

8.0 REMEDIATION AND TREATMENT TECHNOLOGIES

PRINCIPAL FINDINGS

- The most common treatment technologies for EDB are air sparging, soil vapor extraction (SVE), and groundwater pump and treat with granular activated carbon
- 31 LUST sites in South Carolina are using MNA to address EDB and other contaminants
- Seven LUST sites in Kansas are using SVE in combination with air sparging or free product recovery to remediate EDB and other contaminants
- Costs for the corrective actions at the seven LUST sites in Kansas ranged from approximately \$70,000 to \$204,000.

Soil and groundwater contaminated with EDB and EDC have been treated at both Superfund and non-Superfund sites. This section focuses primarily on summarizing information about treatment of EDB contamination. In addition, because information is more readily available for treatment technology use at Superfund sites, this report focuses more on Superfund sites than non-Superfund sites.

To gather information about treatment technologies for EDB and EDC contamination, the following sources were reviewed:

- "Treatment Technologies for Site Cleanup: Annual Status Report, Eleventh Edition" (ASR) – <http://clu.in.org/asr> (Ref. 8-9)
- Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) – <http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm> (Ref. 8-10)
- Federal Remediation Technologies Roundtable, Cost and Performance Case Studies – <http://www.frtr.gov/costperf.htm> (Ref. 8-2)
- State data from Kansas and South Carolina (see Section 7.0) (Refs. 8-3, 8-4)

8.1 TREATMENT TECHNOLOGIES FOR EDB CONTAMINATION

The treatment technologies most commonly used for EDB contamination are air sparging, SVE, and pump and treat (P&T) with granular activated carbon. The following sections provide site-specific information about the treatment of EDB contamination.

8.1.1 Superfund Sites

The ASR includes information about remedial technologies used at final and deleted National Priorities List (NPL) or "Superfund" sites. Based on the ASR, four Superfund sites are treating or have treated EDB contamination using remedial technologies. Site information and remedial technologies used at the sites for treatment of EDB contamination are summarized in Table 8-1.

The projects have included source control and groundwater treatment as well as the use of in situ and ex situ treatment technologies. The remedies were selected in the Records of Decision (ROD) for the sites from 1988 to 1999. Contamination at these sites resulted from fuel-related activities or agricultural chemical applications. The sites are discussed in more detail below.

Table 8-1: Treatment of EDB Contamination at Superfund Sites (1988 to 2003)

Site Name, State	Site Type	Contaminants	Technology	Status
Otis Air National Guard Base, Fuel Spill 12, MA	Petroleum, Oil, and Lubricant (POL) Line	BTEX, EDB	P&T	Operational
		BTEX, EDB	Air sparging	Completed
		BTEX, EDB	SVE	Completed
T.H. Agriculture and Nutrition Site, GA	Pesticide Manufacturing, Use, and Storage	Aldrin, beta-hexachlorocyclohexane (BHC), dichlorodiphenyl-trichloroethane (DDT), dieldrin, lindane, toxaphene, xylene, EDB, pesticides	P&T	Operational
Hastings Groundwater Contamination Site, NE	Agricultural Applications	Carbon tetrachloride, EDB	SVE	Completed
			P&T	Operational
Fort Wainwright, AK	Aboveground Storage Tank, Drum Storage and Disposal, Dry Cleaners, POL Line, Spill, Underground Storage Tank, and Vehicle Maintenance	EDC, benzene, EDB, gasoline, toluene, trichloroethene	Air sparging	Operational
			SVE	Operational

Source: Ref. 8-9

One additional site, the Bangor Naval Submarine Base in Washington, is analyzing groundwater for EDB contamination as part of a remedy using monitored natural attenuation (MNA). If MNA does not achieve the remedial goals, a contingent remedy such as enhanced bioremediation or P&T may be conducted at this site (Ref. 8-9).

According to EPA's Superfund database (CERCLIS), three additional Superfund sites have reported EDB as a contaminant of concern: Lawrence Livermore National Laboratory, Brown & Bryant Inc., and Lowry Landfill (Ref. 8-10). Projects addressing EDB at these sites are not currently included in the ASR, and information was not readily available (Ref. 8-9). Additional information on the sites from Table 8-1 is provided below.

