Overview and Ranking of NPL Sites at the Longhorn Army Ammunition Plant (LHAAP) near Karnack, Texas

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This is an overview and ranking of contaminated sites at the Longhorn Army Ammunition Plant (LHAAP) near Karnack, Texas. All of the sites are on the US EPA's National Priorities List (NPL)[1].

Site ranking is based on environmental risk.

- Rank 1: Sites that present the highest threat to the environment due to the extent or concentration of contaminants. These sites may have active sources of contaminants.

- Rank 2: Sites that present a moderate threat to the environment. Compared to Rank 1 sites, contaminants are not as widespread or their concentrations are not as high.

- Rank 3: Sites that present a low threat or no threat or to the environment. Contaminants at these sites are confined to relatively small areas and are present in low concentrations.

The rankings are based on a brief review of Army documents. Rankings may change after more thorough reviews are performed.

The sites and their rankings are listed in table 1. A brief overview of each of the sites is presented following the table. Appendix 1 is a list of scheduled Army activities. Appendix 2 is a glossary of hydrologic and regulatory terms.

Reference

EPA, 2009a, *Longhorn Army Ammunition Plant, Harrison County, Texas,* November 2009.

[1] LHAAP was placed on the NPL in 1990 (EPA 2009a, page 3).

Table 1
LHAAP Sites

Site ID	Site Name	Description	Rank
LHAAP-001	Inert Burning Ground	1.5 acre site in northwest LHAAP. Used to burn TNT wastes. Soils contaminated with organics and metals. Groundwater contaminated with explosives and other organics.	3
LHAAP-004	Former Pilot Waste Water Treatment Plant	0.5 acre site in northwest LHAAP. Used to treat wastewater collected from sumps. Soils contaminated with mercury and perchlorate. No monitor wells at LHAAP-004 but perchlorate has been detected in monitor wells near the site.	2
LHAAP-011	Suspected TNT Burial Site at P&Q Avenues	10 acre site in central LHAAP. TNT may have been buried at the site. Soils contaminated with explosives, organics, nitrate and arsenic. An explosive was detected in groundwater.	3
LHAAP-012	Active Landfill	7 acre capped landfill in central LHAAP. Used for the disposal of industrial waste. Soils contaminated with organics and metals. Groundwater contaminated with organics, metals, and perchlorate. A plume of contaminated groundwater extends about 250 feet from the landfill.	1
LHAAP-013	Suspected TNT Burial Site Between Active and Old Landfills	0.5 acre site in central LHAAP. TNT wastes and waste acids may have been disposed at the site. Soils contaminated with metals.	3
LHAAP-014	Area 54W Burial Site	0.4 acre site in central LHAAP. Demolition debris, explosives, and acidic wastes were reported to have been disposed at the site. Soils contaminated with organics and barium.	3

Table 1
LHAAP Sites (continued)

Site ID	Site Name	Description	Rank
LHAAP-016	Old Landfill	20 acre capped landfill in south central LHAAP. Used for the disposal of hazardous wastes. Some of the wastes may have been disposed in trenches. Eastern portion of the site is within the floodplain of Harrison Bayou. Groundwater contaminated with organics, explosives, perchlorate, and metals. Contaminated groundwater is discharging to Harrison Bayou.	1
LHAAP-017	No 2 Flashing Area Burning Ground	3.9 acre site in east-central LHAAP. Used to burn waste TNT, photo flash powder, and rocket fuel. Soils contaminated with explosives, dioxin, perchlorate, and barium. Groundwater contaminated with organics and perchlorate.	1
LHAAP-018	Burning Ground/ Rocket Motor Washout Pond	34.5 acre site in central LHAAP. LHAAP-018 contains LHAAP-024. LHAAP-018 was used as a burial and burning ground for industrial wastes. LHAAP-024 was an unlined evaporation pond. Soils contaminated with organics and metals. Groundwater contaminated with organics and metals.	1
LHAAP-024	Former Unlined Evaporation Pond	LHAAP-024 is within the boundaries of LHAAP-018. See above.	1
LHAAP-027 (LHAAP-001-R-01)	South Test/ Bomb Test Area	79 acre site in south-central LHAAP. Used to test photoflash bombs; and demilitarize illuminating devices, munitions, and possibly, mines. Soils contaminated with explosives and metals. Groundwater contaminated with organics and metals.	2

Table 1
LHAAP Sites (continued)

Site ID	Description		Rank
LHAAP-029	Former TNT Production Area	85 acre site in west-central LHAAP. Approximately 400 million pounds of TNT produced between 1942 and 1945. Site later used to “soak out” rocket motors. Soils contaminated with explosives. Groundwater contaminated with organics, explosives, metals, and perchlorate.	1
LHAAP-032	Former TNT Waste Disposal Plant	9 acre site in northwest LHAAP. Plant treated wastewater from LHAAP-29. Soils contaminated with organics, explosives, and metals. Groundwater contaminated with metals.	2
LHAAP-037 (35B)	Quality Assurance Lab Building 29-A	12 acre site in north-central LHAAP. Laboratory built in early-1950s and continued operating as a research and material testing facility until 1999. Groundwater contaminated with TCE and PCE.	2
LHAAP-046	Plant 2 / Pyrotechnic Operation	190 acre site in north-central LHAAP. Plant produced JB-2 propellant fuel from 1944 to 1945, and pyrotechnic and illumination devices from 1952 to 1997. Groundwater contaminated with organics.	2
LHAAP-047	Plant 3 / Hand Signal Assembly	275 acre site in north-central LHAAP. Rocket motors, pyrotechnics, and illumination devices were produced at the site between 1954 and the early 1997. Site contained 53 waste sumps. Soils contaminated with organics, perchlorate, and metals. Groundwater contaminated organics, explosives, perchlorate, and metals.	1

Table 1
LHAAP Sites (continued)

Site ID	Site Name	Description	Rank
LHAAP-049	Former Acid Plant	30 acre site in west-central LHAAP. Between 1942 and 1945, nitric acid, sulfuric acid, and oleum (a mixture of sulfuric acid and sulfur trioxide) were produced and stored at the site. The acids were used to manufacture TNT. Soils contaminated with organics and metals. Groundwater contaminated with nitrate and metals.	2
LHAAP-050	Former Waste Disposal Facility	1 acre site in north-central LHAAP. Between 1955 and 1988 the site contained a 47,000-gallon aboveground storage tank. Tank received industrial wastewater from sumps throughout LHAAP. Soils contaminated with perchlorate. Groundwater contaminated with organics and perchlorate.	2
LHAAP-054 (LHAAP-003-R-01)	Ground Signal Test Area	80 acre site in southeast LHAAP. Beginning in 1963 the site was used to test and or destroy pyrotechnic munitions, rocket motors, button bombs, and, perhaps, mines. Expended mortar rounds, debris associated with pyrotechnic devices, and fuses have been found on the site. Soil contaminated with nitrate and metals. Groundwater contaminated with metals.	2
LHAAP-058 (35A)	Maintenance Complex	11 acre site in north-central LHAAP. Operated from 1942 to 1997. Contained a laundry; and automotive, woodworking, metalworking, painting, refrigeration, and electrical shops. There are two plumes of contaminated groundwater. Groundwater contaminated with organics and metals.	1

Table 1
LHAAP Sites (continued)

Site ID	Site Name	Description	Rank
LHAAP-067	Above Ground Storage Tank	1.9 acre site in central LHAAP. Seven aboveground tanks were used to store fuel oil, kerosene, and solvents. The tanks have been removed. Groundwater contaminated with organics.	2
Pistol Range	Pistol Range	0.4 acre site in southeastern LHAAP. Used for small arms target qualification and recertification from the 1950s through 2004. Groundwater contaminated with lead.	3
LHAAP-001-R-01 (LHAAP-027)	South Test / Bomb Test Area (MMRP)	See LHAAP-027	2
LHAAP-003-R-01 (LHAAP-054)	Ground Signal Test Area (MMRP)	See LHAAP-054	2

LHAAP-001
Inert Burning Ground

LHAAP-001 covers approximately 1.5 acres in the northwest portion of LHAAP[2]. From World War II until the early 1960s, trash, scrap lumber, photo flash powder, and TNT wastes were burned at the site[3]. The burned wastes were covered or mixed with fill materials[4].

The site drains to Goose Prairie Creek, which discharges to Caddo Lake approximately two miles east of the site[5].

The site is underlain by sands, silts, and clays[6]. Depth to groundwater ranges from less than a foot to about 25 feet below land surface[7]. There are also marshy areas and small springs in the southeast portion of the site[8].

Soils at LHAAP-001 contained elevated concentrations of metals (e.g., cadmium, lead, nickel), nitrate/nitrite, and a variety of organic contaminants (e.g., acetone, methylene chloride, toluene, xylene)[9].

A variety of explosives and other organic contaminants have been detected in groundwater at LHAAP-001 (e.g., 2,6-DNT, nitrobenzene, acetone, 2-butanone)[10].

The Army has recommended that no remedial action be performed at LHAAP-001[11].

References

US Army Corps of Engineers, 1997a, *Final Remedial Investigation Report, Group 1 Sites*, Volume 1, May 1997.

US Army, 1998a, *Record of Decision for No Further Action at Group 1 Sites, Longhorn Army Ammunition Plant, Karnack, Texas*, January 1998.

US Army Corps of Engineers, 2004a, *Final Background Soil Study Report, Longhorn Army Ammunition Plant, Karnack, Texas*, July 2004.

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[2] US Army Corps of Engineers, 1997a, page 2-6 and figure 2-2.
[3] US Army Corps of Engineers, 1997a, page 2-6.
[4] US Army Corps of Engineers, 1997a, page 9-1.
[5] US Army Corps of Engineers, 1997a, figures 2-2 and 2-7.
[6] US Army Corps of Engineers, 1997a, figures 2-9, 2-10, and 5-2.
[7] US Army Corps of Engineers, 1997a, page 5-7 and figure 5-2.
[8] US Army Corps of Engineers, 1997a, page 5-6 and figure 5-1.
[9] Elevated concentrations are concentrations above background levels established by the Army at LHAAP (US Army Corps of Engineers, 2004a, table ES-1; and US Army Corps of Engineers, 1997a, tables 9-2 - 9-4).
[10] US Army Corps of Engineers, 1997a, table 9-5.
[11] US Army, 1998a, unnumbered page following title page (Bates number 022218).

LHAAP-004
Former Pilot Waste Water Treatment Plant

LHAAP-004 is a 1/2 acre[12] site in the northwest portion of LHAAP. The plant treated wastewater that was trucked from sumps throughout LHAAP[13]. The plant began operating in 1984 and most of it was demolished in 1997[14]. A concrete slab (approximately 40 ft x 80 ft) that supported storage tanks and other components of the facility was left in place[15].

The site drains to Goose Prairie Creek[16], which discharges to Caddo Lake approximately 1.5 miles northeast of the site.

The site is underlain by sands, silts, and clays[17]. Depth to groundwater ranges from about five feet to about 15 feet below land surface[18]. Groundwater flows to the southwest[19].

Soils at the site contain high concentrations of mercury (up to 89,000 µg/kg) and perchlorate (up to 163,000 µg/kg) [20].

There are no monitor wells at LHAAP-004 but perchlorate has been detected in monitor wells near the site[21].

