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Interim Progress Report — Geophysics: Building E5190 Decommissioning, Aberdeen Proving Ground

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Interim Progress Report — Geophysics: Building E5190 Decommissioning, Aberdeen Proving Ground

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Preface

This report is one of a se.ies on geophysical surveys around perimeters of buildings in the Canal Creek area of the Edgewood section of Aberdeen Proving Ground. The series was initiated in 1991 at Building E5032, where geophysical techniques were tested and a design for the surveys was established. The series continued in 1992, when surveys of Buildings E5190, E5282, E5375, E5440, E5476, E5481, E5485, E5487, E5489, and E5974 were completed. The surveys and reports were done sequentially, with lowest building numbers being completed first. For this reason, deeper insight into the magnetic, electrical, and radar imagery characteristics of the Canal Creek area was gained with progressively increasing building numbers. A survey at the Building 103 Dump, also completed during the spring of 1992, was not specifically designed to assist building decommissioning. This survey is included in the series because it was conducted by our geophysics team using techniques and procedures identical to those for the building decommissioning surveys.

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Abstract

Building E5190 is one of ten potentially contaminated sites in the Canal Creek area of the Edgewood section of Aberdeen Proving Ground examined by a geophysical team from Argonne National Laboratory in April and May 1992. A noninvasive geophysical survey, including the complementary technologies of magnetics, electrical resistivity, and ground-penetrating radar, was conducted around the perimeter as a guide to developing a sampling and monitoring program prior to decommissioning and dismantling the building. The magnetics surveys indicated that multistation, positive magnetic sources are randomly distributed north and west of the building. Two linear trends were noted: one that may outline buried utility lines and another that is produced by a steel-covered trench. The resistivity profiling indicated three conductive zones: one due to increased moisture in a ditch, one associated with buried utility lines, and a third zone associated with the steel-covered trench. Ground-penetrating radar imaging detected two significant anomalies, which were correlated with small-amplitude magnetic anomalies. The objectives of the study — to detect and locate objects and to characterize a located object — were achieved.

1 Introduction

Aberdeen Proving Ground (APG), in the state of Maryland, is currently managing a comprehensive Installation Restoration Program involving more than 360 solid-waste managing units contained within 13 study areas. The Edgewood area and two landfills in the Aberdeen area appear on the National Priority List under the Comprehensive Environmental Response, Compensation, and Liability Act. Therefore, APG has entered into an Interagency Agreement with the U.S. Environmental Protection Agency to address the listed areas.

The West Branch of Canal Creek area (Figure 1) is one of the areas that requires a Source Definition Study because there is an ongoing release of volatile organic compounds into the creek. A report by EAI Corporation (1989) included a list of 29 potentially contaminated buildings.

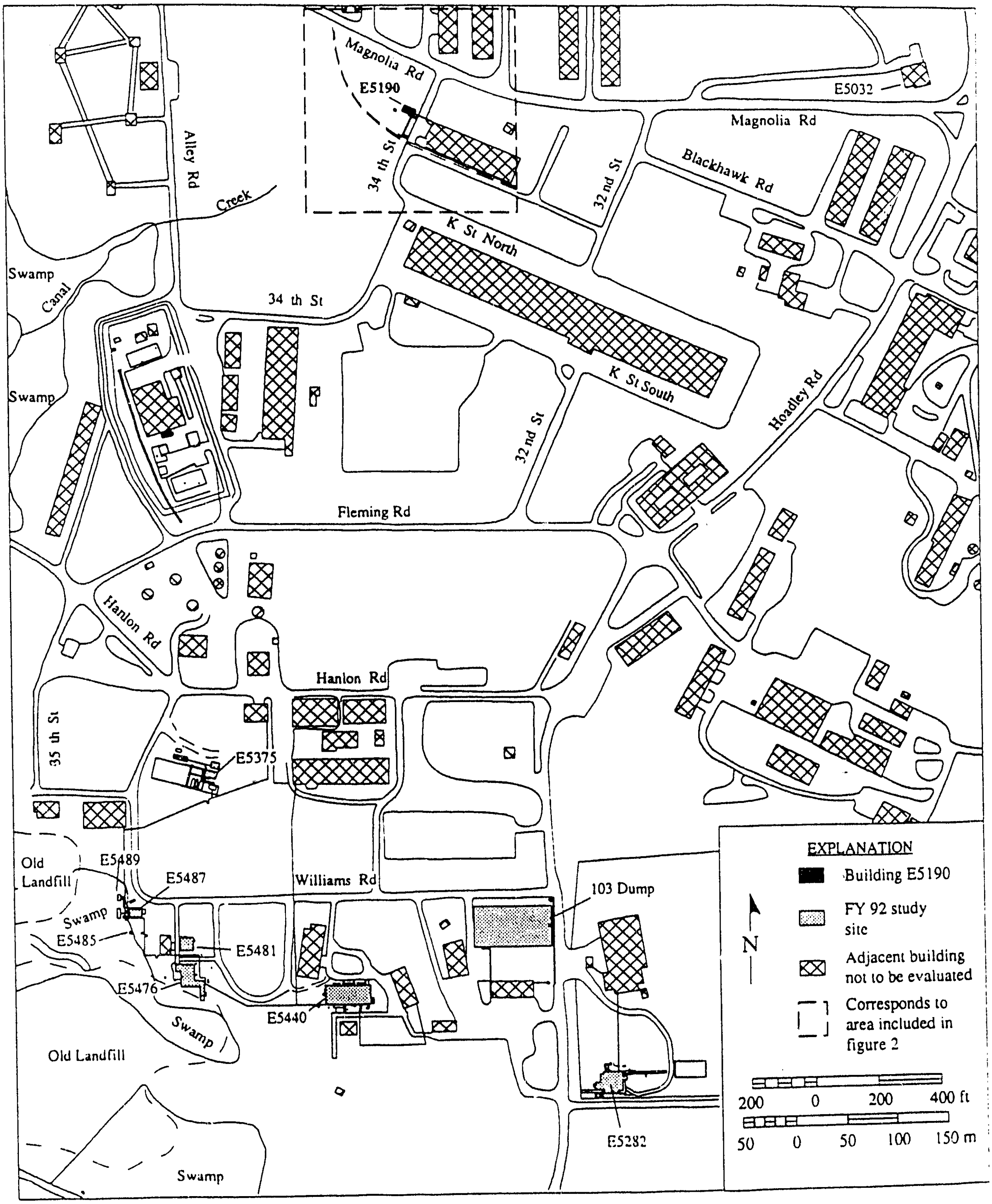

FIGURE 1 General Site Map of Canal Creek Area, Aberdeen Proving Ground, Md.

Sixteen of the buildings contain known contaminants, nine buildings contain unknown contaminants, and four of the buildings are potentially clean. The EAI report recommended that a sampling and monitoring program be established to verify contamination levels in and around each building. Thirteen of the potentially contaminated buildings, including Building E5190 (Figure 2), located on the southwest corner of Magnolia Road and 34th Street, are in the West Branch of Canal Creek area and are potential sources of volatile organic compounds. Operations have ceased and the buildings have been abandoned, but processing equipment, sumps, drains, ventilation systems, and underground storage tanks remain. These appurtenances may contain liquid, solid, or vapor contaminants of unknown nature.

Aberdeen Proving Ground is proceeding with a program to decommission the buildings, which will eliminate the actual or potential release of contaminants into the environment of the West Branch of Canal Creek and other sites within the Edgewood area. Argonne National Laboratory has been assigned the task of developing a plan and scope of work for the proposed decommissioning. Argonne has determined that the first step in this decommissioning process, where it is technically feasible, should be a noninvasive geophysical survey around building exteriors (see Figure 3 for the boundaries of the study area for Building E5190).

1.1 History of Building E5190

Building E5190 (Figure 3) was constructed in 1942 to house a 10,000-gal tank that was used for xylene storage. Cleanup of the facility was initiated in April 1980. The storage tank was filled with alcohol, which was subsequently replaced by approximately 600 gal of water to complete the cleaning process. Construction documents (AEHA 1989) also list the building as a benzene storage facility; however, no evidence has been found to show that the 10,000-gal tank ever contained benzene.

1.2 Site Reconnaissance

The geophysical survey program design for Building E5190 is based upon results from a similar study completed between April 8 and April 19, 1991, for Building E5032 (McGinnis and Miller 1991), which is also located in the Canal Creek area (Figure 1). The initial evaluation was further enhanced by a visit to the site in November 1991. The gently sloping site is accessible on all sides and is surrounded by grass on the north, south, and west.

