Abstract

The 317 Area at Argonne National Laboratory-East (ANL-E) is scheduled to undergo a Resource Conservation and Recovery Act (RCRA) Facility Investigation, or RFI. Prior to the formal RFI, a voluntary, preliminary characterization of the 317 Area was conducted by ANL-E. The characterization results were used to formulate the RFI work plan and provided a better focus for the formal investigation.

This site presents a difficult engineering challenge. The nature of the waste disposed at this site in the past includes both liquid chemicals and radioactive waste. The 317 Area is classified as a radiologically controlled area because of operations currently performed there. Present Department of Energy policy stipulates that waste material from such an area must be considered radioactive. The possible presence of hazardous constituents in the soil and groundwater would require the investigation-derived waste generated at the site be disposed as radioactive mixed waste.

Besides the nature of the waste possibly contaminating this site, the geology of the site poses an equally enigmatic situation. The ANL-E site is located in a region of recessional glacial moraine deposits.

1 James Wescott and Larry Moos are both employed by the University of Chicago at Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439. Audrius Remeikis is the owner of ATR Environmental Services LTD., 308 Logan Street, Lemont, Illinois 60439
DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
These moraines consist primarily of northwestward to southeastward trending reworked tills composed of sand, pebbles, and cobbles deposited within a silty clay matrix. The stratified glacial till deposits are approximately 50 feet thick. These glacial deposits play a large role in the understanding of contaminant migration within the 317 Area.

To overcome these complications, ANL-E and its contractor, Roy F. Weston, Inc. (Weston), employed several innovative technologies to delineate the lateral and vertical extent of contamination. Routine ground-water monitoring and preliminary site characterization have identified several areas contaminated with numerous volatile organics and radionuclides.

After a review of available historical information, ANL-E and Weston utilized surface geophysical methods in the initial phase of the characterization. Based on the results of the geophysical surveys, cone-penetration testing (CPT) technology was used at identified anomalous areas and at assumed clean locations to gain a perspective of the geologic formations underlying the 317 Area. Groundwater samples were collected from the CPT locations and analyzed to ascertain the presence of contaminants near the suspect areas.

The results of this characterization provided a basis for selecting the locations for soil boring and monitoring wells to be utilized during the formal RFI. This paper outlines the planning involved in the preliminary characterization process and the procedures utilized to minimize unnecessary waste generation.

Introduction

Argonne National Laboratory-East (ANL-E) is a multi-program laboratory which focuses on basic and applied research that supports the development of energy related technologies. The University of Chicago operates the laboratory for the Department of Energy. ANL-E currently occupies approximately 1,700 acres in Du Page County, Illinois, approximately 25 miles southwest of Chicago. The Illinois Environmental Protection Agency (IEPA) has identified numerous Solid Waste Management Units which require investigation and possible remediation. The Environmental Projects Group at ANL-E conducts and supervises the on-site environmental restoration efforts. An area of particular interest scheduled for a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) is the 317 Area. The RFI for this site will be the model for future RFI's at ANL.

The purpose of the RFI is to characterize the nature and extent of hazardous constituents released into the environment. Because delays in receiving the Part B permit from the IEPA restricted the start of a formal RFI, ANL-E used the time to undertake a voluntary, preliminary characterization of the 317 Area.
The primary purpose during this initial study was to establish a general understanding of the potential contamination at the site so that the formal RFI could have a clearer focus and streamline the required field activities. The information generated by this survey will be used to guide selection of locations for soil boring and monitoring well installation to be implemented in the initial phase of the RFI.

The preliminary effort had several goals that if successful would be incorporated into other site characterizations at ANL-E. One objective was to minimize the amount of waste generated during the course of the investigation. In addition to hazardous constituents, several sites at ANL-E have suspected radiological contamination or, like the 317 Area, are designated radiologically controlled areas. The Department of Energy issued a hazardous waste disposal moratorium in 1991. This moratorium directs ANL-E to cease shipment of RCRA-hazardous waste originating in a radiation controlled area to commercial facilities not licensed by the Nuclear Regulatory Commission or an agreement state. Since there is no criteria to establish whether RCRA-hazardous waste is radioactive, all waste generated during the characterization at the 317 Area would require disposal as radioactive mixed waste. Limiting the amount of investigation-derived waste was critical because of the difficulty and expense of disposing radioactive mixed waste. Current disposal costs for radioactive mixed waste average $200/ft$^3$.

