FINAL

RECORD OF DECISION
LANDFILL 12 (LHAAP-12)
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

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

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Revision 2

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Acronyms and Abbreviations

ABS	absorption fraction of chemicals through skin
AF	adherence factor (dermal exposure)/adjustment factor (inhalation exposure)
ARAR	applicable or relevant and appropriate requirement
AT	averaging time
bgs	below ground surface
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	square centimeters
cm/sec	centimeters per second
COC	chemicals of concern
COEC	chemicals of ecological concern
COPC	chemical of potential concern
COPEC	chemicals of potential ecological concern
CSEM	conceptual site exposure model
CTE	central tendency exposure
ECOP	environmental condition of property
ED	exposure duration
EF	exposure frequency
EPC	exposure point concentration
ERA	ecological risk assessment
ESL	ecological screening level
FFA	Federal Facility Agreement
FI	Fraction absorbed by the ingestion pathway
FS	feasibility study
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IAL	interim action level
IRA	interim remedial action
IRIS	Integrated Risk Information System
K	volatilization factor
kg	kilogram
Kp	permeability factor
L/day	liters per day
LHAAP	Longhorn Army Ammunition Plant
LUC	land use controls
LUCRD	land use controls remedial design
MCL	maximum contaminant level
MDC	maximum detected concentration
m^3/kg	cubic meters per kilogram
mg/cm^2	milligrams per square centimeters

Acronyms and Abbreviations (continued)

mg/day	milligrams per day
mg/kg-day	milligrams per kilogram per day
MNA	monitored natural attenuation
MSC	medium specific concentration
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
PCB	polychlorinated biphenyl
PEF	particulate emission factor
RAO	remediation action objective
RBSV	risk-based screening value
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RFA	RCRA Facility Assessment
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
SA	surface area
SARA	Superfund Amendments and Reauthorization Act
Shaw	Shaw Environmental, Inc.
SLERA	screening-level ecological risk assessment
SLERE	screening-level ecological risk evaluation
SVOC	semivolatile organic compounds
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
TNRCC	Texas Natural Resources Conservation Commission
TNT	trinitrotoluene
USACE	U.S. Army Corps of Engineers
USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Material
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VF	volatilization factors
VOC	volatile organic compound

1.0 The Declaration

1.1 Site Name and Location

Landfill 12 (LHAAP-12)
Longhorn Army Ammunition Plant
Karnack, Texas

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

1.2 Statement of Basis and Purpose

This decision document presents the selected final remedy for Landfill 12 (LHAAP-12) at the former Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. The remedy was chosen in accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Contingency Plan (NCP).

The remedy selection was based on the Administrative Record file for this site, including the remedial investigation (RI) and baseline risk assessment reports (Jacobs Engineering Group, Inc. [Jacobs] 2001c, 2002b), feasibility study (FS) (Shaw Environmental, Inc. [Shaw], 2005a), the Addendum to the FS (Shaw, 2005b), the Proposed Plan (U.S. Army, 2005), and other related documents contained in the Administrative Record file for LHAAP-12.

This document is issued by the U.S. Army who is the lead agency for this installation. The USEPA (Region 6) and the Texas Commission on Environmental Quality (TCEQ) are the regulatory agencies providing technical support, project review and comment, and oversight of the U.S. Army cleanup program. The USEPA and TCEQ concur with the selected remedy.

1.3 Assessment of the Site

Implementing the response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 Description of the Selected Remedy

The final selected remedy for LHAAP-12 includes utilizing land use controls (LUCs) and monitored natural attenuation (MNA). The final remedy also incorporates those LUCs already in place as a result of an early interim remedial action (IRA), a containment presumptive remedy.

The IRA was implemented from 1996 to 1998 at LHAAP-12 to address the landfill waste materials (source area). The containment remedy, a multilayer landfill cap and cover system, was necessary to mitigate potential risks posed by buried source material at the site. Placement of a multilayer cap isolated the wastes in the landfill. The IRA addressed the risks associated with landfill source materials by eliminating the direct exposure pathway to source area waste material, preventing contaminant transport to surface water via surface runoff, and reducing leaching of contaminants to the groundwater. The IRA ROD called for warning signage, use restrictions, regular inspections, maintenance and repair of the cap and cover system and 5-year reviews. The IRA ROD also noted that a final ROD would be issued when the groundwater investigations and subsequent risk assessment were completed.

The final remedy for this site is LUCs (existing and new) in conjunction with MNA. The remedy meets the remedial action objectives (RAOs) developed for this site to protect human health and the environment by preventing human exposure to trichloroethene (TCE)-contaminated groundwater; preventing TCE-contaminated groundwater from migrating into nearby surface water; and reducing the leaching and migration of landfill hazardous substances into the groundwater.

Due to the unacceptable risk posed by TCE in groundwater, an LUC is needed in the impacted area to ensure the protection of human health and the environment by preventing human exposure to the contaminated groundwater. The selected LUC will prevent human exposure to TCE-contaminated groundwater through the restriction of groundwater use. The LUC will remain in place until applicable or relevant and appropriate requirements (ARARs) are met.

Due to the potential for TCE-contaminated groundwater to migrate, MNA will be implemented to assure that the plume will not migrate to nearby surface water at levels that may present an unacceptable risk to human health and the environment. The monitoring and reporting associated with this remedy will continue until ARARs are achieved. Monitoring will be used to demonstrate that MNA is effective and the modeled medium specific concentrations (MSCs) are not exceeded for the LHAAP-12 groundwater.

Based on groundwater modeling, groundwater ARARs are expected to be met through natural attenuation in 23 to 261 years. The need to continue the LUC to restrict groundwater and MNA will be reviewed every five years, beginning in 2007 when the second five year review for the interim remedy (now part of the final remedy) takes place.

Reduction of the leaching and migration of landfill hazardous substances into the groundwater was achieved with the IRA, the construction of a landfill cap and institution of LUCs for the protection of the cap in 1998. LUCs already in place for the protection of the landfill cap include: warning signage, use restrictions, regular inspections, maintenance and repair of the cap.

The existing LUCs will continue to be necessary to prevent a risk to human health or the environment through degradation of the cap. Groundwater monitoring activities also will be conducted to evaluate the effectiveness of the existing landfill cap. The need to continue groundwater monitoring for this purpose will be evaluated at five year reviews.

The specific LUCs and implementation details will be included in the land use component of the remedial design (RD). The MNA plan will also be presented in the RD. Within 90 days of ROD signature, the Army will prepare and submit the RD to USEPA consistent with the schedule of Section XVI of the Federal Facility Agreement (FFA). The Army will be responsible for implementation, maintenance, periodic inspection, and enforcement of LUCs in accordance with the RD. Although the Army may transfer these responsibilities to another party through property transfer agreement or other means, the Army will remain responsible for: (1) CERCLA 121 (c) five year reviews; (2) notification of the appropriate regulators of any known LUC deficiencies or violations; (3) access to the property to conduct any necessary response; (4) reservation of the authority to change, modify or terminate LUCs and any related transfer or lease provisions; and (5) the Army will ensure that the LUC objectives are met to protect the integrity of the selected remedy.

Army and regulators will consult to determine appropriate enforcement actions should there be a failure of an LUC objective at this site after it has transferred. Army shall obtain USEPA concurrence prior to termination or significant modification of a LUC, or land use change inconsistent with the LUC objectives and use assumptions of the remedy.

1.5 Statutory Determinations

The final selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, and is cost-effective. In addition, the remedy offers long-term effectiveness through the implementation of LUCs, which would minimize the potential risk posed by the contaminated groundwater. Further, evaluation of MNA including determination of contaminant reduction rates and routine monitoring of the attenuation until ARARs are met would document the effectiveness of the selected remedy. The selected remedy is easily and immediately implementable and costs less than the other alternatives considered for LHAAP-12, with the exception of Alternative 1.

The selected remedy would not reduce the toxicity, mobility, or volume of contaminants in the landfill or groundwater through an active remedial process. However, there is no known principal threat material in the landfill or groundwater. Although the selected remedy does not address the statutory preference for treatment to the maximum extent practicable, the selected remedy does offer a similar level of protection to human health and the environment, at a lower cost than those remedial alternatives that satisfy the preference for treatment.

This remedy will result in contaminants remaining in the groundwater with concentrations higher than those allowed for unrestricted use and unrestricted exposure, necessitating 5-year reviews. The reviews of this final remedy will be conducted in conjunction with the reviews already taking place as set forth in the IRA ROD. The reviews are conducted to verify that the remedy continues to provide adequate protection of human health and the environment.

1.6 Data Certification Checklist

The following information is included in the Decision Summary section of this ROD.

- 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)**.
- Chemicals of concern (COCs) and their respective medium specific exposure point concentrations **(Section 2.7)**.
- Baseline risk represented by the COCs **(Section 2.7)**.
- Cleanup levels established for COCs and the basis for these levels **(Section 2.7)**.
- Discusses how source materials constituting principle threats are addressed **(Section 2.11)**.
- Key factor(s) that led to selecting the remedy **(Section 2.12)**.
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected **(Section 2.12.3)**.

Additional information can be found in the Administrative Record file for this site.

1.7 Authorizing Signatures

Thomas E Lederle 15 June 2006

(Name) Date

Thomas E. Lederle
Industrial Branch Chief
BRAC Division, ACSIM
United States Army

Pamela Phillips, Acting 7/24/06

(Name) Date

Samuel Coleman, P.E.
Director
Superfund Division
U.S. Environmental Protection Agency,
Region 6

2.0 Decision Summary

2.1 Site Name, Location, and Description

Landfill 12 (LHAAP-12)
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

Source of Cleanup Money: U.S. Army, Department of Defense

The former Longhorn Army Ammunition Plant (LHAAP) is an inactive, government-owned, formerly contractor-operated and -maintained Department of Defense facility located in central east Texas in the northeast corner of Harrison County. As shown on **Figure 2-1,** LHAAP is approximately 14 miles northeast of Marshall, Texas, and approximately 40 miles west of Shreveport, Louisiana. The former U.S. Army installation occupied 8,493 acres between State Highway 43 at Karnack, Texas, and the southwestern shore of Caddo Lake and is accessed by State Highways 43 and 134.

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

LHAAP-12, a capped landfill, as shown on **Figure 2-2**, encompasses approximately 7 acres and is located in the central portion of LHAAP, approximately 1,700 feet east-northeast of the intersection of Pennington Street and Avenue Q. The site is an open area of grass bounded by heavy timber. Central Creek, which eventually drains into Caddo Lake, is located approximately 500 feet northwest of LHAAP-12. The site is surrounded by an area (approximately 6,000 acres) that was transferred by the U.S. Department of the Army to the U.S. Fish and Wildlife Service (USFWS) for management as the Caddo Lake National Wildlife Refuge. The U.S. Army, the lead agency for environmental response actions at LHAAP, is acting in partnership with USEPA Region 6 and TCEQ in planning and implementing remedial actions at LHAAP-12.

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 trinitrotoluene (TNT). Production of TNT began at Plant 1 in October 1942 and continued through World War II until August 1945, when the facility was placed on standby status until February 1952. In 1952 the facility was reactivated and production of pyrotechnic ammunition, such as photoflash bombs, simulators, hand signals, and tracers for 40 mm ammunition continued at Plant 2 through 1956.

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

Disposal at the LHAAP-12 landfill began in 1963. The landfill was used intermittently for the disposal of industrial solid waste, possibly containing small quantities of hazardous constituents, generated at LHAAP. Disposal began in the upstream end of a diversion ditch that traversed the site from Central Creek and one of its principal tributaries. By December 1978, a previously undisturbed hillside adjoining the ditch had become another location for waste disposal. The hillside subsequently became the northeast boundary of the site. In the early 1980s, a large area alongside the southeastern margin of the former diversion ditch was cleared for waste disposal and was used for this purpose until closure of the site in 1994.

2.2.2 History of Investigative Activities

As part of the Installation Restoration Program, the U.S. Army began an environmental investigation in 1976. The assessments/investigations conducted at LHAAP-12 since then include the following:

- In 1980, U.S. Army Toxic and Hazardous Material (USATHAMA, 1980) 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 define conditions that may have adversely affected human health and the environment.
- Contamination Survey – In 1982 as part of the LHAAP contamination survey, Environmental Protection Systems collected six groundwater samples for laboratory

analyses. Subsequently in 1987, as part of the Resource Conservation and Recovery Act (RCRA) permit application process, and as a continuation of the contamination survey, U.S. Army Environmental Hygiene Agency (USAEHA) identified, described, and evaluated all solid waste management units at LHAAP (USAEHA, 1987). Units requiring further sampling, investigation and corrective action were delineated.

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

- Site and Remedial Investigation/Feasibility Study – Beginning in 1980, a media sampling and analysis program was implemented at LHAAP-12 to determine if a release of potential contaminants from the landfill operations had affected the soil, sediment, surface water, and/or groundwater in the area. From 1993 to 1998, remedial investigation activities were conducted in three phases to identify the presence and extent of contaminants of potential concern in various media. Seventeen monitoring wells were installed in the shallow groundwater zone during the investigations. Four monitoring wells were installed in the intermediate groundwater zone. Soil samples were taken from the monitoring well borings along with one additional boring. A total of 19 surface water and 19 sediment samples were collected from adjacent ditches. As at most of the sites, earlier analyses were limited to volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), explosives, metals, and anions. Later samples were analyzed for pesticides/polychlorinated biphenyls (PCBs) and dioxins/furans. **Figure 2-3** shows the monitoring and sampling locations. Investigation results indicated that there was no significant contamination above screening values in the surrounding soils, sediment, or surface water. Multiple constituents were detected in the groundwater; primarily TCE and perchlorate. From 2002 to 2004, an FS was conducted for LHAAP-12 to present an analysis of remedial approaches and provide a basis for remedy selection consistent with the intended future use of the site as a wildlife refuge (Jacobs, 2002a; Shaw, 2005a and 2005b).

- Perchlorate Investigation – In 2000 and 2001, six soil samples and ten groundwater samples were collected for perchlorate analysis. In 2002, during a plant-wide perchlorate investigation completed by Solutions to Environmental Problems, Inc. (STEP, 2003), eight groundwater samples were collected for perchlorate analysis during each of two sampling events.

- Baseline Risk Assessment – From 1998 to 2004, a baseline human health risk assessment, a screening-level ecological risk evaluation, and a residential risk screening were conducted (Jacobs, 2002b; Shaw, 2004c, 2005b). The human health risk assessment of the non-source area indicated that future maintenance worker exposure to on-site soil generated an acceptable cancer risk and non-cancer hazard. However, the groundwater posed an unacceptable cancer risk and non-cancer hazard to a future maintenance worker. The screening-level ecological risk assessment indicated low potential for ecological risks at the site. The residential risk screening assessment of the non-source area showed that the site soils posed no risk to a potential residential receptor.

2.2.3 History of CERCLA Enforcement Activities

Due to the release of hazardous substances, pollutants, and contaminants from operation and maintenance activities at the facility, LHAAP was placed on the Superfund National Priorities List on August 9, 1990. Activities to remediate contamination associated with the listing of LHAAP as a Superfund site began in 1990. After the listing on the NPL, the U.S. Army, the USEPA, and the Texas Water Commission (currently known as the TCEQ) entered into a CERCLA Section 120 FFA for remedial activities at LHAAP. The FFA became effective December 30, 1991.

In 1995 as part of the public participation requirements under CERCLA, the U.S. Army issued a Proposed Plan for LHAAP-12 followed by a ROD for the site addressing an early IRA. The early IRA was necessary to mitigate potential risks posed by buried source materials. Specifically, the objectives of the IRA were to minimize long-term vertical infiltration of water through the landfill and minimize contaminant transport.

From 1996 to 1998 a landfill cap and cover system was placed over the site (**Figure 2-4**) and was completed as part of an early IRA in accordance with the USEPA presumptive remedy guidance under CERCLA for municipal landfills (USEPA, 1993) and for military landfills (USEPA, 1996).

In order to evaluate a final remedy for the site, a final FS was issued (Shaw 2005a and 2005b). A Proposed Plan (U.S. Army, 2005) facilitating public involvement in the selection of the final remedy for LHAAP-12 was issued in March 2005.

2.3 Community Participation

The U.S. Army, USEPA, TCEQ and the restoration advisory board have provided public outreach to the surrounding community concerning LHAAP-12 and other environmental sites at LHAAP. The outreach program has included fact sheets, media interviews, site visits, invitations to attend quarterly technical and regulatory review meetings, and public meetings consistent with its public participation responsibilities under Sections 113 (k)(2)(b), 117(a), and 121(f)(1)(g) of CERCLA.

The Final Proposed Plan (U.S. Army, 2005) for the selection of the final remedy for LHAAP-12 was released to the Administrative Record file and made available to the public for review and comment on March 25, 2005. A notice of availability of the Proposed Plan and other related documents in the Administrative Record file was published in *The Shreveport Times* and the *Marshall News Messenger* on March 20, 2005. A 30-day public comment period for the Proposed Plan began on March 25, 2005. The public meeting was held on March 29, 2005. One written comment was received from the USEPA. The written comment is addressed in the Responsiveness Summary which is included in this ROD as **Section 3.0**.

Previously copies of the Administrative Record documents were made available to the public at several information repository locations, including LHAAP, USEPA Region 6 Library, TCEQ, and Marshall Public Library. The Proposed Plan for the early IRA was released to the public on March 16, 1995. A public comment period was designated from March 21, 1995 to April 21, 1995, and a public meeting was held on March 23, 1995, at the Karnack High School. The purpose of the meeting was to discuss the Proposed Plan and to solicit public comments on the early IRA for LHAAP-12.

Currently, the Administrative Record can be found at the information repositories maintained at the following locations:

Public Library

Location: Marshall Public Library
300 S. Alamo
Marshall, Texas, 75670

Business Hours: Monday – Thursday 10:00 a.m. – 8:00 p.m.
Friday – Saturday 10:00 a.m. – 5:00 p.m.

Longhorn Army Ammunition Plant

Location: U.S. Army Office Trailer
Longhorn Army Ammunition Plant
Karnack, Texas 75670

2.4 Scope and Role of Response Action

Investigations were conducted at the site to determine if the release of potential hazardous substances from landfill operations had affected the environmental media. Results of the investigation indicated that there was no significant contamination above screening values in the surrounding soil, sediment, or surface water. Constituents were detected in the groundwater; primarily TCE and perchlorate. The groundwater contamination present at the site was likely caused by historic leaching of hazardous substances from the landfill waste to the groundwater via rainwater infiltration prior to capping the landfill.

In 1995, the U.S. Army and USEPA signed a ROD establishing an early IRA for LHAAP-12 to mitigate potential risks posed by buried source material at the landfill. The interim RAO stated in the ROD was to provide long-term protection by minimizing vertical infiltration of water into the landfill and to reduce the possibility of contaminant transport into surface water bodies. The IRA included the construction of a landfill cap, considered a component of the final remedy for the site. A landfill cap and cover system is the preferred remediation technology for containment of the waste and prevention of spreading of contaminants in landfills. Containment is most

appropriate when dealing with landfills containing unknown quantities and types of contaminants, and the exact location of the contaminant source is not readily defined.

The cap construction at LHAAP-12 began in 1996 and was completed in 1998. The cap consists of a low permeability cover consisting of a sodium bentonite geocomposite liner placed over a foundation soil layer used to provide proper grading of the landfill surfaces. A second low permeability layer consisting of a geosynthetic membrane liner was placed over the sodium bentonite layer. Finally, a soil cover with adequate slopes and a vegetative cover were placed at the top. The cap has perimeter berms and drainage swales to control surface drainage **(Figure 2-4)**. The multilayer cap reduces the potential for vertical migration of contaminants via rainfall infiltration through the landfill. In addition, the U.S. Army implemented LUCs by properly maintaining and routinely inspecting the landfill cap and cover system to protect the remedy and monitor the effectiveness of the cap.

The potential exists for groundwater contaminants to pose an unacceptable human health risk to an industrial worker and to discharge to nearby surface water bodies, which could ultimately affect Caddo Lake. The final remedy includes LUCs and MNA. The LUCs will be implemented for groundwater use restriction and for protection of the integrity of the existing landfill cap. Periodic MNA evaluations will be conducted to confirm the reduction of TCE concentrations in groundwater over time. Groundwater monitoring will also be implemented to evaluate the effectiveness of the existing landfill cap in cutting off the source of groundwater contamination. It also will be used to verify that modeled MSCs are not exceeded for the groundwater contaminants that have the potential to impact nearby surface water bodies potentially resulting in exceedances of ARARs. The groundwater LUC is in addition to those already in place for the protection of the existing remedy (landfill cap).

2.5 Site Characteristics

This section of the ROD presents an overview of the characterization of LHAAP-12 with respect to known or suspected sources of contamination, types of contamination, and affected media. Known or potential routes of contaminant migration are also discussed.

LHAAP-12 is a capped landfill, approximately 7 acres in size, located in the central portion of LHAAP **(Figure 2-2)**. The nearest significant surface water body is Central Creek, located approximately 500 feet northwest of the site. Runoff from the site is primarily by sheet flow and is collected by unnamed tributaries and diversion ditches that drain into Central Creek and ultimately enter Caddo Lake via Central Creek. Caddo Lake is a source of drinking water for several communities in Louisiana.

The topsoil at LHAAP-12 ranges in thickness from 0 to 10 feet and consists of clayey silt and silty clay. Excavations at the site had removed soil cover to the native surficial Quaternary soil and exposed the underlying sand, silt, and clay of the Wilcox Group.

The shallow silty to clayey sand layer of the Wilcox Group ranges in thickness from 3 to 12 feet and contains the shallow groundwater zone. A clay layer, ranging in thickness from a few feet in the vicinity of well 12WW04 to approximately 20 feet at well 12WW17, underlies the shallow groundwater zone.

Groundwater at the site generally occurs under unconfined conditions. The elevation of the groundwater at the landfill fluctuates with seasonal variations in rainfall. Groundwater at LHAAP-12 is estimated to occur at depths of 20 to 25 feet beneath the landfill surface and flows generally to the east and northeast, away from the landfill **(Figure 2-5)**.

For the shallow groundwater zone, hydraulic conductivity values ranged from a minimum value of 3.5×10^{-7} centimeter per second (cm/sec) in the north-central portion of the site to a maximum value of 4.54×10^{-3} cm/sec north of the landfill. For the intermediate groundwater zone, hydraulic conductivity values ranged from a minimum value of 3.09×10^{-4} cm/sec to a maximum value of 1.19×10^{-3} cm/sec.

In 2004, a survey to collect creek elevation data was conducted by Shaw. The survey data indicate that the shallow groundwater potentiometric surface may be several feet below the bottom of Central Creek during the dry season, and, thus, shallow groundwater may not discharge into Central Creek during the dry season. However, groundwater may discharge into Central Creek and Harrison Bayou during certain parts of the year when the water table is high.

2.5.1 Conceptual Site Model

Figure 2-6 illustrates the conceptual model for the source area at LHAAP-12. The model presents the role of the landfill cap constructed in the IRA of 1998 (Section 1.4) and specifies the potential exposure pathways that were cut off by the landfill cap. The construction of the cap as part of the IRA is consistent with USEPA (1993) guidance. **Figure 2-7** illustrates the conceptual model for the non-source area, which lies outside the landfill cap, but within the parcel boundary (**Figure 2-3)**, and which may contain residues of waste materials that may have been transported from the landfill prior to the IRA of 1998. The model presents pathways associated with the non-source area media that are complete and are being considered for remediation, and pathways that are likely incomplete or have negligible impact and are not being considered for remediation.

The landfill contents are not thoroughly known, but information obtained from boring logs indicates that the landfill contains wood, plastics, metal, and other items. Consistent with the

USEPA guidance on presumptive remedies for landfills (1993), it was anticipated that the landfill would pose an unacceptable human health risk, and the landfill was capped as part of the 1998 IRA.

Before the landfill was capped, soil outside the landfill, the non source area, could have become contaminated from spills, leaks, and runoff of contaminants from the landfill. Although metals such as barium, chromium, and nickel have been detected in soil outside the landfill cap boundary, none of these constituents pose an unacceptable human health risk or hazard. Perchlorate analysis was also performed. The maximum concentration was detected in surface soil (0- to 0.5-foot interval) at 46.7 micrograms per kilogram (µg/kg) in boring 12SB06. The human health risk assessment indicates that this perchlorate concentration is not sufficient to cause an unacceptable human health risk under an industrial scenario (Jacobs, 2002b). The screening-level ecological risk evaluation for LHAAP-12 (Shaw, 2004c) indicated that the impact to the ecological population from the chemicals detected in soil at the landfill is considered low.

The contaminants in the non-source soil can be transported from the site via runoff through drainage pathways and transported to subsurface soil by rainwater infiltration. Contaminants in the surface soil migrate off LHAAP-12 through runoff, which empties into Central Creek. Surface water and sediment transport of contaminants along drainage pathways from LHAAP-12 does not appear to be significant. Historic releases of contamination from the landfill have caused slightly elevated concentrations of residual contaminants (e.g., metals), but the sediment risk and hazards are within acceptable limits. Contamination in drainage water is minor and does not exceed background concentrations present in surface water from Central Creek that is entering LHAAP.

