Thin Treatment Depths: *A thorn in thermal's side*

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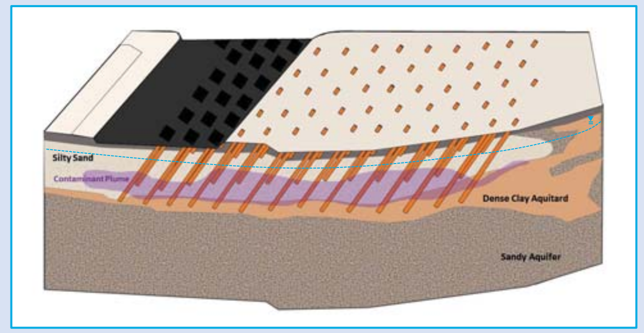
Complex Site Features

The Case Study Site presented herein, contained a 15,595-ft^2 area of contaminated soil and groundwater extending from 2 to 11-ft bg, providing an impacted volume of 5,198- cy. Contaminants of concern (COCs) included PCE with appreciable amounts of BTEX and gasoline range total petroleum hydrocarbons (TPH-G). Several site attributes made remediation efforts technically challenging and required unique design and operational considerations.

The shallow treatment depth, small Vadose zone, and shallow confining aquitard demanded that electrodes be installed on an angle.

Contamination source area extended beneath a busy public road where subsurface utilities, including AT&T's main West coast fiber-optic and communication conduit are buried within the treatment volume , requiring special design considerations to minimize traffic impairments, thermal impacts, and electro-magnetic interference (EMI) to the buried utilities.

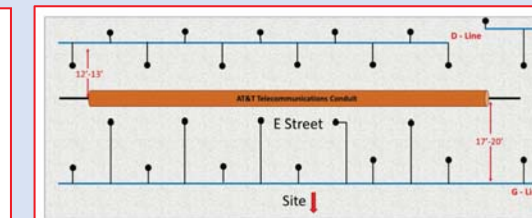
Design Considerations

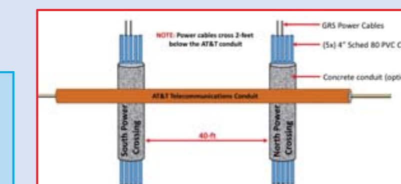


The required level of residual energy necessary to reach the remedial goals on a specific site dictates overall system design, total project energy requirements, and remediation timeline. Historically, if a treatment interval is too thin, the effective vertical heat loss out the top and bottom of a treatment interval can be too great to overcome with engineering measures. Installing electrodes at a 35º angle allowed the ERH system to effectively flux ~25% more power to the treatment volume, than would have been permitted by a typical vertical installation.

	Electrode Length	Surface Area	Power Flux	Power Flux Per Electrode	System Power Flux
Vertical Electrodes	11-feet	26.7- ft^2	0.18-kW/ft^2	4.806-kW	492-kW
Angled Electrodes	13.43-ft	34.34-ft^2	0.18-kW/ft^2	6.180-kW	612-kW

Mitigating EMI to AT&T Telecom Line





Magnetic field generated by the electrode cables running parallel to AT&T conduit where noise is maximized because the angle of incidence is zero:

It is possible for minor disruption to occur at as low as 10 milligauss

$$B = \frac{\mu I(10000)}{2\pi r} \qquad B = \frac{(1.25X10\text{-}6\ kg/sec^2amp^{-1})(25\ amps)(10000)}{2\pi(1.22\ meters)}$$

Where:

- μ = site specific magnetic permeability of the surrounding soil (1.25X10-6 kg/sec2-amp)
- *I* = current in amperes
- r = shortest distance away from the conductor (m)

10 Amps Power		25 Amps Power	
Distance (ft)	EMI (Gauss)	Distance (ft)	EMI (Gauss)
3	0.0220	3	0.054
4	0.0160	4	0.041
5	0.0129	5	0.033
10	0.0065	10	0.016
15	0.0044	15	0.011

Steps Towards Mitigating EMI

Keep Currents **Low**

- 10-25 Amps

Keep Distance from ERH Cable **Large** when crossing Parallel to Conduit

- Min. 4-ft
- Bundle cable to cancel EMF

Run cable perpendicular to the AT&T conduit

- Running perpendicular to the magnetic field, pickup is minimized.

PROJECT OUTCOME

Remediation goals were reached and the project site was closed in early 2017. Confirmatory sampling results showed an overall reduction of PCE in site soil of 99.75% and ~99% in groundwater. Angled electrodes allowed for increased electrode surface area and ultimately permitted higher energy flux into the thin treatment depths, thus allowing the system to overcome vertical heat loss impacts without an engineered site cap. Similarly, engineering controls put in-place during system installation and operation allowed the ERH system to operate without impacting the inter-state telecommunication lines or traffic patterns on the busy city street.