



## Combined Remedies for Improved DNAPL Cleanup Performance

### Project Summary

TRS Group, Inc. (TRS) teamed with KEMRON and AMEC, under KEMRON's U.S. Army Corps of Engineers (USACE) Environmental Remediation Services Multiple Award Task Order Contract (MATOC), to perform electrical resistance heating (ERH) for the remediation of volatile organic compounds (VOCs) in the vadose zone soil and shallow groundwater at Operable Unit 1 (Well 12A) of the Commencement Bay – South Tacoma Channel Superfund site in Tacoma, Washington. The remediation was conducted in cooperation with USEPA, USACE and WA Department of Ecology.

The intent for this project was to design and implement In Situ Thermal Remediation (ISTR) within the designated ISTR treatment zone beneath and in the vicinity of the former Time Oil Building. The specific ISTR treatment goals were:

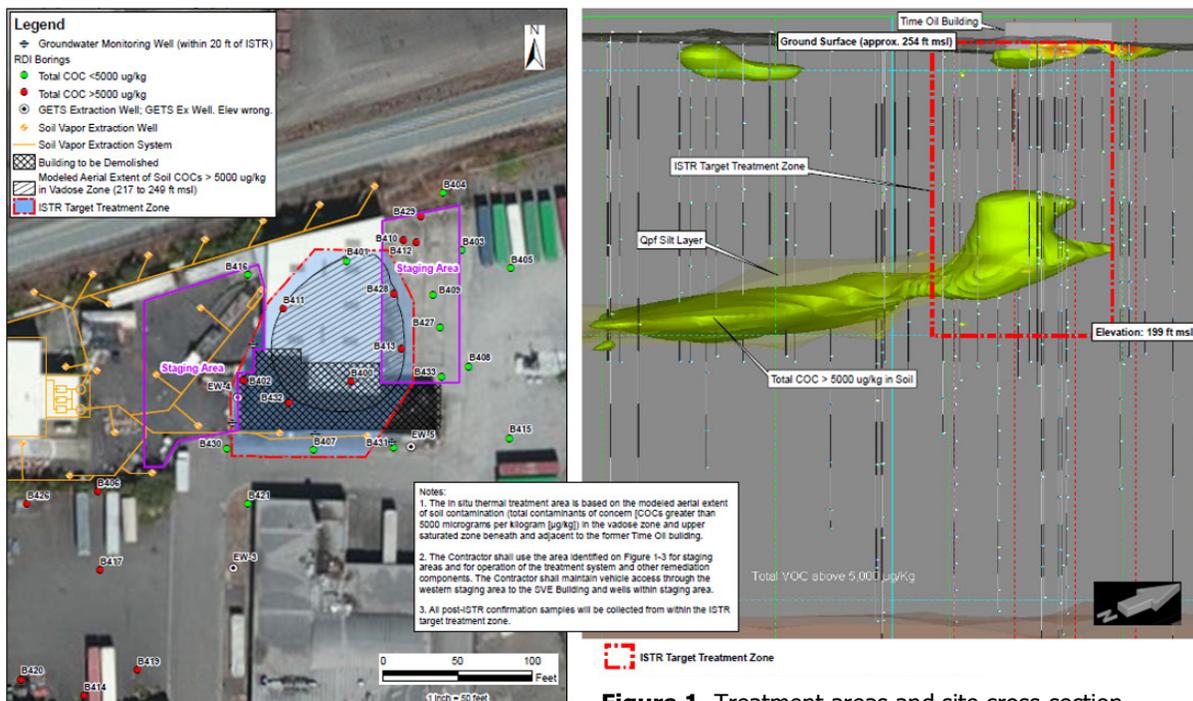
- A 90% reduction in average soil concentrations, based on all samples collected in the vadose and saturated zones.
- No soil sample shall have a concentration that exceeds 10 mg/kg.
- No more than 50% of the soil samples shall exceed the average soil concentration.

### Background

The Well 12A site has been undergoing remediation since 1983 to address releases of chlorinated volatile organic compounds and petroleum hydrocarbons from historical operations at the site, including: paint and lacquer thinner manufacturing, oil recycling and reprocessing, and canning of oil. Previous remedial actions included:

- Air stripping treatment at municipal supply well 12A (1983-present)
- Shallow soil excavation (1986, 1991-1992, 2011-2012)
- Groundwater extraction and treatment (1988-present)
- Soil vapor extraction (1993-1997)

USEPA completed a focused feasibility study in 2009 to analyze potential remedial alternatives to address ongoing contamination at the Well 12A site (CDM Smith, 2009). The 2009 Record of Decision Amendment #2 provided an amended remedy and additional remedial action objectives. The selected amended multi-component remedy includes continued operation of the groundwater extraction and treatment system (GETS), continued wellhead treatment at Well 12A, excavation and disposal of filter cake and shallow contaminated soil east of the former Time Oil Building, in situ thermal remediation (ISTR), enhanced anaerobic bioremediation (EAB), institutional controls, and long-term plume monitoring with a contingency for monitored natural attenuation, shown on Figure 1 below. The right panel depicts a cross-section of the site.





