

# Ground Penetrating Radar Survey of Oak Grove Cemetery

Raleigh County, North Carolina



New South Associates, Inc.



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Raleigh County, North Carolina

Report submitted to:

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# ABSTRACT

New South Associates, Inc., conducted a ground-penetrating radar (GPR) survey of Oak Grove Cemetery in Raleigh, North Carolina. The North Carolina State Historic Preservation Office (HPO) received an Underrepresented Community Grant from the National Park Service for a project that will produce National Register nominations for nine African American historic resources, including Raleigh's Oak Grove Cemetery. As project partners, the Raleigh Historic District Commission (RHDC) and the City of Raleigh (COR) sponsored the ground-penetrating radar study of Oak Grove Cemetery. The primary goal was to identify the extent of marked and unmarked graves in the cemetery. The results will ultimately be used to support a nomination for the National Register of Historic Places (NRHP).

The GPR survey identified approximately 403 graves. Of this number, approximately 152 are associated with an existing marker and 251 are completely unmarked. The graves are distributed throughout the cemetery in dense clusters. New South recommends that the markers and geophysical anomalies identified as probable graves should be treated as such. The GPR data suggest that Oak Grove Cemetery is essentially full, although there are isolated pockets with limited open space. Any future interments should be planned carefully, both to avoid the graves identified in this survey and to consider any unmarked graves that might have been missed.

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# I. INTRODUCTION

New South Associates, Inc., conducted a ground-penetrating radar (GPR) survey of Oak Grove Cemetery in Raleigh, North Carolina (Figure 1). The North Carolina State Historic Preservation Office (HPO) received an Underrepresented Community Grant from the National Park Service for a project that will produce National Register nominations for nine African American historic resources, including Raleigh's Oak Grove Cemetery. As project partners, the Raleigh Historic District Commission (RHDC) and the City of Raleigh (COR) sponsored the ground-penetrating radar study of Oak Grove Cemetery. The primary goal was to identify the extent of marked and unmarked graves in the cemetery. The results will ultimately be used to support a nomination for the National Register of Historic Places (NRHP).

Officially, Oak Grove Cemetery is located at 4303 Beryl Road. However, its actual location is on a rise west of the I-440 right-of-way (ROW) and north of the Western Boulevard exit. It is accessed by turning west on Ligon Street from Method Road and going through the I-440 underpass. The parcel is located at the south end of a complex of research and laboratory buildings owned by North Carolina State University (NCSU).

Fieldwork was conducted September 19 and 23, 2016 by Shawn Patch and Ashley Krauss. On September 19, fieldwork had to be suspended due to severe thunderstorms. Weather on September 23 was excellent and the survey was completed that day.

This report is divided into five chapters. Following this introduction chapter, Chapter II discusses the historic context. Chapter III discusses the environmental setting and current conditions. Chapter IV discusses methods employed during the field investigations and Chapter V discusses the field investigation results and recommendations. Appendix A is a list of GPR anomalies.

Figure 1.  
Project Location Map



Source: USDA NAIP Imagery 2014

## II. HISTORIC CONTEXT

Oak Grove Cemetery is located in the historic African American Method neighborhood. It contains at least 100 plots as mapped in surveys from 1938 and 2005 and is currently active, with a recent interment from 2016. The cemetery contains many of the Method community's African American founders and descendants.

A 2013 historic properties survey by New South documented the area as containing mature oaks, pines, and cedars with grass and ivy obscuring many graves (Turco 2013). Grave markers were a mix of materials including fieldstone, polished granite and marble, concrete, and metal.

The cemetery was not affiliated with any particular church; rather, it was maintained by and for the Method community. Local accounts vary regarding when the cemetery was formally established. Some accounts suggest it was founded in 1870 or 1871, immediately after Method was also established. If so, at least some of the unmarked graves could date from this time. The earliest recorded grave marker is from Lafayette Ligon from 1891, which corresponds to other accounts suggesting Berry O'Kelly donated land for the cemetery at the same time.

Oak Grove was separated from the larger community with the construction of I-440. Certain family members care for their own plots, while others are not maintained. Unfortunately, vandalism has been an issue in the past, with many markers toppled, broken, or stolen. The former boundary fence was also removed at some point in the past and all that remains are two brick piers in the northeast and northwest corners.