The Army plans to excavate contaminated soils (approximately 4,100 square feet, estimated volume of 840 cubic yards) and dispose them off-site[22]. The clean-up goals are to remove all soils that contain more than 150 µg/kg of mercury or more than 7200 µg/kg of perchlorate[23]. This would cost approximately $473,000[24].

Reference

US Army Corps of Engineers, 2009a, *Final Engineering Evaluation and Cost Analysis, Former Pilot Wastewater Treatment Plant, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas*, March, 2009.

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[12] US Army Corps of Engineers, 2009a, page 2-1.
[13] US Army Corps of Engineers, 2009a, pages 1-1 and 2-1.
[14] US Army Corps of Engineers, 2009a, page 2-1.
[15] US Army Corps of Engineers, 2009a, page 2-1 and figure 2-2.
[16] US Army Corps of Engineers, 2009a, page 2-2.
[17] US Army Corps of Engineers, 2009a, figure 2-5.
[18] US Army Corps of Engineers, 2009a, figure 2-5.
[19] US Army Corps of Engineers, 2009a, figure 2-3.
[20] US Army Corps of Engineers, 2009a, figure 2-6. Note: highly contaminated soil samples have been found immediately adjacent to the concrete slab, but no samples have been collected from beneath the slab.
[21] US Army Corps of Engineers, 2009a, figure 2-7.
[22] US Army Corps of Engineers, 2009a, pages 3-1, 3-2, 5-2, and 6-1.
[23] US Army Corps of Engineers, 2009a, page 3-2.
[24] US Army Corps of Engineers, 2009a, page 5-2.

LHAAP-011
Suspected TNT Burial Site at P&Q Avenues

LHAAP-011 is a ten acre site in the central portion of LHAAP[25]. TNT may have been buried at the site in the 1940s[26].

The site drains to Central Creek, which discharges to Caddo Lake approximately two miles northeast of the site[27].

The site is underlain by sands, silts, and clays[28]. Depth to groundwater ranges from about five feet to about 15 feet below land surface[29].

Soils at LHAAP-011 contained explosives (2,4,6-TNT, 1,3,5-TNB)[30] organics (bis(2-ethylhexyl)phthalate, methylene chloride)[31], elevated concentrations of nitrate, and elevated concentrations of arsenic[32].

An explosive, 1,3,5-TNB, was detected in groundwater at LHAAP-011[33].

The Army has recommended that no remedial action be performed at LHAAP-011[34].

References

US Army Corps of Engineers, 1997a, *Final Remedial Investigation Report, Group 1 Sites*, Volume 1, May 1997.

US Army, 1998a, *Record of Decision for No Further Action at Group 1 Sites, Longhorn Army Ammunition Plant, Karnack, Texas*, January 1998.

US Army Corps of Engineers, 2004a, *Final Background Soil Study Report, Longhorn Army Ammunition Plant, Karnack, Texas*, July 2004.

[25] US Army Corps of Engineers, 1997a, page 2-3 and figure 2-2.
[26] US Army Corps of Engineers, 1997a, page 2-3.
[27] US Army Corps of Engineers, 1997a, figures 2-2 and 2-7.
[28] US Army Corps of Engineers, 1997a, page 4-3.
[29] US Army Corps of Engineers, 1997a, 4-5.
[30] US Army Corps of Engineers, 1997a, tables 8-1 and 8-2.
[31] US Army Corps of Engineers, 1997a, tables 8-3 and 8-4.
[32] Elevated concentrations are concentrations above background levels established by the Army at LHAAP (US Army Corps of Engineers, 2004a, table ES-1).
[33] 0.62 µg/L of 1,3,5-TNB was detected in a water sample collected from a soil boring. No explosive have been detected in samples collected from monitor wells at the site (US Army Corps of Engineers, 1997a, pages 8-8 and 8-9).
[34] US Army, 1998a, unnumbered page following title page (Bates number 022218).

LHAAP-012
Active Landfill[35]

LHAAP-012 is a landfill. It covers approximately 7 acres in the central portion of LHAAP.[36] Between 1963 and 1994 it was used intermittently for the disposal of industrial solid waste[37]. It was closed in 1994[38] and was covered with a low permeability cap in 1998[39].

Surface water site drains to small tributaries and diversion ditches that discharge to Central Creek, approximately 500 feet northwest of the site[40]. Central Creek discharges to Caddo Lake, approximately two miles northeast of LHAAP-012.

The site is underlain by sands, silts, and clays[41]. Depth to groundwater ranges from 20 feet to 25 feet below the surface of the landfill[42]. Groundwater flows to the east and to the north[43], and may discharge to either Central Creek or Harrison Bayou[44].

Organic contaminants (e.g., ethylbenzene, toluene, methylene chloride) and elevated concentrations of metals[45] (e.g., arsenic, lead, nickel) have been detected in soils[46].

Organic contaminants (e.g., chlorobenzene, TCE), perchlorate, and high concentrations of metals[47] (e.g., antimony, cadmium, lead) have been detected in groundwater[48]. A narrow plume of contaminated groundwater extends about 250 feet from the northeast portion of the landfill[49].

The Army has chosen a cleanup plan that consists of: maintaining the landfill cap, land use controls, and monitored natural attenuation of groundwater contaminants[50]. The cost of this plan was estimated to be $255,000 (2006 dollars)[51]. The Army estimates

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[35] The landfill was closed in 1994 (US Army Corps of Engineers, 2006a, page 2-2.). It is not known why LHAAP-012 is called an active landfill.
[36] US Army Corps of Engineers, 2006a, page 2-2.
[37] US Army Corps of Engineers, 2006a, page 2-2.
[38] US Army Corps of Engineers, 2006a, page 2-2.
[39] US Army Corps of Engineers, 2006a, page 2-6. From the bottom up, the cap consists of a geosynthetic clay layer, a geomembrane, 18 inches of cover soil, and 6 inches of top soil (US Army Corps of Engineers, 2006a, figure 2-4).
[40] US Army Corps of Engineers, 2006a, page 2-2.
[41] US Army Corps of Engineers, 2006a, page 2-7.
[42] US Army, 2005a, page 4.
[43] US Army Corps of Engineers, 2006a, figure 2-5.
[44] US Army, 2005a, page 4.
[45] Elevated concentrations are concentrations higher than background levels (US Army Corps of Engineers, 2004a, table ES-1).
[46] US Army Corps of Engineers, 2006a, tables 2-1 and 2-2.
[47] Higher than MCLs (EPA, 2006a).
[48] US Army Corps of Engineers, 2006a, table 2-5.
[49] US Army Corps of Engineers, 2006a, figure 2-3.
[50] US Army Corps of Engineers, 2006a, page 2-33.
[51] US Army Corps of Engineers, 2006a, page 2-36.

that contaminant concentrations in groundwater will be reduced to acceptable levels in 23 years and 261 years[52].

References

EPA, 2006a, *2006 Edition of the Drinking Water Standards and Health Advisories, EPA 822-R-06-013*, August 2006.

US Army, 2005a, *Final Proposed Plan For Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plant, Karnack, Texas*, March 2005.

US Army Corps of Engineers, 2004a, *Final Background Soil Study Report, Longhorn Army Ammunition Plant, Karnack, Texas*, July 2004.

US Army Corps of Engineers, 2006a, *Final Record of Decision, Landfill 12 (LHAAP-12), Longhorn Army Ammunition Plant, Karnack, Texas*, April 2006.

LHAAP-013
Suspected TNT Burial Site Between Active and Old Landfills

LHAAP-013 is a 0.5 acre site in the central portion of LHAAP[53]. The lack of vegetation in several areas led to the suspicion that TNT wastes and waste acids were once disposed at the site[54].

Surface water at the site flows northward to Central Creek[55]. Central Creek discharges to Caddo Lake, approximately two miles northeast of the site[56]. The site is underlain by sands, silts, and clays[57].

Five soil borings were drilled at the site and one of the borings was completed as a monitor well[58]. High concentrations of barium and nickel were found in the soils[59].

One monitor well was installed on the site. No volatile, semi-volatile, explosive, or pesticide compounds were detected in a sample taken from this well, and no metal concentrations exceeded MCLs[60].

The Army has recommended that no remedial action be performed at LHAAP-013[61].

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[52] US Army Corps of Engineers, 2006a, page 1-2.
[53] US Army Corps of Engineers, 1995a, pages 1-4 and 1-5.
[54] US Army Corps of Engineers, 1995a, pages 1-9 and 1-10.
[55] US Army Corps of Engineers, 1995a, page 3-2.
[56] US Army Corps of Engineers, 1995a, page 1-5.
[57] US Army Corps of Engineers, 1995a, page 3-10.
[58] US Army Corps of Engineers, 1995a, page 2-4.
[59] Higher than site-specific background concentrations (US Army Corps of Engineers, 1995a, pages 4-3 – 4-5).
[60] US Army Corps of Engineers, 1995a, pages 4-6 and 4-7.
[61] US Army Corps of Engineers, 1995a, page 8-1.

Note: the Army states that a Record of Decision for LHAAP-13 was published in February 1996[62]. This document was not found in the Army's Administrative Record. Also, pages 3-16 and 3-17; and appendices A (Geologic Logs), B (Monitor Well Reports), and C (Geotechnical Data) of *US Army Corps of Engineers, 1995a* were not found in the Administrative Record.

References

US Army Corps of Engineers, 1995a, *Final Remedial Investigations / Feasibility Study, Sites 13 and 14*, Volume I, June 1995.

US Army, 2010a*, Longhorn Army Ammunition Plant Targeted GPRA Goals,* October 14, 2010.

LHAAP-014
Area 54W Burial Site

LHAAP-014 is a 0.4 acre site in the central portion of LHAAP[63]. It contains a small (25 feet x 30 feet) asphalt parking lot[64]. Demolition debris, explosives, and acidic wastes were reported to have been disposed in the area that is now beneath the parking lot[65].

Surface water at the site flows to Harrison Bayou, which discharges to Caddo Lake approximately two miles northeast of the site[66]. The site is underlain by sands, silts, and clays[67].

Three soil borings were drilled at the site and one of the borings was completed as a monitor well[68]. Toluene and butyl benzyl phthalate were detected in a soil sample taken from beneath the parking lot[69]. A high concentration of barium was also detected in soil from beneath the parking lot[70].

No explosives, volatile, or semi-volatile contaminants were detected in groundwater samples collected at the site[71].

The Army has recommended that no remedial action be performed at LHAAP-014[72].

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[62] US Army, 2010a.
[63] US Army Corps of Engineers, 1995a, pages 1-4 and 1-5.
[64] US Army Corps of Engineers, 1995a, page 1-4.
[65] US Army Corps of Engineers, 1995a, page 1-9.
[66] US Army Corps of Engineers, 1995a, pages 3-2 and 3-15.
[67] US Army Corps of Engineers, 1995a, page 3-10.
[68] US Army Corps of Engineers, 1995a, page 2-9.
[69] US Army Corps of Engineers, 1995a, page 4-7.
[70] Higher than the site-specific background concentration (US Army Corps of Engineers, 1995a, page 4-7 and tables 4-7 and 4-9).
[71] US Army Corps of Engineers, 1995a, pages 2-7 and 2-9, and tables 4-10 and 4-11.
[72] US Army Corps of Engineers, 1995a, page 8-1.

