Case Study Abstract

Baker Wood Creosoting Company
Marion, Ohio

Site Name and Location: Baker Wood Creosoting Company Marion, Ohio	**Geophysical Technologies:** Ground penetrating radar Electromagnetic induction	**Date of Investigation:** January and February, 1999
Period of Site Operation: 1890's to 1960's **Operable Unit: N/A**		**Current Site Activities:** Assessment of sediments in the Little Scioto River is being performed. Future plans include installing five or six shallow water wells to determine if the groundwater is contaminated.
Points of Contact: Mark Durno U.S. EPA 25089 Center Ridge Road Westlake, OH 44145 216-522-7260 Mr. Mark Vendl Mail Code SRT-4J USEPA Region 5 77 West Jackson Boulevard Chicago, IL 60604-3507	**Geological Setting:** Two to three feet of silt loam underlain by a firm calcareous clay	**Technology Demonstrator:** U.S. EPA and Ohio State University
Purpose of Investigation: To locate possible buried waste pits or other contaminant-filled structures and to delineate the extent of contamination within the surficial soils.		
Number of Images/Profiles Generated During Investigation: 100 GPR traverses		
Results: Lateral extent of contamination determined in the shallow subsurface by EM and GPR. GPR was operated in a cross- and co-pole antenna configuration which clearly identified a series of buried vaults containing highly contaminated material.		

EXECUTIVE SUMMARY

The former Baker Wood Creosoting Company is located on 60 acres in Marion. The site is located approximately one-half mile northwest of downtown Marion. The Little Scioto River is located one mile to the west of the site. The property was used from the 1890s to the 1960s as a wood treating facility, and the preservatives used were most likely creosote, petroleum, and other solvents. All buildings have been removed from the site, but the concrete pads that supported the creosote storage tanks and a former pump house remain. The geophysical study was conducted within the area that encompasses the former tank area and pump house.

The surficial soils consist of a two- to three-foot surface layer of silt loam, underlain by a firm calcerous clay. Glacial till containing occasional thin interbedded sand layers extends from beneath the surface soil to Silurian limestone/dolomite bedrock, which is present at depths of approximately 13 to 25 feet below ground surface in the area. The limestone/dolomite bedrock appears to contain a shallow and deep aquifer. Regional groundwater flow direction of the deep aquifer is believed to be influenced by the quarry located northeast of the Baker Wood site and by the municipal well field situated west of the site. Typically, the generalized groundwater flow is westward towards the Little Scioto River.

A geophysical investigation was conducted in 1999 to delineate the extent of contamination prior to conducting a time critical removal action. The information in this report was derived from the interpretive report for the geophysical investigation. Two geophysical methods were used during this investigation. A ground penetrating radar (GPR) survey was conducted first, followed by a frequency domain electromagnetic induction (EM) survey. The GPR was used to locate subsurface structures that might contain contamination while EM was used to detect anomalous soil conductivities that might indicate the presence of contamination in the surface and near-surface soils.

The GPR survey identified nine areas with significant subsurface anomalies in the study area. Five of the areas included vaults buried underneath each of four tank pads, a creosote-filled pit, and a trench. The EM survey found areas of low conductivity soils that indicate the potential location of contaminated soil. Areas of low conductivity were less prominent in the lower frequency data than in the higher frequency data indicating that contamination was predominantly present in the near surface. Subsequent exploratory trenching and screening analysis of soils was conducted in the nine areas identified in the geophysical investigation, and significant contamination was found in five of them.

Although soil sampling from 1996 showed contamination in the same area as the GPR survey showed, the lateral extent of contamination was unknown prior to the GPR survey. The GPR survey provided information on lateral extent. Based on the GPR survey, it was estimated that 1800 cubic yards of contamination existed at the Baker Woods site. Because contamination was found to a depth of five and six feet in some locations, and the GPR was only able to see to four feet, an additional 400 cubic yards of contamination was found and removed.

SITE INFORMATION

Identifying Information

Baker Wood Creosoting Company
Holland Road and Kenton Street
Marion, Ohio

Background [1, 2, 3, 4, 5, 7]

Physical Description: The former Baker Wood Creosoting Company is located on 60 acres in Marion, Ohio, in the north-central part of the state, as shown in Figure 1. The Baker Wood Creosoting Company is located at the northwest corner of Holland Road and Kenton Street (State Route 309), and is approximately one-half mile northwest of downtown Marion. The Little Scioto River is located one mile to the west of the site. The topography of the site is flat with a shallow westward gradient.

All buildings have been removed from the site, but the concrete pads that supported the creosote storage tanks and a former pump house remain. The pads and former pump house are located within an area of approximately 130 by 50 feet, just south of a gravel access road. The geophysical study was conducted on a 300- by 100-foot area that encompasses the former tank area and pump house. This part of the site is located in the southeast section of the 60 acres (See Figure 2).

Figure 1: Site Location

Site Use: The property was used from the 1890s to the 1960s as a wood treating facility, and was owned by the Baker Wood Creosoting Company. Historical information indicates that the process used pressure vessels to treat railroad ties and other wood products. The preservatives used were most likely creosote, petroleum, and other solvents. It is currently owned by Baker Wood Limited Partnership and is an inactive site.

It was believed that chemical wastes were discharged to the combined sanitary/storm sewer that is located adjacent to the site, along the southern border. The sewer flows west and discharges directly into North Rockswale Ditch. Drawings indicate that the old sewer tie-ins from the facility may still be in use. This combined sanitary/storm sewer is thought to be a direct link to the surface water contaminant migration pathway leading to the North Rockswale Ditch.

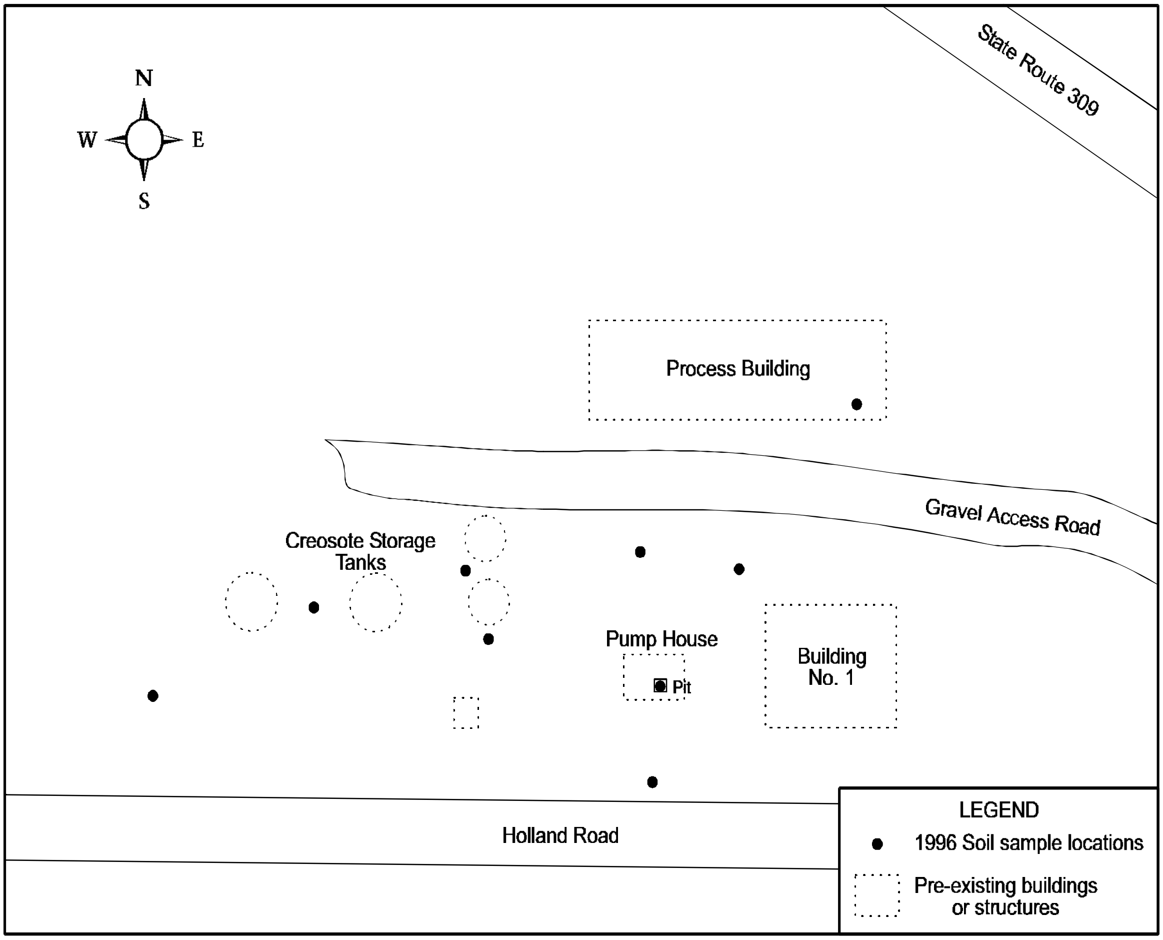

Figure 2: Baker Wood Site Map [1]

Release/Investigation History:

Numerous sampling events have been conducted in and around the Baker Wood site since the 1940s. In 1988 and 1991, the Ohio Environmental Protection Agency (EPA) collected sediment samples from the Little Scioto and Scioto Rivers. Analysis of the samples showed high concentrations of polycyclic aromatic hydrocarbons (PAHs). Investigators observed on both occasions that the banks and bottom sediments of the Little Scioto River were heavily saturated with a black material with a creosote odor. When disturbed, the bottom sediments released an substance that left an oily sheen on the water's surface. The U.S. EPA and Ohio EPA collected soil samples in 1996 around the former creosote storage tanks and pump house. Analytical results from the soil samples revealed some of the highest concentrations of PAHs ever recorded in the published literature.

SITE INFORMATION

Regulatory Context:

The U.S. EPA and Ohio EPA have conducted response actions at the Baker Woods Creosoting Company site under a time critical removal authority provided under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments Reform Act (SARA).

Site Logistics/Contacts

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MEDIA AND CONTAMINANTS

Matrix Identification [3]

Type of Matrix Sampled and Analyzed:
Subsurface soil consisting of silt loam.

Site Geology/Stratigraphy [3, 5]

The surficial soil profile at the Baker Wood site consists of a two- to three-foot surface layer of silt loam, underlain by a firm calcerous clay. Glacial till containing occasional thin interbedded sand layers extends from beneath the surface soil to Silurian limestone/dolomite bedrock, which is present at depths of approximately 13 to 25 feet below ground surface (bgs) in the area. The limestone/dolomite bedrock appears to contain a shallow and deep aquifer. The shallow aquifer is encountered at approximately 40 feet bgs, and the deep aquifer is encountered at about 250 feet bgs.

Regional groundwater flow direction of the deep aquifer is believed to be influenced by the quarry located northeast of the Baker Wood site and by the municipal well field situated west of the site. Typically, the generalized groundwater flow is westward towards the Little Scioto River.

Contaminant Characterization [1]

Primary Contaminant Groups: The primary contaminants of concern at this site are volatile organic compounds (VOCs) and PAHs.

Matrix Characteristics Affecting Characterization Cost or Performance [1]

Clays in the soils and high soil moisture content posed a significant challenge for GPR data collection during the investigation by limiting the depth to which measurements could be taken. Both caused excessive signal attenuation resulting in late signal arrival times. Investigators tried to correct for this interference by using a 300 MegaHertz (MHZ) antenna, but the radio tower, located on the adjacent property, caused interfering noise at that frequency. As a result, a 500 MHZ antenna was used for the investigation, but at this frequency, the investigation depth was limited to three to four feet bgs. The investigation team believed this to be a sufficient depth based on prior knowledge of site conditions.

Standing water, which ranged in depth from 10 to 15 inches, on the site resulted in late signal arrival times, but the standing water was mapped so that the data interpretation would not be affected. The late arrival times were due to the water having a relatively lower velocity than the surrounding areas that did not have water present.

GEOPHYSICAL INVESTIGATION PROCESS

Investigation Goals [1]

The goals for this project were to locate possible buried waste pits or other contaminant-filled structures, and to delineate the extent of contamination within the surficial soils.

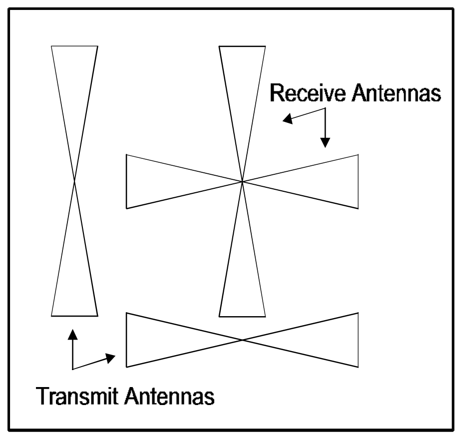
Geophysical Methods [1, 6]

Two geophysical methods were used for this investigation. A ground penetrating radar (GPR) survey was conducted first, followed by a frequency domain electromagnetic induction (EM) survey. The GPR was used to locate subsurface structures that might contain contamination while EM was used to detect anomalous soil conductivities that might indicate the presence of contamination in the surface and near-surface soils.

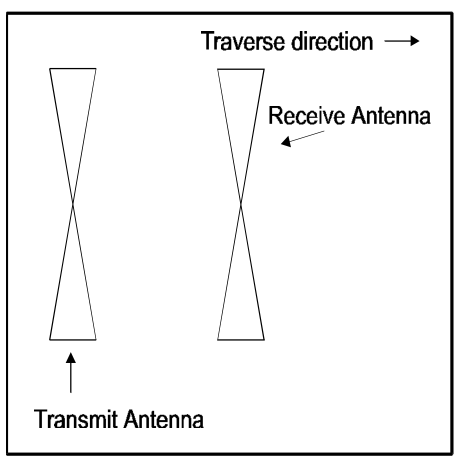
GPR employs an extremely short electromagnetic pulse that penetrates into the earth. A portion of the energy is reflected back to the surface, where it is detected by the receiving antenna. The amplitude of the reflected pulse depends primarily on the soil's dielectric constant, or the measure of electrical conductivity of soils. GPR anomalies result when there is a contrast in the bulk dielectric property between materials, marking a boundary between geologic structures. The time lapse between transmission and receipt of the EM signal it is measured in nanoseconds (ns) and is transmitted to a control unit for processing and display.

The GPR study design for the Baker Wood Site called for the collection of two complementary sets of data. The data were collected using the GPR in a co-pole and then in a cross-pole antenna configuration (See Figure 3). The collection and comparison of the two types of data added an analytical dimension to the GPR data that improved the GPR data, thus improving the interpretation of the results. Each antenna configuration is sensitive to different types of objects in the subsurface.

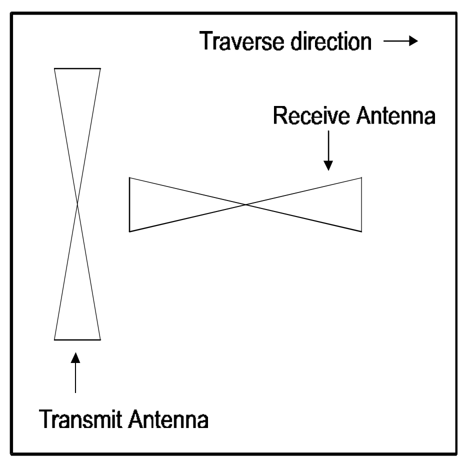
The polarization of reflected electromagnetic energy depends on the geometry of the reflecting surface. Relatively flat subsurface targets or ones with small curvature reflect relatively large currents of linearly polarized signals. Targets that are not planar, or have irregular surfaces, scatter or depolarize the EM waves. A co-pole antenna configuration is primarily sensitive to linearly polarized reflections. The cross-pole configuration is most sensitive to depolarized reflections, while being less sensitive to energy that is scattered parallel to the transmit antenna. Thus, the use of both antenna configurations allowed investigators to identify anomalies representing a wider variety of subsurface geometries.



Multi-component GPR antenna arrangements



Co-pole perpendicular to traverse direction



Cross-pole with transmit antenna perpendicular to traverse direction

Figure 3: Antenna Configurations for Co-Pole and Cross-Pole GPR Measurements

GEOPHYSICAL INVESTIGATION PROCESS

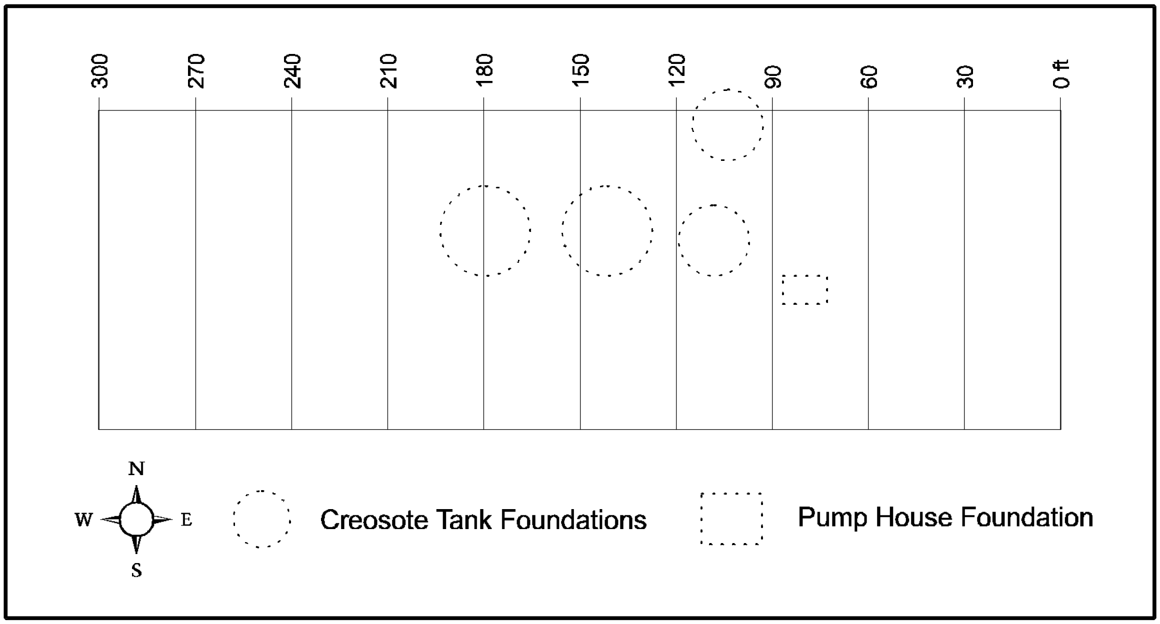


Figure 4: Geophysical Survey Area Showing North-South Traverse Lines [1]

Geophysical surveys were conducted on a 100- by 300-foot grid with a 3-foot spacing between the north-south traverse lines. This area included the foundations of the creosote storage tanks and the former pump house (see Figure 4). Two separate surveys were conducted during January and February 1999. The data from the two surveys was compared to identify variations in the results due to changes in soil moisture. No significant variation was detected in the results of the two surveys.

The GPR survey was conducted using a Geophysical Survey Systems, Inc. (GSSI) 500 MHZ multi-component antenna with a Subsurface Interface Radar (SIR)-10 recording system with a fixed number of traces recorded per distance traveled. The GPR system was towed using a survey wheel to accurately position the data spatially.

The EM survey was conducted to identify the spatial extent of soil contamination, identified b y the survey as areas of anomalous low conductivity resulting from creosote contamination within surficial soils. It has been postulated that when organic contamination interacts with and displaces soil moisture in the vadose zone, a decrease in conductivity can result. In the areas where the highest levels of creosote contamination were found, the EM survey showed the lowest conductivity values in the entire area.

The EM method is based on measuring the response of an electromagnetic field induced into the earth. Low frequency signals, one to ten kilohertz, are transmitted by a small coil. The low frequency, very long wavelength, electromagnetic fields produced by the transmitter induce current flow in electrically conductive media in the earth. This induced current flow produces secondary

GEOPHYSICAL INVESTIGATION PROCESS

electromagnetic fields which will radiate back to the surface. A receiving coil detects the secondary field and measures the strength and phase relative to the transmitted signal.

This EM survey was conducted using a GSSI GEM-300. For the GEM-300 system, the secondary field that is measured is split into in-phase and quadrature components that are expressed in parts per million (ppm) against the primary induced field strength. The in-phase response is sensitive to metal conducting targets and is referred to as the metal detector mode, while the quadrature phase response is sensitive to non-metallic conductors and is referred to as the terrain conductivity mode.

EM measurements were taken every two feet along the same traverse lines on the 100- by 300-foot survey grid used in the GPR survey. Measurements were taken at three different frequencies: 2010 Hz (2kHz), 4410 Hz (4 kHz), and 9810 Hz (9kHz), with the long axis of the instrument oriented parallel to the survey lines and the dipole axis oriented vertical to the plane of the ground. The variation in frequencies provided investigations to different depths. The depth of penetration of the transmitted field is a function of the frequency of operation or frequency of the EM signal. Lower frequencies penetrate deeper, while higher frequencies are attenuated more rapidly.

GEOPHYSICAL FINDINGS

Technology Calibration

No independent calibration information was required for the GPR and EM instruments used in this investigation.

Investigation Results [1]

The GPR survey identified nine areas with significant subsurface anomalies in the study area. Subsequent exploratory trenching and screening analysis of soils at the nine areas found significant contamination in five of them. The five areas included vaults underneath each of four tank pads, a creosote-filled pit, and a trench. The GPR findings discussed in this case study are limited to those that focus on the creosote-filled pit and one of the tank pad vaults as they are representative of the data collected around the other significant anomalies.

Figure 5 shows both two-dimensional (2-D) and three-dimensional (3-D) displays of the cross-pole data collected southeast of the former pump house. Three-dimensional displays were generated by stacking multiple 2-D profiles and provide an enhanced visualization of the GPR anomaly. The anomaly in this profile was determined to be a creosote-filled pit during subsequent sampling and analysis of the soils in the area. Co-pole data collected along the same set of traverses contained more clutter, making identification of the anomaly difficult.

Figure 6 presents 2-D and 3-D views of both co- and cross-pole data collected near the two easternmost storage tank pads. A backfilled-trench, which later was discovered to contain creosote-contaminated drainage tile, can be seen in the profiles, located between the two storage pads. A comparison of the views generated using co- and cross-pole data shows that the cross-pole data contains less clutter and has better resolution. The clutter present in the co-pole data nearly obscures the trenched area between the two pads.

The EM survey in-phase data showed anomalous regions of relative high conductivity in the vicinity of the tank and pump house foundations as a result of rebar within these structures. These regions of relatively high conductivity were also evident in the quadrature responses at the 4 kHz and 9 kHz frequencies measured. Areas of low conductivity, shown as light areas in Figure 7, indicate the potential location of contaminated soil. Research has shown that as the soil moisture becomes contaminated with organic compounds, including those found at this site, the electrical conductivity of those soils decreases. Areas of low conductivity were less prominent in the 4 kHz data than in the 9 kHz data indicating that contamination is predominantly present in the near surface. The 4 kHz data showed areas of low conductivity in the vicinity of the tank foundations, which correlated with soil contamination that was found at greater depths.

Figures 8 shows where the geophysical survey found anomalies and where trenching was to be conducted based on the anomalies. Figure 9 shows where the creosote-filled pits and vaults were located. Comparing the two figures it is apparent that the accuracy with which the GPR survey identified the location of the vaults and pit was within a few feet.

Although soil sampling from 1996 showed contamination in the same area as the GPR survey, the lateral extent of contamination was unknown prior to the GPR survey. Based on the GPR survey, it was estimated that 1,800 cubic yards of contamination existed at the Baker Woods site. During excavation, contamination in some locations was found to a depth of 5 or 6 feet, but primarily, the contamination was excavated from the same depths as those indicated by the EM survey. By the end of the cleanup project, the total soil removed was 2,200 cubic yards. Thus, estimations the results of the geophysical surveys were within 20 percent of the volume of contaminated material excavated at the site.

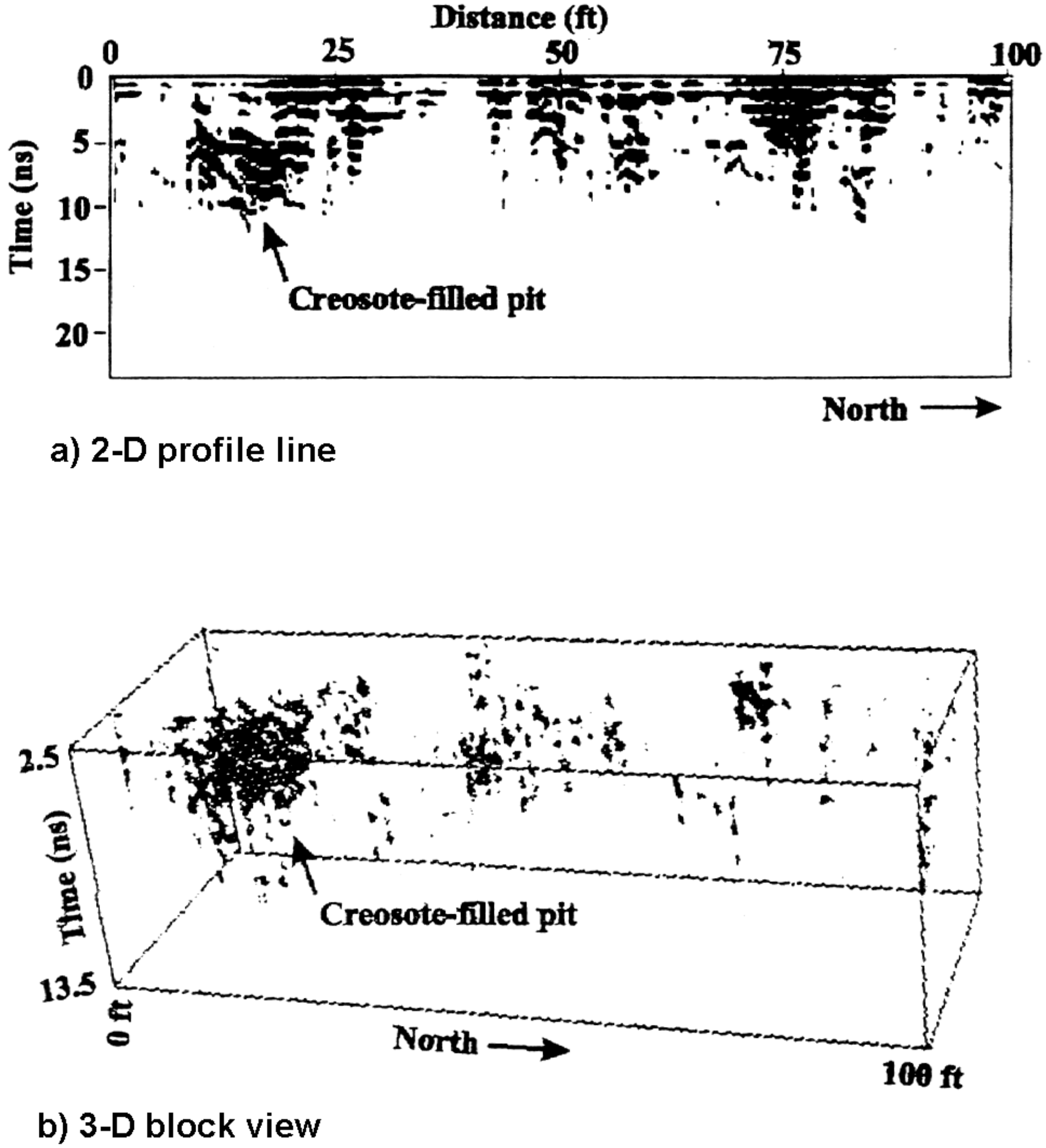


Figure 5: Cross-Pole Data Collected Near Pump House Foundation [1]

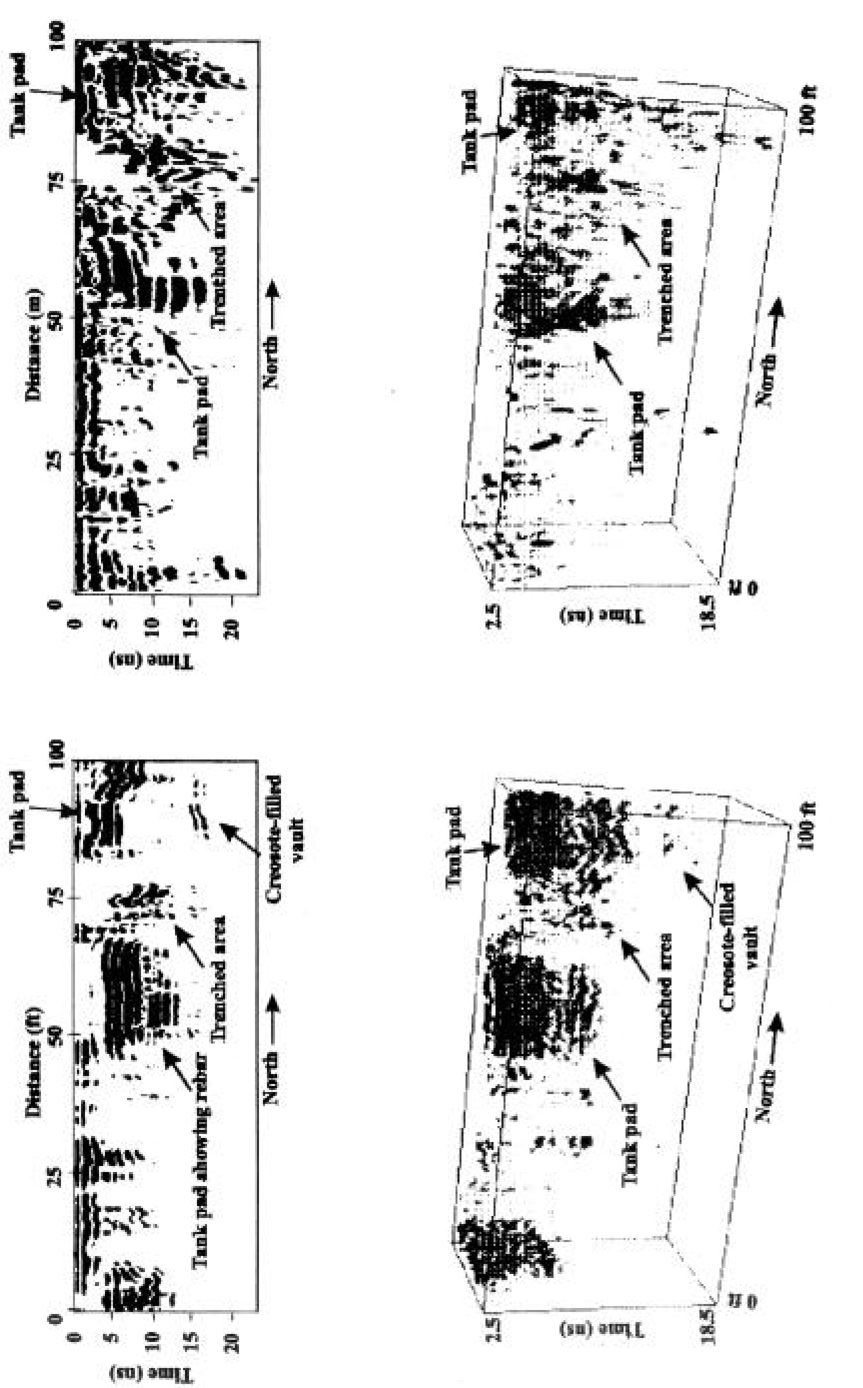


Figure 6: GPR Data Collected Near Eastern Storage Pads [1] [Poor Quality Original]

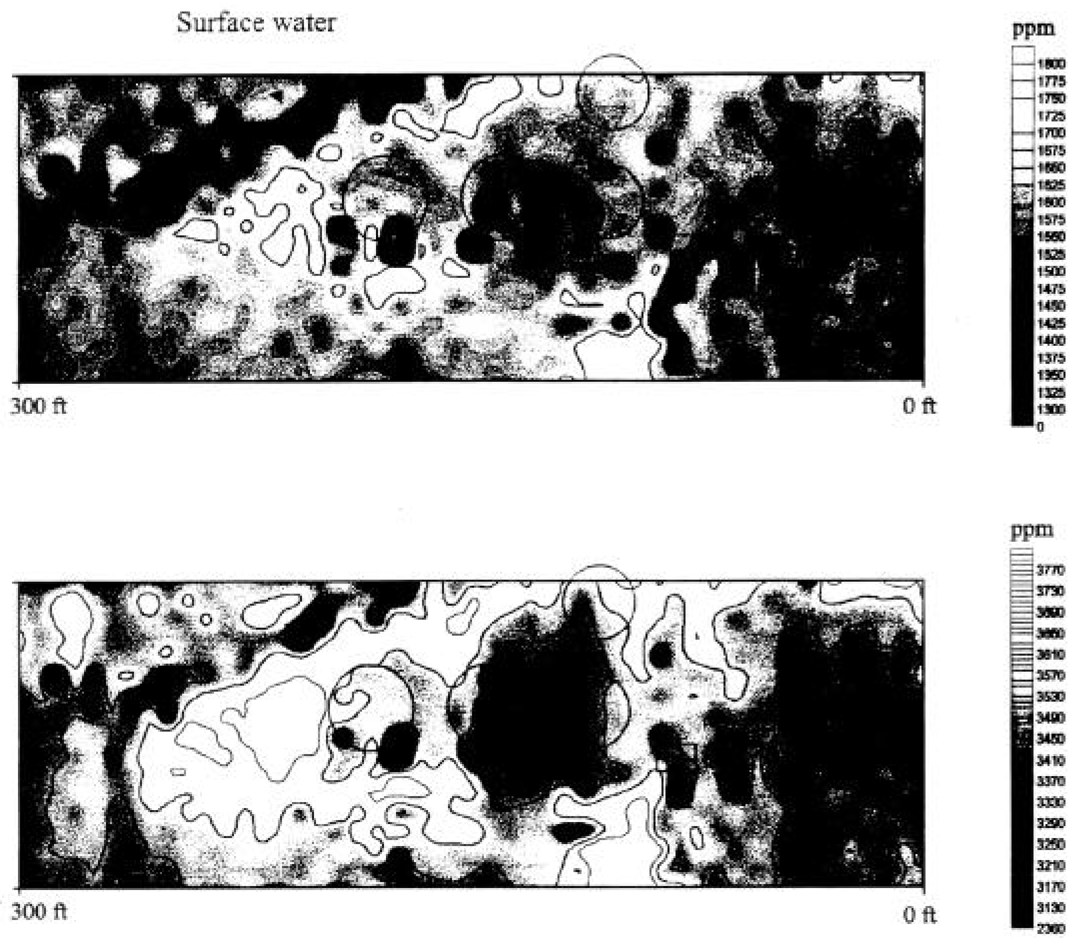


Figure 7: Electromagnetic Conductivity of Soils in Study Area [1]

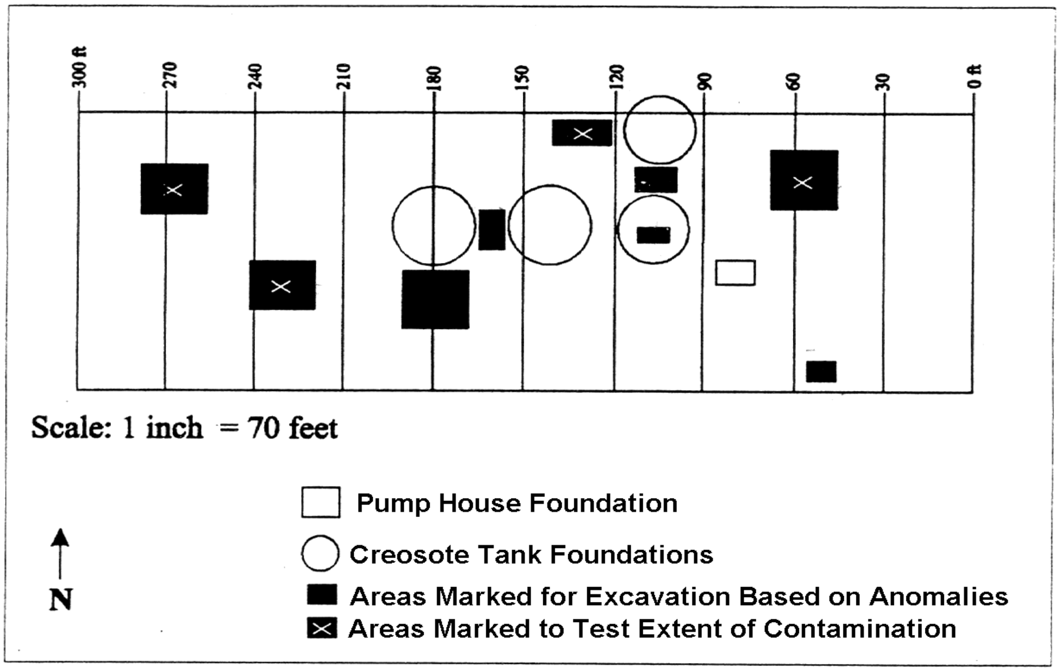


Figure 8: Locations Selected For Screening by Geophysical Surveys [1]

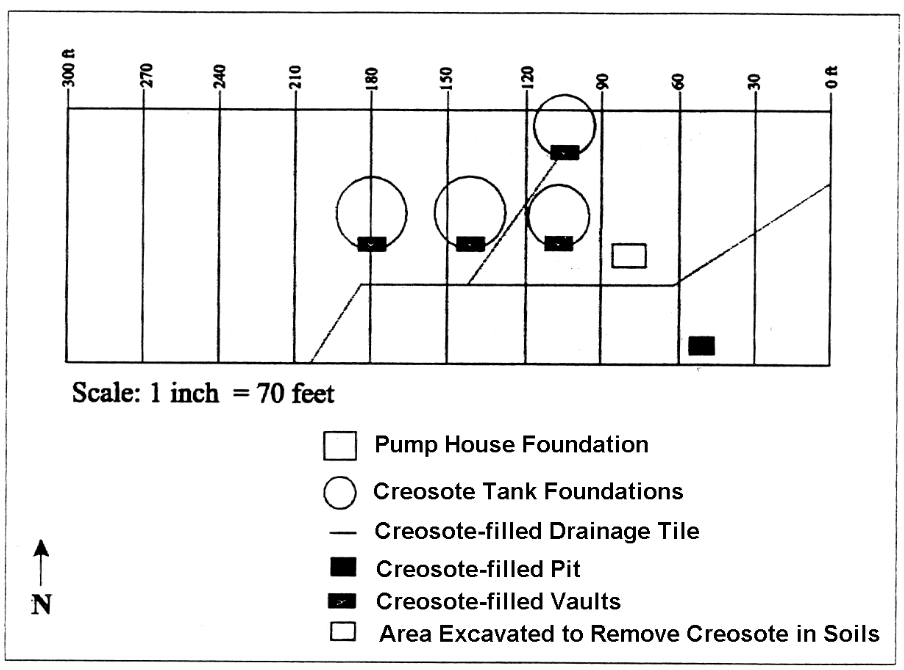


Figure 9: Locations of Significant Soil Contamination [1]

GEOPHYSICAL FINDINGS

Results Validation [1, 7]

Using the GPR and EM results together, investigators were able to identify nine areas for further, invasive investigation. Exploratory trenches were excavated in each of the nine areas and soil samples were taken from the trenches. The soil samples were analyzed in the field using a field portable flame ionization detector. Based on these analytical results, significant contamination was found in five of the nine areas.

LESSONS LEARNED

Some of the lessons learned from this investigation include the following:

- The effectiveness of this GPR survey was improved with the collection and analyses of both co-pole and cross pole data.

- Standing surface water and layered clay soils attenuated the GPR signal in certain portions of the study area, interfering with the interpretation. These areas were mapped. It is anticipated that results would have been clearer in the absence of standing water.

- The GPR survey was successful in identifying subsurface structures that held contaminated material, including a vault hidden beneath a pit. The EM survey was successful in identifying areas of suspected soil contamination. Information from both surveys were used to identify nine areas for investigation. Trenches were excavated and the soils analyzed in each area. Significant contamination was found in five of the areas.

- Although soil sampling from 1996 showed contamination in the same area as the GPR survey showed, the lateral extent of contamination was unknown prior to the GPR survey. Based on the GPR survey, it was estimated that 1800 cubic yards of contamination existed at the Baker Woods site. Because contamination was found to a depth of 5 and 6 feet in some locations, and the GPR was only able to see to 4 feet bgs, an additional 400 cubic yards of contamination was found and removed.

- The low conductivity areas identified in the EM survey correlated with areas of high concentrations of creosote contamination and were verified through soil sample analysis and exploratory trenching.

REFERENCES

1. Guy, E.; Daniels, J.; Holt, J.; Radzevicius, S. *Geophysical Investigations at the Former Baker Wood Site, Marion, Ohio*. Ohio State University. August 1999.

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3. Ohio Environmental Protection Agency. *Bottom Sediment Evaluation of Little Scioto River, Marion, Ohio*. 1992.

4. U.S. Environmental Protection Agency. *Fact Sheet: U.S. EPA Continues Cleanup At Baker Wood Creosoting Site*. July 1999.

5. Ohio Environmental Protection Agency. *Integrated Assessment (IA) Report: Baker Wood Creosoting Site, Marion, Marion County*. 1998.

6. Personal Communication with Mark Vendl of U.S. EPA. September 30, 1999.

7. Personal Communication with Mark Durno of U.S. EPA. September 30, 1999.

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