MULTIPHASE APPROACH TO REMEDIATION USING SUBSURFACE FRACTURING, SURFACE EXTRACTION AND MODIFIED FENTON CHEMISTRY

ABSTRACT

In-situ chemical oxidation with modified Fenton chemistry in conjunction with subsurface fracturing and surface extraction was utilized to effect the remediation of 11,325 m^3 of diesel and gasoline impacted soils and groundwater at a 24 hour operated trucking terminal. The remediation was performed during working hours without disrupting terminal operations. Free phase Liquid Petroleum Hydrocarbons (LPH) covered an area extending approximately 1100 m^2. The average thickness of product detected in the monitoring wells sampled and monitored was calculated to be 0.75m. Therefore, the estimated volume of the LPH plume was determined to be approximately 825 m^3. In ten months the average thickness of LPH was reduced 94% while total dissolved phase PHC's were reduced by 96% demonstrating that a multi-phased remediation approach is possible without facility or business disruption.

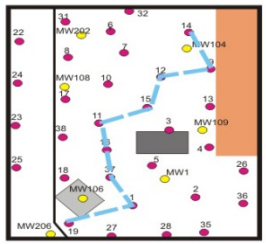
BREAKDOWN OF TECHNOLOGIES

- **Sub-surface Fracturing:** high pressure hydraulic fracturing of sub-surface formation (silty clay and silty sand) with sand emplacement in a biodegradable suspension. Fractures were placed at 5, 6 and 7 meters below ground surface (bgs).
- **Surface Extraction of LPH:** vacuuming LPH with a vacuum truck from the injection wells and sumps.
- **Modified Fenton's Chemistry:** utilizing stabilized liquid hydrogen peroxide to oxidize LPH in the dissolved and soil phase.

OXYTEK

OXY TEKNOLOGIES INC.

Sampling Interval: Day 1



BH or MW

OxyTek Injection Well

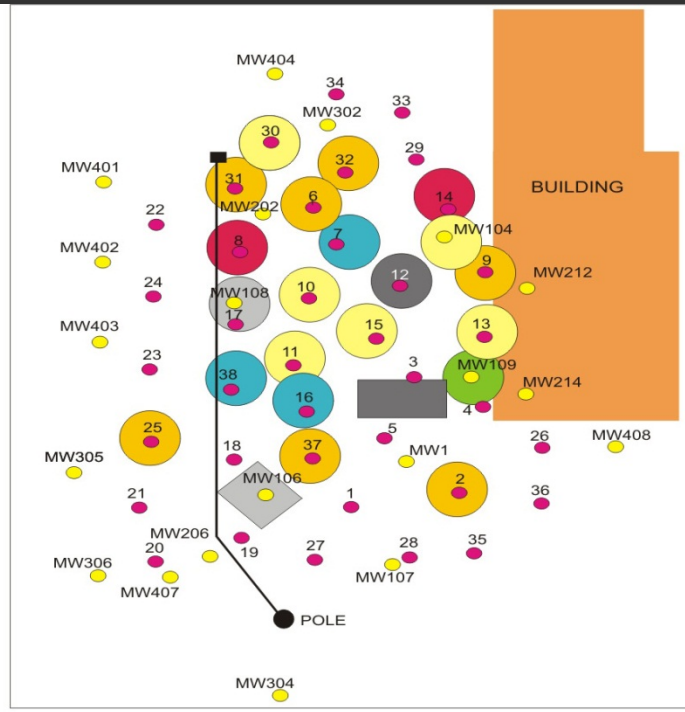
Fracture injection ROI

Gravel

Sand

Sandy silt

Silt



RADIUS OF INFLUENCE PER INJECTION WELL IS ~ 5 M

MONITORING WELL

OXYTEK INJECTION WELL

FREE PHASE PRODUCT MEASURED IN WELL (cm):

OILY SHEEN TO < 2.54 cm (1")

2.54 to <7.62 cm (1" to < 3")

7.62 to <15.24 cm (3" to < 6")

15.24 to <30.48 cm (6" to < 12")