Note: the Army states that a Record of Decision for LHAAP-14 was published in February 1996[73]. This document was not found in the Army's Administrative Record. Also, pages 3-16 and 3-17; and appendices A (Geologic Logs), B (Monitor Well Reports), and C (Geotechnical Data) of *US Army Corps of Engineers, 1995a* were not found in the Administrative Record.

References

US Army Corps of Engineers, 1995a, *Final Remedial Investigations / Feasibility Study, Sites 13 and 14*, Volume I, June 1995.

US Army, 2010a*, Longhorn Army Ammunition Plant Targeted GPRA Goals,* October 14, 2010.

LHAAP-016
Old Landfill

LHAAP-016 occupies approximately 20 acres in the south central portion of the plant[74]. It was operated from 1942 until the 1970s or early 1980s[75]. It received a wide variety of wastes including TNT red water ash, substandard TNT, oil, paint, sulfur, photo flash wastes, barrels of chemicals, solvent wastes, rocket motor casings, construction debris, and scrap metal[76]. The site contained burn pits, a "large bermed depression", and possibly, an artificial pond[77]. The burn pits may have been excavated below land surface and later filled with wastes. Some of the wastes may have been disposed in trenches[78].

The eastern portion of the site is within the floodplain of Harrison Bayou[79]. Harrison Bayou does not flow during extended dry periods[80]. Harrison Bayou discharges to Caddo Lake, approximately 1.8 miles northeast of the site[81].

The materials underlying the landfill consist of unconsolidated sands, silts, and clays[82]. The Army has divided the groundwater system underlying the site into four zones: shallow[83], intermediate[84], upper deep, and lower deep[85]. Depth to groundwater ranges

[73] US Army, 2010a.
[74] US Army, 2010b, page 1.
[75] US Army Corps of Engineers, 1995, pages 1-7 and 1-8.
[76] US Army Corps of Engineers, 1992, pages 3-27 and 3-44.
[77] US Army Corps of Engineers, 1992, page 3-44; US Army Corps of Engineers, 1995 figure 1-2.
[78] Personal communication, Paul Bruckwciki, US Fish and Wildlife Service.
[79] US Army Corps of Engineers, 1992, page 3-46.
[80] The author visited site-16 on October 19, 2010. Harrison Bayou was not flowing.
[81] US Army, 2010a, figure 1-1.
[82] US Army Corps of Engineers, 2000, page 3-2.
[83] US Army Corps of Engineers, 2000, page 3-2; and Jacobs Engineering, 2002a, page 3-2.
[84] The top of the intermediate zone is found at depths of 30 to 50 feet below ground surface (US Army Corps of Engineers, 2000, page 3-2).
[85] US Army, 2010a, appendix A, page 1-1.

from three to 20 feet below ground surface[86]. Groundwater in all four zones flows toward Harrison Bayou[87].

A wide variety of contaminants have been detected in groundwater downgradient of the landfill. These include chlorinated solvents (e.g., TCE, 1,2-DCE, vinyl chloride)[88], SVOCs (e.g., bis(2-ethylhexyl)phthalate)[89], a pesticide (aldrin)[90], dioxins/furans[91], explosives (e.g., RDX, TNT, tetryl)[92], perchlorate[93], and metals (e.g., arsenic, barium, and thallium)[94]. Many of these contaminants are present in concentrations that exceed the limits that have been established to protect human health[95]. Table 16-1 lists the highest contaminant concentrations most recently found at the site.

Table 16-1
Groundwater Contaminants

Contaminant	Current maximum concentration[96] (ug/L)	MCL[97] or TCEQ GW-Res (ug/L)	Monitor well, date
TCE	29,300	5	16WW36, 3/30/09
1,1-DCE	97.1	7	16WW36, 6/11/07[98]
cis-1,2-DCE	51,800	70	16WW36, 3/30/09
trans-1,2-DCE	1660	100	16WW36, 3/30/09
1,2-DCA	125	5	16WW36, 3/30/09
Vinyl chloride	1700	2	16WW36, 3/30/09
Perchlorate	5990	26[99]	16WW12, 10/11/07
Arsenic	123	10	16WW35, 3/19/09
Barium	9900	2000	16WW09, 6/15/95
Thallium	12	2	16WW30, 10/21/97
OCDD[100]	1.36	0.45	16WW16, 1997?

[86] Jacobs Engineering, 2002a, page 3-2.
[87] US Army, 2010a, appendix A, page 1-1.
[88] US Army, 2010a, appendix A, table A-2.
[89] US Army Corps of Engineers, 2000, page 4-36.
[90] US Army Corps of Engineers, 2000, page 4-36.
[91] US Army Corps of Engineers, 2000, pages 4-29 – 4-32.
[92] US Army Corps of Engineers, 2000, pages 4-25 – 4-28.
[93] US Army, 2010a, appendix A, table A-2.
[94] US Army Corps of Engineers, 2000, pages 4-29 – 4-32.
[95] Health based standards are US EPA maximum contaminant levels (MCLs) for drinking water, or, for contaminants without MCLs, the Texas Commission on Environmental Quality (TCEQ) groundwater medium specific concentration for residential use (GW-Res).
[96] Data from most recent analyses available: US Army, 2010a, appendix A, table A-2, and appendix B; and US Army Corps of Engineers, 2000, pages 4-29 – 4-32.
[97] EPA, 2006a.
[98] 1,1-DCE was not detected in a sample collected on 3/30/09. However, the detection limit was 250 ug/L.
[99] TCEQ GW-Res (US Army, 2010a, page 2-13).
[100] A form of dioxin (ATSDR, 2006, page 7).

Contaminated groundwater is discharging to Harrison Bayou[101].

The Army's cleanup plan consists of land use controls, monitored natural attenuation, maintenance of the existing landfill cap, in-situ bioremediation and extraction of groundwater[102], and two passive biobarriers to intercept contaminated groundwater[103]. The in-situ bioremediation would treat both shallow and intermediate groundwater[104]. The passive biobarriers would intercept only shallow groundwater[105]. The cost of this plan is estimated to be $1,980,000[106].

The Army estimates that natural attenuation will reduce groundwater contaminant concentrations to acceptable levels in 280 years[107]. Within the zone affected by in-situ bioremediation, the Army estimates that contaminant concentrations will be reduced to acceptable levels in 30 to 75 years[108].

The Caddo Lake Institute prepared written comments on the Final Proposed Plan for LHAAP-016. The comments were submitted to the Army in November 2010.

References

Agency for Toxic Substances and Disease Registry (ATSDR), 2006, ToxFAQs: CABS™/Chemical Agent Briefing Sheet, Dioxins, March 2006.

EPA, 2009a, *Longhorn Army Ammunition Plant, Harrison County, Texas,* November 2009.

Jacobs Engineering Group Inc., 2002a, *Final Feasibility Study for Site 16, Longhorn Army Ammunition Plant, Karnack, Texas,* March 2002.

US Army, 2010a, *Final Addendum to Final Feasibility Study, LHAAP-16, Longhorn Army Ammunition Plant, Karnack, Texas,* March, 2010.

US Army, 2010b, *Final Proposed Plan For LHAAP-16, Longhorn Army Ammunition Plant, Karnack, Texas*, September, 2010.

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[101] US Army, 2010a, figures 3-1 – 3-10, and appendix A, table A-2. Also, see below.

[102] US Army, 2010b, page 1. The groundwater extraction system will be operated as part of in-situ bioremediation to help draw the carbon source through the contaminant plume (US Army, 2010a, page 4-3).

[103] US Army, 2010b, page 23. The Army may refresh the biobarriers with emulsified oil injections at five year intervals (US Army, 2010a, page 7-1).

[104] US Army, 2010a, page 4-3.

[105] US Army, 2010a, page 4-4.

[106] US Army, 2010b, page 16. This cost assumes 30 years of operation.

[107] US Army, 2010b, page 23; and US Army, 2010a, page 4-8. The Army defines acceptable levels as EPA maximum contaminant levels (MCLs) for drinking water (US Army, 2010b, page 8). However, MCLs have not been established for all contaminants (e.g., perchlorate). For contaminants without MCLs, the acceptable level is the TCEQ Groundwater Medium Specific Concentration for Residential Use (GW-Res) (US Army, 2010b, page 8).

[108] US Army, 2010a, page 4-4.

US Army Corps of Engineers, 1992, *Longhorn Army Ammunition Plant RI/FS, Work Plan,* Volume 1, June 1992.

US Army Corps of Engineers, 1995, *Longhorn Army Ammunition Plant, Marshall, Texas, Installation Restoration Program, Sites 12 and 16 Landfill Caps Interim Remedial Action Focused Feasibility Study, March, 1995.*

US Army Corps of Engineers, 2000, *Final Remedial Investigation Report, Site 16 Landfill, Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas,* October, 2000.

LHAAP-017
No 2 Flashing Area Burning Ground

LHAAP-017 is a 3.9 acre[109] site in the east-central portion of LHAAP. Between 1959 and 1980, waste TNT, photo flash powder, rocket fuel, and material from the Universal Match Corporation were burned at the site. It was also used as a flashing area for decontaminating metals[110].

Soils at LHAAP-017 are contaminated with explosives (TNT, DNT), dioxin, perchlorate, and barium[111].

Groundwater occurs in three zones: shallow, intermediate, and deep[112]. The shallow groundwater is contaminated with VOCs (e.g., TCE, DCE) and perchlorate[113]. Groundwater in the intermediate zone is contaminated with TCE[114] and perchlorate[115].

Table 17-1 lists the contaminant concentrations recently found in groundwater at the site.

[109] US Army, 2010b, page 3.
[110] US Army, 2010b, page 3; US Army, 2010a, page 2-12.
[111] US Army, 2010b, page 5.
[112] US Army, 2010b, page 5.
[113] US Army, 2010a, page 2-13.
[114] US Army, 2010a, page 2-13.
[115] US Army, 2010a, appendix A, table A-1.

Table 17-1
Groundwater Contaminants

Contaminant	Concentration[116] (ug/L)	MCL[117] or TCEQ GW-Res (ug/L)
TCE	6090	5
1,1-DCE	70	7
1,2-DCA	35.8(J)[118]	5
Perchlorate	160,000	72[119]

The Army's clean-up plan consists of the following. Contaminated soil would be excavated and disposed off-site[120]. In the shallow zone, contaminated groundwater would be extracted through wells and treated at the existing water treatment plant (pump and treat)[121]. Pump and treat would continue until perchlorate concentrations are less than 20,000 µg/L[122]. Then, natural attenuation (MNA) would be relied on to reduce contaminant concentrations. In the intermediate zone, only MNA would be relied on to reduce contaminant concentrations[123]. Land use controls would be maintained until contaminant concentrations are reduced to acceptable levels (clean-up levels, i.e., MCLs or State of Texas standards)[124]. The estimated cost of this plan is $2,090,000[125].

The Caddo Lake Institute prepared written comments on the Final Proposed Plan for LHAAP-017. The comments were submitted to the Army in July 2010.

References

EPA, 2006a, *2006 Edition of the Drinking Water Standards and Health Advisories, EPA 822-R-06-013*, August 2006.

United States Army, 2010a, *Final Feasibility Study, LHAAP-17, Burning Ground No. 2/Flashing Area, Group 2, Longhorn Army Ammunition Plant, Karnack, Texas*, April 10, 2010.