The groundwater is affected by contaminants from the landfill. This was probably caused by the migration of contaminants, via rainwater infiltration, from the landfill waste to groundwater prior to capping the landfill. Analytical results from groundwater samples indicate that the groundwater contamination poses a risk at the upper limit of the target risk range primarily due to TCE. Occasionally groundwater analytical results exceed maximum contaminant levels (MCLs). The maximum detected TCE concentration in the groundwater is 495 µg/L. The MCL for TCE is 5 µg/L. TCE was found in well 12WW12 north of the capped area and probably originated from the northern portion of the landfill. TCE was not detected in the soil samples or in groundwater wells adjacent to 12WW12.

2.5.2 Nature and Extent of Contamination

From April 1993 to October 1998, RI activities were conducted in three phases at LHAAP-12. The remedial investigations were conducted to define the nature and extent of contamination detected at the site during previous investigations. Phases I through III of the RI were conducted

by Sverdrup Environmental, Inc. and Jacobs Engineering, Inc (Sverdrup, 2000; Jacobs 2001a, 2001b, 2001c). During the three phases of investigation, surface water, sediment, soil, and groundwater samples were collected and analyzed for VOCs, SVOCs, explosive compounds, metals, and anions. In addition, surface water, sediment, and groundwater samples were analyzed for pesticides, PCBs, dioxins/furans, and select surface water samples were analyzed for total hardness. The sampling locations are shown on **Figure 2-3**. **Tables 2-1** through **2-5** present summaries of the analytical data. Analytical results indicated that environmental contamination exists at LHAAP-12. The contaminated media include the following:

- **Source material.** Landfill material underlying the cap at LHAAP-12. An IRA was implemented in 1996 through 1998 cutting off all exposure pathways to the source area material.
- **Groundwater.** Groundwater contaminated with TCE at LHAAP-12 presents an unacceptable risk under the industrial scenario and perchlorate concentrations in the groundwater have historically exceeded the TCEQ MSC.

2.5.2.1 Source Material

Between 1996 and 1998, as part of the IRA, the source area material was contained by the presumptive remedy implemented at Landfill 12. Although the IRA mitigated potential risks posed by the buried landfill waste, the waste was investigated during the Phase I of the RI to determine the nature of contaminants within the landfill.

Soil samples were collected and analyzed from two soil borings and three monitoring well boreholes within the perimeter of the LHAAP-12 landfill. These borings were also utilized to determine the depth of landfill materials. Six metals (arsenic, barium, chromium, lead, mercury, and nickel) were detected in the five soil samples collected within the landfill boundary. Eight VOCs including 2-hexanone, acetone, ethylbenzene, methyl ethyl ketone (2-butanone), methyl isobutyl ketone, tetrachloroethylene, toluene and total xylene and one SVOC, di-n-butyl phthalate were detected in source area soil. The most common VOC, acetone, was detected in six out of the 18 samples analyzed. The maximum concentration of acetone, at 1,364 J μg/kg, was from the 10- to 11-foot sampling interval in the center of the landfill where seven of the eight VOCs were found. Chlorides, sulfates and nitrates were also detected within the landfill. **Table 2-1** presents a summary of source area soil analytical results. Drilling and sampling at location 12WW04 indicated non-homogeneous landfill debris (e.g., paper, glass, and rubber) to a depth of 18 feet. LHAAP-12 was used as late as 1994; however, it is not likely that hazardous wastes were disposed in the landfill since the late 1970s due to increasingly stringent environmental regulations. Landfill material placed prior to this time is more suspect and may have contained some hazardous wastes. The VOC contamination found in the waste and in the underlying groundwater may be due potentially to hazardous and non-hazardous waste placed in the landfill in the early years of operation.

2.5.2.2 Non-Source Area Soils

During the Phase I RI, soil samples were collected from four monitoring well boreholes outside the perimeter of the landfill. The analytical results indicated that there has been little contaminant migration from the landfill source materials to the surrounding soil. Seven metals including arsenic, barium, chromium, lead, nickel, silver, and thallium were detected in non-source area soil from surface to approximately 12 feet below ground surface (bgs). Methylene chloride was the only VOC detected in the four soil samples collected from non-source soil. Phthalates, including bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, and di-n-butyl phthalate were the only SVOCs detected outside the landfill area, and were detected at low concentrations in subsurface soils sampled to 22 feet bgs. Anions including chlorides, nitrates and sulfates were detected at 10 feet or greater. Perchlorate was detected at the surface at one sampling location (12SB06). The non-source area soil summary is presented in **Table 2-2**. Despite the number of contaminants found, none of the contaminants were determined to have unacceptable risk based on the industrial and residential scenarios.

2.5.2.3 Surface Water and Sediment

Nineteen surface water samples and 19 sediment samples were collected during Phases I through III at locations outside the perimeter of the LHAAP-12 landfill boundary to determine if surface drainage had caused off-site migration of contamination. The areas of investigation included the ditch that collected surface water runoff for the southern portion of the site, the leachate collection location at the northern edge of the landfill, drainage pathways from the site toward Central Creek to the north, and unnamed creeks located upgradient and south of the site.

Surface Water

Analytical results indicated that the majority of the elevated concentrations in the surface water were at locations unlikely to be affected by LHAAP-12. Eleven metals; aluminum, antimony, arsenic, barium, beryllium, cadmium, copper, iron, lead, manganese, and zinc were detected in the surface water samples collected in close proximity to the landfill. Acetone and methylene chloride were the only organics detected in surface water samples. They were detected infrequently and at low concentrations. One dioxin, octachlorodibenzo-p-dioxin, was detected in three samples. Anions including chloride, nitrate, and sulfate were also detected. The surface water analytical results summary is presented in **Table 2-3**. None of the contaminants were determined to have unacceptable risk based on the industrial and residential scenarios.

Sediment

Sixteen metals including aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, potassium, selenium, thallium, vanadium, and zinc were detected in sediment samples. The organic analyses detected three VOCs including acetone, isopropylbenzene, and p-cymene. Four dioxins (1,2,3,4,6,7,8-HpCDD, heptachlorodibenzo-p-dioxin, hexachlorodibenzo-p-dioxin, and octachlorodibenzo-p-dioxin) were detected with the

maximum value for each dioxin detected at location 12SD19. The sediment analytical results summary is presented in **Table 2-4**. None of the contaminants were determined to have unacceptable risk based on the industrial and residential scenarios.

2.5.2.4 Groundwater

During Phases I to III of the RI, 38 groundwater samples were collected from 19 newly installed monitoring wells and two pre-Phase I monitoring wells to characterize the shallow and intermediate groundwater at LHAAP-12. The monitoring wells were installed within and outside of the landfill boundary. **Table 2-5** presents the maximum concentrations of all constituents detected in groundwater at LHAAP-12 during the RI and additional investigations (Jacobs, 2001c). Twenty two metals, including aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, sodium, strontium, thallium, and zinc were detected in multiple monitoring wells. Of the ten VOCs detected in groundwater, seven were detected once in all samples analyzed. Cis-1,2 dichloroethene, 1,4-dichlorobenzene, and 1,2-dichloroethene were detected only in well 12WW12 and 1,1-dichloroethane and vinyl chloride were detected once in well 12WW02. 1,1,1-Trichloroethane and 2-butanone were each detected once in wells 103 and 121, respectively. Three more VOCs including chlorobenzene, chloroform and TCE were detected at the site. TCE was detected at a maximum concentration of 495 µg/L at well 12WW12. Only one SVOC, bis(2-ethylhexyl)phthalate was detected at low concentrations in one monitoring well, 12WW01. Analytical results indicated the presence of dioxins in two monitoring wells, 12WW01 and 12WW12. However, 12WW01 had a duplicate, and based on a comparison of the original and QC samples, the data are questionable. Anions including chloride, nitrate, and sulfate exhibited a high degree of variability across the site.

Subsequent to the remedial investigations, multiple perchlorate sampling events were performed to obtain supplemental information about LHAAP sites suspected of having perchlorate contamination. At LHAAP-12, perchlorate was detected at low concentrations in multiple monitoring wells (all located north of the landfill cap) with a maximum detected concentration of 56 micrograms per liter (µg/L) in well 12WW01 (Jacobs, 2001a, b). However, during the most recent perchlorate sampling event, completed by Solutions to Environmental Problems, Inc. in September 2002 and in three subsequent rounds by the USACE, perchlorate was not detected in LHAAP-12 monitoring wells. The results indicated that perchlorate is currently not present in groundwater at LHAAP-12. Contaminated groundwater has migrated as a small, narrow plume approximately 250 feet east of the northeast corner of the landfill cap boundary with contaminants found in only two monitoring wells (**Figure 2-3**).

Groundwater was determined by the baseline risk assessment to pose an unacceptable risk or hazard to a hypothetical future maintenance worker at LHAAP-12 under an industrial scenario

(Jacobs, 2002b). The primary COC for LHAAP-12 groundwater is TCE due to its significant contribution to the total risk. Although perchlorate did not present an unacceptable risk or hazard, it was considered a COC in the FS due to its exceedance of the TCEQ MSC in historical samples. Additionally, hazardous substances present in LHAAP-12 groundwater could also potentially discharge to surface water in Central Creek or Harrison Bayou, which flow to Caddo Lake, a drinking water supply.

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. Large production activities continued until the facility was determined to be in excess of the Army's needs in 1997. The plant area has been relatively dormant since that time. Selected areas of the plant were used for waste management (e.g., treatment or disposal). LHAAP is surrounded by a fence (except on the border with Caddo Lake), and current security measures at the LHAAP preclude unlimited public access to areas within the fence. Approved access for hunters is very limited.

The anticipated future use is as a part of a wildlife refuge, which is consistent with an industrial use scenario for risk assessment purposes. The U.S. Army has already transferred approximately 6,000 acres to the USFWS for management as The Caddo Lake National Wildlife Refuge. LHAAP-12 is surrounded by an area that has already been transferred to the USFWS. Another potential, though less likely future use, is industrial. There is currently no plan to develop LHAAP for residential use.

2.6.2 Current and Future Surface Water Uses

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

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

2.6.3 Current and Future Groundwater Uses

Groundwater in the deep aquifer (250-430 feet bgs) under and near LHAAP is currently used as a drinking water source. There are currently five active water supply wells near LHAAP. One well is located in and owned by Caddo Lake State Park. The well is completed to a depth of 315 feet and has been in use since 1935. A second well owned by the Karnack Water Supply Corporation services the town of Karnack and is located approximately 2 miles southeast of town. This well is approximately 430 feet deep 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 are all hydraulically upgradient of LHAAP. Because of 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.

There are three water supply wells located on LHAAP (**Figure 2-2**) and all three supply water to the buildings currently in use at the installation. These wells are located upgradient of LHAAP-12. One well is located at the Fire Station/Security Office approximately 1.4 miles northwest of LHAAP-12. The second well is located approximately one-half mile southwest of the Fire Station/Security Office and 1.3 miles west-northwest of LHAAP-12. The third well is located north of the administration building, near the entrance to LHAAP approximately 1.8 miles west of LHAAP-12. Two additional wells previously supplied water to the installation, but these have been plugged and abandoned. None of the water supply wells are associated with or in imminent danger from the localized contaminated groundwater at LHAAP-12.

Based on the anticipated future use of the facility (i.e., a wildlife refuge), the groundwater at LHAAP-12 will not be used in the future as a drinking water source. However, to be conservative, it is assumed that an industrial use scenario, though less likely, is possible. The future industrial scenario for LHAAP assumes limited use of groundwater as a drinking water source.

2.7 Site Risks

Quantitative risk assessments for the non-source areas anticipated to have received contaminants migrating from the source area are consistent with USEPA (1993) guidance for presumptive remedies as conducted in the 1998 IRA. This section summarizes the results of the baseline human health and ecological risk assessments conducted for LHAAP-12 (Jacobs, 2002b; Shaw, 2004c, 2005b). Certain changes to the ecological portion of the assessment were made since 2002 and are discussed below. Risk assessments were conducted during the RI for LHAAP-12 in accordance with USEPA risk assessment guidance (USEPA, 1989). The assessments provide

a basis for taking action, if any, and identify the chemicals and exposure pathways that should be addressed by a remedial action.

Figures 2-7 presents the conceptual site exposure models (CSEM) for exposure pathways associated with the non-source area at LHAAP-12 that may contain residues of waste materials that may have been transported from the landfill prior to construction of the cap. The CSEM illustrates the contaminant source medium, release mechanisms, exposure pathways, migration routes, and potential receptors at the site.

The risk assessments consist of a human health risk assessment (HHRA) and an ecological risk assessment (ERA) (Jacobs, 2002b). The overall goal of both the HHRA and the ERA is to furnish information to risk managers and stakeholders to assist in the evaluation of options for closure, biomonitoring, and/or remediation of a site to mitigate the risks.

2.7.1 Human Health Risk Assessment Summary

An HHRA is based on a conservative estimate of the potential cancer risk or noncancer hazard from potential exposure. The following three factors were considered in the evaluation:

- Nature and extent of contamination at LHAAP-12
- Exposure pathways through which human receptors are or may be exposed to those contaminants at the site
- Potential toxic effects of those contaminants.

Risk from exposure to soil and groundwater are presented in the summary of risks for this site. It should be noted that earlier ecological and human health risk assessments included evaluation of data from surface water and sediment sampling locations near LHAAP-12 (Jacobs, 2002b). However, no surface water bodies are within the LHAAP-12 boundary; therefore, these media are evaluated in other reports and are not included in this ROD.

Potential risks to human health were determined according to USEPA guidance to ensure that conservative estimates of potential health effects are obtained. The risk estimates reflect the assumed uses of the land. A conservative estimate of risk was developed incorporating the potential exposure pathways, which included direct skin contact with contaminated soil, incidental ingestion of soil, inhalation of contaminated chemical vapors and soil particles, ingestion of groundwater, and dermal contact with both soil and groundwater. Plausible human receptors that may be exposed to soil and/or groundwater at the site included an on-site trespasser under current site conditions, and a maintenance worker under future land use conditions (industrial scenario).

The HHRA was performed to determine potential health impacts of human exposure to chemicals detected in surface media for the site (surface soil 0 to 1 foot bgs and subsurface soil down to 10 feet bgs). Health impacts from groundwater were also evaluated should the groundwater underlying LHAAP-12 ever be developed as a potable water source (Jacobs, 2002b).

2.7.1.1 Identification of Chemicals of Concern

No COCs were identified in non-source area soil at LHAAP-12 (Jacobs, 2002b). The risk assessment identified metals (aluminum, antimony, cadmium, manganese, nickel, strontium and thallium), perchlorate, dioxins (2,3,7,8-TCDD toxicity equivalent), bis(2-ethylhexyl)phthalate, and VOCs (cis-1,2-dichloroethane, TCE, and vinyl chloride) as COCs in groundwater. The COCs identified in the Jacobs (Jacobs, 2002b) risk assessment are re-evaluated as chemicals of potential concern (COPCs) as shown in **Table 2-6**, showing the ranges of detected concentrations, frequency of detection, and exposure point concentration (EPC). The maximum concentration of each COPC was used as the EPC in the baseline risk assessments (Jacobs, 2002b; Shaw, 2005b). The residential risk screening (Shaw, 2005b) did not result in identification of any COPCs in the soil.

2.7.1.2 Exposure Assessment

The exposure assessment evaluated potential exposure of current trespassers, future maintenance workers, and residents at the non-source area. Each assessment involved assumptions of the average (central tendency exposure [CTE]) and a high reasonable maximum exposure (RME). The exposure pathways evaluated in the risk assessment are shown in **Figure 2-7**. The HHRA by Jacobs (2002b) evaluated the current trespasser and future maintenance workers at the site and Shaw (2005b) presented an evaluation of a future potential resident.

Trespasser Scenario

The trespasser to the non-source area was assumed to encounter soil at the same EPC in both estimates. The trespasser was assumed to be a 70 kilogram (kg) adult with an averaging time (AT) of 70 years for cancer risk. The trespasser was assumed to visit LHAAP-12 at an average (CTE) exposure frequency (EF) of 42 days/year; the assumed RME EF was 50 days/year. The trespasser was assumed to visit the site for an average (CTE) exposure duration (ED) of 10 years; the assumed RME ED was 12 years. The AT for non-cancer hazard equals the ED value.

The assumed soil ingestion rate was 100 milligrams per day (mg/day) for both the CTE and RME evaluations, but the CTE and RME estimates for the fraction absorbed (FI) were 0.5 and 1.0, respectively.

For the dermal exposure assessment, the CTE and RME estimates for the exposed skin surface area (SA) were 3,400 square centimeters (cm^2) and 3,500 cm^2, respectively. The value of the

adherence factor of soil to skin (AF) for the absorption was 0.1 milligrams per square centimeter (mg/cm^2) in both the CTE and RME estimates. The values of the absorption fraction of chemicals through the skin (ABS) are chemical specific and the same values were used for both the CTE and RME estimates. The details of the ABS calculations are provided in the risk assessment document (Jacobs, 2002b).

For the dust inhalation exposure assessment, the particulate emission factor (PEF) was assumed to equal 4.63×10^9 cubic meters per kilogram (m^3/kg) in both the CTE and RME estimates. Chemical specific volatilization factors (VFs) were calculated for each volatile chemical. Details of these calculations are provided in the risk assessment document (Jacobs, 2002b).

Groundwater ingestion was considered to be an incomplete exposure pathway in the risk assessment for the trespasser scenario **(Figure 2-7)**.

Future On-Site Maintenance Worker Scenario

The maintenance worker in the non-source area was assumed to encounter soil and groundwater at the EPC in both estimates. The maintenance worker was assumed to be a 70 kg adult with an AT of 70 years for cancer risk. The assumed EF for the maintenance worker at LHAAP-12 was 250 days/year for both the CTE and RME evaluations. The CTE and RME values assumed for the maintenance worker were 9 years and 25 years, respectively. The AT for noncancer hazard equals the ED value.

The assumed soil ingestion rate was 100 mg/day and the FI was 1.0 for both the CTE and RME evaluations.

For the dermal exposure assessment, the CTE and RME SA values were 2,000 cm^2 and 3,300 cm^2, respectively. The AF value was 0.2 mg/cm^2 in both the CTE and RME estimates. The same chemical-specific ABS values were used for both the CTE and RME estimates.

For the dust inhalation exposure assessment, the same PEF was used in the trespasser scenario (4.63×109 m^3/kg) in both the maintenance worker CTE and RME estimates. Chemical specific VFs were calculated for each volatile chemical as described for the trespasser scenario.

Exposure to groundwater taken from potential wells in the non-source area was evaluated for the maintenance worker scenario **(Figure 2-7)**. The maintenance worker was assumed to encounter groundwater at the EPC in both the CTE and RME evaluations. The assumed CTE and RME groundwater ingestion rates were 0.7 L/day and 1 L/day, respectively.

Dermal exposures to groundwater were assumed to occur during showering. For the dermal exposure assessment, the CTE and RME SA values were 20,000 cm^2 and 23,000 cm^2, respectively. The assumed exposure time values for the CTE and RME evaluations were 0.12

hours/day and 0.20 hours/day, respectively. The EF and ED values assumed for ingestion exposures were used in the dermal exposure evaluation. The calculations of permeability factor (K_p) that describe absorption of chemicals in water through skin are chemical specific and are described in the risk assessment document (Jacobs, 2002b). The same K_p values were used in both the CTE and RME evaluations.

For the inhalation exposure to vapors from groundwater, an Adjustment Factor (AF) of 0.5 was made to the EF to account for the reduced time that the maintenance worker spends indoors. The volatilization factor (K) of 0.5 L/m^3 was used in the vapor inhalation assessment. The same values of AF and K were used in both the CTE and RME assessments.

Future On-Site Residential Scenario

The future resident in the non-source area was assumed to encounter chemicals at the EPC in soil. No surface water bodies are within the landfill cap boundary. Locations of ephemeral surface water samples in the non-source area are in depressions that would not be satisfactory as building sites or as the front or back yard of a residence. Because future use of groundwater at this site is restricted by LUCs associated with the landfill cap, as described in Sections 1.4 and 2.4 future exposure to groundwater was considered an incomplete pathway in the residential risk screening assessment (Shaw, 2005b).

The COPCs were identified as chemicals that were detected at concentrations that failed one or more highly conservative criteria that include:

- A risk-based screening value (RBSV) provided by the TCEQ that eliminated chemicals that would not contribute significantly to human health risk or hazard. When an RBSV was not available, other sources were consulted to develop risk-based screening concentrations (e.g., USEPA Region 6 medium-specific screening levels [MSSLs]).

- Comparison to site-specific background concentrations developed using the data from the *Background Soil Study, Report, Longhorn Army Ammunition plant, Karnack, Texas* (Shaw, 2004b). Chemicals with maximum detected concentrations lower than the 95 percent upper tolerance limit concentrations were not considered further. Based on TCEQ recommendations, 95 percent upper prediction limits also were calculated for the background data and were reported in the assessment for information.

- Chemicals were eliminated from further evaluation if they were detected infrequently (5 percent or lower detection frequency) at low levels, providing that at least 20 samples wee analyzed for the chemical (Shaw, 2005b). Such chemicals were considered artifacts in the data that do not reflect site-related activity or disposal practices. Chemicals detected infrequently, but at high concentrations, were included in the evaluation unless adequate site background information or historical data suggest that they are unlikely to be related to LHAAP activities and a plausible rationale could be made to exclude them.

No chemicals were identified as COPC in soil at the LHAAP-12 non-source area at concentrations expected to be harmful to a residential receptor. Therefore, the soil medium passes residential risk TCEQ RRS2 standards. Because use of groundwater underlying LHAAP-12 is restricted under LUCs associated with the landfill cap as described in Sections 1.4 and 2.4, and no surface water and sediment exist at the site, no further evaluation of the future residential land-use scenario was considered necessary.

2.7.1.3 Toxicity Assessment

The toxicity factors used to evaluate cancer and non-cancer risk from exposure to COCs in groundwater are shown in **Tables 2-7** and **2-8**. The cancer slope factors, or inhalation unit risk factors, and noncancer reference doses, or inhalation reference concentrations, were selected from the USEPA Integrated Risk Information System (IRIS). If no value was available in the IRIS, then values from the USEPA National Center for Environmental Assessment or the TNRCC now the TCEQ were used.

The primary target organs for noncancer effects are the kidney and liver. Nickel and dioxins affect skin, and manganese is a central nervous system toxicant. Other chemicals are toxic to blood (antimony, thallium, and cis-1,2-dichloroethene) and to bone (strontium). Perchlorate is toxic to the thyroid.

2.7.1.4 Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual to develop cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated form the following equation:

$$\text{Risk} = \text{chronic daily intake (CDI)} \times \text{SF}$$

Where: Risk = the probability of an individual's developing cancer
CDI = chronic daily intake averaged over 70 years (mg/kg-day)

SF = slope factor, expressed as $(\text{mg/kg-day})^{-1}$

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

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

The HQ is calculated s follows:

Noncancer HQ = CDI/RfD
Where: CDI = chronic daily intake
RfD = reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short term).

No unacceptable cancer risk or noncancer hazard was identified for exposures of the trespasser or the future maintenance worker to chemicals in soil. No unacceptable cancer risk or noncancer hazard was identified for the trespasser (Jacobs, 2002b).

All cancer risks associated with potential exposure of the future maintenance worker to groundwater are summarized in **Table 2-9**. The calculated RME cancer risk from all chemicals by all exposure pathways is 1×10^{-4} when rounded to 1 significant figure as specified in USEPA (1989) guidance, which is at the upper value of the 1×10^{-6} to 1×10^{-4} acceptable range (USEPA, 1990). The risk is predominantly associated with exposure to TCE by the ingestion, dermal contact, and inhalation pathways. Exposure to vinyl chloride, a trichloroethene degradation product, by the ingestion and inhalation pathways contributes additional risk. Lesser risks are associated with ingestion and dermal exposure to the 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and bis(2-ethylhexyl)phthalate.

The calculated RME HI for potential exposure to COCs in groundwater is summarized in **Table 2-10**. The calculated HI for all chemicals by all exposure pathways is above the acceptable value of 1 (USEPA, 1990) when rounded to 1 significant figure. The HI is predominantly associated with exposure to TCE by the ingestion and dermal contact pathways. Metals and perchlorate contribute appreciably to the total HI such that the sum of all HQ values

calculated for ingestion exposure is also greater than 1. Calculated HQ values for exposure to the organic compounds bis(2-ethylhexyl)phthalate, cis-1,2-dichloroethene, and vinyl chloride do not sum to 1. The HI value associated with chemicals for which the liver is the primary target organ is less than 1 (2×10^{-2}). The ranges of detected concentrations, MCLs and MSCs for COCs are shown in **Table 2-11.** As indicated in this table, TCE is the primary COC at the site.

2.7.1.5 Uncertainty

Uncertainties in the risk estimates are associated with the use of J-qualified (estimated) values in the assessment. This uncertainty could result in either high or low risk estimates. The use of the maximum groundwater concentration in all groundwater assessments is expected to result in highly conservative risk estimates. Similarly, the use of RME exposure values is expected to result in highly conservative risk estimates in accordance with USEPA policy to ensure that the resulting estimates are protective of human health.

