, Goose Prairie Creek, Saunders Branch, Central Creek, and Caddo Lake), Longhorn Army Ammunition Plant, Karnack, Texas, Final, Oak Ridge, Tennessee, June.(Table 3-72)

Table 2-7. Cleanup Levels for Target COCs in Soil

COCs Targeted for Remediation	Cleanup Level [a] (mg/kg)
Perchlorate	7.2
TCE	0.5

Notes and Abbreviations:
[a] Unless otherwise noted, cleanup level applies to soil from surface to groundwater interface

mg/kg milligrams per kilogram
COC contaminant of concern
GWP-Ind soil medium specific concentration for industrial use based on groundwater protection

Source: HDR, 2021c, Final Feasibility Study Addendum, LHAAP-47, Plant 3, Group 4

Table 2-8. Cleanup Levels for Target COCs in Groundwater

COCs Targeted for Remediation	MCL (µg/L)	TRRP Tier 1 Residential Groundwater PCLs (µg/L)	Background (µg/L)	Cleanup Level (µg/L)
Perchlorate	--	17	--	17
1,1-Dichloroethene	7	--	--	7
1,2-Dichloroethane	5	--	--	5
Acetone	--	22,000	--	22,000
Chloroform	80	--	--	80
cis-1,2-Dichloroethene (cis-1,2-DCE)	70	--	--	70
Tetrachloroethene (PCE)	5	--	--	5
trans-1,2-Dichloroethene (trans-1,2- DCE) (daughter product)	100	--	--	100
Trichloroethene (TCE)	5	--	--	5
Vinyl Chloride (VC)	2	--	--	2
2,4,6-Trinitrotoluene	--	12	--	12
2,4-Dinitrotoluene	--	1.3	--	1.3
2,6-Dinitrotoluene	--	1.3	--	1.3
bis(2-Ethylhexyl)phthalate	6	--	--	6
Pentachlorophenol	1	--	--	1
Aluminum*	--	24,000	2,680	24,000
Antimony	6	--	12.2	12.2
Arsenic	10	--	34.2	34.2
Cadmium	5	--	5.1	5.1
Chromium	100	--	15.8	100
Cobalt*	--	240	187	240
Manganese	--	1,100	7,820	7,820
Nickel	--	490	229	490
Silver	--	120	1.92	120
Strontium	--	15,000	7,330	15,000
Thallium	2	--	--	2
Tin	--	15,000	--	15,000
Vanadium	--	44	3.99	44

<u>Notes and Abbreviations</u>
Source: The source of this table is the *Final Feasibility Study, LHAAP-47, Plant 3, Group 4* (Shaw, 2011)
Background concentration from *Final Evaluation of Perimeter Well Data for Use* as Groundwater Background (Shaw, 2007c)
µg/L micrograms per liter
COCs Contaminants of Concern
MCL Safe Drinking Water Act maximum contaminant level
TRRP Texas Risk Reduction Program
PCL Protective Concentration Level
TRRP Tier 1 Residential Groundwater PCL 4/27/2018 Update

Table 2-9. Monitoring Levels for Perchlorate and VOCs in Surface Water

Chemicals	Texas Surface Water Quality Standards [a] (µg/L)
Perchlorate[b]	17[b]
1,1-Dichloroethene	7
1,2-Dichloroethane	5
Acetone[b]	22,000[b]
Chloroform	70
cis-1,2-Dichloroethene (cis-1,2-DCE)[c]	70 [c]
Tetrachloroethene (PCE)	5
trans-1,2-Dichloroethene (trans-1,2-DCE) (daughter product)[c]	100[c]
Trichloroethene (TCE)	5
Vinyl Chloride (VC)	0.23

Notes and Abbreviations:
[a] Texas Surface Water Quality Standards are adopted from 30 Texas Administrative Code (TAC) §307.6(d)(1) (Human Health Protection for Water and Fish consumption).
[b] There is no Texas surface water quality standard for this chemical. The value provided is the TRRP Tier 1 Residential Groundwater PCL for this chemical
[c] There is no Texas surface water quality standard for this chemical. The value provided is the MCL for this chemical.
µg/L micrograms per liter
TRRP Tier 1 Residential Groundwater PCL
MCL Safe Drinking Water Act maximum contaminant level
PCL Protective Concentration Level
TCEQ Texas Commission on Environmental Quality
TRRP Texas Risk Reduction Program
VOCs Volatile Organic Compounds

Source: Shaw 2011, Final Feasibility Study, LHAAP-47, Plant 3, Group 4

Table 2-10. Comparative Analysis of Alternatives

Comparative Analysis of Alternatives Criteria	Alternative 1 No Action	Alternative 2 Excavation, In Situ Thermal Desorption, In Situ Bioremediation, MNA, and LUC	Alternative 3 Excavation, In Situ Thermal Desorption, Recirculating Bioremediation, MNA, and LUC	Alternative 4 Excavation, In Situ Thermal Desorption, Pump and Treat, In Situ Bioremediation, MNA, and LUC
Overall protection of human health and the environment	No protection. Does not achieve RAOs.	• Achieves RAOs. Protection of human health and environment provided by remediation of groundwater COCs in areas of highest contamination by ISTD and in situ bioremediation.. • Groundwater monitoring and LUC in place until cleanup levels are attained. • Removal of perchlorate contaminated source soils protect the groundwater from future perchlorate migration from soil to groundwater.	• Achieves RAOs. Protection of human health and environment provided by remediation of groundwater COCs in areas of highest contamination by recirculating bioremediation and in situ bioremediation. • Groundwater monitoring and LUC in place until cleanup levels are attained. • Removal of perchlorate contaminated source soils protect the groundwater from future perchlorate migration from soil to groundwater.	• Achieves RAOs. Protection of human health and environment provided by groundwater extraction and ex situ treatment for areas with available water, and by in situ bioremediation for areas without sufficient water to pump. • Groundwater monitoring and LUC in place until cleanup levels are attained. • Removal of perchlorate contaminated source soils protect the groundwater from future perchlorate migration from soil to groundwater.
Compliance with ARARs	No compliance with chemical-specific ARARs.	• Complies with ARARs.	• Complies with ARARs.	• Complies with ARARs.

Comparative Analysis of Alternatives Criteria	Alternative 1 No Action	Alternative 2 Excavation, In Situ Thermal Desorption, In Situ Bioremediation, MNA, and LUC	Alternative 3 Excavation, In Situ Thermal Desorption, Recirculating Bioremediation, MNA, and LUC	Alternative 4 Excavation, In Situ Thermal Desorption, Pump and Treat, In Situ Bioremediation, MNA, and LUC
Long-term effectiveness and permanence	Not effective.	• Should be effective and permanent; however, uncertainty exists concerning the effectiveness and time needed for in situ biological treatment and degradation to cleanup levels. • ERH is expected to be effective on DNAPL in groundwater near Building 46A • In situ bioremediation expected to be effective and permanent for areas of groundwater contamination outside of Building 46A area, however, uncertainty exists concerning the effectiveness and time needed for in situ biological treatment and degradation to cleanup levels. • Treatability study may be required. Long- term groundwater monitoring will follow treatment. • LUC will be effective and reliable so long as they are maintained until cleanup levels are attained. • Removal of perchlorate soil eliminates a potential future source of groundwater contamination via infiltration.	• Should be effective and permanent; however, uncertainty exists concerning the effectiveness and time needed for in situ biological treatment and degradation to cleanup levels. • ERH is expected to be effective on DNAPL in groundwater near Building 46A • Recirculating bioremediation expected to be effective and permanent for areas of groundwater contamination outside of Building 46A area, however, uncertainty exists concerning the effectiveness and time needed for in situ biological treatment and degradation to cleanup levels. • Treatability study may be required. Long- term groundwater monitoring will follow treatment. • Operation & maintenance of recirculation systems will be required. • LUC will be effective and reliable so long as they are maintained until cleanup levels are attained. • Removal of perchlorate soil eliminates a potential future source of groundwater contamination via infiltration.	• Should be effective and permanent. Uncertainty exists concerning time needed for extraction and attenuation to cleanup levels. • ERH is expected to be effective on DNAPL in groundwater near Building 46A • Pilot study may be required. • In situ bioremediation expected to be effective and permanent for areas of groundwater contamination outside of Building 46A area, however, uncertainty exists concerning the effectiveness and time needed for in situ biological treatment and degradation to cleanup levels. • Construction, operation, and maintenance of the extraction system will be required. • LUC will be effective and reliable so long as they are maintained until cleanup levels are attained. • Removal of perchlorate soil eliminates a potential future source of groundwater contamination via infiltration.

Comparative Analysis of Alternatives Criteria	Alternative 1 No Action	Alternative 2 Excavation, In Situ Thermal Desorption, In Situ Bioremediation, MNA, and LUC	Alternative 3 Excavation, In Situ Thermal Desorption, Recirculating Bioremediation, MNA, and LUC	Alternative 4 Excavation, In Situ Thermal Desorption, Pump and Treat, In Situ Bioremediation, MNA, and LUC
Reduction of toxicity, mobility, or volume through treatment	No reduction.	• Provides permanent reduction in groundwater through in situ thermal desorption using ERH, and in situ bioremediation in the areas of highest contamination provided conditions are favorable. Provides permanent reduction of perchlorate contaminated soil by removal.	• Provides permanent reduction in groundwater through in situ thermal desorption using ERH, and in situ bioremediation and recirculation in the areas of highest contamination provided treatment is successful at improving conditions. Provides permanent reduction of perchlorate contaminated soil by removal.	• Provides permanent reduction in groundwater through in situ thermal desorption using ERH, and extraction from areas of highest contamination and ex situ treatment, and from in situ bioremediation. Provides permanent reduction of perchlorate contaminated soil by removal.
Short-term effectiveness	No short-term impacts.	• Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection. Some potential impacts to workers and minimal impact to community during excavation and transportation activities. • Potential for impacts to workers from exposure to hot fluids and high voltage power during ERH application.	• Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection. Some potential impacts to workers and minimal impact to community during excavation and transportation activities. Some potential impacts to workers from exposure to contaminated groundwater in recirculation system. • Potential for impacts to workers from exposure to hot fluids and high voltage power during ERH application.	• Minimal impacts to the community, workers, or the environment from short-term activities. Provides almost immediate protection. Some potential impacts to workers and minimal impact to community during excavation and transportation activities. Some potential impacts to workers from exposure to contaminated groundwater in extraction system and transport pipeline. • Potential for impacts to workers from exposure to hot fluids and high voltage power during ERH application.

Comparative Analysis of Alternatives Criteria	Alternative 1 No Action	Alternative 2 Excavation, In Situ Thermal Desorption, In Situ Bioremediation, MNA, and LUC	Alternative 3 Excavation, In Situ Thermal Desorption, Recirculating Bioremediation, MNA, and LUC	Alternative 4 Excavation, In Situ Thermal Desorption, Pump and Treat, In Situ Bioremediation, MNA, and LUC
Implementability	Inherently implementable.	• Implementable, but uncertainty exists in the effectiveness and time required to reduce contaminants in groundwater to cleanup levels. • Specialized knowledge required for implementation. • ERH has been proven to be effective on DNAPL and within low hydraulic conductivity zones. • Soil excavation readily implemented with standard earthmoving equipment. In situ bioremediation is a commercially available treatment technology.	• Implementable, but uncertainty exists in the effectiveness and time required to reduce contaminants in groundwater to cleanup levels. • Specialized knowledge required for implementation. • ERH has been proven to be effective on DNAPL and within low hydraulic conductivity zones. • Soil excavation readily implemented with standard earthmoving equipment. In situ bioremediation is a commercially available treatment technology.	• Implementable, but uncertainty exists in the effectiveness and time required to reduce contaminants in groundwater to cleanup levels. • Specialized knowledge required for implementation. • ERH has been proven to be effective on DNAPL and within low hydraulic conductivity zones. • Soil excavation readily implemented with standard earthmoving equipment. In situ bioremediation is a commercially available treatment technology.
Capital Cost	$0	$7,158,439	$10,276,520	$7,242,398
Operation and Maintenance Cost	$0	$3,087,383	$3,087,383	$8,073,291
Present Worth	$0	$9,326,411	$12,600,292	$12,950,292

Notes and Abbreviations:
ARARs applicable or relevant and appropriate requirements
LUC land use controls
MCLs maximum contaminant levels
RAOs remedial action objectives
Costs escalated to 2020 dollars
Source: Shaw 2011, Final Feasibility Study, LHAAP-47, Plant 3, Group 4; HDR, 2021c, Draft Final Feasibility Study Addendum for LHAAP-47, Building 46A Plant 3 Area.