[116] US Army, 2010a, table 2-6.
[117] EPA, 2006a.
[118] "J" indicates that a substance was detected at a concentration greater than the detection limit but less than the reporting limit (aka practical quantitation limit). Reporting limits are typically five times greater that the detection limit.
[119] TCEQ GW-Ind (United States Army, 2010a, table 2-4).
[120] US Army, 2010b, page 16.
[121] US Army, 2010a, page 5-9.
[122] US Army, 2010b, page 16. If perchlorate concentrations have not been reduced to 20,000 µg/L within 1.5 years, a contingency action may be performed (e.g., in-situ bioremediation, US Army, 2010b, page 16).
[123] US Army, 2010b, page 12.
[124] US Army, 2010b, page 10. MCL: EPA maximum contaminant limit for drinking water. Because there is no MCL for perchlorate, the State of Texas standard will be used (72 µg/L, GW-Ind; US Army, 2010a, appendix A, page 3-1).
[125] US Army, 2010b, page 13.

United States Army, 2010b, *Final Proposed Plan for LHAAP-17,* Burning Ground No. 2/Flashing Area Group 2, *Longhorn Army Ammunition Plant, Karnack, Texas*, May 10, 2010.

LHAAP-018
Burning Ground / Rocket Motor Washout Pond
and
LHAAP-024
Former Unlined Evaporation Pond

Site 18/24 covers 34.5 acres[126] in the central portion of LHAAP[127]. LHAAP-018 encompasses LHAAP-024[128].

LHAAP-018 (aka Burning Ground No. 3) was used as a burial and burning ground for industrial wastes[129]. It began receiving wastes in 1955[130]. The wastes included solvents, oils, oxidizing agents, detergents, red phosphorous, and rocket motor washout residues[131].

LHAAP-024, an unlined evaporation pond, was constructed in 1963[132]. It held water collected from the rocket motor washout process and from process waste sumps[133]. The water contained solvents, explosives, and metals[134]. Waste disposal at LHAAP-024 stopped in 1984[135].

The site is on a topographic divide between Harrison Bayou and Saunders Branch, but most of the site drains to Harrison Bayou[136]. Harrison Bayou discharges to Caddo Lake, approximately one mile east of the site[137].

The site is underlain by the sand, silts, and clays[138]. Depth to groundwater ranges from five feet to 20 feet below the surface[139].

Organic contaminants have been detected in soils or sediments (e.g., cis-1,2-DCE, methylene chloride, TCE)[140]. Elevated concentrations of metals have also been

[126] Jacobs Engineering Group, Inc., 2001a, page 0-3.
[127] Jacobs Engineering Group, Inc., 2001b, figure 2-1.
[128] Jacobs Engineering Group, Inc., 2001a, page 5-1.
[129] Jacobs Engineering Group, Inc., 2001a, page 5-1.
[130] Jacobs Engineering Group, Inc., 2001a, page 5-1.
[131] Jacobs Engineering Group, Inc., 2001a, page 5-1.
[132] Jacobs Engineering Group, Inc., 2001a, page 5-1.
[133] Jacobs Engineering Group, Inc., 2001a, page 5-1.
[134] Jacobs Engineering Group, Inc., 2001a, page 5-1.
[135] Jacobs Engineering Group, Inc., 2001a, page 5-1.
[136] Jacobs Engineering Group, Inc., 2001a, page 5-5.
[137] Jacobs Engineering Group, Inc., 2001a, pages 5-5 and 5-6.
[138] Complete Environmental Service, 2002a, page 9; and Jacobs Engineering Group, Inc., 2001b, figures 5-3 – 5-7.
[139] Complete Environmental Service, 2002a, page 10.

detected in soil or sediments (e.g., arsenic, lead, thallium)[141]. Dioxins and furans were detected in sediments[142].

Organic contaminants have been detected in surface water (e.g., acetone, cis-1,2-DCE, and TCE)[143]. The concentration of TCE exceeded the MCLs[144]. Metals have also been detected in surface water in concentrations that exceed the MCLs (e.g., antimony, arsenic, chromium)[145]. Dioxins and furans were also detected in surface water[146].

Various organic contaminants and toxic metals have been detected in groundwater. Several of them were found in concentrations exceeding the MCLs. These contaminants are listed in table 18/24-1. Nitrate plus nitrite also exceeded the MCL[147]. Dioxins and furans were also detected in groundwater[148].

Table 18/24-1
Organic Contaminants Detected in Groundwater[149]

Contaminant	Maximum concentration (ug/L)	MCL[150] (ug/L)
Methylene chloride	7,300,000	5
Cis-1,2-DCE	250	70
TCE	210,000	5
Antimony	333(J)[151]	6
Barium	6000	2000
Chromium	18,000(J)	100
Lead	18	15
Thallium	3.7(J)	2

[140] Jacobs Engineering Group, Inc., 2001a, tables 5-6 and 5-9.
[141] Elevated concentrations are concentrations above background levels established by the Army at LHAAP (US Army Corps of Engineers, 2004a, table ES-1; and Jacobs Engineering Group, Inc., 2001a, tables 5-8 and 5-9).
[142] Jacobs Engineering Group, Inc., 2001a, table 5-9.
[143] Jacobs Engineering Group, Inc., 2001a, table 5-13.
[144] Maximum TCE concentration = 45 µg/L, MCL = 5 µg/L (Jacobs Engineering Group, Inc., 2001a, table 5-13; and US EPA, 2006a).
[145] Maximum antimony concentration = 32 µg/L, MCL = 6 µg/L; maximum arsenic concentration = 50 µg/L, MCL = 10 µg/L; maximum chromium concentration = 159(J) µg/L, MCL = 100 µg/L; (Jacobs Engineering Group, Inc., 2001a, table 5-13; and US EPA, 2006a).
[146] Jacobs Engineering Group, Inc., 2001a, table 5-13.
[147] Nitrate plus nitrite = 51 µg/L, MCL = 10 µg/L (US EPA, 2006a).
[148] Jacobs Engineering Group, Inc., 2001a, table 5-16.
[149] Jacobs Engineering Group, Inc., 2001a, table 5-16.
[150] US EPA, 2006a.
[151] "J" indicates that a substance was detected at a concentration greater than the detection limit but less than the reporting limit (aka practical quantitation limit). Reporting limits are typically five times greater that the detection limit.

Several remedial actions have been performed at site 18/24. In 1986 approximately 7800 cubic yards of sludge was removed from the pond[152]. The pond was then backfilled and capped[153]. In 1997 approximately 30,000 cubic yards of soil were excavated and treated on-site in low temperature thermal desorbers[154]. A groundwater extraction system was installed consisting of wells and approximately 5000 feet of interceptor trenches[155]. A water treatment plant was built to treat the groundwater[156]. The treated water is discharged to Harrison Bayou[157].

The Army planned to publish a *Remedial Investigation/Feasibility Study* (RI/FS) for site 18/24 in December 2010, but it has been delayed[158]. The RI/FS should contain more recent analytical data for soils, sediment, surface water, and groundwater.

References

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Jacobs Engineering Group, Inc., 2001a, *Final Report - Remedial Investigation Report - Volume 1: Report for the Group 2 Sites Remedial Investigation Report, Sites 12, 17, 18/24, 29 and 32 at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas,* April 2001.

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US Army Corps of Engineers, 2004a, *Final Background Soil Study Report, Longhorn Army Ammunition Plant, Karnack, Texas*, July 2004.

US Army, 2010a, *Longhorn Army Ammunition Plant Targeted GPRA Goals,* October 14, 2010.

US EPA, 2006a, *2006 Edition of the Drinking Water Standards and Health Advisories, EPA 822-R-06-013*, August 2006.

[152] Complete Environmental Service, 2002a, page 11.
[153] Complete Environmental Service, 2002a, page 12.
[154] Complete Environmental Service, 2002a, page 12.
[155] Jacobs Engineering Group, Inc., 2001a, page 5-12; and Complete Environmental Service, 2002a, page 12.
[156] Complete Environmental Service, 2002a, page 12.
[157] Complete Environmental Service, 2002a, page 12.
[158] US Army, 2010a,

LHAAP-027
(LHAAP-001-R-01)
South Test Area/Bomb Test Area

LHAAP-027 is a 79 acre site in the south-central portion of LHAAP[159]. From 1954 until the early 1980s it was used to test photoflash bombs and demilitarize (burn, detonate?) leaking illuminating devices, leaking white phosphorous (WP) munitions, and, possibly, mines[160]. Spent flares, 155-mm primer caps, and a 155-mm WP round have been found on the site[161]. The WP round was blown-in-place. The site also contains a patch of distressed vegetation which, based on aerial photos, appears to have persisted for several decades[162].

LHAAP-027 drains to Harrison Bayou, and Harrison Bayou discharges to Caddo Lake approximately two and a half miles northeast of the site[163].

The site is underlain by interbedded sands, silts, and clays[164]. Some portions of the site, are covered by alluvium (silty sands) deposited by Harrison Bayou[165]. Depth to groundwater ranges from less than a foot to approximately eight feet below ground surface[166].

Three soil samples and groundwater samples from two monitor wells were collected in 1982. TNT was found in two soil samples[167]. In addition, shallow soils contained elevated concentrations of nitrate and barium[168].

Groundwater samples contained organics[169] and high concentrations of some metals (e.g., cadmium, thallium)[170]. Groundwater may discharge to Harrison Bayou[171].

The Army plans to remediate the site by 1) establishing land use controls (LUCs)[172], and 2) searching[173] for and destroying explosive devices[174]. All explosive devices would be destroyed on site[175].

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[159] US Army Corps of Engineers, 2008b, appendix I, page 1-2.
[160] US Army Corps of Engineers, 2008a, page 7.
[161] US Army Corps of Engineers, 2008a, page 5. Note: the identification of the round as a white phosphorous round has been questioned by the Army (ibid.).
[162] US Army Corps of Engineers, 1992a, pages 3-206 and 3-207.
[163] US Army Corps of Engineers, 1992a, page 3-212.
[164] US Army Corps of Engineers, 1992a, page 3-210.
[165] US Army Corps of Engineers, 1992a, page 3-210.
[166] US Army Corps of Engineers, 1992a, pages 3-211 and 3-213.
[167] US Army Corps of Engineers, 1992a, page 3-215.
[168] US Army Corps of Engineers, 1992a, pages 3-215 and 3-217. Elevated concentrations are concentrations above background levels (US Army Corps of Engineers, 2004a, table ES-1).
[169] Diethyl phthalate (52 µg/L) and 2-(1,1-dimethylethoxy)-ethanol (24 µg/L) (US Army Corps of Engineers, 1992a, page 3-216).
[170] US Army Corps of Engineers, 1992a, pages 3-215 and 3-216. High concentrations are concentrations that exceed the MCL (US EPA, 2006a).
[171] US Army Corps of Engineers, 1992a, page 3-219.
[172] LUCs would include signs warning of the possible presence of explosives, and a restriction on intrusive activities such as digging (US Army Corps of Engineers, 2008b, appendix I, pages 1-7 and 1-8).

References

US Army Corps of Engineers, 1992a, *Longhorn Army Ammunition Plant, RI/FS Work Plan, Volume 1, General,* June 1992.

US Army Corps of Engineers, 2004a, *Final Background Soil Study Report, Longhorn Army Ammunition Plant, Karnack, Texas*, July 2004.

US Army Corps of Engineers, 2008a, *Final Explosives Safety Submission, Munitions and Explosives of Concern Removal Action, Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas,* February 2008.