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61 to <90 cm

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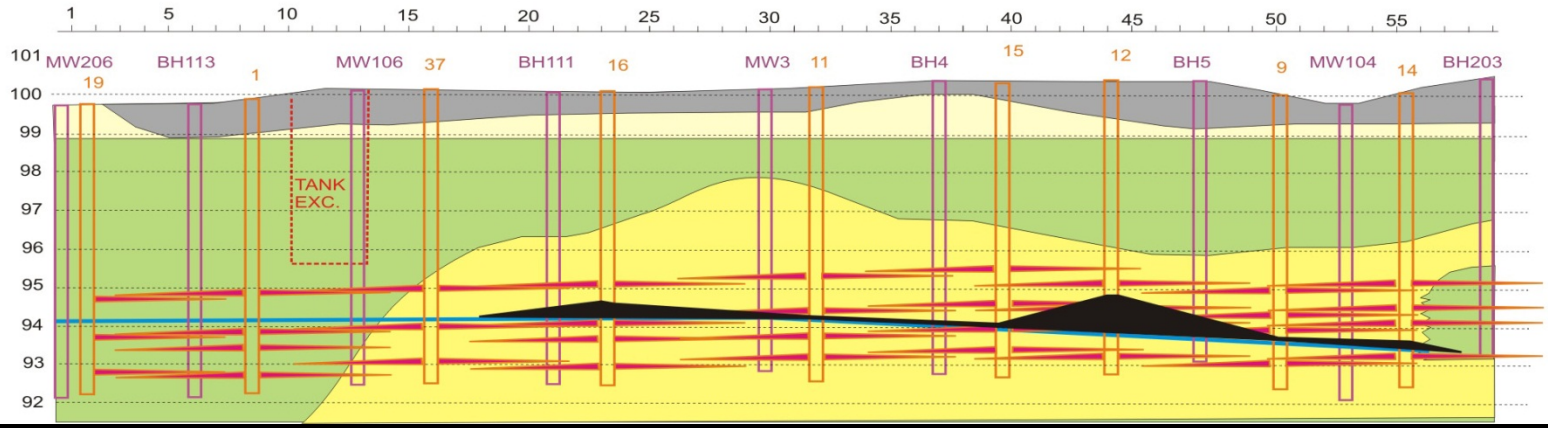

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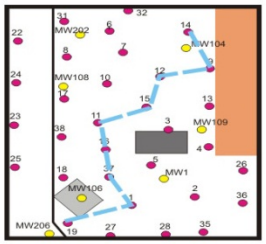
Sampling Interval: Feb 28



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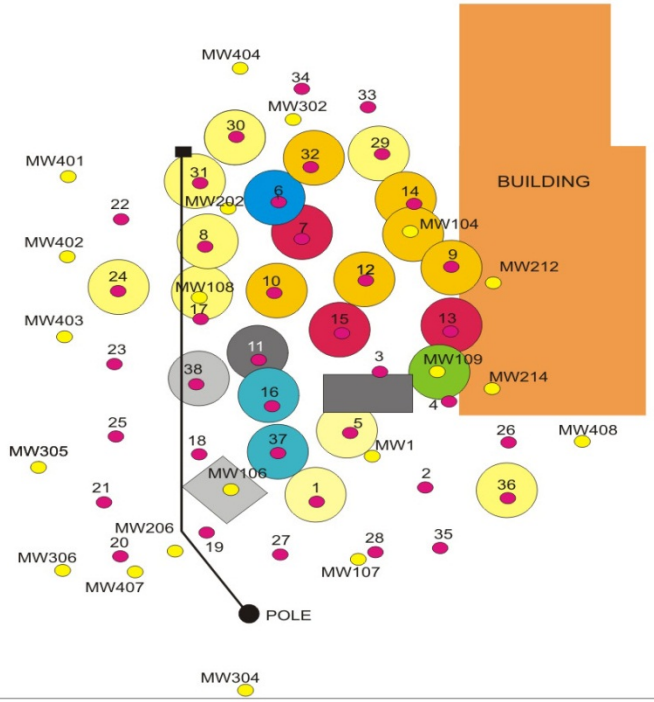

