Tibbetts Road

Excavation—Ex-Situ Thermal Treatment—In Situ Chemical Oxidation—Monitored Natural Attenuation—Multiphase Extraction—Phytoremediation—Pump and Treat

Site Name: Tibbetts Road
Site Location: Barrington, New Hampshire
Technology Used:

- Excavation
- Ex-Situ Thermal Treatment (ESTT)
- In Situ Chemical Oxidation (ISCO) (Sodium Permanganate)
- Monitored Natural Attenuation (MNA)
- Multiphase Extraction (MPE)
- Phytoremediation
- Pump and Treat (P&T)

Regulatory Program: U.S. EPA Superfund NPL site
Remediation Scale: Full
Project Duration: 1986 to present

Site Information: The site consists of about two acres of land in a rural, residential neighborhood with nearby pockets of dense forested areas. The property originally contained a single family residence. Between 1945 and 1958, the owner is reported to have transported numerous drums containing wastes from industrial processes, primarily from automobile production and painting, to his property for storage and use. Contamination was discovered at the site in 1982.

Contaminants: The groundwater is contaminated with volatile organic compounds (VOCs), including benzene, trichloroethene (TCE), toluene, xylenes, and arsenic. Soil was contaminated with solvents, polychlorinated biphenyls (PCBs), and dioxin. See Table 1 for maximum concentrations detected in soil and groundwater.

Hydrogeology: The site is on a drainage divide that diverts the groundwater flow in two directions. The overburden aquifer, which is heterogeneous, consists of glacial fill, a mix of gravel, silt, and sand. The aquifer is about 20 to 30 ft thick and is underlain in the general vicinity of the site by a 50 ft thick lodgement till of compacted silt/clay resembling a dense concrete. The lodgement till is practically impervious to groundwater and limits groundwater flow into the underlying bedrock aquifer; however, the aquitard pinches out to the northeast, which allows a greater degree of contamination to reach the bedrock.

The bedrock, which formerly served as a drinking water aquifer, is highly fractured to depths ranging from 5 to 40 ft below the top of the rock. While the rock is more competent with depth, the remaining fracture zones are capable of producing over 100 gallons per minute (gpm).

Table 1. Maximum Concentration Levels Detected for Select Contaminants

Contaminant	Soil (mg/kg)	Overburden Groundwater (µg/L)	Shallow Bedrock (µg/L)
Acetone	NA	27,000	17,000
Arsenic	NA	97	26
Benzene	17	6,300	3,100
2-Butanone	NA	1,887	6.8
1,2-Dichloroethene	NA	18,000	4,000
Ethylbenzene	720	4,700	4,000
Lead	270	21	NA
Manganese	NA	14,900	NA
Methylene chloride	NA	1,200	3,400
4-Methyl-2-pentanone	NA	96,000	76,000
Naphthalene	NA	440	ND
Polychlorinated biphenyls (PCBs)	9,570	NA	NA
Tetrachloroethene	57	<5,000	<5,000
Toluene	1,000	140,000	30,000
1,1,1-Trichloroethane	NA	<5,000	<5,000
Trichloroethene	2,700	27,000	<5,000
Xylenes	NA	29,000	5,000D

D=Dilution; ND=Not detected; NA=Not given in report

Source: ATSDR 1994 and U. S. EPA 2003

Groundwater in both the overburden and bedrock aquifers on the southwestern portion of the site flows to the west, and on the northeastern two-thirds of the site, it flows to the east. The depth to water varies from near the surface in the fall and spring to 7 ft or more below ground surface (bgs) in the summer.

Project Goals: The Record of Decision (ROD) proposed the following goals:

- Prevent the ingestion of contaminated groundwater.
- Prevent further migration of contaminated groundwater to uncontaminated portions of the overburden and bedrock aquifers.
- Cleanup contaminated groundwater in the overburden and bedrock aquifers to federal and state Applicable or Relevant and Appropriate Requirements, including drinking water standards (Maximum Contaminant Levels).
- Prevent dermal contact, ingestion, or inhalation of contamination found on site.

Cleanup Approach: In 1986, before the remedial investigation and feasibility study, drums were removed and obviously contaminated soil was excavated and disposed of offsite. The excavated areas were regraded with clean fill and covered with a geotextile. Loam soil placed over the geotextile was seeded, and a chain-link fence was erected around the site. Dioxin-contaminated soil, which was discovered during soil sampling, was stored on site until a mobile incinerator could be obtained to destroy it.

A water supply system was constructed initially to provide drinking water to the 45 homes with contaminated wells or wells that could become contaminated to prevent ingestion of contaminated groundwater. In 1993, the water supply system was expanded to include several additional residences nearby. The local water district also issued institutional controls forbidding the use of the aquifer for drinking water in the vicinity of the site.

Soil and groundwater treatment began in 1995 with the installation of extraction wells and a MPE system. The configuration of the MPE system included a liquid-ring pump, a 150-gallon knockout tank, a centrifugal-type transfer pump, a cartridge-type particulate bag filter, a pair of 100 lb liquid-phase granular activated carbon drums in series, and a pair of 100 lb vapor-phase granular activated carbon drums in series. The liquid-ring pump was designed to recover both groundwater and soil gas from the extraction wells. The air/water mixture from the extraction wells would then flow into the knockout tank where the vapors would pass through two vapor-phase carbon drums prior to being discharged into the atmosphere. Groundwater in the knockout tank was to be pumped through a particulate filter bag and then through two liquid-phase carbon drums before being discharged to the ground surface at the site.

