ANL/ES/CP-101048

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DEPLOYMENT OF PHYTOREMEDIATION AT THE 317/319 AREA AT ARGONNE NATIONAL LABORATORY - EAST

by

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for

Workshop on Phytoremediation of Inorganic Contaminants

Argonne National Laboratory
November 30 - December 2, 1999

Sponsored by:

U.S. Department of Energy – EM-50
SCFA – Metals and Radionuclides Product Line

January 2000

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Deployment of Phytoremediation at the 317/319 Area at Argonne National Laboratory-East

Introduction and Background

The 317 and 319 Areas are located on the extreme southern end of the ANL-E site, immediately adjacent to the DuPage County Waterfall Glen Forest Preserve. The 317 Area is an active hazardous and radioactive waste processing and storage area. In the late 1950s, liquid waste was placed in the unit known as the French Drain. Since that time, this waste has migrated into underlying soil and groundwater. The principal environmental concern in the 317 Area is the presence of several VOCs in the soil and groundwater and low levels of tritium in the groundwater beneath and down gradient of the site. The 319 Area Landfill and French Drain are located immediately adjacent to the 317 Area. The principal environmental concern in the 319 Area is the presence of radioactive materials in the waste mound, in the leachate in the mound, and in the shallow groundwater immediately down gradient of the landfill. Several interim actions have already been implemented in this area, to reduce the VOC and tritium releases from these areas, as the result of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) conducted from December 1994 through September 1996.

The final action to complete corrective action for removing contamination in the 317 and 319 Areas is the deployment of phytoremediation. For this application, phytoremediation is defined as the engineered use of natural processes by which woody and herbaceous plants extract pore water and entrained chemical substances from subsurface soils, degrade, sequester, and transpire them along with water vapor into the atmosphere. In 1999, EM-40 and EM-50, through the Accelerated Site Technology Deployment (ASTD) Program, jointly funded the deployment of a phytoremediation system in the 317/319 Area with the following objectives: (1) minimize water infiltration into the 317 Area French Drain soils, some of which were treated previously by soil mixing and iron addition; (2) stabilize the treated soil surface in the 317 Area French Drain area to prevent erosion, runoff, and downstream sedimentation; (3) hydraulically contain groundwater migration and continue remediation of the residual VOCs within the 317 Area French Drain and down gradient of the French Drain; and (4) hydraulically contain the VOCs and tritium and VOC plume south of the 319 Area Landfill.

The installed system consists of plantings of shallow-rooted hybrid willows and special deep-rooted hybrid poplars. This system will prevent the further generation of contaminated groundwater in the source area by degrading the contaminants, and will also prevent the further migration of these plumes by removing groundwater from shallow saturated zones down gradient from the source area.

Soon after DOE funded the project, the U.S. EPA and. DOE agreed to include this remediation technology deployment in the projects evaluated by the U.S. EPA Superfund Innovative Technology Evaluation (SITE) Program. Under this program, the U.S. EPA will independently monitor and evaluate the technology's performance at the ANL-E 317/319 site in addition to the scheduled monitoring activities conducted by ANL-E.

Technological Approach and Expected Results

The use of trees to remediate contaminated groundwater has been successfully demonstrated in treating contaminated groundwater. Applied Natural Sciences, Inc, (ANS) demonstrated the use of phreatophytic trees (i.e., plants such as poplars and willows that do not rely on precipitation water but seek water deep in soils) with its *TreeMediation®* and *TreeWell®* systems, that use a unique and patented process to enhance the aggressive rooting ability of selected trees to clean up soil and groundwater up to 50 ft deep. Under a CRADA, ANL-E and ANS researched phytoremediation applications since 1994.

The hydrogeology at the 317/319 Site is a complex framework of glacial tills interlaced with sands, gravels, and silts of varying character, thickness, and lateral extent. The subsurface is a complex arrangement of approximately 60 ft of glacial geologic deposits over Silurian dolomite bedrock. The glacial sequence is comprised of Lemont drift overlain by the Wadsworth Formation. Both units are dominated by fine-grained, low-permeability till. Permeable zones of varying character and thickness are present in each. These materials range from silty sands to sandy, clayey gravels to gravelly sands. In some locations, pure silt was encountered. If deep enough, this silt was saturated, and it is assumed to play in important role in the flow of groundwater in the study area. The permeable zones have a wide range in shape, including thin, lenticular, alluvial deposits; thick plugs of possible slump or channel-fill material; interfingerings; and a thick, basal, proglacial sand and gravel. Their thicknesses range from less than 1 ft to roughly 15 ft and they have limited lateral extent.