2.7.2 Ecological Risk Assessment Summary

An ERA is a process that evaluates the likelihood that adverse ecological effects may occur, or are occurring, as a result of exposure to one or more stressors. A stressor is any physical, chemical, or biological entity that can induce an adverse ecological response. The ERA for LHAAP-12 focuses only on chemical stressors.

Ecological risk does not exist unless:

- The stressor has the inherent ability to cause adverse effects
- It co-occurs with or contacts an ecological component (i.e., organism, populations, communities, or ecosystem) long enough and at sufficient intensity to elicit an adverse effect

The ERA for LHAAP-12 evaluated exposure of terrestrial receptors to soil and used a hazard quotient (HQ) to describe ecological risks (Shaw, 2004c). For HQs below 1, adverse effects to ecological receptors are not expected due to the conservative nature and methodology used to develop HQs. For HQs greater than 1, further evaluation may be required to assess the potential for adverse effects. HQs were calculated for ecological receptors, based on exposure to the contaminants in soil. Ecological receptors consisted of soil invertebrates, plants, and other sensitive wildlife. The product of the ERA process is a presentation of the potential for adverse ecological effects and a description of the most important contributing chemicals.

Multiple ecological evaluations have been performed at LHAAP-12. First, a screening-level ecological risk assessment (SLERA) was conducted at LHAAP-12 (Jacobs, 2002b) to evaluate soil, which was defined as 0-5 feet bgs. However, the SLERA used very conservative assumptions and contained multiple data gaps (i.e., information was incomplete or missing).

Therefore, LHAAP-12 was re-evaluated in a Screening-Level Ecological Risk Evaluation (SLERE) (Shaw, 2004c). This SLERE used an updated data set with additional soil data, evaluated a more appropriate depth interval of soil for potential ecological exposure that was agreed upon by LHAAP stakeholders (0-3 feet bgs), and used additional lines of evidence to identify chemicals of potential ecological concern (COPEC). Because the SLERE is more current and provides information that is more useful for risk managers than the SLERA, it was used as the basis for environmental decision-making at LHAAP-12. Thus, the results of the initial SLERA are summarized here, but the focus of the Ecological Risk Assessment Summary for this ROD is the more recent and more applicable SLERE.

2.7.2.1 Identification of Chemicals of Ecological Concern

The first step for identifying chemicals of ecological concern (COEC) is to select COPECs in the medium or media of interest. COPECs are chemicals that are present at concentrations above conservative screening levels. Chemicals below these screening levels are unlikely to be harmful to the environment. Not all COPECs are harmful, however. If COPECs are identified at LHAAP-12, additional information must be acquired to determine if they are truly COECs that are likely to cause adverse affects to organisms at LHAAP-12.

COPEC Selection in the SLERA (Jacobs, 2002b)

The SLERA concluded that several COPECs were present in LHAAP-12 soils (0-5 feet bgs). These COPECs included arsenic, chromium, lead, mercury, nickel, selenium, thallium, methylene chloride, butyl benzyl phthalate, bis(2-ethylhexyl)phthalate, chloride, sulfate, perchlorate, barium, and di-n-butyl phthalate (Jacobs, 2002b). These chemicals were selected as COPECs based on comparisons to ecological benchmarks, bioaccumulation potential, and food web modeling. TCEQ benchmark values were the only source of ecological benchmarks used in the SLERA. Many chemicals did not have TCEQ benchmarks, and were conservatively retained as COPECs. Also, the model assumptions used in the SLERA were extremely conservative. Therefore, the SLERA was not used as the basis for making remedial decisions, and the results of the COPEC selection are presented here for informational purposes only.

COPEC Selection in the SLERE (Shaw, 2004c)

As previously discussed, LHAAP-12 was re-evaluated in a SLERE (Shaw, 2004c), which presented a revised COPEC selection step. Because the SLERE used a more current environmental data set and a more complete list of chemical screening concentrations, the SLERE was used as the basis for making remedial decisions at LHAAP-12. Chemicals were retained as COPECs in the SLERE if their maximum detected concentration (MDC) exceeded their benchmark screening value, if no benchmark value was available, or if the chemical had the propensity to bioaccumulate (as in some inorganic analytes and organochlorine pesticides). The soil data set used for the SLERE included soil samples from 0 to 3 feet bgs. Only samples at LHAAP-12 and around it were included. Sample locations under the landfill cap were excluded

because the landfill cap prevents exposure to ecological receptors. **Table 2-12** presents the occurrence, distribution, and selection of COPECs for soil at LHAAP-12. Of the 13 chemicals detected in at least one sample, three inorganic analytes (chromium, lead, and nickel), sulfate, perchlorate, and two semivolatile organic compounds (bis[2-ethylhexyl]phthalate and butyl benzyl phthalate) were identified as COPECs. It is noted that the LHAAP-12 SLERE (Shaw, 2004c) results apply to LHAAP-12 and the area around it. Environmental data from LHAAP-12 is also being evaluated as part of an ongoing installation-wide ecological risk assessment. Data from LHAAP-12 have been analyzed separately in this ROD solely as part of an agreement with LHAAP stakeholders. Any releases associated with LHAAP-12 that may have resulted in impacts beyond the site will be evaluated in the installation-wide risk assessment.

Additional evaluation of the chemicals identified as COPECs at LHAAP-12 in the SLERE was conducted as part of this ROD to determine if they should be identified as COECs. To determine if the chemical was naturally occurring, the MDCs were compared to site-specific background concentrations (Shaw, 2004b). If the MDC was lower than the background concentration, it was assumed that the chemical was naturally occurring. Other considerations were taken into account, as well, such as the magnitude by which the screening benchmark was exceeded, how frequently the chemical was detected, possible sources of the chemical not related to previous site activities, etc.

Following further analysis using these multiple lines of evidence, it was determined that none of the chemicals selected as COPECs at LHAAP-12 were COECs requiring further investigation. A summary of the rationale that was used in making this decision for each COPEC is presented in **Table 2-13**.

2.7.2.2 Exposure Assessment

The objective of the exposure assessment is to determine the pathways and media through which receptors may be exposed to LHAAP-12 contaminants. Potential exposure pathways are dependent upon habitats and receptors present at LHAAP-12, the extent and magnitude of contaminants, and environmental fate and transport of ecological COECs.

LHAAP-12 is a 7-acre site in the central portion of LHAAP. This site consists of a capped landfill that was used for the disposal of industrial solid waste from 1978 to 1994. The central portion of LHAAP-12 was formerly an open area bounded by heavy timber on the north and west, and a soil borrow area on the east. The southern section of LHAAP-12 was an open area with little vegetation and bounded by heavy timber on the west and east. The site currently consists of an open area covered with sparse vegetation where the landfill cap is located, surrounded by hardwood/pine forest. There are no water bodies within the site boundary.

Table 2-14 presents the ecological exposure pathways of concern for LHAAP-12 including the exposure medium of interest (i.e., soil), sensitivity of the environment, receptors, endangered/ threatened species information, exposure routes, and assessment and measurement endpoints.

Receptor species groups were based on the screening values used in the COPEC selection process **(Table 2-12)** (i.e., the species the screening values were developed to protect). The screening values selected are primarily benchmarks that are protective of earthworms and plants (the TCEQ and ecological screening level [ESL] values) and that are protective of sensitive wildlife species (i.e., shrews and voles) (the ESL values). Therefore, these are the three ecological receptor groups that were evaluated. It is assumed that if concentrations are protective of these receptor groups, which have an intimate association with soil, then they are protective of other terrestrial organisms as well, such as birds.

2.7.2.3 Ecological Effects Assessment

This section provides a description of the assessment and measurement endpoints chosen for the LHAAP-12 SLERE (Shaw, 2004c). Assessment and measurement endpoints are summarized in **Table 2-14**.

Assessment Endpoints

Because the LHAAP-12 ecological investigation was a screening-level exercise, assessment endpoints were restricted to the organisms at the base of the food chain and sensitive wildlife receptor groups that the screening benchmark values are protective of. Therefore, the assessment endpoints for LHAAP-12 focused on the viability of terrestrial invertebrates and plants, and on the maintenance of sensitive wildlife species such as shrews and voles.

Measurement Endpoints

Measurement endpoints are measurable characteristics that are related to the valued characteristics selected as assessment endpoints. Measurement endpoints should be linked to the assessment endpoints by the mechanism of toxicity and the route of exposure. Measurement endpoints are used to derive a quantitative estimate of potential effects, and form a basis for extrapolation to the assessment endpoints.

The measurement endpoints selected for the LHAAP-12 SLERE (Shaw, 2004c) were the ecological benchmark screening concentrations presented in **Table 2-12**. These values represent media concentrations that are presumed to be safe to biota with the likelihood of being the most exposed (i.e., soil invertebrates and earthworms). Thus, these measurement endpoints are appropriate for the protection of the selected assessment endpoints.

2.7.2.4 Ecological Risk Characterization

Risk characterization quantitatively defines the magnitude of potential risks to ecological receptors under a specific set of circumstances. It is the process of applying numerical methods

and professional judgment to determine whether adverse effects are occurring or are likely to occur due to the presence of ecological COECs at a site.

Because no chemicals were considered COECs (see above), no additional characterization of the risk of chemicals to ecological receptors was necessary for LHAAP-12. Chemicals detected in soil at LHAAP-12 were considered to represent a low threat to the environment, and it was determined that no remediation for the protection of ecological receptors was necessary at LHAAP-12.

2.8 Remedial Action Objectives

The RAOs developed for LHAAP-12 include:

- Protection of human health by preventing human exposure to TCE contaminated groundwater
- Protection of human health and the environment by reducing the leaching and migration of landfill hazardous substances into the groundwater
- Protection of human health and the environment by preventing TCE contaminated groundwater from migrating into nearby surface water

2.9 Description of Alternatives

Groundwater is the medium at LHAAP-12 presenting an unacceptable risk or hazard. Thus the purpose of the remedial alternatives is to present the decision maker with technical and economic options for remediation of groundwater at LHAAP-12. The alternatives were developed to achieve the RAOs and the statutory requirements under CERCLA; however, each alternative is unique in its strategy and approach and presents a reasonable spectrum of final conditions. The four alternatives considered for LHAAP-12 are discussed in the following sections.

2.9.1 Description of Remedy Components

Alternative 1 – No Further Action, Maintenance of Existing Landfill Cap, and Land Use Controls for Protection of the Existing Landfill Cap. As required by the NCP, the No Further Action alternative provides a comparative baseline against which the action alternatives can be evaluated. Under this alternative, the LUCs for protection of the existing landfill cap remedy will continue. However, under this alternative, groundwater contamination presenting an unacceptable risk to human health would be left "as is," without implementing any additional containment, removal, treatment, or other mitigating action. No additional actions (e.g., groundwater LUCs) would be implemented to prevent potential human exposure to contaminated groundwater or to demonstrate that nearby surface water bodies are protected from groundwater impacts.

Estimated Capital Cost: $0
Estimated O&M Cost: $109,000
Estimated Present Worth Cost: $47,000

Alternative 2 –Land Use Controls for Groundwater Use Restriction and Maintenance of the Existing Landfill Cap, Land Use Controls for Protection of the Existing Landfill Cap, and Monitored Natural Attenuation. Alternative 2 is the preferred alternative. This alternative includes LUCs with MNA. The goal of this alternative is to allow for and monitor natural attenuation of TCE over time and protect the industrial worker by preventing exposure to contaminated groundwater. MNA relies on natural biological, chemical and physical processes that act to reduce the mass and concentration of groundwater COCs under favorable conditions. These natural attenuation processes include biodegradation, dispersion, dilution, adsorption, volatilization, and abiotic destruction of contaminants.

A review of the available groundwater data showed the presence of daughter products of TCE such as cis-1,2-dichloroethene and vinyl chloride in groundwater indicating that TCE has undergone some degree of biodegradation at LHAAP-12. Results of the recent modeling indicated that under a range of degradation rates, the maximum TCE concentration detected at the site will require 23 to 261 years to naturally attenuate to the MCL of 5 µg/L.

This alternative includes LUCs to protect the integrity of the existing landfill cap cover and to prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health. The LUC objectives are:

- Prohibit digging or disturbing the existing cover or contents of the landfill
- Ensure no residential use or residential development of the property
- Ensure no withdrawal or use of LHAAP-12 groundwater for other than environmental monitoring and testing

The U.S. Army would be responsible for implementation, maintenance, inspection, reporting, and enforcement of the LUCs. Although the Army may transfer these responsibilities to another party through property transfer agreement or other means, the Army will remain responsible for: (1) CERCLA 121 (c) five year reviews; (2) notification of the appropriate regulators of any known LUC deficiencies or violations; (3) access to the property to conduct any necessary response; (4) reservation of the authority to change, modify or terminate LUCs and any related transfer or lease provisions; and (5) the Army will ensure that the LUC objectives are met to protect the integrity of the selected remedy.

The Army intends to provide details of the LUCs implementation actions in an LUC remedial design (LUCRD) for LHAAP-12. LUC implementation and maintenance actions would be

described in the LUCRD. The groundwater restriction component of the LUCs shall be maintained until the concentration of TCE in groundwater has been reduced to levels below the MCL of 5 µg/L and any residual contamination has been sufficiently reduced to allow unrestricted use of the groundwater at LHAAP-12. LUCs would be included in the property deed and transfer documents. In addition, the Texas Department of Licensing and Regulation responsible for notifying well drillers of groundwater restrictions would be notified and a notification and/or recordation with the County Courthouse would include a map showing the area of groundwater restriction at the site.

Monitoring activities associated with the LUCs and MNA would be undertaken to evaluate the effectiveness of the cap and to demonstrate that medium specific concentrations (MSCs) are not exceeded for the groundwater contaminants. MSCs are contaminant concentration limits in groundwater that would be protective of site surface water from groundwater impacts. MSCs have been established for LHAAP-12 via modeling calculations (Shaw, 2004a, 2005c). LUCs already in place for the protection of the cap would be continued.

Estimated Capital Cost: $15,000
Estimated O&M Cost: $479,000
Estimated Present Worth Cost: $255,000

Alternative 3 – Groundwater Extraction to Achieve MCLs at and beyond the Waste Unit Boundary, Land Use Controls for Groundwater Use Restriction and Maintenance of the Existing Landfill Cap and Land Use Controls for Protection of the Existing Landfill Cap. The goals of this alternative are to protect the industrial worker by preventing exposure to contaminated groundwater. In this alternative, the existing LUCs for the protection of the cap would be continued as in Alternative 2, but groundwater extraction would be utilized to achieve MCLs for the groundwater contaminants. The extracted groundwater would be treated at the existing LHAAP-18/24 groundwater treatment plant. Land use controls would also be maintained under this alternative to prevent human exposure to residual groundwater contamination within untreated areas (i.e., beneath the landfill) that may present an unacceptable risk to human health.

Estimated Capital Cost: $285,000
Estimated O&M Cost: $2,350,000
Estimated Present Worth Cost: $1,350,000

Alternative 4 – Landfill Removal, Off-Site Disposal, In-Situ Bioremediation and Monitored Natural Attenuation to Achieve MCLs throughout the Site, Land Use Controls (Short Term). The goals of this alternative are similar to those of Alternative 3: to protect the industrial worker, to achieve MCLs for LHAAP-12 groundwater contaminants, and to prevent human exposure to residual groundwater contamination until the remediation levels are achieved.

The primary differences between the goals for this alternative and those for Alternative 3 are that MCLs would be achieved throughout the site via in-situ bioremediation and MNA, and the landfill waste material would be removed to achieve a higher level of permanence. Also under this alternative, LUCs would be maintained only until such time that the MCLs are achieved for groundwater contaminants through remediation and the landfill material has been removed. Activities included in Alternative 4 reduce contamination to levels that would allow future unrestricted reuse of the site with no long-term reliance on LUCs.

Estimated Capital Cost: $34,400,000
Estimated O&M Cost: $1,630,000
Estimated Present Worth Cost: $35,400,000

2.9.2 Common Elements and Distinguishing Features of Each Alternative

Because groundwater contamination that occurred prior to the placement of the landfill cap would still be in place at LHAAP-12 indefinitely for Alternatives 1 and 2, and because contaminated groundwater would be present for the duration of remedial activities in Alternatives 3 and 4, LUCs (groundwater use restriction) would be common to these alternatives. The LUCs would support the RAOs. The Army intends to provide details of the LUCs implementation actions in a LUCRD for LHAAP-12. The LUCRD will also address those LUCs set forth in the IRA ROD for the protection of the cap. In order to transfer this property to USFWS, an Environmental Condition of Property (ECOP) document will be prepared and attached to the letter of transfer. The property will be transferred subject to the land use and restriction covenants that come with the land as identified in the ECOP. These restrictions would prohibit or restrict property uses that may result in damage to the existing remedy (landfill cap) or exposure to the contaminated groundwater (e.g., drilling restrictions, residential/agricultural land use restrictions, and drinking water well restrictions). Land use restriction areas for the landfill cap and groundwater use for LHAAP-12 are shown on **Figure 2-3**.

Alternatives 2, 3, and 4 include the inspection and long-term groundwater monitoring activities. Monitoring would be continued as required to demonstrate compliance with ARARs, TBCs, and the RAOs, and in support of CERCLA 5-year reviews.

Although the U.S. Army may later transfer these procedural responsibilities to the USFWS by property transfer agreement, the U.S. Army shall retain ultimate responsibility for remedy integrity.

2.10 Summary of Comparative Analysis of Alternatives

Nine criteria identified in the NCP 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. The "Detailed Analysis of Alternatives" can be found in the FS (Shaw 2004c). **Table 2-15** summarizes the comparative analysis of the alternatives presented in this ROD.

1. Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled. The four alternatives provide varying levels of human health protection. Alternative 1, no further action, provides continued maintenance of the existing landfill cap remedy and continued implementation of LUCs to restrict cap usage and access. This alternative, however, does not satisfy the RAO goal of achieving protection from the contaminated groundwater. Alternative 1 provides the least protection of all the alternatives because the potential risk to human health and potential surface water impacts from the contaminated groundwater are not addressed.

Alternatives 2, 3, and 4 all satisfy the RAOs for LHAAP-12. Alternative 2 provides adequate confirmation that human health and the environment are protected because monitoring would be conducted to document that TCE is effectively being reduced to the MCL via MNA. The LUCs would protect human health by preventing human access to the contaminated groundwater. In addition, the groundwater monitoring activities included under Alternative 2 would evaluate the effectiveness of the cap and ensure that MSCs for contaminants in the groundwater are not exceeded, thereby protecting nearby surface water bodies. Alternative 3, which also relies on LUCs to prevent human exposure to contaminated groundwater, provides a slightly higher level of protection than Alternative 2 because groundwater extraction would achieve the chemical ARARs for groundwater contaminants at and beyond the landfill boundary. Alternative 4 provides the highest degree of protection because the landfill waste material would be removed from the site entirely, and the chemical ARARs for groundwater contaminants would be achieved throughout the site, thereby eliminating unacceptable exposure risks. However, the remedial actions planned under Alternative 4 would have the greatest potential for risks to human health and the environment while they are being conducted due to the extensive handling of the excavated waste material.

2. Compliance with ARARs

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) requires that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations, which are collectively referred to as "ARARs" unless such ARARs are waived under CERCLA Section 121(d)(4).

Alternative 1 does not comply with chemical-specific ARARs because no additional remedial action would be implemented. Alternative 2 does comply with groundwater ARARs because

modeling results indicate MNA will likely reduce the TCE concentrations in groundwater to the MCL. This Alternative would also comply with surface water ARARs by monitoring to ensure that the MSCs for contaminants in the groundwater are not exceeded, thereby protecting nearby surface water bodies. Alternative 3 complies only with chemical-specific ARARs in groundwater at and beyond the waste unit boundary because contaminant MCLs would be achieved in this area, and protects nearby surface water bodies from ARAR exceedances. Alternative 4 complies with the chemical-specific ARARs for groundwater and surface water.

Location-specific and action-specific ARARs would not apply to Alternative 1 since additional remedial activities would not be conducted, however, the existing landfill cap would remain in place. Alternatives 2, 3, and 4 comply with the location-specific and action-specific ARARs.

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 is not effective for groundwater because it does not prevent human exposure to the contaminated groundwater, and does not demonstrate protection of surface water bodies from potential groundwater impacts.

Alternatives 2 would document effectiveness through the confirmation of MNA and TCE rate reduction and routine monitoring of the attenuation and migration of TCE in groundwater. Uncertainties exist regarding the effectiveness of natural attenuation for reducing site groundwater contaminants to the MCLs, and therefore further evaluation would be required. However, recent modeling results indicate that MNA will likely be effective for reduction of TCE to the MCL in LHAAP-12 groundwater.

Alternatives 2 and 3 offer a high degree of long-term effectiveness through the implementation of LUCs, which would minimize the potential risk posed by the contaminated groundwater. Although both Alternatives 2 and 3 would require that LUCs are maintained, these controls would not be required for Alternative 3 beyond the waste boundary once MCLs are met for the groundwater contaminants. However, uncertainties do exist regarding the ability of groundwater extraction under Alternative 3 to actually meet the MCLs for groundwater contaminants at LHAAP-12. Should the groundwater extraction system be considered ineffective after some amount of time, the remedy or the remediation levels may need to be reevaluated.

Alternative 4 would significantly and permanently remove the landfill waste material and reduce groundwater contaminant concentrations to the MCLs, and therefore offers the highest degree of

long-term effectiveness compared to the other alternatives. However, significant uncertainty exists regarding the effectiveness of in-situ bioremediation for the combined treatment of both perchlorate and volatile organic compounds in groundwater. Uncertainties also exist regarding the effectiveness of natural attenuation for reducing site groundwater contaminants to the MCLs, and therefore further evaluation would be required.

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 would not reduce the toxicity, mobility or volume of contaminants in the landfill or groundwater through an active remedial process, but the potential mobility and toxicity of the landfill waste contaminants would be minimized through proper landfill cap maintenance.

Natural biodegradation under Alternative 2 is an irreversible treatment process that would reduce the mass and concentration of contaminants. Alternative 2 would not reduce the toxicity, mobility, or volume of contaminants in the landfill or groundwater through an active remedial process. However, there is no known principal threat material in the landfill or groundwater. Although the selected remedy does not satisfy the statutory preference for treatment to the maximum extent practicable, the selected remedy does offer a similar level of protection to human health and the environment, at a lower cost than those remedial alternatives that satisfy the preference for treatment. Furthermore, although it is anticipated that natural attenuation would reduce TCE over time, daughter products may be generated temporarily. The MNA process would be routinely monitored and evaluated so that daughter products would be quantified, documented and evaluated.

The implementation of groundwater extraction under Alternative 3 would permanently reduce the toxicity, mobility, and volume of the groundwater contaminants at and beyond the waste unit boundary. The potential mobility and toxicity of the landfill waste contaminants would be minimized through proper maintenance of the landfill cap.

Alternative 4 would provide the greatest degree of reduction in toxicity, mobility, and volume of the landfill waste contaminants and groundwater contaminants. However, this reduction in groundwater contaminants would only occur provided the results of treatability testing and further evaluations of in-situ bioremediation and MNA are favorable.

5. Short-Term Effectiveness

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

The activities associated with Alternatives 1, 2 and 3 would have little potential for short-term risk to workers or the environment, other than the minimal risks to workers associated with the exposure to contaminants during groundwater monitoring and extraction activities. Alternative 1 does not provide protection from the contaminated groundwater. Alternative 2 would provide almost immediate protection from all contaminated media because the LUCs could be implemented relatively quickly, maintenance of these controls would be required until natural attenuation processes reduce contaminant concentrations to below MCLs. Although the LUCs and groundwater extraction for Alternative 3 could also be implemented relatively quickly, operation of the groundwater extraction system would most likely be required beyond a 30-year period of time since the contaminant source (i.e., landfill waste material) would remain on site.

Alternative 4 would involve the highest level of short-term risks to workers, the community, and the environment due to the extensive handling of waste materials. Potential risks to the community would be associated with truck traffic and the possibility of spills during waste transport to the disposal facility. Short-term risks to workers include those generally associated with construction activities or contaminant exposure through either ingestion or inhalation during waste handling activities. Risks to the environment may involve contaminant migration to nearby surface water bodies via surface water runoff during storm events. The implementation of this alternative would require more time than the other alternatives due to the requirement for an RD and treatability testing.

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.

Alternatives 1 and 2 are easily implemented from a technical standpoint because no additional engineered remedial activities would be performed, although routine inspections and maintenance of the landfill cap, maintenance of LUCs, evaluation of MNA, and sampling (Alternative 2) would be required. Alternative 3 is also technically implementable, although less so than Alternative 2 because of the uncertainties associated with the ability of groundwater extraction to lower contaminant levels sufficiently to reach the MCLs.

