COST AND PERFORMANCE REPORT

Phytoremediation at Aberdeen Proving Grounds
Edgewood Area J-Field Site
Edgewood, MD

May 2002

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

Phytoremediation at Aberdeen Proving Grounds, Edgewood Area J-Field Site, Edgewood, MD
Excerpted from: NATO CCMS Pilot Study; 2001 Annual Report
EPA 542-R-02-001; January 2002
Project Completed 1999

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1. INTRODUCTION

The efficacy and cost of phytoremediation to clean up shallow groundwater contaminated with chlorinated solvents (primarily trichloroethylene), is being evaluated at the field scale in demonstration projects at Aberdeen Proving Grounds Edgewood Area J-Field Site in Edgewood, Maryland, the Edward Sears site in New Gretna, New Jersey, and Carswell Air Force Base in Fort Worth, Texas. These projects will demonstrate the use of hybrid poplars to hydraulically control the sites and ultimately to remove the volatile organic compounds (VOCs) from the groundwater. When completed, these projects will allow a comparison of phytoremediation at three sites under varied conditions within different climatic regions.

2. SUMMARY AND LATEST OBSERVATIONS

At the Aberdeen Proving Ground site, a process called deep rooting is being used to achieve hydraulic influence. Hybrid poplar trees were initially planted in the spring of 1996 at five to six feet below ground surface to maximize groundwater uptake. The field demonstration and evaluation will be for a five year period. The U.S. Geological Survey has estimated that hydraulic influence will occur when 7,000 gallons of water per day are removed from the site.

Several trees were excavated in the fall of 1998 to determine root growth. The tree roots were found to be confined to the hole in which they were placed. In an attempt to increase root depth and width, new trees were planted in holes of varying sizes and depths.

The latest field data indicates that hydraulic influence is occurring. Current tree uptake is 1,091 gallons (4,129 liters) per day and is expected to increase to 1,999 gallons (7,528 liters) at the end of 30 years. Contaminant uptake is minimal at this time but is expected to improve as the trees mature. Groundwater sampling indicates that the contaminated plume has not migrated off-site during the growing season and sampling data showed non-detectable emissions from transpiration gas. There are several on-going studies to determine if deleterious compounds retained in the leaves and soil could pose risks to environmental receptors.

3. SITE DESCRIPTION

Aberdeen Proving Grounds is located at the tip of the Gunpowder Neck Peninsula in Maryland, which extends into the Chesapeake Bay. The Army practiced open trench (toxic pits) burning/detonation of munitions containing chemical agents and dunnage from the 1940s to the 1970s. Large quantities of decontaminating agents containing solvents were used during the operation. The surficial groundwater table had been contaminated with solvents (1,1,2,2-TCA, TCE, DCE) at levels up to 260 parts per million (ppm). The contamination is 5 to 40 ft (3.5 to 13 m) below ground surface. The plume is slow-moving due to tight soils and silty sand. The impacted area is a floating mat-type fresh water marsh approximately 500 ft (160 m) southeast. A low environmental threat is presented by the contaminant plume.

4. DESCRIPTION OF THE PROCESS

Phytoremediation was selected to provide both hydraulic influence of the groundwater plume and mass removal of contaminants.

The plantation area being monitored is approximately 2034 m^2 and contains 156 viable poplars. 1,1,2,2-TCA and TCE are 90 percent of the contaminants (total approximately 260 ppm solvents). USGS estimated 7000 gals/day removal would achieve hydraulic influence. The duration of evaluation will be five years.