Otis Air National Guard Base

At the Otis Air National Guard Base in Massachusetts, a pipeline carrying jet fuel and aviation gasoline since 1965 leaked in 1972. Nearly 70,000 gallons of aviation fuel were released into the soil. The area of soil contamination came to be known as Fuel Spill 12. Groundwater contamination was first discovered in 1990 when the nearby water district detected hydrocarbon odors in two exploratory wells installed off base. The contaminants were identified as BTEX and EDB. In 1993, the source area was defined as being approximately 11 acres in size. The petroleum contamination in subsurface soil was estimated to be present in a 10- to 20-foot layer above the water table. The leak resulted in a contaminant plume that was about 4,800 feet long; a maximum of 2,000 feet wide; 60 to 130 feet thick; and more than 90 feet below the ground surface. The plume had a maximum EDB concentration of 600 µg/L (Ref. 8-1).

Air sparging and SVE were selected in a 1996 action memorandum to treat petroleum-derived hydrocarbon contamination in the soil. The objective of the removal action was to prevent migration of benzene and EDB from soil to groundwater. The cleanup standards for EDB were based on Massachusetts Method 1 Cleanup Standards of 0.005 mg/kg for soil and the state MCL of 0.02 µg/L for groundwater. The air sparging and SVE system operated from October 23, 1995 to February 25, 1998 when monitoring revealed that soil and groundwater concentrations of EDB were below the cleanup standards. During system operation, compressed air was injected into the subsurface through 23 air sparging wells and withdrawn through 23 SVE wells. Oxygen in the air stimulated bioremediation in the subsurface. The SVE system thermally destroyed BTEX using catalytic oxidation. Because EDB is not readily removed by thermal oxidation and to prevent a release of EDB to air, gases from the catalytic oxidation unit were passed through a carbon adsorption unit. From October 1995 to February 1998, approximately 45,000 pounds of BTEX and EDB were removed and treated (Refs. 8-1 and 8-9).

In addition to air sparging and SVE, P&T was selected to address deeper groundwater contamination. The 1995 interim ROD, which selected P&T as a remedy, set the cleanup goal for EDB in groundwater at 0.02 µg/L based on the state MCL. The P&T system includes 25 extraction wells and 23 reinjection wells. The P&T system started operating in September 1997 and treats over 1 million gallons of groundwater per day. Extracted groundwater is treated using granular activated carbon to remove organic contamination. The system originally included ultraviolet (UV) oxidation in addition to the granular activated carbon. However, in November 1997, the UV oxidation unit was taken off line because concentrations of organic compounds (including EDB) were not high enough to warrant its use. A system modification performed in December 2000 included converting an existing reinjection well into an extraction well to remove zones of EDB contamination west of the main plume. The total flow rate of the system is 688 gallons per minute. From September 1997 to December 2001, 131 pounds of EDB and 270 pounds of benzene were removed from the groundwater. The plume's size has decreased significantly, and it is estimated that 97 percent of both the benzene and EDB has been removed. Based on May 2002 sampling results, EDB concentrations in the source area have been reduced from more than 500 µg/L to less than 20 µg/L since system startup. EDB concentrations in the western area of the site have been reduced from 2.2 µg/L to 0.045 µg/L (Refs. 8-1 and 8-9).

T.H. Agriculture and Nutrition Superfund Site

The 12-acre T.H. Agriculture and Nutrition Superfund site consists of two former pesticide formulation facilities that were used from the 1950s until the 1980s. Removal activities began at the site in 1982. During the remedial investigation and feasibility study for the site, the potentially responsible parties found pesticides and other organic contaminants in soil and groundwater. A pit containing pure pesticide product was also found. The removal action included excavation of contaminated soil, with some soil being treated by low-temperature thermal desorption in 1999. Contaminants of concern at the site include DDT, toxaphene, alpha-BHC, beta-BHC, aldrin, dieldrin, and EDB (Refs. 8-8 and 8-9).

In 1993 and 1996, RODs were issued that selected P&T for Operable Unit (OU) 1 and 2 to address groundwater contamination at the site. The groundwater cleanup standard for EDB is the federal MCL (0.05 µg/L). Construction of the P&T system for OU1 was completed in spring 1997, and the system is expected to operate for at least 20 years. The treatment system consists of a light non-aqueous phase liquid (LNAPL) separator, a microfilter, and granular activated carbon. EDB concentrations ranged from 1.5 to 1,200 µg/L in groundwater samples collected from 1994 through 2001. During a sampling event in 2001, EDB concentrations in the groundwater ranged from nondetect to 600 µg/L. An estimated 480 pounds of contaminants, including 7 pounds of contaminants of concern (such as EDB), have been removed by the system. Approximately 3.5 million gallons of groundwater have been treated. However, after 5 years of system operation, there has been little change in the contaminant concentrations and plume size. LNAPL is still present at the site and is not being captured by the P&T system. Annual operation and maintenance (O&M) costs for this P&T project total about \$200,000 (Refs. 8-8 and 8-9).