Alternative 4 would be the most difficult to implement from a technical standpoint because more time, equipment, and technical expertise would be required. The in-situ groundwater treatment elements can be designed and constructed only by a select few vendors. The excavation of the landfill would require extensive coordination for excavation, sampling, transportation, and disposal activities. Also, given the uncertain nature of the waste in the landfill, the potential for delays in excavation exist should anomalous items or debris be encountered that slow the process.

Administratively, all of the alternatives are implementable; however, Alternative 4 would be the least implementable of all the alternatives. Alternative 4 requires Army, State, and USEPA approval of an off-site landfill. Various Department of Transportation regulations may also apply to the transportation of waste such as that expected from the landfill. The waste acceptance criteria of the disposal facility must also be satisfied.

7. Cost

Cost estimates are used in the CERCLA FS 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 +50 to –30 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.

Costs developed are capital costs (including fixed-price remedial construction) and long-term O&M costs (post-remediation). Overall 30-year present-worth costs are developed for each alternative, assuming a discount rate of 7 percent.

Alternative 1 has the lowest capital, operation and maintenance, and present worth costs of all the alternatives. The present-worth cost of Alternative 2 is significantly lower than that of Alternative 3, primarily due to O&M of the groundwater extraction system under Alternative 3. However, these two alternatives are significantly less expensive than Alternative 4, which is greater than 26 times the present-worth cost of Alternatives 2 and 3. The high present-worth cost of Alternative 4 is due primarily to the high capital cost associated with the excavation and backfilling of the existing landfill at LHAAP-12. Cost summaries are presented in **Table 2-15**.

8. State/Support Agency Acceptance

The USEPA and TCEQ have reviewed the Proposed Plan. The preferred alternatives for the final remedy were fully evaluated and the response to the comment received from the USEPA is included in the Responsiveness Summary at the end of this ROD. In addition, evaluation of MNA was added as part of the selected remedy in response to the regulatory agencies comments to the Draft Final ROD. The response to comments is also included in the Responsiveness Summary.

9. Community Acceptance

Community acceptance is an important consideration in the final evaluation of the final remedy. There were no public comments received during the 30-day public comment period and no public comments were made at the March 29, 2005 public meeting. The community appears to support the selected final remedy (Alternative 2) as detailed in the Proposed Plan. In response to

the regulatory agencies comments, the remedy has been modified by adding evaluation of MNA as part of the final remedy.

2.11 Principal Threat Wastes

LHAAP-12 was used primarily as a municipal-type solid waste landfill. Placement of a multilayer cap isolated the wastes in LHAAP-12 landfill and cut off the leaching of hazardous substances to groundwater. With this remedy in place, the landfill source material at LHAAP-12 does not currently pose a principle threat to human health and the environment.

2.12 The Selected Remedy

2.12.1 Summary of Rationale for the Selected Remedy

Alternative 2, land use controls for groundwater use restrictions, maintenance of the existing landfill cap and land use controls for protection of the existing landfill cap, and monitored natural attenuation is the preferred alternative for LHAAP-12 and is consistent with the intended future use of the site as a part of a wildlife refuge. This alternative will satisfy the RAOs for the site as follows:

- Groundwater use restriction LUCs will ensure protection of human health by preventing human exposure to TCE contaminated groundwater. The LUCs will remain in place until ARARs are met.

- The LUCs for the protection of the landfill cap will ensure the integrity of the landfill cap thus protecting human health and the environment by reducing the leaching and migration of landfill hazardous substances into the groundwater;

- MNA remedy will be implemented to assure the protection of human health and the environment by preventing TCE contaminated groundwater from migrating into nearby surface water at levels that exceed ARARs. The monitoring and reporting associated with this remedy will continue until ARARs are achieved.

Furthermore, monitoring activities associated with MNA will ensure that MSCs are not exceeded in groundwater that is likely to discharge to the nearby creek, thus protecting the surface water bodies.

Based on information currently available, the U.S. Army believes that the preferred alternative offers a high degree of long term effectiveness, can easily and immediately be implemented, and costs less than the other alternatives. The preferred alternative also provides the best balance of tradeoffs among the other alternatives with respect to the CERCLA criteria used to evaluate remedial alternatives.

The USEPA and TCEQ have expressed acceptance of the preferred alternative provided that appropriate LUCs are implemented. The Army intends to provide details of the LUCs implementation actions in an LUC remedial design (LUCRD) for LHAAP-12.

2.12.2 Description of the Selected Remedy

The goals of the preferred alternative are to monitor the effectiveness of MNA in reducing TCE concentrations over time and protect the industrial worker by preventing exposure to contaminated groundwater. MNA relies on natural biological, chemical and physical processes that act to reduce the mass and concentration of groundwater COCs under favorable conditions. These natural attenuation processes include biodegradation, dispersion, dilution, adsorption, volatilization, and abiotic destruction of contaminants.

A review of the available groundwater data showed the presence of daughter products of TCE such as cis-1,2-dichloroethene and vinyl chloride in groundwater indicating that TCE has undergone some degree of biodegradation at LHAAP-12. Results of the recent modeling indicated that under a range of degradation rates, the maximum TCE concentration detected at the site will require 23 to 261 years to naturally attenuate to the MCL of 5 µg/L.

This alternative includes LUCs to protect the integrity of the existing landfill cap cover and to prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health. The LUC objectives are:

- Prohibit digging or disturbing the existing cover or contents of the landfill;
- Ensure no residential use or residential development of the property;
- Ensure no withdrawal or use of LHAAP-12 groundwater for other than environmental monitoring and testing.

The U.S. Army would be responsible for implementation, maintenance, inspection, reporting, and enforcement of the LUCs. Although the Army may transfer these responsibilities to another party through property transfer agreement or other means, the Army will remain responsible for: (1) CERCLA 121 (c) five year reviews; (2) notification of the appropriate regulators of any known LUC deficiencies or violations; (3) access to the property to conduct any necessary response; (4) reservation of the authority to change, modify or terminate LUCs and any related transfer or lease provisions; and (5) the Army will ensure that the LUC objectives are met to protect the integrity of the selected remedy.

LUC implementation and maintenance actions would be described in the LUCRD for LHAAP-12. The groundwater restriction component of the LUCs shall be maintained until the concentration of TCE in groundwater has been reduced to levels below the MCL of 5 µg/L and any residual contamination has been sufficiently reduced to allow unrestricted use of the

groundwater at LHAAP-12. The LUCs area for groundwater use restriction is shown on **Figure 2-3**. LUCs would be included in the property deed and transfer documents. In addition, the Texas Department of Licensing and Regulation responsible for notifying well drillers of groundwater restrictions would be notified and a notification and/or recordation with the County Courthouse would include a map showing the area of groundwater restriction at the site.

Monitoring activities associated with the LUCs and MNA would be undertaken to evaluate the effectiveness of the cap and to demonstrate that medium specific concentrations (MSCs) are not exceeded for the groundwater contaminants. MSCs are contaminant concentration limits in groundwater that would be protective of site surface water from groundwater impacts. MSCs have been established for LHAAP-12 via modeling calculations (Shaw, 2004a, 2005c). LUCs already in place for the protection of the cap would be continued.

The reasonably anticipated future land use will be as a part of a national wildlife reserve. The land's current use is as a closed landfill. The selected LUCs are necessary because CERCLA hazardous substances could otherwise pose unacceptable risks if property use was not controlled or restricted. Further, the LUC will be needed due to the presence of hazardous substances in the groundwater that will remain above concentrations that are acceptable for unrestricted use and unlimited exposure. The LUCs will therefore be implemented to preclude unrestricted use of groundwater at the site.

The groundwater restriction component of the LUCs supplements those remedy components already in place as a result of the IRA, through which construction of a landfill cap and associated LUCs for the protection of the cap were implemented. LUCs already in place for the protection of the landfill cap include posting of signage, restriction of invasive activities, and use restrictions. Further, cap maintenance and monitoring activities are also required as part of the IRA. The existing LUCs are necessary because landfill waste could otherwise pose unacceptable risks if property use is not controlled or restricted. The LUCs will continue to be needed due to the presence of the landfill waste material that will remain above concentrations that are acceptable for unrestricted use and unlimited exposure. The LUCs area for landfill cap protection is shown on **Figure 2-3**.

Although the current cap is in good condition, it would be monitored, maintained, and repaired, as necessary, to ensure its long-term effectiveness. Monitoring would consist of regular inspections of the soil cover and vegetation for signs of settlement, biointrusion, and erosion. Routine maintenance and repair would consist of those actions needed to ensure that the integrity of the cap is maintained (e.g., mowing, aerating, seeding, settlement and erosion repair).

Long-term operational requirements under this alternative would include maintenance of the landfill cap and of the LUCs. Proper and prompt cap maintenance should extend the lifetime of

the cap. Long-term environmental monitoring would be performed at LHAAP-12 for the target contaminants. The need for continued monitoring will be evaluated every five years during the reviews. Sampling frequency and analytical requirements will be presented as an appendix to the LUCRD for LHAAP-12.

2.12.3 Summary of the Estimated Remedy Costs

Table 2-16 presents detailed cost estimates for the preferred alternative, Alternative 2. The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the course of implementation of the remedial alternative. The costs included in this ROD are estimated to be within +50 to -30 percent of the actual project cost. The total project present worth cost of this alternative is approximately $255,000. The total direct capital cost is estimated at $15,000. No indirect capital costs are required for this alternative. The total O&M cost is estimated at approximately $479,000. The O&M cost includes maintenance of the existing cap, evaluation of MNA, maintenance of LUCs, and long-term monitoring through year 30. The long-term monitoring would support the required CERCLA 5-year reviews. The cost estimates are in addition to the previously incurred cost of placing a multilayered landfill cap under the IRA.

2.13 Statutory Determinations

Under CERCLA §121 and the NCP, the U.S. Army must select remedies that are protective of human health and the environment, compliant with ARARs, 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.

Protection of Human Health and the Environment

The selected remedy, Alternative 2, will achieve the RAOs for LHAAP-12. Although this alternative does not provide for human intervention to remediate groundwater, the alternative is an active subsurface remediation process or treatment conducted by natural processes and mechanisms. This alternative provides adequate confirmation that human health and the environment are protected because monitoring would be conducted to document the effectiveness of MNA.

LUCs would prevent human access to the contaminated groundwater between the source (landfill) and the point of entry into the surface water body. Preliminary MSCs for TCE and perchlorate in the groundwater at LHAAP-12 have been calculated to be protective of Central Creek, Harrison Bayou, and Caddo Lake (Shaw 2004c). A comparison of the maximum

observed concentrations of TCE and perchlorate in the LHAAP-12 groundwater to the MSCs indicates that the TCE and perchlorate concentrations at the site do not exceed the MSCs. Therefore, the maximum observed concentrations of TCE and perchlorate are already at levels that are protective of the nearby surface water bodies. The monitoring activities associated with LUCs will ensure that the MSCs are not exceeded for TCE and perchlorate over time and that nearby surface water bodies are protected. Continued maintenance of the cap along with LUCs will prevent human access and exposure to landfill waste material that may pose an unacceptable risk to human health. Land use controls put in place will prevent disturbance and penetration of the landfill cap.

Hazardous substances detected in soil at this site were considered to represent a low threat to the environment, and it was determined that no remediation for the protection of ecological receptors was necessary at LHAAP-12.

Compliance with ARARs

Chemical-Specific ARARs

This alternative will comply with groundwater ARARs as recent modeling results indicate MNA will likely reduce TCE concentrations to levels below the MCL of 5 µg/L. Since the MSCs developed for groundwater contaminants are significantly higher than the maximum observed concentrations of these contaminants, nearby surface water bodies will be protected from ARAR exceedances. It is anticipated that contaminant concentrations in groundwater will continue to decline with time until ARARs (MCLs) are eventually met.

Location-Specific ARARs

The activities to be conducted under this alternative will comply with all location-specific ARARs. No activities will take place in sensitive environments such as wetlands, and no impacts to archeological resources are anticipated. Due to the limited number and locations of the activities associated with this alternative, threatened and endangered species will not likely be impacted.

Action-Specific ARARs

The activities that will be conducted under this alternative would comply with all action-specific ARARs.

Cost-Effectiveness

Alternatives 1, 2 and 3 have the lowest present worth and capital costs of the active remedial alternatives. The present worth cost of Alternatives 1 and 2 are significantly lower than that of Alternative 3 primarily due to O&M of the groundwater extraction system under Alternative 3. However, these three alternatives are significantly less expensive than Alternative 4, which is greater than 26 times the present worth cost of Alternatives 1, 2 and 3. The high present worth cost of Alternative 4 is primarily due to the high capital cost associated with the excavation and

backfilling of the existing cap at LHAAP-12. Alternative 2 offers a high degree of long-term effectiveness, and costs less than the other alternatives.

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

The selected final remedy does not address the issue of permanent solution though disposal, treatment or recovery of contaminants. However, removal and treatment or disposal of landfill waste would involve the greatest potential for risks to workers, the community and the environment. Removal of landfill waste would pose potential risks to the community from truck traffic and the possibility of spills during waste transport to the disposal facility. Other exposure pathways would include ingestion or inhalation during waste handling activities. Risks to the environment may involve contaminant migration to nearby surface water bodies via surface water runoff during storm events. Removal of landfill material would not be consistent with USEPA guidance for containment as a presumptive remedy for municipal landfills and for military landfills (USEPA, 1993, 1996).

Preference for Treatment as a Principal Element

The selected remedy would not reduce the toxicity, mobility, or volume of contaminants in the landfill or groundwater through an active remedial process. However, there is no known principal threat material in the landfill or groundwater. Although the selected remedy does not satisfy the statutory preference for treatment to the maximum extent practicable, the selected remedy does offer a similar level of protection to human health and the environment, at a lower cost than those remedial alternatives that satisfy the preference for treatment.

Five-Year Review Requirements

Section 121(c) of CERCLA and NCP§300.430(f)(5)(iii)(c) provide the statutory and legal bases for conducting 5-year reviews. Because this remedy will result in contaminants that remain on site above levels that allow unlimited use and unrestricted exposure, a review will be conducted in coordination with the reviews already in place for the landfill waste, to ensure that the remedy continues to provide adequate protection of human health and the environment.

2.14 Significant Changes from the Proposed Plan

The monitoring of on-site wells where TCE has been detected has been added to the monitoring program proposed initially to address the USEPA's comment to the Proposed Plan. In addition, evaluation of MNA was added as part of the selected remedy in response to the regulatory agencies comments to the Draft Final ROD. The response to comments is included in the Responsiveness Summary.

Table 2-1
Source Area Soil
Summary of Analytical Data

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location	Frequency of Detections
Volatile Organic Compounds (µg/kg)					
2-Hexanone	15	15	4/18/1993	12SB04A(10-11)	1/18
Acetone	24	1,364 J	4/18/1993	12SB04A(10-11)	6/18
Ethylbenzene	10	68	4/18/1993	12SB04A(10-11)	3/18
Methyl ethyl ketone	110	110	4/18/1993	12SB04A(10-11)	1/18
Methyl isobutyl ketone	23	23	4/18/1993	12SB04A(10-11)	1/18
Tetrachloroethylene	9.8	9.8	6/1/1993	12SB02(1-2)	1/18
Toluene	26	73	4/19/1993	12WW03(5-6)	2/18
Xylene (total)	8	109	4/18/1993	12SB04A(10-11)	3/18
Semivolatile Organic Compounds (µg/kg)					
Di-n-butyl phthalate	3,400	5,300	4/19/1993	12WW03(0-2)	2/18
Metals (mg/kg)					
Arsenic	1.33 J	5.42	4/19/1993	12WW02(0-2)	12/18
Barium	15.1	175	4/19/1993	12WW02(5-7)	18/18
Chromium	2.22	30.3	6/3/1993	12WW02(0-2)	18/18
Lead	2.67	37.6	4/19/1993	12WW05(0-1.5)	18/18
Mercury	0.14	0.14	4/19/1993	12WW02(5-7)	1/18
Nickel	1.5	16.2	5/12/1993	12WW02(0-2)	18/18
Anions (mg/kg)					
Chloride	1.3	240	4/18/1993	12WW06(10-11)	18/18
Nitrate	0.14	0.3	4/19/1993	12WW03(5-6)	2/18
Sulfate	0.94	451.1	6/1/1993	12SB02(1-2)	17/18

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.

µg/kg micrograms per kilogram
mg/kg milligrams per kilogram

Table 2-2
Non-Source Area Soil
Summary of Analytical Data

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location for Maximum Concentration	Frequency of Detections
Volatile Organic Compounds (µg/kg)					
Methylene chloride	5.7	11	4/28/1993	12WW02(20-22)	4/19
Semivolatile Organic Compounds (µg/kg)					
Bis(2-ethylhexyl)phthalate	660	5,000	4/19/1993	12WW07(10-12)	5/19
Butyl benzyl phthalate	750	2,700	4/27/93 & 4/19/93	12WW01(5-7) & 12WW07(10-12)	6/19
Di-n-butyl phthalate	560	4,700	4/28/1993	12WW02(0-2)	6/19
Metals (mg/kg)					
Arsenic	2.22	16.1	4/28/1993	12WW02(0-2)	13/19
Barium	23.3	436 J	4/28/1993	12WW02(5-7)	19/19
Chromium	2.63	24.2	4/28/1993	12WW02(0-2)	19/19
Lead	3.27	16.7	4/19/1993	12WW05(0-1.5)	19/19
Nickel	1.73	38 J	4/28/1993	12WW02(5-7)	19/19
Silver	1.31	1.31	4/28/1993	12WW02(0-2)	1/19
Thallium	1.61	1.85	5/3/1993	12WW05(10-12)	2/19
Anions (mg/kg)					
Chloride	2.9	390	4/27/1993	12WW01(10-12)	12/19
Nitrate	0.2	0.25	4/27/1993	12WW01(10-12)	2/19
Sulfate	1.18	61.4	4/27/1993	12WW01(15-17)	15/19
Perchlorate	46.7	46.7	5/2000	12SB06(0-0.5)	1/6

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.

µg/kg micrograms per kilogram

mg/kg milligrams per kilogram

Table 2-3
Surface Water
Summary of Analytical Data

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location for Maximum Concentration	Frequency of Detections
Volatile Organic Compounds (µg/L)					
Acetone	10	10	3/151995	12SW12	1/19
Methylene chloride	10	17	3/151995	12SW11	2/19
Metals (mg/L)					
Aluminum	0.4	2.4	10/7/1998	12SW19	5/5
Antimony	0.019	0.019	10/7/1998	12SW19	1/19
Arsenic	0.01	0.011	10/6/1998	12SW18	2/19
Barium	0.067	0.272	2/18/1995	12SW15	12/19
Beryllium	0.0007	0.0007	10/6/1998	12SW05	1/5
Cadmium	0.00574	0.00574	5/18/1993	12SW03	1/19
Copper	0.007	0.028	10/7/1998	12SW19	4/16
Iron	0.14	3.6	10/6/1998	12SW18	5/5
Lead	0.003	0.01	10/6/1998	12SW15	6/19
Manganese	0.073	0.615 J	10/6/1998	12SW15	5/5
Zinc	0.004	0.039	2/18/1995	12SW05	8/16
Dioxins and Furans (pg/L)					
Octachlorodibenzo-p-dioxin	23.1	50.8	10/7/1998	12SW19	3/3
Anions (mg/L)					
Chloride	0.378	4.6	5/18/1993	12SW03	7/8
Nitrate	5.47	5.47	5/4/1993	12SW02	1/3
Nitrate+Nitrite (as N)	0.138	0.138	10/6/1998	12SW15	1/5
Sulfate	2.1	5	10/7/1998	12SW19	6/8

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.

µg/L micrograms per liter
mg/L milligrams per liter
pg/L picograms per liter

Table 2-4
Sediment
Summary of Analytical Data

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location for Maximum Concentration	Frequency of Detections
Volatile Organic Compounds (µg/kg)					
Acetone	30	76	2/18/1995	12SD08QC	3/19
Isopropylbenzene	9.9	9.9	10/6/1998	12SD15	1/5
p-Cymene	48	48	10/6/1998	12SD18	1/5
Metals (mg/kg)					
Aluminum	1,300	4,500	10/6/1998	12SD16	5/5
Arsenic	1.01 J	10.3 J	4/22/1993	12SD01	14/19
Barium	18.6	384 J	5/3/1993	12SD03	19/19
Cadmium	1.28	6.27 J	3/15/1995	12SD10	2/19
Chromium	3.47	35.8	3/1/1995	12SD13	19/19
Cobalt	6.8	6.8	10/6/1998	12SD15QC	1/5
Copper	1.3	11.4	3/1/1995	12SD13	11/16
Iron	2,100	6,800	10/7/1998	12SD19	5/5
Lead	4.42 J	16.6	2/18/1995	12SD06	19/19
Manganese	77.8	362	10/6/1998	12SD15QC	5/5
Nickel	2.4	11.4 J	5/3/1993	12SD03	14/19
Potassium	1,000	1,000	10/6/1998	12SD18	1/5
Selenium	0.62	0.62	3/15/1995	12SD12	1/19
Thallium	4.11	4.11	5/3/1993	12SD03	1/19
Vanadium	13	16	10/7/1998	12SD19	2/5
Zinc	4.7	42.7	2/18/1995	12SD07	16/16
Dioxins and Furans (ng/kg)					
1,2,3,4,6,7,8-HpCDD	2.85	4.18	10/7/1998	12SD19	2/3
Heptachlorodibenzo-p-dioxin	0.528	10.4	10/7/1998	12SD19	3/3
Hexachlorodibenzo-p-dioxin	1.01	1.01	10/7/1998	12SD19	1/3
Octachlorodibenzo-p-dioxin	6.5	195	10/7/1998	12SD19	3/3

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.

µg/kg micrograms per kilogram
mg/kg milligrams per kilogram
ng/kg nanograms per kilogram

Table 2-5
Groundwater
Summary of Analytical Data

Parameter/Units	Minimum Concentration Detected	Maximum Concentration Detected	Date Sampled	Location for Maximum Concentration	Frequency of Detections
Volatile Organic Compounds (µg/L)					
Cis 1,2 Dichloroethene	110	110	7/15/1998	12WW12	1/27
1,1 Dichloroethane	3	3	7/15/1998	12WW02	1/42
1,4 Dichlorobenzene	15	15	7/15/1998	12WW12	1/17
Chlorobenzene	7	28	7/15/1998	12WW12	2/42
Vinyl chloride	2.1	2.1	7/15/1998	12WW02	1/42
1,1,1-Trichloroethane	66	66	5/28/1993	103	1/42
1,2-Dichloroethene	122	122	4/20/1995	12WW12	1/15
Chloroform	1.2	1.7	7/15/1998	12WW12	3/42
2-Butanone	11	11	5/30/1993	121	1/42
Trichloroethene	1	495	4/20/1995	12WW12	6/42
Semivolatile Organic Compounds (µg/L)					
Bis(2-ethylhexyl)phthalate	15	15	6/13/1993	12WW01	1/23
Metals (mg/L)					
Aluminum	0.91	22	7/15/1998	12WW15	9/16
Antimony	0.005	0.033	7/15/1998	12WW18	11/41
Arsenic	0.005	0.009	4/18/1995	12WW04	7/41
Barium	0.026	1.63	4/19/1995	12WW09	26/41
Beryllium	0.0008	0.0031	7/15/1998	12WW17	6/16
Cadmium	0.0012	0.006	4/19/1995	12WW09	3/41
Calcium	6.4	260	7/15/1998	12WW08	16/16
Chromium	0.01	2.42	4/19/1995	12WW09	29/41
Cobalt	0.08	0.11	7/15/1998	12WW17	2/16
Copper	0.032	0.049	7/15/1998	12WW16	5/16
Iron	0.68	23	7/15/1998	12WW15	16/16
Lead	0.003	20	4/19/1995	12WW09	25/41
Magnesium	5.8	240	7/15/1998	12WW08	16/16
Manganese	0.065	2.75	7/15/1998	12WW17	16/16
Mercury	0.0004	0.0017	7/15/1998	12WW12	2/41
Nickel	0.05	1.6	7/15/1998	12WW16	22/41
Selenium	0.005	0.01	7/15/1998	12WW12	5/41
Silver	0.01	0.02	7/15/1998	12WW-08,15	6/41
Sodium	58	1,100	7/15/1998	12WW08	16/16
Strontium	0.14	12	7/15/1998	12WW08	16/16
Thallium	0.0011 J	0.0016 J	7/15/1998	12WW16	4/41
Zinc	0.03	0.15	7/15/1998	12WW17	14/16
Dioxins and Furans (pg/L)					
1,2,3,4,6,7,8-HpCDD	1.25	9.654	7/15/1998	12WW12	¾
Heptachlorodibenzo-p-dioxins	1.248	23.812	7/15/1998	12WW12	4/4
Hexachlorodibenzofuran	0.432	0.892	7/15/1998	12WW01	2/4
Octachlorodibenzo-p-dioxin	12.7	123.185	7/15/1998	12WW12	4/4
Pentachlorodibenzo-p-dioxin	181.034	181.034	7/15/1998	12WW01QC	¼
Anions (mg/L)					
Chloride	2	3,490	7/15/1998	12WW08	23/23
Nitrate	0.6	2	6/12/1993	12WW06QC	1/23
Sulfate	3.8	640	7/15/1998	12WW17 & 12WW19QC	23/23
Perchlorate	0.0016	0.056	1/2001	12WW01	5/26

Notes:

J The analyte was not positively identified: the associated numerical value is the approximate concentration of the analyte in the sample.
ug/L micrograms per liter
mg/L milligrams per liter
pg/L picograms per liter

Table 2-6
Occurrence, Distribution, and Selection of Chemicals of Potential Concern - Groundwater

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

	Chemical	Concentration Detected[1]		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units[1]	Statistical Measure
		Min	Max					
	Volatile OrganicCompounds							
	cis-1,2-Dichloroethene	1.10E-01	1.10E-01	mg/L	1/27	1.10E-01	mg/L	max
	Trichloroethene	1.00E-03	4.95E-01	mg/L	6/42	4.95E-01	mg/L	max
	Vinyl Chloride	2.10E-03	2.10E-03	mg/L	1/42	2.10E-03	mg/L	max
	Semi-Volatile Organic Compounds							
	bis(2-Ethylhexyl)phthalate	1.50E-02	1.50E-02	mg/L	1/23	1.50E+1	mg/L	max
	Metals							
	Aluminum	9.1E-01	2.20E+01	mg/L	9/16	2.20E+01	mg/L	max
	Antimony	5.00E-03	3.30E-02	mg/L	11/41	3.30E-02	mg/L	max
	Cadmium	1.20E-03	6.00E-03	mg/L	3/41	6.00E-03	mg/L	max
	Manganese	6.50E-02	2.75E+00	mg/L	16/16	2.75E+00	mg/L	max
	Nickel	5.00E-02	1.60E+00	mg/L	22/41	1.60E+00	mg/L	max
	Strontium	1.40E-01	1.20E+01	mg/L	16/16	1.20E+01	mg/L	max
	Thallium	1.10E-03	1.60E-03	mg/L	4/41	1.60E-03	mg/L	max
	Dioxin/Furans							
	2,3,7,8-TCDD TEQ	NA	NA	mg/L	NA	3.29E-09[3]	mg/L	max
	Anion							
	Perchlorate	1.60E-03	5.60E-02	mg/L	ND	5.60E-02	mg/L	max

Notes:

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

mg/L: milligrams per liter

NA: Not applicable.