US Army Corps of Engineers, 2008b, *Land Use Control Plan for the MEC Removal Action at the Former LHAAP LHAAP-001-R (Site 27) and LHAAP-003-R (Site 54), Karnack, Texas*, July 2008.

US EPA, 2006a, *2006 Edition of the Drinking Water Standards and Health Advisories, EPA 822-R-06-013*, August 2006.

LHAAP-029
Former TNT Production Area

LHAAP-29 is an 85 acre site in the west-central portion of LHAAP[176]. Approximately 400 million pounds of TNT were produced on six production lines between 1942 and 1945. Between 1959 and the mid-1970s, LHAAP-029 was used to "soak out" out-of-specification rocket motors. This process used Turco, a methylene chloride-based solvent[177].

The site currently contains the production line foundations and underground pipelines used to convey cooling water and TNT wastewater[178]. The lines were made of wood, cement/asbestos (transite), and vitrified clay/asbestos[179].

The northern portion of the site drains to Goose Prairie Creek, the southern portion to Central Creek[180]. Both of these creeks discharge to Caddo Lake, approximately two and a half miles northeast of the site[181].

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[173] Geophysical instruments will be used to detect explosives (US Army Corps of Engineers, 2008a, pages 13 and 14).
[174] US Army Corps of Engineers, 2008a, pages 9 and 16.
[175] US Army Corps of Engineers, 2008a, page 17.
[176] Shaw Environmental, Inc., 2010a, page ES-1.
[177] Shaw Environmental, Inc., 2010a, pages 1-4 and 1-5.
[178] Shaw Environmental, Inc., 2010a, page 1-4.
[179] Shaw Environmental, Inc., 2010a, pages 1-4 and 1-5.
[180] Shaw Environmental, Inc., 2010a, page 1-5.
[181] Shaw Environmental, Inc., 2010a, figure 1-2.

The Army has designated three groundwater zones at LHAAP-029: a shallow zone (depth ranges from 17 to 45 feet below ground surface (bgs)), an intermediate zone (extends to approximately 88 feet bgs), and a deep zone (extends to approximately 155 feet bgs)[182]. Groundwater in the shallow and intermediate zones flows to the east-northeast[183].

Soils and groundwater are contaminated with a variety of solvents, explosives, and metals (tables 29-1 and 29-2). Contaminants have also been found in soils adjacent to the wastewater lines, and in water in the cooling water lines (table 29-3).

The Army has developed three remedial alternatives for LHAAP-029[184].

- Alternative 1 is no action.

- Alternative 2 consists of excavation and off-site disposal of contaminated soil, plugging waste lines, monitored natural attenuation for groundwater in the shallow zone, in-situ chemical oxidation of contaminated groundwater in the intermediate zone, and land use controls.

- Alternative 3 is the same as alternative 2 except that instead of in-situ chemical oxidation, groundwater in the intermediate zone would be extracted and treated at the existing groundwater treatment plant.

[182] Shaw Environmental, Inc., 2010a, page 1-6.
[183] Shaw Environmental, Inc., 2010a, page 1-6.
[184] Shaw Environmental, Inc., 2010a, page ES-3.

Table 29-1[185]
Contaminants in Soils

Contaminant	Maximum Concentration Detected (mg/kg)	Regulatory Standard[186] (mg/kg)
1,3-DNB[187]	1.08	GWP-Ind = 1
2-amino-4,6-DNT[188]	48	SAI-Ind = 17 GWP-Ind = 1.7
4-amino-2,6-DNT[189]	16	SAI-Ind = 170 GWP-Ind = 1.7
2,4-DNT[190]	8000	SAI-Ind = 4.2 GWP-Ind = 0.042 EcoPRG = 12
2,6-DNT[191]	15	EcoPRG = 2.7
TNT[192]	26,000	SAI-Ind = 510 GWP-Ind = 5.1 EcoPRG = 4.7
Perchlorate	8.6	SAI-Ind = 950 GWP-Ind = 7.2

[185] Shaw Environmental, Inc., 2010a, pages 2-14, 2-18, and 2-19.
[186] See glossary for definition of terms.
[187] 1,3-DNB: 1,3-dinitrobenzene.
[188] 2-amino-4,6-DNT: 2-amino-4,6-dinitrotoluene.
[189] 4-amino-2,6-DNT: 4-amino-2,6-dinitrotoluene.
[190] 2,4-DNT: 2,4-dinitrotoluene.
[191] 2,6-DNT: 2,6-dinitrotoluene.
[192] TNT: 2,4,6-trinitrotoluene.

Table 29-2[193]
Contaminants in Groundwater

Contaminant	Maximum Concentration Detected (µg/L)	Regulatory Standard[194] (µg/L)
Methylene chloride	7,110,000	MCL = 5
1,2-DCA	5520	MCL = 5
TCE	4340	MCL = 5
Arsenic	141	MCL = 10
Mercury	6.1	MCL = 2
Nickel	8400	MCL = 2000
2-nitrotoluene	8140	GWP-Ind = 1000
3-nitrotoluene	451	GWP-Ind = 1000
4-nitrotoluene	1400	GWP-Ind = 1000
2,4-DNT	50.9	GWP-Ind = 0.42
2,6-DNT	239	GWP-Ind = 0.42
Perchlorate	16,800	GWP-Ind = 72

Table 29-3[195]
Contaminants in Water in Cooling Water Lines

Contaminant	Maximum Concentration Detected (µg/L)	Regulatory Standard[196] (µg/L)
2-amino-4,6-DNT	220	GWP-Ind = 17
4-amino-2,6-DNT	290	GWP-Ind = 17
2,4-DNT	15	GWP-Ind = 0.42
2,6-DNT	27	GWP-Ind = 0.42
TNT	5200	GWP-Ind = 51

Reference

Shaw Environmental, Inc., 2010a, *Final Feasibility Study, LHAAP-29, Former TNT Production Area, Group 2, Longhorn Army Ammunition Plant, Karnack, Texas,* April 2010.

[193] Shaw Environmental, Inc., 2010a, pages 2-14 – 2-17, 2-20, and 2-21.
[194] See glossary for definition of terms.
[195] Shaw Environmental, Inc., 2010a, page 2-20.
[196] See glossary for definition of terms.

LHAAP-032
Former TNT Waste Disposal Plant

LHAAP-32 is a nine acre site in the northwest portion of LHAAP[197]. Between 1942 and 1945 the plant treated wastewater from the nearby TNT Production Area (LHAAP-29)[198]. The wastewater was transferred to LHAAP-032 via a 6-inch wooden pipeline[199]. The liquid portion of the treated wastewater was discharged to Goose Prairie Creek via the 'blue water' ditch[200]. The solidified portion was burned in an on-site incinerator[201]. The incinerator ashes were first disposed in the Old Landfill (LHAAP-016)[202]. Later, they were sluiced to Goose Prairie Creek[203].

The site drains to Goose Prairie Creek, which discharges to Caddo Lake approximately two miles east of the site[204]. The site is underlain by interbedded sands, silts, and clays[205]. The Army has designated three groundwater zones at the site: a shallow zone, an intermediate zone, and a deep zone[206].

Organic contaminants (e.g., acetone, di-n-butyl phthalate), explosives (e.g., TNT, HMX), dioxin, and elevated concentrations of metals[207] (e.g., antimony, arsenic, lead) have been detected in soils[208].

Dioxin and high concentrations of metals[209] (e.g., antimony, lead)[210] have been detected in groundwater.

The Army has decided that no remedial action is needed at LHAAP-032[211].

References

Jacobs Engineering Group, Inc., 2001a, *Final Report - Remedial Investigation Report - Volume 1: Report for the Group 2 Sites Remedial Investigation Report, Sites 12, 17, 18/24, 29 and 32 at the Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas,* April 2001.

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[197] U.S. Army Corps of Engineers, 2008a, page 2-1 and figure 2-2.
[198] U.S. Army Corps of Engineers, 2008a, page 2-1.
[199] Jacobs Engineering Group, Inc., 2001a, page 7-1.
[200] Jacobs Engineering Group, Inc., 2001a, page 7-2.
[201] U.S. Army Corps of Engineers, 2008a, page 2-2.
[202] U.S. Army Corps of Engineers, 2008a, page 2-2.
[203] U.S. Army Corps of Engineers, 2008a, page 2-2.
[204] U.S. Army Corps of Engineers, 2008a, page 2-4 and figure 2-2.
[205] U.S. Army Corps of Engineers, 2008a, page 2-4.
[206] U.S. Army Corps of Engineers, 2008a, page 2-4.
[207] Elevated concentrations are concentrations higher than the background concentrations established for LHAAP (US Army Corps of Engineers, 2004a, table ES-1).
[208] U.S. Army Corps of Engineers, 2005a, attachment 1, table 3-1.
[209] High concentrations are concentrations higher than MCLs (US EPA, 2006a).
[210] Maximum antimony concentration = 27 µg/L, MCL = 6 µg/L; maximum lead concentration = 18.6 µg/L, MCL = 15 µg/L (US EPA, 2006a; and U.S. Army Corps of Engineers, 2005a, attachment 1, table 3-1).
[211] U.S. Army Corps of Engineers, 2008a, page 1-2.

US Army Corps of Engineers, 2004a, *Final Background Soil Study Report, Longhorn Army Ammunition Plant, Karnack, Texas*, July 2004.

U.S. Army Corps of Engineers, 2005a, *Final Site Evaluation Report, LHAAP-32, Former TNT Waste Disposal Plant, Longhorn Army Ammunition Plant, Karnack, Texas*, November 2005.

U.S. Army Corps of Engineers, 2008a, *Final Record of Decision, LHAAP-32, Former TNT Waste Disposal Plant, Longhorn Army Ammunition Plant, Karnack, Texas,* August 2008.

US EPA, 2006a, *2006 Edition of the Drinking Water Standards and Health Advisories, EPA 822-R-06-013*, August 2006.

LHAAP-037(35B)
Quality Assurance Lab Building 29-A

LHAAP-037 is a 12 acre site in the north-central portion of LHAAP[212]. The laboratory was built between 1953 and 1955, and continued operating as a research and material testing facility until 1999.

The site drains to Goose Prairie Creek[213], which discharges to Caddo Lake approximately one and a half miles northeast of the site. Depth to groundwater ranges from 12 feet to 33 feet below ground surface[214].

Groundwater is contaminated with TCE and PCE[215].

The Army's preferred clean-up plan consists of the following. Natural attenuation (MNA) would be relied on to reduce concentrations of groundwater contaminants, and land use controls would be maintained until contaminant concentrations were reduced to acceptable levels (MCLs)[216]. The estimated cost of this plan is $282,000[217].

The Caddo Lake Institute prepared written comments on the Final Proposed Plan for LHAAP-037(35B). The comments were submitted to the Army in April 2010.

[212] United States Army, 2008b, page 3.
[213] United States Army, 2008b, page 4.
[214] United States Army, 2008b, page 4.
[215] Shaw, 2007c, table 5-3.
[216] United States Army, 2008b, pages 12 and 17.
[217] United States Army, 2008b, page 13.

References

Shaw, 2007c, *Final Natural Attenuation Evaluation LHAAP-12, LHAAP-35B (37), and LHAAP-67, Longhorn Army Ammunition Plant, Karnack, Texas,* June 2007.

