United States Department of Agriculture

Natural Resources Conservation Service

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Subject: Archaeology -- Geophysical Assistance --

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To: Luana E. Kiger
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PURPOSE:

To assist the Bureau of Land Management (BLM) assess actual number and locations of graves within the Upper Clover Creek Cemetery near Bliss, Idaho.

PARTICIPANTS:

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ACTIVITIES:

All field activities were completed on 24 and 25 September 1998.

EQUIPMENT:

The radar unit used in this study was the Subsurface Interface Radar (SIR) System-2, manufactured by Geophysical Survey Systems, Inc.[1] The SIR System-2 consists of a digital control unit (DC-2) with keypad, VGA video screen, and connector panel. A 12-volt battery powered the system. Morey (1974), Doolittle (1987), and Daniels and others (1988) have discussed the use and operation of GPR. Antennas used were the models 5106 (200 mHz) and 5103 (400 mHz).

The electromagnetic induction meters used in this study was the EM38 manufactured by Geonics Limited. [1] This meter is portable and requires only one person to operate. McNeill (1986) has described principles of operation. No ground contact is required with this meter. This meter provides limited vertical resolution and depth information. Lateral resolution is approximately equal to the intercoil spacing. The EM38 meter operates at a frequency of 14,600 Hz. It has theoretical observation depths of about 0.75 and 1.5 meters in the horizontal and vertical dipole orientations, respectively (McNeill, 1986). Values of apparent conductivity are expressed in milliSiemens per meter (mS/m).

To help summarize the results of this study, the SURFER for Windows software program developed by Golden Software Inc. was used to construct two-dimensional simulations. [1] Grids were created using kriging methods. In each of the enclosed plots, shading and filled contour lines have been used. These options were selected to help emphasize spatial patterns. Other than showing trends and patterns in values of apparent conductivity (i.e., zones of higher or lower electrical conductivity), no significance should be attached to the shades themselves.

[1] Trade names have been used to provide specific information. Their use does not constitute endorsement.

BACKGROUND:

Historic accounts specify that the Upper Clover Creek Cemetery contains at least 28 graves. The earliest grave dates to about 1852. However, most interments date from about 1880 to1940. In 1938, the original markers were replaced with small cement markers. The Bureau of Land Management presently manages the land. In 1995, unknown to BLM, a resident was buried in the cemetery. This burial has prompted the BLM to consider releasing the land.

The actual number and locations of graves within the Upper Clover Creek Cemetery are uncertain. Local residences have questioned the number of burials at this site. Some markers may have been placed over unoccupied sites. The CCC may have displaced other markers from their actual graves. This investigation was conducted to help assess the Upper Clover Creek Cemetery.

STUDY SITE:

The Upper Clover Creek Cemetery (667450 N and 4765950 N) is located north of the town of Bliss, Idaho. The cemetery is on an east-facing slope of a small butte that overlooks Clover Creek.

FIELD PROCEDURES:

Two survey grids (referred to as Grid #1 and Grid #2) were laid out across portions of the cemetery. Grid #1 was located in the extreme northeast corner of the cemetery. Grid # 2 was located in the extreme western part of the cemetery. Survey lines were established at a distance of three feet from the wire fence that forms the boundary to the cemetery. For each grid, the spacing interval was 5 feet. Survey flags were inserted in the ground at each grid intersection and served as observation point. This procedure resulted in 225 and 174 observation points within Grid #1 and Grid #2, respectively. At each observation point, measurements were taken with an EM38 meter placed on the ground surface in the vertical dipole orientation. Within each grid, radar traverses were completed by pulling the 200 mHz antenna along each north-south trending grid line.

ELECTROMAGNETIC INDUCTION (EMI):

Background:

Electromagnetic induction (EMI) is a noninvasive geophysical tool that has been used to locate and define archaeological features (Bevan, 1983; Frohlich and Lancaster, 1986; and Dalan, 1991). Studies have demonstrated the utility of EMI for locating, identifying, and determine the boundaries of various types of cultural features such as buried structures, tombs, filled fortification ditches, and earthen mounds. Advantages of EMI methods include speed of operation and moderate resolution of subsurface features. Results of EMI surveys are interpretable in the field. This technique can provide in a relatively short time the large number of observations needed for site characterization and assessments. Maps prepared from correctly interpreted apparent conductivity data provide a basis for assessing site conditions and for planning further investigations.