Table 2-11. Escalated Costs and Present Worth Analysis of Selected Remedy

Alternative 2 – Excavation, In Situ Thermal Desorption, In Situ Bioremediation, MNA and LUC Costs and Present Value, 2011 and 2020 Escalated Values

Alternative 2															
Years		**Capital Costs**											**O&M Costs**		
		Design, permitting, Construction Management		**Bioremediation**		**Excavation**		**Monitoring**		**Electrical Resistance Heating (ERH)**			**MNA/LUCs**	**5 Year Review (2011 FS)**	
Estimate Base Year		2011	2020	2011	2020	2011	2020	2011	2020	2020	2011		2020	2011	2020
1		$ 163,122	$ 203,903	$ 591,970	$ 739,963	$ 1,385,818	$ 1,732,273	$ 59,439	$ 74,299	$ 3,161,400	$ 440,364		$ 550,455		
2											$ 440,364		$ 550,455		
3				$ 160,900	$ 201,125						$ 200,944		$ 251,180		
4											$ 200,944		$ 251,180		
5						`					$ 200,944		$ 251,180	$ 42,525	$ 53,156
6				$ 418,191	$ 522,739						$ 81,244		$ 101,555		
7											$ 81,244		$ 101,555		
8											$ 81,244		$ 101,555		
9											$ 81,244		$ 101,555		
10											$ 81,244		$ 101,555	$ 42,525	$ 53,156
11				$ 418,191	$ 522,739										
12															
13															
14															
15											$ 81,244		$ 101,555	$ 42,525	$ 53,156
16															
17															
18															
19															
20											$ 81,244		$ 101,555	$ 42,525	$ 53,156
21															
22															
23															
24															
25											$ 81,244		$ 101,555	$ 42,525	$ 53,156
26															
27															
28															
29															
30											$ 81,244		$ 101,555	$ 42,525	$ 53,156
2011 Cost Estimate		**$ 163,122**		**$ 1,589,252**		**$ 1,385,818**		**$ 59,439**			**$ 2,214,756**			**$ 255,150**	
2020 Cost Estimate			**$ 203,903**		**$ 1,986,565**		**$ 1,732,273**		**$ 74,299**	**$ 3,161,400**			**$ 2,768,445**		**$ 318,938**
2020 Total Capital/O&M Cost										**$ 7,158,439**					**$ 3,087,383**
2020 Total Alternative Cost															**$ 10,245,821**

Table 2-11. Escalated Costs and Present Worth Analysis of Selected Remedy (continued)

Alternative 2 – Excavation, In Situ Thermal Desorption, In Situ Bioremediation, MNA and LUC Costs and Present Value, 2011 and 2020 Escalated Values

Net Present Value														
Discount Rate 2.8%														
		Design, permitting, Construction		**Bioremediation**		**Excavation**		**Monitoring**		**Electrical**	**MNA/LUCs**		**5 Year Review (2011 FS)**	
Estimate Base Year	**Discount Factor**	**2020 Cost**	**NPV**	**2020 Cost**	**NPV**	**2020 Cost**	**NPV**	**2020 Cost**	**NPV**	**NPV**	**2020 Cost**	**NPV**	**2020 Cost**	**NPV**
1	0.97	$ 203,903	$ 198,349	$ 739,963	$ 719,808	$ 1,732,273	$ 1,685,090	$ 74,299	$ 72,275	$ 3,075,292	$ 550,455	$ 535,462		
2	0.95										$ 550,455	$ 520,877		
3	0.92			$ 201,125	$ 185,134						$ 251,180	$ 231,210		
4	0.90										$ 251,180	$ 224,912		
5	0.87										$ 251,180	$ 218,786	$ 53,156	$ 46,300.83
6	0.85			$ 522,739	$ 442,921						$ 101,555	$ 86,048		
7	0.82										$ 101,555	$ 83,705		
8	0.80										$ 101,555	$ 81,425		
9	0.78										$ 101,555	$ 79,207		
10	0.76										$ 101,555	$ 77,050	$ 53,156	$ 40,329.53
11	0.74			$ 522,739	$ 385,798									
12	0.72													
13	0.70													
14	0.68													
15	0.66										$ 101,555	$ 67,113	$ 53,156	$ 35,128.34
16	0.64													
17	0.63													
18	0.61													
19	0.59													
20	0.58										$ 101,555	$ 58,457	$ 53,156	$ 30,597.93
21	0.56													
22	0.54													
23	0.53													
24	0.52													
25	0.50										$ 101,555	$ 50,918	$ 53,156	$ 26,651.80
26	0.49													
27	0.47													
28	0.46													
29	0.45													
30	0.44										$ 101,555	$ 44,351	$ 53,156	$ 23,214.58
Total NPV			**$ 198,349**		**$ 1,733,661**		**$ 1,685,090**		**$ 72,275**	**$ 3,075,292**		**$ 2,359,521**		**$ 202,223**
		Total Capital Cost NPV		**Total O&M/Five Yr Review Cost NPV**										
		$ 6,764,667		**$ 2,561,744**										
		Total Cost NPV		**$ 9,326,411**										

Table 2-12. Description of ARARs for the Selected Remedy

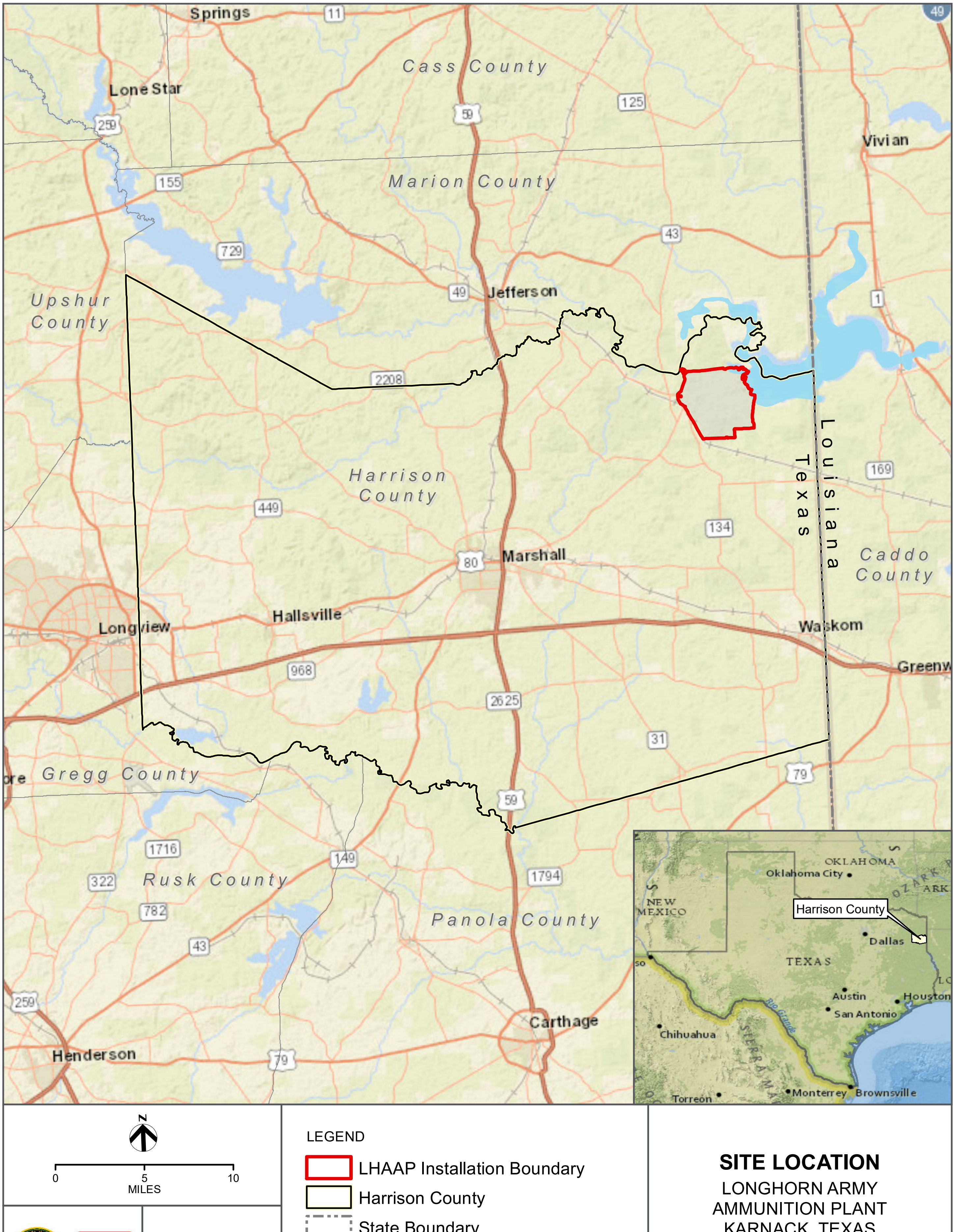
Citation	Activity or Prerequisite/Status	Requirement
Chemical-specific ARARs		
Surface/Subsurface Soil		
TCEQ Texas Risk Reduction Rules 30 TAC 335.558 and 335.559(g)(2)	Ensures adequate protection of human health and the environment from potential exposure to contaminants associated with releases – **relevant and appropriate** for remediation of contaminated soil for cross-media contamination pathways such as soil to groundwater and for hypothetical future maintenance workers.	Non-residential (industrial) soils shall conform to the non-residential soil-to-groundwater cross media protection concentration MSC (GWP-Ind) values for TCE and Perchlorate in accordance with 30 TAC §335.559(g)(2) and as listed in Table 2-7 of this report.
Groundwater		
Federal Safe Drinking Water Act MCLs 40 CFR §141.61 and §141.62	Applicable to drinking water at the tap—**relevant and appropriate** for water that could potentially be used for human consumption.	Must not exceed SDWA MCLs for water designated as a current or potential source of drinking water. The MCLs for organic contaminants TCE, PCE, 1,2-DCA, 1,1-DCE, cis-1,2-DCE, bis-2-ethylhexylphtlalate, pentachlorophenol, chloroform, trans-1,2-DCE, and VC are provided in 40 CFR §141.61(a) and the MCLs for inorganic contaminants arsenic, cadmium, chromium and thallium are provided in 40 CFR §141.62 (b) and Table 2-8 of this report.
Surface Water [(1)]		
Texas Surface Water Quality Standards (30 TAC §307.6(d)(1))	Applicable to chemicals in surface water (Goose Prairie Creek) for water that could potentially be used for human consumption.	Chemicals must not exceed the Texas surface water quality standards in waters of the Goose Prairie Creek. The surface water quality standards for TCE, PCE, 1,2-DCA, 1,1-DCE, chloroform and VC are provided in 30 TAC §307.6(d)(1) and Table 2-9 of this report.
Location-specific ARARs		
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 part of LHAAP-47 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.
Action-specific ARARS		
General Site Preparation, Construction, and Excavation Activities		
Air Contaminants – General Nuisance Rules 30 TAC 101.4	Emissions of air contaminants— **applicable**.	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.
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 §122.26;	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.
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.	• Remedial activities derived waste (from monitoring and treating contaminated groundwater) is expected for this facility. 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	On-site storage/treatment of RCRA hazardous waste in containers for greater than 90 days— **applicable** if hazardous waste is generated (e.g.,	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.

40 CFR §264.171–264.173 30 TAC 335.69(e) 30 TAC 335.152(a)(7)	PPE) and is stored in containers.	
Well Construction		
Well Construction Standards— Monitoring or Injection Wells 16 TAC 76.1000	Construction of water wells**—applicable**to construction of new monitoring orinjection wells, if needed.	Injection wells shall be completed in accordance with the technical requirements of Section 76.1000, as appropriate. Substantive requirements applicable to the injection wells will be adhered to.
Class V Injection Wells 30 TAC §331.9(a); 30 TAC §331.10(a); 30 TAC §331.10(d); 30 TAC §331.21; 30 TAC §331.132(a); 30 TAC §331.132(b)(1); 30 TAC §331.132(c); 30 TAC §331.132(d)(1); 30 TAC §331.132(d)(4); 30 TAC §331.133(e)	Installation, operation, and closure ofinjection wells fall in the category of Class V Injection Wells – **relevant andappropriate**.	• 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.
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.	• Substantive requirements applicable to extraction (recovery) wells will be adhered to. 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 characteristicallyhazardous waste intended for disposal—**applicable** if extracted groundwater isdetermined to be RCRA characteristically hazardous.	Disposal is not prohibited if such wastes are managed in a treatment system subjectto 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 landsurface to a depth of not less than 2 feet. Undesirable water or constituents or the freshwater zone(s) shall be isolated with cementplugs.