ND: No data

TCDD: tetrachloro-p-dibenzodioxin
Note: Winter 2004 groundwater data was not included

Table 2-7
Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal

Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (MM/DD/YYYY)
Metals						
Aluminum	NTV	NTV	–	not classified	–	–
Antimony	NTV	NTV	–	not classified	–	–
Cadmium	NTV	NTV	–	B1	TNRCC	03/15/2001
Manganese	NC	NC	–	D	TNRCC	03/15/2001
Nickel	NTV	NTV	–	A	TNRCC	03/15/2001
Strontium	NTV	NTV	–	not classified	–	–
Thallium	NC	NC	–	not classified	–	–
Non-Metallic Anion						
Perchlorate	NTV	NTV	–	not classified	–	–
Volatile Organics						
cis-1,2-Dichloroethene	NC	NTV	–	D	TNRCC	2001
Trichloroethene	1.10E-02	1.10E-02	$(mg/kg\text{-}day)^{-1}$	B2	EPA NCEA	2001
Vinyl Chloride	1.50E+00	1.50E+00	$(mg/kg\text{-}day)^{-1}$	A	EPA IRIS	2001
Dioxin/Furan						
2,3,7,8-TCDD	1.50E+05	3.00E+05	$(mg/kg\text{-}day)^{-1}$	not classified	EPA HEAST	1997
Semi-Volatile Organics						
bis(2-Ethylhexyl)phthalate	1.40E-02	7.37E-02	$(mg/kg\text{-}day)^{-1}$	B2	EPA IRIS	2001

Pathway: Inhalation

Chemical of Concern	Unit Risk Factor	Units	Inhalation Cancer Slope Factor	Units	Weights of Evidence/Cancer Guideline Description	Source	Date (YYYY)
Metals							
Aluminum	NTV	–	–	–	not classified	–	–
Antimony	NTV	–	–	–	not classified	–	–
Cadmium	1.80E-03	$(mg/m^3)^{-1}$			B1	EPA IRIS	2001
Manganese	NC	–	–	–	D	TNRCC	2001
Nickel	4.80E -1	$(mg/m^3)^{-1}$			A	EPA IRIS	2001
Strontium	NTV	–	–	–	not classified	–	–
Thallium	NC	–	–	–	not classified	–	–
Non-Metallic Anion							
Perchlorate	NTV	–	–	–	not classified	–	–
Dioxin/Furan							
2,3,7,8-TCDD	3.30E+04	$(mg/m^3)^{-1}$			not classified	EPA HEAST	1997
Semi-Volatile Organics							
bis(2-Ethylhexyl)phthalate	4.00E-3	$(mg/m^3)^{-1}$			B2	EPA NCEA	2001
Volatile Organics							
cis-1,2-Dichloroethene	NC				D	TNRCC	2001
Trichloroethene	1.70E-3	$(mg/m^3)^{-1}$	–	–	B2	EPA NCEA	2001
Vinyl Chloride	8.80E-3	$(mg/m^3)^{-1}$			A	EPA IRIS	2001

Table 2-7 (*continued*)
Cancer Toxicity Data Summary

Key

EPA Group:
— : No information available
EPA: U.S. Environmental Protection Agency
IRIS: Integrated Risk information System, EPA
mg/kg-day: milligrams per kilogram per day
mg/m^3: milligrams per cubic meter
NC: Chemical not classified as a carcinogen
NTV: no toxicity value available
TCDD: tetrachlorodibenzo-p-dioxin

A - Human carcinogen
B1- Probable human carcinogen – Indicates that limited human data are available
B2- Probable human carcinogen – Indicates sufficient evidence in animals and inadequate or no evidence in humans
D - Not classifiable as a human carcinogen

References

EPA. United States Environmental Protection Agency Online Database for Toxicity Information Hazardous Chemicals.

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

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

TNRCC, 2001. Update to 1998 Consistency Memorandum. Toxicity Factors Table, 15 March 2001.

Summary of Toxicity Assessment

The table provides carcinogenic risk information which is relevant to the contaminants of concern in ground water. At this time, slope factors are not available for the dermal or inhalation routes of exposure. In some cases, the dermal slope factors used in the assessment have been extrapolated from oral values.

Two of the COCs are considered carcinogenic via the inhalation route. Nickel and vinyl chloride have inhalation unit risk factors of 4.8E-01 $(mg/m^3)^{-1}$ and 8.8E-03 $(mg/m^3)^{-1}$, respectively (EPA-IRIS 1998). Cadmium, which is considered probably carcinogenic via the inhalation route, has an inhalation unit risk factor of 1.8E-03 $(mg/m^3)^{-1}$ (EPA-IRIS 1998). Trichloroethylene and bis(2-ethylhexyl)phthalate lack sufficient toxicity information via the inhalation route in humans to support the development of specific inhalation carcinogenic toxicity criteria.

Table 2-8
Non-Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal									
Chemical of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Dermal RfD	Dermal RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Source of RfD Target Organ	Dates of RfD: Target Organ (YYYY)
Metals									
Aluminum	chronic	1.00E+00	mg/kg-day	1.00E-01	mg/kg-day	NA	NA	EPA-NCEA	2001
Antimony	chronic	4.00E-04	mg/kg-day	6.00E-05	mg/kg-day	blood	1000/1	EPA-IRIS	2001
Cadmium	chronic	5.00E-04	mg/kg-day	1.25E-05	mg/kg-day	kidney	10/1	EPA-IRIS	2001
Manganese	chronic	4.70E-02	mg/kg-day	2.82E-03	mg/kg-day	CNS	1/1	EPA-IRIS	2001
Nickel	chronic	2.00E-02	mg/kg-day	8.00E-04	mg/kg-day	Skin, decreased body and organ weights	300/1	EPA-IRIS	2001
Strontium	chronic	6.00E-01	mg/kg-day	1.20E-01	mg/kg-day	bone	300/1	EPA-IRIS	2001
Thallium	chronic	8.00E-05	mg/kg-day	8.00E-05	mg/kg-day	blood	3000/1	EPA-IRIS	2001
Non-Metallic Anion									
Perchlorate	NA	9.00E-04	mg/kg-day	9.00E-04	mg/kg-day	thyroid		EPA-NCEA	2001
Dioxin/Furan									
2,3,7,8-TCDD	–	NTV	–	NTV	NTV	skin	–	EPA-NCEA	2001
Semi-Volatile Organics									
bis(2-Ethylhexyl)phthalate	chronic	2.00E-02	mg/kg-day	3.80E-03	mg/kg-day	liver	1000/1	EPA-IRIS	2001
Volatile Organics									
cis-1,2-Dichloroethene	chronic	1.00E-02	mg/kg-day	1.00E-02		blood	3000/1	EPA-HEAST/ EPA-IRIS	1997/2001
Trichloroethene	NA	6.00E-03	mg/kg-day	6.00E-03		NA	NA	EPA-NCEA	2001
Vinyl Chloride	chronic	3.00E-03	mg/kg-day	3.00E-03		liver	30/1	EPA-IRIS	2001
Pathway: Inhalation									
Chemical of Concern	Chronic/ Subchronic	Inhalation RfC	Inhalation RfC Units	Inhalation RfD	Inhalation RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Source of RfC/RfD Target Organ	Dates (YYYY)
Metals									
Aluminum	NA	0.0035	mg/kg-day	–	–	NA		EPA-NCEA	2001
Antimony	chronic	0.0005	mg/kg-day	–	–	lung	300/1	EPA-IRIS	2001
Cadmium	chronic	0.0002	mg/kg-day	–	–	kidney		EPA-NCEA	2001
Manganese	chronic	0.00005	mg/kg-day	–	–	CNS	1000/1	EPA-IRIS	2001
Nickel	chronic	0.0002	mg/kg-day	–	–	lung	NA	ASTDR	1997
Strontium	NA	NTV	–	–	–		–	–	–
Thallium		0.0001	mg/kg-day	–	–	Increased liver enzymes SGOT, LDH	NA	EPA-IRIS	2001
Non-Metallic Anion									
Perchlorate	–	NTV	–	–	–	–	–	–	–
Dioxin/Furan									
2,3,7,8-TCDD	–	NTV	–	–	–	–	–	–	–
Semi-Volatile Organics									
bis(2-Ethylhexyl)phthalate	–	NTV	–	–	–	–	–	–	–
Volatile Organics									
cis-1,2-Dichloroethene	–	0.793	mg/kg-day	–	–	–	–	TNRCC	2001
Trichloroethene	–	NTV	–	–	–	–	–	–	–
Vinyl Chloride	chronic	0.1	mg/kg-day	–	–	liver	30/1	EPA-IRIS	2001

Table 2-8 (*continued*)
Non-Cancer Toxicity Data Summary

Key

—: No information available
CNS: Central nervous system
GIT: Gastrointestinal tract
IRIS: Integrated Risk Information System, EPA
mg/kg-day: milligrams per kilogram per day
NA: Information not available
NTV: No toxicity value available

References

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

EPA, 1998. Perchlorate Environmental Contamination Toxicological Review and Risk Characterization based on Emergency Information, Review Draft, Office of Research and Development. NCEA-1-0503, 31 December, 1998.

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

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

TNRCC, 2001. Update to 1998 Consistency Memorandum. Toxicity Factors Table, 15 March, 2001.

Summary of Toxicity Assessment

This table provides non-carcinogenic risk information relevant to the contaminants of concern in ground water. Three of the COCs have toxicity data indicating a higher potential for adverse non-carcinogenic health effects in humans. The chronic toxicity data available for cadmium, manganese and vinyl chloride for oral exposures, have been used to develop oral reference doses (RfDs). The oral RfDs for cadmium, manganese, and vinyl chloride are 5.0×10^{-4} mg/kg/day, 1.4×10^{-1} mg/kg/day, and 3.0×10^{-3} mg/kg/day, respectively (Source: EPA-IRIS, 2001). The available toxicity data, from both chronic and subchronic animal studies, indicate that cadmium primarily affects the kidney, while manganese primarily affects the central nervous system, and vinyl chloride primarily affects the liver. At this time, inhalation reference concentrations are not available for any of the COCs.

Table 2-9
Risk Characterization Summary - Carcinogens

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

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogen Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater		*Metals*				
		Ingestion Direct Contact	Aluminum	NTV	NE	NE (Kp<=0.01)	N/A
		Ingestion Direct Contact	Antimony	NTV	NE	NE (Kp<=0.01)	N/A
		Ingestion Direct Contact	Cadmium	NTV	NE	NE (Kp<=0.01)	N/A
		Ingestion Direct Contact	Manganese	NC	NE	NE (Kp<=0.01)	N/A
		Ingestion Direct Contact	Nickel	NTV	NE	NE (Kp<=0.01)	N/A
		Ingestion Direct Contact	Strontium	NTV	NE	NE (Kp<=0.01)	N/A
		Ingestion Direct Contact	Thallium	NC	NE	NE (Kp<=0.01)	N/A
			Non-Metallic Anion				
		Ingestion Direct Contact	Perchlorate	NTV	NE	NE (Kp<=0.01)	N/A
			Dioxin/Furan				
		Ingestion Direct Contact	2,3,7,8-TCDD	1.7E-06	NE	1.4E-05	1.6E-05
			Semi-Volatile Organics				
		Ingestion Direct Contact	bis(2-Ethylhexyl)phthalate	7.3E-07	NE	4.8E-07	1.2E-06
			Volatile Organics				
		Ingestion Direct Contact	cis-1,2-Dichloroethene	NC	NC	NE (Kp<=0.01)	N/A
		Ingestion Direct Contact	Trichloroethene	1.9E-05	N/A	2.5E-05	4.4E-05
		Ingestion Direct Contact	Vinyl Chloride	1.1E-05	N/A	NE (Kp<=0.01)	1.1E-05
	Air		*Metals*				
		Inhalation	Aluminum	N/A	NE	N/A	N/A
		Inhalation	Antimony	N/A	NE	N/A	N/A
		Inhalation	Cadmium	N/A	NE	N/A	N/A
		Inhalation	Manganese	N/A	NE	N/A	N/A
		Inhalation	Nickel	N/A	NE	N/A	N/A
		Inhalation	Strontium	N/A	NE	N/A	N/A
		Inhalation	Thallium	N/A	NE	N/A	N/A
			Non-Metallic Anion				
		Inhalation	Perchlorate	–	–	–	N/A
			Dioxin/Furan				
		Inhalation	2,3,7,8-TCDD	N/A	NE	N/A	N/A

Table 2-9 (*continued*)
Risk Characterization Summary - Carcinogens

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

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogen Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Air		*Semi-Volatile Organics*				
		Inhalation	bis(2-Ethylhexyl)phthalate	N/A	NE	N/A	N/A
	Air		*Volatile Organics*				
		Inhalation	cis-1,2-Dichloroethene	N/A	NC	N/A	N/A
		Inhalation	Trichloroethene	N/A	5.1E-05	N/A	5.1E-05
		Inhalation	Vinyl Chloride	N/A	1.1E-06	ND	1.1E-06
						Groundwater risk total=	1E-04
						Total risk=	1E-04

Key

N/A	Not applicable
NC	Not classified as a carcinogen
ND	Not detected in associated media or not selected as a chemical of potential concern
NE	Not evaluated through this exposure pathway. Chemical is not identified as a volatile
NE(Kp<=0.01)	Based on EPA 6 guidance, COPCs with a Kp<=0.01 were not evaluated for dermal contact while showering (EPA, 1995)
NTV	No toxicity value available to quantitatively address this exposure

References

EPA, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A)*, OSWER Directive 9285.7-01a, Office of Emergency and Remedial Response, Washington, DC, 1989)

EPA, *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300*, March 8, 1990.

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

Summary of Risk Characterization

Calculated cancer risks for potential exposure to chemicals of concern in groundwater at LHAAP-12 are 1E-04, rounded to 1 significant figure as specified in EPA guidance (EPA, 1989). The calculated cancer risk from all chemicals by all exposure pathways is at the upper value of the 1E-06 to 1E-04 acceptable range (EPA, 1990). The risk is predominantly associated with exposure to trichloroethene by the ingestion, dermal contact and inhalation pathways. Exposure to vinyl chloride, a trichloroethene degradation product, by the ingestion and inhalation pathways contributes additional risk. Lesser risks are associated with ingestion and dermal exposure to the semivolatile compounds 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and bis(2-ehylhexyl)phthalate.

Table 2-10
Risk Characterization Summary – Non-Carcinogens

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

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Tota
Groundwater	Groundwater		*Metals*					
		Ingestion/Dermal Direct Contact	Aluminum	N/A	2.2E-01	NE	NE (Kp<=0.01)	2.2E-01
		Ingestion/Dermal Direct Contact	Antimony	Blood	8.1E-01	NE	NE (Kp<=0.01)	8.1E-01
		Ingestion/Dermal Direct Contact	Cadmium	Kidney, Blood	1.2E-01	NE	NE (Kp<=0.01)	1.2E-01
		Ingestion/Dermal Direct Contact	Manganese	CNS	5.7E-01	NE	NE (Kp<=0.01)	5.7E-01
		Ingestion/Dermal Direct Contact	Nickel	GIT	7.8E-01	NE	NE (Kp<=0.01)	7.8E-01
		Ingestion/Dermal Direct Contact	Strontium	Bone	2.0E-01	NE	NE (Kp<=0.01)	2.0E-01
		Ingestion/Dermal Direct Contact	Thallium	Blood	2.0E-01	NE	NE (Kp<=0.01)	2.0E-01
			Non-Metallic Anion					
		Ingestion/Dermal Direct Contact	Perchlorate	Thyroid	6.1E-01	NE	NE (Kp<=0.01)	6.1E-01
			Dioxin/Furan					
		Ingestion/Dermal Direct Contact	2,3,7,8-TCDD	Skin	NTV	NTV	–	N/A
			Semi-Volatile Organics					
		Ingestion/Dermal Direct Contact	bis(2-Ethylhexyl)phthalate	Liver	7.3E-03	NE	4.8F-03	1.2E-02
			Volatile Organics					
		Ingestion/Dermal Direct Contact	cis-1,2-Dichloroethene	Blood	1.2E-01	N/A	NE (Kp<=0.01)	1.2E-01
		Ingestion/Dermal Direct Contact	Trichloroethene	N/A	8.1E-01	NTV	1.1E+00	1.9E+00
		Ingestion/Dermal Direct Contact	Vinyl Chloride	Liver	6.8E-03	N/A	NE (Kp<=0.01)	6.8E-03
	Air		*Metals*					
		Inhalation	Aluminum	N/A	N/A	NE	N/A	N/A
		Inhalation	Antimony	Blood	N/A	NE	N/A	N/A
		Inhalation	Cadmium	Kidney, Blood	N/A	NE	N/A	N/A
		Inhalation	Manganese	CNS	N/A	NE	N/A	N/A
		Inhalation	Nickel	GIT	N/A	NE	N/A	N/A
		Inhalation	Strontium	Bone	N/A	NE	N/A	N/A
		Inhalation	Thallium	Blood	N/A	NE	N/A	N/A
			Non-Metallic Anion					
		Inhalation	Perchlorate	N/A	N/A	NTV	N/A	N/A
			Dioxin/Furan					
		Inhalation	2,3,7,8-TCDD	N/A	N/A	NTV	N/A	N/A

Table 2-10 (*continued*)
Risk Characterization Summary – Non-Carcinogens

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

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Tota
Groundwater	Air		*Semi-Volatile Organics*					
		Inhalation	bis(2-Ethylhexyl)phthalate	Liver	N/A	NE	N/A	N/A
			Volatile Organics					
		Inhalation	cis-1,2-Dichloroethene	Blood	N/A	2.6E-02	N/A	2.6E-02
		Inhalation	Trichloroethene	N/A	N/A	–	N/A	N/A
		Inhalation	Vinyl Chloride	Liver	N/A	3.6E-03	N/A	3.6E-03
							Ground-Water Hazard Index Total=	5
							Receptor Hazard Index=	5
							Liver Hazard Index=	2E-02

Key

–:	Toxicity criteria are not available to quantitatively address this route of exposure
CNS	Central nervous system
GIT	Gastrointestinal track
N/A:	Information was not available
ND	Not detected in associated media or not selected as a chemical of potential concern
NE	Not evaluated through this exposure pathway
NE (Kp<=0.01)	Based on EPA 6 guidance, COPCs with a Kp<=0.01 were not evaluated for dermal contact while showering (EPA, 1995)
NTV	No toxicity value available to quantitatively address this exposure

References

EPA, *Risk Assessment Guidance for Superfund. Vol. I: Human Health Evaluation Manual, (Part A)*, OSWER Directive 9285.7-01a, Office of Emergency and Remedial Response, Washington, DC, 1989.

EPA, *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300, March 8, 1990*.

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

Summary of Risk Characterization

The calculated noncancer Hazard Index (HI) for potential exposure to chemicals of concern in groundwater at LHAAP-12 is 5, rounded to 1 significant figure as specified in EPA guidance, (EPA, 1989). The calculated HI for all chemicals by all exposure pathways is above the acceptable value of 1(EPA, 1990). The HI is predominantly associated with exposure to trichloroethene by the ingestion and dermal contact pathways. Metals and perchlorate ion contribute appreciably to the total HI such that the sum of all Hazard Quotient (HQ) values calculated for ingestion exposure is also greater than 1. Calculated HQ values for exposure to the organic compounds bis(2-ethylhexyl)phthalate, cis-1,2-dichloroethene, and vinyl chloride do not sum to 1. The HI value associated with chemicals having liver as the primary target organ is less than 1 (2E-02).

Table 2-11
Occurrence, Distribution, and Selection of Chemicals of Concern - Groundwater

Exposure Medium: Groundwater											
Chemical	Minimum Concentration [1] (ppm)	Maximum Concentration [1] (ppm)	Mean Concentration (ppm)	95% UCL of the Mean (ppm) [2]	Background Concentration (ppm)	Screening Toxicity MSC Value (ppm) [3]	Screening Toxicity Value Source	MCL (ppm)	Carcinogen Risk Value	HQ Value	COC Flag (Y or N)
Volatile Organic Compounds											
Cis-1,2-Dichloroethene	1.10E-01	1.10E-01	NA	NA	ND	7.0E-02	TCEQ	7.0E-02	--	1.20E-01	Y
Trichloroethene	1.00E-03	4.95E-01	NA	NA	ND	5.0E-03	TCEQ	5.0E-03	4.4E-05	1.9E+00	Y
Vinyl chloride	2.10E-03	2.10E-03	NA	NA	ND	2.0E-03	TCEQ	2.0E-03	1.1E-05	6.8E-03	Y
Semivolatile Organic Compounds											
Bis(2-ethylhexyl)phthalate	1.50E-02	1.50E-02	NA	NA	ND	6.0E-03	TCEQ	6.0E-03	1.2E-06	1.2E-02	Y
Metals											
Aluminum	9.10E-01	2.20E+01	NA	NA	1.99E+00	1.0E+02	TCEQ	ND	--	2.20E-01	N
Antimony	5.00E-03	3.30E-02	NA	NA	1.15E-02	6.0E-03	TCEQ	6.0E-03	--	8.10E-01	Y
Cadmium	1.20E-03	6.00E-03	NA	NA	2.29E-03	5.0E-03	TCEQ	5.0E-03	--	1.20E-01	Y
Manganese	6.50E-02	2.75E+00	NA	NA	5.57E+00	1.4E+01	TCEQ	ND	--	5.70E-01	N
Nickel	5.00E-02	1.60E+00	NA	NA	9.20E-02	2.0E+00	TCEQ	ND	--	7.80E-01	N
Strontium	1.40E-01	1.20E+01	NA	NA	7.33E+00	6.1E+01	TCEQ	ND	--	2.00E-01	N
Thallium	1.10E-03	1.10E-03	NA	NA	ND	2.0E-03	TCEQ	2.0E-03	--	2.00E-01	N
Dioxins and Furans											
2,3,7,8-TCDD TEQ	3.29E-09	3.29E-09	NA	NA	ND	3.0E-08	TCEQ	3.0E-08	1.6E-05	--	N
Anions											
Perchlorate	1.60E-03	5.60E-02	NA	NA	ND	7.2E-02	TCEQ	ND	--	6.10E-01	Y

Notes:
[1] Minimum/maximum detected concentration above the reporting limit.
[2] The 95% upper confidence limit (UCL) of mean concentration.
[3] TCEQ: Texas Commission on Environmental Quality (TCEQ) Texas Risk Reduction Rules (30TAC§335) as updated through April 2005 MSC values shown are for commercial/industrial land use.
HQ: Hazard quotient
MCL: Maximum Contaminant Level specified by the Safe Drinking Water Act and adopted by the TCEQ.
mg/L: milligrams per liter
MSC: Medium Specific Concentration (GW-Ind) for groundwater established by the TCEQ rules (30TAC§335).
NA: Not applicable. TCEQ guidance requires use of the maximum measured concentration in groundwater evaluations (30TAC§335).
ND: No data
TCDD tetrachloro-p-dibenzodioxin
2,3,7,8-TCDD TEQ Relative toxicities of all measured dibenzo-p-dioxin and dibenzofuran congeners expressed as equivalent to the 2,3,7,8-TCDD congener. TCEQ and USEPA guidance only specifies regulatory limits for the 2,3,7,8-TCDD congener.
Y = Yes, maximum concentration is greater than the background concentration and the MCL value.
N = No, the maximum concentration is less than the MCL value.