## Project Results

The tables below provide the baseline conditions in the thermal treatment zones and the soil concentration goals and corresponding percent reductions results post ISTR/ERH.

**Table 1.** Baseline Conditions

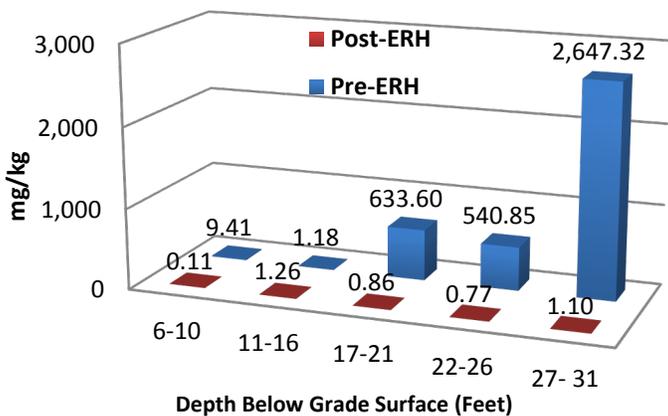
	Baseline ISTR Vadose Zone	Baseline ISTR Saturated Zone	Baseline ISTR Treatment Zone
Mean soil concentration assuming data for 6 VOCs <sup>1</sup>	6.6 mg/kg	37.5 mg/kg	17.0 mg/kg
Maximum soil concentration assuming data for 6 VOCs <sup>1</sup>	66.9 mg/kg	568.1 mg/kg	568.1 mg/kg

**Table 2.** ISTR Treatment Results

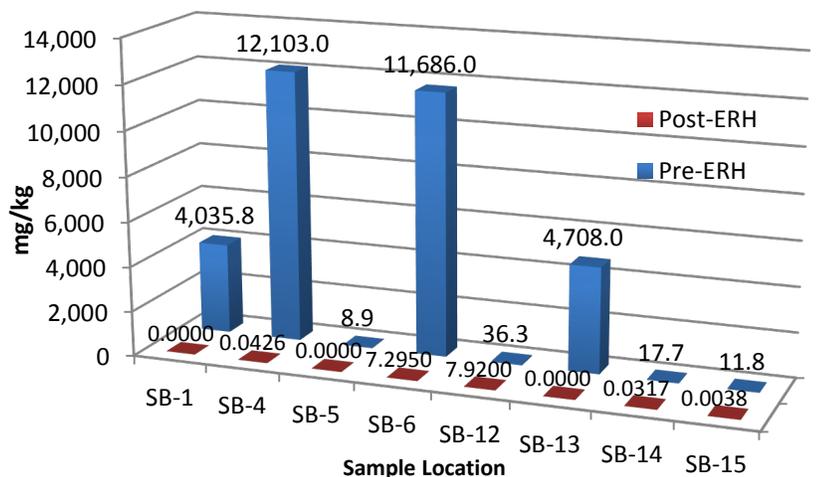
	Post ISTR Vadose Zone	Post ISTR Saturated Zone	Post ISTR Treatment Zone	ISTR remediation Goal
Mean soil concentration assuming data for 6 VOCs <sup>1</sup>	0.66 mg/kg	3.75 mg/kg	1.7 mg/kg	Achieve a 90% reduction
Maximum soil concentration assuming data for 6 VOCs <sup>1</sup> , % (Reduction % at 10 mg/kg)	85%	98%	98%	No sample can exceed 10 mg/kg
Percentage of samples that exceed the mean assuming data for 6 VOCs <sup>1</sup>	NA	NA	14%	No more than 50% can exceed the average concentration

<sup>1</sup>Total VOCs are the sum of the six primary VOC contaminants of concern, which include 1,1,2,2-PCA; cis-1,2-DCE; trans-1,2-DCE; TCE; PCE; and VC from 65 soil samples collected from borings including B400, B401, B402, B407, B411, B413, B428 and B432 with n=43 samples collected in the Vadose Zone and n=22 samples collected in the Saturated Zone.

Figure 3 below shows total pre and post ERH CVOC concentrations in soil by treatment depth. Figure 4 depicts total CVOC concentrations pre and post ERH by sample location.