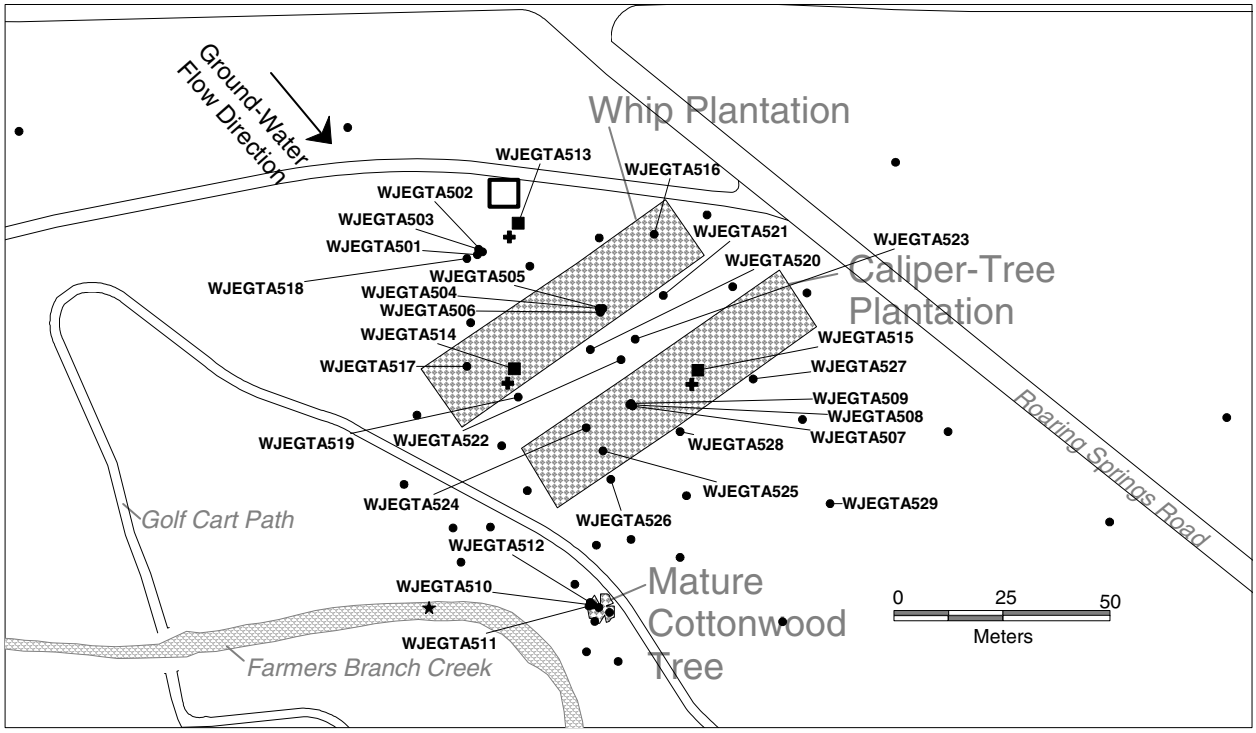
Process Description —
After agronomic assessment, two-year-old hybrid poplar 510 trees were planted 5 to 6 ft (1.6 to 2 m) deep in the spring of 1996. Surficial drainage system was installed to remove precipitation quickly and allowed trees to reach groundwater.

Various sampling methods were employed during the 1998 growing season to determine if project objectives are being met. The methodologies which yielded the most valuable data include: groundwater sampling; sap flow monitoring; tree transpiration gas and condensate sampling; and exposure pathway assessments. In addition to field sampling activities, new trees were planted on the site in October 1998 to increase the phytoremediation area and assess the usefulness of native species for phytoremediation.

5. RESULTS AND EVALUATION

1. Examination of groundwater level data revealed an area of depression within the poplar plantation indicating that hydraulic influence is occurring. Currently, the trees are removing approximately 1,091 gallons per day (4,129 L/day) and at the end of 30 years are expected to remove approximately 1,999 gallons per day (7,528 L/day).
2. Groundwater sampling indicated that the contaminated plume has not migrated off-site during the growing seasons.
3. There are no ecological impacts that are attributable to the plantation area. Sampling data have shown non-detectable off-site migration of emissions from transpiration gas.
4. Peak transpiration is estimated to occur in approximately 10 to 15 years.
5. Limitations include depth of contamination, but there are no limitations for concentrations of up to 260 ppm for solvents. Weather and growing season are the most influential factors.
6. Contaminant uptake is minimal at this time but is expected to improve as the trees mature.

