Cascade Corporation

Pump and Treat—Dual Phase Extraction—Soil Vapor Extraction—Air Sparging—Phytoremediation—Biostimulation—Bioremediation Barrier Wall

Site Name: Cascade Corporation
Site Location: Troutdale, Oregon
Technology Used:

- Pump and Treat (P&T)
- Dual Phase Extraction
- Soil Vapor Extraction (SVE)
- Air Sparging (AS)
- Phytoremediation
- Bioremediation with Biostimulation
- Bioremediation Barrier Wall (Mulch)

Regulatory Program: Oregon Department of Environmental Quality
Remediation Scale: Full
Project Duration: 1991 to present

Site Information: The 47-acre Cascade forklift manufacturing facility has operated continuously at the site since 1956. Between 1956 and 1963, the production facility included a paint booth, a parts and hydraulic cylinders assembly area, and a maintenance shop. From 1963 to 1966, the facility was expanded to incorporate nickel and chrome electroplating operations and vapor degreasing of parts. The vapor degreaser was removed in 1975 and replaced by hot water and biodegradable soaps for cleaning of parts.

Contaminants: Wastes from the parts machining and cleaning were land disposed onsite in several areas. Spent trichloroethene (TCE) was reportedly discharged to the ground in two locations. These areas are currently beneath the production facility, which expanded after these disposal practices occurred. TCE and its degradation products are the principal groundwater contaminants (Table 1). Source areas for TCE contamination were not sampled because they are under the operating facility.

In addition, sludges from the degreaser tank and cutting oils were disposed near the former underground storage tank (UST) location and the edge of the parking lot located west of the production facility. Both of these areas are now beneath the current limits of the paved parking lot. Light non-aqueous phase liquids (LNAPL) or floating product was discovered near the former UST location in 1995. LNAPL has been detected in two monitoring wells at thicknesses of up to 1 ft. LNAPL has not been observed in any other areas. The LNAPL is believed to be used cutting oils and to contain chlorinated solvents. TCE was detected in a sample of the LNAPL at a concentration of 26,000 parts per million (ppm) (2.6%). The LNAPL serves as a long-term source of dissolved-phase volatile organic compound (VOC) contamination to groundwater.

Table 1. Maximum Contaminant Concentration Detected in Groundwater (µg/L)	
Tetrachloroethene	1300
Trichloroethene	33,000
1,2-Dichloroethene	55,000
Vinyl Chloride	106
Chromium	172

Hydrogeology: Geologic units under the site include Quaternary deposits and the Tertiary Troutdale Formation. The Quaternary deposits are less than 15 ft thick and consist of unconsolidated gravel with silt, sand and clay. The Troutdale Formation is an interbedded clastic deposit of volcanic and fluvial origin consisting of silt, clay, sand, sandstone, siltstone and conglomerate.

Hydrogeologic units beneath and in the vicinity of the site, listed in order of increasing depth, are the Troutdale Gravel Aquifer (TGA), confining unit one (CU1), the Troutdale Sandstone Aquifer (TSA), confining unit two (CU2), and the Sand and Gravel Aquifer (SGA). CU1 and CU2 are aquitards that separate the TGA from the TSA and the TSA from the SGA, respectively (Figure 1).

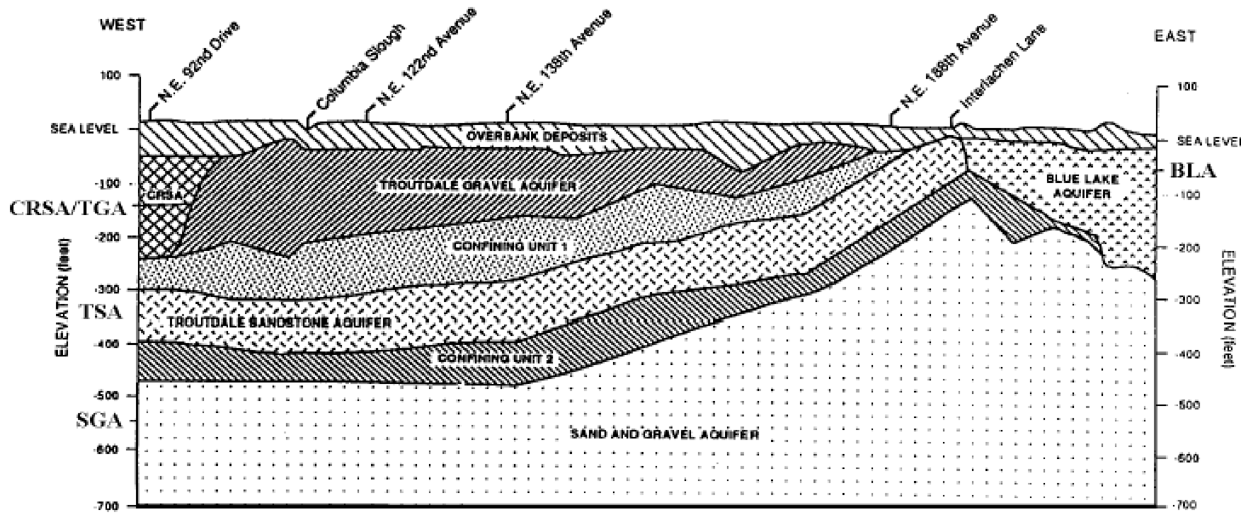

Figure 1. Generalized Geologic Cross Section

Source: Wells 1996

CU1 is estimated to be more than 60 ft thick beneath the southern portion of the site. It gradually thins to less than 15 ft in thickness north of the site, being thinner near the erosional boundary. CU1 is 40 to 45 ft thick near the north property boundary. It consists of interbedded siltstone and claystone; sandstone interbeds are common within CU1.

