ANL/ESD/TM-98

Contamination Source Review for Building E1489, Edgewood Area, Aberdeen Proving Ground, Maryland

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Contamination Source Review for Building E1489, Edgewood Area, Aberdeen Proving Ground, Maryland

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by

K.A. Billmark, D.C. Hayes, A.K. Draugelis
J. Rueda, and R.E. Zimmerman

Summary

This report was prepared by Argonne National Laboratory (ANL) to document the results of a contamination source review of Building E1489 at the Aberdeen Proving Ground (APG) in Maryland. This report may be used to assist the U.S. Army in planning for the future use or disposition of this building. The review included a historical records search, physical inspection, photographic documentation, and geophysical investigation. The field investigations were performed by ANL during 1994 and 1995.

Building E1489 (APG designation) is located in J-Field on the Gunpowder Peninsula in APG's Edgewood Area. The building housed a power generator that supplied electricity to a nearby observation tower. The construction date is unknown. Building E1489 and the generator were abandoned in 1974. The building was demolished by APG personnel and removed from real estate records. Numerous layers of asbestos shingles cover the remaining foundation.

A physical inspection and photographic documentation of Building E1489 were completed by ANL staff during November 1994. At the time of the inspection, Building E1489 had been demolished. Originally, the single-story, square structure contained one room. The 8 ft by 10 ft building was of wood-frame construction with an (assumed) gable roof. Exterior walls were constructed of wood and were covered with transite shingle siding. The roof was a wood frame structure covered with asbestos shingles. The building had a concrete floor supported by a concrete foundation. Information regarding interior wall and ceiling construction is unavailable because the building was demolished prior to the ANL inspection. No evidence of plumbing, heating, or electrical connections or floor drains was observed by ANL during the inspection.

In 1994, ANL staff conducted geophysical surveys in the immediate vicinity of Building E1489 by using several nonintrusive methods. Survey results suggest the presence of some underground objects near Building E1489, but they do not provide conclusive evidence of the source of geophysical anomalies observed during the survey.

No air monitoring was conducted at the site, and no information on underground storage tanks associated with Building E1489 was available.

On the basis of information collected and reviewed for Building E1489, it is the authors' judgment that further investigation and evaluation is needed to confirm the findings of the geophysical surveys. Because of the condition of the building materials, any air contamination from the building itself would have occurred already.

1 Introduction

The U.S. Army Aberdeen Proving Ground (APG) commissioned Argonne National Laboratory (ANL) to conduct a contamination source review to identify and define areas of toxic or hazardous contaminants and to assess the physical condition and accessibility of APG buildings. The information obtained from this review may be used to assist the U.S. Army in planning for the future use or disposition of the buildings. The contamination source review consisted of the following tasks: historical records search, physical inspection, photographic documentation, and geophysical investigation. This report provides the results of the contamination source review for Building E1489.

Located on Chesapeake Bay in Harford and Baltimore countries, Maryland, APG occupies approximately 30,000 acres. The facility is divided into the Aberdeen and Edgewood areas (Figure 1). The primary mission at APG has been the testing and evaluation of U.S. Army warfare materials. Since its beginning in 1917, the Edgewood Area of APG has been the principal location for chemical warfare agent research, development, and testing in the United States. APG was also used for producing chemical warfare agents during both world wars and has been a center for the storage of chemical warfare material (Nemeth 1989).

Many of the APG facilities constructed between 1917 and the 1960s are no longer used because of obsolescence and their poor state of repair. Because many of these buildings were used for research, development, testing, and/or pilot-scale production of chemical-warfare agents and other military substances (such as incendiary materials or munitions containing these materials), the potential exists for portions of the buildings to be contaminated with these substances, their degradation products, and other laboratory or industrial chemicals. These buildings and associated structures or appurtenances (e.g., underground or aboveground storage tanks, pipes, sumps) may contribute to environmental concerns at APG.

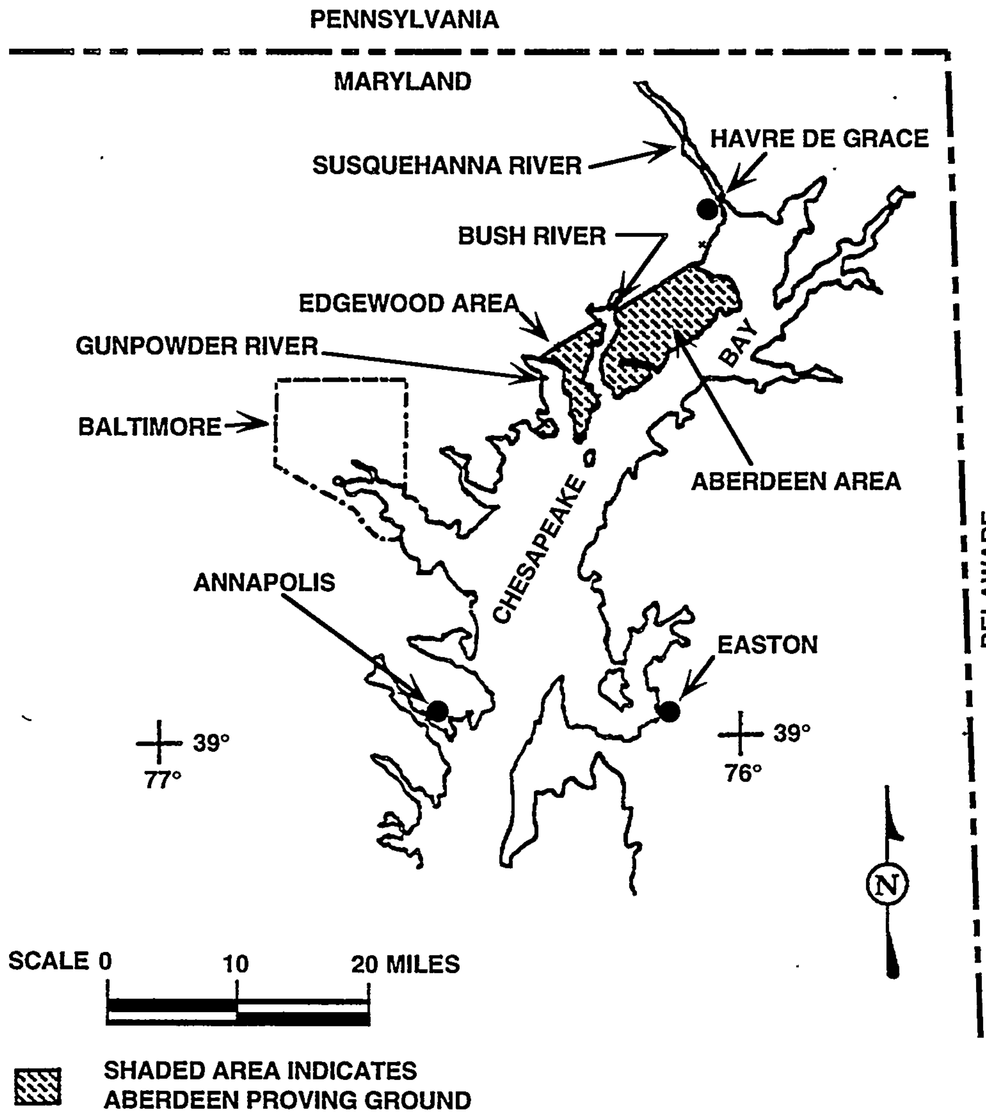


FIGURE 1 Map of Aberdeen Proving Ground Location

2 Methodology

Before the detailed building inspection, ANL personnel made a preliminary site visit to locate the building and obtain building records from APG, identify potential issues to be addressed in the health and safety plan, resolve any access restriction issues, and identify required support services.

Photographs were taken of the building's remains during the inspection in November 1994. The photographs followed a set sequence whenever possible. The exterior was photographed starting on the north side and continuing clockwise around the building.

Detailed descriptions of the methodologies used for the geophysical investigation are provided in the appendix to this report.

3 Historical Record Search

Building E1489 (APG designation) is located in J-Field on the Gunpowder Peninsula at APG. The building housed a power generator that supplied electricity to a nearby observation tower (EAI Corporation 1989). The construction date is unknown. Building E1489 and the generator were abandoned in 1974. The building was demolished by APG personnel and removed from real estate records. Numerous layers of asbestos shingles cover the remaining foundation (EAI Corporation 1989).

4 Building Description

This section provides a physical description of Building E1489 and the surrounding area as they appeared during the ANL inspection in November 1994. Building E1489 has been demolished, and all that remains on-site is the concrete slab, asbestos shingles from the roof, and other miscellaneous debris. The area is overgrown with vegetation. Exterior elevation descriptions are taken from the floor plan.

4.1 Site Description

4.1.1 Location

Building E1489 is located in the southeast corner of J-Field at APG (Figure 2).

4.1.2 Proximity to Other Buildings

The building is south of a watchtower overlooking the Bush River.

4.1.3 Building Structure

Building E1489 was a single-story, rectangular structure containing one room. The building, constructed of wood framing covered with asbestos shingles, had a concrete floor and foundation. Figure 3 shows the floor plan of the building developed during the ANL survey and from historical documentation (EAI Corporation 1989). Figures 4 and 5 present photographs of the building.

4.1.4 Exterior Dimensions

The exterior dimensions of Building E1489 were 8 ft by 10 ft (Figure 3).

4.1.5 Topography

The building is surrounded by soil covered by uncut vegetative cover.