Table 2-12
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern – Soil

Exposure Medium: Soil (0-3 feet)										
Chemical	Minimum Concentration[1] (mg/kg)	Maximum Concentration[1] (mg/kg)	Mean Concentration (mg/kg)	95% UCL of the Mean[2] (mg/kg)	Background Concentration[3] (mg/kg)	Screening Benchmark Value (mg/kg)	Screening Benchmark Source[4]	HQ Value[5]	Bioaccumulative Flag[6] (Y or N)	COPEC[7] Flag (Y or N)
Arsenic	1.71	16.1	5.98E+00	NA	NA	3.70E+01	TCEQ	0.4	N	N
Barium	54.4	179.00	1.19E+02	NA	NA	3.30E+02	TCEQ	0.5	N	N
Chloride	2.7	2.9	1.37E+00	NA	NA	Nutrient	NA	NA	N	N
Chromium	9.67	24.2	1.35E+01	NA	3.86E+01	4.00E-01	TCEQ	60.5	Y	Y
Lead	6.43	21.1	1.22E+01	NA	2.76E+01	5.00E+01	TCEQ	0.4	Y	Y
Nickel	4.72	9.27	5.99E+00	NA	1.52E+01	3.00E+01	TCEQ	0.3	Y	Y
Silver	1.31	1.31	7.51E-01	NA	NA	2.00E+00	TCEQ	0.7	N	N
Sulfate	1.47	216.8	4.74E+01	NA	1.60E+02	NSV	NA	NA	N	Y
Perchlorate	0.0467	0.0467	1.39E-02	NA	-	NSV	NA	NA	N	Y
bis(2-Ethylhexyl)phthalate	1	3.35	1.20E+00	1.87E+00	-	9.25E-01	ESL	2.0	N	Y
Butyl benzyl phthalate	1.2	3	1.18E+00	1.62E+00	-	2.39E-01	ESL	6.8	N	Y
di-n-Butyl phthalate	1.6	4.7	1.55E+00	NA	-	2.00E+02	TCEQ	0.024	N	N
Methylene chloride	0.0099	0.0099	4.41E-03	NA	-	1.04E+01	ESL	0.001	N	N

Notes:

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

[2] The 95% upper confidence limit (UCL) calculated using bootstrapping with 5000 replications. The 95% UCL was not calculated for chemicals with a detection frequency less than 5%, or with 5 or fewer samples.

[3] Background concentrations are only provided for chemicals flagged as COPECs. Concentrations represent the higher of the upper tolerance limit and upper prediction limit background concentrations calculated for the chemical.

[4] TCEQ = Texas Natural Resource Conservation Commission (TNRCC), 2001, Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas, RG-263 (Revised). ESL = U.S. Environmental Protection Agency (EPA), 2003, U.S. EPA Region 5 RCRA Ecological Screening Levels (ESL), Website version last updated August 22, 2003: http://www.epa.gov/reg5rcra/ca/edql.htm.

[5] Hazard quotient (HQ) is defined as the Maximum Concentration divided by the Screening Benchmark Value.

[6] Per TNRCC, 2001.

[7] COPEC = Chemical of Potential Ecological Concern.

Y - If screening hazard quotient is greater than or equal to 1.0, chemical does not have a screening benchmark value, or chemical is bioaccumulative.

- Information not available.

mg/kg milligrams per kilogram

NA Not applicable

NSV No screening value

Y = Yes, N = No

Table 2-13
Description of Chemicals of Potential Ecological Concern Identified in Soil

Exposure Medium: Soil (0-3 feet)							
COPEC[1]	Detection Frequency	Maximum Concentration[2] (mg/kg)	95% UCL of the Mean[3] (mg/kg)	Background Concentration[4] (mg/kg)	HQ Value[5]	COEC[6] Flag (Y or N)	Justification for COEC Flag
Chromium	5/5	24.2	NA	3.86E+01	60.5	N	Maximum concentration below background concentration; chemical naturally occurring.
Lead	5/5	21.1	NA	2.76E+01	0.4	N	Maximum concentration below background concentration; chemical naturally occurring; HQ < 1.
Nickel	5/5	9.27	NA	1.52E+01	0.3	N	Maximum concentration below background concentration; chemical naturally occurring; HQ < 1.
Sulfate	4/5	216.8	NA	1.60E+02	NA	N	Ubiquitous compound in the environment; toxicity generally considered low; only one sample had concentration higher than background; not bioaccumulative constituent.
Perchlorate	¼	0.0467	NA	-	NA	N	Detection frequency low; low likelihood for regular exposure to organisms.
bis(2-Ethylhexyl)phthalate	3/7	3.35	1.87E+00	-	2.0	N	HQ value only marginally exceeds 1; low potential to bioaccumulate; common laboratory contaminant.
Butyl benzyl phthalate	3/7	3	1.62E+00	-	6.8	N	HQ value relatively low (i.e., < 10) ; low potential to bioaccumulate; common laboratory contaminant.

Notes:

[1] COPEC = Chemical of Ecological Concern. Chemical was selected as a COPEC during the screening level ecological risk evaluation (Shaw, 2004c) if screening hazard quotient is greater than or equal to 1.0, chemical does not have a screening benchmark value, or chemical is bioaccumulative (See Table 2-11).

[2] Maximum detected concentration above the reporting limit.

[3] The 95% upper confidence limit (UCL) calculated using bootstrapping with 5000 replications. The 95% UCL was not calculated for chemicals with a detection frequency less than 5%, or with 5 or fewer samples.

[4] Concentrations represent the higher of the upper tolerance limit and upper prediction limit background concentrations calculated for the chemical.

[5] Hazard quotient (HQ) is defined as the Maximum Concentration divided by the Screening Benchmark Value.

[6] COEC = Chemical of Ecological Concern.

• Information not available.

mg/kg milligrams per kilogram

NA Not applicable

N No

Table 2-14
Ecological Exposure Pathways of Concern

Exposure Medium	Sensitive Environment Flag (Y or N)	Receptor	Endangered/ Threatened Special Flag (Y or N)	Exposure Routes	Assessment Endpoints	Measurement Endpoints
Soil	N	Terrestrial Invertebrates	N	Ingestion and direct contact with chemicals in soil	Survival and growth of terrestrial invertebrate community	Ecological Screening Benchmarks (TCEQ and ESLs)
	N	Terrestrial Plants	N	Uptake of chemicals via root systems	Survival and growth of terrestrial plant community	Ecological Screening Benchmarks (TCEQ and ESLs)
	NA	Wildlife	N	Bioaccumulation in food items (soil to plant and soil to invertebrate)	Survival, growth, and reproduction of wildlife community	Ecological Screening Benchmarks (ESLs)

Notes:

ESL *U.S. Environmental Protection Agency (EPA), 2003, U.S. EPA Region 5 RCRA Ecological Screening Levels (ESL), Website version last updated August 22, 2003: http://www.epa.gov/reg5rcra/ca/edql.htm.*

N *No*

NA *Not applicable*

TCEQ *Texas Natural Resource Conservation Commission (TNRCC), 2001, Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas, RG-263 (Revised).*

Table 2-15
Comparative Analysis of Alternatives

Criteria	Alternative 1 No Further Action, Maintenance of Existing Landfill Cap, and Land Use Controls for Protection of the Existing Landfill Cap	Alternative 2 Land Use Controls for Groundwater Use Restriction and Maintenance of the Existing Landfill Cap, Land Use Controls for Protection of the Existing Landfill Cap and Monitored Natural Attenuation	Alternative 3 Groundwater Extraction to Achieve MCLs at and beyond the Waste Unit Boundary, Land Use Controls for Groundwater Use Restriction and Maintenance of the Existing Landfill Cap and Land Use Controls for Protection of the Existing Landfill Cap	Alternative 4 Landfill Removal, Off-Site Disposal, In-Situ Bioremediation and Monitored Natural Attenuation to Achieve MCLs throughout the Site, Land Use Controls (Short Term)
Overall protection of human health and the environment	Protection of human health and environment provided by maintenance of landfill cap and associated land use controls. No additional protection from exposure to groundwater. Does not demonstrate protection of surface water bodies from potential groundwater impacts. Does not achieve RAO goal for groundwater.	Achieves RAOs. Protection of human health and environment provided by maintenance of landfill cap and land use controls. Protection of surface water provided by compliance with developed groundwater contaminant MSCs. MSC calculations have been completed. Maximum observed TCE and perchlorate concentrations at the site do not exceed these MSCs.	Achieves RAOs. Protection of human health and environment provided by maintenance of landfill cap, land use controls, and restoration of groundwater at and beyond landfill boundary to MCLs and perchlorate IAL. Protection of surface water provided by groundwater restoration.	Achieves RAOs. Protection of human health and environment provided by complete landfill waste removal and restoration of all groundwater to the MCLs/perchlorate IAL. No long-term reliance on land use controls.
Compliance with ARARs	No compliance with chemical-specific ARARs in groundwater. Complies with location- and action-specific ARARs.	Does not comply with chemical-specific ARARs in groundwater. Complies with location- and action-specific ARARs.	Complies with all ARARs, except for chemical-specific ARARs in groundwater beneath landfill.	Complies with all ARARs.
Long-term effectiveness and permanence	Landfill Cap and associated land use controls would be effective and reliable so long as they are maintained indefinitely. Not effective for groundwater.	Landfill cap and land use controls would be effective and reliable so long as they are maintained until natural attenuation processes reduce TCE to the MCL.	Landfill cap and land use controls would be effective and reliable so long as they are maintained indefinitely. Somewhat less reliant on long-term land use controls, but uncertainty exists whether groundwater extraction would sufficiently lower contaminant concentrations to remediation levels.	Should be effective and permanent; however, considerable uncertainty exists concerning the effectiveness of in-situ biological treatment and natural attenuation for reducing groundwater contaminant concentrations to remediation levels. Extensive treatability testing and evaluations would be required to further assess the effectiveness of these treatment methods.
Reduction of toxicity, mobility, or volume through treatment	No active reduction.	No active reduction would be accomplished.	Extraction and treatment of contaminated groundwater beyond the waste boundary reduces volume of groundwater contaminants in this area.	Provides permanent and irreversible reduction only if the results of biological treatability testing and further evaluations of MNA prove favorable.

Table 2-15 (*continued*)
Comparative Analysis of Alternatives

Criteria	Alternative 1 No Further Action, Maintenance of Existing Landfill Cap, and Land Use Controls for Protection of the Existing Landfill Cap	Alternative 2 Land Use Controls for Groundwater Use Restriction and Maintenance of the Existing Landfill Cap, Land Use Controls for Protection of the Existing Landfill Cap and Monitored Natural Attenuation	Alternative 3 Groundwater Extraction to Achieve MCLs at and beyond the Waste Unit Boundary, Land Use Controls for Groundwater Use Restriction and Maintenance of the Existing Landfill Cap and Land Use Controls for Protection of the Existing Landfill Cap	Alternative 4 Landfill Removal, Off-Site Disposal, In-Situ Bioremediation and Monitored Natural Attenuation to Achieve MCLs throughout the Site, Land Use Controls (Short Term)
Short-term effectiveness	Minimal impact to the community, workers, or the environment from short-term activities.	Minimal impacts to the community, workers or the environment from short-term activities. Provides almost immediate protection.	Minimal impacts to the community, workers or the environment from short-term activities.	Significant short-term impacts to community from waste transportation and risks to workers from excavation and extensive waste handling. Extensive engineering controls would be required to control impacts to the environment during remedial activities (e.g. contaminant runoff during excavation).
Implementability	Readily implemented.	Readily implemented.	Implementable, but uncertainty exists whether groundwater extraction would sufficiently lower contaminant concentrations to remediation levels. Further studies would be required.	Very difficult to implement. Considerable coordination required for excavation, waste transportation, and disposal activities. Significant studies required for groundwater treatment component.
Cost*				
• Capital	$0	$15,000	$285,000	$34,400,000
• O&M	$109,000	$479,000	$2,350,000	$1,630,000
• Present worth	$47,000	$255,000	$1,350,000	$35,400,000

Notes and Abbreviations:

**Costs have been rounded off to three significant figures.*

ARAR applicable or relevant and appropriate requirement
FS feasibility study
IAL interim action level
LHAAP Longhorn Army Ammunition Plant
MCL maximum contaminant level
MNA monitored natural attenuation
MSC medium specific concentration
NA not applicable
O&M operation and maintenance
RAO remedial action objective
TCE trichloroethylene
VOC volatile organic compound

Table 2-16
Remediation Cost Table
Alternative 2

WBS	Summary Description	Costs
Capital Costs		
1.20.10	Regulatory Documents	
1.20.20	Remedial Design	
1.20.20.10	Remedial Design Documents	
1.20.20.20	Treatability Studies	
	Subtotal Indirect Costs	
1.20.30	Remedial Action	
1.20.30.10	General Contractor Construction Management	
1.20.30.20	Remediation	
1.20.30.20.10	Landfill Remediation Cost	
1.20.30.20.10.10	Deed Restriction / Admin. Controls	$15,000
1.20.30.20.10.20	Conventional Excavation / Soil Cover	
1.20.30.20.20	Groundwater Remediation Cost	
1.20.30.20.20.10	Extraction Well Installation	
1.20.30.20.20.20	In-situ Bioremediation	
	Subtotal Direct Costs	$15,000
	Subtotal Capital Cost	**$15,000**
Operations and Maintenance		
1.20.40	O&M	
1.20.40.10	Landfill O&M Cost	
1.20.40.10.10	Maintain Existing Cap	$109,495
1.20.40.20	Groundwater Treatment O&M Cost	
1.20.40.20.10	Long Term Monitoring	$369,493
1.20.40.20.20	Extraction Well O&M	
1.20.40.20.30	Bioremediation O & M	
	Subtotal O&M Cost	**$478,988**
Total Cost		**$493,988**
Present Value for Capital		$15,000
Present Value for O&M		$239,889
Present Value Total		$254,889

Note: WBS is work breakdown structure

Figure 2-1
Location of Longhorn Army Ammunition Plant

Figure 2-2
Site Location Map, LHAAP-12

Figure 2-3
Sampling Locations, TCE Plume, and Land Use Control Boundaries, LHAAP-12

Figure 2-4
Landfill Cap, LHAAP-12

Figure 2-5
Groundwater Potentiometric Surface in the Shallow Permeable Zone (Based on August 25, 2003 Water Level Measurements)

Figure 2-6
Conceptual Site Model LHAAP-12 – Source Area

Figure 2-7
Conceptual Site Model LHAAP-12 – Non-Source Area

00041275

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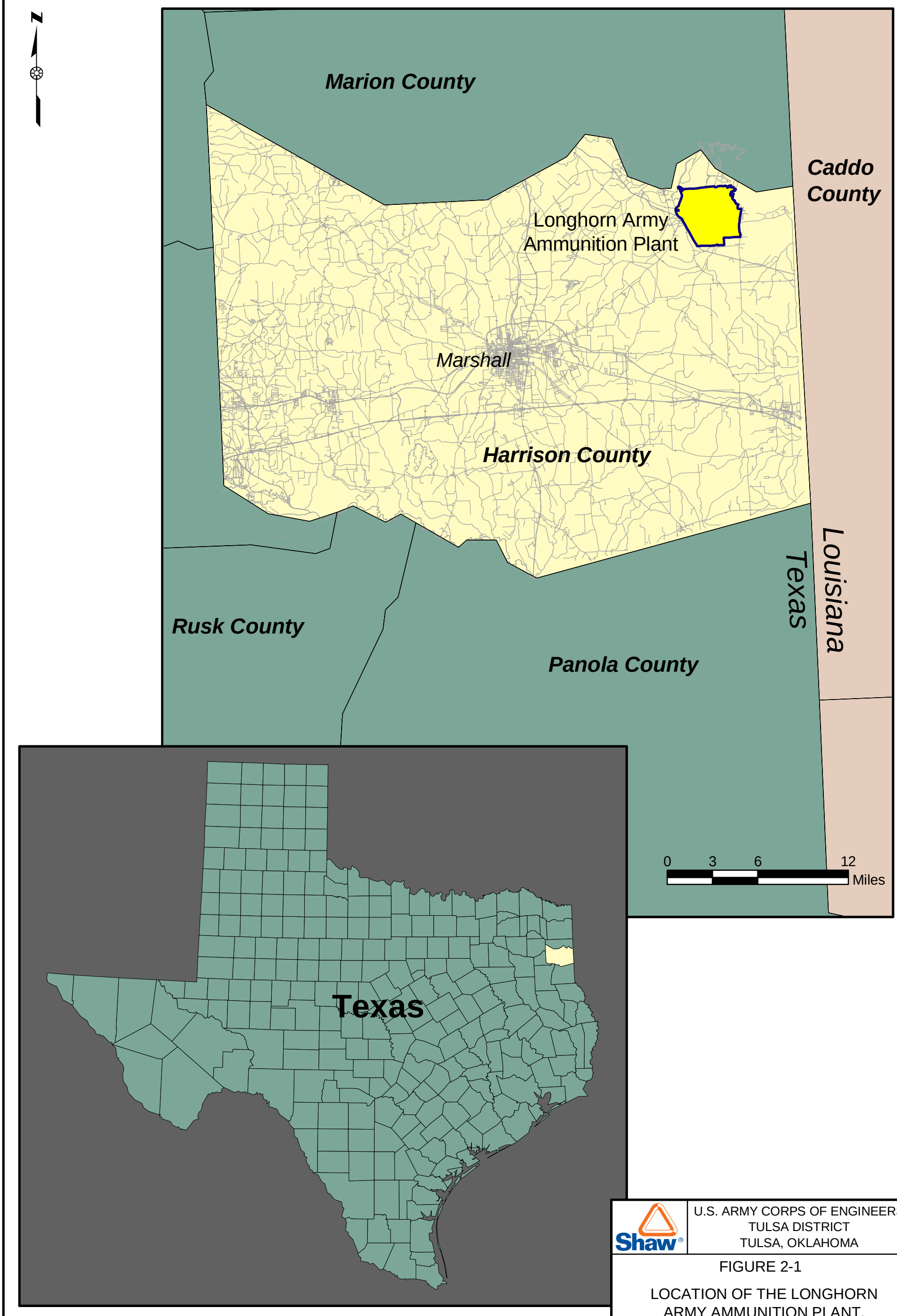

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FIGURE 2-1

LOCATION OF THE LONGHORN ARMY AMMUNITION PLANT, HARRISON COUNTY, TEXAS

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

00041276

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
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PLOT DATE: 8/9/04
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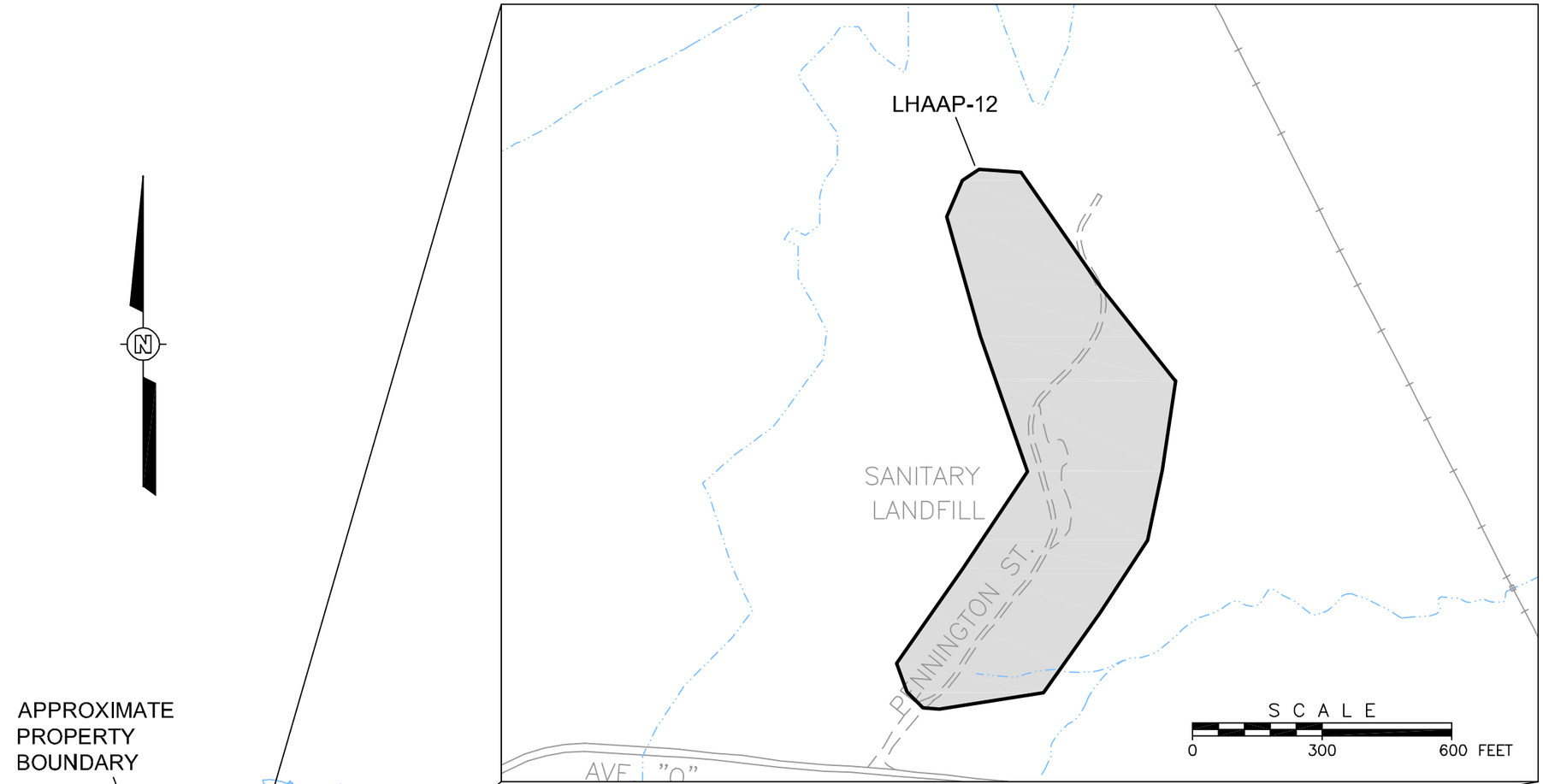
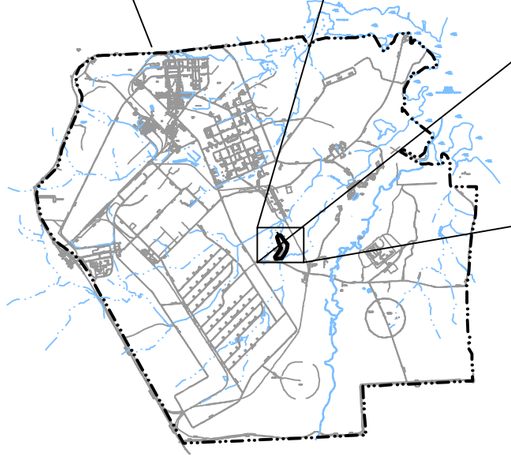