United States Army, 2008b, *Final Proposed Plan for LHAAP-35B (37), Chemical Laboratory and LHAAP-67, Aboveground Storage Tank Farm, Longhorn Army Ammunition Plant, Karnack, Texas*, June 9, 2008.

LHAAP-046
Plant 2 / Pyrotechnic Operation

LHAAP-046 is a 190 acre site in the north-central portion of LHAAP[218]. The plant produced JB-2 propellant fuel from 1944 to 1945[219]. Between 1952 and 1997 the plant produced pyrotechnic and illumination devices[220].

The site drains to Goose Prairie Creek[221], which discharges to Caddo Lake approximately one mile northeast of the site. Depth to groundwater ranges from approximately 11 feet to 23 feet below ground surface[222].

TCE[223], bis(2-ethyhhexylphthalate)[224], and thallium[225] have been detected in groundwater at the site. There are two plumes of contaminated groundwater, one in the shallow zone and one in the intermediate zone.[226]

The Army's preferred clean-up alternative is Alternative 2. This consists of land use controls (LUCs), and monitored natural attenuation[227]. LUCs would be maintained until contaminant concentrations were reduced to acceptable levels[228].

The Caddo Lake Institute prepared written comments on the Final Proposed Plan for LHAAP-046. The comments were submitted to the Army in February 2010.

References

Caddo Lake Institute, 2010a, *Comments on Proposed Final Plans for LHAAP Sites 35A(58), 46, and 50,* George Rice, February 2010.

[218] US Army, 2010b, page 3.
[219] US Army, 2010b, page 3.
[220] US Army, 2010b, page 3.
[221] US Army, 2010b, page 4.
[222] US Army, 2010b, page 4.
[223] Shaw, 2009b, figures 3-1 and 3-2.
[224] Caddo Lake Institute, 2010a.
[225] Caddo Lake Institute, 2010a.
[226] Shaw, 2009b, page 3-6.
[227] US Army, 2010b, page 13.
[228] US Army, 2010b, page 9.

Shaw, 2009b, *Final Feasibility Study, LHAAP-46*, Longhorn Army Ammunition Plant, Karnack, Texas, October 2009.

US Army, 2010b, *Final Proposed Plan for LHAAP-46, Plant 2 Area, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas*, January 2010.

LHAAP-047
Plant 3 / Hand Signal Assembly

LHAAP-047 is a 275 acre site in the north-central portion of LHAAP[229]. Rocket motors, pyrotechnics, and illumination devices were produced at the site between 1954 and 1997[230]. The site contained 53 waste sumps[231].

Goose Prairie Creek runs through the southern portion of the site[232]. The creek discharges to Caddo Lake about a mile north-east of the site[233]. The site is underlain by interbedded sands, silts, and clays[234]. The Army has designated three groundwater zones at LHAAP-047: a shallow zone (10 feet to35 feet below ground surface (bgs)), an intermediate zone (40 feet to 60 feet bgs), and a deep zone (70 feet to 95 feet bgs)[235].

Liquids and sludges collected from sumps contained organic contaminants (e.g., ethylbenzene, PCE, vinyl chloride)[236] and elevated[237] concentrations of metals (e.g., antimony, arsenic, lead)[238].

Soils contained organic contaminants (e.g., benzene, PCE, TCE), dioxins, perchlorate, and elevated concentrations of metals (e.g., antimony, arsenic, mercury, lead)[239].

Groundwater has been contaminated with a variety of substances. Representative contaminants are listed in table 47-1.

[229] US Army Corps of Engineers, 2002a, page 9-1.
[230] US Army Corps of Engineers, 2002a, page 9-1.
[231] US Army Corps of Engineers, 2002a, page 9-1.
[232] US Army Corps of Engineers, 2002a, figure 9-2.
[233] US Army Corps of Engineers, 2002a, figure 1-2.
[234] US Army Corps of Engineers, 2002a, page 9-5 and figures 9-3 - 9-6.
[235] US Army Corps of Engineers, 2002a, page 9-5.
[236] US Army Corps of Engineers, 2002a, tables 9-5 and 9-6.
[237] Elevated concentrations are concentrations higher than the background concentrations established for LHAAP (US Army Corps of Engineers, 2004a, table ES-1) or concentrations greater than the MCL(US EPA, 2006a).
[238] US Army Corps of Engineers, 2002a, tables 9-5 and 9-6.
[239] US Army Corps of Engineers, 2002a, tables 9-7 and 9-9.

Table 47-1[240]
Contaminants in Groundwater

Contaminant	Maximum Concentration Detected (µg/L)	Regulatory Standard[241] (µg/L)
1,1-DCE	40	MCL = 7
PCE	168	MCL = 5
TCE	20,410	MCL = 5
Vinyl chloride	127	MCL = 2
2,4-DNT	0.1(J)[242]	GWP-Ind = 0.42
2,6-DNT	0.2	GWP-Ind = 0.42
TNT	6.8	GWP-Ind = 51
Perchlorate	82.9	GWP-Ind = 72
Antimony	76(J)	MCL = 6
Arsenic	137(J)	MCL = 10
Chromium	43,000(J)	MCL = 100
Lead	248(J)	MCL = 15
Thallium	93	MCL = 2

Note: The Army planned to publish a *Remedial Investigation / Feasibility Study* (RI/FS) for LHAAP-047 in December 2010, but it has been delayed[243]. The RI/FS should contain more recent analytical data for soils, sediment, surface water, and groundwater.

References

Shaw Environmental, Inc., 2010a, *Final Feasibility Study, LHAAP-29, Former TNT Production Area, Group 2, Longhorn Army Ammunition Plant, Karnack, Texas,* April 2010.

US Army Corps of Engineers, 2002a, *Final Remedial Investigation Report, Volume 1: Report, Group 4 Sites, Sites 35A, 35B, 35C, 46, 47, 48, 50, 60, and Goose Prairie Creek, Longhorn Army Ammunition Plant, Karnack, Texas*, January 2002.

US Army Corps of Engineers, 2004a, *Final Background Soil Study Report, Longhorn Army Ammunition Plant, Karnack, Texas*, July 2004.

US EPA, 2006a, *2006 Edition of the Drinking Water Standards and Health Advisories, EPA 822-R-06-013*, August 2006.

[240]. US Army Corps of Engineers, 2002a, table 9-10.
[241] EPA MCL or Texas GWP-Ind (US EPA, 2006a; and Shaw Environmental, Inc., 2010a, pages 2-14 – 2-17, 2-20, and 2-21).
[242] "J" indicates that a substance was detected at a concentration greater than the detection limit but less than the reporting limit (aka practical quantitation limit). Reporting limits are typically five times greater that the detection limit.
[243] US Army, 2010a.

LHAAP-049
Former Acid Plant

LHAAP-049 is a 30 acre site in the west-central portion of LHAAP[244]. Between 1942 and 1945, nitric acid, sulfuric acid, and oleum (a mixture of sulfuric acid and sulfur trioxide)[245] were produced and stored at the site[246]. The acids were used to manufacture TNT[247].

The site drains to Goose Prairie Creek, and the creek discharges to Caddo Lake approximately two miles east of the site[248].

The site is underlain by interbedded clays, silts, and sands[249]. The Army has designated three groundwater zones at LHAAP-049: shallow, intermediate, and deep[250]. Depth to groundwater ranges from about 20 feet to about 30 feet below land surface[251].

Elevated levels of lead and mercury, as well as pesticides, PCBs, dioxins, and methylene chloride have been detected in soils at LHAAP-49[252].

High concentrations of nitrate, antimony, arsenic, chromium, and selenium have been detected in groundwater[253].

The Army does not intend to perform remedial action at LHAAP-049[254].

References

EPA, 2006a, *2006 Edition of the Drinking Water Standards and Health Advisories, EPA 822-R-06-013*, August 2006.

US Army Corps of Engineers, 2009a, *Final Site Evaluation Report,* LHAAP-49, Former Acid Storage Area, *Longhorn Army Ammunition Plant, Karnack, Texas*, June 2009.

US Army Corps of Engineers, 2010a, *Final* Record of Decision, *LHAAP-49, Former Acid Storage Area, Longhorn Army Ammunition Plant, Karnack, Texas*, August 2010.

[244] US Army Corps of Engineers, 2010a, page 2-1.
[245] US Army Corps of Engineers, 2009a, page 2-1.
[246] US Army Corps of Engineers, 2010a, page 2-2.
[247] US Army Corps of Engineers, 2010a, page 2-2.
[248] US Army Corps of Engineers, 2010a, page 2-4 and figure 2-2.
[249] US Army Corps of Engineers, 2010a, page 2-4.
[250] US Army Corps of Engineers, 2010a, page 2-4.
[251] Information from groundwater sampling forms in appendix E, US Army Corps of Engineers, 2009a.
[252] US Army Corps of Engineers, 2010a, page 2-5.
[253] US Army Corps of Engineers, 2009a, in response to agency comments, table RTC-1. High concentrations are higher than MCLs (EPA, 2006a).
[254] US Army Corps of Engineers, 2010a, page 1-1.

LHAAP-050
Former Waste Disposal Facility

LHAAP-050 (aka former Sump Water Tank) is a 1 acre site in the north-central portion of LHAAP[255]. Between 1955 and 1988 the site contained a 47,000-gallon aboveground storage tank[256]. The tank stored industrial wastewater from industrial waste sumps throughout LHAAP[257].

The site drains to Goose Prairie Creek[258], and the creek discharges to Caddo Lake approximately one and a half miles northeast of the site. Groundwater occurs approximately 20 feet below land surface[259].

Soils are contaminated with perchlorate[260]. Groundwater is contaminated with solvents (e.g., TCE, cis-1,2-DCE, vinyl chloride) and perchlorate[261].

The Army's preferred clean-up alternative is Alternative 2. Under this alternative, the most highly contaminated soils would be excavated and disposed in an off-site facility.[262] Natural attenuation (MNA) would be relied on to reduce concentrations of groundwater contaminants, and land use controls would be maintained until contaminant concentrations were reduced to acceptable levels[263].

The Caddo Lake Institute prepared written comments on the Final Proposed Plan for LHAAP-050. The comments were submitted to the Army in February 2010.

References

Shaw, 2009c, *Final Feasibility Study, LHAAP-50, Longhorn Army Ammunition Plant, Karnack, Texas*, November 2009.

US Army, 2010c, *Final Proposed Plan for LHAAP-50, Former Sump Water Tank, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas*, January 2010.

[255] US Army, 2010c, page 3.
[256] US Army, 2010c, page 3.
[257] US Army, 2010c, page 3.
[258] US Army, 2010c, page 4.
[259] US Army, 2010c, page 5.
[260] Shaw, 2009c, figure 2-1.
[261] Shaw, 2009c, figures 2-2 and 2-3.
[262] US Army, 2010c, page 10.
[263] US Army, 2010c, page 10.

LHAAP-054
(LHAAP-003-R-01)
Ground Signal Test Area

LHAAP-054 (aka LHAAP XX)[264] is an 80 acre site in the southeastern portion of LHAAP[265]. Beginning in 1963[266] the site was used to test or destroy pyrotechnic munitions (e.g., flares, signal devices, Illuminating mortar rounds), rocket motors, button bombs, and, perhaps, mines[267]. Expended mortar rounds, debris associated with pyrotechnic devices, and fuses have been found on the site. No high explosives have been found[268].