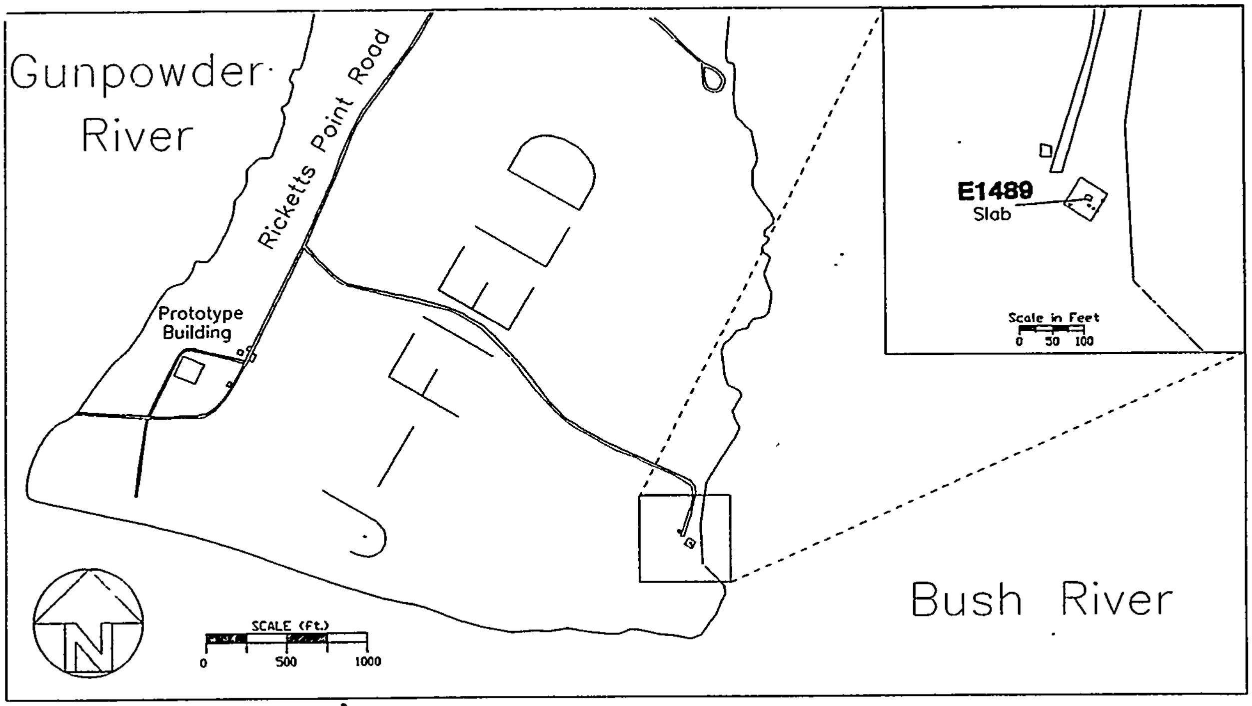


FIGURE 2 Map of Building E1489 Location

4.1.6 Vegetation in the Immediate Vicinity

The vegetation surrounding Building E1489 is uncut and consists of a mixture of forbes, vines, and grasses. There are several trees growing along the south and east sides of the building site (Figure 4).

4.1.7 External Aboveground Structures or Equipment

None.

4.1.8 Connections with Adjacent Buildings

None.

4.1.9 Underground Structures

None.

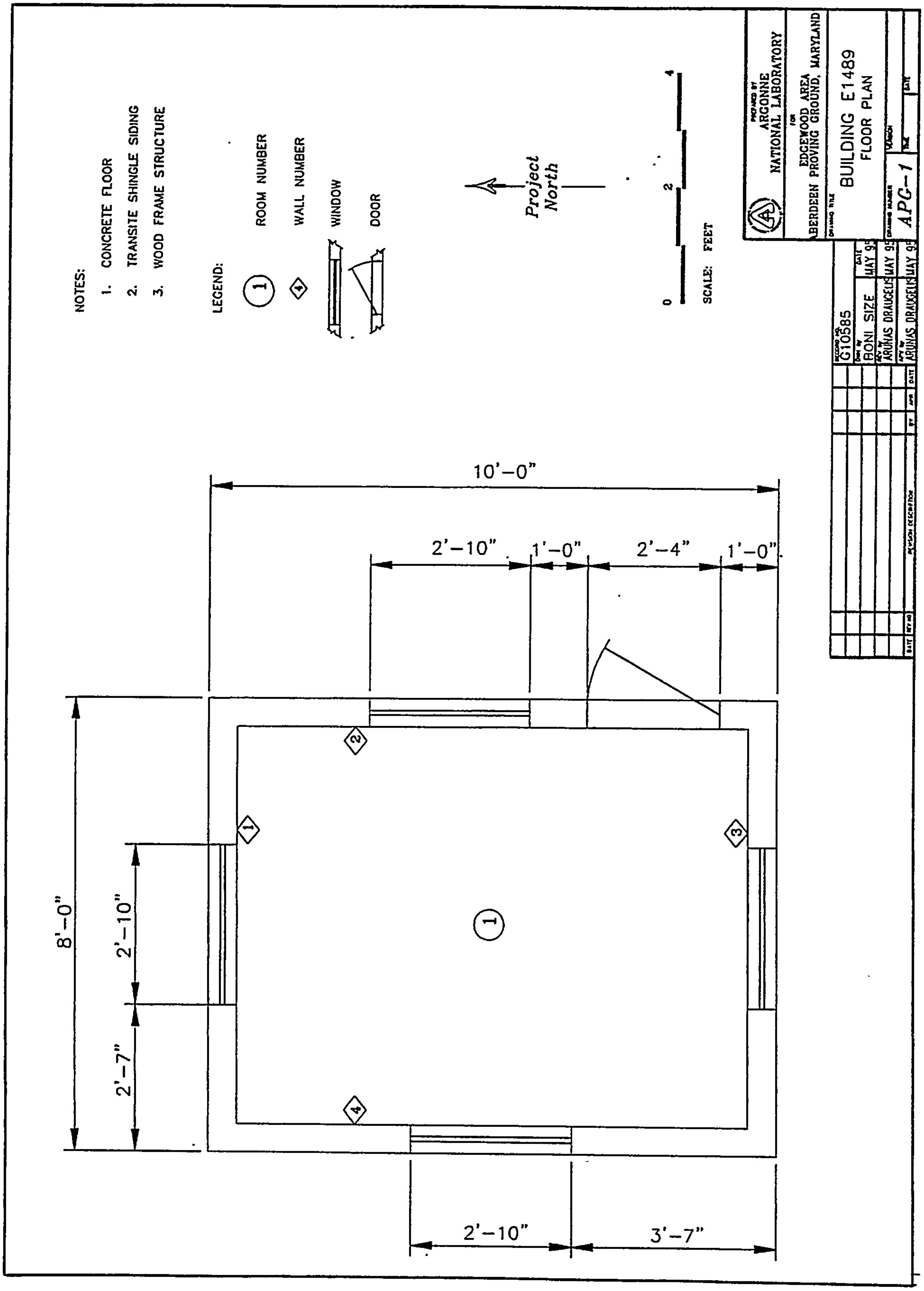


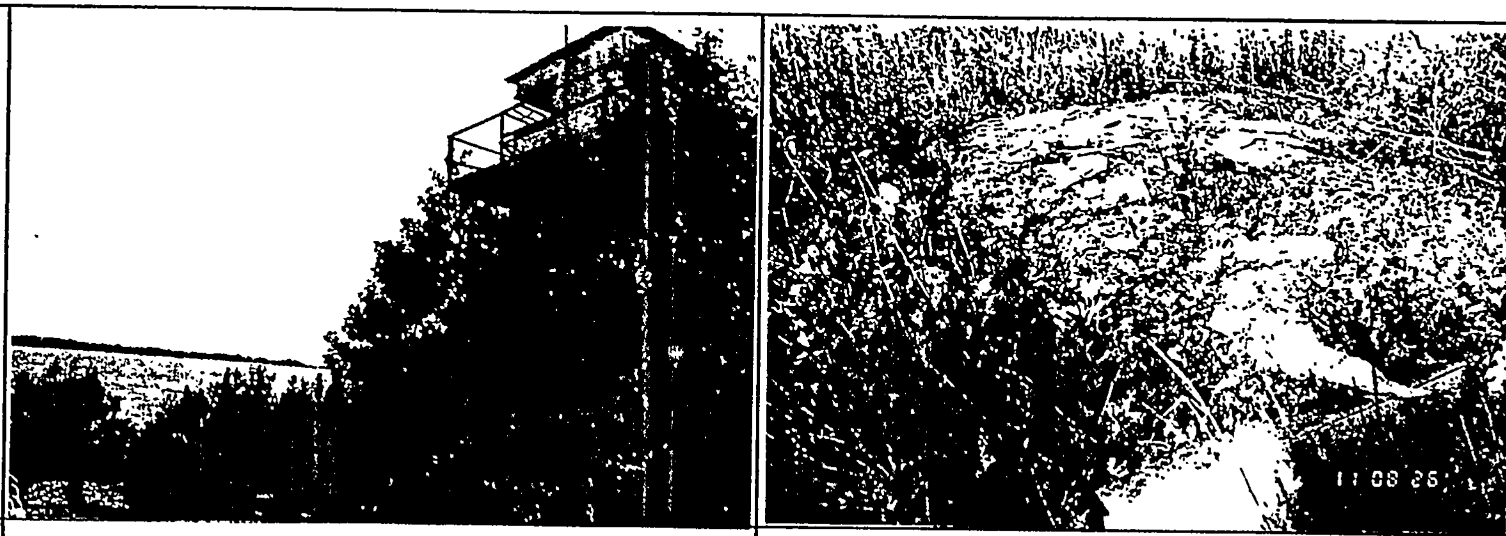
FIGURE 3 Building E1489 Floor Plan

A	North Elevation
C	South Elevation

East Elevation	B
West Elevation	D

FIGURE 4 Photographs of Building E1489 Exterior

A



B

C

Not Used

Not Used

D

A	Overview of Building	
C	Not Used	

Overview of Building	B	
Not Used	D	

FIGURE 5 Photographs of Building E1489 Exterior — Overview

4.1.10 Surface Drainage System

None.

4.1.11 Utility Access Points

None.

4.1.12 Exterior Piping

None.

4.1.13 Nearby Roads and Sidewalks

Building E1489 is east of a dirt road that travels northwest across J-Field to Ricketts Point Road.

4.2 North Exterior Elevation

None.

4.3 East Exterior Elevation

None.

4.4 South Exterior Elevation

None.

4.5 West Exterior Elevation

None.

4.6 Roof

None.

4.7 Interior Floor Plan

A floor plan presented in Figure 3 for Building E1489 was developed by ANL on the basis of the field survey and historical documentation (EAI Corporation 1989).

5 Geophysical Investigation

ANL personnel conducted geophysical surveys of the area surrounding Building E1489 in December 1994. Noninvasive geophysical survey methods were used, including magnetics, electrical conductivity, electromagnetic field (EMF) techniques, and ground-penetrating radar. The geophysical surveys indicated that no buried pipes, trenches, or sewer lines were present. However, point anomalies located near the western corner of Building E1489 were detected by two instruments. Geophysical profiles parallel to the beach near the Building E1489 site suggest the presence of buried metallic objects. The geophysical interim progress report on Building E1489 is presented in the appendix. The following conclusions were drawn from the geophysical investigation at Building E1489:

- The surveys revealed no buried pipes, trenches, or sewer lines. Magnetic, conductivity, and EMF anomalies were observed near well JF-1, the foundation of Building E1489, and the footings for the observation tower.

- Magnetic and EMF observations suggest the presence of buried metallic material near the western corner of Building E1489.

- Low-amplitude magnetic, conductivity, and EMF anomalies are present in profiles that were run parallel to the beach. The relationship of these anomalies to activities at Building E1489 is unknown.

6 Air Monitoring

No air monitoring was conducted at this site.

7 Underground Storage Tanks

No information on underground storage tanks associated with Building E1489 is available.

8 Conclusions

Based on the information collected and reviewed for Building E1489 by ANL, it is the authors' judgment that further investigation and evaluation is needed to confirm the findings from the geophysical surveys. Because of the condition of the building materials, any air pollution contamination from the building itself would have previously occurred.