Electromagnetic induction techniques use electromagnetic energy to measure the apparent conductivity of earthen materials. Apparent conductivity is a weighted average conductivity measurement for a column of earthen materials to a theoretical observation depth. Variations in apparent conductivity are produced by changes in the electrical conductivity of earthen materials. The electrical conductivity of soils is influenced by the volumetric water content, type and concentration of ions in solution, temperature and phase of the soil water, and amount and type of clays in the soil matrix, (McNeill, 1980). The apparent conductivity of soils increases with increases in the amount of soluble salts, water, and/or clays.

In this study, EMI was used to measure lateral variations in apparent electrical conductivity. Values of apparent conductivity are seldom diagnostic in themselves, but variations in these measurements can be used to infer the locations of buried cultural features. Interpretations of the EMI data are based on the identification of spatial patterns within data sets. The location, orientation, size, and shape of patterns revealed on two-dimensional plots provide clues as to the features causing them.

The detection of buried cultural features is affected by the electromagnetic gradient existing between the buried cultural feature and the soil. The greater or more abrupt the difference in electrical properties between the buried cultural feature and the surrounding soil matrix, the more likely the artifact will be detected. Buried cultural features with electrical properties similar to the surrounding soil matrix are often difficult to discern.

The size, orientation, and depth to an artifact affect interpretations. Large objects are easier to detect than small objects. Small cultural features may be detectable at shallow depths. However, these features are generally undetectable where deeply buried. The presence of scattering bodies in the soil complicates interpretations. Strongly stratified soil horizons, stones and cobbles, roots, animal burrows, modern cultural features or recently disturbed soils produce unwanted noise that can mask the presence of some buried cultural features. In this study, fence lines that bordered the cemetery interfered with the meter's electromagnetic fields. On survey lines near these fence lines, measurements of apparent conductivity were noticeably affected and were anomalously high.

Results:

Grid #1

The site was located in the extreme northeast corner of the cemetery. An 80 by 65-foot grid was established across this portion of the cemetery.

Figures 1 and 2 represent the spatial distribution of apparent conductivity within the upper 1.5 meters of the soil profile. In each plot, the locations of existing grave markers have been shown. Figure 1 is a color image of the collected data. Figure 2 is a two-dimensional plot of apparent conductivity within the surveyed area. The isoline interval is 10 mS/m.

In figures 1 and 2, measurements of apparent conductivity are higher adjacent to the fence lines that form the eastern and northern boundaries of the surveyed area. Measurements collected within 8 feet of the fence lines were influence by these features. In both figures, a zone of conspicuously higher apparent conductivity extends across the northeast corner of the site. This area could reflect changes in soil type and properties. However, as the area is nearly devoid of vegetation, it is believed to represent a disturbed area.

In both figures 1 and 2, anomalously high and low values of apparent conductivity and exceedingly complex patterns of iso-conductivity lines occur in the north-central portion of the survey area. These values and patterns are believed to represent burials. Anomalous measurements of apparent conductivity correspond with only four of the twelve marked graves. For the other eight markers, EMI did not detect interments. It is possible that some markers may have been placed over undisturbed sites.

In other portions of Grid #1, values of apparent conductivity are moderate and spatial patterns appear less complex. It is assumed that broad spatial patterns reflect gradual changes in soil properties. The presence of additional graves in these portions of the surveyed area is considered less probable.

Grid #2

The site was located along the extreme western boundary of the cemetery. The survey area extended east and north from the southwest corner of the cemetery. A 250 by 20-foot grid was established across this portion of the cemetery.

Figures 3 and 4 represent the spatial distribution of apparent conductivity within the upper 1.5 meters of the soil profile. No marked graves occurred within this survey area. Figure 3 is a color image of the collected data. Figure 4 is a two-dimensional plot of apparent conductivity within the surveyed area. The isoline interval is 10 mS/m.