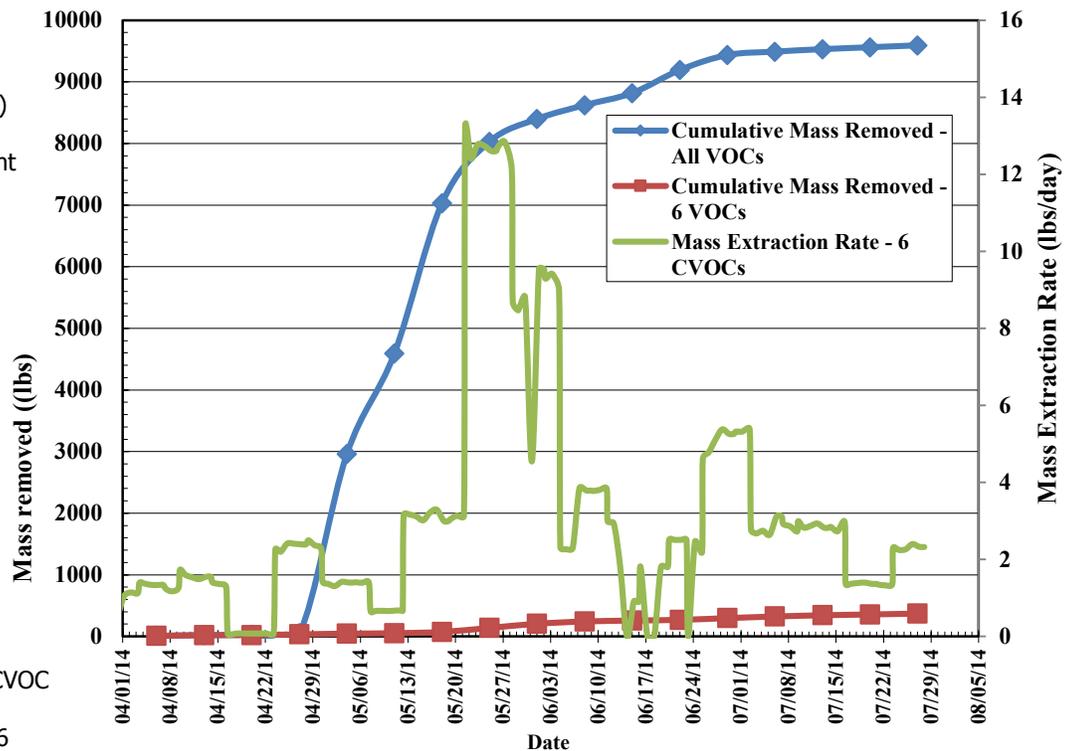


**Figure 3.** Pre/Post ERH - CVOC concentrations by depth



**Figure 4.** Pre/Post ERH of total CVOCs by soil boring

In addition, throughout ERH operations data was collected concurrent with vapor phase granular activated carbon (VGAC) influent samples for laboratory mass extracted. As expected, influent concentrations and total mass extracted increased with increasing temperatures until a maximum extraction rate was observed in late May 2014. Once significant drops in mass extraction were observed, TRS began optimizing the system through increased drip addition to the shallow and deep vadose zones and increasing energy application to shallow soils and the edges of the TTZ. These adjustments resulted in a secondary peak that occurred in late June 2014. Figure 5 shows CVOC mass extracted and CVOC mass extraction rates in vapor for the 6 primary CVOCs.



**Figure 5.** Vapor CVOC mass extraction rate and total

It is estimated that a minimum of 31,898 pounds of total contaminant mass was recovered. This estimate includes total mass in vapor phase (shown above), water, NAPL, and vapor-phase aliphatic hydrocarbons.

### Heat Enhanced Bioremediation

In 2015, TRS working with CDM Smith are planning to perform low temperature, heat enhanced bioremediation of two distinct NAPL hot spots at the Well 12A site that are down gradient of the former ERH remediation area for the purpose of enhancing reductive dechlorination of the target VOCs in these remaining source areas. The target temperature range for the low temp ERH is 35°C to 70°C. Significant cost savings will be realized by eliminating the need for a vacuum blower, steam condenser, and vapor/water treatment. The target treatment area and subsurface interval are 2,000 square feet and 48 to 56 ft bgs, respectively. The resulting treatment volume is 600 yd<sup>3</sup>. The low temperature ERH system will operate for 365 days.

### Summary

<i>TRS Project Manager/Senior Project Manager:</i>	<i>Jeff Brink/Lynette Stauch</i>
<i>TRS Project Engineer</i>	<i>Jake Seeman</i>
<i>Site Geology and Hydrology:</i>	<i>Sand, gravel, clay, and silt. Groundwater on average 33 ft bgs</i>
<i>Treatment Area Size, Volume, and Depth:</i>	<i>13,700 ft<sup>2</sup>; 27,900 yd<sup>3</sup>; and average 2 to 55 ft bgs</i>
<i>Beginning Contaminant Concentrations:</i>	<i>Average Total CVOCs – 766 mg/kg</i>
<i>Remedial Goal(s):</i>	<i>90% reduction in all VOCs; all confirmatory samples &lt;= 10 mg/kg; &lt;= 50% can exceed the average VOC concentration</i>
<i>Actual Cleanup Achieved:</i>	<i>Average Total CVOCs – 0.82 mg/kg or 99.9% reduction Removed approximately 31,898 pounds of contaminant mass, including VOCs and LNAPL</i>
<i>Period of Performance:</i>	<i>April – July 2014; 117 operation days</i>
<i>Contract Terms:</i>	<i>Standard Fixed Price Remediation (SFPR)</i>

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