Notes and Abbreviations:

ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CFR	Code of Federal Regulations
CWA	Clean Water Act of 1972
FR	Federal Register
GWP-Ind	soil MSC for industrial use based on groundwater protection
lb/gal	pound per gallon
LHAAP	Longhorn Army Ammunition Plant
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MSC	Medium-specific concentration
%	percent
PPE	personal protective equipment
ppm	parts per million
RCRA	Resource Conservation and Recovery Act of 1976
SWDA	Safe Drinking Water Act
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
USEPA	United States Environmental Protection Agency
USC	United States Code
(1)	No constituents of concern (COCs) are identified in surface water at Site 47. However, surface water will be monitored for perchlorate and VOCs (chemicals contributing to the primary risk) in soil and groundwater at LHAAP-47site.

Source: Shaw 2011, Final Feasibility Study, LHAAP-47, Plant 3, Group4



SITE LOCATION

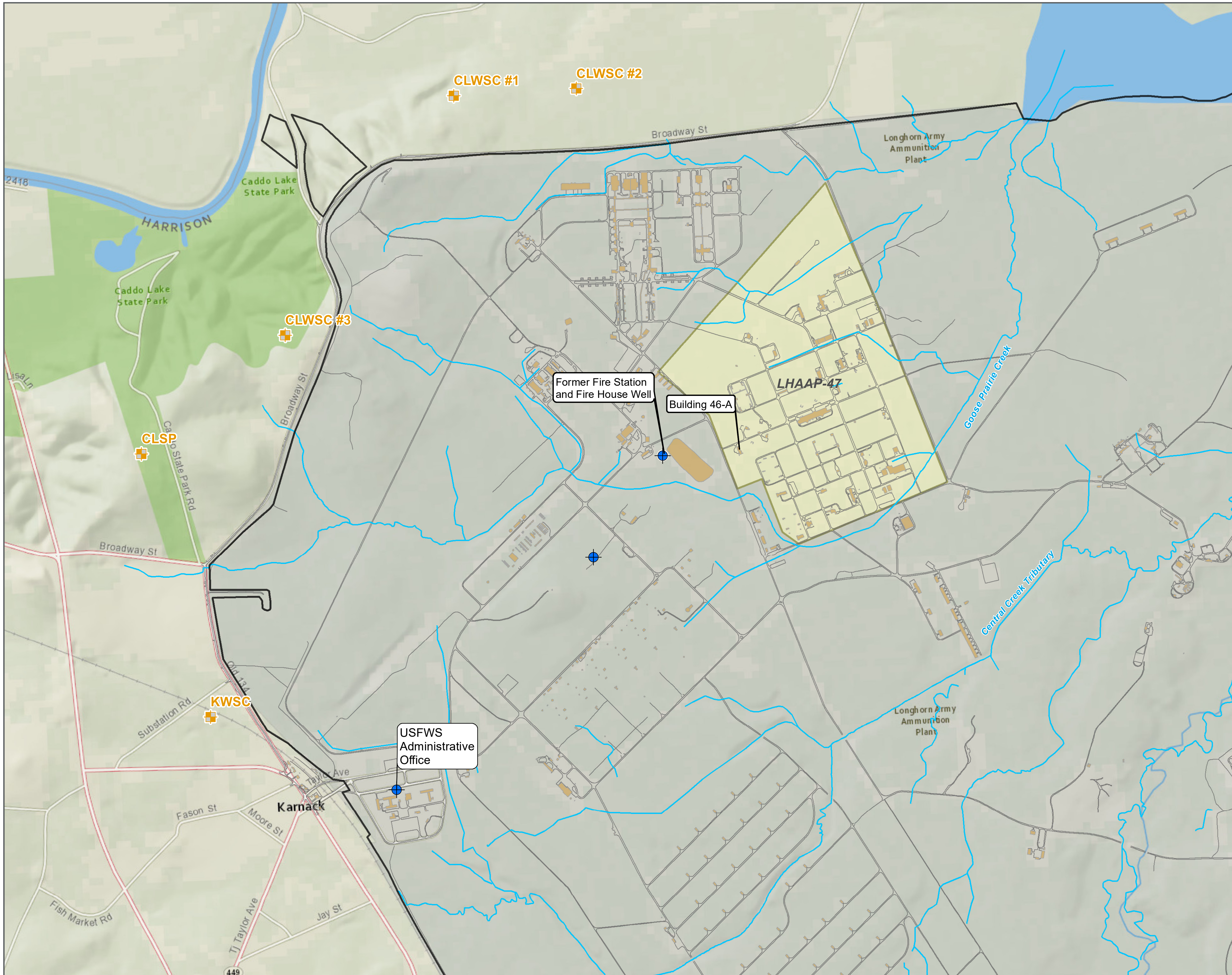
LONGHORN ARMY
AMMUNITION PLANT
KARNACK, TEXAS

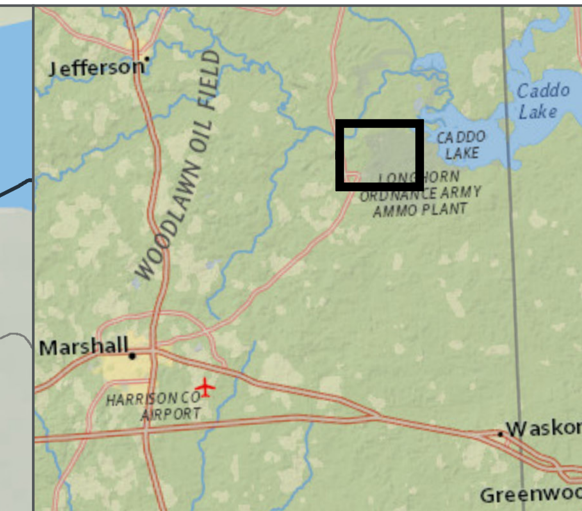
DATA SOURCES: USACE 2011, LHAAP-16 Record of Decision

DISCLAIMER: Map information was compiled from the best available sources.
No warranty is made for its accuracy or completeness.

FIGURE 2-1

PATH: J:\2018\18-025_LHAAP_SITES29_47_18AND24_ROD_(WERNER)\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\LHAAP47\ROD_2021\LHAAP47_ROD2021_LHAAP_SITE_LOCATION_FIG2_1.MXD - USER: KLOFGREN - DATE: 9/20/2021





LEGEND

- Public Water Supply Well Locations
- Potable Water Wells
- Stream
- Roads
- Buildings
- LHAAP-47 Site

DATA SOURCES:July 2011 Final Feasability Study Report for LHAAP-47, Plant 3 Area, Group 4, Longhorn Army Ammunition Plant, Karnack, Harrison County, Texas (Shaw, 2011)

Surface Water and Sediment Sampling Locations are taken from the Remedial Investigation RI Report (Jacobs, 2002).

DISCLAIMER: Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.

SITE VICINITY

LHAAP 47
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

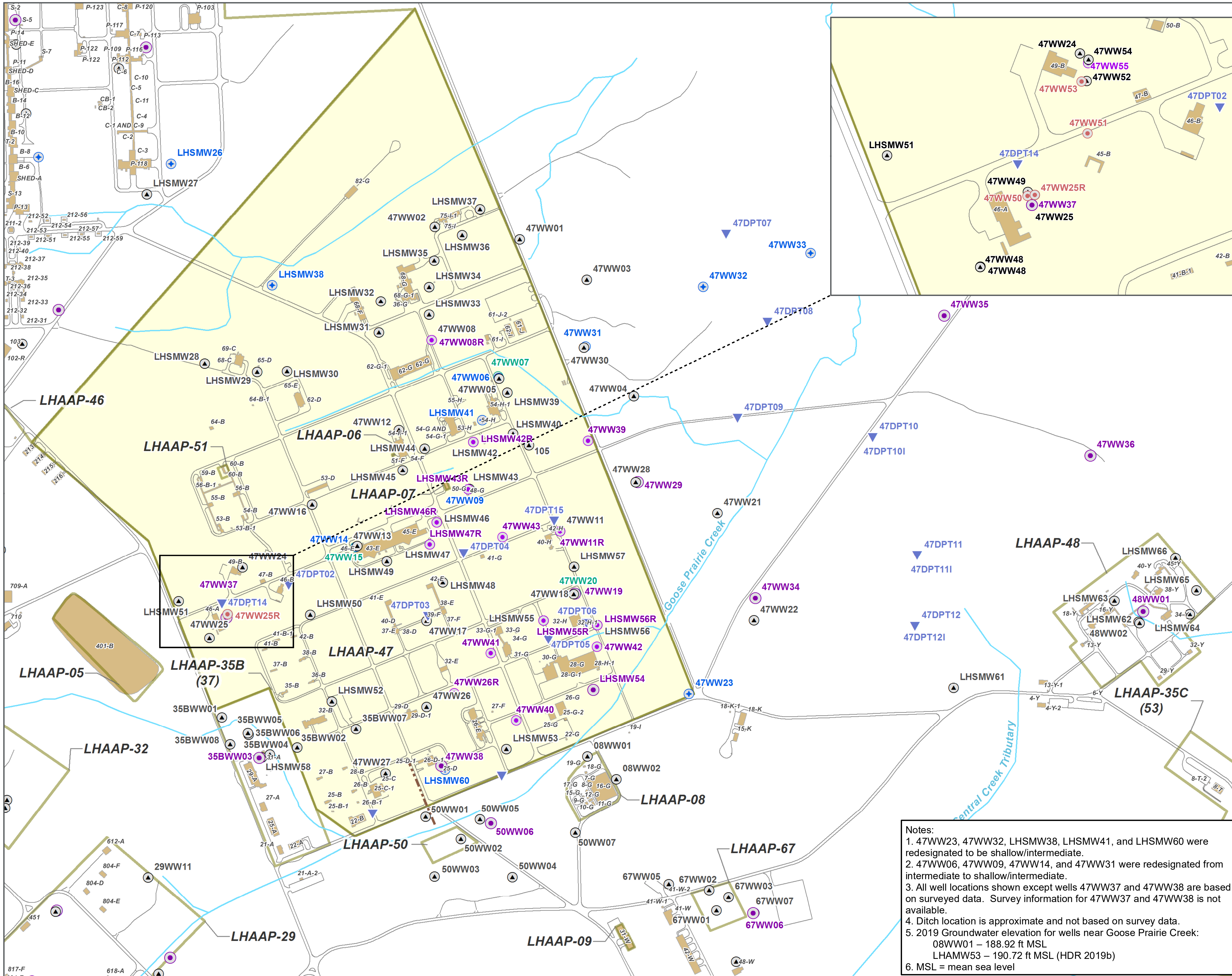
N

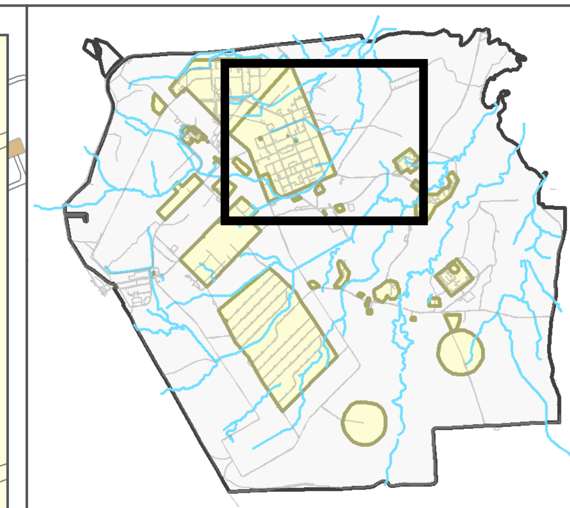
0 1,000 2,000
FEET

HDR

FIGURE 2-2

PATH: J:\2018\18-025_LHAAP_SITES29_47_18AND24_ROD_(WERNER)\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\LHAAP47\ROD_2021\LHAAP47_ROD2021_SITE_VICINTY_FIG2_2.MXD - USER: KLOFGREN - DATE: 1/17/2022





Notes:
1. 47WW23, 47WW32, LHSMW38, LHSMW41, and LHSMW60 were redesignated to be shallow/intermediate.
2. 47WW06, 47WW09, 47WW14, and 47WW31 were redesignated from intermediate to shallow/intermediate.
3. All well locations shown except wells 47WW37 and 47WW38 are based on surveyed data. Survey information for 47WW37 and 47WW38 is not available.
4. Ditch location is approximate and not based on survey data.
5. 2019 Groundwater elevation for wells near Goose Prairie Creek:
08WW01 – 188.92 ft MSL
LHAMW53 – 190.72 ft MSL (HDR 2019b)
6. MSL = mean sea level

LEGEND
- DPT Sample 2010
- Shallow Monitoring Well
- Shallow/Intermediate Monitoring Well
- Intermediate Monitoring Well
- Upper Intermediate Monitoring Zone
- Deep Monitoring Well
- Ditches
- Stream
- Roads
- Buildings
- LHAAP-47 Site
- LHAAP Site

NOTES: 47WW25R was abandoned and replaced by 47WW50.