In Figures 3 and 4, apparent conductivity is higher adjacent to the fence lines that form the western and southern boundaries of the surveyed area. Measurements collected within 8 feet of the fence lines appear to be influence by these features.

In both figures, patterns of apparent conductivity were relatively extensive and simple. These spatial patterns reflect gradual changes in soil types and properties. Compared with Grid #1, the lacks of complex and anomalous patterns within Grid #2 are presumed to reflect the absence of disturbance and additional graves.

GROUND-PENETRATING RADAR:

Background:

Archaeologists are using ground-penetrating radar to facilitate excavation strategies, decrease field time and costs, and locate buried artifacts and archaeological features. Studies have documented the use of GPR to locate buried cultural features in many areas of the world (Batey, 1987; Berg and Bruch, 1982; Bevan, 1977, 1984a and 1984b; Bevan and Kenyon, 1975; Bevan et al., 1984; Bruzewicz et al., 1986; Cole, 1988; Dolphin and Yetter, 1985; Doolittle, 1988; Doolittle and Miller, 1991, Gibson, 1989; Grossman, 1979; Imai et al., 1987; Kenyon, 1977; Parrington, 1979; Sakayama et al., 1988; Vaughan, 1986; Vickers and Dolphin, 1975; Vickers et al., 1976; and Weymouth and Bevan, 1983). Recently, forensic scientists for crime scene investigations (Davenport et al., 1990; Hoving, 1986; Mellett, 1992; and Strongman, 1992) have used GPR technology.

However, even with favorable site conditions (e.g., dry, coarse-textured soils) the detection of a buried cultural feature with GPR is not guaranteed. The detection of buried cultural features is affected by the electromagnetic gradient existing between a cultural feature and the soil, the size, shape, and orientation of the buried cultural feature, and the presence of scattering bodies within the soil (Vickers et al., 1976).

The amount of energy reflected back to an antenna by an interface is a function of the dielectric gradient existing between the buried cultural feature and the soil. The greater or more abrupt the difference in electromagnetic properties, the greater the amount of energy reflected back to the antenna, and the more intense will be the amplitude of the recorded image. Buried cultural features with electromagnetic properties similar to the surrounding soil matrix are poor reflectors of electromagnetic energy and are difficult to detect on radar profiles (Doolittle, 1988; Gibson, 1989; Vaughan, 1986).

Most recently buried cultural features contrast with the surrounding soil matrix. However, with the passage of time, buried cultural features decay or weather and become less electrically contrasting with the surrounding soil matrix. For burials, the degree of preservation is dependent on both intrinsic and extrinsic factors. Intrinsic factors include the shape, size, density and chemistry of the cultural feature. Intrinsic factors are often dependent upon the genetic age and health of the deceased as well as length of burial (Killam, 1990). Extrinsic factors influencing the degree of preservation include time, soil type, moisture content, temperature, flora and fauna (Killam, 1990). Corpses deteriorate more rapidly in highly acidic soils than in neutral or alkaline soils (Mellett, 1992). Rodriquez and Bass (1985) noted a direct correlation between rates of decomposition or preservation and soil type, soil temperature, and depth of burial.

The size, orientation, and depth to an anomaly affect detection. Large objects reflect more energy and are easier to detect than small objects. Small, shallowly buried features will be missed, unless located directly beneath the aperture of the radar antenna. With GPR surveys covering extensive areas and using large grid intervals, the detection of small cultural features is often considered fortuitous. The detection of a corpse reported by Mellett (1992) is an example of a fortuitous detection. Small, deeply buried cultural features are difficult to discern on radar profiles. In many soils, signal attenuation limits observation depths. In addition, the reflective power of an object decreases proportional to the fourth power of the distance to the object (Bevan and Kenyon, 1975).