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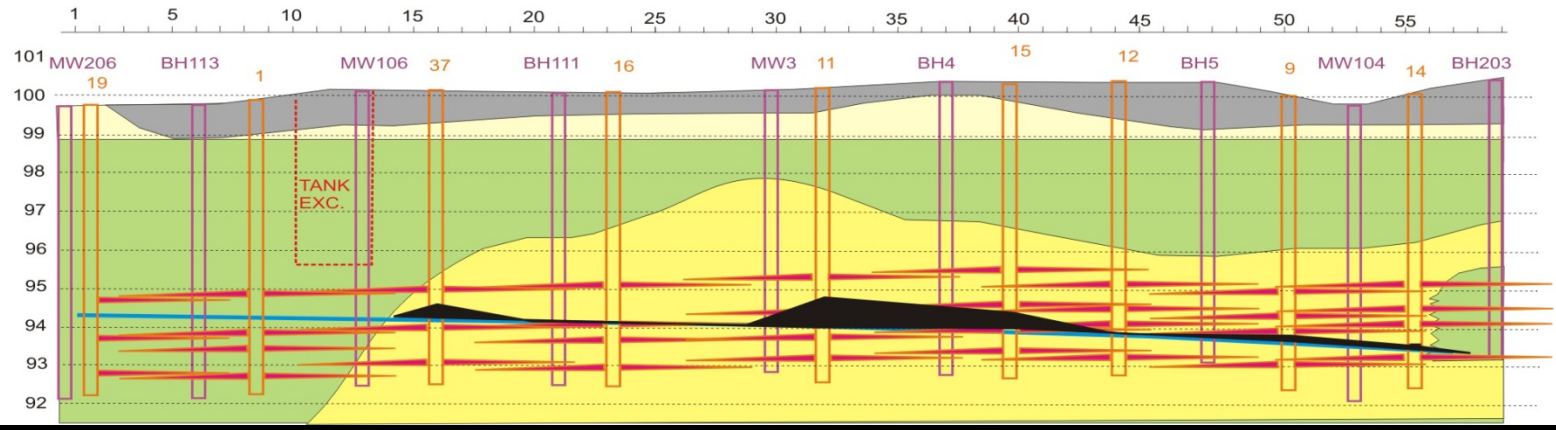

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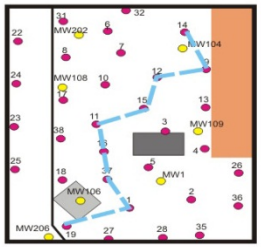

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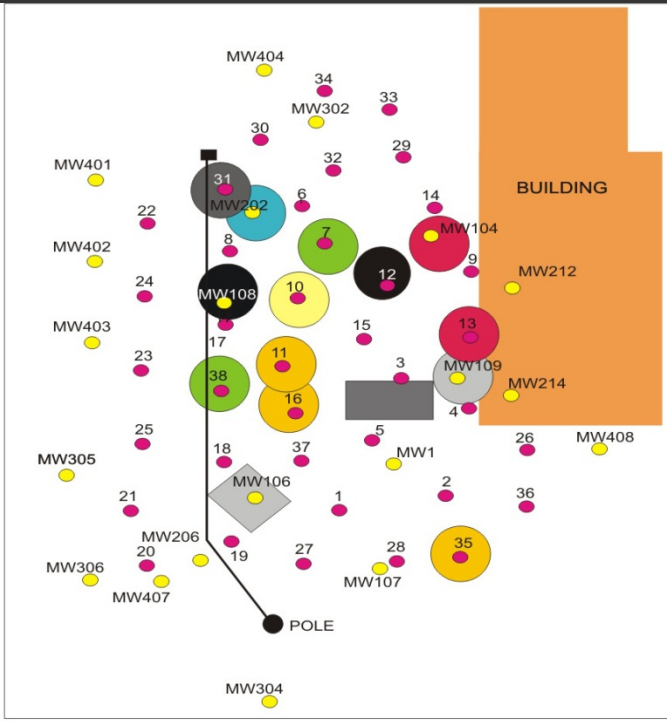