Another objective was to utilize innovative technologies that would provide flexibility in the field and limit the amount of time spent preparing for each subsequent phase of the investigation. Working with Roy F.
Weston, Inc. (Weston), the subcontractor for the project, ANL-E decided to utilize multiple surface geophysical techniques and cone penetration testing (CPT) technology as the initial steps in characterizing the nature and extent of contamination at the 317 Area (Weston, 1993). These methods limited the amount of intrusive activity at the site while providing the capability to quickly concentrate on areas that revealed possible contamination.

Site Background

The 317 Area is currently used as a staging and storage area for dry radioactive waste material. Work associated with the laboratory’s waste management mission takes place in the area on a daily basis. The 317 Area comprises approximately 8 acres. The site is located at the extreme southern perimeter of ANL-E. The site was established in the late 1940’s (Moos, 1990). During this period six partially-buried concrete structures, or vaults, were constructed. The vaults are aligned east-west in two rows of three. Footing drains installed beneath the vaults collect groundwater which is pumped into the laboratory waste water treatment system. Five of the vaults have been used to store low-level radioactive and transuranic waste. The sixth vault, or Alkali Metal Water Reaction Tank (AMWRT), was used until 1989 as a Part A interim status RCRA treatment unit for water reactive alkali metals. A second permitted treatment unit, the Shock Treatment Unit, was located adjacent to the AMWRT and, until 1988, was used to dispose of shock sensitive hazardous compounds. In addition to the permanent structures, several bins of low-level radioactive waste material and orphan waste objects are present on the site.

In the early 1950’s numerous liquid chemical wastes were disposed at the site in what is referred to as a French drain. This structure was a shallow drainage ditch that was filled with gravel and graded. At one end of the French Drain a manhole cover was placed on top of the gravel. Workers at ANL-E would pour spent solvents and other liquid waste into the drain. Once use of the drain ceased, the manhole cover was removed and the area was regraded with gravel. The French Drain was located somewhere north of the vaults, but little documentation exists on the exact location of the drain or the identity of material deposited into the trench.

Site Geology and Hydrogeology

The ANL-E site is located in a region of recessional glacial moraine deposits. These moraines consist primarily of northwestward to southeastward trending reworked tills composed of sand, pebbles and cobbles deposited within a silty clay matrix. The stratified glacial till deposits are approximately 50 to 70 feet thick.

The thick glacial tills and stratified glacial
deposits are part of the Valparaiso Moraine system deposits. An unidentified till member comprised of a silty clay overlies the Lemont Drift deposits (silty clay). The distinction between the two glacial units is subtle and is based primarily on the clay content of each unit. The two units have not been differentiated within the 317 area.

Figure 2. The 317 Area Vaults

The Lemont Drift overlies the uppermost bedrock unit underlying ANL-E. The uppermost bedrock is the Silurian-aged Niagaran Series, Racine Formation dolomite. The Racine Formation is a medium gray (mottled with light or dark gray), massive dolomite with reef/inter-reef origin.

The dolomite is the first usable aquifer underlying ANL-E. The primary method of recharge for this aquifer is vertical leakage through the till deposits. Hydraulic conductivity tests at other ANL-E locations indicated hydraulic conductivities of the glacial tills range from $3.2 \times 10^7$ to $4.2 \times 10^6$ cm/sec. Ground water seepage velocities have been estimated to be 17 to 58 cm/yr.

Historical Data Review

Available documentation regarding the 317 Area was compiled by employee interviews (retired and current), aerial photographs, and declassified documents from the National Archives and Federal Record Center. The available documents included memorandums, weekly Health Physics reports, photographs, drawings, contracts, disposal
records, field notes, boring logs, and laboratory results. Soil gas sampling and shallow groundwater sampling as well as electromagnetic geophysical surveys had been conducted at selected portions of the 317 Area. The results of these previous studies and a review of the accessory historical information provided a foundation to design a series of geophysical surveys.

Geophysical Methods

Based on the historical information three geophysical techniques were used to evaluate different sections of the site. The three methods were each meant to discern particular subsurface features. The geophysical methods used were electromagnetic, DC resistivity, and ground penetrating radar (GPR).

Electromagnetic

Electromagnetic surveys were conducted with Geonics EM-31 and EM-34 instruments. The intention was to isolate the footing drains that ran below this area as well as to provide a general indication of any anomalies that would require further investigation. The surveys were in an east-west direction with data being recorded at 50 foot intervals. The EM-31 was operated in the vertical dipole orientation in both quadrature and in-phase modes. The two coils on the EM-31 are at a fixed distance and provide terrain conductivity readings at approximately 6 meters below ground surface (McNeill, 1980).