DATA SOURCES: July 2011 Final Feasability Study Report for LHAAP-47, Plant 3 Area, Group 4, Longhorn Army Ammunition Plant, Karnack, Harrison County, Texas (Shaw, 2011)

DISCLAIMER: Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.

MONITORING WELL LOCATIONS

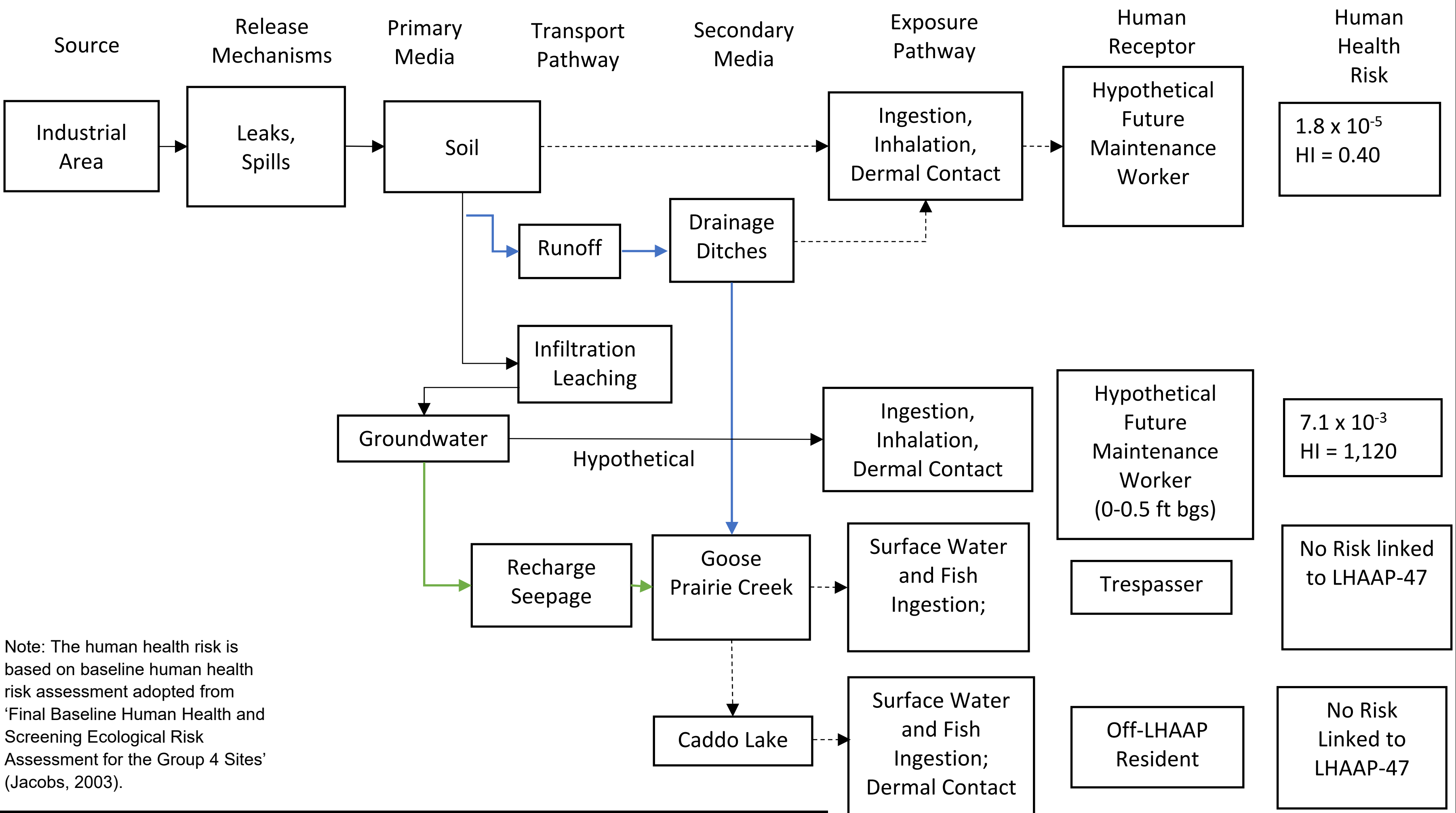
LHAAP 47
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

N

0 500 1,000
FEET

FIGURE 2-3

PATH: J:\2018\18-025_LHAAP_SITES29_47_18AND24_ROD_(WERNER)\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\LHAAP47\ROD_2021_ARCHIVE\LHAAP47_ROD2021_MONITORINGWELL_LOCATIONS_FIG2_3.MXD - USER: KLOFGREN - DATE: 1/17/2022



Note: The human health risk is based on baseline human health risk assessment adopted from 'Final Baseline Human Health and Screening Ecological Risk Assessment for the Group 4 Sites' (Jacobs, 2003).

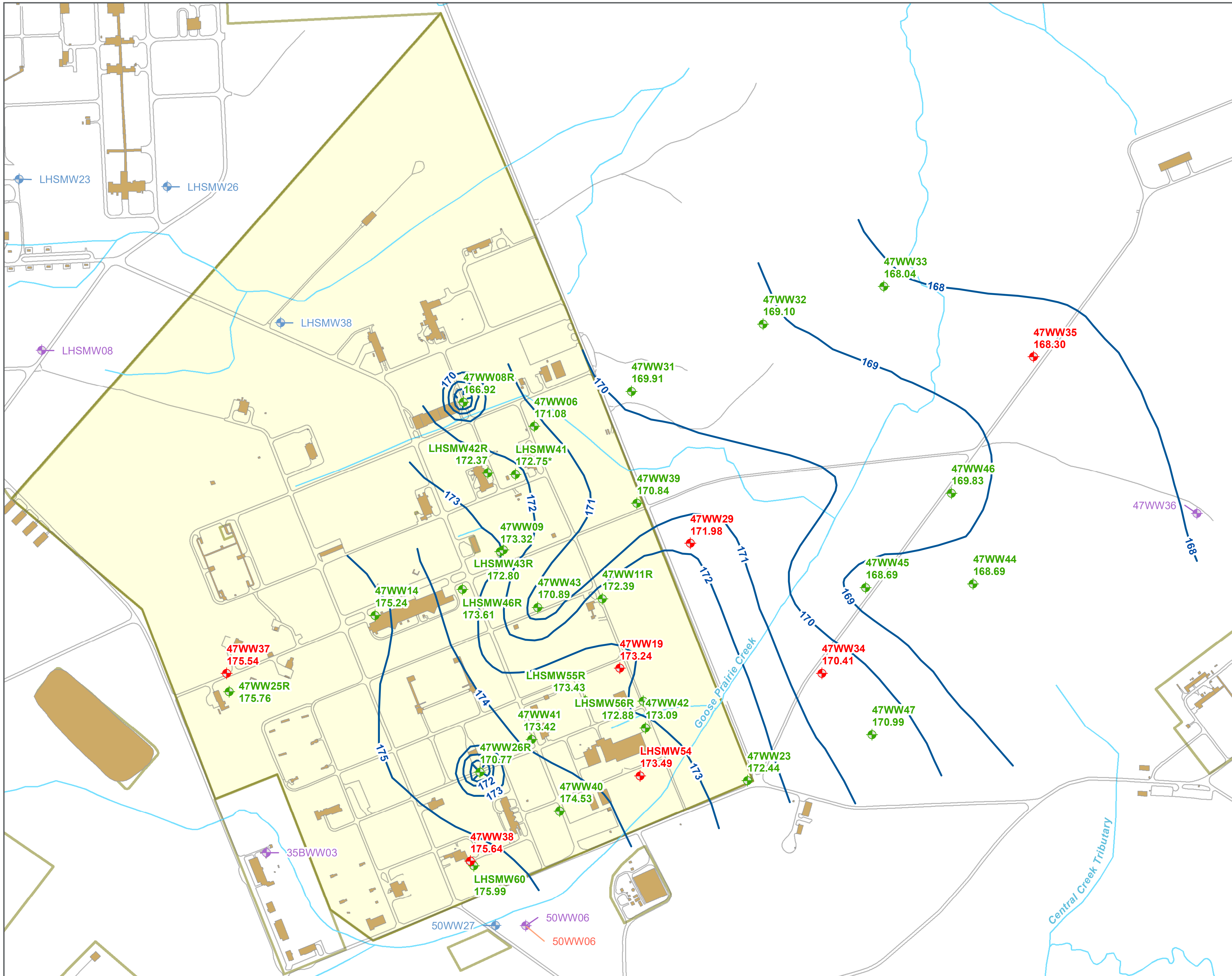
Legend

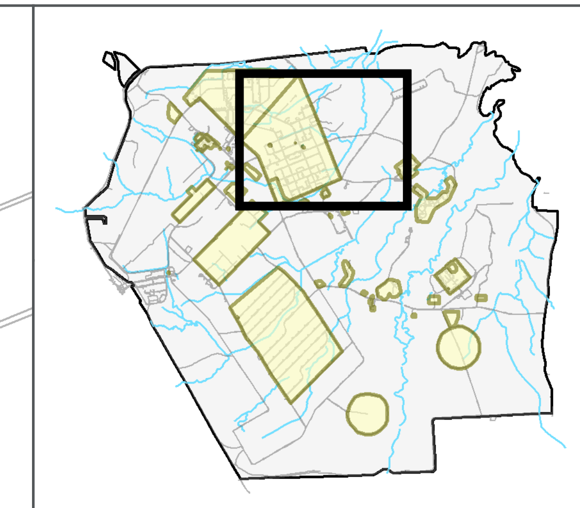
- Pathway considered for remedial measure
- Pathway not considered for remedial measure
- Although this pathway is not currently a transport pathway, groundwater levels could rise to the stream base and impact surface water.
- This transport pathway is recognized as complete for perchlorate-contaminated soil near Building 25C and considered for remediation. There is a temporary measure (liner) in place preventing runoff from perchlorate-contaminated soil, but a final remedy is planned.

HI = Hazard Index

Conceptual Site Model
LHAAP-47
Longhorn Army Ammunition Plant

Figure 2-4





LEGEND

- Intermediate (Upper) Monitoring Well (Not Measured)
- Intermediate (Upper) Monitoring Well (with Groundwater Elevation)
- Intermediate Monitoring Well (Not Measured)
- Intermediate Monitoring Well (with Groundwater Elevation)
- Groundwater Elevation Contour
- Road
- Stream
- Building
- LHAAP-47 Site
- LHAAP Site

NOTES:
* = July 2018 water level

DISCLAIMER: Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.