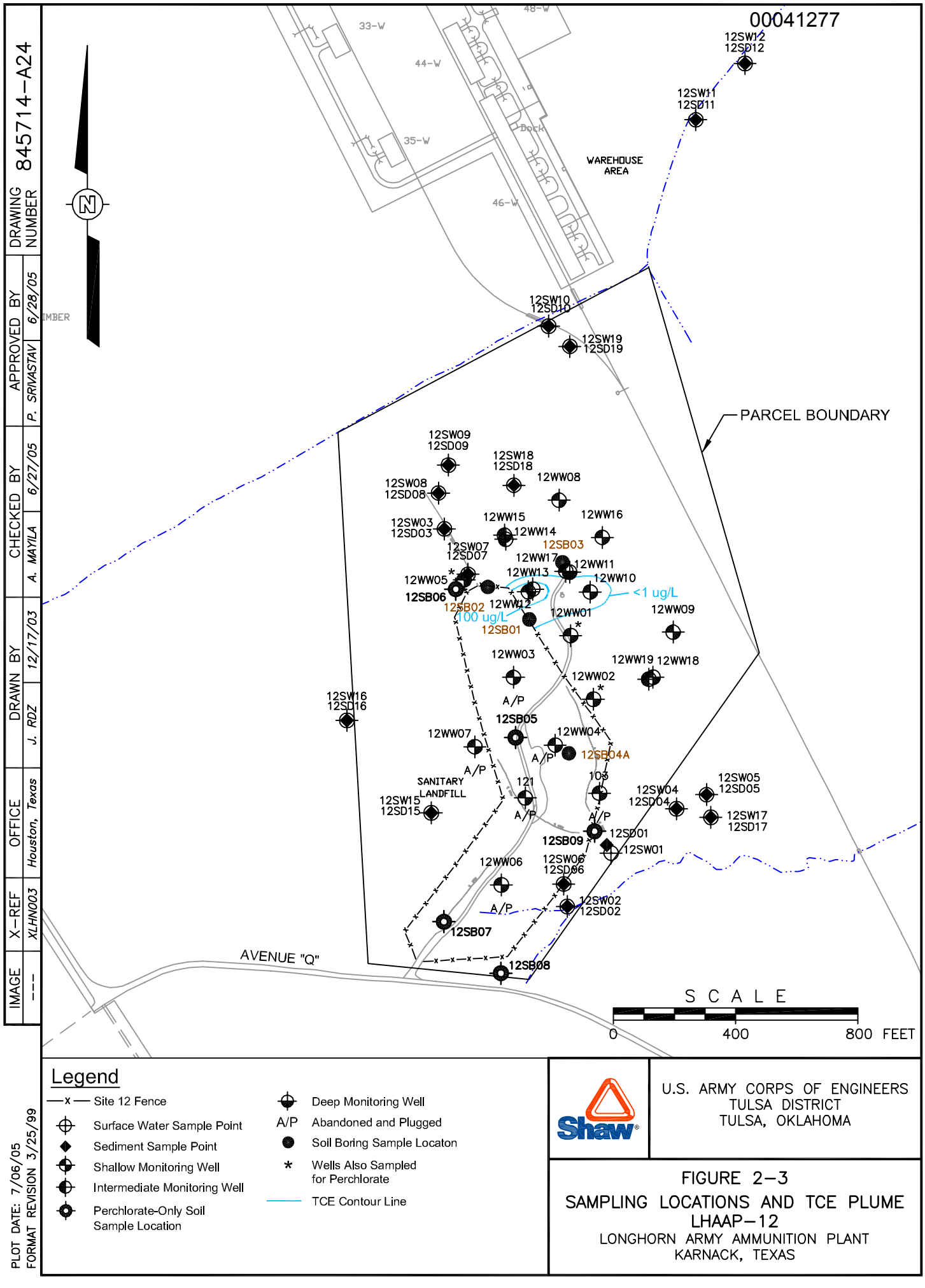
LEGEND:

- CREEK/BAYOU
- PAVED ROADS
- UNIMPROVED ROAD

FIGURE 2-2

SITE LOCATION MAP
LHAAP-12

LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS


00041277
12SW12
12SD12
12SW11
12SD11
WAREHOUSE AREA
12SW10
12SD10
12SW19
12SD19
PARCEL BOUNDARY
12SW09
12SD09
12SW18
12SD18
12WW08
12SW08
12SD08
12WW15
12WW16
12SW03
12SD03
12WW14
12SB03
12SW07
12SD07
12WW17
12WW11
12WW13
12WW10
12WW05
12SB06
12SB02
12WW12
<1 ug/L
100 ug/L
12WW01
12WW09
12SB01
12WW03
12WW19
12WW18
12WW02
12SW16
12SD16
A/P
12SB05
12WW07
12WW04
12SB04A
A/P
A/P
SANITARY LANDFILL
121
103
12SW15
12SD15
12SW05
12SD05
12SW04
12SD04
12SW17
12SD17
12SD01
12SB09
12SW01
12WW06
12SW06
12SD06
12SW02
12SD02
A/P
12SB07
12SB08
AVENUE "Q"
33-W
44-W
46-W
48-W
35-W
Dock
SCALE
0
400
800 FEET
Legend
Site 12 Fence
Surface Water Sample Point
Sediment Sample Point
Shallow Monitoring Well
Intermediate Monitoring Well
Perchlorate-Only Soil Sample Location
Deep Monitoring Well
A/P Abandoned and Plugged
Soil Boring Sample Locaton
* Wells Also Sampled for Perchlorate
TCE Contour Line
Shaw
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TULSA DISTRICT
TULSA, OKLAHOMA
FIGURE 2-3
SAMPLING LOCATIONS AND TCE PLUME
LHAAP-12
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS
IMAGE ---
X-REF XLHN003
OFFICE Houston, Texas
DRAWN BY J. ROZ 12/17/03
CHECKED BY A. MAYILA 6/27/05
APPROVED BY P. SRIVASTAV 6/28/05
DRAWING NUMBER 845714-A24
PLOT DATE: 7/06/05
FORMAT REVISION 3/25/99

00041278

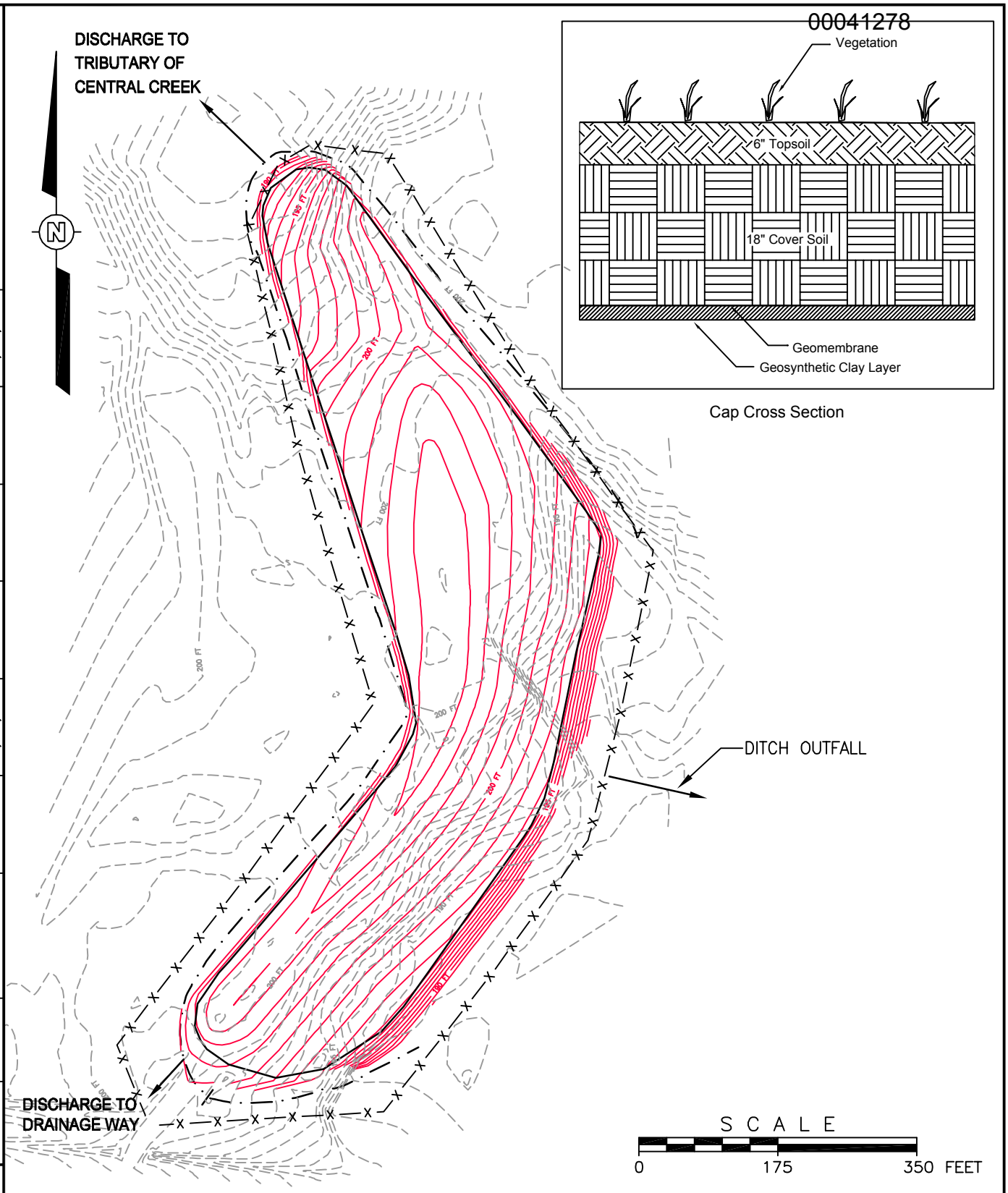

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
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PLOT DATE: 12/22/04
FORMAT REVISION 3/25/99

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FIGURE 2-4
SITE MAP
LHAAP-12
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

Plot Date: 01/07/00
Revision Format: 10/08/04

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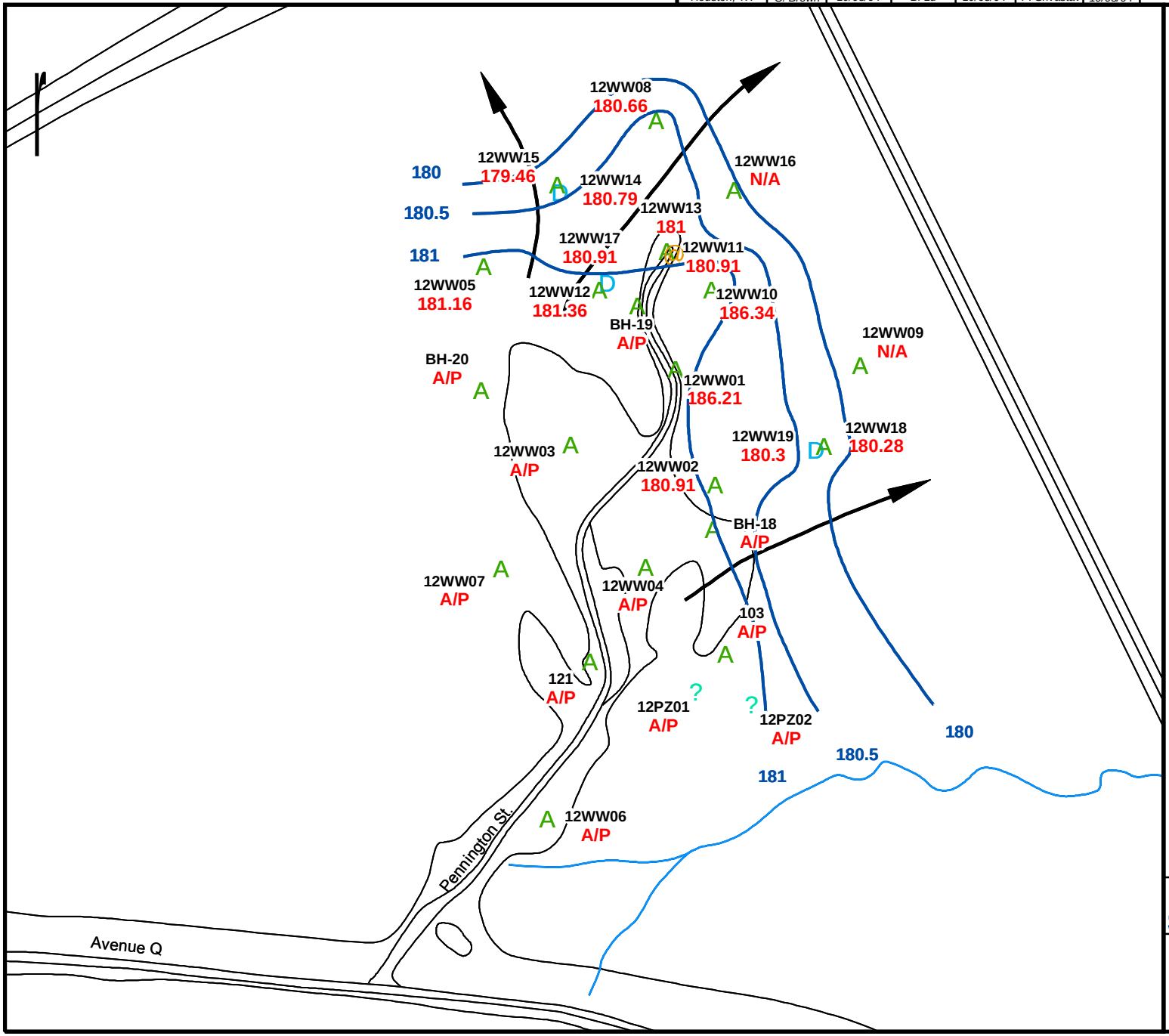

Legend

- A — Shallow Monitoring Well
- D — Intermediate Monitoring Well
- @ — Deep Monitoring Well
- ? — Piezometer
- A/P — Abandoned and Plugged
- Stream
- Flow Direction
- Groundwater Level Above Mean Sea Level
- AMSL (feet)

Reference:
Group 2 Remedial Investigation (Figure 11-2)
Longhorn Ammunition Plant Karnak, Texas
(Jacobs Engineering)

0 50 100 200 Feet

Shaw®

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TULSA DISTRICT
TULSA, OKLAHOMA

FIGURE 2-5
GROUNDWATER POTENTIOMETRIC SURFACE IN THE SHALLOW PERMEABLE ZONE (BASED ON AUGUST 25,2003 WATER LEVEL MEASUREMENTS)
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

PLOT DATE: 7/05/05
FORMAT REVISION 5/13/02

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
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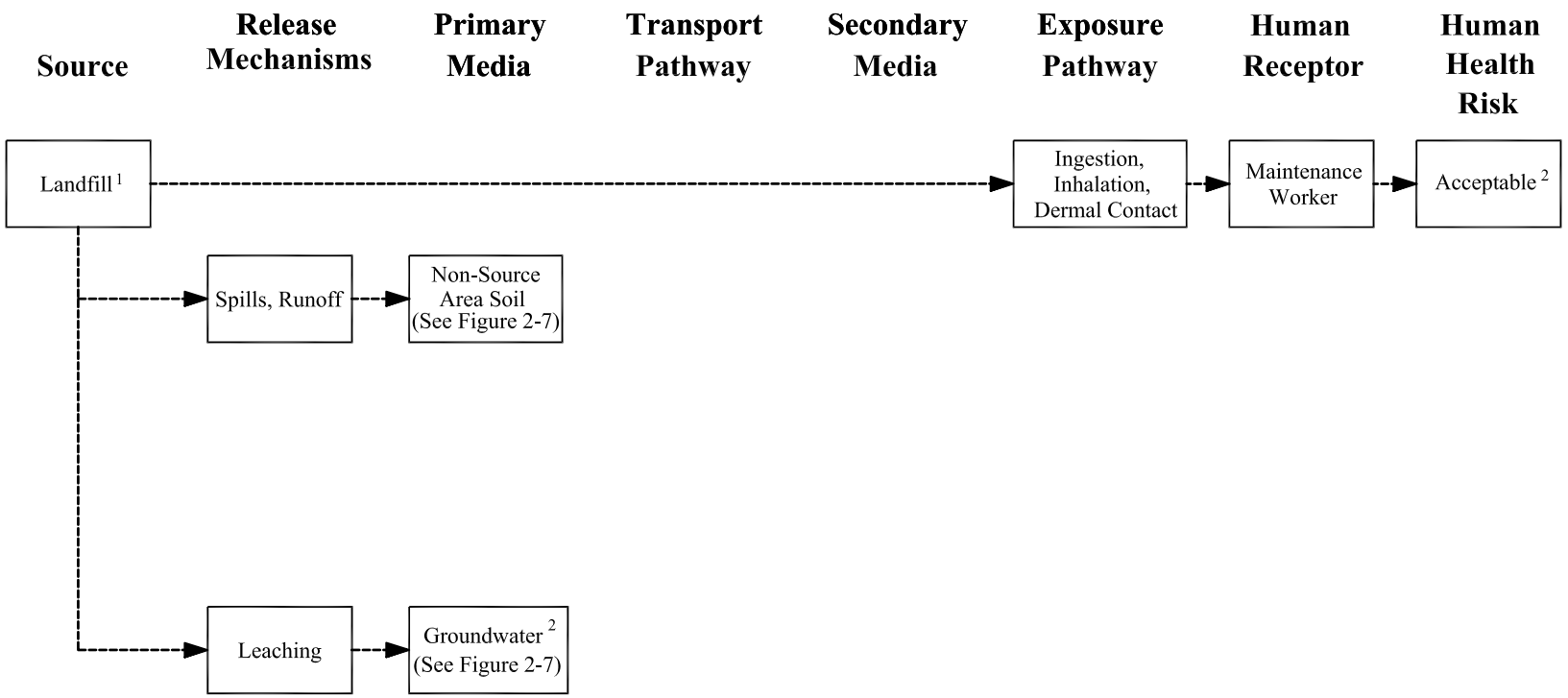

Pathway cut off by cap

Notes:

1. The Site 12 Landfill cap was completed as part of an Interim Remedial Measure in 1998.

2. Landfill cap cuts off direct exposure pathways and hydraulically isolates source area from groundwater.

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TULSA, OKLAHOMA

FIGURE 2-6
CONCEPTUAL SITE MODEL LHAAP-12
SOURCE AREA
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

PLOT DATE: 7/05/05
FORMAT REVISION 5/13/02

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
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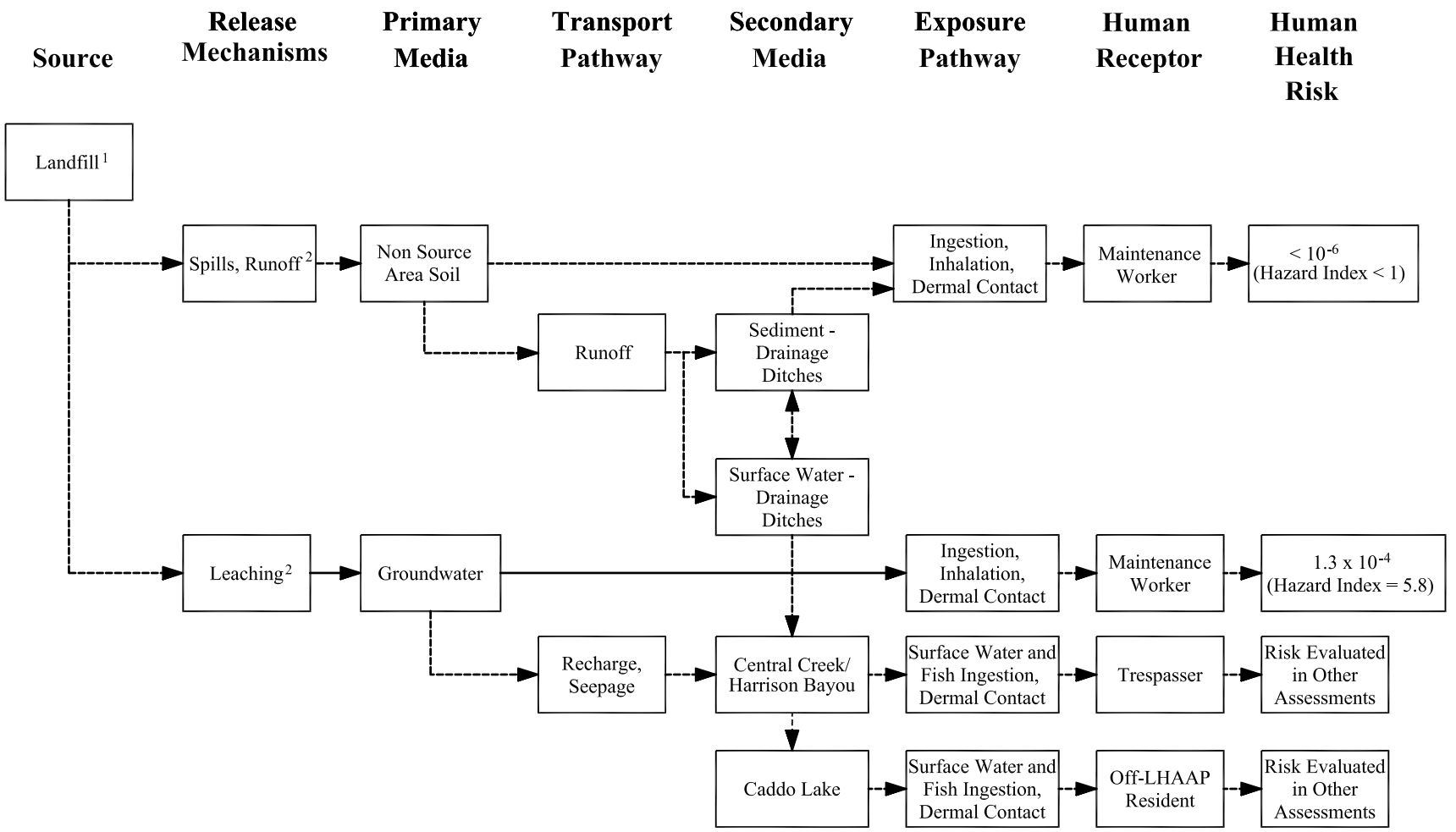

Pathway considered for remediation

Pathway not considered for remediation 3

Notes:

1. The Site 12 Landfill cap was completed as part of an Interim Remedial Measure in 1998.
2. Prior to Interim Remedial Measure in 1998
3. Risks are within acceptable range or are evaluated in separate assessments of Central Creek, Harrison Bayou, or Caddo Lake.

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TULSA, OKLAHOMA

FIGURE 2-7
CONCEPTUAL SITE MODEL LHAAP-12
NON-SOURCE AREA
LONGHORN ARMY AMMUNITION PLANT
KARNACK, TEXAS

3.0 Responsiveness Summary

The Responsiveness Summary serves three purposes. First, it provides the U .S. Army, USEPA, and TCEQ with information about community concerns with LHAAP-12's preferred alternative presented in the Proposed Plan. Second, it shows how the public's comments were factored into the decision-making process for selection of the final remedy. Third, it provides a formal mechanism for the U.S. Army to respond to public comments.

This Community Responsiveness Summary provides written responses to comments submitted regarding the Proposed Plan of Action for the final remedy for Landfill 12 (LHAAP-12) at Longhorn Army Ammunition Plant, Karnack, Texas. The summary is presented in two sections:

- Background of Community Involvement
- Summary and Responses to Comments Received

BACKGROUND OF COMMUNITY INVOLVEMENT

Community interest in LHAAP-12 dates back to 1995 when the community participated in a public meeting held to discuss the interim remedial action at LHAAP-12. The community raised some concerns and made both oral and written comments on the proposed interim remedial action as well as past and future exposure to site contaminants. The concerns and comments expressed during the interim remedial planning activities and the U.S Army responses for LHAAP-12 were summarized and included in the Record of Decision for Early Interim Remedial Action at LHAAP-12 and 16 Landfills (U.S Army, September 1995). In addition, local officials and community members in the technical review committee have held quarterly meetings at LHAAP since 1992. Beginning December 2004, the technical reviews have been conducted by the Restoration Advisory Board.

SUMMARY OF COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND U.S. ARMY RESPONSES

On March 20, 2005, the U.S. Army published a public notice announcing the public comment period in the Shreveport Times and Marshall News Messenger. The Proposed Plan of the final remedy for LHAAP-12 was released to the general public on March 23, 2005 and the public comment period was held from March 25 to April 25, 2005. A public meeting was held on March 29, 2005 at the Karnack Community Center in Karnack, Texas. The purpose of the meeting was to discuss the proposed plan and solicit public comments on the preferred final remedy for LHAAP-12. Representatives of the U.S. Environmental Protection Agency (USEPA), Texas Commission on Environmental Quality, and local community attended the meeting.

During the public comment period, one comment was received from the USEPA. There were no comments received from the general public. Following is the USEPA comment and the U. S. Army's response:

Comment 1:
The Proposed Plan identified Alternative 2 as the preferred alternative. Alternative 2 includes maintenance of the existing landfill cap, alternate concentration limit (ACL) development, and land use controls. In regards to ACL development, the use of ACLs is intended to provide flexibility in establishing ground water cleanup criteria under certain circumstances. Section 121(d)(2)(B)(ii) of the Comprehensive Environmental Response, Compensation, and Liability Act states the following:

> *"(ii) For the purpose of this section, a process for establishing alternate concentration limits to those otherwise applicable for hazardous constituents in groundwater under subparagraph (A) may not be used to establish applicable standards under this paragraph if the process assumes a point of human exposure beyond the boundary of the facility, as defined at the conclusion of the remedial investigation and feasibility study, except where–*
>
> (I) there are known and projected points of entry of such groundwater into surface water; and
> (II) on the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream; and
> (III) the remedial action includes enforceable measures that will preclude human exposure to contaminated groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface water, then the assumed point of human exposure may be at such known and projected points of entry."

In regards to Site 12 (as discussed in the Final Propose Plan for Landfill 12), the contaminated groundwater has migrated approximately 250 feet east of the northeast corner of the landfill cap. The nearest significant surface water body to Site 12 is Central Creek which is located approximately 500 feet northwest of the site. There are no known points of entry of contaminated groundwater into the surface water (i.e., situation does not meet the first ACL condition [I]). Thus, ACLs cannot be used. This being the case, the USEPA is unable to support the selection of Alternative 2 for Site 12. As we have discussed, I look forward to working with you in developing an alternative remedy for Site 12 which the USEPA can support.

Response:
The primary contaminant of concern at LHAAP-12 is trichloroethene (TCE). This chemical exceeded its maximum contaminant level (MCL) in groundwater.