Large, electrically contrasting features reflect more energy and are easier to detect than small, less contrasting features. Foundation walls of a large buried structure are more likely to be detected than a small, isolated artifact. Bevan (1991) noted that GPR is more likely to detect the disturbed soil within a grave shaft, a partially or totally intact coffin, or the chemically altered soil materials surrounding a burial rather than the bones themselves. Killam (1990) believes that most bones are too small and not directly detectable with GPR. This author noted that the disruption of soil horizons makes most graves and some cultural features detectable. However, in soils that lack contrasting horizons or geologic strata, the detection of a grave shaft is improbable. In addition, with the passage of time, natural soil-forming processes erase signs of disturbances.

In highly attenuating soils, profiling depths are restricted and many subsurface features are not directly sensed with GPR. Under highly attenuating conditions, the location and identification of buried cultural features are frequently inferred from bowed, disrupted, or disturbed soil horizons. At many sites, the most distinctive feature of a grave is the disturbed soil materials that fill and cover the grave shaft (Bevan, 1991). However, caution must be exercised as a number of artificial and natural processes can produce disturbed soil conditions.

Cultural features are difficult to distinguish in soils having numerous rock fragments, roots, animal burrows, modern cultural features, or stratified or segmented soil layers. These scattering bodies produce undesired subsurface reflections that complicate radar imagery and mask the presence of buried cultural features. Under such conditions, "desired" cultural features can be indistinguishable from the background clutter. In soils having numerous scattering bodies, GPR surveys often provide little meaningful information to supplement traditional sampling methods (Bruzewicz et al., 1986). The identification of buried cultural features were complicated by scattering bodies in radar surveys conducted by Bevan (1991), Dolphin and Yetter (1985), Doolittle (1988), and Vaughan (1986). Roots and brush produced unwanted reflections on the radar profiles.

In the search for buried cultural features with GPR, success is never guaranteed. Even under ideal site and soil conditions, buried cultural features will be missed with GPR. The usefulness of GPR for site assessment purposes depends on the amount of uncertainty or omission that is acceptable.

Calibration Trials:

Calibration trials were conducted near the entrance to the cemetery. Radar traverses were conducted with the 200 and 400 mHz antennas across both sides of three aligned grave markers. The 400 mHz antenna was severely depth restricted and was considered unsuitable for use in these soils. The 200 mHz antenna provided suitable observation depths and resolution of subsurface interfaces. At the calibration site, the 200 mHz antenna detected a burial beneath the northern most marker. No evidence of disturbance was noted beneath the other two markers. Oral history has mentioned that only one person had been buried here, but three markers had been erected. The radar record appears to agree with the oral history.

Results:

Radar profiles collected within the cemetery were interpretable and contained an abundance of subsurface information. A cursory review of the radar profiles from the surveyed areas revealed 38 and 7 identifiable subsurface point reflectors in Grid #1 and Grid #2, respectively. Some of these point reflectors are believed to represent roots or rock fragments. Some may represent buried cultural features. Survey lines were retraced after the radar survey. During this procedure, the locations of bushes and survey flags that were crossed by the antenna were confirmed and identified on radar profiles.

The approximate locations of point reflectors are plotted in figures 2 and 4. In Figure 2, a majority of the detected point reflectors are located in the north and north-central portion of the survey area. The location of many point reflectors correspond with grave markers, other do not. The alignment of two or more point reflectors suggests burials. In Figure 2, several point reflectors are aligned and suggest eleven possible burials. In contrast, in Grid #2 the relative absence of buried point reflectors is apparent (see Figure 4). This area was not believed to contain burials. However, the orientation and alignment of two reflectors along column 216 feet suggest a possible interment site.

CONCLUSIONS:

1. Interpretations contained in this report are considered preliminary estimates of site conditions. These interpretations do not substitute for direct observations, but rather reduce their number, direct their placement, and supplement their interpretations. Interpretations should be verified by ground-truth observations.

2. A large number of buried point reflectors were identified within Grid #1. Some of these reflectors represent buried cultural features. A review of the radar profiles showed that several point reflectors are aligned and suggest eleven likely burials. Location maps have been prepared for the two surveyed areas. These maps may help archaeologists develop search strategies.

It was my pleasure to work again in Idaho and with members of your fine staff.