2018 INTERMEDIATE ZONE GROUNDWATER ELEVATIONS

LHAAP-47
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

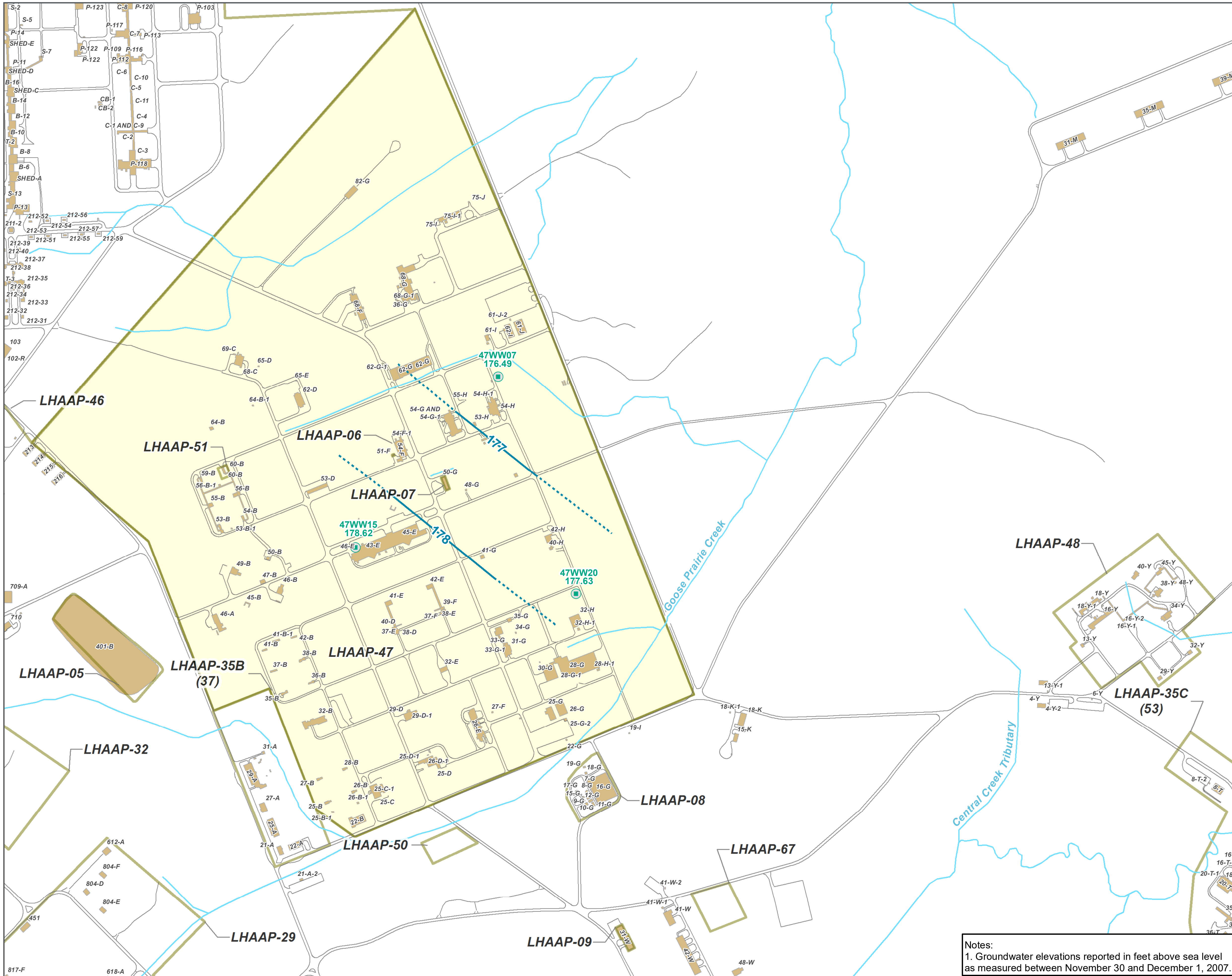
N

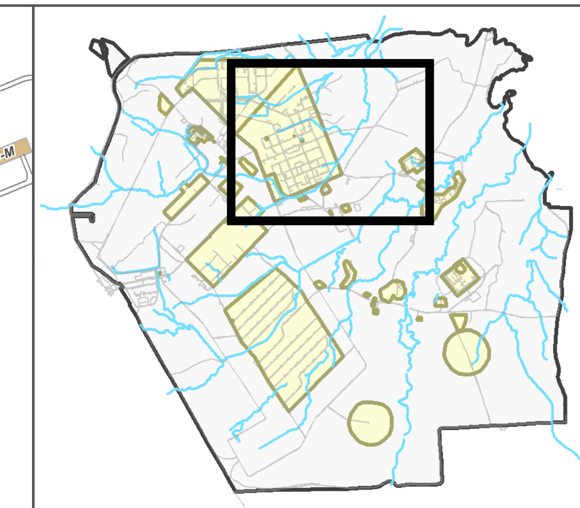
0 500 1,000
FEET

HDR

FIGURE 2-5

PATH: J:\2018\18-025_LHAAP_SITES29_47_18AND24_ROD_(WERNER)\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\LHAAP47\ROD_2021\LHAAP47_ROD2021_GW_ELEVATIONS_SI_INTERMEDIATE_FIG2_5.MXD - USER: KLOFGREN - DATE: 9/21/2021





LEGEND

- Deep Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Stream
- Roads
- Buildings
- LHAAP-47 Site
- LHAAP Site

DATA SOURCES: July 2011 Final Feasability Study Report for LHAAP-47, Plant 3 Area, Group 4, Longhorn Army Ammunition Plant, Karnack, Harrison County, Texas (Shaw, 2011)

DISCLAIMER: Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.

2007 DEEP ZONE GROUNDWATER ELEVATIONS

LHAAP 47
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

N

0 500 1,000
FEET

HDR

FIGURE 2-6

Notes:
1. Groundwater elevations reported in feet above sea level as measured between November 30 and December 1, 2007.

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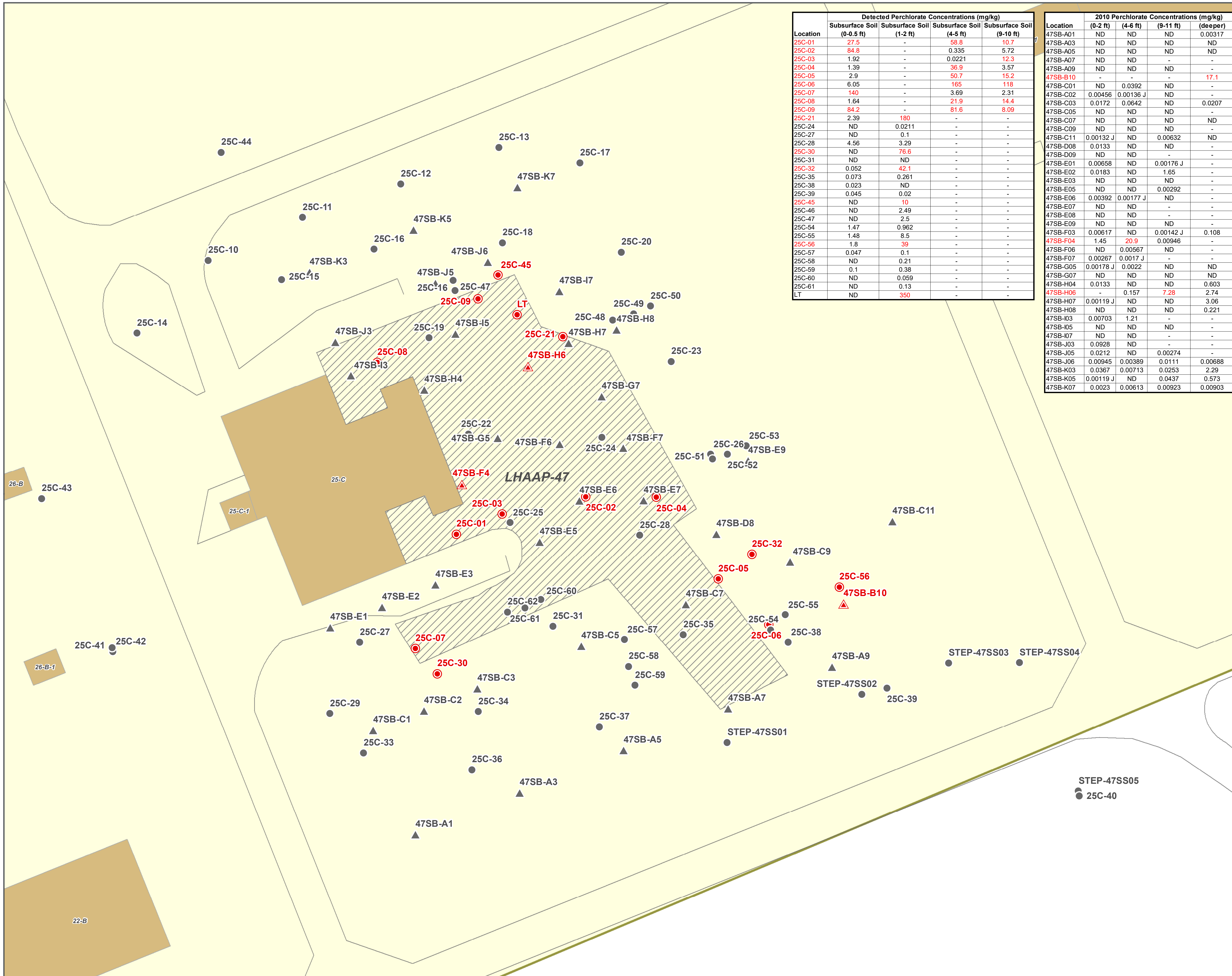
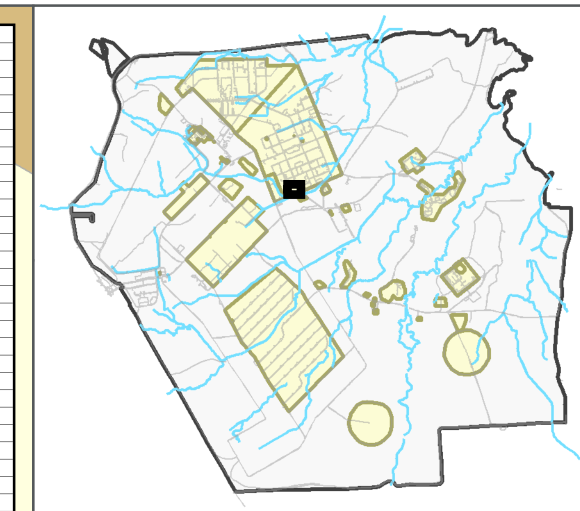
PERCHLORATE IN SOIL AT BUILDING 25C (FEASIBILITY STUDY, 2011)

LHAAP 47
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS



Location	Detected Perchlorate Concentrations (mg/kg)			
	Subsurface Soil (0-0.5 ft)	Subsurface Soil (1-2 ft)	Subsurface Soil (4-5 ft)	Subsurface Soil (9-10 ft)
25C-01	27.5	-	58.8	10.7
25C-02	84.8	-	0.335	5.72
25C-03	1.92	-	0.0221	12.3
25C-04	1.39	-	36.9	3.57
25C-05	2.9	-	50.7	15.2
25C-06	6.05	-	165	118
25C-07	140	-	3.69	2.31
25C-08	1.64	-	21.9	14.4
25C-09	84.2	-	81.6	8.09
25C-21	2.39	180	-	-
25C-24	ND	0.0211	-	-
25C-27	ND	0.1	-	-
25C-28	4.56	3.29	-	-
25C-30	ND	76.6	-	-
25C-31	ND	ND	-	-
25C-32	0.052	42.1	-	-
25C-35	0.073	0.261	-	-
25C-38	0.023	ND	-	-
25C-39	0.045	0.02	-	-
25C-45	ND	10	-	-
25C-46	ND	2.49	-	-
25C-47	ND	2.5	-	-
25C-54	1.47	0.962	-	-
25C-55	1.48	8.5	-	-
25C-56	1.8	39	-	-
25C-57	0.047	0.1	-	-
25C-58	ND	0.21	-	-
25C-59	0.1	0.38	-	-
25C-60	ND	0.059	-	-
25C-61	ND	0.13	-	-
LT	ND	350	-	-

Location	2010 Perchlorate Concentrations (mg/kg)			
	(0-2 ft)	(4-6 ft)	(9-11 ft)	(deeper)
47SB-A01	ND	ND	ND	0.00317
47SB-A03	ND	ND	ND	ND
47SB-A05	ND	ND	ND	ND
47SB-A07	ND	ND	-	-
47SB-A09	ND	ND	ND	-
47SB-B10	-	-	-	17.1
47SB-C01	ND	0.0392	ND	-
47SB-C02	0.00456	0.00136 J	ND	-
47SB-C03	0.0172	0.0642	ND	0.0207
47SB-C05	ND	ND	ND	-
47SB-C07	ND	ND	ND	ND
47SB-C09	ND	ND	ND	-
47SB-C11	0.00132 J	ND	0.00632	ND
47SB-D08	0.0133	ND	ND	-
47SB-D09	ND	ND	-	-
47SB-E01	0.00658	ND	0.00176 J	-
47SB-E02	0.0183	ND	1.65	-
47SB-E03	ND	ND	ND	-
47SB-E05	ND	ND	0.00292	-
47SB-E06	0.00392	0.00177 J	ND	-
47SB-E07	ND	ND	-	-
47SB-E08	ND	ND	-	-
47SB-E09	ND	ND	ND	-
47SB-F03	0.00617	ND	0.00142 J	0.108
47SB-F04	1.45	20.9	0.00946	-
47SB-F06	ND	0.00567	ND	-
47SB-F07	0.00267	0.0017 J	-	-
47SB-G05	0.00178 J	0.0022	ND	ND
47SB-G07	ND	ND	ND	ND
47SB-H04	0.0133	ND	ND	0.603
47SB-H06	-	0.157	7.28	2.74
47SB-H07	0.00119 J	ND	ND	3.06
47SB-H08	ND	ND	ND	0.221
47SB-I03	0.00703	1.21	-	-
47SB-I05	ND	ND	ND	-
47SB-I07	ND	ND	-	-
47SB-J03	0.0928	ND	-	-
47SB-J05	0.0212	ND	0.00274	-
47SB-J06	0.00945	0.00389	0.0111	0.00688
47SB-K03	0.0367	0.00713	0.0253	2.29
47SB-K05	0.00119 J	ND	0.0437	0.573
47SB-K07	0.0023	0.00613	0.00923	0.00903



LEGEND

Perchlorate Sample Locations

- 2010 <7.2 mg/kg
- 2010 >7.2 mg/kg
- Previous <7.2 mg/kg
- Previous >7.2 mg/kg
- Approximate Extent of Liner
- Stream
- Roads
- Buildings
- LHAAP-47 Site
- LHAAP Site

DATA SOURCES: Shaw 2011 Feasibility Study Report

DISCLAIMER: Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.