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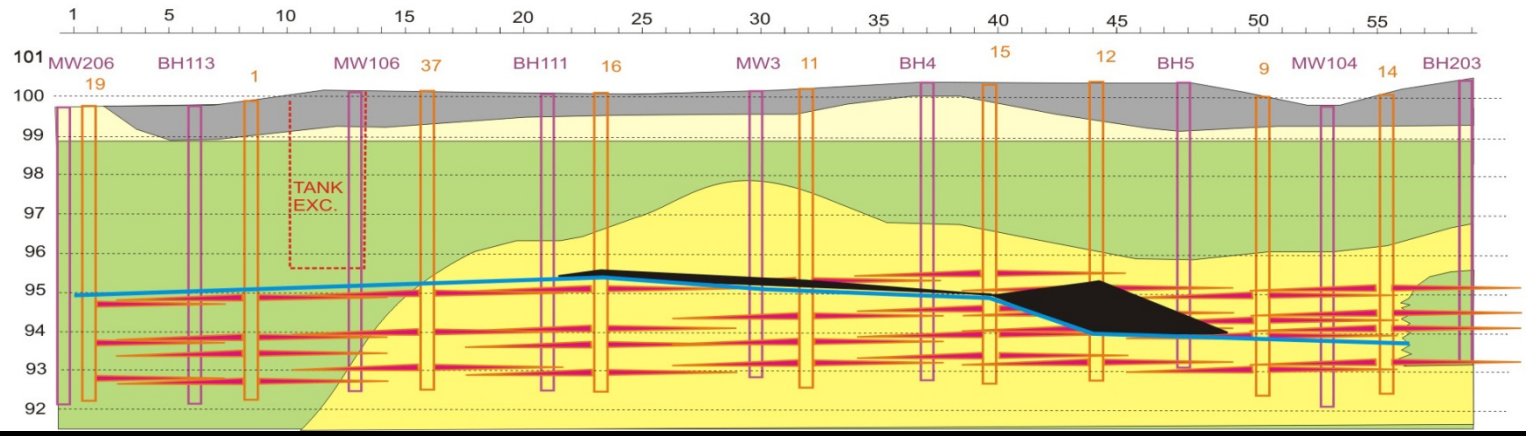

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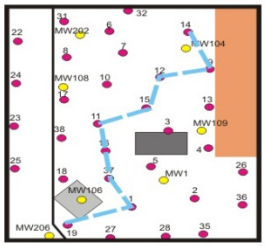

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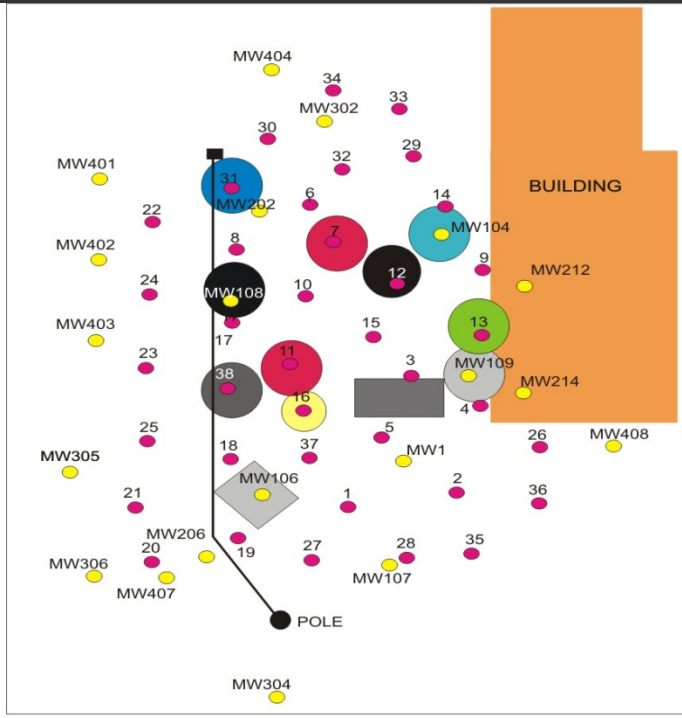