The EM-34 was operated in both vertical and horizontal dipole orientations. The two coils on the EM-34 are flexibly connected. This allows for measurements at various depths. The instrument was used at intercoil spacings of 10, 20, and 40 meters with frequencies of 6400, 1600, and 400 Hz, respectively.

DC Resistivity

DC resistivity measurements were conducted to establish a better understanding of site geology. DC resistivity measures the resistive properties of soil to determine the stratigraphic layers underlying the surface. An ABEM 300 meter and the Schlumberger array were used for the depth soundings. Ten soundings were conducted in the vicinity of the 317 Area, four in the southern half of the 317 Area and six around the perimeter of the site. Soundings were located near existing monitoring wells so that well logs could aid the interpretation of resistivity data. Stratigraphic cross sections were developed from the measurements with a five-layer Schlumberger Earth model.

Ground Penetrating Radar (GPR)

GPR is effective in locating and characterizing the
distribution of nonmetallic components to a depth of 20 feet. GPR detects subsurface objects that have electrical properties which contrast with those of the surrounding medium. The GPR was used north of the vaults in the general area of the French Drain. Lines were run in both the north-south and east-west direction. The GPR surveys were conducted with a GSSI Subsurface Interface Radar (SIR) Model 8. The GPR was operated in monostatic mode, with the antenna pulled manually across the ground surface. Data acquisition was accomplished with 120, 300, and 500 MHz antennas. The selection of a particular antenna was based on site conditions including target depth and soil conductivity. Record scans were recorded at a fixed time interval while the transmitter and receiver were moved across the ground surface.

Figure 3. EM-31 Results

Geophysical Results

The electromagnetic surveys in the southern half of the site did not detect any anomalies. This confirmed waste burial activities did not occur in the southern portion of the site. The surveys had difficulty locating the two footing drains that extend south from the vaults. Cultural interferences such as the metal fence surrounding the site, the metal bins stored on the site, and power lines overhead
reduced effectiveness of the electromagnetic equipment.

The DC resistivity data was compiled with the Schlumberger Earth model. Bedrock within the 317 area ranged from a depth of 45 to 55 feet. The depth to bedrock just north of 317 was 45 feet and reached 66 feet south of 317. The overburden material above the bedrock consists of clay to silty clay, and clayey sand and gravel with resistivities ranging from 101 to 246 \( \Omega \text{ft} \).

Several anomalies were detected with the GPR in the area north of the vaults. These anomalies represent potential locations of the footing drains. The specific location of the French Drain was not located.

<table>
<thead>
<tr>
<th>SCHLUMBERGER RESISTIVITY SOUNDING</th>
<th>THICKNESS (ft)</th>
<th>DEPTH (ft)</th>
<th>GRAPHIC COLUMN</th>
<th>LITHOLOGY/RESISTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>1.4</td>
<td></td>
<td></td>
<td>CLAY, SAND &amp; GRAVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( p = 177 , \Omega \text{ft} )</td>
</tr>
<tr>
<td>12.9</td>
<td></td>
<td></td>
<td></td>
<td>CLAY (HIGH PI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( p = 75.8 , \Omega \text{ft} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.3</td>
<td></td>
<td>SILTY CLAY (LOW PI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( p = 140 , \Omega \text{ft} )</td>
</tr>
<tr>
<td>6.7</td>
<td></td>
<td>21</td>
<td></td>
<td>CLAYEY SAND &amp; GRAVEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( p = 235 , \Omega \text{ft} )</td>
</tr>
<tr>
<td>9.8</td>
<td></td>
<td>30.8</td>
<td></td>
<td>LIMESTONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( p = 330 , \Omega \text{ft} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( p = 1872 , \Omega \text{ft} )</td>
</tr>
</tbody>
</table>

Figure 4. Stratigraphic Column

Cone Penetration Testing and Groundwater Collection

After the geophysical results were evaluated, CPT locations were finalized. The CPT locations were determined based on terrain, historical records, and the geophysics results. The historical information available on the French Drain resulted in locating several CPT points in the vicinity of the French Drain around the vaults. The geophysical results, particularly the electromagnetic data,
allowed us to shift emphasis away from the southern half of the 317 Area and concentrate on other areas of the site. A total of 21 separate points were chosen for CPT and groundwater sampling. Fourteen of these points were within 317. Several CPT points were in the area north of the vaults where the French Drain plume was detected. Groundwater collection inside 317 was accomplished using a slip-screen cone, a variation of the Hydropunch, fabricated by the CPT contractor. A Hydropunch was planned for use outside the 317 Area. This groundwater collection system was not successful at some CPT locations. At these points a 1-inch PVC slotted tube was placed into the hole and groundwater collected with an inertial pump.