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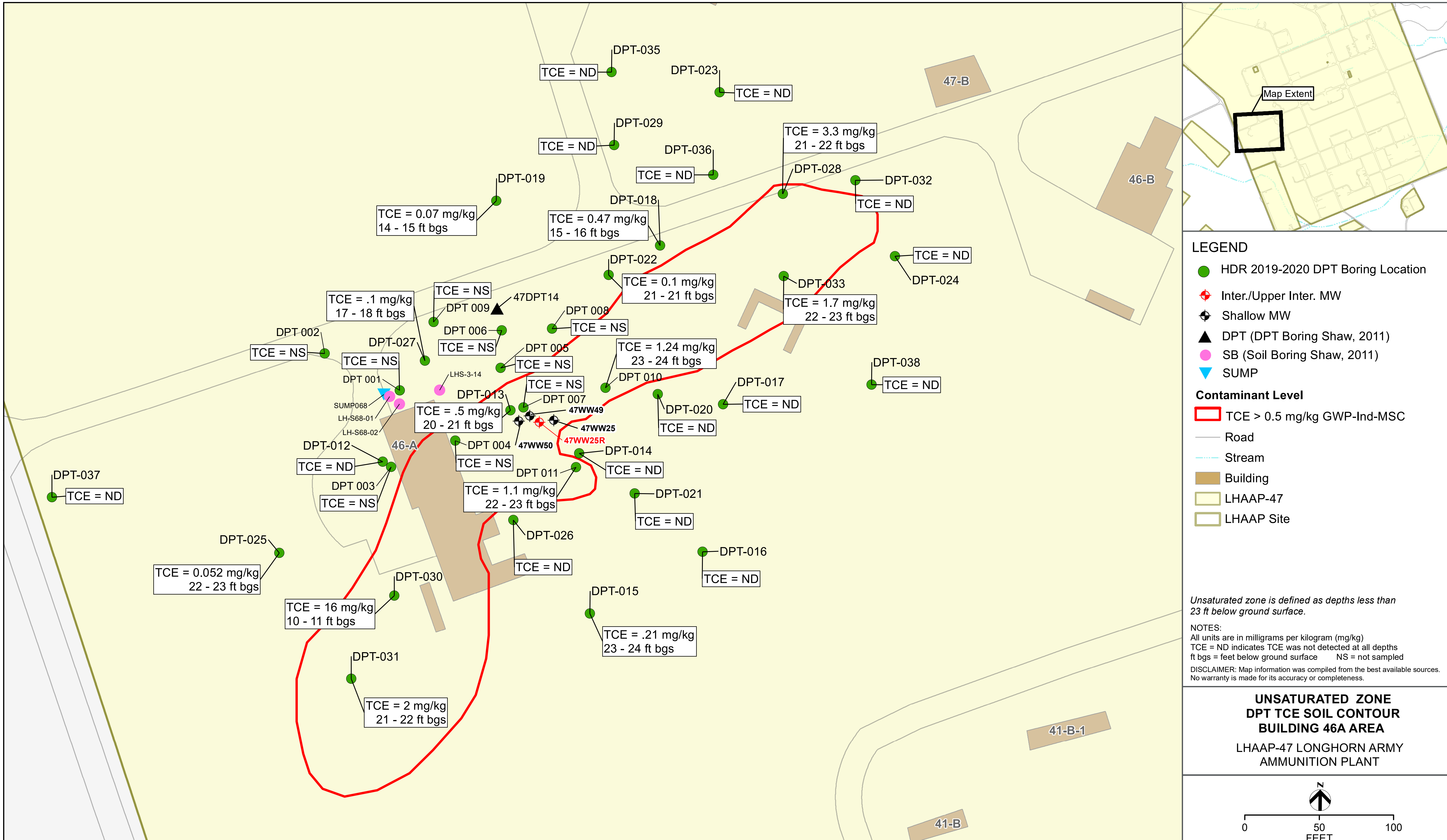
FIGURE 2-7

PATH: J:\2018\18-025_LHAAP_SITES29_47_18AND24_ROD_(WERNER)\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\LHAAP47\ROD_2021\LHAAP47_ROD2021_PERCH_IN_SOIL_BUILDING25C_FIG2_7.MXD - USER: KLOFGREN - DATE: 9/20/2021



Unsaturated zone is defined as depths less than 23 ft below ground surface.

NOTES:
All units are in milligrams per kilogram (mg/kg)
TCE = ND indicates TCE was not detected at all depths
ft bgs = feet below ground surface NS = not sampled

DISCLAIMER: Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.

UNSATURATED ZONE
DPT TCE SOIL CONTOUR
BUILDING 46A AREA

LHAAP-47 LONGHORN ARMY AMMUNITION PLANT

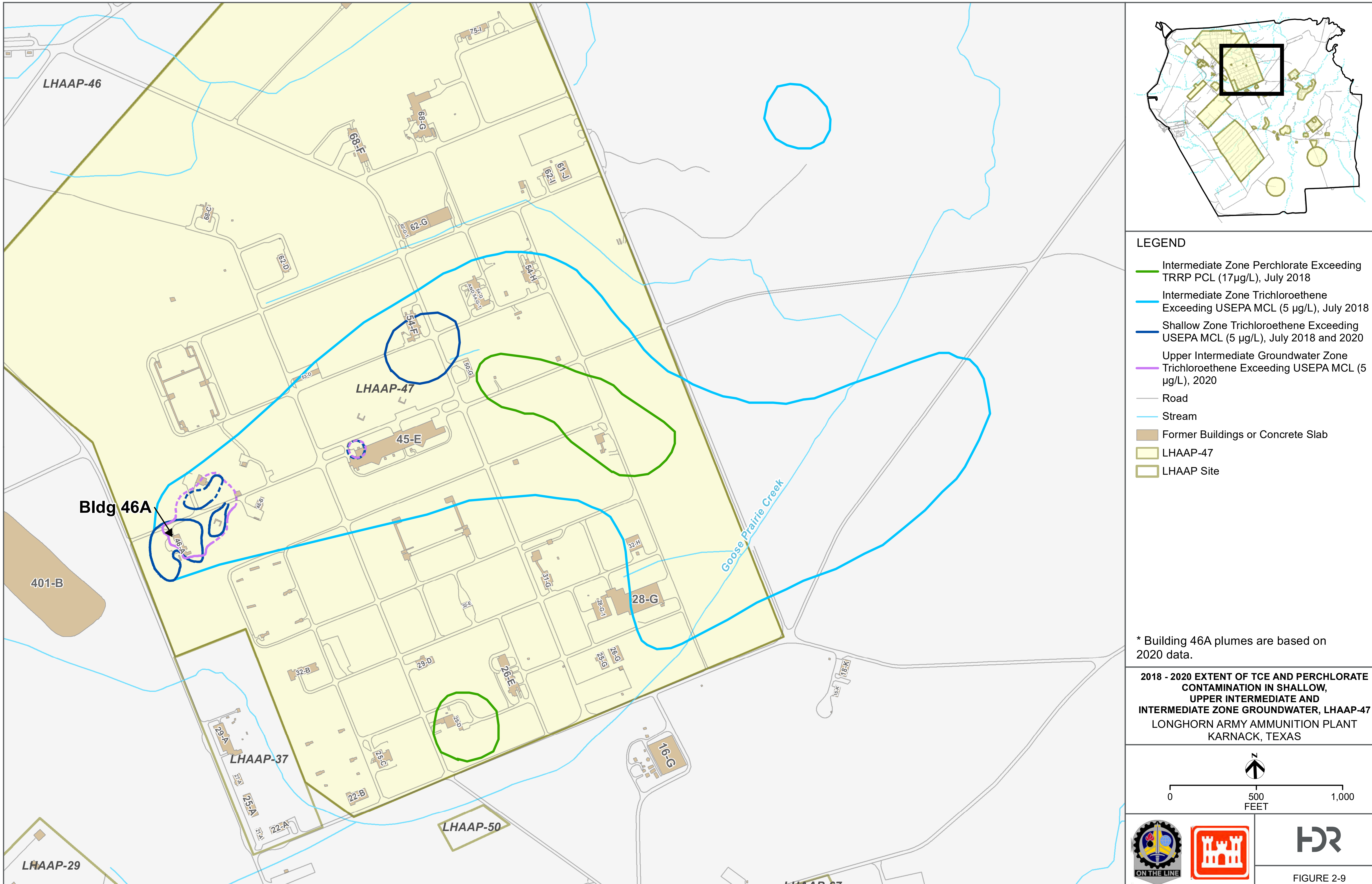
ON THE LINE

HDR

FIGURE 2-8

March 2022

PATH: J:\2018\18-025_LHAAP_SITES29_47_18AND24_ROD_(WERNER)\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\LHAAP47\ROD_2021\LHAAP47_ROD2021_BUIDING46A_2019_2020_DPT_TCE_ISO_CONCENTRATION_UNSATURATED_FIG2_8.MXD - USER: KLOFGREN - DATE: 9/21/2021



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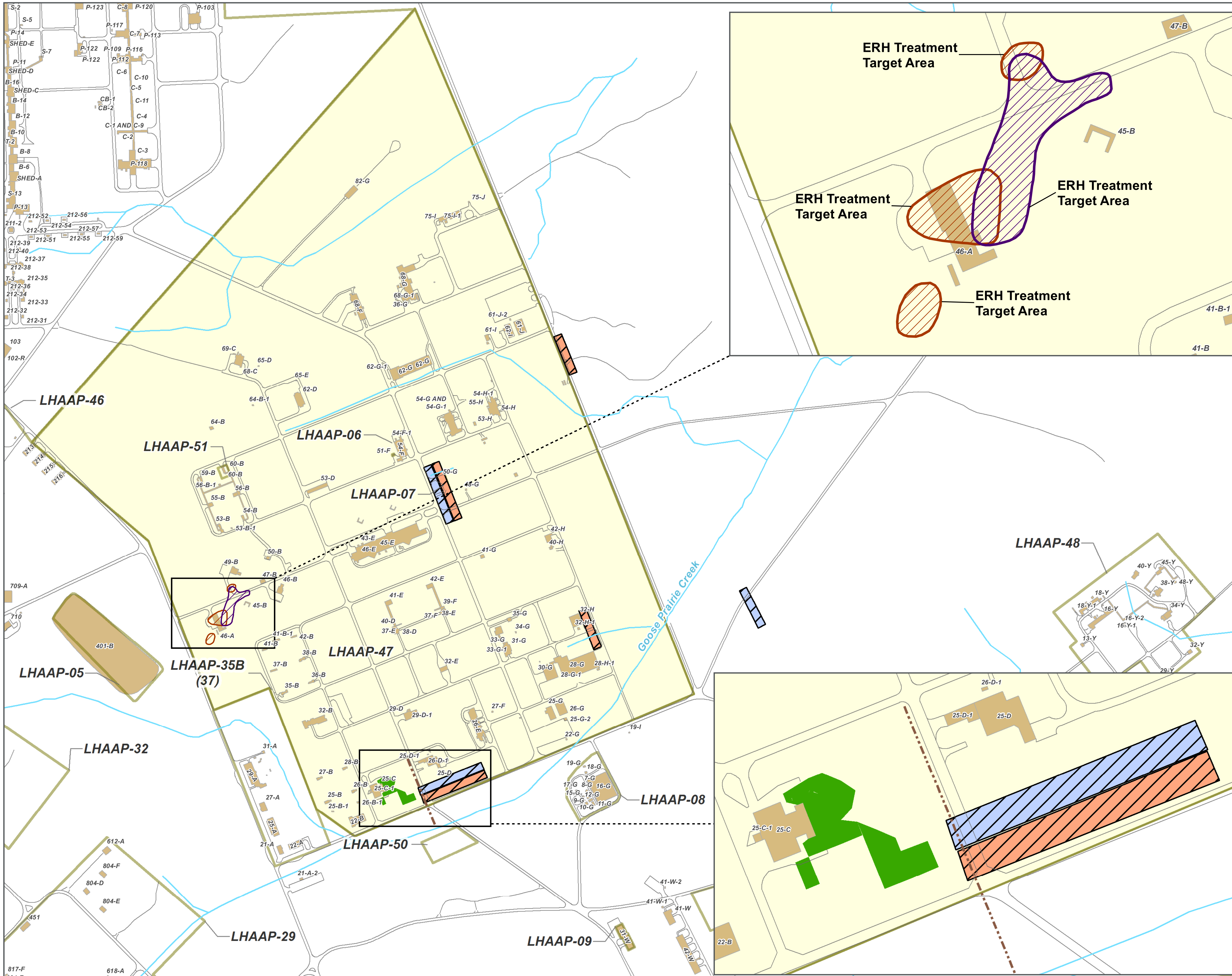

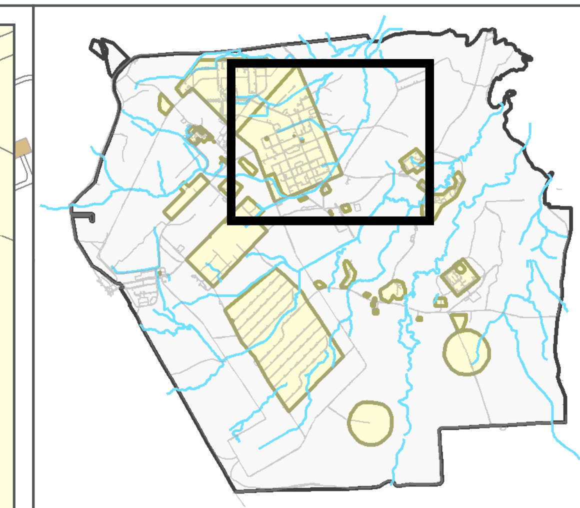

LEGEND

Shallow Groundwater Zone TCE Iso-Concentration Contours

- TCE > 10,000 µg/L

Upper Intermediate Groundwater Zone TCE Iso-Concentration Contours

- TCE > 10,000 µg/L
- ISB Biobarrier Intermediate
- ISB Biobarrier Shallow
- Building 25C - Proposed Excavation
- Ditches
- Stream
- Roads
- Buildings
- LHAAP-47 Site
- LHAAP Site

Biobarrier locations are based on the FS and the extent of contaminated groundwater has changed since 2010. The final locations and design will be presented in the Remedial Design.