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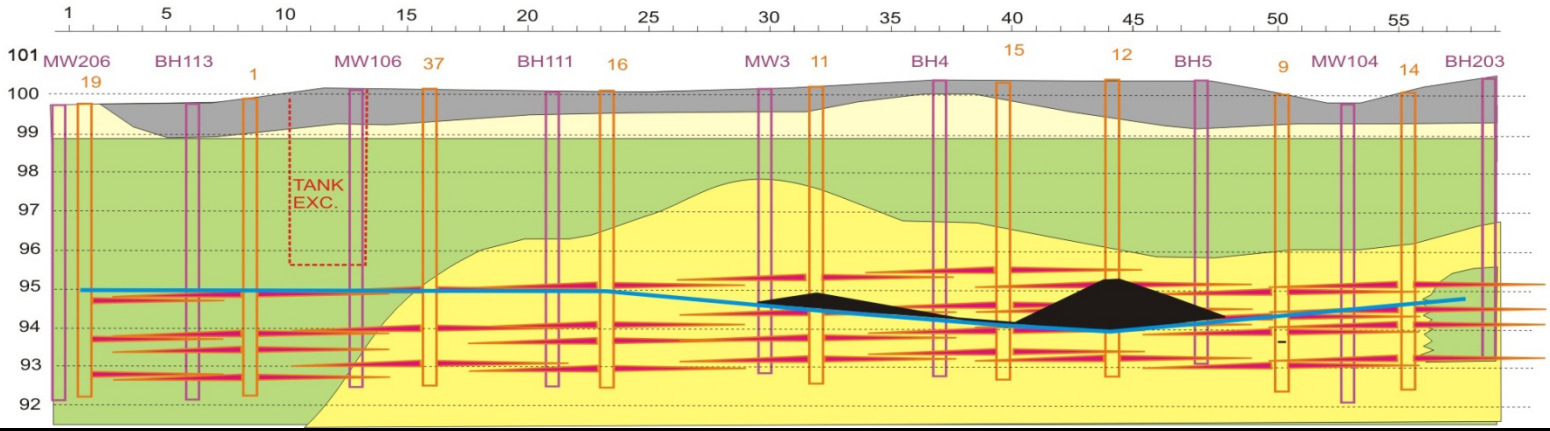

OXYTEK

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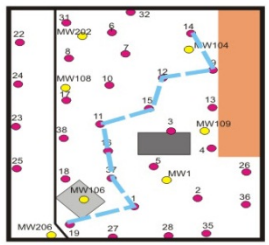

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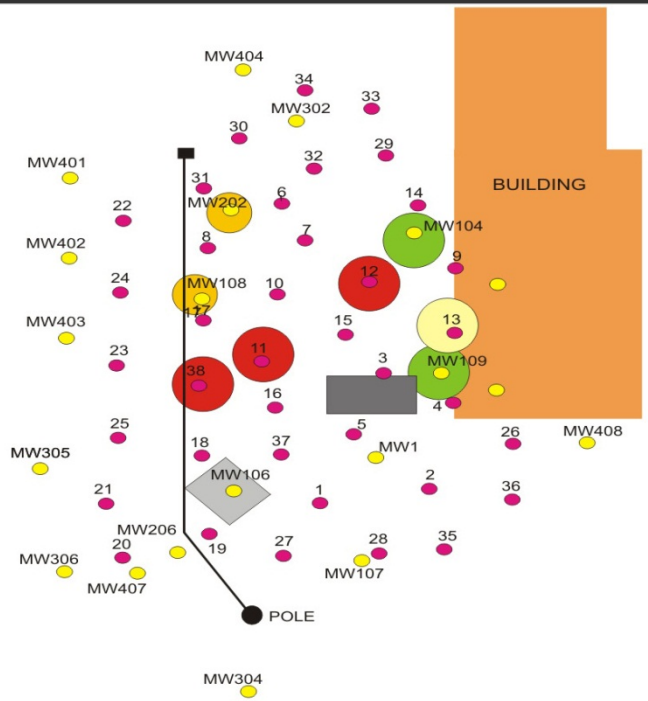