With kind regards,

James A. Doolittle
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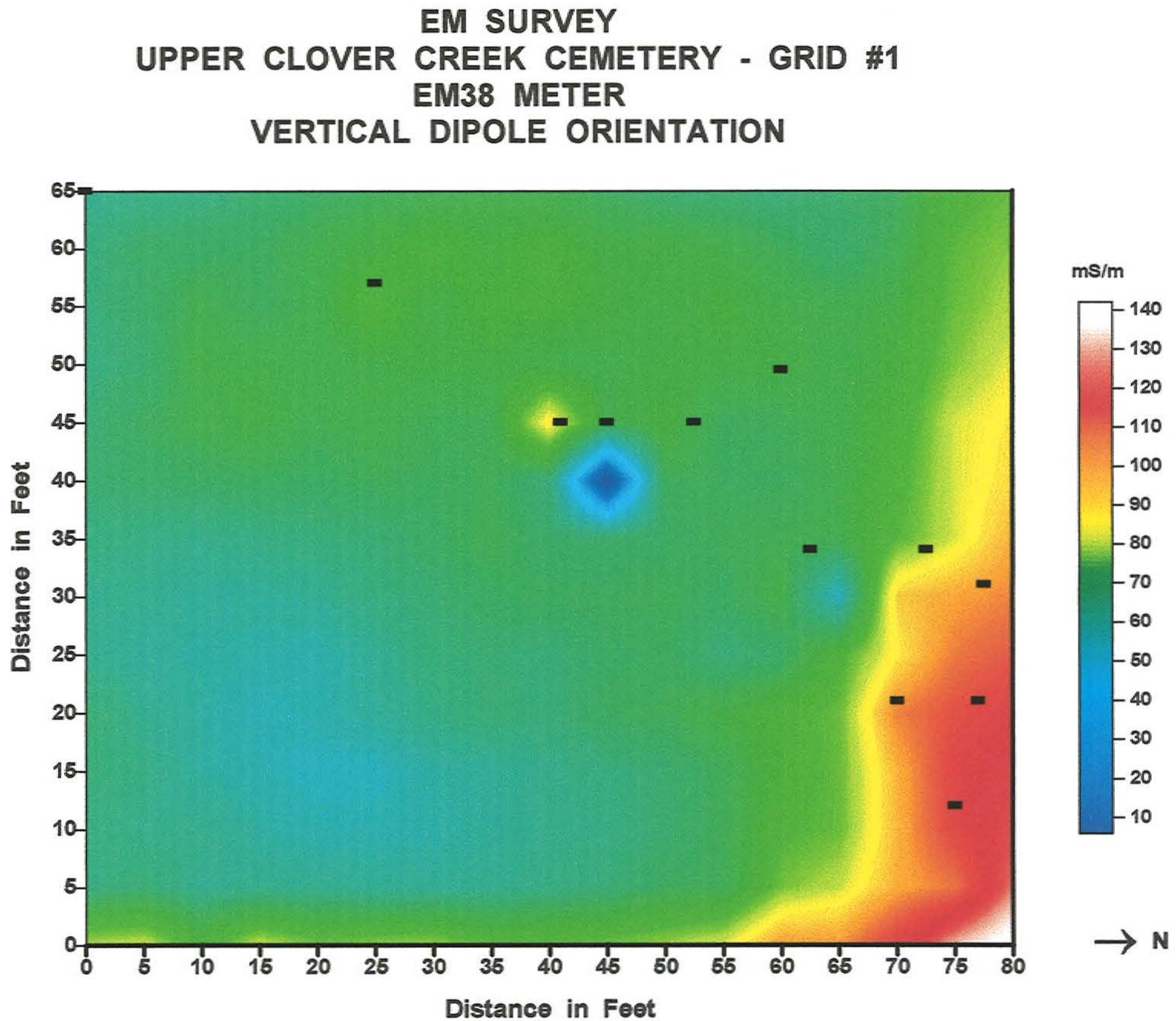