Figure 1: Aberdeen Proving Grounds, Maryland



EXPLANATION

- • MONITORING WELL: Well number indicates well was sampled throughout the entire location
- ó MONITORING WELL WITH WATER-LEVEL RECORDER
- i STREAM-STAGE GAGE
- [TENSIOMETER NEST
- □ WEATHER STATION

7. A groundwater model is under development to quantify the degree of containment generated by the trees. The model requires an accurate estimate of water withdrawal rates by the trees to determine if phytoremediation will work as a remedial alternative for the site.
8. This demonstration project is on-going and will be further evaluated for efficacy and costs.

Groundwater samples and elevations were collected, seasonally from the on-site wells to determine VOC concentrations and if trees were facilitating hydraulic influence of the plume. Results indicated that an area of drawdown exists within the tree zone during the spring and summer when tree transpiration is the greatest. In 1998, additional wells were installed using a Geoprobe® in order to more accurately assess VOC concentrations and groundwater elevation. A groundwater model is currently being developed to predict potential VOC removal by the trees and when complete hydraulic influence may be attained. Given the success of the groundwater sampling, sampling objectives for 1999 included groundwater elevation monitoring and sampling and a continued effort to refine the groundwater model.

Sap flow monitoring was performed to determine the amount of water being removed by individual trees. In order to increase monitoring accuracy, new sap flow probes were purchased which are placed directly into the tree tissue as opposed to resting on the trunk of the tree. Comparison of new equipment with previous methods indicates that the new methodology provides an even more accurate estimation of net

transpiration rate with less data interference or "noise." Future sampling objectives for the site include continued seasonal sap flow monitoring for the purposes of estimating transpiration rates.

Seasonal tree transpiration gas and condensate sampling continued in the 1998 sampling season to assess the release of VOCs from the trees. Previous methods consisted of placing a 100-liter Tedlar® bag over a section of branch and then sampling the gas and any condensate trapped within the bag. This method was modified in 1998 with the addition of a cold trap which would potentially remove excess moisture from the bag and keep the leaves in a more ambient temperature. Comparison of the two methods, with and without cold trap, indicates that the cold trap apparatus may not be powerful enough to sufficiently cool the temperature within the bag. Future transpiration gas monitoring was planned for the 1999 sampling season with the addition of a modified cold trap attachment.

Several studies were designed which examined exposure pathways. Leaves and soil were collected from the phytoremediation area and a reference area for a leaf degradation study. The study is designed to determine whether or not there are deleterious compounds retained within the study leaves or within the associated soil which could pose risk to an environmental receptor. The results of this study are still being analyzed. Additional studies involved nematode analyses which examined the trophic assemblage of the nematode community. Data collected in 1997 indicated that the nematode community was enhanced in the phytoremediation area as compared with data collected prior to the tree planting.

No trees were planted in the 1999 sampling season. The objectives were: 1) to assess the phyto-remediation capabilities of native Maryland species, tulip trees and silver maples, in addition to hybrid poplar trees; 2) to increase the area of hydraulic influence; 3) to diversify the age of trees to ensure continued containment and contaminant removal; and 4) to assess new planting methods. The last objective relates to the three tree excavations performed in the fall of 1998. Three trees were excavated and replanted in their same areas on the site to examine root depth and structure and whether or not the trees were utilizing groundwater. Examinations revealed that most tree roots appeared to be confined to the hole in which they were placed and did not appear to radiate extensively from this area. It did appear however, that the tree roots were deep enough to access the groundwater. Three new planting methods (i.e., hole sizes and widths) were employed for the new trees in an attempt to provide the tree roots with either increased depth, increased width or a combination of increased width and depth. Monitoring of these new trees during the 1999 sampling season attempted to discern the phytoremediation capabilities of the native species versus the hybrid poplars and to assess the growth of the new trees given the various planting methods employed for each.

6. COSTS

Site Preparation (?): $5,000
Capital: $80,000 for UXO clearance of soil during planting; $80/tree.

Operation and maintenance: $30,000 due to no established monitoring techniques

7. REFERENCE

Eberts, S., G. Harvey, S. Jones, and S. Beckman, In press. A Multiple Process Assessment of Phtoremediation of a Chlorinated Solvent Plume at a Subhumid Field Site, John Wiley and Sons.