Approximately 70% of the site drains to Saunders Branch and the remainder drains to Harrison Bayou[269]. Both of these streams discharge to Caddo lake, approximately 2 miles from the site[270].

The site is underlain by interbedded sands, silts, and clays[271]. Groundwater occurs approximately 15 feet below land surface[272].

Three soil samples, and groundwater samples from two monitor wells were collected in 1982. No explosives or other organic contaminants were detected. However, shallow soils appear to have elevated concentrations of nitrate and metals (e.g., aluminum, barium, lead)[273].

High concentrations of cadmium (up to 9.99 µg/L) and thallium (up to 140 µg/L) were detected in samples from both monitor wells[274].

The Army plans to remediate the site by 1) establishing land use controls (LUCs)[275], and 2) searching[276] for and destroying explosive devices[277]. All explosive devices will be destroyed on site[278].

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[264] US Army Corps of Engineers, 1992a, page 3-191.
[265] US Army Corps of Engineers, 2008b, appendix I, page 1-2.
[266] US Army Corps of Engineers, 1992a, page 3-191.
[267] US Army Corps of Engineers, 2008b, appendix I, page 1-2; and US Army Corps of Engineers, 1992a, page 3-191.
[268] US Army Corps of Engineers, 2008a, page 9.
[269] US Army Corps of Engineers, 1992a, page 3-195.
[270] US Army Corps of Engineers, 1992a, page 3-195.
[271] US Army Corps of Engineers, 1992a, pages 3-192 and 3-195.
[272] US Army Corps of Engineers, 1992a, page 3-195.
[273] US Army Corps of Engineers, 1992a, page 3-201.
[274] US Army Corps of Engineers, 1992a, pages 3-199 and 3-200.
[275] LUCs would include signs warning of the possible presence of explosives, and a restriction on intrusive activities such as digging (US Army Corps of Engineers, 2008b, appendix I, pages 1-7 and 1-8).
[276] Geophysical instruments will be used to detect explosives (US Army Corps of Engineers, 2008a, pages 13 and 14).
[277] US Army Corps of Engineers, 2008a, pages 9 and 16.
[278] US Army Corps of Engineers, 2008a, page 17.

References

US Army Corps of Engineers, 1992a, *Longhorn Army Ammunition Plant, RI/FS Work Plan, Volume 1, General,* June 1992.

US Army Corps of Engineers, 2008a, *Final Explosives Safety Submission, Munitions and Explosives of Concern Removal Action, Longhorn Army Ammunition Plant (LHAAP), Karnack, Texas,* February 2008.

US Army Corps of Engineers, 2008b, *Land Use Control Plan for the MEC Removal Action at the Former LHAAP LHAAP-001-R (Site 27) and LHAAP-003-R (Site 54), Karnak, Texas*, July 2008.

LHAAP-058 (35A)
Maintenance Complex

LHAAP-058 (aka 35A, Shops Area), covers approximately 11 acres in the north-central portion of LHAAP[279]. LHAAP-058 began operating in 1942 and contained automotive, woodworking, metalworking, painting, refrigeration, and electrical shops, and a laundry [280]. The site stopped operating in 1997[281]. There are other sites are within the LHAAP-058 boundary: LHAAP-002 (vacuum truck overnight parking), LHAAP-003 (paint shop building 722 (waste collection)), LHAAP-060 (pesticide storage building), LHAAP-068 (mobile storage tank parking), and LHAAP-069 (service station underground storage tanks)[282].

The site drains to Goose Prairie Creek[283] and the creek discharges to Caddo Lake, approximately one and a half miles northeast of the site.

The Army has designated three groundwater zones at LHAAP-029: a shallow zone (depth ranges from 10 feet to 25 feet below ground surface (bgs)), an intermediate zone (60 feet - 71 feet bgs), and a deep zone (126 feet to 140 feet bgs)[284].

There are two plumes of contaminated groundwater at the site: an eastern plume and a western plume[285]. Groundwater is contaminated with VOCs (e.g., PCE, TCE, 1,1-DCE)[286] and metals (e.g., arsenic, selenium, thallium)[287].

The proposed remedies for the eastern plume are in-situ bioremediation, land use controls (LUCs), and monitored natural attenuation (MNA). The proposed remedies for

[279] US Army, 2010a, page 3.
[280] US Army, 2010a, page 3.
[281] US Army, 2010a, page 3.
[282] US Army, 2010a, page 3.
[283] US Army, 2010a, page 4.
[284] US Army, 2010a, pages 4 and 5.
[285] US Army, 2010a, page 5.
[286] Shaw, 2009a, appendix A, table A-1.
[287] Shaw, 2009a, appendix B.

the western plume are LUCs and MNA.[288] LUCs would be maintained until contaminant concentrations were reduced to acceptable levels [289].

The Caddo Lake Institute prepared written comments on the Final Proposed Plan for LHAAP-058(35A). The comments were submitted to the Army in February 2010.

References

Shaw, 2009a, *Final Feasibility Study, LHAAP-35A(58), Longhorn Army Ammunition Plant, Karnack, Texas*, December 2009.

US Army, 2010a, *Final Proposed Plan for LHAAP-35A(58), Shops Area, Group 4, Longhorn Army Ammunition Plant, Karnack, Texas*, January 2010.

LHAAP-067
Above Ground Storage Tank

LHAAP-067 is a 1.9 acre site in the central portion of LHAAP. Seven aboveground tanks were used to store fuel oil, kerosene, and solvents at the site[290]. The tanks have been removed[291].

The site drains to Central Creek[292], and the creek discharges to Caddo Lake approximately one and a half miles east of the site.

Groundwater at the site occurs from 17 feet to 20 feet below ground surface[293]. Groundwater is contaminated with TCE, 1,1-DCE, and 1,2-DCA[294].

Under the Army's clean-up plan, natural attenuation (MNA) would be relied on to reduce concentrations of groundwater contaminants, and land use controls would be maintained until contaminant concentrations were reduced to acceptable levels (MCLs)[295]. The estimated cost is $316,000[296].

The Caddo Lake Institute prepared written comments on the Final Proposed Plan for LHAAP-067. The comments were submitted to the Army in April 2010.

[288] US Army, 2010a, page 8.
[289] US Army, 2010a, page 9.
[290] Shaw, 2007c, page 1-1.
[291] United States Army, 2008b, page 7.
[292] United States Army, 2008b, page 7.
[293] United States Army, 2008b, pages 7 and 9.
[294] Shaw, 2007c, table 5-5.
[295] United States Army, 2008b, pages 12 and 17.
[296] United States Army, 2008b, page 13.

References

Shaw, 2007c, *Final Natural Attenuation Evaluation LHAAP-12, LHAAP-35B (37), and LHAAP-67, Longhorn Army Ammunition Plant, Karnack, Texas,* June 2007.

United States Army, 2008b, *Final Proposed Plan for LHAAP-35B (37), Chemical Laboratory and LHAAP-67, Aboveground Storage Tank Farm, Longhorn Army Ammunition Plant, Karnack, Texas*, June 9, 2008.

Pistol Range

The former Pistol Range covers approximately 0.4 acres in the southeastern portion of LHAAP. It was used by LHAAP security personnel for small arms target qualification and recertification. It was established in the 1950s and was used intermittently through 2004.[297]

High concentrations of arsenic, copper, lead, nickel, and zinc have been found in soils[298]. High concentrations of lead have been found in groundwater[299].

In August 2009, soil with lead concentrations greater than 1000 mg/kg was excavated and disposed off-site[300]. The excavation was backfilled with clean soil[301].

References

U.S. Army Corps of Engineers, 2009a, Final Engineering Evaluation/Cost Analysis, *Former Pistol Range, Longhorn Army Ammunition Plant, Karnack, Texas*, February 2009.

U.S. Army Corps of Engineers, 2009b, *Final Additional Investigation Results, The Pistol Range, Building 407 at LHAAP-46 (Plant 2 Area/Pyrotechnic Operations Area), Longhorn Army Ammunition Plant, Karnack, Texas*, February 2009.

U.S. Army Corps of Engineers, 2010a, *Final Record of Decision, Former Pistol Range, Longhorn Army Ammunition Plant, Karnack, Texas*, August 2010.

[297] U.S. Army Corps of Engineers, 2010a, page 2-1.
[298] High concentrations are greater than upper predicted limit of background soil concentrations (U.S. Army Corps of Engineers, 2009b, figure 2).
[299] High concentration is greater than the MCL (15 µg/L). 17.2 µg/L total lead in monitor well PRWW01 on 7/9/2007 (U.S. Army Corps of Engineers, 2009a, page 2-19).
[300] U.S. Army Corps of Engineers, 2010a, page 2-9.
[301] U.S. Army Corps of Engineers, 2010a, page 2-10.

LHAAP-001-R-01
South Test Area/Bomb Test Area (MMRP)

See LHAAP-027.

LHAAP-003-R-01
Ground Signal Test Area (MMRP)

See LHAAP-054.

Appendix 1
Scheduled Army Activities

Table A-1[302]
LHAAP Sites

Site ID	Site Name	Scheduled Activities	Recent Activities/Comments
LHAAP-001	Inert Burning Ground		RA completed and ROD/DD issued January 1998
LHAAP-004	Former Pilot Waste Water Treatment Plant	Begin RI/FS May 2011, Issue ROD/DD September 2011	
LHAAP-011	Suspected TNT Burial Site at P&Q Avenues		RA completed and ROD/DD issued January 1998
LHAAP-012	Active Landfill	RA/Closure 2040	ROD/DD issued July 2006
LHAAP-013	Suspected TNT Burial Site Between Active and Old Landfills		ROD/DD issued February 1996
LHAAP-014	Area 54W Burial Site		ROD/DD issued February 1996
LHAAP-016	Old Landfill	Issue ROD/DD December 2010	CLI comments submitted to Army November 2010
LHAAP-017	No 2 Flashing Area Burning Ground	Issue RD April 2011	ROD/DD issued November 2010 (?), CLI comments submitted to Army July 2010
LHAAP-018	Burning Ground / Rocket Motor Washout Pond	Begin RI/FS December 2010, Issue ROD/DD August 2011	
LHAAP-024	Former Unlined Evaporation Pond	Begin RI/FS December 2010, Issue ROD/DD August 2011	

[302] Most of the information in this table is from US Army, 2010a. The acronyms are defined in the glossary, Appendix 2.

