FEASIBILITY EVALUATION

OF

ALTERNATIVE GREEN REMEDIATION APPLICATIONS

Delphi - Moraine

March 2010

INTRODUCTION

Toxicological & Environmental Associates, Inc. (TEA) reviewed the Motors Liquidation Company (MLC) site portfolio to determine if there are candidates for Alternative Green Remedial approaches, either solely or in combination with other remedies previously identified for those sites. Alternative Green Remedial approaches were defined in a memorandum submitted on October 2, 2009, entitled "Site Selection Criteria for the Identification of Candidate Sites for Alternative Green Remediation" and included, but were not limited to, phytoremediation, source area reduction of dense non-aqueous phase liquid (DNAPL), and various in-situ technologies. Eight sites from the MLC portfolio were identified for conceptual development. These eight sites included:

1. Former Delco Chassis Plant (Livonia)
2. Willow Run Company Vehicle Operations
3. GMPT Bay City
4. Danville Central Foundry
5. Stamping - Grand Rapids
6. Buick City
7. Former GM Delco Plant 5 (Kokomo)
8. Delphi - Moraine

In addition to these sites, GMPT Massena (New York), Buick City and others were targeted for feasibility evaluation of an emerging polychlorinated biphenyl (PCB) abatement technology for paints, soils, sediment, sludge, and light non-aqueous phase liquid (LNAPL) treatment for oils containing PCBs.

TEA prepared "Conceptual Design and Preliminary Cost" reports for these sites which were uploaded to the IDEA database in October 2009. Based on subsequent discussions among the remedial and planning team members, TEA evaluated these sites in further detail to assess the practical feasibility of incorporating alternative green technologies into remedial plans for those specific sites. Assessments of potential cost impacts were also evaluated during the current assignment.

The limited information and data available for TEA's "Conceptual Design and Preliminary Cost" reports were expanded to generate this document. The feasibility evaluations presented herein are based solely on data available on the IDEA database and telephone discussions with site project managers.

The objectives of this submittal are to evaluate practical, logistical, technical, regulatory, and financial issues related to these sites in which alternative green remedies may be considered within the course of proposed remediation schemes. Considered during the evaluations were implementability, effectiveness, cost, and green sustainable principles and practices. Estimates of capital costs, O&M costs, and monitoring costs were refined for the alternative green remedies proposed for each site. The results of the evaluation are presented succinctly using the following general outline:

I. Problem Statement
   - compounds/contaminants
   - media
   - saturated/unsaturated zones
   - landfill, etc.

II. Site Characteristics
   - Hydrogeology
     a. depth to groundwater
     b. groundwater flow direction
     c. hydraulic conductivity, groundwater velocity, etc.
   - Extent of contaminant plume
   - Potential receptors

III. Proposed Alternative Green Remedy
   - Purpose and objectives
   - Description of alternative green remedial technology
   - Sustainability
   - Analysis of Green and Sustainable Remediation
   - Monitoring program
   - Term of operation
   - Advantages and disadvantages

IV. Regulatory Outlook
   - Existing order
   - Regulatory agency
   - Potential obstacles

V. Green and Sustainable Remediation (GSR) Comparison

VI. Costs

- Capital/O&M/Monitoring
- Assumptions
- Potential savings

VII. Conclusions

Estimated costs for the proposed alternative green remedies proposed in this submittal were refined based on all information and data gathered by TEA to date. At this time, costs are not necessarily intended to modify overall remediation estimates necessary for these sites. These estimates are mostly intended for consideration during future planning and design of site remediation as proven, implementable, sustainable, and effective cost-saving measures.

Delphi - Moraine
MLC # 1317

I. Problem Statement

One of the key environmental issues at the Delphi-Moraine Facility resulted from activities at the Former Oil House – AOI-7. These issues consist of a chlorinated hydrocarbons source area (i.e. PCE, TCE and decay products) in the vadose zone soil and groundwater encompassing an area of approximately 100,000 sq. ft. In addition, a dissolved plume emanates from the source area to create an overall footprint of approximately 200,000 sq. ft. The current Corrective Measures Proposal (CMP) includes source area treatment with in-situ oxidation and downgradient dissolved plume treatment with enhanced natural attenuation using molasses.

II. Site Characteristics

AOI-7 Former Oil House Area - This area of interest is approximately 100,000 sq. ft in size and includes the former oil house and an associated AST and UST storage area located directly north of the Oil House. This area is currently covered with asphalt, and has been delineated as the primary source area for vadose zone soils and shallow groundwater for PCE.