In addition to surface conditions at the site, subsurface characteristics were considered in planning the geophysical surveying:

1. Surficial sediments consist of estuarine silts, sands, and clays that have intermediate resistivities and are nonmagnetic. The underlying soil properties

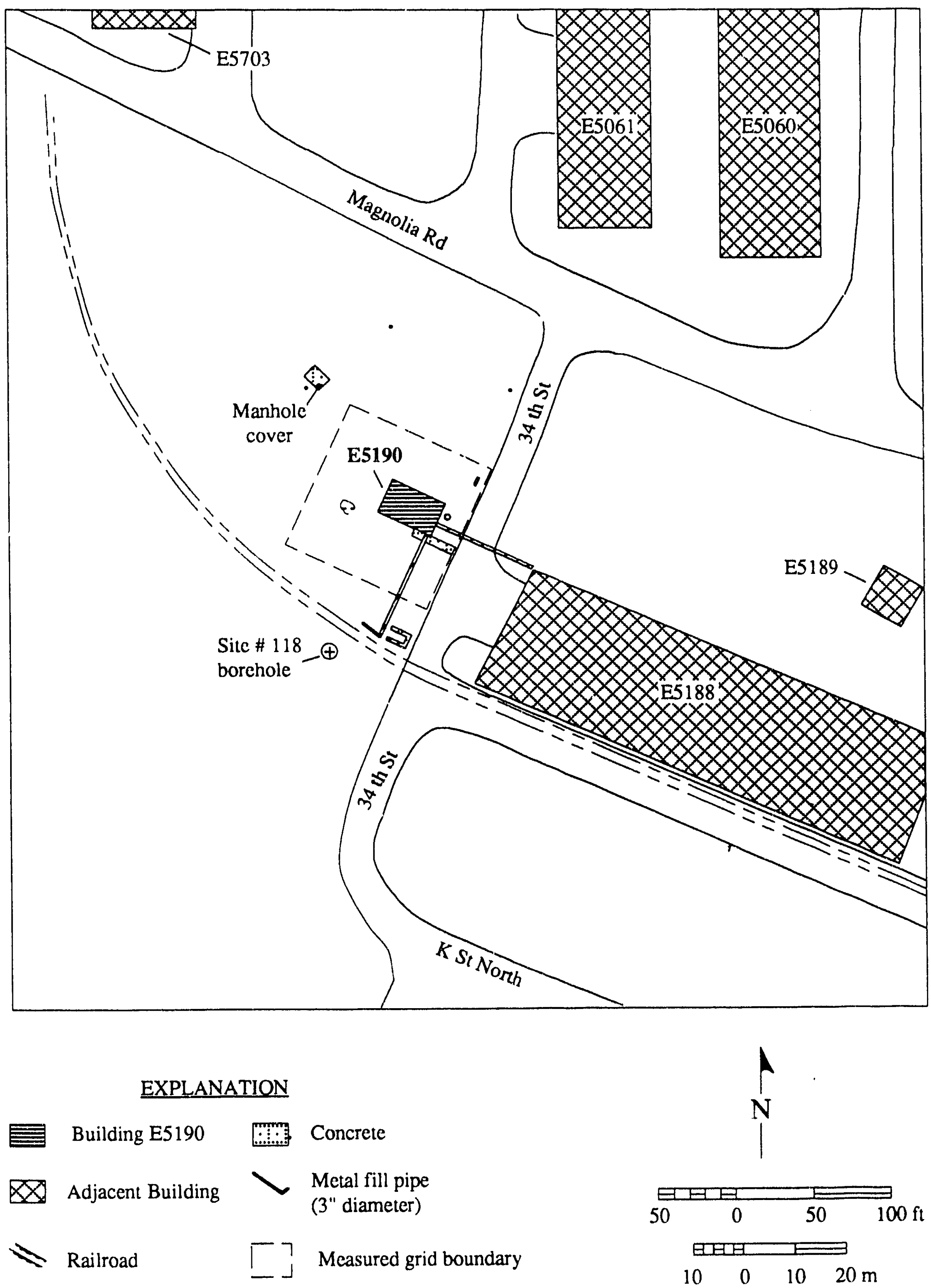

FIGURE 2 General Location Map of Building E5190

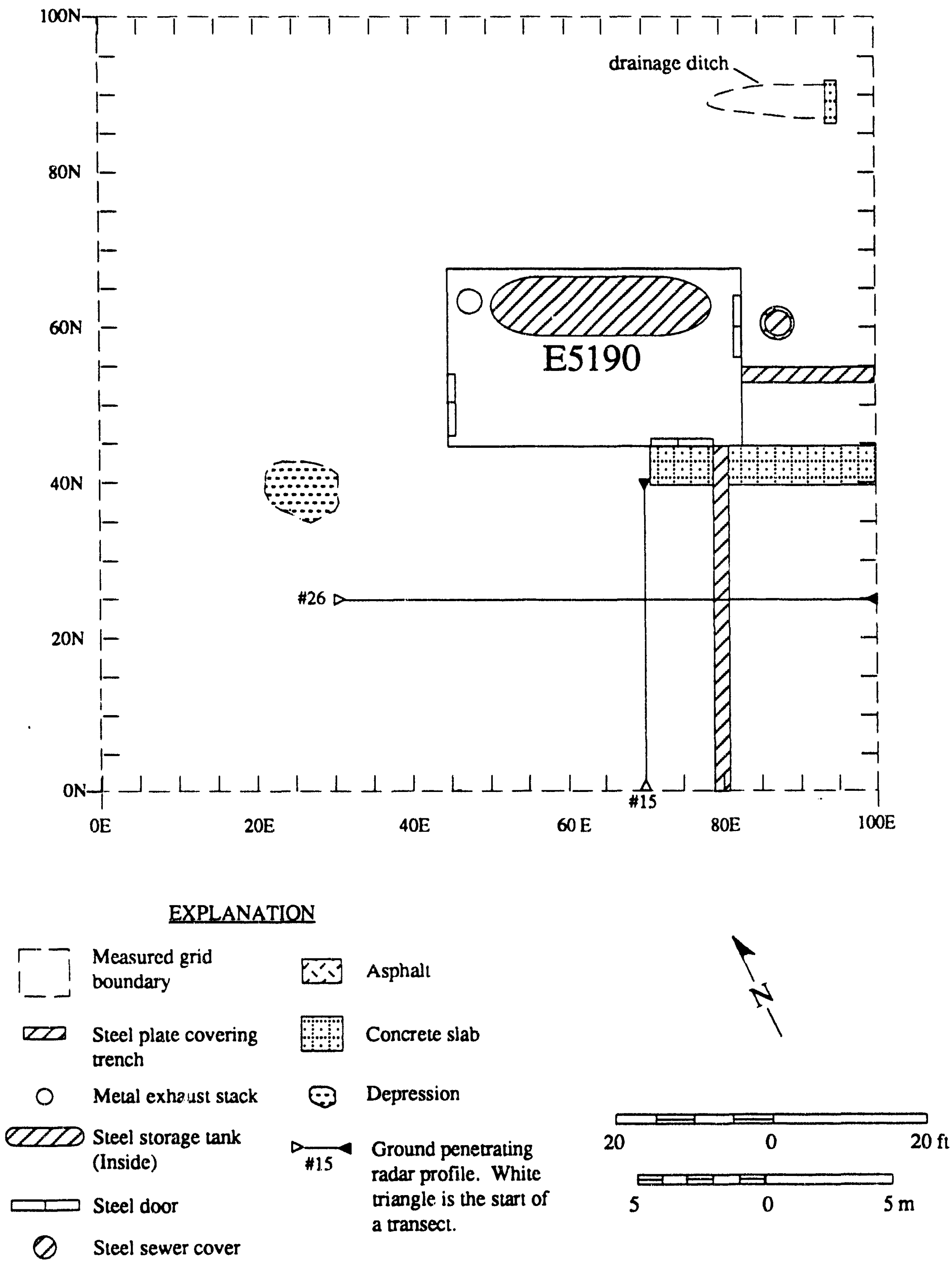

FIGURE 3 Geophysical Survey Boundaries for Building E5190

are expected to vary both horizontally and vertically in the proximity of the site, depending on naturally occurring conditions and on the presence of building excavations and operations.

2. Buildings and other attributes of the Edgewood section of Aberdeen, such as radio and radar transmissions, will contribute to interference of magnetic and electrical fields and will cause electromagnetic surveying (an easily applied, low-cost method that is frequently used to identify buried conductive objects) to be generally inapplicable (AEHA 1989).

3. Multiple sources, such as iron-rich magnetized objects, nonmagnetic objects, subsurface channels containing contaminants, and plumes of contaminants of variable resistivity, may be present in the subsurface.

Multiple working technologies were utilized in the program design to mitigate interference and to either directly detect or provide inferential data on subsurface characteristics.

1.3 Geology and Physiographic Setting

The site is contained in the topographically low and flat terrain of the Coastal Plain physiographic province. The Canal Creek area is underlain by alluvial and estuarine sands, silts, and clays. A thin veneer of sediments of the Talbot Formation of Pleistocene age overlies unconsolidated sediments of the Potomac Group of Cretaceous age (Oliveros and Gernhardt 1989). The water table is less than 10 ft from the surface, and groundwater has measurable concentrations of contaminants (U.S. Geological Survey 1992).

Lithologies at the site were determined from the sample study of a borehole (site No. 118) drilled approximately 100 ft south of Building E5190 (see Figure 2). The descriptive log given in Table 1 was part of a hydrogeologic study of the Canal Creek area performed by the U.S. Geological Survey (Oliveros and Gernhardt 1989). Facies represented include silt and sand fill material, with some fill material at the surface and to a depth of about 4 ft. This is followed by thin beds of varying stratigraphy, consisting primarily of sands, silts, and clays. The greatest thickness of a single unit was a 12.3-ft-thick clayey silt (U.S. Geological Survey 1992).

Building E5190 is located in the eastern half of the area of study, which is bordered to the south and west by an old railroad bed. Initial construction probably involved considerable amounts of excavation and filling, so most of the shallow sediment at the site is reworked.

TABLE 1 Lithologic Log of Borehole at Site No. 118

Description	Depth (ft)	Thickness (ft)
Sandy soil zone, light tan-gray; with pebbles and fill material	1.0	1.0
No sample	4.0	3.0
Sandy soil zone, light tan-gray; with pebbles and fill material	4.4	0.4
Silt, clayey, olive-gray, lignitic; with light gray reduced zones	9.0	4.6
Silt and clay, red, yellow, and brown, lignitic, micaceous, dense; with maroon nodules	21.3	12.3
Sand, silty, gray to brown; with finely laminated light and dark gray layers	25.3	4.0
Sand, yellow, brown, and purple, micaceous, quartzose; with clayey lenses near top, and iron-cemented sandstone and siltstone layer at upper contact; bottom 0.5 ft wet	29.0	3.7

Source: Oliveros and Gernhardt (1989).