On the basis of a preliminary agronomic assessment, hybrid willow and hybrid poplar trees were selected for the system. In the summer of 1999, a total of approximately 800 trees were planted in three locations: the 317 Area French Drain, south of the 317 Area French Drain and 319 Area Landfill (the 317 and 319 Hydraulic Control Areas), and in the waste trench south of the 319 Area Landfill. Figure 1 shows the location of the plantings.

In the 317 and 319 Hydraulic Control Areas, poplar trees were planted in boreholes spaced 16 ft apart drilled down to the contaminated aquifer using ANS's *TreeWell®* system. This technology was selected, in consideration of the hydrogeological setting of the site, to target root growth in the contaminated glacial-drift permeable unit approximately 30-ft deep. The poplars were planted in 2-ft diameter caisson boreholes lined with plastic sleeves in order to direct the roots exclusively to the main contaminated aquifer. These boreholes were filled with a mixture of topsoil, sand, peat, and manure to promote root growth and tree development. The capillarity of the mixture provides an added benefit of drawing water to where it is available to the young trees. Figure 2 presents a diagram of a TreeWell® installation, and Figure 3 shows the borehole being drilled in the 317 Hydraulic Control Area.

Willow trees were planted in the two other areas in boreholes spaced 10 ft apart at the surface in areas of relatively shallow groundwater contamination, without the plastic liner in order to address the contamination and moisture in the whole soil profile. All boreholes were also provided with aeration tubes to ensure a supply of air to the growing roots.

To support the deployment of the phytoremediation system, a groundwater flow model was developed. Flow modeling was conducted initially to model the natural, transient changes in the flow field caused by seasonal changes in recharge to the aquifer. The model was calibrated

to approximately 10 years of water level measurements from site monitoring wells. Anticipated effects of the phytoremediation system were included. The model, updated to include the as-built configuration of the phytoremediation system, indicates that the as-built plantation will provide hydraulic containment even during the winter months when the trees are dormant.

Planting phreatophytic trees at the capillary fringe in the year 1999 is expected to provide full hydraulic control by the year 2002-2003 and be self sustaining for the full expected life of the engineered plantation. Hybrid poplar and hybrid willow trees typically have a life span of about 40 years. The Path to Closure Plan committed ANL-E to have all remedial work at the 317/319 area completed by October 2000.

ANL-E proposed to establish a groundwater management zone (GMZ) that incorporates the 317/319 Area. Once the Illinois EPA (IEPA) approves the GMZ, periodic sampling of the wells that bound the zone is expected to show that the groundwater outside the zone meets the Tiered Approach to Corrective Action Objectives (TACO) Tier 1 cleanup objectives set by the Illinois Administrative Code. ANL-E will continue its corrective actions inside the GMZ until such time that the IEPA determines that the actions can be discontinued.

ANL-E installed 48 groundwater monitoring wells on the phytoremediation project site to track the performance of the phytoremediation system. Monitoring activities have started at the completion of the construction phase and include recording climatic conditions, plant growth and transpiration rates, soil moisture, VOCs degradation in plant tissue, groundwater elevation and concentration of VOCs and tritium, ambient air concentration of VOCs and tritium, and transpirate concentration of VOCs. Root development will be observed through specially designed viewing ports (minirhizotrons). This monitoring program is a combined and independent effort between ANL-E (funded by the ASTD program and EM-40) and the U.S. Environmental Protection Agency through the Superfund Innovative Technology Evaluation (SITE) program.

At the end of the remedial process, when a final analysis will verify the absence of the contaminants in the biomass, the trees will be cut down at ground level, chipped, and air dried. The roots will be left in place to decay through natural processes and the chips will be reused on site as mulch for the planting of native prairie species, in accordance with the planned final restoration of the area.

Technology Advantages

The conventional, baseline method of remediation of the target 317 and 319 areas included placing a cap and installing extraction wells (pump-and-treat) down gradient of the contaminant plumes from which contaminated water would be withdrawn and discharged to a lift station, which pumps water to Argonne's waste treatment plant. The subsurface at the site may be comprised of units of widely varying lateral or vertical extent, with gradational or sharp transitions in permeability. The fibrous nature of roots allows the trees to penetrate and remediate both the relatively fast-flowing pore spaces and the less permeable zones. Fundamentally, this distinguishes phytoremediation from extraction wells, which remove water mainly from the most permeable aquifer media.

The plant based system is expected to have lower operating and maintenance costs: preliminary evaluations put the cost savings over the lifetime of the deployment at 50% compared to the baseline approach. A significant cost saving is the avoidance of secondary waste (pumped groundwater) and related treatment.