Table A-1
LHAAP Sites (continued)

Site ID	Description	Scheduled Activities	Recent Activities/Comments
LHAAP-027 (LHAAP-001-R-01)	South Test / Bomb Test Area	Begin RI/FS September 2011	ROD/DD issued January 1998
LHAAP-029	Former TNT Production Area	Issue ROD/DD February 2011	
LHAAP-032	Former TNT Waste Disposal Plant		RA completed and ROD/DD issued August 2008
LHAAP-037 (35B)	Quality Assurance Lab Building 29-A	Complete RA January 2011	ROD/DD issued June 2010, RD issued October 2010? CLI comments submitted to Army April 2010
LHAAP-046	Plant 2/ Pyrotechnic Operation	Issue RD February 2011, Complete RA May 2011	ROD/DD issued September 2010, CLI comments submitted to Army February 2010
LHAAP-047	Plant 3/Hand Signal Assembly	Begin RI/FS December 2010, Issue ROD/DD August 2011	
LHAAP-049	Former Acid Plant		RA completed and ROD/DD issued September 2010
LHAAP-050	Former Waste Disposal Facility	Issue RD February 2011	ROD/DD issued September 2010, CLI comments submitted to Army February 2010
LHAAP-054 (LHAAP-003-R-01)	Ground Signal Test Area		RA completed and ROD/DD issued January 1998
LHAAP-058 (35A)	Maintenance Complex	Issue RD February 2011, Complete RA May 2011	ROD/DD issued September 2010, CLI comments submitted to Army February 2010

Table A-1
LHAAP Sites (concluded)

Site ID	Description	Scheduled Activities	Recent Activities/Comments
LHAAP-067	Above Ground Storage Tank	Complete RA January 2011	ROD/DD issued June 2010, RD issued October 2010, CLI comments submitted to Army April 2010
Pistol Range		Complete RA September 2015	ROD/DD issued September 2010
LHAAP-001-R-01 (LHAAP-027)	South Test/ Bomb Test Area (MMRP)	Begin RI/FS September 2011	
LHAAP-003-R-01 (LHAAP-054)	Ground Signal Test Area (MMRP)	Begin RI/FS September 2011	

Reference

US Army, *2010a, Longhorn Army Ammunition Plant Targeted GPRA Goals,* October 14, 2010.

Appendix 2
Glossary

Administrative Record: a collection of documents that contains all the information used to select a remedial action at a Superfund site.

Aquifer: A saturated geologic formation capable of transmitting an economically significant quantity of water.

Background water quality: The water quality that would exist if it were not affected by the area in question. Background groundwater quality is usually established by collecting samples immediately up-gradient of the area. Background surface water quality is usually established by collecting samples immediately upstream of the area. It is not the necessarily the same as native water quality (see below). Background water quality may be affected by human activity.

Biodegradation (biologic decay): The destruction of organic contaminants (e.g., TCE, toluene) by microorganisms. This process may convert one contaminant into another, e.g., TCE biodegrades to DCE, which biodegrades to vinyl chloride.

Bulk density: The density of a material, usually soil or rock, including pore spaces. The in-place or undisturbed density. For example, the density of the minerals that make up a soil may be 170 pounds per cubic foot. But the bulk density of the soil; including pore spaces, organic matter9 and minerals, may be 110 pounds per cubic foot.

Capillary fringe: A zone immediately above the water table. The water in this zone is held by capillary forces and cannot flow freely. Portions of the capillary fringe may be saturated.

COC: Chemical of concern. A chemical that has the potential to adversely affect human health or the health of other organisms. At contaminated sites, COCs are the contaminants that are to be cleaned-up. That is, the remedial action is designed to reduce COC concentrations to acceptable levels, e.g., MCLs.

COPC: Chemical of potential concern.

Dehalogenation: The removal of a halogen atom (e.g., chloride, fluoride) from a molecule.

Discharge: The movement of water out of a. groundwater system. Water may be discharged naturally through springs and evapotranspiration, or through man made structures such as wells and drains.

Dispersion: The dilution of a contaminant due to spreading of the contaminant plume. The spreading occurs in all directions; parallel to the flow (longitudinal dispersion) and perpendicular to flow (transverse dispersion). It is caused by variations in groundwater

flow directions and speeds. An analogous processes is the spreading (dispersion) of a plume of smoke from a smokestack.

DNAPL: Dense Non-Aqueous Phase Liquid. Liquids that are more dense than water. Hence, they tend to sink to the bottom of aquifers. Most chlorinated solvents (e.g., TCE, DCE) are DNAPLs. DNAPLs are liquids, sometimes referred to as 'pure product'. They should not be confused with solutes - contaminants that are dissolved in the groundwater. For example, TCE may be exist as a pure product (DNAPL) or as a solute dissolved in the water.

EcoPRG: Ecological preliminary cleanup level.

Effective porosity (also·see porosity): The amount of interconnected porosity available for the transmission of fluids. Effective porosity is expressed as a ratio or percentage. In most materials, effective porosity·and total porosity are nearly equal. However, some materials, such as clays, have high total porosities but low effective porosities because the pore spaces are too narrow to allow water to flow freely. In other materials, such as volcanic rocks, the pore spaces may not be interconnected.

Graphical User Interface (GUI): A computer program. Pre-processor and post-processor tools that allow modelers to automate some aspects of model design (e.g., grid generation, calibration), integrate optimization tools with models, and create maps of model results.

GWP-Ind: State of Texas health-based standard. Groundwater concentration limit for industrial use. When applied to soils, it is the concentration limit to prevent unacceptable concentrations of contaminants from leaching from soils into underlying groundwater.

HI: Hazard index. A measure of the health risk associated with all non-carcinogenic COCs at a site. The HI is the sum of the hazard quotients for all COCs to which an individual is exposed. A HI value of 1.0 or less indicates that no adverse non-cancer human health effects are expected to occur.

HQ: hazard quotient. A measure of the health risk associated with a single non-carcinogenic COC at a site. Each HQ is a comparison of an estimated chemical intake (dose) with a reference dose level below which adverse health effects are unlikely. The HQ is expressed as the ratio of the estimated intake (numerator) to the reference dose (denominator). The value is used to evaluate the potential for non-cancer health effects, such as organ damage, from chemical exposures.

Hydraulic conductivity: A measure of the ability of a material allow water to flow through it. The higher the hydraulic conductivity of a material, the easier it is for water to flow through it. Hydraulic conductivity is expressed as length per unit time (e.g., feet per day, centimeters per second).

Hydraulic head: The elevation of water in a well. Groundwater flows from areas of higher hydraulic head·to areas of lower hydraulic head. Hydraulic head is a measure of the energy of groundwater and is the sum of two components: elevation head and pressure head.

LNAPL: Light Non-Aqueous Phase Liquid. Liquids that are less dense than water. Hence, they float on the water table. Common LNAPLs include oil, gasoline, and diesel fuel. LNAPLs are liquids, sometimes referred to as 'pure product'. They should not be confused with solutes - contaminants that are dissolved in the groundwater. For example, gasoline may exist as a free product floating on the water table. Some of the components of gasoline (e.g., benzene, toluene) may also exist as solutes dissolved in groundwater.

LUC: Land use control.

MCL: Maximum contaminant level. The US EPA drinking water standard. The maximum concentration of a contaminant allowed in drinking water. MCLs are legally enforceable limits.

MDL: Method detection limit). Tthe minimum concentration of an analyte that the laboratory can measure and report with 99% confidence that the analyte concentration is greater than zero. The MDL is determined by the laboratory for each analyte in a given matrix (water, soil, or vapor. It is a measure of the concentration an instrument can detect or ‘see’ in a given matrix.

MNA: Monitored natural attenuation.

NPL: National Priorities List. The list of hazardous waste sites eligible for remedial action under the federal Superfund program. US EPA regulations outline a formal process for assessing hazardous waste sites and placing them on the NPL. The list is based primarily on the score a site receives from the Hazard Ranking System. Only sites that are on the NPL may be cleaned-up using money from Superfund.

NAPL: Non-Aqueous Phase Liquid. General term that includes DNAPLs and LNAPLs. NAPLs are liquids, sometimes referred to as 'pure product'.

Native water quality: Water quality unaffected by affected by human activity. Not necessarily the same as background water quality (see above).

Organic: Derived from plant or animal materials.

Organic carbon: Carbon derived from organic sources (e.g., plant material). Distinguished from carbon derived from non-organic sources (e.g., atmospheric carbon dioxide, carbonate minerals). Organic carbon sorbs organic contaminants.

Oxidation: The addition of oxygen to an atom or molecule, or the removal of electrons from an atom or molecule.

Partition coefficient: A measure of the degree to which a solute is adsorbed. Solutes with higher partition coefficients (e.g. TCE) are more strongly adsorbed (i.e., bound to the solid material of the aquifer) and migrate more slowly (are more retarded) than contaminants with lower partition coefficients (e.g., vinyl chloride). For organic contaminants, the partition coefficient increases as the amount of solid organic carbon in an aquifer increases.

Porosity: A measure of void space in a material. The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment. Voids may be spaces between sand grains, fractures, or solution cavities. In the saturated zone, the void spaces are completely filled with water. In the unsaturated zone, the voids are filled with water and air.

Precipitation (chemical): The combination of solutes to form a solid material. Metals often precipitate, as when dissolved iron and carbonate combine to form the mineral siderite. Precipitation reactions are often not reversible, and the precipitated contaminant is permanently removed from the groundwater.

Recharge: The entry of water into a groundwater system. Recharge often occurs along streambeds, mountain fronts, and through the bottoms of playas.

RA: Remedial action.

RD: Remedial design.

Reduction: The addition of electrons to an atom or molecule.

Retardation: Due to sorption, most contaminants move more slowly than the groundwater which transports them. Their movement is said to be retarded with respect to the groundwater.

Retardation coefficient: A measure of retardation - the rate at which a solute travels through a groundwater system, compared to the velocity of the groundwater. The ratio of the groundwater velocity to the solute velocity. A solute with a retardation coefficient of 2 moves at 1/2 the velocity of the groundwater that is transporting it.

RI/FS: Remedial investigation/feasibility study.

ROD/DD: Record of decision/decision document.

SAI-Ind: State of Texas health-based standard for soil. Concentration for industrial use based on inhalation, ingestion, and dermal contact.

Saturated zone: A zone where the void spaces are completely filled with water or some other liquid.

SDL: Sample detection limit (aka SQL: sample quantitation limit). The MDL adjusted to reflect sample-specific actions, such as dilution or use of smaller aliquot sizes than prescribed in the analytical method, and taking into account sample characteristics and sample preparation. It is a measure of the concentration an instrument can detect or 'see' in a given sample.

Sensitivity study: A test of a model's response to changes in parameter values or assumptions (e.g., hydraulic conductivity, boundary conditions).

Sink, groundwater: See discharge.

Solute: A substance dissolved in a liquid.

Sorption: A process that binds, usually temporarily, a contaminant to a mineral surface or to organic matter. This temporary binding acts to reduce (retard) the contaminant migration rate with respect to the groundwater. Sorption is a general term used to encompass the processes of absorption and adsorption.

Source, groundwater: See recharge.

SPLP: Synthetic precipitation leaching procedure. A chemical test in which a liquid (synthetic precipitation) is passed through solid materials (e.g., soils, wastes). The liquid is then analyzed to determine what the concentrations of constituents (e.g., metals, pesticides) it picked up (leached) as it passed through the solids. SPLP tests are often performed to determine whether infiltrating precipitation could carry contaminants in soils to underlying groundwater.

Storage coefficient: A measure of the ability of an aquifer to store and release water. The volume of water an aquifer releases from or takes into storage, per unit surface area of the aquifer, per unit change in hydraulic head.

SVOC: Semi-volatile organic compound.

Unsaturated zone: A zone where the void spaces are not completely filled with water or some other liquid.

Vadose zone: The unsaturated zone plus the capillary fringe immediately above the water table. The capillary fringe may be saturated.

VOC: Volatile organic compound.

Volatilization/Vaporization: The formation of gasses that may emerge from soil or water as vapors.

2-D model: A model that simulates flow or contaminant transport in two space dimensions. The dimensions may be horizontal or vertical (cross section).

3-D model: A model that simulates flow or contaminant transport in three space dimensions.