Groundwater in the TGA at the site is shallow and discharges at an erosional face in the form of springs.

Project Goals: The remedial action goals set for cleanup included:

- Restore the TGA to background or the lowest protective concentrations, if feasible, in a reasonable time. If this is not feasible, minimize the areal extent of the TGA that contains contaminants above maximum contaminant levels (MCLs). MCLs for the target contaminants are given in Table 2.
- Prevent ingestion of TGA groundwater or surface water that contains contaminants at concentrations above MCLs or acceptable risk-based cleanup levels.
- Protect environmental receptors by preventing discharge of TGA groundwater to surface water at VOC concentrations that may exceed ambient water quality criteria.
- Prevent direct contact with unsaturated soil that has contaminant concentrations exceeding risk-based protective cleanup levels.

Table 2. Maximum Contaminant Levels for Chemicals of Concern (µg/L)

Tetrachloroethene	5
Trichloroethene	5
cis-1,2-Dichloroethene	70
Vinyl Chloride	2
Chromium (total)	100

Cleanup Approach: Contaminated groundwater was discovered in 1988 at an adjacent facility during an impoundment closure. Subsequent investigation indicated that a number of private water supply wells were contaminated with TCE and that the contaminant plume encompassed both facilities. Alternative water supplies were provided to the owners of the impacted supply wells and a three well pump and treat system was installed to prevent further migration of the plume offsite. A fourth well was added in 1994 and a monitoring well was converted to an extraction well bringing the total to five.

The contaminated aquifer discharges to springs whose overland travel serves to recharge a lower aquifer. A 400-ft interception trench was placed across the upper aquifer in 1995 to intercept any offsite flow of contaminated plume water and cut off the water to the springs. Extracted groundwater was treated using a packed-column air stripper.

In 2001, approximately 800 poplar trees were planted downgradient of the French drain but upgradient of the springs. The trees are intended as a polishing step for the shallow contaminated water that exists downgradient of the drain system. The trees were planted in a configuration that is sufficiently long so that water entering the root zone during their dormant season will not be able to exit before the trees become active again in spring.

Extraction wells placed in the LNAPL zone captured both LNAPL and groundwater and pumped the mixture to an oil water separation tank.

The ROD augmented the extraction well system bringing the total to 18. The full system (including the drain) originally pumped and treated approximately 10 million gallons of water a year. Continuous full-scale groundwater extraction well operation continued through April 2003 and was followed by pulse pump operation of source area extraction wells through May 2006. After this time, source area extraction ceased while onsite downgradient perimeter extraction continued. The system uses a packed column air stripper. Treatment of the stripped vapors is not required.

To remediate the vadose zone source areas, a combined remedy was specified. It included installation of 21 SVE wells. In addition, air sparging wells were placed in the vicinity of the SVE extraction wells to strip the high concentration VOCs from source area groundwater. An evaluation of the SVE contaminant throughput revealed that the air sparging system was contributing very little additional contaminant load to the system and it was shut down in the spring of 1999. The SVE system was subsequently shut down in October 1999 because of asymptotic recovery concentrations. It was restarted in June 2000 using pulse pumping because of rebound and operated through April 2003, when stable levels protective of groundwater were achieved. The SVE system used activated carbon to treat off-gas.

An evaluation of the groundwater monitoring data showed that contaminant concentrations at several areas on the site were not appreciably falling as they were elsewhere. This indicated the potential for a source zone in the saturated soil beneath the main building. A pilot test of emulsified oil was carried out to determine if biostimulation would be effective at the site. In June 2006, full-scale biostimulation was conducted using 82,509 gallons of an emulsified oil/water solution in one area (Prowell 2007) and a sodium lactate solution in another area. Two more biostimulation events were planned but after the second was carried out, the concentrations fell to a level that the third treatment was not considered necessary. The biostimulation was proposed and carried out without reopening the ROD.

Also in 2006, with contaminant concentration levels offsite falling considerably, the interception trench was expanded by 80 ft and converted to a mulch biobarrier. Biobarriers are much cheaper to operate and maintain than pump and treat systems especially when the contaminant concentration per gallon of water is very small.

Project Results: Remedial activities both onsite and offsite have reduced concentrations in the contaminant plume to where the French drain system could be converted to a biobarrier, which has considerably reduced the pump and treat costs. The biobarrier allows water to flow through it thus restoring some flow to the springs. Maximum TCE concentrations (2.6 μg/L) in the springs in November 2006 were below remedial objective levels (Prowell 2007).

The poplar tree field is established and acting as a polishing step for the residual contamination in the upper aquifer that lies between the springs and the biobarrier. Although its effectiveness in removing contaminants has not been fully evaluated, it has been fairly effective in reducing water flow to the springs and seeps along the erosional face of the TGA (Prowell 2007).

Average TCE concentrations near onsite source areas dropped 22 to 61% in 2006 from 2005 levels. Average groundwater concentrations of contaminants of concern in the TCE disposal source area, which was the object of aggressive biostimulation activities, were below remedy cleanup levels (5 µg/L for TCE).

Average groundwater concentrations of TCE between the onsite P&T wells and the biobarrier have dropped to 5.2 µg/L.

The site has been systematically turning off downgradient extraction wells as the groundwater reaches cleanup goals. The Oregon DEQ and Cascade expect the site to reach cleanup goals by 2013 at which point DEQ will issue a no further action order (DEQ 2011).

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