9 References

EAI Corporation, 1989, *Historical Records Search and Site Survey of the Edgewood Area Building — Final Report*, prepared for U.S. Army Chemical Research, Development, and Engineering Center, Aberdeen Proving Ground, Maryland, under contract no. DAAIS-87-D0021.

Nemeth, G., 1989, *RCRA Facility Assessment Report, Edgewood Area, Aberdeen Proving Ground, Maryland,* unnumbered report prepared for Aberdeen Proving Ground, Maryland.

Appendix:

Interim Progress Report — Environmental Geophysics: Building E1489 Decommissioning, Aberdeen Proving Ground

Interim Progress Report — Environmental Geophysics: Building E1489 Decommissioning, Aberdeen Proving Ground

Prepared by

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Preface

This report is one of a series on environmental geophysical studies around perimeters of buildings in the Edgewood Area of Aberdeen Proving Ground. The series was initiated in 1991 at Building E5032, where techniques were evaluated and a design for the surveys was established. Studies continued in 1992 and 1993, when surveys of Buildings E5190, E5282, E5375, E5440, E5476, E5481, E5485, E5487, E5489, E5974, E5978, and the Building E103 Dump were completed. In 1994, geophysical surveys were completed around Buildings E1489, E2370, E3162, E3163, E3180, E3236, E3613, E3640, E6891, and E7995, and Building E5032 was resurveyed; newer, continuously recording equipment was used in all 1994 surveys. Deeper insight into the magnetic, electrical, and radar imagery characteristics of the Canal Creek and Kings Creek Areas has been gained from the completion of each geophysical survey. Subsequent improvements in survey design and data acquisition, processing, and interpretation have been realized at more recent sites, including Building E1489.

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by

M.A. Benson, J.E. Stefanov, G. Keucher,
M.A. Glennon, M.D. Thompson, and C.R. Daudt

Abstract

Noninvasive geophysical techniques were used to survey Building E1489, a potentially contaminated site in the J-Field Area of Aberdeen Proving Ground. Magnetic, electrical conductivity, and electromagnetic field techniques, and ground-penetrating radar were used as part of a sampling and monitoring program prior to decommissioning of the building. The geophysical surveys indicated that no buried pipes, trenches, or sewer lines were present. However, point anomalies, located near the western corner of Building E1489 and beneath the observation tower, were detected with at least two instruments. Geophysical anomalies were also observed near concrete foundations and a well. Geophysical profiles that were run parallel to the beach near the Building E1489 site suggest the presence of buried metallic objects. It is not known if these anomalies are related to past activities at Building E1489.

1 Introduction

Aberdeen Proving Ground (APG), in the state of Maryland, is managing a comprehensive Installation Restoration Program involving more than 360 solid-waste-managing units contained within 13 study areas. The Edgewood Area of Aberdeen Proving Ground appears 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.

A report prepared by the EAI Corporation (1989) included a list of 29 potentially contaminated buildings in the Edgewood Area of Aberdeen Proving Ground. The buildings have been abandoned and operations have ceased, but processing equipment, incinerators, sumps, drains, ventilation systems, and underground storage tanks remain. These appurtenances may contain liquid, solid, or vapor contaminants of unknown nature. 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. Most of the effort thus far has been in the western Canal Creek Area and the Kings Creek Area.

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. Argonne National Laboratory (ANL) 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.

1.1 History of Building E1489

Building E1489 was located on level terrain in the J-Field Area on the Gunpowder peninsula adjacent to the Bush River, east of the Prototype Building and Rickett's Point Road (Figure 1). This building housed an electric power generator that supplied a nearby observation tower. It is not known when Building E1489 was built. However, unspecified quantities of petroleum, oil, and lubricant (POL) materials were used to service the power generator until 1974, when the generator and the building were abandoned. In 1987, the building was demolished, leaving behind numerous layers of asbestos shingles on top of the concrete foundation (EAI Corporation 1989). The Building E1489 site is classified as having unknown contamination because very little information is known about the building.

1.2 Site Reconnaissance

The geophysical survey program design for Building E1489 was based on similar studies conducted by ANL personnel at APG since 1991 (McGinnis and Miller 1991; L.D. McGinnis et al. 1992a,b, 1994, 1995; M.G. McGinnis et al. 1992a,b; Miller et al. 1992a,b; Thompson et al. 1992a,b, 1994, 1995; Daudt et al. 1995). The initial evaluation was enhanced by a November 1991 site visit and by inspection of aerial photos available to Argonne personnel.

The cement foundation of Building E1489 was covered with debris. Within the survey area, the ground was covered with tall grasses and weeds. Two small cement pads of unknown origin are located about 5-10 ft south and east of the foundation. In addition, footings for an existing observation tower are set on the eastern edge of the survey area. U.S. Geological Survey (USGS) well JF-1 is situated at the western corner of the area (Figure 2).

In planning the geophysical survey, subsurface characteristics at the site were considered in addition to surface conditions. Surficial sediments consist of estuarine sands, silts, and clays that are nonmagnetic and have electrical properties that vary both horizontally and vertically due either to natural conditions or to excavation and building effects. Such sources as iron-rich magnetized objects, nonmagnetic objects, and subsurface channels containing contaminants may be present in the subsurface.

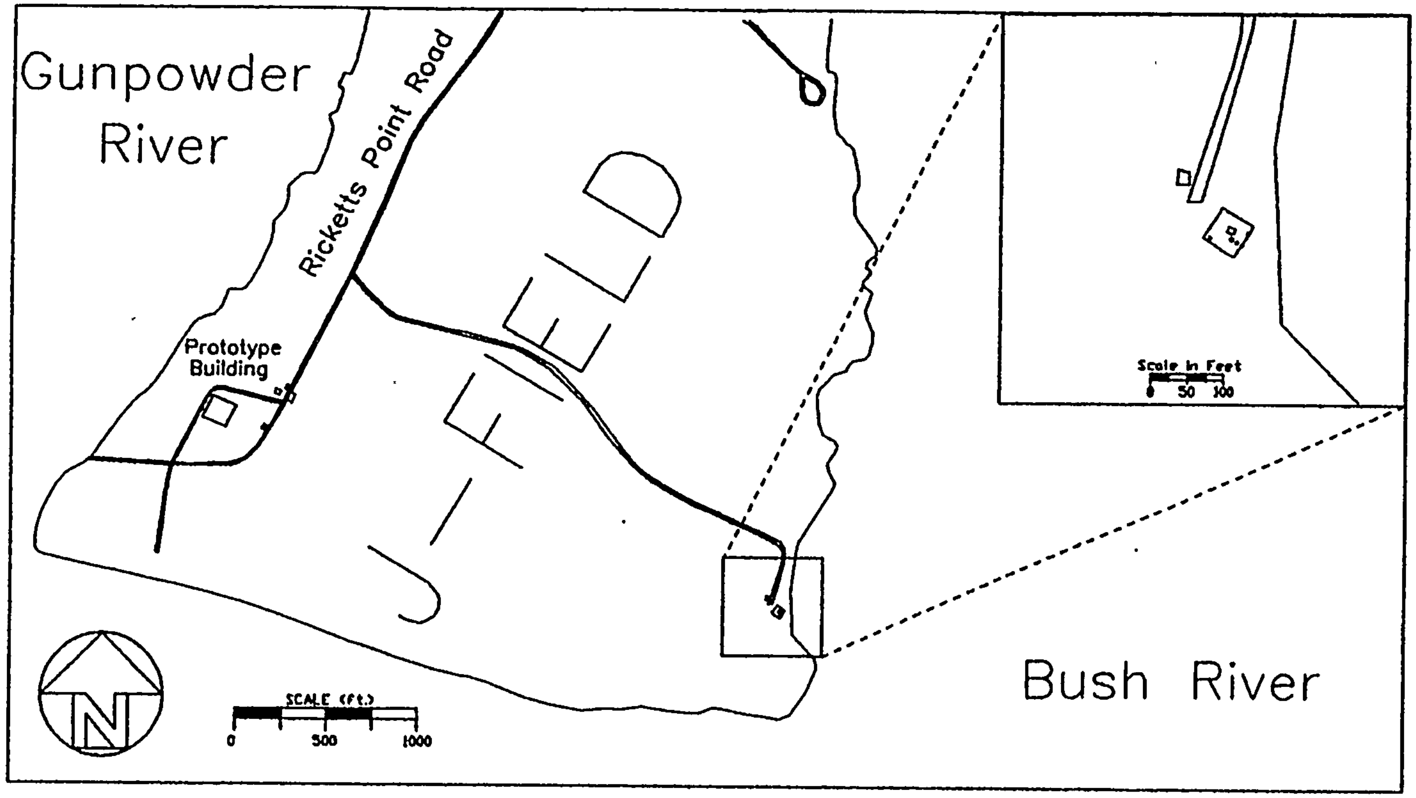

FIGURE 1 General Location Map of the J-Field Area, Aberdeen Proving Ground, Md.

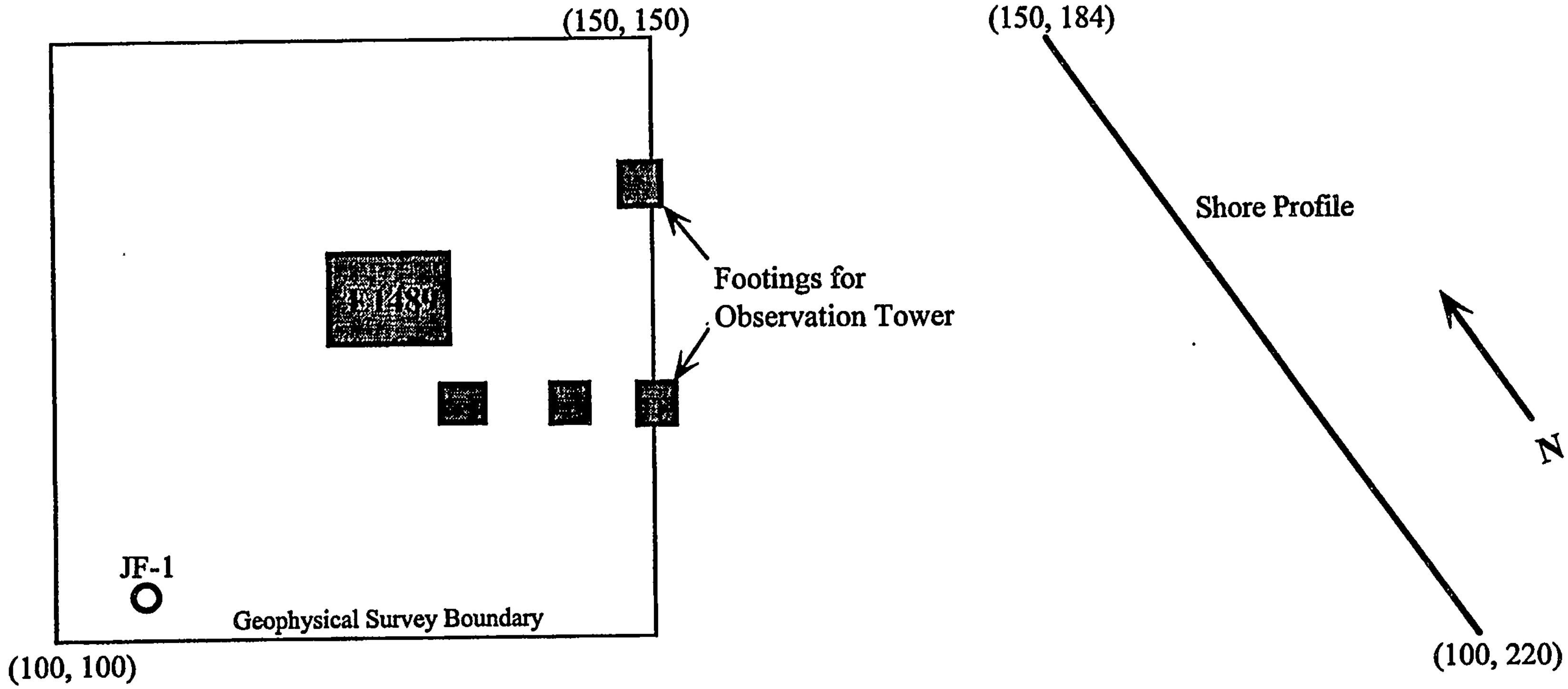

FIGURE 2 Detailed Site Map of the Building E1489 Site, Showing the Location of the Transect near the Shoreline

1.3 Geology and Physiographic Setting

The J-Field Area is contained in topographically low and flat terrain of the Coastal Plain physiographic province, where alluvial and estuarine sands, silts, and clays underlay the region. A thin veneer of sediments of the Talbot Formation of Pleistocene age overlies unconsolidated sediments of the Potomac Group of Cretaceous age (Hughes 1993).

Lithologies at the site were determined from well JF-1 (Table 1), which is located less than 30 ft from Building E1489 (Figure 2). This well was part of a hydrogeologic study of the J-Field Area performed by the USGS (Hughes 1993). Facies represented include a thin layer of sandy soil followed by about 40 ft of unconsolidated medium- to fine-grained sand. About 127 ft of clay lies beneath the sand layer.

1.4 Surveys

Geophysical data were acquired during five days of field operations during December 1994. On-site personal computers (both notebook and desktop), interactive software, and field equipment designed specifically for APG building studies were used to expedite data acquisition and processing. Surveys were conducted to measure total field magnetics, electrical conductivity, induced electromagnetic field (EMF), and ground-penetrating radar (GPR) profiles.

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. The exact alignment of Building E1489 relative to geographic north is not known with certainty. Therefore the orientation of north in all figures should be considered approximate. The zero coordinate was considered to be located west of the building foundation pad. Positive X and Y coordinates were measured southeast and northeast of the zero coordinate; negative coordinates to the northwest and southwest. The survey grid was oriented so that its primary axes were parallel to the edges of the cement pad. Geophysical profiles, spaced 5 ft apart, were traversed in both X and Y directions.

East of the primary survey area, geophysical profiles were run along a line oriented parallel to the shoreline located between the Building E1489 site and the Bush River (Figure 2) (two wooden stakes mark the ends of this transect). Although this area was not initially planned as part of the survey, these profiles were run to check for the existence of sewers or drainlines that potentially transported contaminants from buildings into wetlands, rivers, and creeks. Positions of anomalies along the shore profile are probably accurate to within 20 ft.

TABLE 1 Lithologic Log of Well No. JF-1, Located near the Building E1489 Site

Description[a]	Depth (ft)	Thickness (ft)
Soil, fine quartz sand (fL); minor silt and clay, trace of rounded pebbles, dark brown (10 YR 3/4)	1.2	1.2
Medium and fine (mU to fU) subangular quartz sand, minor silt, brownish yellow (10 YR 6/6), gradual boundary	4.0	2.8
Medium and fine (mU to fU) subangular quartz sand, minor silt, mottled brownish yellow (10 YR 6/6) and light brownish gray (2.5 YR 6/2), abrupt boundary	4.4	0.4
Clay, fine (fL) quartz sand, gray (N5), trace peat, clear boundary	4.5	0.1
Medium (mL) subrounded quartz sand, abundant silt, gradual boundary	5.8	1.3
Quartz sand, medium and fine (mU to fU), mottled brownish yellow (10 YR 6/6) and light brownish gray (2.5 Y 6/2), bedding 2.0-3.0-cm thick	9.0	3.2
Quartz sand, medium (mL), subrounded, light brownish gray (2.5 Y 6/2)	18.0	9.0
No sample	20.0	2.0
Quartz sand rounded, coarse (cU to cL); gravel and pebbles to 1.0-cm diameter, silt common, gray (5 Y 4/1) clay minor	40.0	20.0
Dark gray (5 Y 4/1) clay, abundant bivalve shell fragments from 55.0-60.0 ft, silt common	60.0	20.0
Dark gray (5 Y 4/1) clay, silt common, minor wood fragments, bivalve shell fragments common	80.0	20.0
Dark gray (5 Y 4/1) clay, massive silt common, bivalve shell fragments and wood fragments minor, very fine sand (vfL) minor	82.0	2.0
Dark gray (5 Y 4/1) clay, silt common, shell fragments minor, organic material minor; sand minor	147.0	65.0
Very coarse (vcU and vcL) quartz sand, rounded and subrounded, grains are clear and golden; rock fragments of sandstone and granite (vcU) common	162.0	15.0
Very coarse (vcU and vcL) quartz sand, rounded; gravel consisting of rock fragments of sandstone, shale, metamorphic gneiss (up to 2.0-cm diameter) common; clay, dark gray (5 Y 4/1) and white (10 YR 8/1)	182.0	20.0
Medium (mL) quartz sand, rounded, light brownish gray (10 YR 6/2), very clear	184.0	2.0
No sample	202.0	20.0
Clay, light gray (10 YR 7/1); silt common	208.0	6.0
Clay, red (2.5 YR 4/8)	242.0	34.0
Clay, light gray (10 YR 7/1); silt common; mixed with sand, quartz, medium (mL) rounded.	277.0	35.0
No sample	304.0	27.0

[a] Codes enclosed in parentheses at selected horizons refer to color designations specified in the *Munsell Soil Color Charts* (1975).

Source: Hughes (1993).

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. The MAC-51B is an audio device used only for rapid detection of magnetic materials for further analysis with complementary instrumentation.

Maps or models are not constructed from observations made with this instrument because the MAC-51B is not a calibrated system and it does not have digital data recording. Anomalies are identified by changes in sound amplitude and frequency. Any anomalies detected with the MAC-51B are marked on the ground surface prior to the initiation of other surveys. If the anomalies detected with the MAC-51B cannot be verified with the magnetometer (see Section 2.2), the anomaly is assumed to be insignificant.

Surveying with the MAC-51B in its receiver mode is the first geophysical operation following establishment of survey limits. A qualitative description of the site, with 100% ground coverage, is achieved by 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 Total-Field Magnetics Meter G-822L

Magnetometer surveys are used for identifying such ferromagnetic objects as tanks, drums, drain pipes, water lines, and small ferrous objects. An EG&G Geometrics G-822L cesium-vapor magnetometer was used to measure the total magnetic field around Building E1489. The G-822L was operated in a continuous-recording mode and acquired a magnetic measurement at intervals of approximately one-third of a foot.

Because of the dipolar field, a magnetic anomaly due to a source having a simple shape exhibits a characteristic signature consisting of a positive magnetic peak and at least one negative magnetic trough. If a symmetrically shaped body of iron-rich waste is buried in the northern hemisphere and becomes magnetized in the Earth's field, a large positive anomaly with a weak negative offset to the north will occur. The horizontal distance between the paired peak and trough is proportional to the depth of burial, the size, and the shape of the source, whereas, the amplitude of the anomaly is inversely proportional to the square of the depth of burial. Metallic debris at, or just below, the ground surface produces strong, closely spaced, magnetic peaks and troughs separated by high gradient areas.

When using the G-822L magnetometer, the sign of magnetic anomalies must be viewed with extreme caution, because in a region of high gradients, the magnetometer becomes untuned and provides zero readings. Contouring software for the G-822L has been designed to bridge the zero gap with mean values taken from the last readable data along the profile. Thus, because of the bipolarity of magnetic anomalies and the variability of gradients, it is possible for an isolated anomaly or a lineament to change from a positive to a negative feature along the trend. For the purpose of this study, the polarity of the anomaly is unimportant. The absolute strength of the magnetic anomaly and whether the anomaly appears as a "point" source or as a linear feature are more important to the geophysical interpretation.

2.3 Conductivity Meter EM-31

Mean conductivities were obtained with the Geonics EM-31, an electromagnetic (EM) induction instrument that measures mean terrain conductivity to depths of approximately 20 ft. The induction coil of the EM-31 transmits an EM field into the ground, and a receiver measures the secondary magnetic field caused by the low-intensity eddy currents induced in the subsurface. The field strength of the secondary magnetic currents are almost linearly proportional to the electrical conductivity of the surrounding sediment.

Data were collected at 0.5-s intervals with the EM-31 and were stored on the OMNI 720 data logger, which can log quad-phase electrical conductivity data, and in-phase inductive data for metals simultaneously, as well as store survey geometry. For this survey, data were recorded in quad-phase only. Internal software permits downloading data directly into an on-site computer. Conductivity contouring in units of millisiemens per meter (mS/m) is incorporated into the field acquisition procedure, so that daily map outputs were available for observation and interpretation. EM methods have been used extensively in the Edgewood Area at Beach Point, J-Field, and various buildings surveyed by ANL staff.

2.4 Time-Domain Millivolt Meter EM-61

EMF data were obtained in millivolts with a Geonics EM-61, a portable, time-domain, electrical induction instrument that transmits an electrical pulse into the ground and measures secondary EMFs caused by metallic objects beneath the instrument. As a consequence of its coil arrangement, the EM-61 is relatively insensitive to surface interference and is more sensitive to deeply buried metallic targets. Data are recorded on three channels: responses from an upper coil, a lower coil, and a coil difference.

Data were collected at a rate of three readings per second and were stored on the OMNI 720 data logger. Internal software permitted downloading data directly into an on-site computer. Contouring of data in millivolts (mV) was incorporated into the field acquisition procedure, so that daily map outputs were available for observation and interpretation. Inspection of the data sets acquired at Building E1489 and at other APG sites surveyed by Argonne personnel indicates that the measurements obtained from the lower coil are sufficient to identify buried metallic sources within the gridded area.

2.5 Ground-Penetrating-Radar System

Ground-penetrating radar surveying and data processing were accomplished using Geophysical Survey Systems, Inc., Radan III software (Galinovsky and Levin, 1990) and a model SIR-2 radar connected to a transceiver with a cable approximately 300 ft long. Data from the SIR-2 system were downloaded directly to the personal computer. The control unit/thermal printer was located in the transport vehicle. A computer was located in a field office, so that the radar operator could download, check data quality, and do preliminary processing after a day's run.

Wave-velocity characteristics of near-surface materials were derived from tables of travel-time conversion to depth for various earth materials (Geophysical Survey Systems, 1987). For example, the two-way conversion to depth for average soil is 7-9 ns/ft. As the degree of soil saturation increases, the two-way conversion to depth also increases which, in effect, decreases the maximum penetration depth. Clay also tends to decrease the maximum penetration depth. For example, at Building E1489, a range setting of 70 ns was used within the geophysical survey area. Due to unknown saturation conditions and subsurface heterogeneities, the depth of penetration with GPR at E1489 can range between 8 and 12 feet below the ground surface. For the purposes of this report, a maximum penentration depth of 10 feet was assumed. A range setting of 150 ns was used along the beach profiles and a maximum penetration depth of 20 feet was assumed.

Ground-penetrating radar is 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.

3 Geophysical Measurements and Surveys

Gridding of the total magnetic field (G-822L), terrain conductivity (EM-31), and time-domain EMF (EM-61) data sets was achieved using SURFER Version 4.0 software by Golden Software, Inc., Golden, Colorado (1991) with the minimum curvature method. Documentation supplied for the MINC gridding program suggests that grid intervals from one-half to one-fifth of the profile spacing will yield adequate gridding results for data acquired along profiles (Cordell 1992). Thus, a grid interval of 1.25 ft was used for each set of grid data, which represents a grid interval of one-fourth of the profile spacing (5 ft). Following processing and gridding with the SURFER software, anomalies were enhanced by using color-contouring software developed at ANL by Thompson (1994). These color-contour maps are presented in this report. The data set comprises 5,260 magnetic measurements; 1,156 EM-31 measurements; and 1,371 EM-61 measurements. Profile plots of selected GPR traverses are also presented and are part of a data set comprising 600 linear feet.

3.1 Total-Field Magnetics Measurements

The magnetic field measured around Building E1489 is shown in Figure 3. Also depicted are the magnetometer profiles that were run in both the X and Y directions. In the western corner of the site, the magnetic field is dominated by USGS well JF-1. Any anomalies caused by metal buried within 10-15 ft of this feature are obscured by the magnetic field surrounding the well.

Well-defined, localized magnetic anomalies occur beneath and just southwest of the remains of Building E1489. The high-low magnetic anomaly pair observed directly beneath the slab may be caused by rebar within the slab that is magnetically polarized. This type of anomaly may be caused by a buried metallic object.

The magnetic highs observed along X = 150 and centered at Y = 138 and Y = 120 are probably caused by the observation tower. A strong GPR anomaly is observed near the magnetic low at (150,125). Other unexplained magnetic anomalies are observed at coordinates (135,122) and (145,117).

3.2 Terrain Conductivity Measurements

Two illustrations using orthogonal data sets (Figures 4 and 5) are used to define conductivity anomalies because of the azimuthal bias inherent in the EM-31.

On both north-south (Figure 4) and east-west (Figure 5) transects, conductivity lows surround the Building E1489 site, which suggests that the concrete foundation is underlain by a

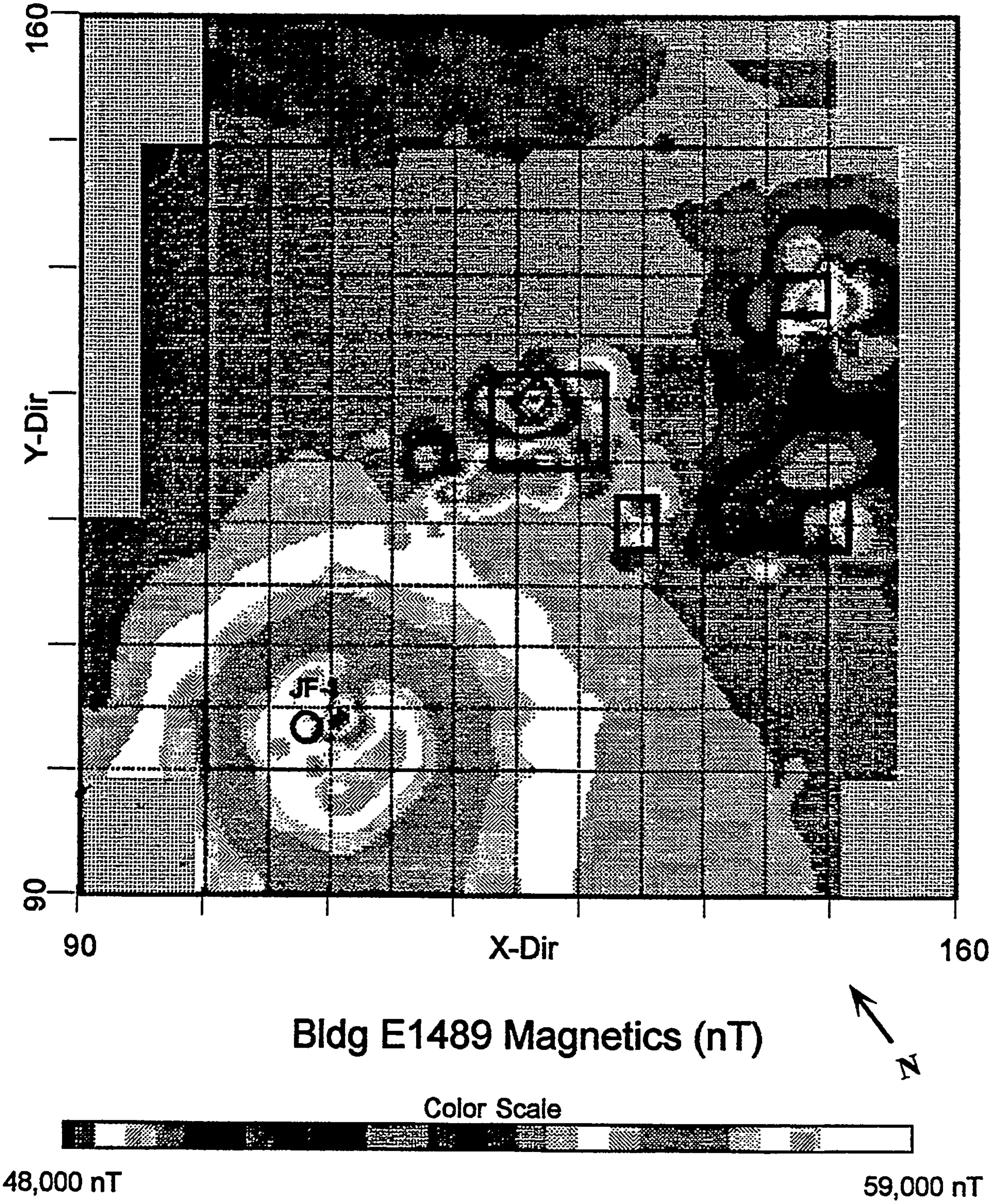

FIGURE 3 Map of the Total Magnetic Field Anomalies at Building E1489 (measured by using a Geometrics G-822L cesium-vapor magnetometer)

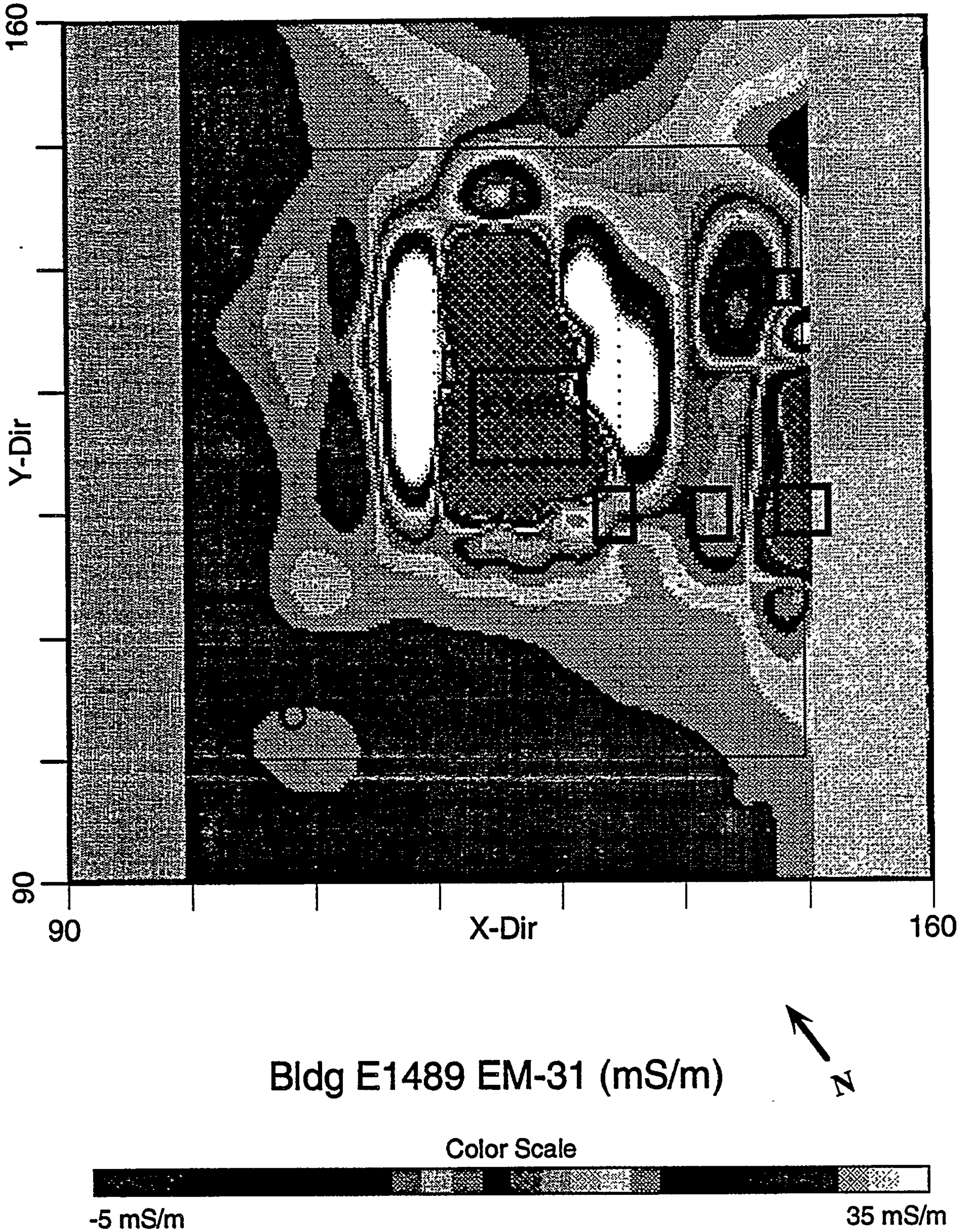

FIGURE 4 Map of Terrain Conductivity Anomalies along North-South Transects at Building E1489 (measured by using a Geonics EM-31 instrument)

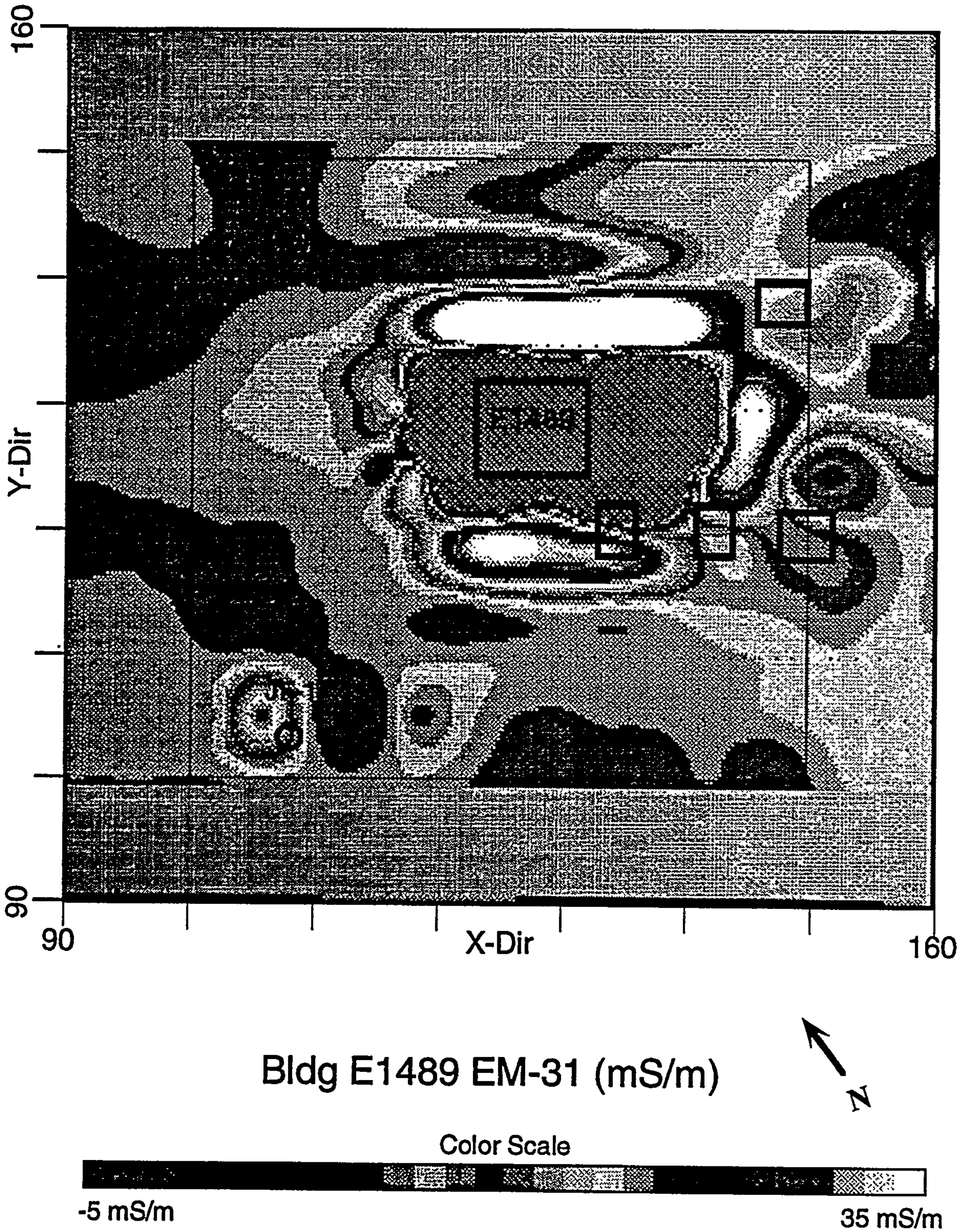

FIGURE 5 Map of Terrain Conductivity Anomalies along East-West Transects at Building E1489 (measured by using a Geonics EM-31 instrument)

poor conductor, such as high porosity unsaturated sands or gravels. High conductivities adjacent to the building site are difficult to interpret. However, in Figure 5, the positive anomaly extending between Y = 125 and Y = 135 is probably caused by interference from the observation tower.

Well JF-1 produced the localized anomaly observed along line Y = 105 (Figure 5).

3.3 Induced-EMF Measurements

A color-contour map constructed from EM-61 lower coil data, which responds to all signal from the surface to approximately 9 ft, is shown in Figure 6. The negative anomalies on either side of both Building E1489 slab and well JF-1 are gridding artifacts. Steep gradients from the two structures force the minimum curvature algorithm to overshoot.

The positive EMF anomaly associated with the slab is consistent with the interpretation that the Building E1489 foundation was reinforced with rebar. The EMF positive anomaly that extends from the western corner of the Building E1489 slab corresponds to a magnetic high and a lateral change in the GPR signal.

Positive EMF anomalies are also observed near the tower and the well. A smaller amplitude anomaly is seen east of the small central slab, located southeast of the main slab.

3.4 Ground-Penetrating-Radar Measurements

Figure 7 shows the locations of GPR profiles conducted near Building E1489. Coordinates of the starting and ending points for each profile are presented in the Attachment. 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 100-, 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 70 ns was used for the entire survey, at a scan rate of 32 scans per second.

Without verification by another technique or by passing the antenna over an object of known depth, characteristics of radar anomalies may only be inferred. However, where anomalies are also seen with magnetic or resistivity profiling, a diagnostic interpretation of the radar anomaly is possible. Good penetration was observed over most of the site, with resolution down to about 7 ft below the ground surface.

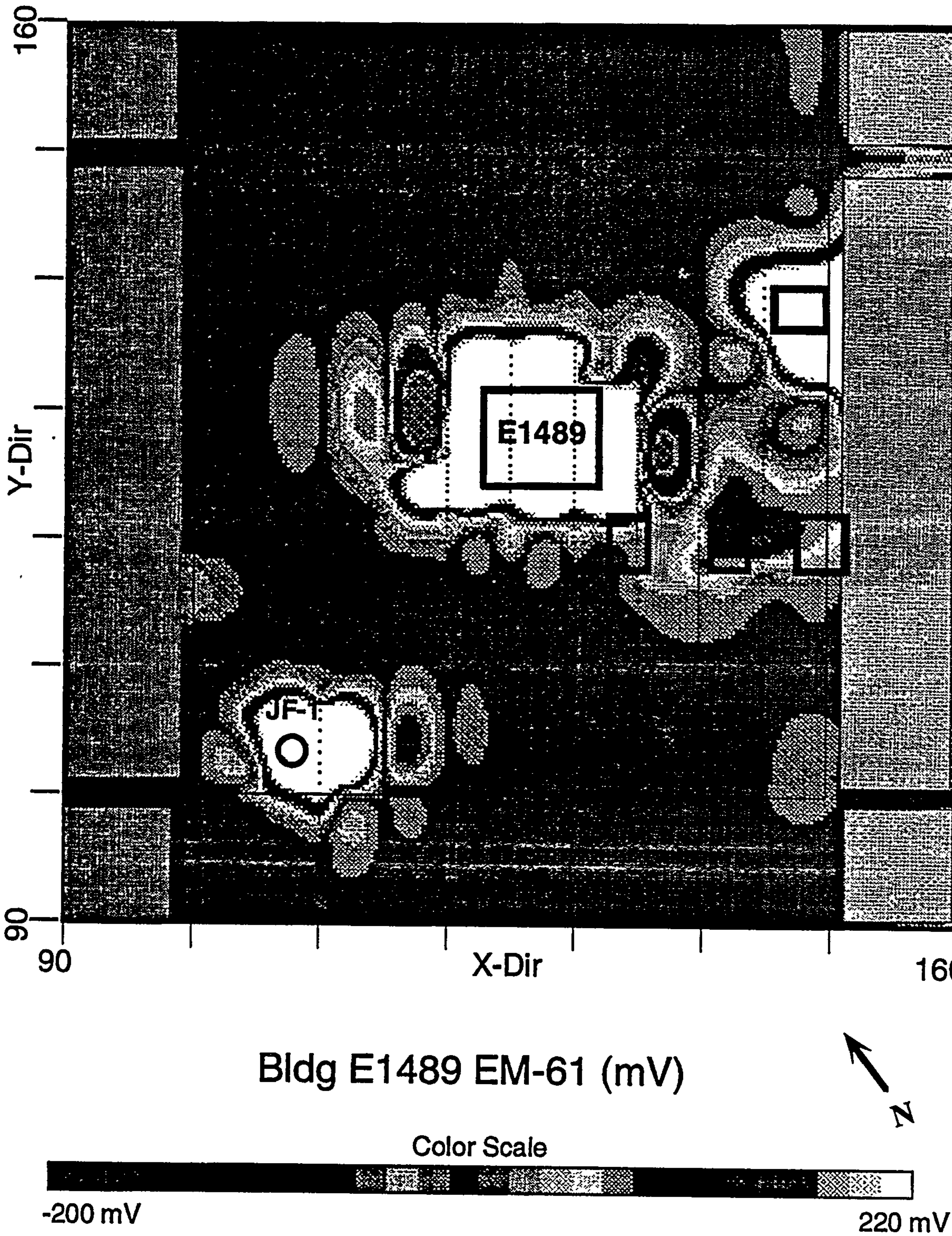

FIGURE 6 Map of the EMF Anomalies at Building E1489 (measured by using a Geonics EM-61 instrument)

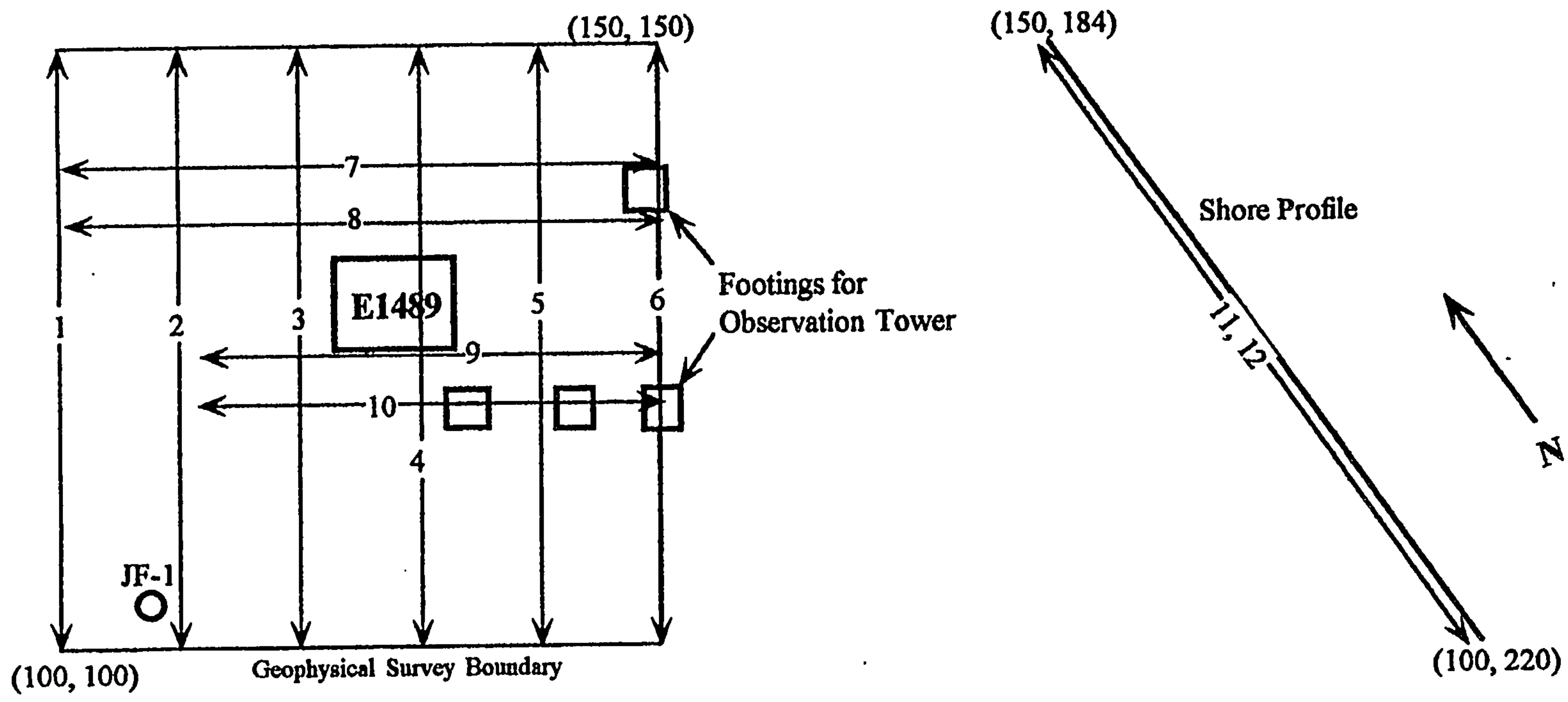

FIGURE 7 Map of GPR Profile Locations

GPR transects were run over the survey area surrounding Building E1489 along X transects spaced 5 ft apart and Y transects spaced 10 ft apart. A subtle change in electrical properties was observed along line Y = 120 near X = 123 at a depth of about 3 ft (Figure 8). Immediately adjacent to and slightly above this subtle change is a set of weak hyperbolas that start just below the land surface. Both magnetic and EMF anomalies are located nearby. The causes of these anomalies are unknown.

The foundation of Building E1489 is delineated by the GPR transect along Y = 125, shown in Figure 9. At about X = 145, another anomalous region is observed that corresponds to a broad magnetic low. This area is located beneath the observation tower, and the observed anomalies may be related to that structure.

3.5 Beach Profiles

The data for the magnetic, conductivity, and EMF profiles that were run parallel to the beach are plotted in Figure 10; the direction shown in the plots is from south to north. A profile location of 0 ft corresponds to about X = 220, Y = 100 in map coordinates (Figure 2). The transects for the geophysical surveys may be misaligned relative to each other by as much as 20 ft, because only two stakes were available to mark the area.

Low-amplitude magnetic and EMF anomalies are observed between 15 and 25 ft from the start of the transect [map coordinates (211,112) and (206,119)]. Although a conductivity anomaly is also detected north of the magnetic and EMF anomalies, all of these anomalies may be produced by the same source. At the northern end of the profile [map coordinates (191,140)], a small-amplitude magnetic anomaly is observed. The source of these anomalies is unknown. No anomalies were found on GPR transects run along the beach (Figure 11).

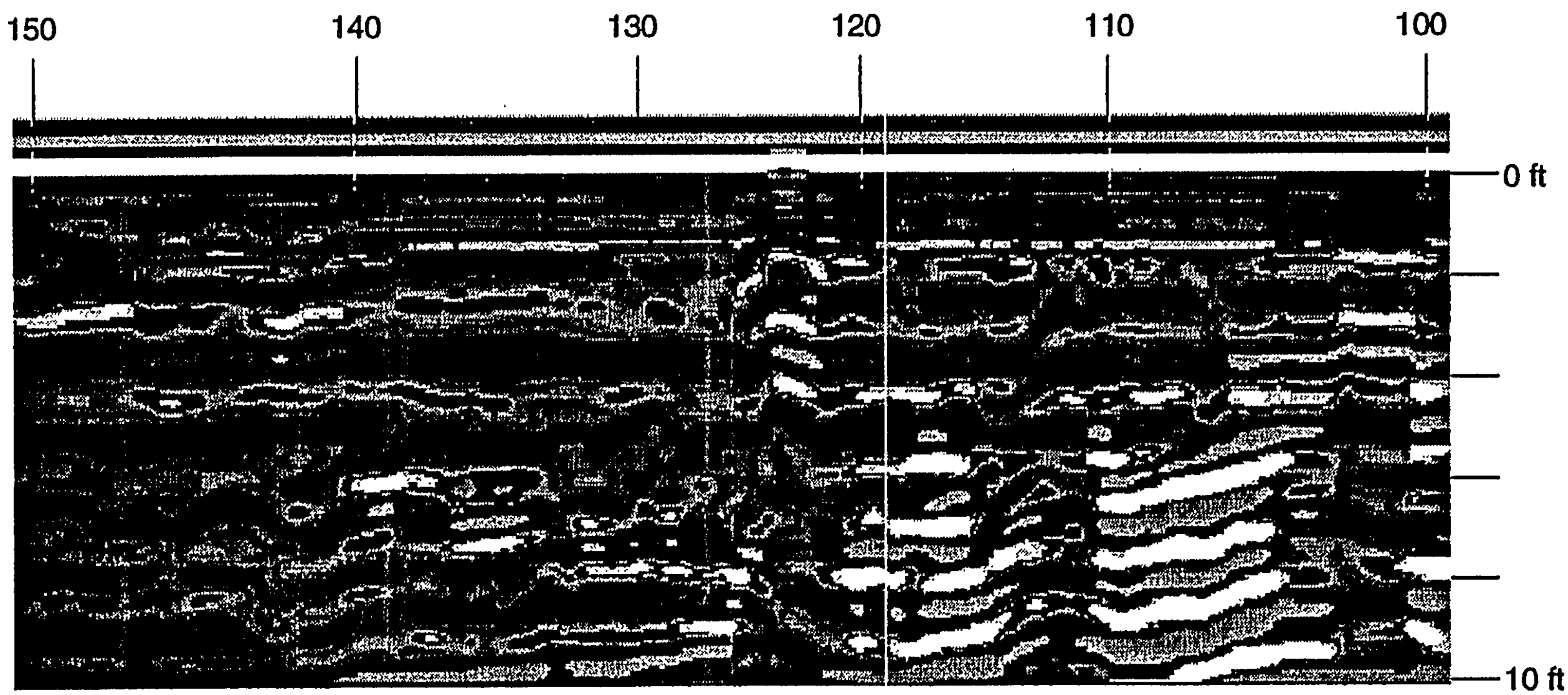

FIGURE 8 GPR Profile along Y = 120, Showing a Change in Subsurface Electrical Properties at about X = 123 (depth of 3 ft) that Corresponds to a Magnetic Anomaly

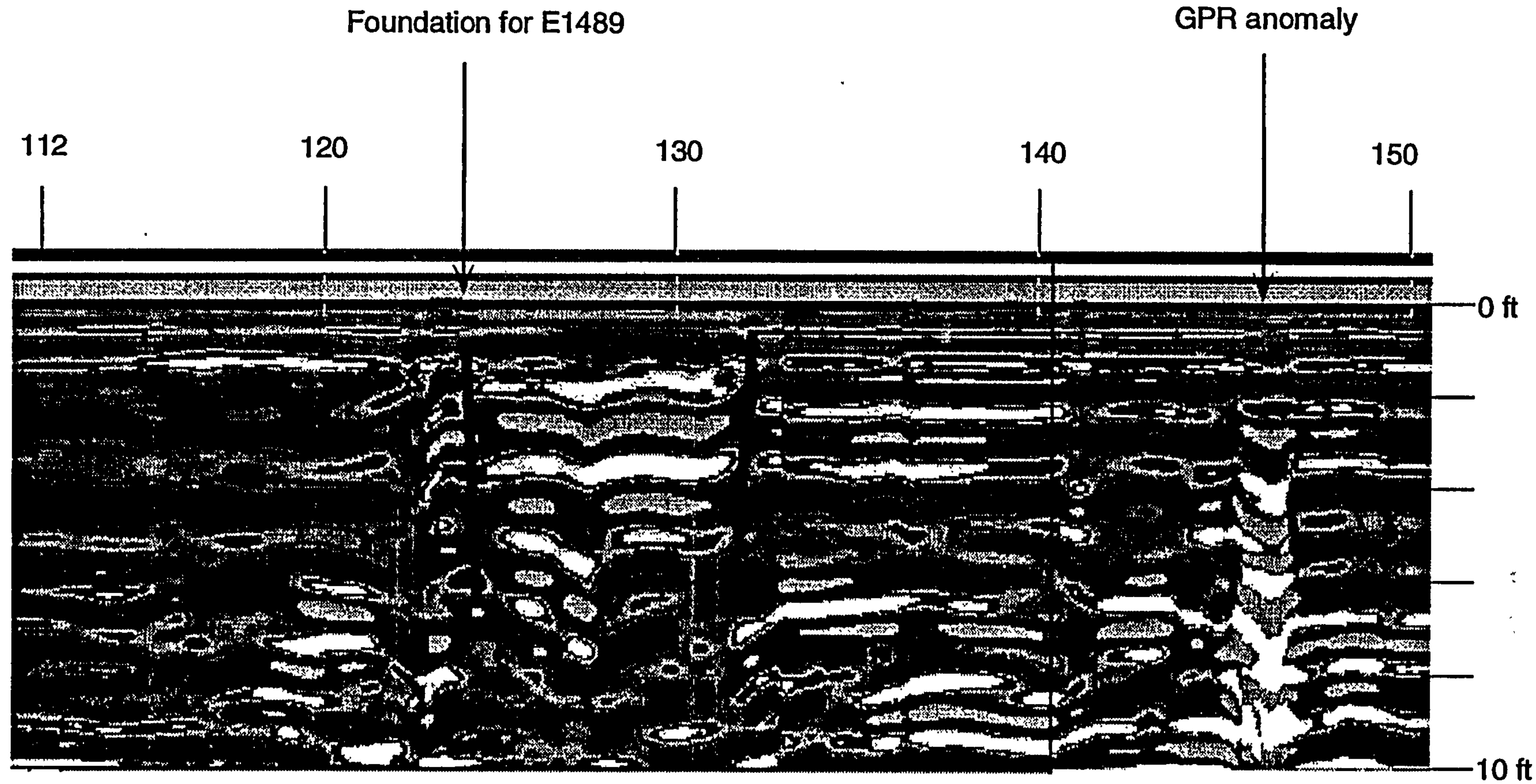

FIGURE 9 GPR Profile along Y = 125, Showing the Foundation of Building E1489 between X = 125 and X = 132 and an Anomaly at X = 145 that Corresponds to a Magnetic Low

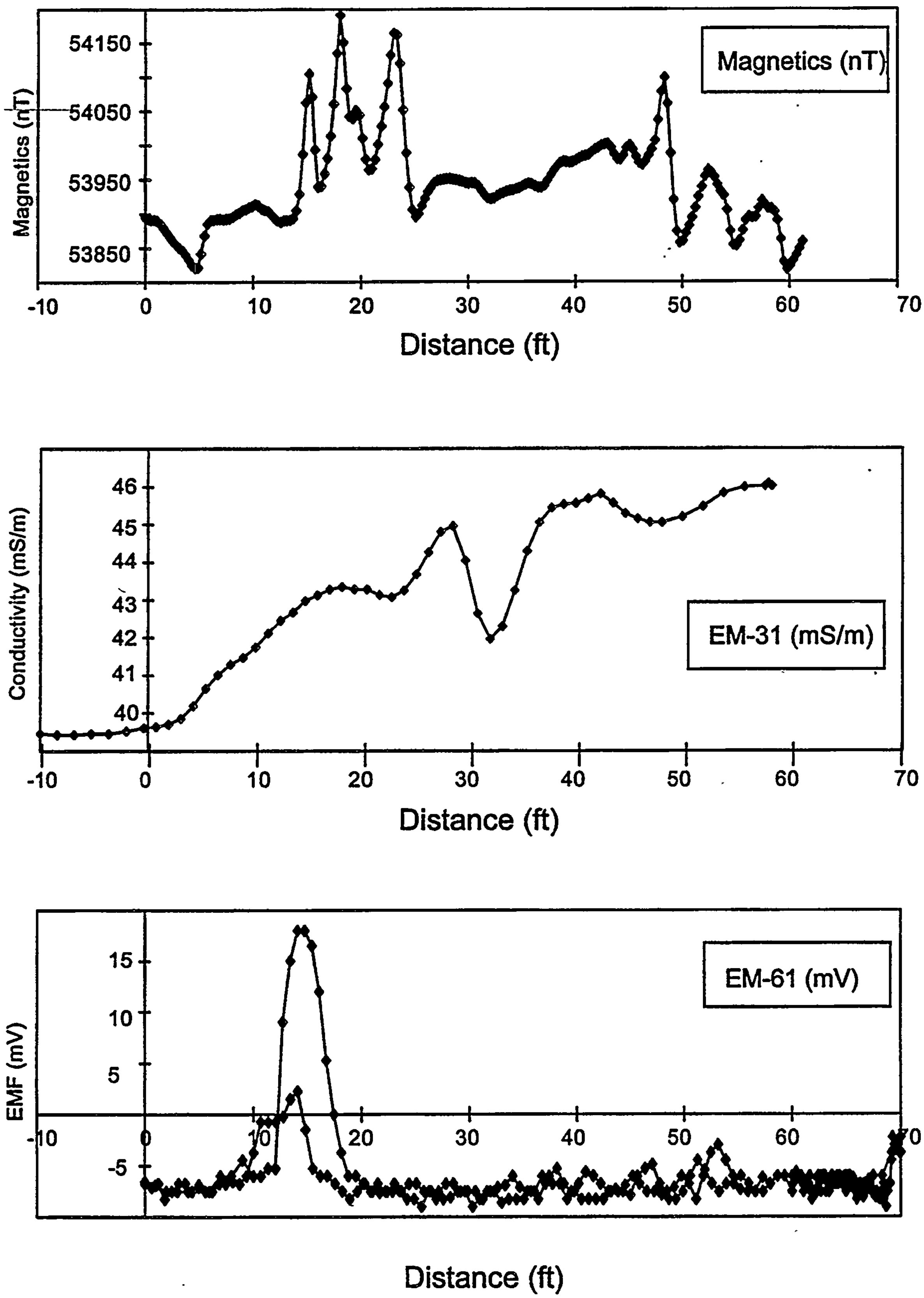

FIGURE 10 Magnetic, Conductivity, and EMF Profiles Parallel to the Shoreline East of Building E1489 (plotted from south to north)

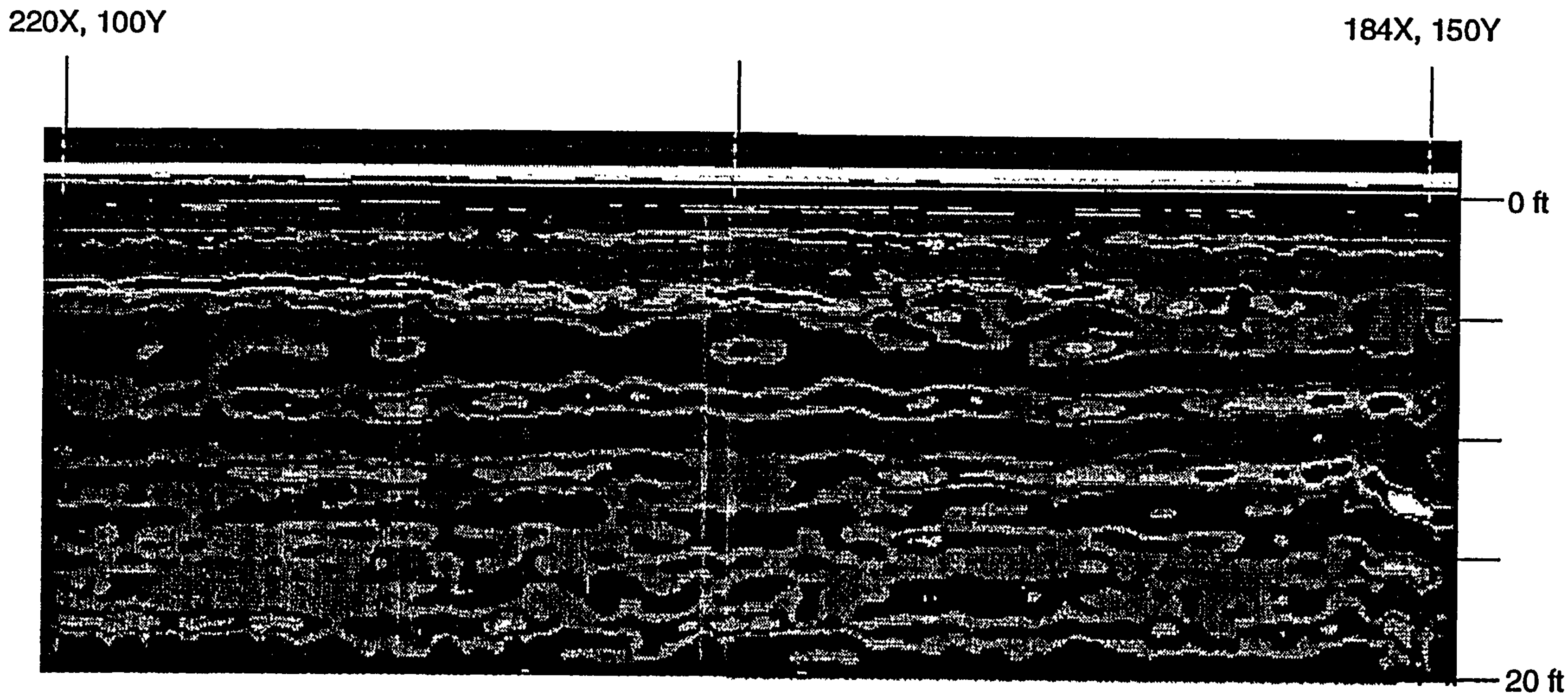

FIGURE 11 GPR Profile Run Parallel to the Shoreline East of Building E1489 Showing Absence of GPR Anomalies [coordinates (220,100) correspond to 0 ft in the profiles shown in Figure 10]

4 Discussion

A strong correlation exists between EMF and magnetic observations throughout the area. EMF and magnetic highs surrounding Building E1489 suggest the presence of metallic materials (such as rebar-reinforced concrete). Conductivity lows surround Building E1489, implying that the foundation is underlain by unsaturated high-porosity materials. GPR detected anomalous material beneath the foundation to a depth of about 3 ft. Within the study area, geophysical observations give no indication of buried pipes, trenches, or sewer lines.

Near the western corner of Building E1489, magnetic and EMF highs suggest the presence of buried metallic material. A weak GPR anomaly is also observed in this region.

Magnetic and EMF anomalies are also observed near the concrete associated with the observation tower and near the slabs southeast of Building E1489. In this area, a weak magnetic low at (145,125) correlates with GPR observations, but the source of this anomaly is unknown.

Anomalies are present in the magnetic, conductivity, and EMF profiles that were run parallel to the beach east of Building E1489, suggesting the presence of buried metallic objects. These anomalies are low in amplitude and were not observed on GPR profiles.

5 Conclusions

Geophysical surveys around Building E1489 permit the following conclusions:

1. Buried pipes, trenches, or sewer lines are not indicated. Magnetic, conductivity, and EMF anomalies are observed near well JF-1, the foundation of Building E1489, and the footings for the observation towers.

2. Magnetic and EMF observations suggest the presence of buried metallic material near the western corner of Building E1489.

3. Low-amplitude magnetic, conductivity, and EMF anomalies are present in profiles that were run parallel to the beach. It is not known if these anomalies are related to activities at Building E1489.

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Attachment:

Coordinates of Ground-Penetrating-Radar Profiles at Building E1489

Attachment:

Coordinates of Ground-Penetrating-Radar Profiles at Building E1489

	Start Coordinates		End Coordinates	
Line No.	X	Y	X	Y
1	100	150	100	100
2	110	100	110	150
3	120	150	120	100
4	130	150	130	100
5	140	150	140	100
6	150	150	150	100
7	100	140	150	140
8	100	135	150	135
9	112	125	150	125
10	112	120	150	120
11	184	150	220	100
12	220	100	184	150