EM SURVEY
UPPER CLOVER CREEK CEMETERY - GRID #1
EM38 METER
VERTICAL DIPOLE ORIENTATION
mS/m
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Distance in Feet
Distance in Feet
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
N

FIGURE 1

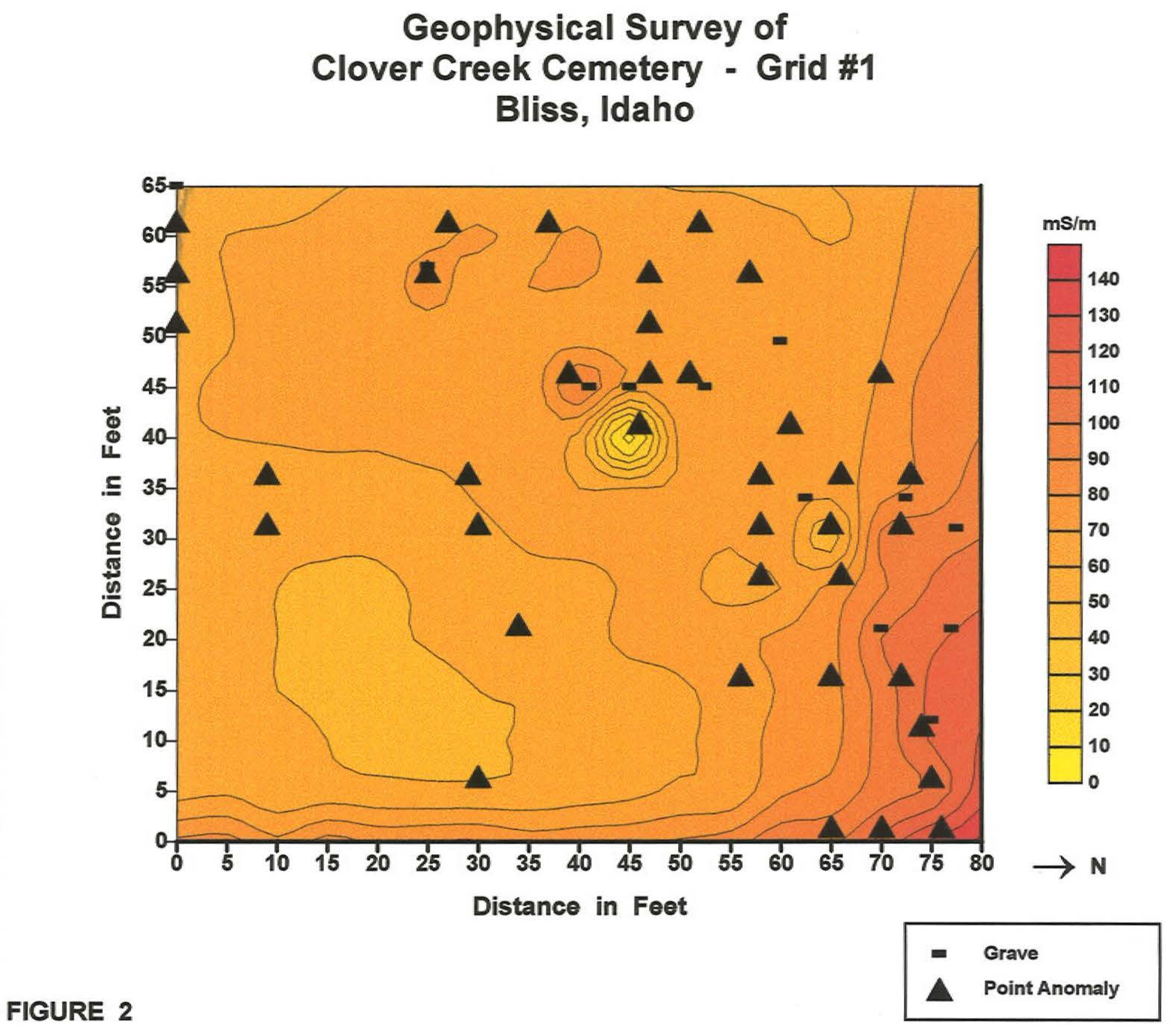
Geophysical Survey of
Clover Creek Cemetery - Grid #1
Bliss, Idaho
mS/m
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Distance in Feet
Distance in Feet
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
65 60 55 50 45 40 35 30 25 20 15 10 5 0
N
Grave
Point Anomaly