Additional advantages of the phytoremediation system are (1) the ability of trees to also actively promote and assist in the degradation of the contaminants at the source area, which the baseline asphalt cap would not do, and (2) the optimal fit of the vegetation with the planned future land use of the contaminated site and adjacent areas, as the phytoremediation plantation will contribute to increase soil fertility to host subsequent prairie species.

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Figure 1 – Aerial picture of the 317/319 area phytoremediation project and location of plantings:
——— 317 French drain area
– – – – 317/319 Hydraulic control area
..... 319 Waste trench area

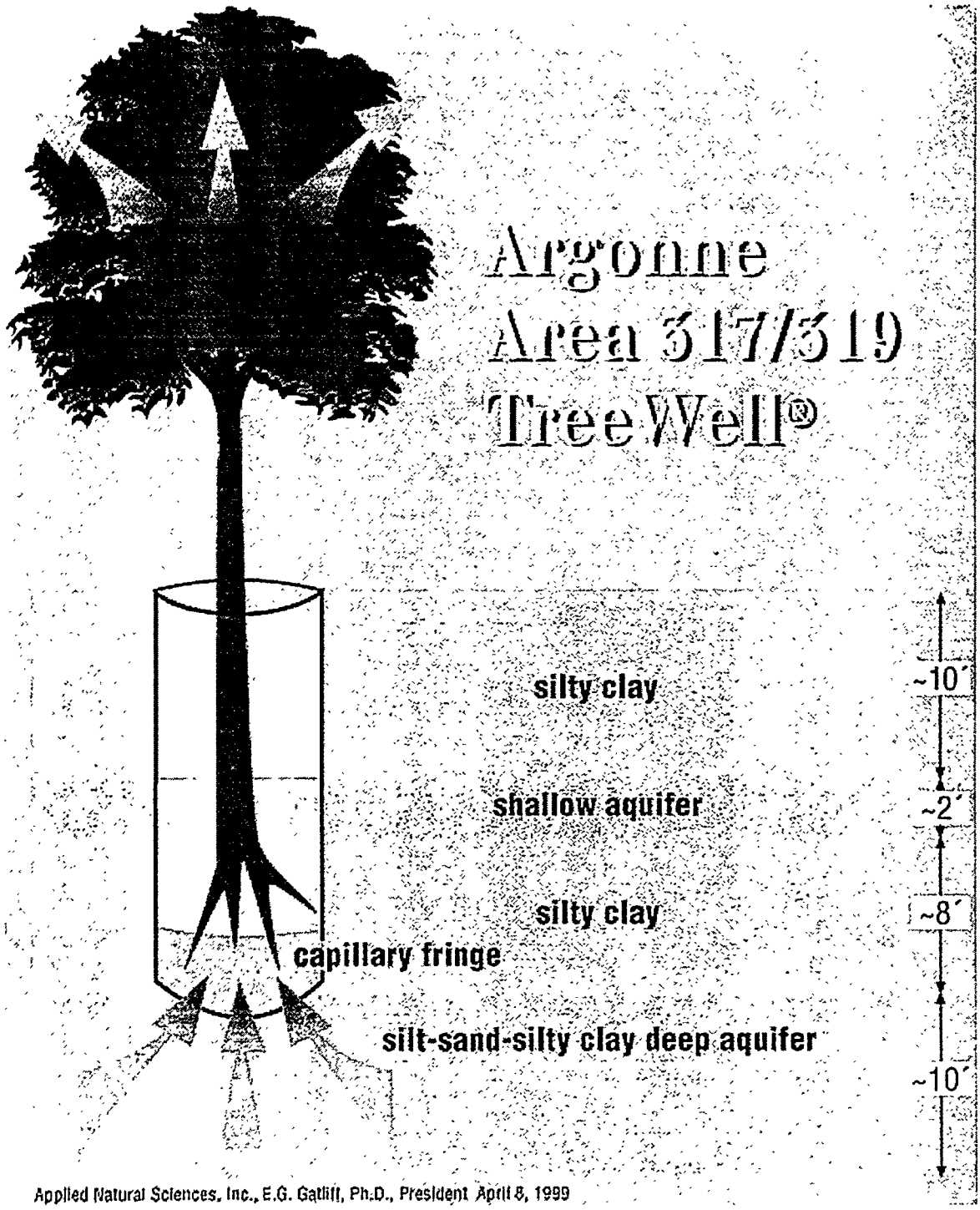

Figure 2 Schematic of a *TreeWell*® installation.

Figure 3 A borehole being drilled in the 317 Hydraulic Control Area.