The subsurface geology at the site has been characterized as 3 hydrogeologic units;

- An upper-sand and gravel unit is 30-70 feet thick with a saturated thickness of 10-40 feet.
- A clay till zone ranging up to 50-feet thick lies beneath the upper sand and gravel unit
- A lower-sand and gravel unit at least 50-feet thick that is fully saturated and semi-confined.

Beneath the Oil House, the upper sand and gravel aquifer extends to approximately 55 ft below ground surface (bgs). In this area of the site, a perched, low permeability clay till separates the upper aquifer into shallow and deep units. The contaminants are primarily contained in the shallow portion of the upper aquifer unit. This shallow portion of the upper aquifer extends from approximately 25 – 35 ft bgs.

III. Proposed Alternative Green Remedy

Purpose and Objective

The purpose of the remedial solution proposed herein is to provide an alternative green remedy for the vadose and groundwater contamination in the source area (AOI-7), as well as, the area of the extended dissolved plume. To achieve this objective we propose a combination of in-situ injection of EZVI and *ENGINEERED_PHYTOREMEDIATION*℠ for source area and groundwater treatment, respectively.

Description of Technology

ENGINEERED_PHYTOREMEDIATION℠ is very well suited for establishing hydraulic barriers and removing dissolved phased contaminants in groundwater. Past experience with *ENGINEERED_PHYTOREMEDIATION*℠ at sites in similar climates indicates that phreatophytic trees such as willows or poplars planted on 15 ft spacings can transpire approximately 1,000,000 gallons of groundwater/acre. To maximize the hydraulic effects, the trees can be located on the downgradient boundary of the plume to create a hydraulic barrier to downgradient migration of contaminated groundwater. To maximize contaminant reduction, the trees can be located in areas of higher groundwater contaminant concentrations. By locating the trees across the entire area of the plume, both hydraulic and treatment effects area maximized.

The *ENGINEERED_PHYTOREMEDIATION*℠ system for plume reduction and control in the groundwater can include the following components.

- A *TreeWell*® system that will be installed to address the contaminant plume in the shallow upper aquifer 25 to 35 feet bgs.
- Two foot diameter holes will be augered to into the saturated zone.
- Up to 3 gallons of EZVI will be added to the bottom of each hole to enhance contaminant reduction in the groundwater.

The emulsified zero-valent iron (EZVI) technology is designed specifically for in-situ source area treatment. The CMP for this site indicates PCE hotspots in both vadose soils and the shallow groundwater and soil beneath AOI-7. We propose to inject EZVI in both of these areas.

In the vadose soil an area is targeted inside the 10,000 mg/kg PCE isopleths for EZVI injection at 10% of pore space (assuming 30% porosity) over a 15 foot deep zone (60,000

gallons of EZVI). It is well known that for ZVI to react with and reductively dechlorinate chlorinated hydrocarbons, such as PCE and decay products, the ZVI must be in association with water. In vadose soils EZVI is effective due to the fact that the ZVI is contained within aqueous micelles, and therefore the hydrogen donor for the reductive dechlorination reaction is in place.

In addition to vadose soils, EZVI is proposed for shallow aquifer groundwater and soil hotspots that are delineated in the 2008 CMP for this site. We propose to inject EZVI in two areas of the shallow aquifer, both of which are located directly beneath the two hotspots in vadose soils. For the groundwater and soil hotspots we are targeting the area within the 1000 ug/l isopleths for EZVI injection at 10% of porespace (assuming 30% porosity) over a 10 ft deep zone (40,000 gallons of EZVI).

Description of Monitoring Program

The monitoring requirements for the phytoremediation remedy consist of a standard groundwater monitoring program (hydraulic and quality) with limited additional assessments of tree health during the initial years of implementation. Additionally, standard groundwater monitoring will be used to evaluate the efficacy of the EZVI injections.

Term of Operation

Although trees will begin using water during the initial growing season in which they are planted, full hydraulic effects of the trees are expected 3 to 5 years after planting. Contaminant reduction by the trees can be realized in the first year. Typically, EZVI treatment areas should have concentration decreases of greater than 90% within 12 months.