DATA SOURCES: July 2011 Final Feasability Study Report for LHAAP-47, Plant 3 Area, Group 4, Longhorn Army Ammunition Plant, Karnack, Harrison County, Texas (Shaw, 2011)

DISCLAIMER: Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.

MODIFIED ALTERNATIVE 2 ISB BIOARRIER, SOIL EXCAVATION, AND ERH TARGET AREAS

LHAAP 47

LONGHORN ARMY AMMUNITION PLANT

KARNACK, TEXAS

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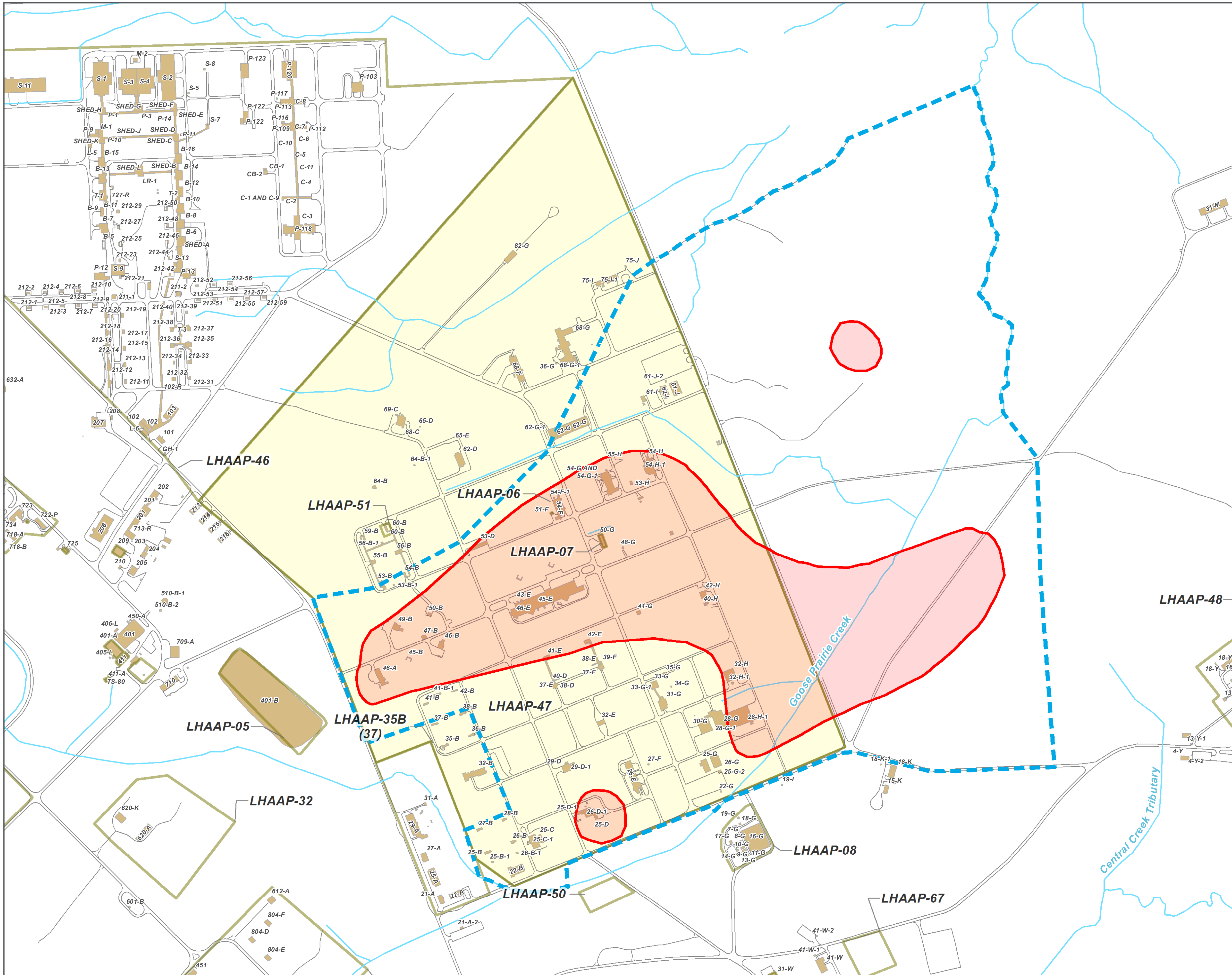
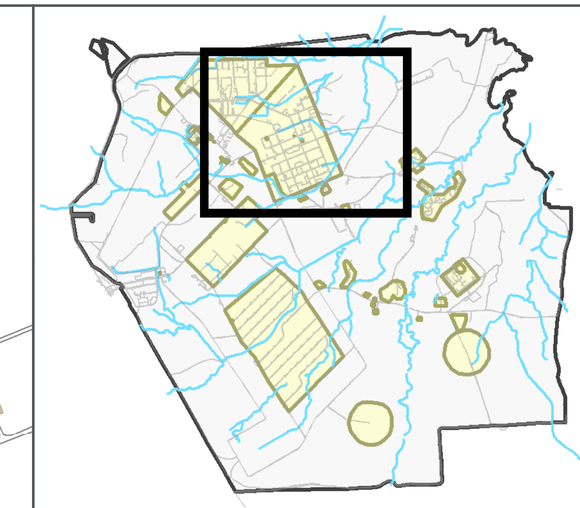
FIGURE 2-10

PATH: J:\2018\18-025_LHAAP_SITES29_47_18AND24_ROD_(WERNER)\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\LHAAP47\ROD_2021\LHAAP47_ROD2021_PLUMES_BIOBARRIERS_FIG2_10.MXD - USER: KLOFGREN - DATE: 9/21/2021





LEGEND

- Contamination Extent
- Preliminary Land Use Control Boundary
- Stream
- Roads
- Building
- LHAAP-47
- Site LHAAP

NOTES: Maximum extent of contamination is based on the MCL for TCE (5 ug/L) and PCL for perchlorate (17 ug/L) .

DISCLAIMER: Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.

PRELIMINARY LAND USE CONTROL BOUNDARY
LHAAP 47
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

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FEET

HDR

FIGURE 2-11

PATH: J:\2018\18-025_LHAAP_SITES29_47_18AND24_ROD_(WERNER)\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\LHAAP47\ROD_2021\LHAAP47_ROD2021_LUC_BOUNDARY_FIG2_11.MXD - USER: KLOFGREN - DATE: 2/23/2022

3. 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-47 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-47 through public meetings, the Administrative Record for the facility, and announcements published in the Marshall News Messenger. **Section 2.3** discusses community participation on LHAAP-47, 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:

- Transcripts of the public meetings on January 9, 2013 and July 21, 2021.
- Presentation slides from the January 9, 2013 and July 21, 2021 public meetings.
- Written questions and comments from the public during the public comment period, and the U.S. Army response to those comments.

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.

3.1.1 2021 Revised Proposed Plan, Public Meeting and Presentation Comments

Question/Comment: Has the Army implemented thermal treatment technology at any other sites?

Response: *The Army has not implemented these technologies at this point but have confidence that it will work at Longhorn. ISB would not be effective to treat the residual DNAPL areas, and excavation would not be feasible due to the depth of contamination and total volume that would have to be removed. Dewatering would also be an issue for excavation.*

Question/Comment: Is there a schedule or timeline for implementing thermal technology at the other two Longhorn sites where it is planned?

Response: *Thermal treatment is planned at both LHAAP-29 and LHAAP-18/24. LHAAP-18/24 will likely be the first site, with RD to be completed in mid-2022, and remedy construction and implementation in 2023. LHAAP-29 might possibly be first, depending on additional investigation required to complete the RD. Simultaneous implementation at these two sites is not expected.*

Question/Comment: Where will the power for this come from?

Response: *Power is anticipated to be connected to the lines operated by the co-op that run near the site. This will be evaluated and details for getting power to the site will be developed as part of the RD.*

Question/Comment: What temperature do you need to heat the groundwater to for the technology to work?

Response: *Heating is usually to near the boiling point of water. Heating was to about 90 degrees Centigrade at an Air Force site.*

Question/Comment: None of the metals really represent a problem except for arsenic. If you want to establish a cleanup level for metals at any site, either the MCL should be used or the background study should be redone to obtain reliable values. Was there current testing done for arsenic at Building 46A?

Response: *Arsenic is a naturally occurring metal that is present in groundwater across the state and it has been demonstrated at Longhorn that it is present naturally in site groundwater. Elevated levels of arsenic in LHAAP-47 groundwater data may be the result of suspended particulates (high turbidity). Low-flow sampling is frequently utilized to reduce turbidity during sample collection. Arsenic can also be temporarily mobilized by reducing conditions that may be present within contaminant plumes. Once the plume is remediated, the reducing conditions no longer exist and the arsenic will return to a less soluble form and not occur at such high concentrations in groundwater. Please refer to Appendix B of the Feasibility Study (Shaw, 2011) for a thorough discussion and analysis of arsenic in groundwater at LHAAP-47.*

The PSI conducted for the Building 46A area focused on VOCs due to the discovery of TCE DNAPL and metals were not tested during that effort. Arsenic and other metals have been included as part of LTM and the need for post-remedial monitoring and evaluation of arsenic concentrations can be done at that time.

Question/Comment: The Army's cleanup standard for perchlorate in groundwater is a risk-based level of 26 µg/L. However, the EPA has decided to regulate perchlorate under the Safe Drinking Water Act and has established an Interim Drinking Water Health Advisory of 15 µg/L. The EPA and the Army are currently discussing this issue. Pending the outcome of discussions with the EPA, the Army should assume that the perchlorate cleanup level will be 15 µg/L, and plan accordingly.

Note - the purpose of excavating perchlorate contaminated soils will be to protect the underlying groundwater. A more stringent perchlorate groundwater standard may mean that the cleanup standard for soils will also have to be more stringent.

Response: *The groundwater cleanup level for perchlorate is 17 µg/L the TRRP Tier 1 PCL for residential groundwater use as established through the dispute resolution process. The potential for groundwater impacts from perchlorate will be evaluated as part of the LTM program and if it appears that perchlorate levels are not decreasing, the need for additional action will be evaluated.*

Question/Comment: Surface Water Modeling. The Army recognizes the deficiencies in modeling performed to assess the effect of groundwater contaminants on surface water in Goose Prairie Creek. The Army will re-do the modeling. This is the correct course of action.

Response: *As noted, surface water modeling will be updated as part of the RD.*

3.1.2 2013 and 2021 Proposed Plan, Public Meeting and Presentation Comments

The following comments were received for both the 2013 and 2021 public meetings/public comment periods.

Question/comment: Time to complete cleanup. All of the alternatives evaluated by the Army have an estimated cleanup time of more than 100 years. It is not possible to determine whether this is a reasonable length of time because the Army did not design an alternative with a significantly shorter cleanup time. Remediation methods that might result in shorter cleanup times include:

- Bioremediation or pump and treat in areas beyond the hot spots.
- Air sparging/vapor extraction in areas beyond the hot spots.
- Horizontal wells or trenches along the axes of contaminant plumes.