Limited information is available about the P&T system for groundwater at OU2. This system was constructed in 1999. Soil contamination is still present in the area, and the extent of this soil contamination's impact on groundwater is currently being evaluated (Ref. 8-8).

Hastings Groundwater Contamination Superfund Site

The Far-Mar-Co portion of the Hastings Groundwater Contamination Superfund site stored and handled agricultural products, mostly grains, for more than 30 years. EDB and carbon tetrachloride are the primary contaminants of concern for this OU. A ROD was issued in 1988 that selected SVE to remediate soil contamination at the OU. The volume of contaminated soil to be treated was approximately 34,000 cubic yards (to a depth of 120 feet). SVE was conducted from 1997 until 2002 (2 years after the goals for the OU were met). Annual O&M costs for the SVE system ranged from \$40,000 to \$186,000 from 1997 through 2002 (Refs. 8-5, 8-7, and 8-9).

In addition, P&T was selected to treat contaminated groundwater at this OU. The maximum EDB concentration found in the groundwater was 220 µg/L. The P&T system processes 450 gallons of groundwater per minute. Since its startup in 1997, the system has treated over 1 billion gallons of groundwater and removed 14 pounds of EDB (Ref. 8-7).

Fort Wainwright

The West Quartermaster's Fueling System (WQFS) area at Fort Wainwright is divided into four subareas (WQFS 1 through 4). This summary focuses on the remedial actions at WQFS-1. Vehicle maintenance activities, spills, and leaks from former fuel storage facilities are the primary sources of petroleum contamination in the subarea. Soil and groundwater samples collected in this subarea contained diesel range organic, gasoline range organic, solvent, and benzene contamination. According to the 5-year review report issued in 2001, EDB had recently been detected at concentrations exceeding remedial action objectives in groundwater samples collected at WQFS-1. EDB had not been detected in this subarea at the time of the ROD's issuance. Monitoring for EDB will be incorporated into the long-term management plan for the subarea (Refs. 8-6 and 8-9).

A treatability study was begun in spring 1997 that involved use of a horizontal well air sparging/SVE system. This system was expanded by adding vertical probes in summer 1998. The system removed over 227,000 pounds of VOCs in 2000 and had a thermal/catalytic oxidizer efficiency of 99.5 percent. A second air sparging/SVE system was selected for a remedial action in a 1999 ROD. The contaminant plume to be addressed by this system was approximately 7.5 acres in size, and the groundwater depth ranged from 12 to 18 feet below ground surface. The system began operating in August 1999 and removed 43,000 pounds of VOCs during its first 2 years of operation. Soil heating (using six-phase heating and radio frequency heating) to enhance this system was evaluated in 1999 but was not found to be cost-effective. In 2000, all abandoned, buried fuel lines at WQFS-1 were purged and capped (Refs. 8-6 and 8-9).

8.1.2 Additional Sites Addressing EDB

Data provided by SC DHEC included thirty-one LUST sites in South Carolina that are using MNA to address EDB as well as other contaminants. Information about remedial performance was not available for these sites (Ref. 8-4).

Data obtained from KDHE for seven LUST sites indicated SVE in combination with air sparging or product recovery was being used to treat EDB and other contaminants (Ref. 8-3). Six of these seven sites are using SVE and air sparging to treat the contamination present, and one site is using SVE with product recovery. Costs for the corrective actions at these seven sites range from approximately \$70,000 to \$204,000. A summary of total treatment costs for these sites is presented in Table 8-2. The costs are for the treatment of various contaminants present at the sites and are not for EDB alone. Based on the source documents, the volumes of soil treated and the treatment performance at these 7 LUST sites are not available (Ref. 8-3).