The CPT system is mounted on a three-axle truck with 23 tons of dead weight used to counteract the thrust of the hydraulic ram. The CPT probe continuously measures pore water pressure, side shear friction, end-bearing resistance, and electrical conductivity. Soil type classifications are interpreted from end-bearing resistance and side shear stress. Sands tend to have a high end-bearing resistance and a low shear stress; the opposite is true for clay-rich materials. Pore water pressure was measured using a piezometric pressure transducer. The variations in the pore water pressure were used to distinguish water bearing layers in the subsurface.

Two penetrations were performed at each location. The first penetration used the electronic cone to collect stratigraphic and hydrogeologic information. The cone was advanced to refusal at each point. Data from the cone was recorded on a real-time basis for every inch of soil penetrated. This allowed for the instantaneous production of "boring logs" for the field engineer.

Once a water bearing layer was identified, the cone was removed and a second hole was punched into the subsurface. The second hole was in the proximity of the first hole, but spaced so as to minimize the chance of cross contamination. When the water bearing layer was located the equipment was partially withdrawn, exposing the slip-screen. Groundwater flowed through the screen and collected in the cavity of the cone. Groundwater was withdrawn using an inertial pump for metals, chloride and tritium analyses. The slip-screen assembly was then withdrawn and the water remaining in the cone collected for volatile organic compounds (VOCs) analysis. For the points where the Hydropunch was ineffective, a PVC slotted tube was inserted into the second hole. When sufficient water had collected in the tube groundwater samples were collected with an inertial pump at these points.

Each time the downhole equipment was withdrawn from the subsurface, grout was pumped down along the sides of the equipment. This prevented any contaminated groundwater from contaminating other saturated layers. Decontamination of the downhole equipment inside the 317 area occurred as the equipment was being withdrawn. The rods passed through a washing chamber mounted on the bottom of the hydraulic
ram assembly. The rods were steam cleaned in the chamber. The wash water was collected in the chamber and later transferred to 55 gallon drums. The CPT and groundwater collection outside the 317 area used a slightly different rig. At these points the rods were completely removed from the ground, then taken a sufficient distance from the hole where they were steam-cleaned.

**CPT and Groundwater Analyses Results**

The CPT field work began one week after the completion of the geophysical surveys. The field work, especially the CPT, proceeded slower than expected, but this was mostly weather related. Thawing conditions made it difficult for the heavy CPT rig to navigate easily around the site. Flexibility, rather than speed, was important. At several CPT locations the first groundwater sampling hole was dry because of the variation in the till seams. The CPT rig could quickly offset a few feet and punch another hole. At only two locations were no water samples able to be secured.

The soil within the 317 area consists primarily of low permeability cohesive clay and silty clay till deposits. Several discontinuous, shallow, silty sand lenses underlie the site (Weston, 1993). The lenses within 317 are thin and range from 1 foot to approximately 10 feet thick. Numerous cobbles and boulders were also encountered, which is common of the glacial till formations in the region. Because of the composition of the soil matrix, the CPT probe was limited in its penetration depth. On average the probe met refusal at approximately 25 feet below grade. The probe would either hit an obstruction that it could not push through or the angle of inclination became too severe.

Potentiometric and soil electrical conductivity measurements indicate the shallow till is generally wet and saturated below 10 feet. Potentiometric levels in the granular lenses tend to decrease with depth, indicating downward gradients throughout much of the site. Water-bearing silty sand lenses are present on the north side of the vaults in the same area as the French Drain plume. A 2-foot-thick silty sand lens was encountered at a depth of 20 to 25 feet below surface. A second 3-foot-thick silty sand lens was encountered at approximately 30 feet below surface. Deep soundings at two CPT points reached approximately 55 feet. Potentiometric measurements from this depth indicated water table conditions within a granular layer.