Recommendation: The Army should design and evaluate at least one alternative that will result in a cleanup time that is significantly less than 100 years.

Response: *Based on the extents of the TCE and perchlorate plumes, and current concentrations, any alternative that is designed to achieve cleanup time shorter than 30 years (or significantly shorter than 100 years) will cost at least an order of magnitude more than the current alternatives evaluated. As shown below for comparative analysis, a cost estimate was developed for a remedial scenario in which ISB using EVO will be implemented in a combination of grid and biobarriers across the entire TCE and perchlorate plumes in the shallow and intermediate zones. The objective of this scenario is to reduce the time frame to achieve cleanup levels by actively targeting the entire TCE and perchlorate plumes. The total estimated time frame for this scenario is ten years including remedial action, O&M, and LTM. The table below provides a summary of the estimated costs.*

Remedial Activity	Estimated Cost (1)
Remedial Design	$315,592
Remedial Action	$15,779,620
Operation and Maintenance	$64,822,490
Long-term Monitoring	$423,525
TOTAL	**$81,341,227**

(1) The estimated cost was developed using Remedial Action Cost Engineering and Requirements software (AECOM, 2013b), accepted for government environmental project estimating purposes.

Based upon the reuse of the property as a wildlife refuge, the high cost of this alternative makes it unreasonable to carry forward beyond this point in the CERCLA process. It is also noted that implementation of this aggressive approach would not ensure that cleanup goals will be met given the properties of the COCs and the type and complexity of the hydrogeologic regime. In addition, ISB or biobarriers would not be effective to treat the newly discovered residual TCE DNAPL since the high concentrations are toxic to the microbes needed to metabolize the TCE and other VOCs. The proposed thermal treatment is anticipated to reduce TCE concentrations by more than 99% within the estimated implementation duration of 137 to 183 days.

Question/Comment: Evidence that natural attenuation is occurring. The Army cites reduction in contaminant concentrations in specific wells as evidence that natural attenuation is occurring at LHAAP-47. However, while natural attenuation appears to be reducing perchlorate and PCE concentrations, it is not as effective for TCE.

TCE is the most widespread contaminant at LHAAP-47, but TCE concentrations are decreasing in only about half of the contaminated wells. In the remainder of the wells, TCE concentrations either fluctuate without a clear trend, or are increasing.

Because TCE is so widespread, the overall effectiveness of natural attenuation at this site is questionable.

Response: *As indicated in the Proposed Plan, if MNA is not found to be effective, a contingency remedy may be implemented. This MNA evaluation will be completed after 8 quarters of monitoring.*

Question/Comment: Evaluation of MNA Effectiveness. The Army would use several criteria to determine whether natural attenuation is reducing contaminant concentrations at an acceptable rate. However, the Army's primary criterion is vague:

- Demonstrate that MNA is occurring according to the expectations.

Recommendation: The Army should use quantifiable criteria to determine whether natural attenuation is reducing contaminant concentrations at an acceptable rate (e.g., a reduction in contaminant concentrations by a given percentage within two years).

Response: *The USEPA Guidance Document, Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (USEPA, 1998) will be used to evaluate MNA remedy. In addition, as indicated by the TCEQ, the non-parametric Mann-Kendall statistic may be used to evaluate solute plume stability. Specific quantifiable criteria that may be used will be discussed in the RD.*

Question/Comment: Estimation of natural attenuation rates. The Army calculated contaminant half-lives as a means of estimating natural attenuation rates. However, most of the half-life calculations do not satisfy the EPA's requirement for performing the calculations. The EPA states that a decrease in contaminant concentration of at least one order of magnitude is necessary in order to reliably calculate a half-life (rate law). Only eight of the 21 calculations meet this requirement.

Recommendation: The Army should not use any half-lives that do not satisfy the EPA's requirement.

Response: *The calculated half-lives that were previously used were based on preliminary data available at the time. As part of MNA evaluation, estimation of natural attenuation rates will be performed in accordance with EPA's requirements using the Guidance Document Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (USEPA, 1998).*

Question/Comment: Estimating hydraulic conductivity. The Army used slug tests to estimate hydraulic conductivity. However, estimates of hydraulic conductivity based on slug test data are subject to large errors. Slug test data are often affected by a 'skin effect' that is caused by incomplete development. This results in estimates of hydraulic conductivity that are too low. Because calculated groundwater flow rates are directly proportional to the hydraulic conductivity, any groundwater flow rates based on the slug test data will probably be low.

Recommendation: The Army should not rely on data from slug tests to estimate hydraulic conductivity. The Army should use a more reliable method, such as pumping tests.

Response: *Limitations to slug test data are acknowledged. Provided water table conditions are amenable for a pump test, limited aquifer pump testing may be performed during RD to validate/refine previous hydraulic conductivity estimates (and, thereby, groundwater flow rates).*

Question/Comment: Metals. High concentrations of metals are present in groundwater (e.g., arsenic, cadmium, thallium), but the proposed cleanup plan does not directly address metals. Instead, the Army states: *Monitoring will be performed to track metals concentrations for future potential treatment or elimination as COCs.* This statement does not specify how, or when, the Army would decide to implement cleanup methods designed for metals.

Recommendation: The Army should develop explicit and quantifiable criteria to address the cleanup of metals.

Response: *Many metals are believed to be present due to turbidity or well-corrosion and not due to CERCLA releases. It is also possible that some exceedances are associated with presence of VOCs in groundwater. No explicit treatment is directed at reducing metals because of the small percentage of hazard associated with them (2.5% of non-carcinogenic hazard). Metals will be monitored during the remedy implementation. While metals may potentially increase in concentrations during ISB implementation, they typically attenuate without additional treatment. The RD will discuss specific criteria to address metals' cleanup.*

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Appendix A

Public Notices

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PUBLIC NOTICE

The United States Army invites public comment on the Proposed Plan for environmental site

LHAAP-47 (PLANT 3)

Longhorn Army Ammunition Plant, Texas

The U.S. Army is the lead agency for environmental response actions at the former 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 a Proposed Plan for site LHAAP-47. Although the Proposed Plan identifies the preferred remedy for the site, the U.S. Army welcomes the public's review and comments. **The public comment period begins January 1, 2013 and ends January 31, 2013. On Wednesday, January 9, 2013, from 7:00 to 8:00 p.m., the U.S. Army is inviting all interested parties to attend an open house forum to review the Proposed Plan and ask questions. The open house forum will be held at the Karnack Community Center, Highway 134 and Spur 449, Karnack, Texas.** Copies of the Proposed Plan and supporting documentation are available for public review at the Marshall Public Library, 300 S. Alamo Blvd, Marshall, Texas 75670. A summary of LHAAP-47, including a short discussion of the planned Remedial Action, is provided below.

LHAAP-47, known as Site 47, was identified in historical records as Plant 3, is approximately 275 acres and is located in the north-central portion of the former plant. The site produced rocket motors, and pyrotechnic and illumination devices beginning in July 1953 until approximately 1997. The contaminant(s) of concern (COC) are perchlorate in soil and perchlorate, VOCs, SVOCs, TNT, 2,4-DNT, 2,6-DNT, and metals in groundwater. In November 1999, plastic liner material was placed around Building 25-C by the U.S. Army over areas known to contain perchlorate in the soil to prevent migration of perchlorate into Goose Prairie Creek. The Preferred Alternative to clean-up the soil will include removal and offsite disposal of the plastic liner and perchlorate contaminated soil to eliminate potential for migration of perchlorate from soil into the surface water and groundwater. The Preferred Alternative to clean-up the groundwater is in-situ bioremediation with monitored natural attenuation in groundwater which is expected to reduce COCs, prevent migration of the plume, and reduce or eliminate exposure to contaminated groundwater. Appropriate Land Use Controls will also be established and maintained until contaminant levels in affected media are reduced below levels consistent with residential use.

For further information or to submit comments contact:

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rose.zeiler@us.army.mil

US Army Corps of Engineers ®
Tulsa District

THE UNITED STATES ARMY INVITES PUBLIC COMMENT ON THE REVISED PROPOSED PLAN FOR THE FINAL REMEDY FOR ENVIRONMENTAL SITE LHAAP-47, PLANT 3 AREA, SOLID ROCKET MOTOR FUEL PRODUCTION, LONGHORN ARMY AMMUNITION PLANT, TEXAS

PUBLIC MEETING ON JULY 21, 2021 AT THE CADDO LAKE STATE PARK GROUP HALL, KARNACK, TX

The U.S. Army is the lead agency for environmental response actions at Longhorn Army Ammunition Plant (LHAAP). In partnership with the U.S. Environmental Protection Agency Region 6 (USEPA), the lead Oversight Agency, and Texas Commission on Environmental Quality, the Supporting Agency, the U.S. Army has developed the Revised Proposed Plan for site LHAAP-47, Plant 3 Area, Solid Rocket Motor Fuel Production. The purpose of this Revised Proposed Plan is to present for public review proposed modifications to Alternative 2 for LHAAP-47, which was selected in 2013. After public review during the public comment period from January 1 – January 31, 2013 and the public meeting held January 9, 2013 at the Karnack Community Center in Karnack, TX, Alternative 2 was selected. Although the Revised Proposed Plan identifies the preferred technology to supplement the final remedy for the site, the U.S. Army welcomes the public's review and comment. Beginning on July 7, 2021, copies of the Revised Proposed Plan, the 2012 Proposed Plan, and supporting documentation will be available for public review at the Marshall Public Library, 300 S. Alamo, Marshall, Texas, 75670 and on the LHAAP website at http://www.longhornaap.com/LHAAP-47. The public comment period is July 7, 2021 through August 6, 2021. **The public meeting will be held on July 21, 2021 at the Caddo Lake State Park Group Hall, Karnack, TX beginning at 6:00 PM and ending at 7:30 PM.** Caddo Lake State Park is located at 245 Park Road 2, Karnack TX 75661. Questions, comments, and responses on the Proposed Plan will be recorded by a court reporter during the public meeting. Written comments will be accepted throughout the public comment period.

LHAAP is an inactive, government-owned, formerly contractor-operated industrial facility located in central-east Texas in the northeastern corner of Harrison County. The former installation occupied 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 production of secondary explosives, rocket motor propellants, and various pyrotechnics. LHAAP was found to have actual and potential releases of hazardous substances or pollutants or contaminants associated with past operations, and it was added to the National Priorities List (NPL) in 1990.

LHAAP-47, known as the Plant 3 Area, Solid Rocket Motor Fuel Production, is 275 acres, located in the north-central portion of LHAAP. The Plant 3 site produced rocket motor, pyrotechnic, and illumination devices. Construction of Plant 3 began in July 1953 and production of rocket motors began in December 1954. Rocket motor production continued until the early 1980s. Some of the rocket motor production facilities were converted to produce pyrotechnic and illumination devices and were active until approximately 1997. Industrial solid wastes and hazardous wastes, such as parts cleaners and spent solvents, may have been generated by these activities. Fifty waste process sumps and three waste rack sumps were located within the LHAAP-47 site. Production activities at Building 46A began in 1960 when it was constructed as a casting and curing building. Among other things, it contained two degreasers. A sump was located on the north end of the building. Investigations conducted between 2018-2020 identified sufficiently high concentrations of trichloroethene (TCE) in groundwater to indicate the presence of residual Dense Non-Aqueous Liquid (DNAPL) near Building 46A, and TCE in soil at concentrations exceeding groundwater protection levels.

The Revised Proposed Plan for LHAAP-47 addresses potential risks associated with exposure to contaminated soil and groundwater in the shallow, upper intermediate, and intermediate zones, and also identifies technologies to prevent contaminated soil and groundwater from migrating and impacting surface water at unacceptable levels. The Revised Proposed Plan presents the preferred supplemental technology to remediate residual TCE DNAPL in groundwater and TCE in soil near Building 46A. The previously selected Alternative 2 has been modified to include in-situ thermal desorption technology (ISTD) to address the DNAPL in addition to the previously identified remedy components to address contaminants across the remainder of the site. The modified alternative includes excavation and off-site disposal and Land Use Controls (LUCs) for perchlorate in soil; ISTD using Electrical Resistance Heating technology for residual TCE DNAPL in groundwater and TCE in soil near Building 46A; in-situ bioremediation and biobarriers for groundwater in other parts of the site; and Monitored Natural Attenuation and LUCs for groundwater across the remainder of the site. This remedy will assure protection of human health and the environment. Through the use of treatment technologies Alternative 2 will permanently reduce the toxicity, mobility, and volume of source materials that constitute the principal threat wastes at the site.

For further information or to submit written comments, contact:
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