The system envisioned in the 1992 ROD included a flocculation unit for treating inorganic contaminants. However, the pilot study showed that vacuum extraction caused geochemical changes in the aquifer that removed the metal contaminants while they were still in the aquifer. The introduction of air into the aquifer and recovery well stripped the VOC contaminants from the groundwater. The result was an air stream contaminated with VOCs and a stream of extracted groundwater that met EPA's cleanup levels. The vacuum extraction system rarely recovered more than 5 gpm during the remedy and usually recovered 3 gpm or less. Therefore, it was only necessary to treat the air stream with vapor-phase granular activated carbon. This change resulted in the construction of a much smaller treatment system. As a precaution, the recovered groundwater was filtered through carbon prior to discharge to the overburden aquifer.

The MPE system operated for about three years before it was turned off due to declining contaminant recovery efficiencies. At the time of shut off, contaminant levels in two of the three areas of concern had reached their cleanup goals. The third area of concern apparently has pockets of contamination that the MPE was not addressing.

Because of declining levels of contaminants, EPA investigated alternative technologies to replace the MPE system in 1997. A microcosm study showed that anaerobic biodegradation was completely degrading those contaminants subject to anaerobic degradation pathways.

Other evidence showed that phytoremediation could retard contaminated groundwater flow in the overburden aquifer. As a result, The ROD was amended in 1998 to provide for primary treatment of the overburden and bedrock aquifers using bioremediation and phytoremediation and 1,400 poplar trees were planted on the site. An intensified groundwater monitoring program was also initiated to help determine degradation rates and the contribution of the trees to those rates.

As a result of studying groundwater contamination patterns at the site, a new bedrock groundwater extraction well was added in 2001, and two older wells were closed. Contaminant levels in the new well were relatively high (e.g., 34,000D[1] µg/L 4-methyl-2-pentanone, 30,000 µg/L toluene, and 5,600D µg/L benzene).

During the following year, about 92,873 gallons of groundwater from the new well and two wells from the southwest side of the site were treated at an average flow rate of 0.61 gpm.

Phytoremediation and MNA had been allowing contaminated water to leave the site. Thus, a pilot study was conducted in 2003 using ISCO injection with sodium permanganate as an alternative to phytoremediation, and MNA in the contaminated bedrock and shallow overburden of the northeast section of the site. The sodium permanganate treatments were continued through 2006.

While considerable progress has been made in reducing concentrations of contaminants in the overburden, the concentrations in the bedrock have not been decreasing as quickly. Four new bedrock wells were installed in 2011 and a series of packer pumping tests were conducted to evaluate fracture zone continuity. As a result of these tests, the Agency plans to initiate a pilot recirculation well remedial system in 2012 using persulfate.

Figure 1. Poplar Trees at Tibbetts Road

Source: U.S. EPA

Project Results: The groundwater and soil vapor treatment systems recovered about 800 lbs of contaminants, and cleanup levels have been met in several areas of the site.

The poplar trees have succeeded in reducing the gradient of the overburden groundwater. The trees also provide more time for onsite bioremediation.

ISCO, which involved periodic sodium permanganate treatments, has greatly reduced contamination in the overburden aquifer but has not succeeded in remediating the bedrock aquifer.

The Agency expects to implement an ISCO (persulfate) recirculation well treatment system in the bedrock source area in 2013. The goal will be to reduce the contaminant concentrations to values compatible with MNA.

Sources:

Agency for Toxic Substances and Disease Registry. 1994. Public Health Assessment Tibbetts Road Barrington, Strafford County, New Hampshire, CERCLIS No. NHD989090469. http://www.atsdr.cdc.gov/hac/pha/pha.asp?docid=1195&pg=0

ARCADIS. 2012. Summary of Environmental Monitoring 2011 Tibbetts Road Site Barrington, New Hampshire.

[1] D=Sample was diluted to bring concentration within the instrument's range; hence, the true value may be somewhat higher or lower.

http://www.epa.gov/region1/superfund/sites/tibbetts/509899.pdf

U.S. EPA. Tibbetts Road Site Description web-page. U.S. Environmental Protection Agency. Accessed April 2, 2013. http://yosemite.epa.gov/r1/npl_pad.nsf/701b6886f189ceae85256bd20014e93d/c875c2d48055e87a8525691f0063f6fe!OpenDocument

U.S. EPA. 1992. Record of Decision: Tibbetts Road, EPA ID: NHD989090469, OU 01 Barrington, NH, 09/29/1992. U.S. Environmental Protection Agency, 49 pp. http://www.epa.gov/superfund/sites/rods/fulltext/r0192068.pdf

U.S. EPA. 1998. Record of Decision Amendment: Tibbetts Road, EPA ID: NHD989090469 OU 01, Barrington, NH, 09/28/1998. U.S. Environmental Protection Agency, 69 pp. http://www.epa.gov/superfund/sites/rods/fulltext/a0198117.pdf

U.S. EPA. 2003. First Five-Year Review Report for the Tibbetts Road Superfund Site Town of Barrington Stafford County, New Hampshire. U.S. Environmental Protection Agency, 76 pp. http://www.epa.gov/superfund/sites/fiveyear/f03-01015.pdf

Project Contacts:

Darryl Luce
U.S. EPA Remedial Project Manager
Phone: 617-918-1336
Email: luce.darryl@epa.gov