Nineteen groundwater samples were collected from the CPT locations, 12 inside 317 and 7 outside the 317 Area. Three of the holes were either completely dry or would not yield a sufficient volume of water. The fabricated slip-screen sampler used inside the 317 Area was effective in collecting water sample, but the Hydropunch used outside the site was easily clogged by sediment and its use had to be abandoned. Groundwater samples outside the 317 Area were
subsequently collected from 1-inch PVC slotted tubes inserted into the ground.

![Soil Profile Constructed from CPT Soundings](image)

Figure 5. Soil Profile Constructed from CPT Soundings

The majority of the contamination detected was from VOCs. Twenty different individual compounds were detected. The highest detection levels were north of the vaults in the French Drain plume. Tetrachloroethene was detected at the highest level at 47,000 µg/L. The highest concentrations were located in an area north of the vaults. Smaller concentrations of VOC's were detected between the two rows of vaults, and east, west and south of the vaults. It appears that the plume is moving within the saturated layers of soil, about 6 feet below ground surface. The plume is concentrated between a crane tower and the northern row of vaults. The vaults present a barrier to the desired direction of flow for the plume. The plume has consequently extended around both ends of the vaults.

Ten metals were detected in the groundwater. Metals concentrations were similar to upgradient sample concentrations. Chloride concentrations were highest in the vicinity of the vaults with concentrations ranging from 79.8 to 712 mg/L. Tritium was detected at 17 of the CPT locations. Tritium concentrations ranged from 0.08 to 4.7 pCi/mL, which are well below drinking water standards for tritium. The highest concentration of tritium was north of the vaults in the same area as the French Drain plume. It is not suspected that tritium was disposed in the drain. The vaults have historically held radioactive material awaiting disposal. Over the years the vaults have developed cracks and are now subjected to periodic flooding by
groundwater and release of radioactive material.

Conclusions

All of the objectives for this characterization effort were satisfied. A general picture of the stratigraphy, hydrogeology, and contamination in the 317 area has emerged. Most of the contamination was as expected in the area of the French Drain. One interesting result was the depth and lateral extent that the plume has migrated within the till. The presence of very low levels of tritium in the same area presents further complications from a waste treatment and disposal perspective.

By conducting the intensive preliminary characterization, ANL-E was able to generate a much more accurate conceptual site model which was used to direct the sampling and analysis efforts for the formal RFI investigation. The State of Illinois has organized the RFI process into three phases: phase I being geared toward identifying contaminant release from a unit, phase II identifying the nature and extent of soil contamination and phase III identifying the extent of ground-water contamination. The magnitude of preliminary characterization data generated and included in the RFI work plan allowed the investigation to move immediately into phases II and III at the more complex units, greatly accelerating the completion of the investigation of these units. The knowledge of the general nature and distribution of contaminants also allowed the analysis requirements to be minimized. Significant reductions in the cost of analysis were realized by including only those contaminants identified during the preliminary characterization.

Providing extensive preliminary characterization data to the IEPA gave them the confidence to approve the RFI work plan on the first review.

A limited amount of waste was generated during the characterization. Five 55 gallon drums of decontamination fluid, primarily from the cleaning of the CPT rods, were generated. The water was analyzed for VOCs, RCRA metals, and tritium. No VOC’s or RCRA metals were detected in the water. Elevated levels of tritium prevented the water from being discharged to the laboratory sewer system. The water was treated in the ANL-E low-level radioactive liquid waste evaporator. Three drums of solid low-level radioactive waste were generated. This waste consisted of personnel protective equipment and hardware generated during the groundwater sampling. The waste was disposed as low-level radioactive waste.

In general, the Environmental Projects Group resolved several issues for future site investigations at ANL-E.

• Electromagnetics work well in open areas, providing a great deal of data quickly.
• CPT technology is excellent in shallow, glacial till deposits.
Waste minimization can be accomplished without sacrificing data collection.

Electromagnetic equipment may not be appropriate on sites with a large concentration of metallic structures or objects.

Terrain and weather can adversely impact the effectiveness of CPT technology.

The composition of the soil matrix under ANL-E may preclude the use of CPT technology for sampling below 50 feet.

The Hydropunch requires modifications to be effective in collecting groundwater samples in the glacial till deposits underlying ANL-E.

Acknowledgement: The authors would like to acknowledge the assistance of Roy F. Weston, Inc., without whose work this paper would not have been possible.


The submitted manuscript has been authored by a contractor of the U.S. Government under contract No. W-31-109-ENG-38. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes.

References