1.4 Surveys

The geophysical phase of the building decommissioning program at Building E5190 was carried out as planned during the period April 6 to May 8, 1992. Geophysical measurements conformed to the work plan (McGinnis et al. 1992), which called for magnetics, ground-penetrating radar (GPR), and horizontal direct-current electrical resistivity (DCER) surveys. An addition to the plan was the use of a magnetic gradiometer/metal detector to ensure detection of anomalies between survey profiles and grid stations. Seismic imaging information was not required at the site. Each technique had its own specific objectives:

- Gradiometer/metal detector sweep — to provide a rapid, 100% sweep of the site;

- Magnetometer measurements — to determine the location of such buried, iron-rich objects as tanks, pipes, debris, etc.;

- Horizontal DCER survey — to establish the regional conductive nature of the subsurface and to identify contaminant plumes to depths of approximately 10 ft; and

- Ground-penetrating radar survey — to determine the geometry of, and to find the approximate depth to, buried objects.

The following data were acquired during field operations: (1) nonpermanent ground markings of magnetic objects, (2) 1,002 magnetic observations, (3) 503 horizontal DCER observations, and (4) 3,595 (linear) ft of GPR profile along 48 lines. Field operations required two days total for a four-person team. On-site personal computers (both notebook and desktop), interactive software, field equipment designed specifically for Aberdeen, and an all-terrain vehicle were used to expedite data acquisition and processing.

1.5 Survey Grid and Locations of Observations

Prior to geophysical surveying, wooden stakes were placed at the site corners to mark the area to be surveyed so that its sides were approximately parallel to the sides of the building. Geophysical measurements on the east side of the site were somewhat restricted by the proximity of the building to 34th Street. Grid spacing was at 5-ft intervals. The zero coordinate was at the southwest corner of the surveyed area. Positive numbers are measured north and east of the zero coordinate, whereas negative coordinates are measured south and west. The building is not perfectly aligned north-south and east-west.

2 Instrumentation

2.1 Magnetic Gradiometer and Cable Locator

The Schonstedt MAC-51B magnetic gradiometer and cable locator is a dual-mode instrument designed for detecting shallow buried iron and steel objects and tracing underground cables and pipes. The system consists of a transmitter and a dual-function receiver designed to detect anomalous magnetic gradients.

Maps or models are not constructed from observations made with this instrument because it is not a calibrated system. The MAC-51B is an audio device used only for rapid detection of magnetic materials for further analysis with complementary instrumentation. Anomalies are identified by changes in sound amplitude and frequency and are marked on the ground surface prior to the initiation of other surveys. If anomalies detected with the MAC-51B cannot be verified with the magnetometer (see section on magnetometer), the anomaly is assumed to be insignificant.

Application of the MAC-51B in its receiver mode was the first geophysical operation following establishment of survey limits. A qualitative description of the site with 100% ground coverage is achieved using the gradiometer, whereas the results obtained with other techniques, although more quantitative, are spatially limited to single-point, survey-grid observations or to continuous readings along spaced profiles.

2.2 Magnetometer/Gradiometer

Magnetics is the best technique for identifying such buried magnetized objects as tanks, drums, and small iron-rich debris. The EDA OMNI IV magnetometer/gradiometer is a total field, proton-precession, microprocessor-based instrument that can also measure magnetic gradients. Internal software permits down-loading directly into an on-site computer.

Total field magnetic observations were made at 5-ft and smaller intervals along profiles, yielding a grid of data that was contoured using the SURFER V. 4.0 software by Golden, Inc. (1991), to identify potential sources of contaminants and to distinguish them from background. The SURFER software was incorporated into the field acquisition procedure, so that daily map outputs were available for observation and interpretation.

The earth's magnetic field is reasonably well-known at a given time and place, although small changes in the field occur continuously, with larger changes occurring during magnetic storms. To adjust for field changes, the instrument has internal calibration to correct observations made at cross lines and base stations. Repeat readings were used to correct data for diurnal field fluctuations.

2.3 Direct-Current Electrical Resistivity Meter

Data on the electrical properties of soils at APG may permit detection of abnormally conductive or nonconductive liquid or solid contaminants. Most of the electrical properties of sedimentary materials are a product of the chemistry of interstitial fluids. Consequently, resistivity data can be diagnostic and complement magnetic and radar measurements. Direct-current electrical resistivity measurements have been incorporated into the APG study to take the place of conductivity measurements typically made for investigations of this type using electromagnetic methods. Electromagnetic methods could not be used because of previously reported interference problems (AEHA 1989).

Resistivity equipment used on the Aberdeen project consisted of an ABEM Terrameter and Booster, model SAS 300C, that utilized a variety of electrode configurations. A modified, eight-electrode Wenner array was the configuration selected, and it was towed behind an all-terrain vehicle. Profiles were coincident with GPR and magnetic lines, and data were recorded at 5-ft intervals along the lines. Consistency of repeat observations over a test profile and over known electrical anomalies provided assurance of relative data quality and variations. Data were contoured using SURFER software as described in the magnetics section.

Electrical depth-sounding curves using a Schlumberger electrode array were also determined in the Canal Creek area to add a three-dimensional view to horizontal mapping. Each sounding curve was interpreted using the RESIX PLUS software package written by Interpex (1988). Resistivities of undisturbed soils were comparable with those observed at Building E5032, which averaged 60 Ω-m.* (See Appendix A for further information.)

2.4 Ground-Penetrating Radar System

Ground-penetrating radar surveying was accomplished using a Geophysical Survey Systems, Inc. (GSSI), model SIR-3 radar connected to a transceiver with a cable approximately 300 ft long. Data were recorded on a digital audio tape to permit playback and computer processing. The control unit/graphic recorder was located in the transport vehicle. An IBM-compatible processing computer was located in a field office, so that the radar operator could down-load, check data-tape quality, and do preliminary processing after a day's run. Radan I computer software written by GSSI was used for processing the GPR data.

Wave-velocity characteristics of materials to be found at the Aberdeen/Edgewood area were derived from known positions of buried objects. Internal calibration was run at least twice each day to ensure that the graphic record of the range setting was consistent. Studies conducted during

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* Resistivity data acquisition and processing were done using the metric system of measurement. To convert meters to feet, multiply values given in meters by 3.28.

the 1991 field season suggest wave velocities of 6-7 × 10^{-9} s/ft for near-surface sediment at Aberdeen; however, conditions vary with the heterogeneity of the subsurface. Typical wave velocities for different materials are shown in Table 2.

Ground-penetrating radar is probably the best method available to determine depth and geometry of objects buried near the surface. The weakness of the method is its limited depth of exploration due to wave-propagating constraints imposed by the electrical properties of soils. The maximum depth of penetration with GPR at Building E5190 was approximately 8 ft below the ground surface.

TABLE 2 Approximate Two-Way Travel Times for Various Materials

Material	Two-Way Travel Time (10^{-9} s/ft)
Air	2
Fresh water	18
Sea water	18
Sand (dry)	4.5
Sand (saturated)	11
Silt (saturated)	6
Clay (saturated)	6
Dry, sandy, coastal land	6
Marshy forested land	7
Rich agricultural land	8
Fresh-water ice	4
Granite (dry)	4.5
Limestone (dry)	5
Concrete	5
Asphalt	4-5

Source: Geophysical Survey Systems, Inc. (1987).

3 Geophysical Measurements and Surveys

3.1 Magnetometer Measurements

Total magnetic field observations were made at 1,002 stations for use in construction of the magnetic map shown in Figure 4. Station spacing was normally 5 ft, but where the presurvey scan identified anomalous zones, stations were read at intervals as small as 1 ft. The area directly south of Building E5190 appeared to be anomalous with the Schonstedt scan; however, a tight grid of detailed stations failed to identify any significant anomalies as point sources or lineaments. From north to south, anomalies are listed as follows:

1. The northern third of the survey site contains five anomalies unrelated to any surface feature. The anomalies are high-amplitude, small-diameter features, generally less than 15 ft in width.

2. The western third of the site contains a complex of small anomalies extending west from the building. These anomalies are linked to a complex of anomalies clustered in the west central part of the surveyed area. They are not associated with the conductive zone shown on the resistivity map of Figure 5 that extends from the southwest corner of the building.

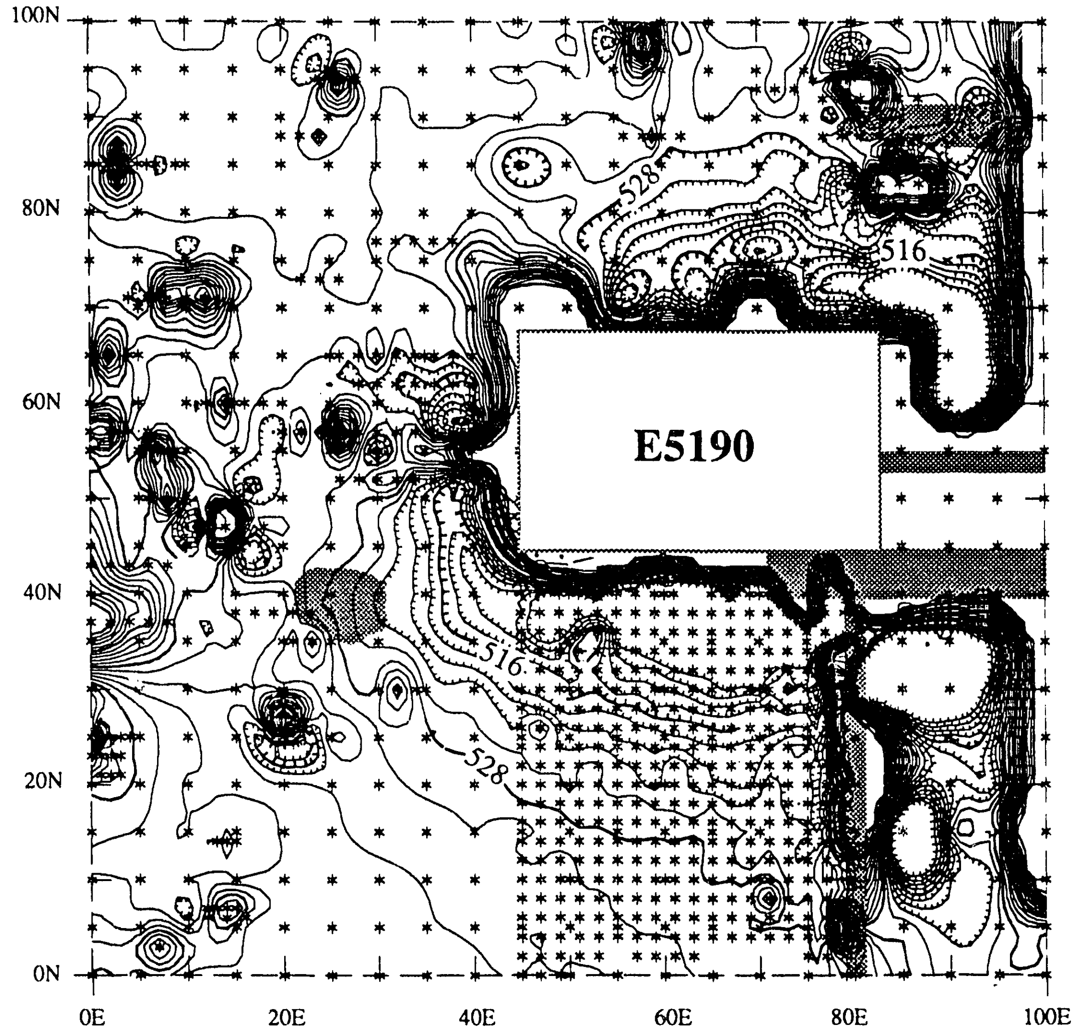
3. Magnetic anomalies in the southeast corner of the site are caused by the steel-covered drainage ditch.

3.2 Direct-Current Electrical Resistivity Measurements

Results of the DCER survey are illustrated on the resistivity map in Figure 5. The electrode spacing was 2 m, a configuration that provides an average resistivity for materials lying between the surface and a depth of about 3 m. Apparent resistivity values ranged from a minimum of 24 Ω-m near the south-central wall of the building to a high value of 78 Ω-m in the south-central part of the mapped area. Low resistivity values mean that these areas are underlain by relatively good electrical conductors. From previous work (McGinnis and Miller 1991), background resistivities for these fine-grained, organic-rich materials were found to range from 50 to 150 Ω-m. Electrical depth-sounding curves collected for background in the Edgewood area indicate that resistivity values normally decrease with depth, probably due to increasing saturation and salinity. Where anomalous materials are present, this generalization is not valid.

The results indicate that all obvious resistivity anomalies are minima at this site. Anomalies of note are listed below.

1. An east-west, low-resistivity feature, reaching 28 Ω-m, projects westward from the southwest corner of the building.



NOTE - Magnetic contours have been overlaid on Figure 3; refer to Figure 3 for description of gray areas on this figure.

N

EXPLANATION

20 0 20 ft

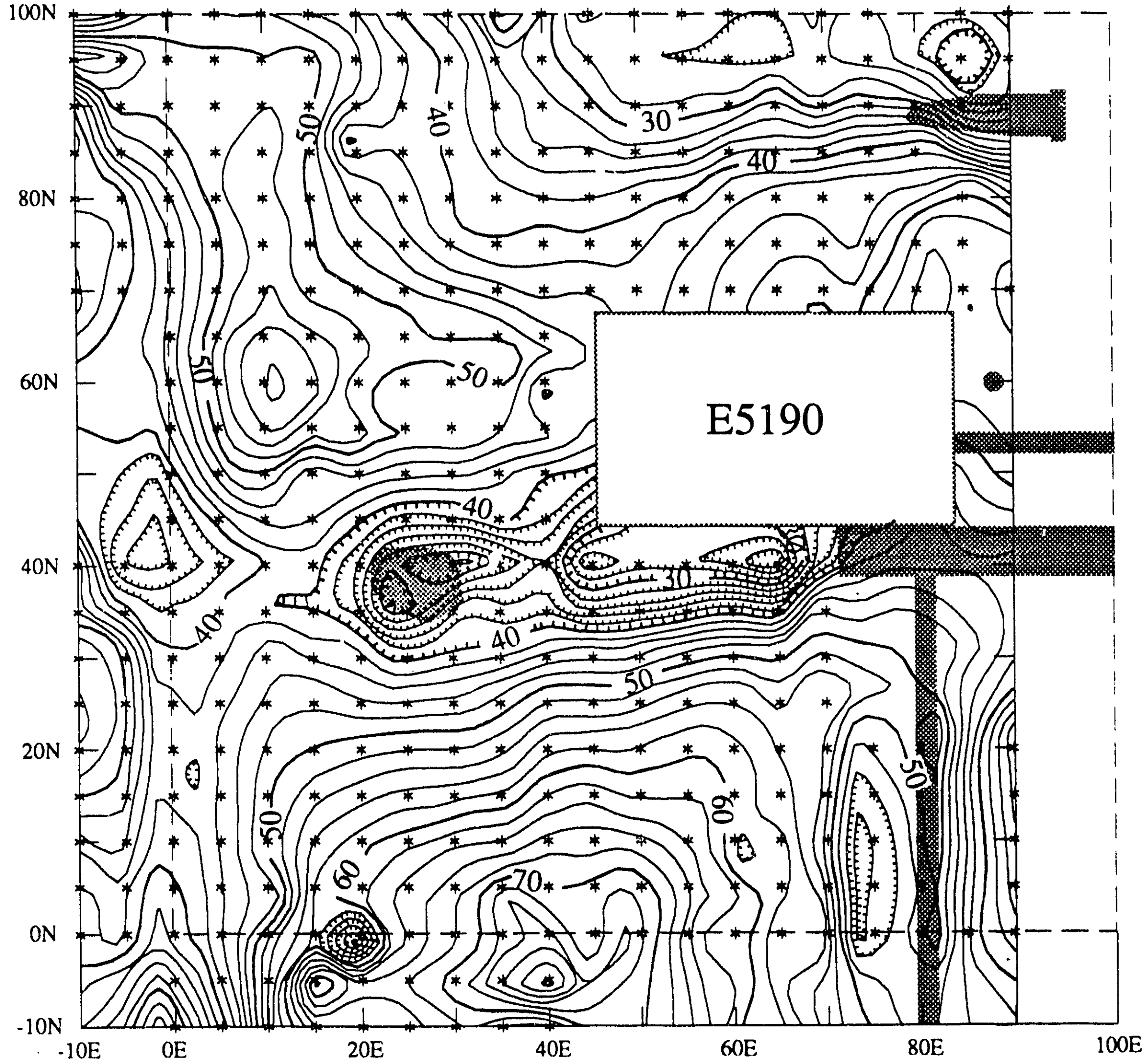
5 0 5 m

516 Magnetic contour (hachured areas denote magnetic lows)

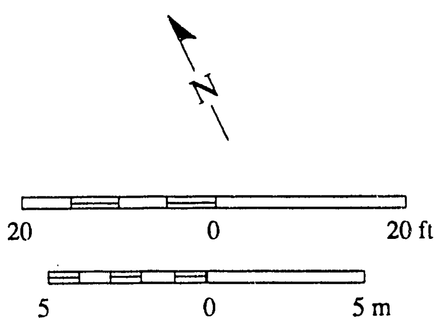
* Magnetic station

Contour Interval: 2.4 x 10 ^{2} gammas

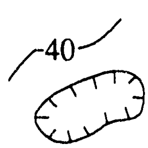
FIGURE 4 Total Intensity Magnetic Map of Building E5190



NOTE - Resistivity contours have been overlaid on Figure 3; refer to Figure 3 for description of gray areas on this figure.



EXPLANATION



Resistivity contour (hachured areas denote resistivity lows)

* Center of electrode array

Contour Interval: 2 Ω - m

FIGURE 5 Apparent Resistivity Map of Building E5190

2. A north-south, 44-Ω-m anomaly is located in the southeast corner of the mapped area.

3. A low-resistivity, north-south anomaly, reaching 26 Ω-m, borders the western limits of the mapped area.

4. A low-resistivity, diffuse zone in the northeast corner, reaching lows of 20 Ω-m at several points, is probably associated with the drainage ditch shown in Figure 3.

As a basis for comparison with minima observed in other areas, a value of 6 Ω-m was observed over the "bare spot", a suspected buried tank at Building E5032, and high resistivities, up to 180 Ω-m, were observed in the vicinity of a suspected old railroad bed.

Anomalies 1 and 3 are joined between coordinates 35 and 40 N and 5 and 15 E. This conductive zone enters diagonally from the west near coordinates 75 N and 10 E and exits at the southwest corner of the surveyed area. The width of this feature and its linearity suggest that it is caused by a large, conductive, buried pipe. The fact that it enters the surveyed area from the northwest suggests that it is connected to the underground utility covered by a concrete slab and steel manhole cover centered approximately 25-ft west of the northwest corner of the surveyed area and shown in Figure 2. Because of their apparent relation to a utility line and similarity to the resistivity value in the north ditch, the low values are attributed to increased soil saturation caused by proximity to storm/sanitary sewer lines.

Anomaly 2 in the southeast corner of the site is caused by the steel plate covering the trench, as shown in Figure 3.

Anomaly 4 is associated with the drainage ditch in the northeast corner of the survey site. The cause of the more conductive materials having minimum values of 20 Ω-m near the ditch may be that the soils beneath the ditch tend to be wetter than the surrounding area. The resistivity calculated from an electrical sounding at a depth of 1 m in the ditch northeast of Building E5032 is 24 Ω-m (McGinnis and Miller 1991, Figure 11).

The anomalies determined by the resistivity measurements are linear features that can be associated with known or suspected surface or subsurface modifications of the site. All other resistivity values in the surveyed area are representative of expected, normal background.

3.3 Ground-Penetrating Radar Measurements

Ground-penetrating radar measurements around the building perimeter were made at 5-ft intervals over 3,595 ft of traverse along 48 individual profiles, coincident with magnetic and

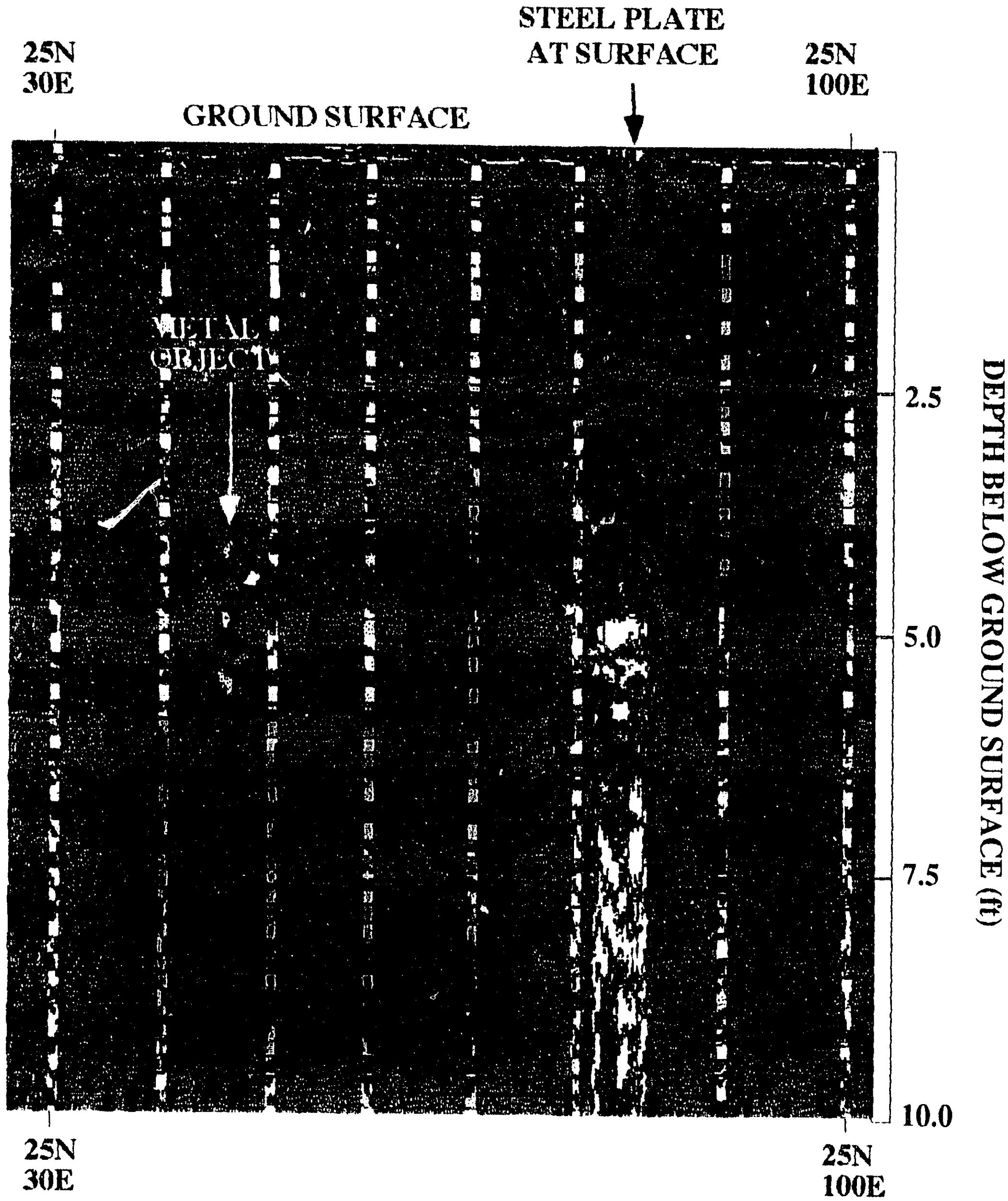


FIGURE 6 West-East Ground-Penetrating Radar Profile for the Area South of Building E5190 (The location of this profile is shown in Figure 3 as line No. 26.)

resistivity profiles. The lines are numbered in sequence and are listed in Appendix B, along with the beginning and ending positions relative to the grid survey. Prior to running the production lines for the survey, replicate runs were made over the same line to determine which of the three transceivers — the 80-, 300-, or 500-MHz antenna — was best suited to study the terrain surrounding the site. The transceiver providing the best penetration and resolution of buried objects was the 300-MHz unit. Different range settings were also tested over the same transect to determine the optimum resolution and depth of penetration. A range setting of 90 ns was used for the entire survey at a scan rate of 16 scans/s. Antennas were pulled by hand at approximately 3 ft/s.

Most of the profiling was done in the areas north, south, and west of the building; some lines were run in the narrow space between the building and the road to the east. Perimeter profiles were designed to detect buried objects extending radially from the building. Figures 6 and 7 show the GPR profiles. The vertical scale is shown on the right side of the profile, whereas lines are marked at 10-ft intervals for the horizontal scale.

Without verification by another technique or by passing the antenna over a known buried object, characteristics of radar anomalies may only be inferred. However, where anomalies are also seen with the magnetometer or electrical resistivity meter, some interpretation of the radar anomaly is possible.

Good penetration was observed over most of the site, with resolution down to about 8 ft below the ground surface. The major findings of the GPR survey around Building E5190 are the following anomalies:

1. A buried metallic object located at coordinates 25N,45E corresponds to a small, low-amplitude magnetic anomaly. This anomaly is seen in line No. 15, which runs from south to north as shown in Figure 3. Figure 6 shows the object at approximately 3.5 ft below the ground surface. The determination of the depth of any object in a GPR profile is a rough approximation unless the electrical properties of the soils at each profile are known. This object is less than 1 ft in diameter, judging from the size of the reflector. The radar signal is unable to penetrate below the metal object, and the ringing multiples below the first reflector are not real. The other prominent feature in Figure 6 is the GPR signature caused by the steel plate that covers a concrete-lined trench.

2. A buried metallic object located at coordinates 08N,70E corresponds to a small, low-amplitude, magnetic anomaly. This anomaly is seen in line No. 26, which runs from west to east as shown in Figure 3. Figure 7 shows the object at approximately 4 ft below the ground surface. The diameter of this object is less than 1 ft.

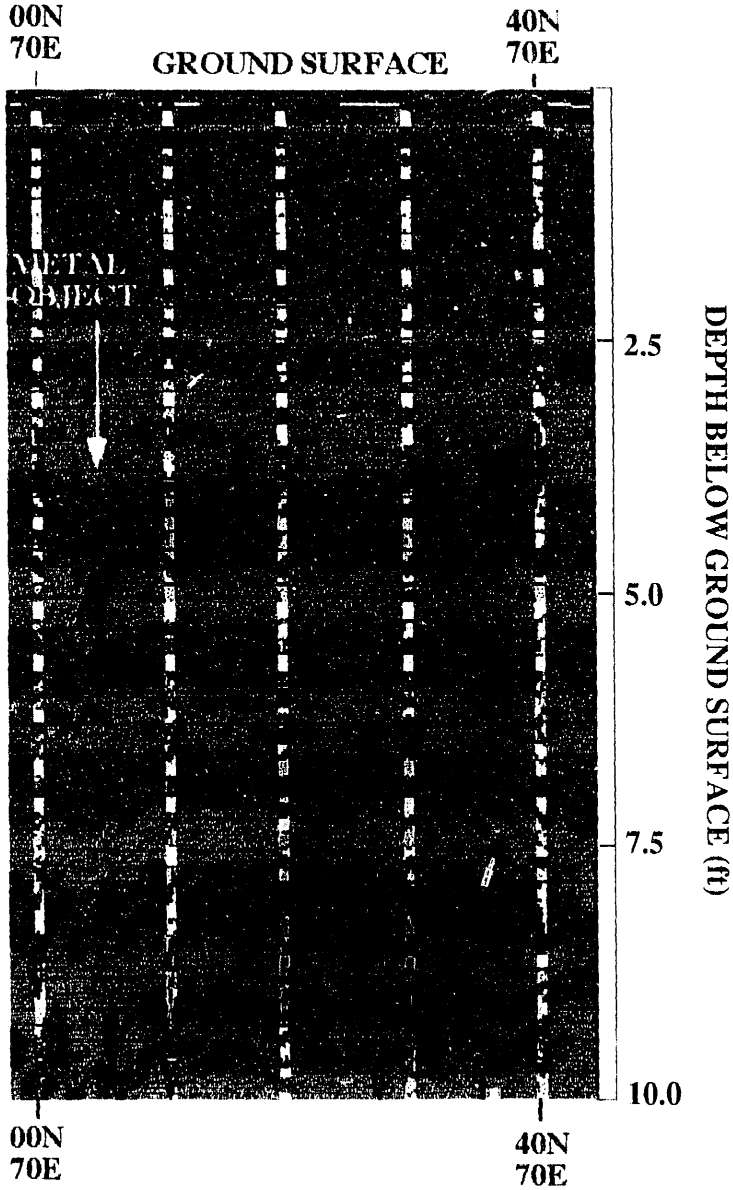


FIGURE 7 South-North Ground-Penetrating Radar Profile for the Area South of Building E5190 (The location of this profile is shown in Figure 3 as line No. 15.)

4 Discussion

Maps of magnetics and DCER results for Building E5190 do not show a common trend, except for the obvious north-south lineament extending southward from the southeast corner of the building. This feature is caused by the steel-covered trench also noted in the discussion of the GPR profile. The fact that GPR soundings did not detect anomalous materials beneath the majority of the magnetic anomalies, and also that the DCER survey showed no anomalous conductive material associated with the magnetic features, suggests that the magnetic sources are associated with small, unconnected bits of metal that lie relatively close to the surface. These materials may be metallic wastes that were incorporated in fill material used in construction.

Although a common magnetic/DCER trend is not present at the site, the resistivity map, shown in both Figures 5 and 8, does have several prominent lineaments, not including the steel cover in the southeast corner. These lineaments are conductive features, associated with zones of

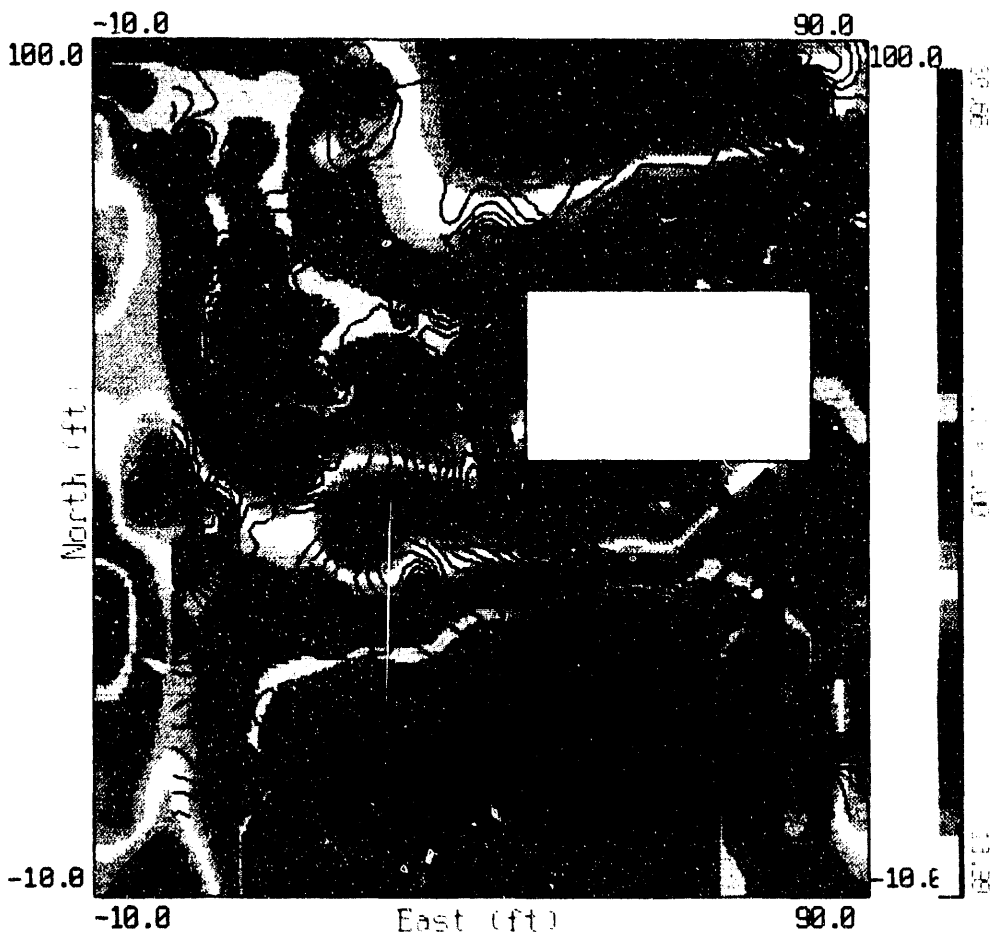


FIGURE 8 Magnetics/Resistivity Overlay Map of Building E5190

increased saturation. Because the north-south trend has a west bend aiming at the manhole shown in Figure 2, we believe that this feature is associated with a sewer line. This conductive feature is also connected with a similar lineament trending east-west and connecting with Building E5190. The east-west branch also intersects a surface depression we believe is caused by differential settlement over the pipe. A third electrical lineament on the north is believed to be caused by increased saturation in the area of a roadside drainage ditch. This feature is probably not associated with a subsurface source, but is due to increased saturation near a topographic depression.

The integration of all the geophysical data obtained around Building E5190 further enhances the interpretation. The two GPR profiles (Figures 6 and 7) that show small anomalies to the south of the building correlate very closely with two low-amplitude magnetic anomalies. The source of the anomaly shown in Figure 6 corresponds with the magnetic anomaly located at grid coordinates 8N,70E (see Figure 4). In addition, the GPR anomaly shown in Figure 7 corresponds with the magnetic anomaly located at 25N,45E. The size of these objects is estimated at less than 1 ft in diameter from the GPR profiles. The GPR data do not reveal sources corresponding to any of the other magnetic anomalies that are seen west of the building. This could be the result of very reflective soils at the surface, or the magnetic anomalies may be clusters of iron-bearing objects too small to be seen with GPR. A cluster of several small iron-bearing objects could appear as one single larger magnetic anomaly. Objects of less than 2-in. diameter buried 2-3 ft below the surface would be very difficult to see with GPR.

5 Conclusions

Specific conclusions drawn from site surveys are as follows:

- Magnetic anomalies are due to small, scattered, metallic debris that probably poses no environmental hazard.

- Resistivity lineaments outline trends of increased saturation. If liquid contaminants were present in the subsurface, they would be associated with the lineament trending westerly from the building, particularly in the area around the surface depression.

- GPR anomalies are due to small sources that probably pose no environmental hazard.

References

AEHA: see U.S. Army Environmental Hygiene Agency.

EAI Corporation, 1989, *Historical Records Search and Site Survey of Edgewood Area Buildings, Final Report*, prepared for U.S. Army Chemical Research, Development, and Engineering Center, Aberdeen Proving Ground, Md., under contract No. DAA15-87-D0021.

Geophysical Survey Systems, Inc., 1987, *Operations Manual for Subsurface Interface Radar (SIR System-3).*

Golden Software, Inc., 1991, *SURFER Version 4*, Golden, Colo.

Interpex Limited, 1988, *RESIX PLUS User's Manual*, Golden, Colo.

McGinnis, L.D., and S.F. Miller, 1991, *Interim Progress Report - Geophysics: Building E5032 Decommissioning, Aberdeen Proving Ground*, report ANL/ESD/TM-20, Argonne National Laboratory, Argonne, Ill.

McGinnis, L.D., S.F. Miller, M.G. McGinnis, and M.D. Thompson, 1992, unpublished information, Argonne National Laboratory, Argonne, Ill.

Oliveros, J.P., and P. Gernhardt, 1989, *Hydrogeologic Data for the Canal Creek Area, Aberdeen Proving Ground, Maryland, April 1986-March 1988*, U.S. Geological Survey Open-File Report 89-387.

U.S. Army Environmental Hygiene Agency (AEHA), 1989, *RCRA Facility Assessment Report, Edgewood Area, Aberdeen Proving Ground, Maryland.*

U.S. Geological Survey, 1992, *Contamination of Groundwater, Surface Water, and Soil, and Evaluation of Selected Pumpage Scenarios in the Canal Creek Area of Aberdeen Proving Ground, Maryland*, draft open file report.

Appendix A:

Electrical Depth-Sounding Curves

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Electrical Depth-Sounding Curves

Four Schlumberger electrical depth-soundings near buildings in the Edgewood area provide a depth dimension to resistivities of soils, sediment, and anomalous unidentified materials. Soundings were made near Buildings E5282, E5440, E5481, and E5974. Locations of centers of stations and orientations of electrode arrays are listed in Table A.1, and the curves are shown at the end of Appendix A as Figures A.1-A.4.

Inversion of these curves using the Interpex code, RESIX PLUS (Interpex Limited 1988), indicates that resistivity of dry soils is from 200 to 300 Ω-m;* saturated sediments, about 100 Ω-m; saturated, organic-rich sediments, about 200 Ω-m; and anomalous materials range from less than 10 to 10,000 Ω-m. Maximum current electrode spacings (AB/2) ranged from 40 to 100 m, providing information to depths of about 50 m.

Normal undisturbed curves were observed at Buildings E5282 and E5481. These stations were located in topographically low areas where the water table lies within 3 m of the surface.

A reasonable interpretation of the curve at Building E5440, which was centered in an open area northeast of the building, is not feasible without more historical information about the site. Former roads, landfills, and other subsurface artifacts could explain the orders of magnitude change in resistivity values from 15 Ω-m to 10,000 Ω-m at a depth of 11 m.

TABLE A.1 Location of Centers of Stations and Orientations of Electrode Arrays for Schlumberger Electrical Depth-Soundings at APG

Station Center	Array Orientation	Maximum Electrode Spacing (m)
Northeast of Building E5282	E-W	50
Northeast of Building E5440	NW-SE	40
North of Building 5481	E-W	80
Northwest of Building E5974	NW-SE	100

* Electrical depth-soundings were measured in the unit of ohm-meter. Thus, discussion of electrical depth-soundings in this report gives depths measured in meters. To convert from meters to feet, multiply depths in meters by 3.28.

The sounding curve at Building E5974 displays the most unusual surface resistivities. A 2.7-m-thick layer of extraordinarily high resistivity (3,055 Ω-m) near the surface is underlain by a layer having a higher than normal value (440 Ω-m) extending to a depth of 50 m. This is underlain by a layer having normal resistivities of near 123 Ω-m.

Earth resistivity models calculated from inversion of the sounding curves are shown in Table A.2.

TABLE A.2 Resistivity Models Calculated from Electrical Depth-Soundings

Station	Resistivity (Ω-m)	Thickness (m)	Depth (m)
E5282	108	0.4	0.4
	244	4.5	4.9
	95	unknown	unknown
E5440	269	1.2	1.2
	14	10.1	11.3
	11,525	unknown	unknown
E5481	366	4.1	4.1
	105	unknown	unknown
E5974	783	0.9	0.9
	3,055	2.7	3.6
	440	46.4	50.0
	123	unknown	unknown

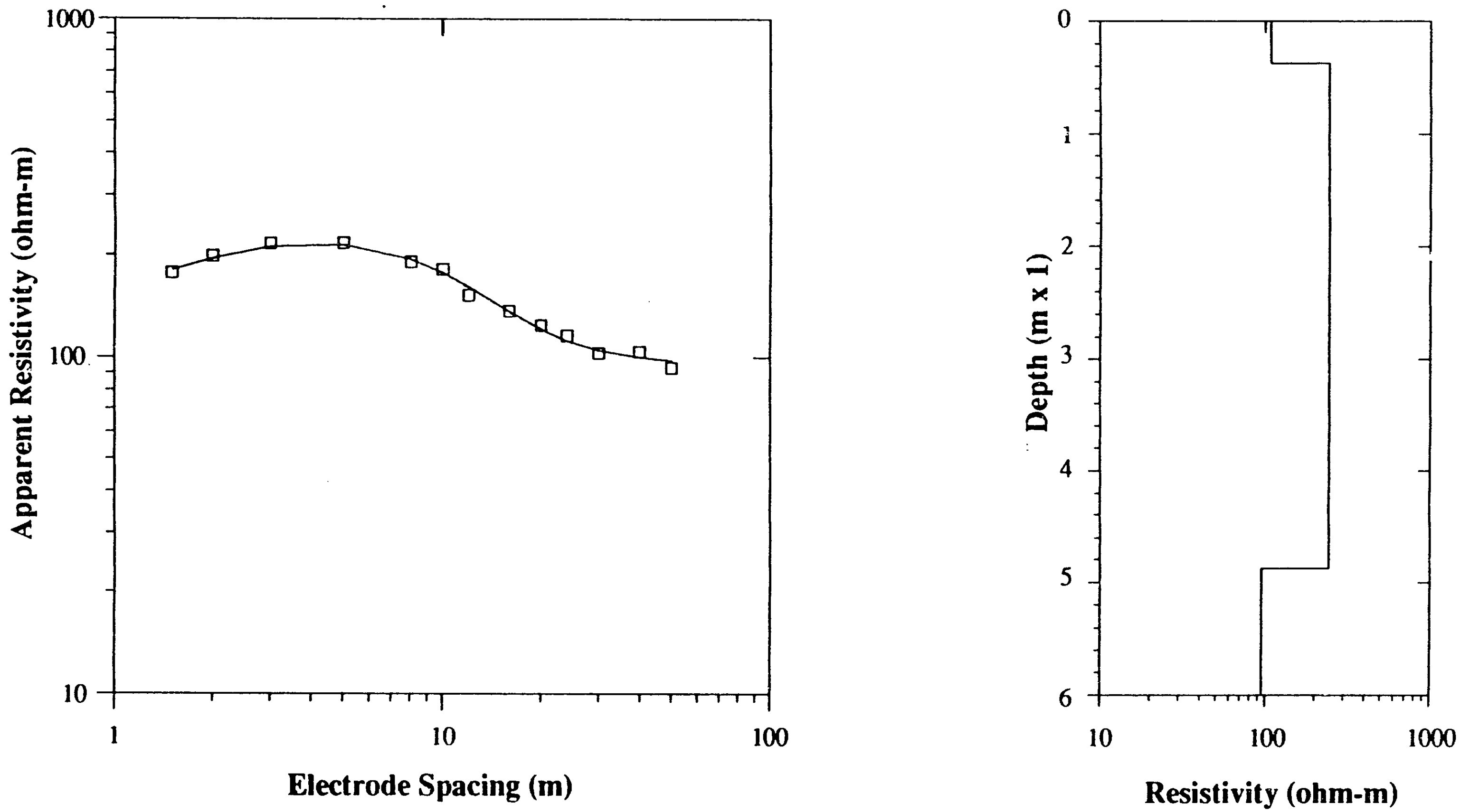

FIGURE A.1 Electrical Depth-Sounding Curve Near Building E5282

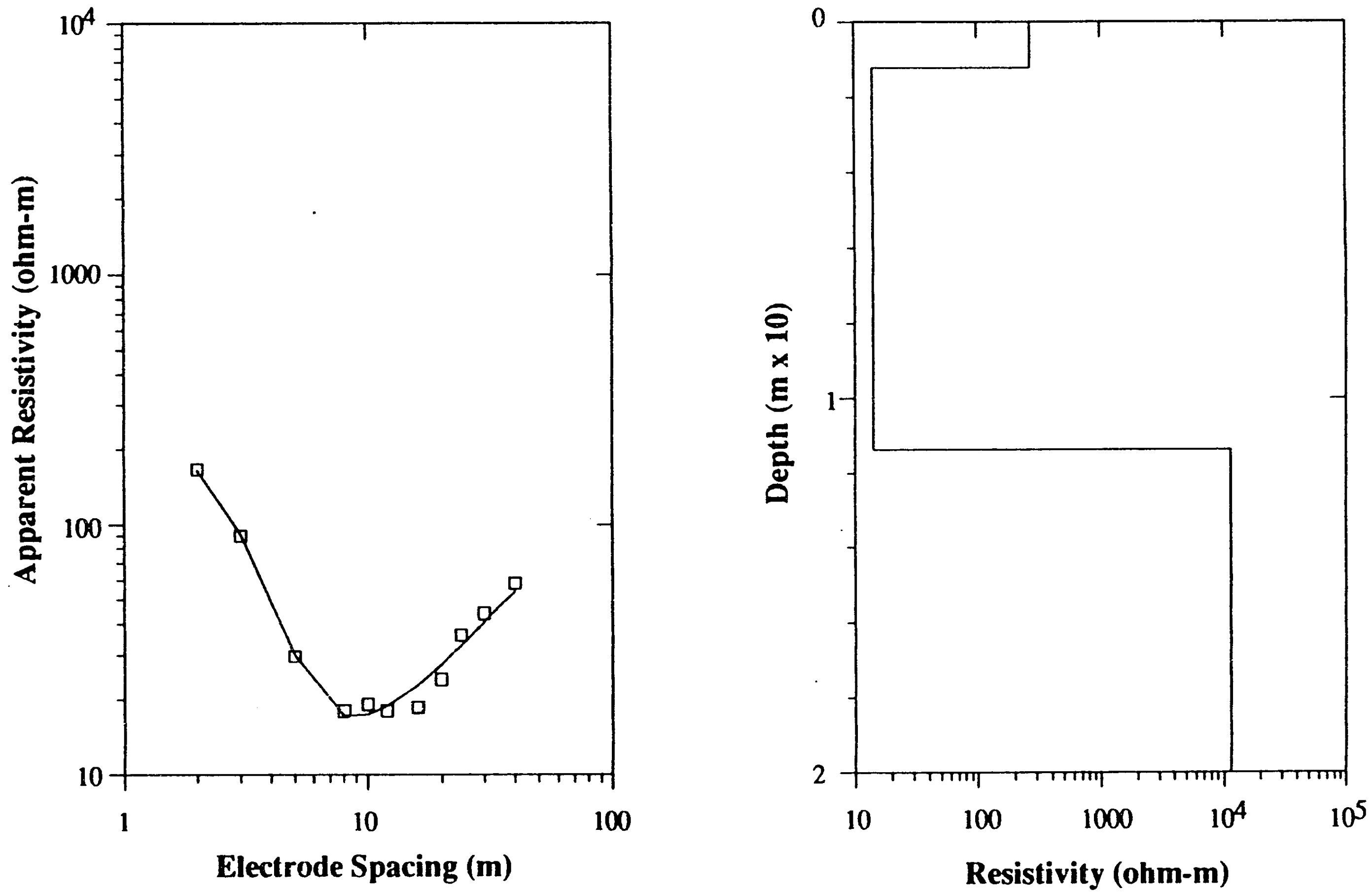

FIGURE A.2 Electrical Depth-Sounding Curve Near Building E5440

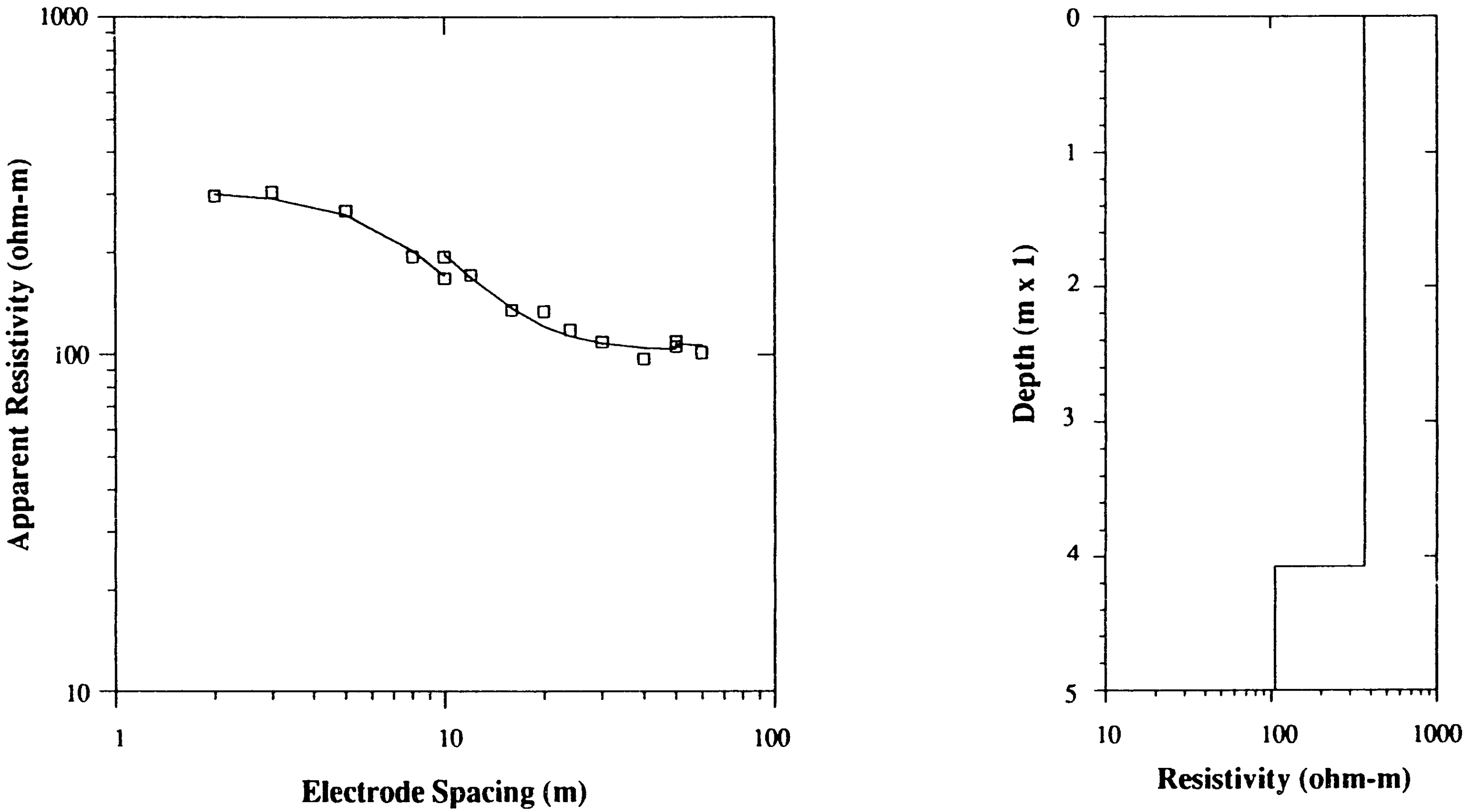

FIGURE A.3 Electrical Depth-Sounding Curve Near Building E5481

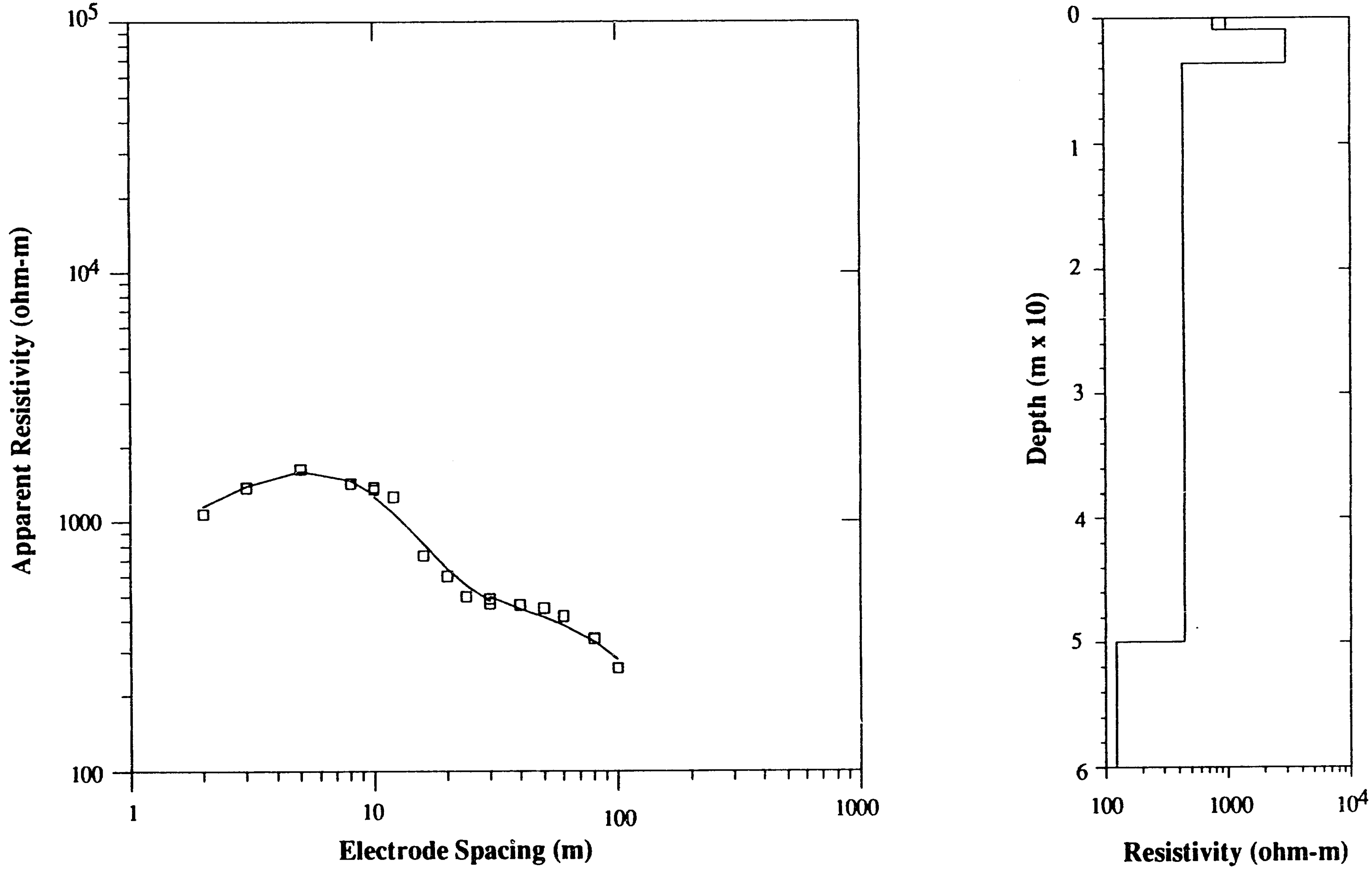

FIGURE A.4 Electrical Depth-Sounding Curve Near Building E5974

Appendix B:

Ground-Penetrating Radar Line Coordinates

Appendix B:

Ground-Penetrating Radar Line Coordinates

Line No.	Start Coordinates North	Start Coordinates East	End Coordinates North	End Coordinates East
1	00	00	100	00
2	00	05	100	05
3	00	10	100	10
4	00	15	100	15
5	00	20	100	20
6	00	25	100	25
7	00	30	100	30
8	00	35	100	35
9	00	40	100	40
10	00	45	44	45
11	00	50	44	50
12	00	55	44	55
13	00	60	44	60
14	00	65	44	65
15	00	70	44	70
16	00	75	44	75
17	00	85	100	85
18	00	90	100	90
19	00	95	100	95
20	00	100	100	100
21	00	00	00	100
22	05	00	05	100
23	10	00	10	100
24	15	00	15	100
25	20	00	20	100
26	25	00	25	100
27	30	00	30	100
28	35	00	35	100
29	40	-50	40	44
30	45	00	45	44
31	50	00	50	44
32	55	00	55	44
33	60	00	60	44
34	65	00	65	100
35	70	00	70	100
36	75	00	75	100
37	80	00	80	100
38	85	00	85	100
39	90	00	90	100
40	95	00	95	100
41	100	00	100	100
42	69	50	100	50
43	69	55	100	55
44	69	60	100	60
45	69	65	100	65
46	69	70	100	70
47	69	75	100	75
48	69	80	100	80

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