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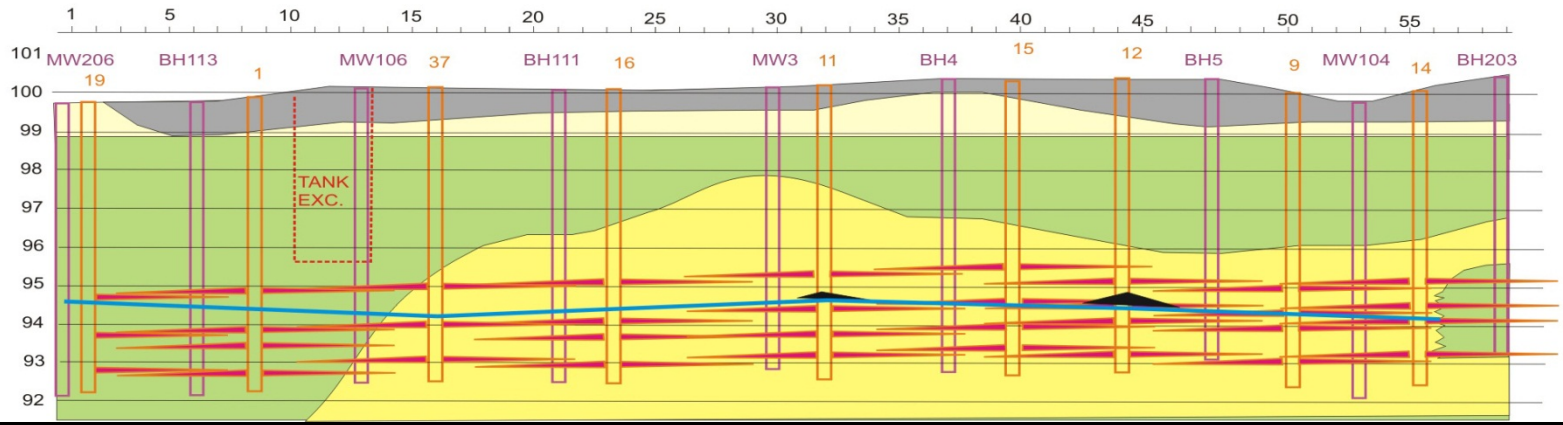

LPH Measurements

Sample Date	28-Feb		13-Apr		12-May		16-Jun		25-Sep	
Well ID	LPH	WT	LPH	WT	LPH	WT	LPH	WT	LPH	WT
1	trace									
5	trace									
6	40	466								
7	17.5	563	14	487	16	492				
8	trace									
9	2.5	644								
10	2.5	565	2	486						
11	90	498	4	478	17	506	16	543	2	485
12	2.5	635	170	619	129	605	27	554		
13	15	649	23	480	14	501	1	514		
14	2.5									
15	30	472								
16			4	449	1	473				
23									2	602
24	1									
29	2.5	665								
30	1	654								
31	trace	612	94	602	32	553				
36	trace	667								
37	32.5									
38	75	526	11	483	116	593	17	542		
MW 108	2.5	650	167	646	180	673	7	553		
MW 104	7.5	552	29	502	49	546	10	549		
MW 109			71	519	88	563	11	528		
MW 202			50	560	20	535	7	557		

LEGEND:

- sheen to < 2.54 cm (< 1")
- 2.54 to 7.62 cm (1 to < 3")
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NS - not sampled
LPH - liquid petroleum hydrocarbon level measured in cm
WT - water table measured in cm
- no LPH recorded

RESULTS

- LPH Removal – utilizing surface vacuuming and sub-surface fracturing (8%), and chemical oxidation (86%) removed a total 94%.

- Dissolved Phase Reduction – surface vacuuming contributed a 12% reduction and chemical oxidation removed 84%.

- Soil Phase Reduction – chemical oxidation reduced the soil phase by 88%.

CONCLUSIONS AND DISCUSSION

- Sub-Surface Fracturing – was only effective in half of the contaminated area and showed no significant results in the other half of the contaminated area. Costs were high compared to added value of the fracturing. Unpredictability of fracturing routes and fracture diffusion are problems with this technology as well as costs.
- Surface Extraction of LPH – was limited by cold surface conditions, limited fracturing effectiveness and seasonality of the water table. Overall the method gave equal or superior results to a pump and treat system at significantly lower costs.

CONCLUSIONS AND RESULTS CONT.

- Modified Fenton's Chemistry – Chemical oxidation with stabilized hydrogen peroxide was very effective in degrading the LPH as well as the dissolved and absorbed phase LPH. The limiting factor was the ability to get the oxidant into contact with the LPH due to the tight soil conditions. Undermining of the asphalt during chemical oxidation was an ongoing problem but was handled with spot repairs of the asphalt. Winter conditions were also a limiting factor because it was difficult to locate injection wells when snow and ice covered and working conditions were difficult.

CONCLUSIONS AND RESULTS CONT.

- The methods used in this remediation project resulted in cost savings of appropriately 2.3 million dollars when compared to standard dig and haul and an additional 3.6 million is potential relocation and lost business costs for a total savings of 5.9 million dollars. Additionally and most significantly, the environmental problem has been dealt with and not moved for future generations to deal with!

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