In response to the USEPA's concern about the use of ACLs at this site, the term ACL has been replaced with medium-specific concentration (MSC), defined as a modeled concentration in the groundwater that will be protective of the surface water should the groundwater discharge to a surface water body. The title of the preferred remedy for LHAAP-12 is redefined as (Alternative 2), "Land Use Controls for Groundwater Use Restriction and Maintenance of the

Existing Landfill Cap, Land Use Controls for Protection of the Existing Landfill Cap, and Monitored Natural Attenuation." One component of the remedy is groundwater monitoring of two new groundwater compliance wells to monitor the migration of the groundwater contamination and to ensure that the target contaminants do not discharge to nearby surface water bodies at such levels that applicable or relevant and appropriate requirements are exceeded. In order to address USEPA's concerns, the following monitoring activities will be added to the monitoring program, which is part of Alternative 2:

- The U.S. Army will conduct sampling of the on-site monitoring wells where TCE has been detected. On-site wells will be sampled for TCE at a frequency to be specified in the land use control remedial design document.
- The monitoring program will also involve sampling of two compliance wells to monitor the migration of the groundwater contamination and to ensure that the target contaminants do not discharge to nearby surface water bodies at such levels that applicable or relevant and appropriate requirements are exceeded. These wells will also be sampled for TCE at a frequency to be specified in the land use control remedial design document.
- Perchlorate will not be included in the monitoring program because its concentrations were below the TCEQ MSC and it has not been detected in the past three sampling rounds by USACE (February 2003, February 2004, and December 2004).

ADDITIONAL COMMENTS

Additional comments were received from the USEPA and TCEQ during the review of the Draft Final ROD document. In response to those comments the U. S. Army added the evaluation of MNA as part of the selected remedy. MNA remedy relies on natural biological, chemical, and physical processes that act to reduce the mass and concentration of groundwater COCs under favorable conditions. These natural attenuation processes include biodegradation, dispersion, dilution, adsorption, volatilization, and abiotic destruction of contaminants. Due to the potential for TCE-contaminated groundwater to migrate, MNA will be implemented to assure that the plume will not migrate to nearby surface water at levels that may present an unacceptable risk to human health and the environment. The monitoring and reporting associated with this remedy will continue until ARARs are achieved. Based on groundwater modeling, groundwater ARARs are expected to be met through natural attenuation in 23 to 261 years.

The Response to Comments to the Draft Final ROD is also included in **Appendix A**.

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U.S. Army and USEPA, 1995, *Record of Decision for Early Interim Remedial Action at the LHAAP 12 and 16 Landfills, Longhorn Army Ammunition Plant, Karnack, Texas*, September.

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

U.S. Environmental Protection Agency (USEPA), 1989, *Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, (Part A),* OSWER Directive 9285.7-01a, Office of Emergency and Remedial Response, Washington, DC.

USEPA, 1990, *National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, 40 CFR Part 300,* March.

USEPA, 1993, *Presumptive Remedy for CERCLA Municipal Landfill Sites, EPA/540/F-93/035.*

USEPA, 1996, *Application of CERCLA Presumptive Remedy to Military Landfill Sites, EPA/540F-96/020.*

USEPA, 2003, Region 6, *Human Health, Medium-Specific Screening Levels, Dallas, Texas*, November.

USEPA, 2004, Region 9 *Preliminary Remediation Goals (PRG) Table, San Francisco, California*, October.

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

Glossary of Terms

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

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

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

Background Levels – Naturally-occurring concentrations of inorganic elements (metals) that are present in the environment and have not been altered by human activity.

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

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

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

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

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

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

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

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

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

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

Perchlorate – Ammonium perchlorate is a strong oxidizing compound that was used in various industries (solid rocket and jet propellant, medical field, and other processes).

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

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

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

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

Screening-Level Ecological Risk Assessment – The initial phase of a baseline ecological risk assessment in which conservative concentrations of site chemicals are quantitatively compared to chemical- and media-specific generic effect levels. Those chemicals selected as chemicals of potential ecological concern are further refined through quantitative comparison to chemical- and species-specific effect doses, as well as qualitative examination. Those chemicals identified as chemicals of concern may be investigated further, remediated, or left in place per the decision of the risk managers.

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

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

Surface Media – The soil (surface or subsurface), surface water, and sediment present at a site as applicable. The source material in the surface media may be contributing to groundwater contamination.

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

Trichloroethene (TCE) – TCE is a colorless or blue liquid with an odor similar to ether. It is man made and does not occur naturally in the environment. TCE was once commonly used to remove oils and grease from metal parts and is used in the dry cleaning industry.

Appendix A
Response to Comments on Draft Final Record of Decision, LHAAP-12, Landfill 12

RESPONSE TO COMMENTS ON
DRAFT FINAL RECORD OF DECISION (NOVEMBER 2005)
LHAAP-12, LANDFILL 12,
LONGHORN ARMY AMMUNITION PLANT, KARNACK, TEXAS

MARCH 2006

Reviewers: Chris G. Villarreal, USEPA Region 6 and Alan Etheredge (TCEQ)
Respondents: Agnes Mayila and Praveen Srivastav, Shaw Environmental, Inc.

1. Respondent Concurs (C), Does Not Concur (D), Take Exception (E), or Delete (X).
2. Commenter Agrees (A) with response, or Does Not Agree (D) with response.

Comment #	Page	Section/ Paragraph	Comment	C, D[1], E or X	Response	A or D[2]
Comments from Chris Villarreal (EPA)						
1	Pg 1-2	Section 1.5 Statutory Determinations	Text states, "*The final selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, and is cost effective."* In other sections of the document (e.g., Section 2.10.2 – Compliance with ARARs; Section 2.13 – Statutory Determinations), it is clear that the chemical-specific ARAR (i.e., MCL for TCE) is not satisfied. The relevant and appropriate TCE MCL must be complied with or waived under one of the six types of ARAR waivers provided in the NCP. As such, this section should specify, if supported by the administrative record, that the TCE MCL will be met through monitored natural attenuation in a specified number of years. The monitored natural attenuation remedy should be supported by modeling or other reasonable technical information. The modeling or other reasonable technical information should also show that the TCE contamination will not result in the contamination of nearby surface waters. Text states, "*The selected remedy would not reduce the*	C	The ROD will be revised to include monitored natural attenuation as part of the selected remedy (Alternative 2). As per discussions with the EPA and TCEQ the following actions will be implemented : • The change in the selected remedy to include MNA will be included in the Responsiveness Summary • There will be no modifications to the Proposed Plan document for LHAAP-12 • Another public meeting is not required for LHAAP-12, however a notification will be posted in the local Newspapers and the RAB will be informed of the change in the selected remedy • Results of the recent modeling to estimate the time for TCE to attenuate to the MCL will be added to the Administrative Record. The ROD text will be revised to include the results of the recent modeling which indicated that TCE will	

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			toxicity, mobility, or volume of contaminants in the landfill or groundwater through an active remedial process. However, there is no known principal threat material in the landfill or groundwater and, therefore, the statutory preference for treatment is not applicable." 40 CFR § 300.430 (e)(2)(iii)(D) [Reduction of toxicity, mobility, or volume through treatment] defines this evaluation criteria as follows: "*The degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site…"* The "*statutory preference for treatment is not applicable" language needs to be removed.* Revise text as follows: The selected remedy would not reduce the toxicity, mobility, or volume of contaminants in the landfill or groundwater through an active remedial process. However, there is no known principal threat material in the landfill or groundwater. Although the selected remedy does not address the statutory preference for treatment to the maximum extent practicable, the selected remedy offers a similar level of protection to human health and the environment, at a lower cost than those remedy alternatives which satisfy the preference for treatment. Similar language [see page 2-25 (sic) (Preference for Treatment as a Principal Element)] concerning the "*statutory preference for treatment is not applicable"* should also be removed and replaced with the suggested		naturally attenuate to the MCL of 5 µg/L in the time period ranging from 23 to 261 years depending on the assumed rate of degradation. Previous modeling results (Shaw 2005, Draft Final Derivation of Soil and Groundwater Concentrations Protective Of Surface Water and Sediment, Longhorn Army ammunition Plant) indicated that the current maximum concentrations at the source are lower than the medium specific concentrations (MSCs) protective of surface water for the COCs. The text on pages 1-2, 2-30, and 2-38 will be revised to reflect the comment.	

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			language above. Text states, "*This remedy will result in potential contaminants remaining in the ground water with concentrations higher than those allowed for unrestricted use and unrestricted exposure."* Revise text as follows: This remedy will result in contaminants remaining in the ground water with concentrations higher than those allowed for unrestricted use and unrestricted exposure.		The text on page 1-3 will be revised to reflect the comment.	
2	Pg 1-4	Authorizing Signatures	Please use the following signature block for the EPA Superfund Division Director _____ _____ Samuel Coleman, P.E. Date Director Superfund Division U.S. Environmental Protection Agency Region 6	C	The signature block provided by the EPA will be used as the authorizing signature.	
3	Pg 2-4	Section 2.2.3 History of CERCLA Enforcement Activities	Text states, "*Due to release of chemicals from operation and maintenance activities at the facility, LHAAP was placed on the Superfund National Priorities List …"* The text should be revised as follows: "*Due to the release of hazardous substances, pollutants*	C	The text will be revised to reflect the comment.	

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			and contaminants from operation and maintenance activities at the facility, LHAAP was placed on the Superfund National Priorities List …" This distinction is important as it provides an accurate account of why the facility was listed. TCE is a hazardous substance as provided in 40 CFR 302.4. In addition, provided anyone should ever attempt to recover response costs incurred at the site, CERCLA 107 provides for the recovery of response costs due to the release of hazardous substances at any given site; not the release of "chemicals." As such, this document should use the term hazardous substance instead of chemicals, and contaminants where applicable (also see Section 2.4 at page 2-5; Section 2.5.2.4 at page 2-12; Section 2.11 at page 2-31; Section 2.13 at page 2-34).			
4	Pg 2-24	Section 2.8 Remedial Action Objectives	This Section does not clearly state what the RAOs are. It appears the RAOs are: • Protection of human health by preventing human exposure to TCE contaminated groundwater; • Protection of human health and the environment by reducing the leaching and migration of landfill hazardous substances into the groundwater; and • Protection of human health and the environment by preventing TCE contaminated groundwater from migrating into nearby surface water. Revise section expressing the RAOs in bullet form.	C	The RAOs will be expressed in bullet form as suggested.	

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5	Pg 2-25	Section 2.9.1 Description of Remedy Components Alternative 2	This section should specify what the LUCs are, who is responsible for implementation, maintenance and inspection, reporting and enforcement. If this alternative relies on monitored natural attenuation, then it should say so. It seems reasonable to specify when and where the MCLs will be achieved based upon the administrative record.	C	The following text will be included in the ROD: This alternative includes LUCs with MNA. The goal of this alternative is to allow for and monitor natural attenuation of TCE over time and protect the industrial worker by preventing exposure to contaminated groundwater. MNA relies on natural biological, chemical and physical processes that act to reduce the mass and concentration of groundwater COCs under favorable conditions. These natural attenuation processes include biodegradation, dispersion, dilution, adsorption, volatilization, and abiotic destruction of contaminants. A review of the available groundwater data showed the presence of daughter products of TCE such as cis-1,2-dichloroethene and vinyl chloride in groundwater indicating that TCE has undergone some degree of biodegradation at LHAAP-12. Results of the recent modeling indicated that under a range of degradation rates, the maximum TCE concentration detected at the site will require 23 to 261 years to naturally attenuate to the MCL of 5 µg/L. This alternative includes LUCs to protect the integrity of the existing landfill cap cover and to prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health. The LUC objectives are: • Prohibit digging or disturbing the existing cover or contents of the landfill; • Ensure no residential use or residential	

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					development of the property; • Ensure no withdrawal or use of LHAAP-12 groundwater for other than environmental monitoring and testing. The U.S. Army would be responsible for implementation, maintenance, inspection, reporting, and enforcement of the LUCs. Although the Army may transfer these responsibilities to another party through property transfer agreement or other means, the Army will remain responsible for (1) CERCLA 121 (c) five year reviews; (2) notification of the appropriate regulators of any known LUC deficiencies or violations; (3) access to the property to conduct any necessary response; (4) reservation of the authority to change, modify or terminate LUCs and any related transfer or lease provisions; and (5) the Army will ensure that the LUC objectives are met to protect the integrity of the selected remedy. The Army intends to provide details of the LUCs implementation actions in an LUC remedial design (LUCRD) for LHAAP-12. LUC implementation and maintenance actions would be described in the LUCRD. The groundwater restriction component of the LUCs shall be maintained until the concentration of TCE in groundwater has been reduced to levels below the MCL of 5 µg/L and any residual contamination has been sufficiently reduced to allow unrestricted use of the groundwater at LHAAP-12.	

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6	Pg 2-26	Section 2.9.2 Common Elements and Distinguishing Features of Each Alternative	The LUC language should specify who is responsible for implementation, maintenance and inspection, reporting and enforcement of the LUCs.	C	See response to comment No. 5.	
7	Pg 2-28	Section 2-10 Summary of Comparative Analysis of Alternatives 2, Compliance with ARARs	This section seems to ignore the fact that compliance with ARARs is mandated, unless a legitimate waiver is appropriate. The relevant and appropriate TCE MCL must be complied with or waived under one of the six types of ARAR waivers provided in the NCP. As such, this section should specify, if supported by the administrative record, that the TCE MCL will be met through monitored natural attenuation in a specified number of years. The monitored natural attenuation remedy should be supported by modeling or other reasonable technical information. The modeling or other reasonable technical information should also show that the TCE contamination will not result in the contamination of nearby surface waters.	C	See response to comment No. 1	
8	Pg 2-30	Section 2.10 Summary of Comparative Analysis of Alternatives 6, Implementability	This section seems to ignore the fact that compliance with ARARs is mandated, unless a legitimate waiver is appropriate. The relevant and appropriate TCE MCL must be complied with or waived under one of the six types of ARAR waivers provided in the NCP. As such, this section should specify, if supported by the administrative record, that the TCE MCL will be met through monitored natural attenuation in a specified number of years. The monitored natural attenuation remedy should be supported by modeling or other reasonable technical information. The modeling or other reasonable technical information should also show that	C	See response to comment No. 1	

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			the TCE contamination will not result in the contamination of nearby surface waters.			
9	Pg 2-32	Section 2.12.1 Summary of Rationale for the Selected Remedy	Text states "*the USEPA and TCEQ have expressed acceptance of the preferred alternative provided that appropriate LUCs are implemented."* This may be true in terms of how the contaminated groundwater can be addressed. However, please revised the Statutory Determinations and the Compliance with ARARs Sections as noted.	C	See response to comment No. 1	
10	Pg 2-32 & 2-33	Section 2.12 Description of the Selected Remedy	The selected remedy has the goal of protecting nearby surface waters from exposure/communication with TCE-contaminated groundwater based upon language in Section 2.8 (Remedial Action Objectives). This being the case, this Section needs to address the goal of protecting surface waters from the TCE-contaminated groundwater. It appears the selected remedy is monitored natural attenuation plus LUCs. As such, the monitoring of groundwater and the natural attenuation of TCE-contaminated ground water should be discussed by referencing modeling and/or other technical information to show that the natural attenuation will be effective in protecting nearby surface waters.	C	See response to comment No. 1. Further, medium specific concentration (MSC) limits in groundwater that would be protective of site surface water from groundwater impacts have been established for LHAAP-12 via modeling calculations. A comparison of the maximum observed concentrations of TCE and perchlorate in the LHAAP-12 groundwater to the MSCs indicates that the TCE and perchlorate concentrations at the site do not exceed the MSCs. Therefore, the maximum observed concentrations of TCE and perchlorate are already at levels that are protective of the nearby surface water bodies.	
11	Pg 2-34	Section 2.13 Statutory Determinations	See the discussion in comment 1. Also see the discussion included in comment 7 concerning compliance with ARARs.		See response to comment No. 1	

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12	Pg 2-34	Section 2.13 Statutory Determinations, Compliance with ARARs	See the discussion included in comments 1 and 7.		See response to comment No. 1	
13	Pg 2-35	Section 2.13 Statutory Determinations, Preference for Treatment	See the discussion included in comment 1.		See response to comment No. 1	
14	Pg 2-52	Table 2-12 Description of Chemicals of Potential Ecological Concern (COPEC) Identified in Soil	Table identified which COPECs were determined to be Chemicals of Ecological Concern (COEC). All COPECs listed were identified as not being COECs. The September 2004 *Screening-Level Ecological Risk Evaluation for Site 12 Soil did not make this finding. It found that "the potential for chemicals detected in soil as Site 12 to result in significant impacts to ecological populations at LHAAP is considered low."* Revise table to indicate this finding. In regards to bis(2-Ethylhexyl)phthalate and Butyl benzyl phthalate, table states that they were detected relatively infrequently. As indicated in the table, they were detected in three out of seven samples (i.e., 43%). In regards to bis(2Ethylhexyl)phthalate, table indicates that is a common laboratory contaminant, however, it was not flagged as such during the data validation.	C	It will be clarified that Table 2-12 presents the COPECs that were identified in the September 2004 SLERE, and then makes a determination as to whether each COPEC is a COEC based on information presented in the SLERE. "Detected relatively infrequently" will be eliminated as a "Justification for COEC Flag" in Table 2-12 for bis(2-ethylhexyl)phthalate and butyl benzyl phthalate. However, the justification that they are common laboratory contaminants will be retained. Chemicals may still be present in samples as the result of laboratory contamination even if they are not explicitly flagged as such during data validation. It is highly suspicious that these phthalate esters are the only organic chemicals selected as COPECs at this site. The likelihood of these chemicals being present in site soil at these relatively low concentrations as a result of a site-related release-- particularly given the absence of other significant contamination—is low, and their presence in the soil is considered questionable. This is a legitimate weight-of-evidence	

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					observation for the purpose of determining whether they should be considered COECs and investigated further.	
15		Figure 2-3 Sampling Locations and TCE Plume LHAAP-12	The figure identifies the parcel boundary within which land use restrictions will be designated. Recent conversations at the December 13, 2005 Managers Meeting indicated that the proposed parcel boundary may be adjusted to exclude a former railroad spur. Please revise figure if this is the case.		The figure will be revised to show that the LUC boundary lies west of the railroad spur.	
Comments from Alan Etheredge (TCEQ)						
1	1-4	Section 1.7 Authorizing Signature	The TCEQ concurrence line should be removed from this page. Upon receipt of an acceptable document the TCEQ will provide a letter of concurrence to be included as an appendix to the ROD.	C	The TCEQ concurrence line will be removed from the signature page.	
2	2-6	Section 2.4 Scope and Role of Response Action	The sentence reading "The multilayer cap hydraulically isolates the wastes in the LHAAP-12 landfill. " Should be modified to read "The multilayer cap reduces the potential for vertical migration of contaminants via rainfall infiltration through the landfill. "	C	The text will be revised to reflect the comment.	
3	2-15	Section 2.7.1.1 Identification of Chemicals of Concern	The reference to "Table 2-7" should be corrected to reference "Table 2-6	C	Reference will be corrected from Table 2-7 to show the correct Table 2-6.	

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4		General	Both the TCEQ and the US Environmental Protection Agency made their concurrence with the "Screening Level Ecological Risk Evaluation for Site 12 Soil" (Shaw, September 2004) contingent upon the understanding that potential impacts associated with historic releases from Site 12 would be addressed in the pending Installation-Wide Ecological Risk Assessment. The submitted document should consistently and explicitly limit the scope of the ROD, in regard to ecological risks, to the area within Site 12 and acknowledge the pending Installation-Wide Ecological Risk Assessment to address potential impacts beyond Site 12.	C	The ecological discussion in the ROD will clarify that the conclusions of the SLERA apply to LHAAP-12 and the area around it. Also added to Section 2.7.2.1, page 22: "Any releases associated with LHAAP-12 that may have resulted in impacts beyond the site will be evaluated in the installation-wide risk assessment".	
5			Remedial (performance) objectives should be explicitly described as they pertain to addressing each distinct potential risk associated with the site.	C	RAOs will be explicitly described as they pertain to addressing each distinct potential risk associated with the site as follows: • Protection of human health by preventing human exposure to TCE contaminated groundwater; • Protection of human health and the environment by reducing the leaching and migration of landfill hazardous substances into the groundwater; and • Protection of human health and the environment by preventing TCE contaminated groundwater from migrating into nearby surface water.	
6		General	In all descriptions of the selected remedy the ROD should clearly distinguish between land use controls (LUCs) aimed at addressing human health risks associated with exposure to groundwater having contamination exceeding MCLs and LUCs aimed at addressing risks to surface water quality associated with potential impact from groundwater having contamination	C	The following text will be included in the ROD: This alternative includes LUCs with MNA. The goal of this alternative is to allow for and monitor natural attenuation of TCE over time and protect the industrial worker by preventing exposure to contaminated groundwater. MNA relies on natural biological, chemical and physical processes that act to reduce	

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			exceeding MSCs. In describing LUCs the ROD should include all of the elements described in the Navy Principles promulgated by the Department of Defense in 2003, particularly those described in "General Procedures," paragraph "2. Record of Decision."		the mass and concentration of groundwater COCs under favorable conditions. These natural attenuation processes include biodegradation, dispersion, dilution, adsorption, volatilization, and abiotic destruction of contaminants. A review of the available groundwater data showed the presence of daughter products of TCE such as cis-1,2-dichloroethene and vinyl chloride in groundwater indicating that TCE has undergone some degree of biodegradation at LHAAP-12. Results of the recent modeling indicated that under a range of degradation rates, the maximum TCE concentration detected at the site will require 23 to 261 years to naturally attenuate to the MCL of 5 µg/L. This alternative includes LUCs to protect the integrity of the existing landfill cap cover and to prevent human exposure to residual groundwater contamination presenting an unacceptable risk to human health. The LUC objectives are: • Prohibit digging or disturbing the existing cover or contents of the landfill; • Ensure no residential use or residential development of the property; • Ensure no withdrawal or use of LHAAP-12 groundwater for other than environmental monitoring and testing. The U.S. Army would be responsible for implementation, maintenance, inspection, reporting, and enforcement of the LUCs.	

RESPONSE TO COMMENTS ON
DRAFT FINAL RECORD OF DECISION (NOVEMBER 2005)
LHAAP-12, LANDFILL 12,
LONGHORN ARMY AMMUNITION PLANT, KARNACK, TEXAS

MARCH 2006

Reviewers: Chris G. Villarreal, USEPA Region 6 and Alan Etheredge (TCEQ)
Respondents: Agnes Mayila and Praveen Srivastav, Shaw Environmental, Inc.

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					Although the Army may transfer these responsibilities to another party through property transfer agreement or other means, the Army will remain responsible for (1) CERCLA 121 (c) five year reviews; (2) notification of the appropriate regulators of any known LUC deficiencies or violations; (3) access to the property to conduct any necessary response; (4) reservation of the authority to change, modify or terminate LUCs and any related transfer or lease provisions; and (5) the Army will ensure that the LUC objectives are met to protect the integrity of the selected remedy. LUC implementation and maintenance actions will be described in the LUC Remedial Design for LHAAP-12 document. The groundwater restriction component of the LUCs shall be maintained until the concentration of TCE in groundwater has been reduced to levels below the MCL of 5 µg/L and any residual contamination has been sufficiently reduced to allow unrestricted use of the groundwater at LHAAP-12. There are no LUCs associated with surface water. The remedy of MNA will also be protective of surface water, assuring that the plume will not migrate at concentrations that pose an unacceptable risk to human health or the environment.	
7		General	TCEQ suggests that the ROD should include a table of all COCs and associated applicable MCLs / MSCs. This would establish the performance expectations under this ROD and eliminate potential future confusion in cases where standard regulatory values for MCLs and/or MSC are revised based on new toxicological data.	C	A Table showing COCs and their applicable MCLs/MSCs will be included in the final ROD.	

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8		Section 2.7.1.1 Identification of Chemicals of Concern	Identification of Chemicals of Ecologic Concern - The final paragraph of this section describes an analysis of data that was used to identify COECs from among COPECs. This data is also summarized in Table 2-12. TCEQ does not find data in the administrative record to support the definitive identification or elimination of COECs.		Section 2.7.1.1 discusses the selection of chemicals of concern (COC) for the baseline human health risk assessment conducted for LHAAP-12; it does not address chemicals of ecological concern (COEC). Rather, COECs are discussed in Section 2.7.2.1. The selection of COPECs and a weight-of-evidence discussion for each COPEC was provided in Shaw, 2004, Screening-Level Ecological Risk Evaluation for Site 12 Soil, Longhorn Army Ammunition Plant, Karnack, Texas, September. The "analysis" referred to in Section 2.7.2.1 that was done to identify COECs is simply an evaluation of the information (i.e., weight-of-evidence) provided in the September 2004 SLERE (and summarized in Table 2-12) to determine whether any of the COPECs warranted designation as a COEC. The text will be clarified to indicate that the analysis and determination of COECs is part of the ROD itself, rather than included in previous documents in the administrative record, such as the SLERE.	