FIGURE 2

EM SURVEY
UPPER CLOVER CREEK CEMETERY - GRID #2
EM38 METER
VERTICAL DIPOLE ORIENTATION

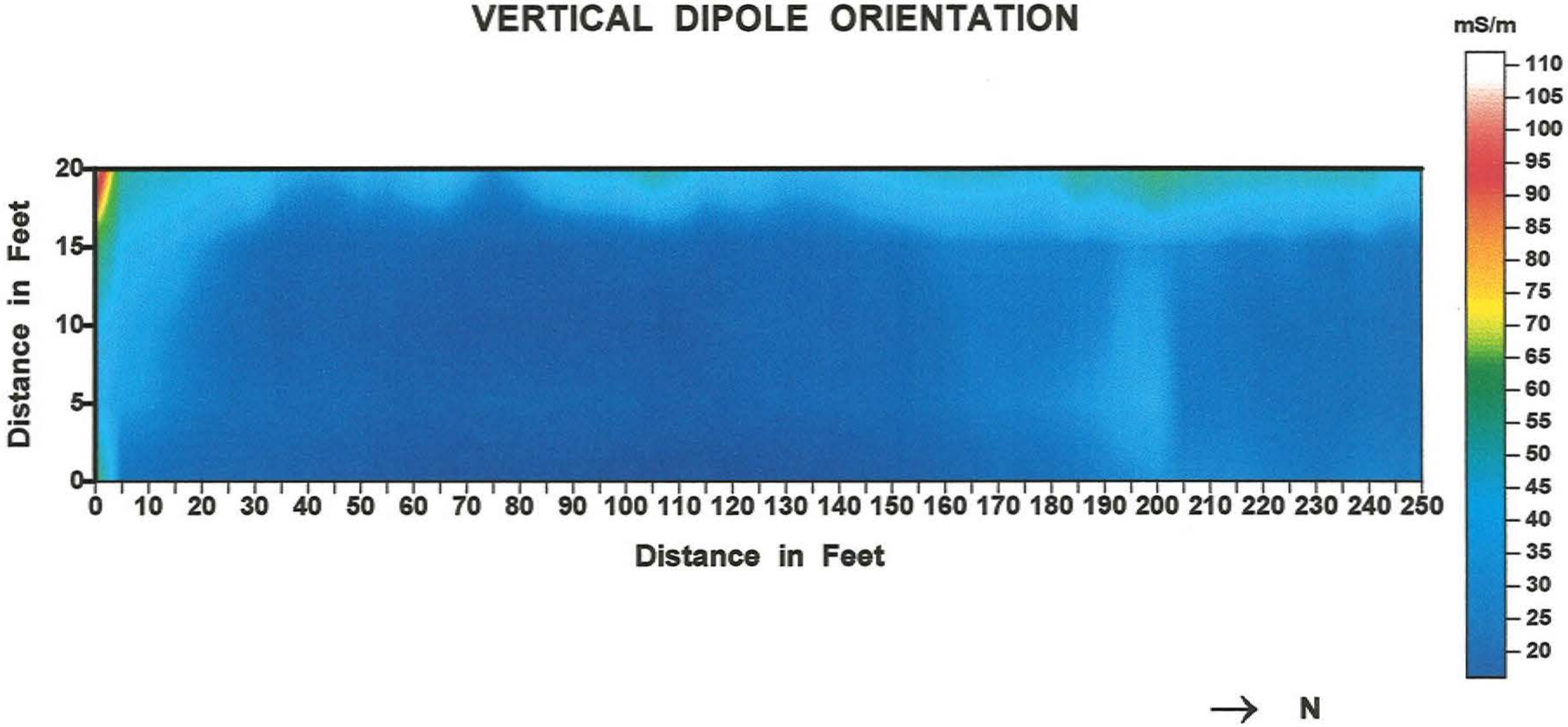