Table 8-2: Treatment Costs at Seven LUST Sites in Kansas

Site ID No.	Technology (No. of wells)	Corrective Action Cost (\$)	O&M Cost (\$)
U1 086 0910	SVE (5) and AS (3)	91,420	60,000
U2 087 0288	SVE (3) and AS (9)	79,813	18,000
U2 087 13363	SVE (3) and AS (10)	80,960	27,213
U2 078 01344	SVE (2) and AS (3)	82,329	38,000
U6 091 221	SVE (12) and AS (4)	203,902	48,400
U6 020 628	SVE (5) and AS (3)	68,372	52,800
U6 083 194	SVE (16) and PR (3)	985,200	240,000

Source: Ref. 8-3

Notes:

AS: Air sparging

O&M: Operation and maintenance

PR: Product recovery

SVE: Soil vapor extraction

One Federal Remediation Technologies Roundtable (FRTR) case study was identified that describes remediation of EDB contamination. According to this case study, the Campbell Street Fuel Farm site at the Marine Corps Air Station, Camp Lejeune, in North Carolina is using groundwater P&T with granular activated carbon to treat EDB. The P&T system was implemented in 1996 and continues to operate. The maximum EDB concentration in groundwater between December 1996 and March 1999 was 3.5 µg/L, while the cleanup level for EDB is 0.004 µg/L. The P&T system removed little cumulative contaminant mass during this period (less than 3.5 pounds over 2.5 years), and there is little evidence that the system is contributing significantly to the restoration of the aquifer. Active remediation may be discontinued at the Campbell Street Fuel Farm, because only low levels of contaminants are currently being recovered and no source materials remain at the site (Ref. 8-2).

8.2 TREATMENT TECHNOLOGIES FOR EDC CONTAMINATION

According to data in the ASR, remediation of EDC contamination is more common than EDB-related remediation. A total of 70 Superfund sites have performed or are performing treatment of EDC contamination. Table 8-3 lists the technologies used to address EDC at these sites. Note that some sites have more than one technology. The projects involve both source control and groundwater treatment as well as in situ and ex situ treatment technologies. These remedies were selected in RODs issued from 1985 to 2002. Additional information about the sites and remedies is presented in Appendix B (Ref. 8-9).

Table 8-3: Summary of EDC Contamination Treatment at Superfund Sites (1985 to 2002)

Technology	Number of Superfund Projects
P&T (treatment not specified)	33
P&T (with air stripping)	12
Air sparging	10
SVE	8
Bioremediation (in situ)	5
Multiphase extraction	3
Chemical treatment	2
Bioremediation (ex situ)	1
Flushing	1
Incineration	1
Phytoremediation	1
P&T (with carbon absorption)	1
Thermal desorption	1
Thermally enhanced recovery	1
TOTAL	80

Notes:

Some sites use more than one treatment technology.

P&T: Pump and treat

SVE: Soil vapor extraction

Source: Ref. 8-9

8.3 REFERENCES

- 8-1 Air Force Center for Environmental Excellence/Massachusetts Military Reservation (MMR). 2003. "Second Five-Year Review (1998-2002). MMR Superfund Site, Otis Air National Guard Base, Massachusetts." Accessed on September 2, 2004. On-Line Address: <http://www.mmr.org>
- 8-2 Federal Remediation Technologies Roundtable (FRTR). 2004. Remediation Case Study Searchable Database. Website Accessed on August 31, 2004. On-Line Address: <http://www.frtr.gov/costperf.htm>
- 8-3 Kansas Department of Health and Environment (KDHE). 2004. Analytical Data for Sites in Kansas. (see Appendix A-1)
- 8-4 South Carolina Department of Health and Environmental Control (SCDHEC). 2004. Analytical Data for Sites in South Carolina. (see Appendices A-2 and A-3)
- 8-5 U.S. Environmental Protection Agency (EPA). 1988. "Record of Decision. Hastings Groundwater Contamination, Hastings, Nebraska." September 28.
- 8-6 EPA. 2001. "Five-Year Review. Fort Wainwright, Alaska." September 25.

- 8-7 EPA. 2002. "Five-Year Review. Hastings Groundwater Contamination, Hastings, Nebraska." July.
- 8-8 EPA. 2003. "Five-Year Review. T.H. Agriculture, Albany, Georgia." March.
- 8-9 EPA. 2004. "Treatment Technologies for Site Cleanup: Annual Status Report, Eleventh Edition." EPA-542-R-03-009. Accessed on August 31, 2004. On-Line Address: <http://cfpub.epa.gov/asr/search.cfm>
- 8-10 EPA. 2004. Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). Website Accessed on August 31, 2004. On-Line Address: <http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm>