Case Study Abstract

New Hampshire Plating Co.
Merrimack, NH

Site Name and Location: New Hampshire Plating Co. Merrimack, NH	**Geophysical Technologies:** Marine seismic-reflection surveys Ground-penetrating radar Natural gamma EM borehole logs	**CERCLIS #** NHD0010091453
Period of Site Operation: 1962 to 1985 **Operable Unit:** N/A		**Current Site Activities:** EPA issued a proposed cleanup plan to the public in January 1998. The EPA plans to conduct a treatability study in Summer or Fall, 1999. In addition, on-going groundwater monitoring is being conducted.
Point of Contact: Thomas Mack U.S. Geological Survey 603-226-7805	**Geological Setting:** Alluvial terrace underlain by glaciolacustrine sediments and till. The underlying bedrock consists of schists and phyllites with minor amounts of granite and gneiss.	**Technology Demonstrator:** United States Geological Survey
Purpose of Investigation: To use geophysical methods to identify contamination from the New Hampshire Plating Company and to determine underlying lithology. The geophysical methods used were marine-seismic reflection, ground-penetrating radar, and natural-gamma radiation and electromagnetic-induction borehole logging.		
Number of Images/Profiles Generated During Investigation: Seismic-Reflection Profiles: 3 lines Ground-penetrating Radar Profiles: 4 lines Borehole Geophysical Logs: 7		
Results: The natural gamma used in combination with the EM logs identified a probable plume of groundwater contamination from the electroplating facility. The contamination is moving toward Horseshoe Pond and Merrimack River.		

EXECUTIVE SUMMARY

The New Hampshire Plating Company Site is located on 13.1 acres in Merrimack, New Hampshire. On the property are a former plating facility, a large pond, and four lagoons. The Merrimack River is located about 600 feet (ft) east of the plating facility and the northern end of Horseshoe Pond is located about 500 ft south of the plating facility. From 1962 until 1965 the property was used for electroplating activities. The contamination was a result of the facility discharging 35,000 to 60,000 gallons per day of electroplating wastes into the four unlined lagoons. The wastes consisted of cyanide plating baths and sludges, acids and chlorinated solvents.

The site geology is comprised of an alluvial terrace consisting of sand, silt and some gravel. Under the alluvial terrace is glaciolacustrine sediments and till which consists primarily of sand, silt, clay and some gravel. Under the glaciolacustrine sediments and till is bedrock consisting of schist and phyllites with minor amounts of granite and gneiss. The water table is encountered at depths ranging from five to 20 ft in the study area.

A geophysical investigation was conducted at the site as part of a larger effort to delineate site conditions and the scope of contamination. The information presented in this report was derived from the interpretive report of the geophysical investigation. The geophysical investigation used four different technologies. Continuous seismic reflection and ground penetrating radar surveys were performed to characterize the site geology and locate bedrock structures. The seismic surveys were conducted near the shore of Horseshoe Pond and along the eastern side and the middle of the Merrimack River. The profiles conducted in Horseshoe Pond indicated that the bedrock ranged from the water surface to less than 20 ft below (the survey could only identify to that depth at this location–this may not be true elsewhere). The profiles conducted in the Merrimack River indicated that bedrock ranged from 10 to 50 ft below the water surface. The ground penetrating radar (GPR) method was used to produce geophysical profiles of the land area around the facility and the lagoons. The GPR profiles successfully determined soil types to a depth of 30-35 ft.

Natural gamma logs were used to delineate the stratigraphy of sub-surface materials in eight monitoring wells, and electromagnetic induction (EM) logs were used to identify zones of conductive groundwater that would indicate the presence of contaminated groundwater. The gamma logs correlated well with existing lithologic logs for the wells. The EM logs showed significant spikes, indicating possible zones of contamination. The depths at which the spikes occurred correlated well with measures of specific conductance of groundwater taken as part of the on-going monitoring program in those wells.

The seismic and radar surveys were moderately successful, but some difficulties were encountered due to the presence of fine-grained sediments in the bottom of the pond and in the soils around the facility. Fine-grained sediments limited the penetration of the radar signals, resulting in blank areas on the profiles. The GPR profiles conducted on water bodies were inconclusive because the signal was attenuated by the water column and was unable to penetrate beneath the bottom sediments. The gamma and EM logs were very successful in characterizing the stratigraphy and identifying zones of highly conductive groundwater that may indicate contaminated groundwater.

SITE INFORMATION

Identifying Information

New Hampshire Plating Company
Wright Avenue
Merrimack, New Hampshire

Background [1]

Physical Description: The New Hampshire Plating Company is located on Wright Avenue in Merrimack, Hillsborough County, New Hampshire. The surrounding area is primarily used for light industrial and commercial purposes, with some residential areas nearby. The site covers 13.1 acres of leased property and includes the former plating facility and four lagoons (see Figure 1). The plating facility is located approximately 600 ft west of the Merrimack River. The study area consisted of the land around the former facility and the lagoons, and extended east to the Merrimack River and south to Horseshoe Pond, to determine if the contamination was moving in those directions. The site lies in the 100-year floodplain of the Merrimack River, and the topography of the site has little relief.

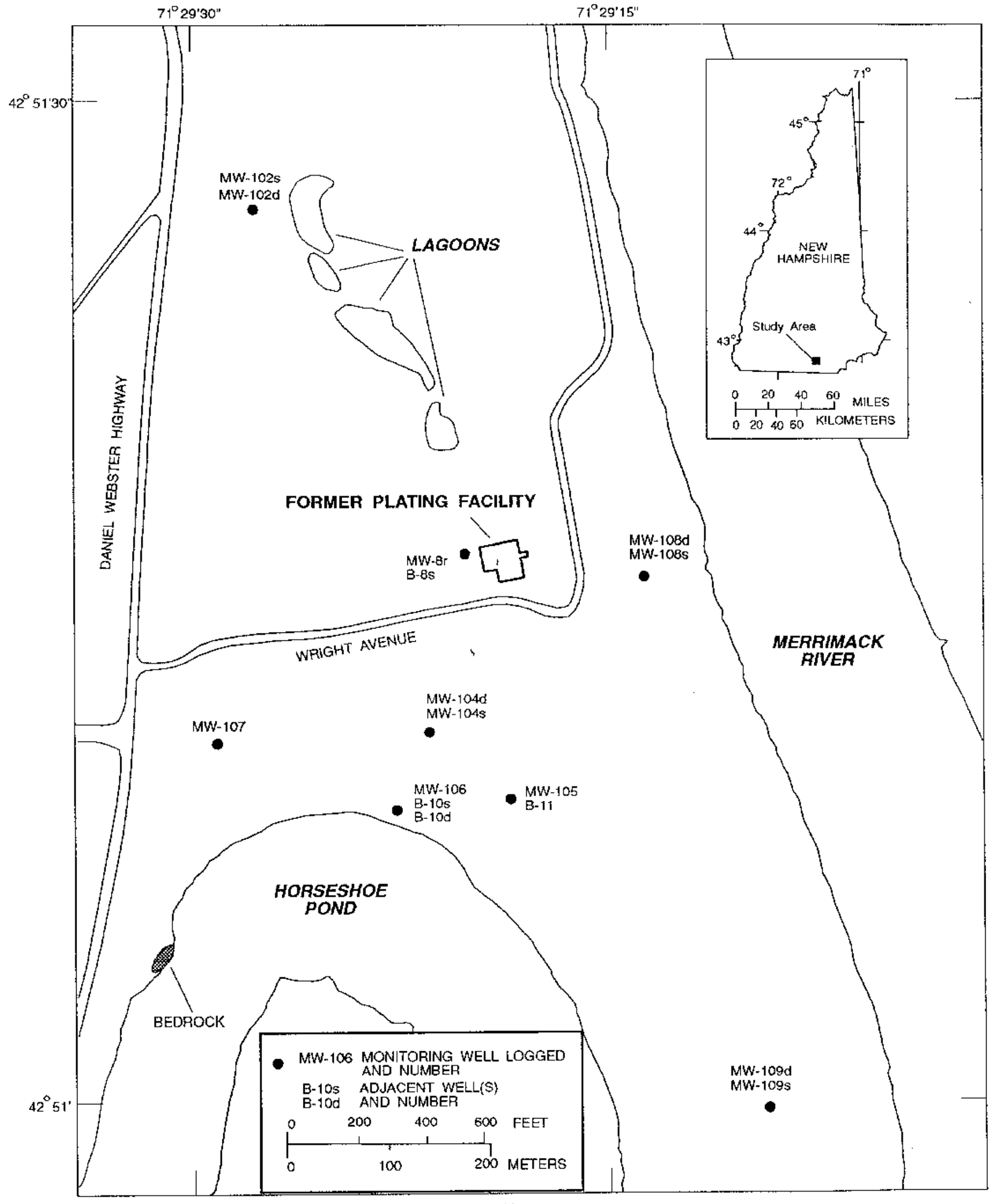
Site Use: The property was used from 1962 until 1985 for electroplating activities. The four lagoons on site were used for disposal of wastes and wastewaters resulting from the electroplating operations. These lagoons were unlined and had no leachate detection or collection.

Release/Investigation History: From 1962 to 1985, the facility discharged on-site 35,000 to 60,000 gallons per day (gpd) of electroplating wastes into a series of four unlined lagoons. The wastes included cyanide plating baths and sludges, acids, and chlorinated solvents. Discharge of degreasing solvents into lagoon was discontinued in the late 1970s. In 1980, the New Hampshire Plating Company (NHPC) notified the EPA that it was a hazardous waste disposal facility under Subtitle C of the Resource Conservation and Recovery Act (RCRA). An inspection by the New Hampshire Department of Environmental Services (NHDES) and the Environmental Protection Agency (EPA) in April 1982 noted several RCRA violations. As a result, the New Hampshire Division of Public Health Services issued a Notice of Violations and Order of Abatement to NHPC. In February 1983, the State of New Hampshire filed a civil suit against NHPC. NHPC halted operations in 1985 because it lacked the financial resources necessary to meet compliance standards and continue hydrogeologic investigations at the property.

In June 1987, a contractor for New Hampshire Division of Environmental Services treated the lagoon system with lime and a sodium hypochlorite solution, removed debris, drums, and plating tank liquids to a regulated disposal facility, and conducted a superficial cleaning of the manufacturing building. In 1990, EPA used emergency funds to solidify the contaminated sludge and soil at the property.

SITE INFORMATION

Regulatory Context: This investigation was conducted to support the characterization of waste under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Manufacturing operations at the site were regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA), and the New Hampshire Division of Environmental Services.



Base modified from U.S. Army Corps of Engineers, 1:1,200, 1992.

Figure 1: Site Map of NH Plating Company [1]

SITE INFORMATION

Site Logistics/Contacts

Federal Lead Agency: EPA

Federal Oversight Agency: None

Remedial Project Manager:
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617-918-1247

Geophysical Subcontractor:

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MEDIA AND CONTAMINANTS

Matrix Identification

Type of Matrix Sampled and Analyzed: Sand, silt, fine-grained lake bottom sediments, and coarse-grained stratified drift.

Site Geology/Stratigraphy

Site geology is composed of an alluvial terrace consisting of sand, silt, and some gravel, ranging in thickness from less than five to 25 feet (ft). The total thickness of surficial sediments overlying bedrock in the study area ranges from zero at the northwestern bank of Horseshoe Pond to greater than 120 ft between the center of the Horseshoe Pond and the plating facility, and approximately 20 ft along the northeastern bank of Horseshoe Pond.

The alluvial terrace is underlain by glaciolacustrine sediments and till. The glaciolacustrine sediments consist primarily of sand, silt, and clay with some gravel. Coarse-grained sediments are interspersed with fine-grained lake bottom sediments within this unit. The till is a poorly sorted mixture of silt, sand, and gravel with some boulders and clay. The total thickness of these units could be as much as 100 ft.

Underlying the glaciolacustrine sediments and till is a bedrock unit consisting of schists and phyllites with minor amounts of granite and gneiss. The bedrock surface forms a north-south trending trough and outcrops at the northwestern bank of Horseshoe Pond.

The depth to the water-table is approximately 5 to 20 ft in the study area. Groundwater flows beneath the site to the east toward the Merrimack River and to the south toward Horseshoe Pond.

MEDIA AND CONTAMINANTS

Contaminant Characterization

Primary Contaminant Groups: The primary contaminants of concern include cadmium, chromium, copper, cyanide, iron, nickel, zinc, tin, arsenic, lead, manganese, sodium, and trichloroethylene.

Matrix Characteristics Affecting Characterization Cost or Performance

The effectiveness of the ground penetrating radar (GPR) survey was limited by the fine-grained bottom sediments in the water bodies, as well as by the depth of the water. The fine-grained sediments found along the bottom of Horseshoe Pond limited the penetration of the seismic signal, which had already been attenuated by the water column. Although such sediments were less prevalent in the Merrimack River, similar problems occurred along some of the survey lines there. The fine-grained soils present across the site had a similar effect on the land GPR surveys in some locations, resulting in blank records in the images along certain survey lines. These blank areas on the profiles occurred under fine-grained sediments and also coincided with areas known to contain highly conductive groundwater.

The effectiveness of the seismic survey was limited by the presence of organic sediments on the bottom of Horseshoe Pond, and, to a lesser degree, along the bottom of the Merrimack River. The seismic survey was, however, able to clearly identify the fine-grained sediments that impeded the performance of the GPR survey.

No site characteristics impeded the performance of the natural gamma or EM borehole logs, such as complex lithology, e.g. clay content, organic matter, magnetic minerals content, etc.

GEOPHYSICAL INVESTIGATION PROCESS

Investigation Goals

The goal of the investigation was to confirm stratigraphic information collected during earlier investigations and to characterize zones of highly conductive groundwater that may indicate the presence of a groundwater contaminant plume. Continuous seismic reflection and ground penetrating radar surveys were used to confirm the stratigraphy across the site. Natural gamma logs were used to develop vertical profiles of stratigraphy in existing monitoring wells. Electromagnetic induction logs were used to identify the zones of conductive groundwater.

Geophysical Methods

The continuous seismic reflection method uses an acoustic source to emit a signal downward into the subsurface and measures the travel time of a seismic signal from the surface to subsurface reflectors, i.e. bedrock, and back. Travel time, or velocity, is typically measured in feet per second (ft/s). In New England geology, the velocity of sound through saturated glacial sediments ranges

GEOPHYSICAL INVESTIGATION PROCESS

from 4,000 to 6,000 ft/s [2]. This study used a seismic sound velocity of 5,000 ft/s to calculate penetration depth of the seismic signal. The continuous seismic reflection profile was carried out using Geoacoustic's Geopulse© equipment operated at a frequency of 700 to 1500 hertz.

The ground penetrating radar (GPR) method uses an antenna to radiate short pulses of high-frequency radio waves into the subsurface and a receiving antenna to record variations in the reflected return signal. Interpretations of GPR profiles depend on the sediments penetrated and the scale adjustments as those sediments change. For example, the electromagnetic velocity in saturated unconsolidated sediments is 0.2 feet per nanosecond (ft/ns) as compared to 0.4 ft/ns in unsaturated unconsolidated sediments. The primary factor limiting depth of penetration is the electrical conductivity of the sediments [1]. The type of equipment used was a GSSI System 10 operated at a frequency of 80 megahertz.

Natural gamma logging is the continuous physical measurement of the release of natural gamma radiation from the soil and rocks surrounding the length of a borehole. The gamma log measures the total gamma radiation, in counts per second, as the detector is raised in the well column. In the glaciated sediments of the northeast, fine-grained sediments rich in clay are generally more radioactive than quartz sand or carbonate rocks [1]. The natural gamma data were gathered using Century Equipment Natural Gamma detector which is capable of logging at a rate of 30 ft/min.

The electromagnetic induction method uses a transmitter coil that generates an electromagnetic field that induces currents in the earth. A receiver coil intercepts the electromagnetic fields generated induced current as a voltage that is linearly related to subsurface conductivities. Subsurface conductivities are measured in terms of millisiemens/centimeter (µS/cm). The EM conductivity of unconsolidated glacial sediments is primarily affected by the presence of clay minerals and the conductivity of ground water. The presence of ions in water, such as dissolved metals, increases the electrical conductivity of that water [1]. The EM data were acquired using a Century Equipment EM Flow Meter, Model 9721.

GEOPHYSICAL FINDINGS

Technology Calibration

The only calibration conducted was to focus the EM probe so that the maximum response was obtained from soils about one foot from the probe, or the center of the borehole. This measure was taken to avoid any interference with the well casing materials. The seismic, ground penetrating radar and natural gamma instruments needed no calibration.

Investigation Results

Continuous seismic reflection profiles were generated along 16 lines around Horseshoe Pond. Along some lines, organic sediments at the bottom of the Pond impeded the penetration of the seismic wave, resulting in ambiguous results. The profiles generated for Horseshoe Pond indicated that bedrock, overlain at times by coarse-grained sediments, was identified at depths ranging from the surface of the pond to approximately 20 ft below the surface. At the northernmost end of the pond, the method was unable to detect bedrock known to be present at a depth of 100 ft. The investigator believed that the inability of the method along this line was due to the presence of organic bottom sediments that prevented the penetration of the seismic signal.

The seismic survey of the Merrimack River included eight lines along the western shore and five lines taken along the midline of the river. Bedrock was found underneath the river at depths ranging from 10 to 50 ft below the river surface, and to depths of 20 ft along the shoreline. The results from the river survey were markedly better than those for the pond survey. The lack of organic sediments in the river resulted in a better profile of the bedrock surface in all lines.

Ground penetrating radar profiles were generated along 12 lines around the plating facility and extending north and south from the facility. Along most of the lines, the survey found that the subsurface materials consisted mainly of silt, sand, and clay. The subsurface materials graded to a fine sand along the southernmost survey line, close to Horseshoe Pond. Bedrock outcrops can be seen in a few of the profiles. The fine materials tended to limit the penetration of the radar signal to depths no greater than 35 ft, and obscured the water table along most lines. In several of the profiles, blank areas appear below a depths of 10 to 12 ft. These blank areas were interpreted to represent the failure of the radar signal to penetrate fine-grained soils, or the presence of highly conductive groundwater. Radar surveys taken on the pond and the river yielded ambiguous results, as the radar signal was attenuated by the water and failed to penetrate the fine-grained sediments along the pond bottom.

Natural gamma logs were developed for seven existing monitoring wells, one upgradient of the plating facility and its lagoons, and six downgradient. The gamma logs were useful in delineating the stratigraphy of the subsurface materials and identifying permeable and impermeable zones. The EM log was used to vertically delineate zones of increased electrical conductivity to identify potential contaminant plumes.

Three of these logs have been reproduced in Figures 2 to 4. The EM and gamma logs in these figures are shown along with the lithologic logs developed at the time the wells were installed (presented to the right of the geophysical logs). The lithologic logs indicate significant heterogeneity in the distribution of layers of coarse to fine materials. The only consistent stratum found in each of the logs was the near-surface very fine sand layer. The gamma readings in each of these borings correlated closely with the lithologic logs. Gamma readings were clearly higher in strata composed of finer sands and silts and lower in sandy strata. Gamma counts of less than 100 counts per second (cps) consistently were measured in strata that were identified in the lithologic logs as medium to coarse sands. Higher counts, in the range of 100 to 150 cps, were registered in the layers of fine sand and silts.

The EM logs were taken to identify zones of conductive groundwater that may indicate the presence of chromium-contaminated groundwater. In each of the logs shown in Figures 2 to 4, there are significant spikes in the EM readings, indicating possible zones of contamination. MW-8r (Figure 2), which is immediately downgradient of the lagoons and directly west of the plating facility, showed three distinct zones of conductive ground water, centered at altitudes of approximately 15, 58, and 92 ft above mean sea level (msl). In MW-104d which is located to the south of the lagoons, only one such zone can be seen, centered at 75 ft msl (Figure 3). In MW-108d, located to the east of the plating facility, a single zone is seen at 54 ft msl (Figure 4). It is interesting to note that in each of the wells, the spikes in the EM readings occur in strata composed of finer materials.

Results Validation

The results of the EM measurements were compared with water samples that were being collected as part of the ongoing monitoring. Specific conductance was measured in each well and the result printed on the geophysical logs in Figures 2 to 4 (shown to the right of the lithologic log). The altitude at which the conductance log is printed and indicates the depth of the well screen. The measured conductance correlated well with the locations with high conductivity from EM logging in two of the three logs. In MW-8r and MW-108d, the specific conductance was higher at the depths at which the EM measurements were also high. In MW-104d, however, high specific conductance was measured near the bottom of the well, but the EM readings at that altitude were not high relative to a higher location in the well. Measures of specific conductance can be sensitive to naturally occurring ions, as well as ions associated with chromium contamination.

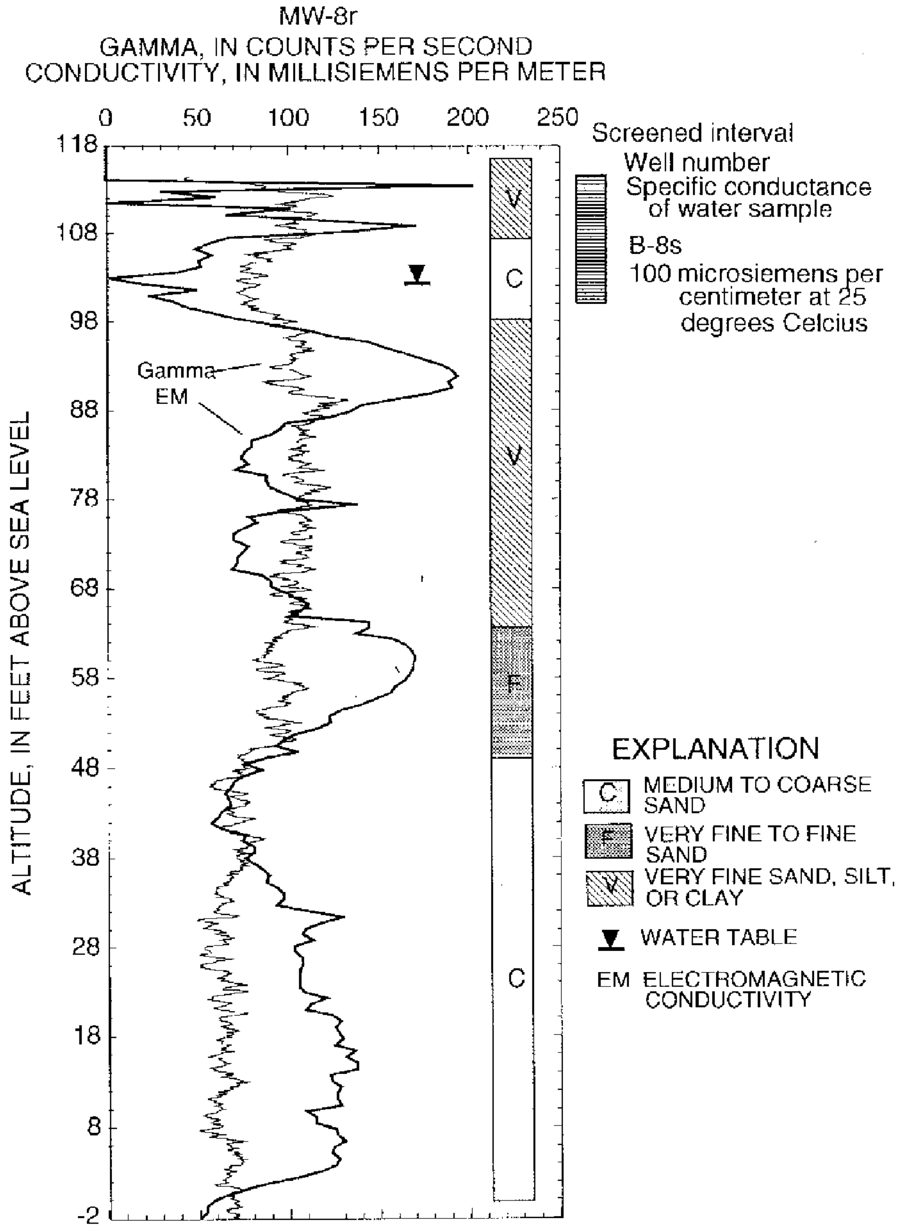

Figure 4. Borehole geophysical logs, lithologic section, screened interval, and associated specific conductance of ground water in Merrimack, New Hampshire at well MW-8r.

Figure 2: Geophysical Log for MW-8r [3]

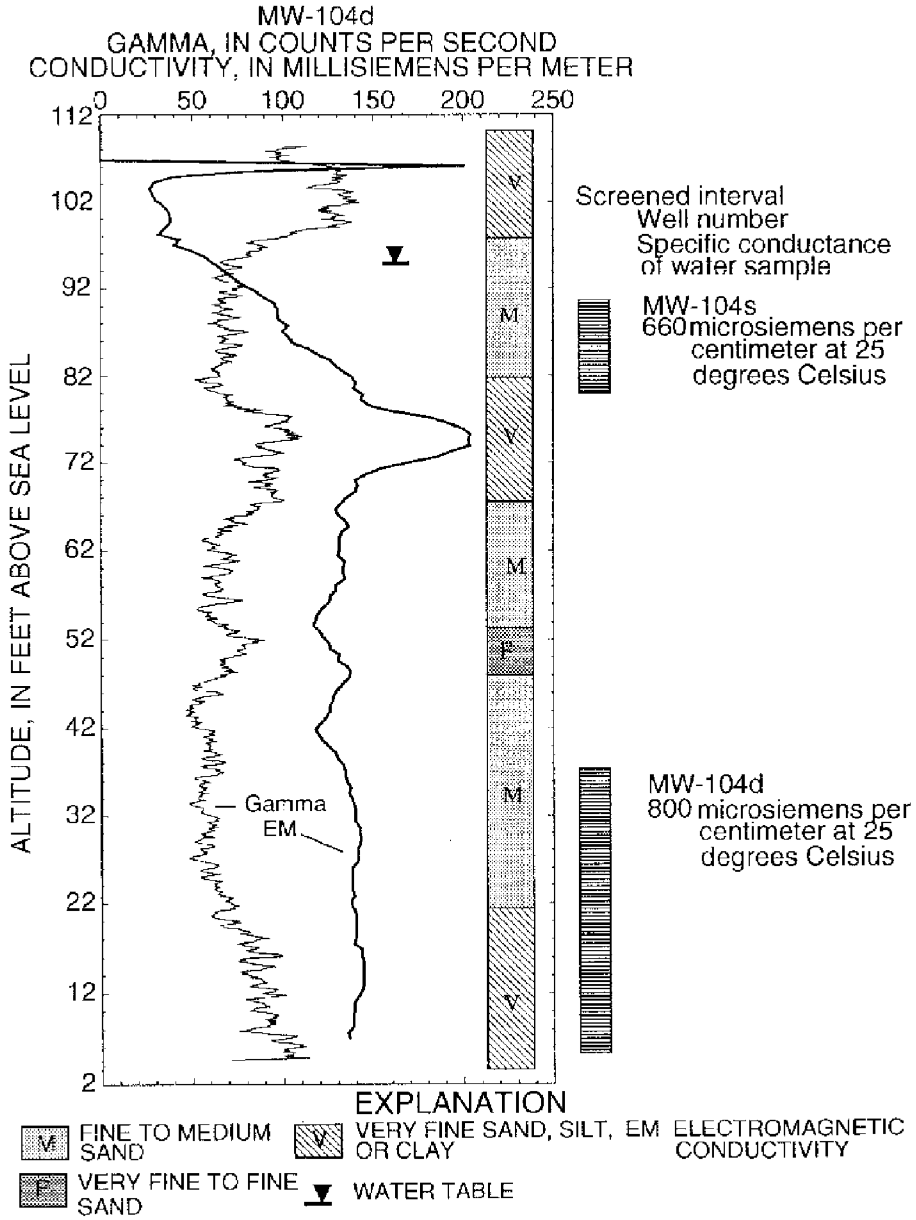

Figure 5. Borehole geophysical logs, lithologic section, screened intervals, and associated specific conductance of ground water in Merrimack, New Hampshire at well MW-104d.

Figure 3: Geophysical Log for MW-104d

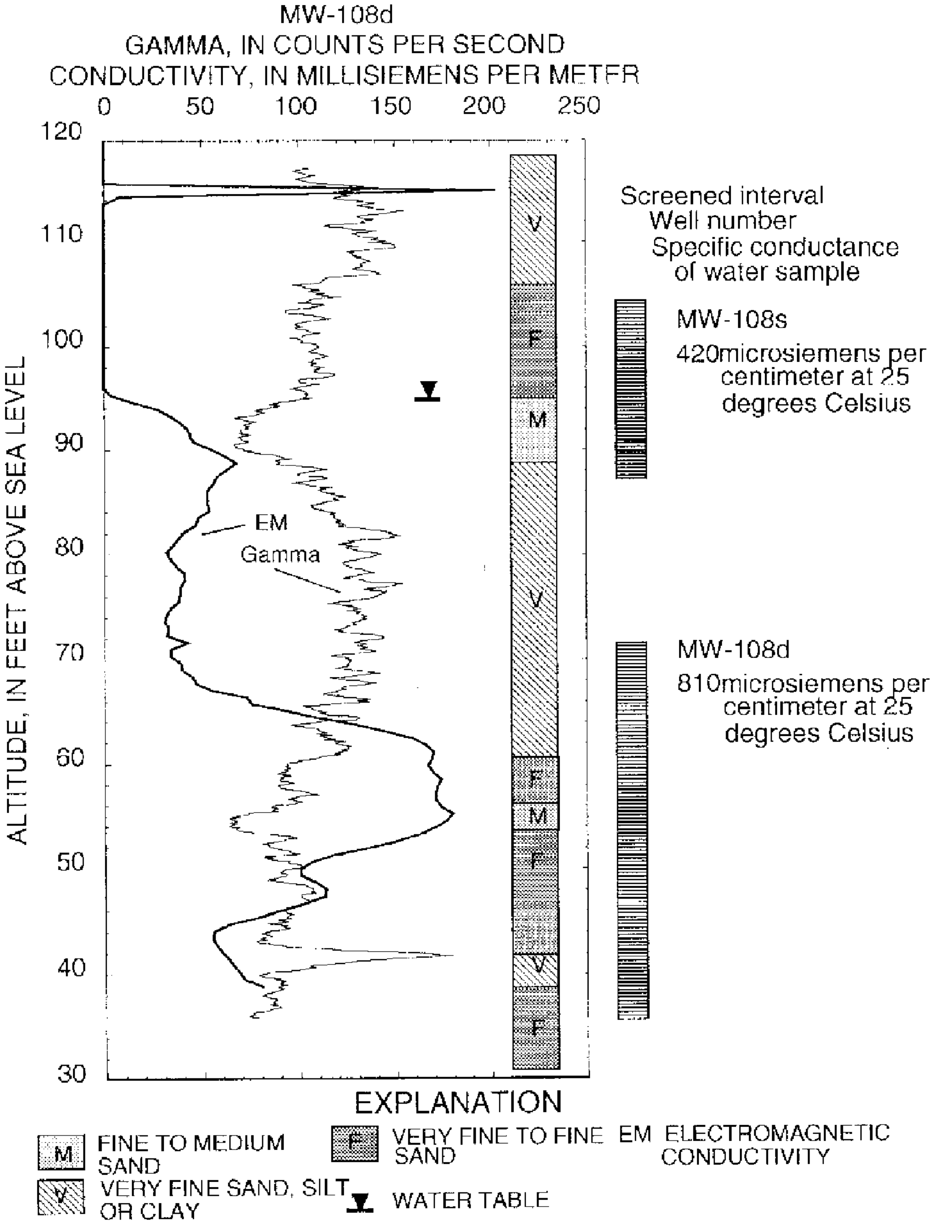

Figure 8. Borehole geophysical logs, lithologic section, screened intervals, and associated specific conductance of ground water in Merrimack, New Hampshire at well MW-108d.

Figure 4: Geophysical Log for MW-180d

LESSONS LEARNED

The lessons learned during this investigation are the following:

- Downhole technologies provide more information on the stratigraphy and potential plumes of contaminated groundwater beyond shallow depths than surface geophysical techniques.
- Downhole technologies are effective in developing contour maps of lithologic units including subsurface structures that might promote or inhibit contaminant pathways.
- The two borehole technologies may be especially effective for large sites with deep contamination and complex stratigraphy. Borehole technologies may be useful along with boring and monitoring well placement during initial site evaluations. For sites with limited areal extent, shallow contamination, and/or simple stratigraphy, borehole technologies may be less cost-effective.
- Caution should be taken not to mistake natural conductivity in EM surveys with contamination.
- Both EM and natural gamma were much more effective in delineating deep subsurface features than seismic-reflection and GPR.
- Interpretation of the results of the investigation is useful in identifying the utility of the borehole technologies and comparison with utility of seismic-reflection and GPR. The following paragraphs discuss the technology usefulness and limitations as they relate to this investigation.
- The wells that had been installed for on-going monitoring missed the most contaminated sections of the aquifer. These wells were unable to identify the contaminated zones with typical monitoring well techniques. EM was useful in identifying likely elevations where plumes of contaminated groundwater exist. However, the levels of peak conductivity in both the measurement of groundwater samples and EM are strong indicators of contamination, for this site, because the background well had much lower conductivity. Further, the pattern of downgradient conductivity was consistent with a groundwater contamination plume pattern.
- Natural gamma logging can provide consistent information on stratigraphy. When accurate surface elevations are obtained for each boring, a contour map can be developed for any of the lithologic units that were identified in the survey. This information can be used to identify subsurface structures that might provide migration pathways for contaminants.
- The two borehole technologies may be especially effective for sites with the following features: unconsolidated sediments, large areal extent, deep contamination that may have

traveled far, and for more complex stratigraphy. In these situations, the borehole technologies may be most effective in combination with examination of boring logs and limited initial monitoring well placement. The monitoring wells are cost-effectively placed in combination with the borehole technologies investigation and are useful for correlating results. Following the combination of initial efforts of boring log examination, groundwater monitoring, and borehole technologies evaluations, additional borings and monitoring wells may be placed more cost-effectively, than if only borings and monitoring wells were placed.

- However, for sites with limited areal extent, shallow contamination, and/or simple stratigraphy, borehole technologies (EM and natural gamma) are less cost-effective.

REFERENCES

1. Mack, Thomas J. *Geophysical Investigations in the Vicinity of a Former Electroplating Facility in Merrimack, New Hampshire*: U.S. Environmental Protection Agency, Region 1, 1994.

2. Haeni, F.P. *Application of continuous seismic-reflection methods to hydrologic studies.* Ground Water, 1996, v. 24, no. 1, p. 23-31.

3. Beres, Milan Jr., and Haeni, F.P. *Application of ground-penetrating-radar methods in hydrogeologic studies.* Ground Water, 1991, v. 29, no. 3, p. 375-386.

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