FIGURE 3

Geophysical Survey of Clover Creek Cemetery - Grid #2 Bliss, Idaho

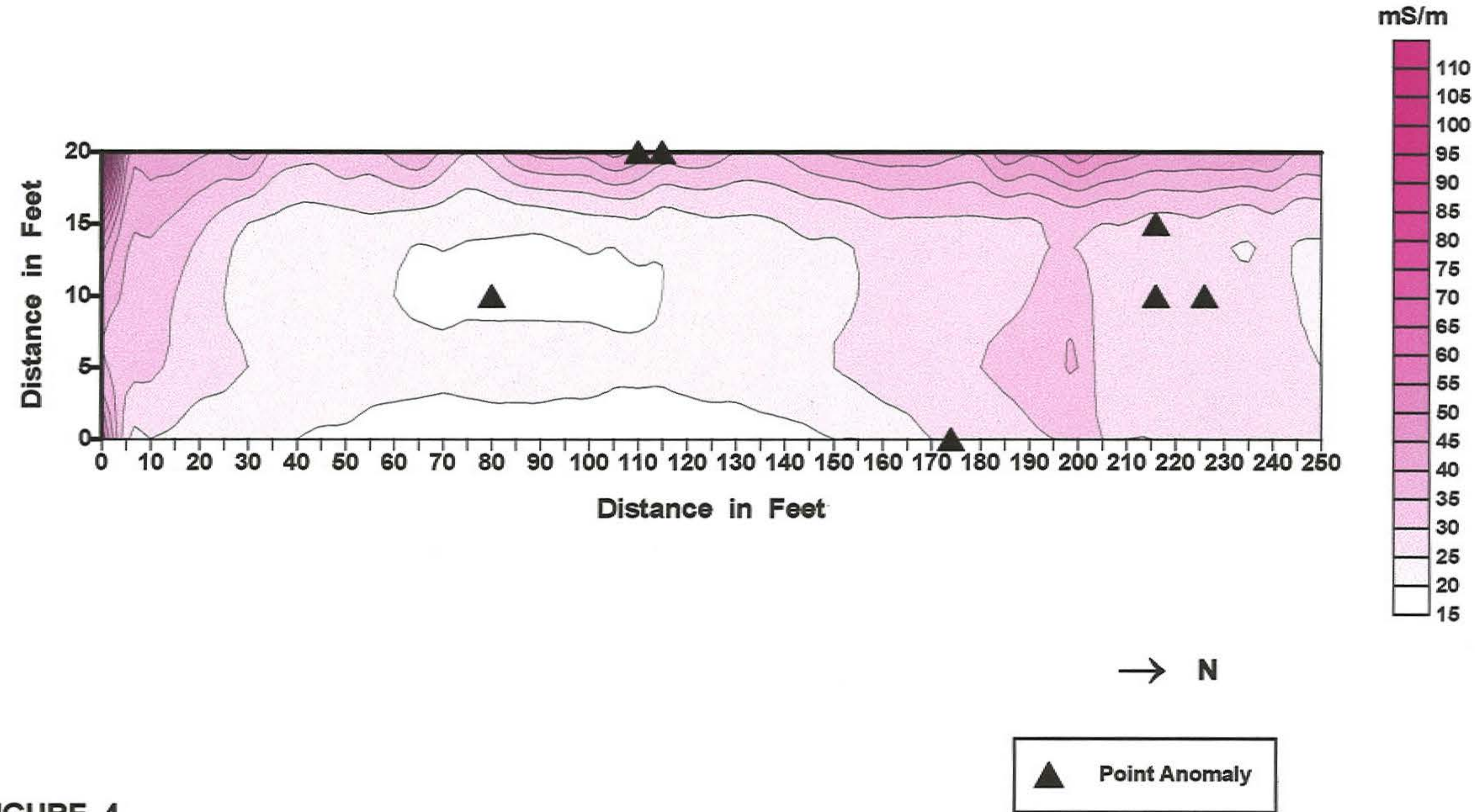

FIGURE 4