Advantages and Disadvantages

Advantages

- No external energy inputs required during operation
- Low maintenance requirements
- Pumping capacity is spread out over many pumping units
- Effectiveness of phytoremediation technologies has been demonstrated at many environmental sites under many conditions by many different agencies
- Effectiveness of EZVI source area treatment of chlorinated organics is well proven

- Provides for direct treatment of PCE and TCE source areas in both vadose and shallow groundwater zones, as well as, dissolved plume treatment and hydraulic containment

- Initial installation costs lower using proposed alternative green remedies

- EZVI treatment will enhance downgradient enhanced natural attenuation remedies by supplying a slow release carbon source for indigenous bacteria

- Efficient and effective removal of ongoing source areas, through combination of sequestration and abiotic/biotic dehalogenation processes enabled through the EZVI technology

Disadvantages

- Average of three year lag time until full hydraulic effects of trees can be realized

IV. Regulatory Outlook

In August 2008 a Corrective Measures Proposal (CMP) was submitted to the EPA. Corrective measures have not been finalized for this site. The potential regulatory obstacles for this proposed alternative green remedy most likely include:

- Regulatory approval for modifications to the CMP.

V. GSR Comparison

	Proposed Remedy	Alternative
Technology	ISCO, enhanced bioremediation and long-term MNA; pump and treat	*ENGINEERED_PHYTOREMEDIATION*SM and EZVI
Energy Inputs		
Materials	High – manufacturing of energy source, well materials, vapor collection system, etc.	Low – growing trees, manufacturing of root sleeve, fertilizer
Installation	High – equipment to capture and treat volatile off-gassing from subsurface	Moderate
O&M	High – electricity to run system	Low

Waste Generation	None	None other than vegetative matter
Effectiveness	Able to maintain hydraulic gradient	Minimize and possibly eliminate off-site migration
CO_2 sequestration	None	Sequesters carbon in trees
Land and Ecosystem Impacts	Neutral compared to existing site condition	Positive impact on ecosystem
Air Emissions	Depends upon power source, necessary to control volatile off-gassing with capture and treatment system	No emissions, positive effect on ambient air quality
Maintenance	High – requires constant O&M and inputs of energy and activated carbon	Low – Once established, system is essentially self-sustaining
Risk Reduction	Risk reduction through off-gassing collection/treatment, and destruction of contaminants	Risk reduction through hydraulic control and destruction of contaminants
Site Reuse	Long-term site land and groundwater use restrictions will apply	Long-term site land and groundwater use restrictions will apply. Phytoremediation trees also provide a natural habitat
Water usage	Does not require additional water inputs	*ENGINEERED_PHYTOREMEDIATION*℠ and EZVI does not require additional water inputs
Natural Processes Utilization	Uses natural processes for bacterial degradation and MNA	Utilizes all natural processes
Renewable Resources	Not renewable	Trees are renewable
Reduction/destruction of contaminant mass	Reduces on-site contaminant mass only through off-gassing volatiles	Potential to stimulate *in-situ* degradation of contaminants

VI. Costs

- Capital costs for this solution - The estimate presented herein is based on the planting of 800 trees in the source area and the extended plume area using an *ENGINEERED_PHYTOREMEDIATION℠* system as described above and the injection of 100,000 gallons EZVI in vadose soils and shallow groundwater source areas. For budgetary purposes, it is assumed that the installed cost per *TreeWell®* unit will be $1,250. Thus the cost for installing the phytoremediation is estimated to be $1,000,000. The EZVI component is estimated to cost $30/gal installed for a total cost of $3,000,000. An additional $150,000 for design and project management is assumed, bringing the total capital cost to $4,150,000.

- O&M/Monitoring costs for this solution – The OMM cost for this combined EZVI/Phyto solution will be significantly lower than on-going injections of molasses and in-situ chemical oxidation.

- Potential savings – The current remediation cost estimate for this site in current dollars (2009) is $9,600,000 compared to the estimated cost of this alternative green remedy of $4,150,000. This represents approximately $5,450,000 in monetary savings for source area treatment alone.

VII. Conclusions

The proposed alternative green remedial technology chosen for the Delphi Moraine, OH site is EZVI and *ENGINEERED_PHYTOREMEDIATION℠*. This remedy is implementable, sustainable, provides effective hydraulic control, dissolved contaminant and source area treatment, and lowers both short-term remediation costs and the long-term cost of ownership by significantly decreasing time to clean up site and therefore decreasing OMM budget.

This is a large site and there is potential to supplement the current Corrective Measures Program with EZVI and Engineered Phytoremediation.

Source area treatment in vadose soils and saturated zone with EZVI and utilization of *TreeWells®* in the AOI-7 source location will enhance the remediation program at the site.

Capital and maintenance costs for currently proposed source area are $9.6 million. Use of EZVI and Engineered Phytoremediation would be approximately half of that or a savings of $5 million projected.

It is not known what specific cost savings would be using *TreeWells*® as a supplement to the containment technologies (i.e., pump and treat) for generalized plume control. It is anticipated that these cost control measures using alternative GSR technologies could be significant.