Oak Grove Cemetery has been designated as property number WA 6449 by the North Carolina SHPO. Previous historical research has indicated that Oak Grove Cemetery possesses special historical significance for the City of Raleigh (Turco 2013). The cemetery was recommended eligible for the NRHP under Criterion A for its representation of the area's early settlement and evolving sense of community, Criterion C for embodying the folkways and artistic traditions of the Method community's residents, and Criterion D for its potential to yield additional important information about freedmen cemeteries.

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### III. ENVIRONMENTAL SETTING

#### SOILS

Soils are a critical variable in any GPR survey because of how they affect signal strength and attenuation. Soils in the cemetery are classified as Cecil sandy loam. Cecil gravelly sandy loam, 2-6 percent slopes, moderately eroded, covers approximately 90 percent of the area. Parent material consists of saprolite derived from granite and gneiss and/or schist. It is well drained and is more than 80 inches to the water table. A typical profile consists of Ap (0-7 in.) gravelly sandy loam, E (7-14 in.) gravelly sandy loam, Bt1 (14-35 in.) clay, Bt2 (35-44 in.) clay loam, and BC (44-80 in.) sandy loam. Cecil sandy loam, 10-15 percent slopes, is located in the far northeast corner of the cemetery that slopes downward toward I-440.

#### EXISTING CONDITIONS

Much of the area is covered by mature tree canopy but there are few surface obstructions (Figure 2). The overall setting is a prominent rise about the surrounding area. Topography within the cemetery is relatively flat with an overall gentle slope toward the east and southeast. The western and northern boundaries are defined by slopes leading to a gravel road (west) and Ligon Street (north). At the time of the survey, the cemetery had been recently mowed and cleared of large sticks and other debris. It was necessary to move one pile outside the boundaries in order to collect seamless data.

Figure 2.  
Photographs Showing Existing Conditions

A. Looking Southeast



B. Looking East



C. Looking East





## IV. METHODS

### GEOPHYSICS

Current trends in geophysical archaeology are moving toward expanding the interpretive value of geophysical data to explicitly address anthropological questions (Aspinall et al. 2008; Conyers 2012; Kvamme 2003; Thompson et al. 2011). There is a growing recognition among practitioners that geophysical data can provide unique and highly detailed perspectives on archaeological sites that goes beyond simply identifying subsurface features. Technological advances in recent years have demonstrated the effectiveness of various equipment and methods.

Contrast is the single most important variable for detecting cultural features. Successful detection depends on matching the physical properties of the features with the appropriate sensor, the amount of physical contrast between the feature and surrounding matrix, the size of the feature relative to the spatial resolution of the measurements, the depth of the feature with respect to signal attenuation and noise factors that might obscure it, the degree of patterning the feature exhibits, and the use of multiple sensors that allow detection of different physical properties (Kvamme et al. 2006:13). Factors such as soil type, particle size, soil density, and moisture content are all important.

Clutter is another important element of every archaeological site. This includes sources of interference that are not of interest such as rodent and animal burrows, tree roots, plow scars, previous excavations, randomly distributed rocks, recent trash, and modern utilities. Unfortunately, all of these sources can also be detected by geophysical survey, and they must be filtered out or eliminated from the features of interest. At a certain level, there is always the problem of identifying false positives that upon further investigation are non-archaeological.

The goal of geophysical survey is to identify anomalies and make interpretations about their archaeological significance (Kvamme et al. 2006:45). This process includes data collection, data processing, GIS organization, identification of geophysical anomalies, and classification of anomalies into potential archaeological feature types (Kvamme et al. 2006:18). The end result is to produce clear imagery that looks like buried archaeology. These types of imagery will be familiar and more meaningful to non-specialists, citizens, and SHPO staff (Kvamme et al. 2006:17).

Geophysical data are typically evaluated through subjective interpretations of the data combined with deductive reasoning. It requires knowledge of the kinds of features that might occur in a particular site (Kvamme et al. 2006:234). Successful interpretations rely on expertise in local archaeology and knowledge of corresponding archaeological signatures in geophysical data (Kvamme et al. 2006:163). This method relies on visual interpretation of geophysical maps and manually digitizing cultural anomalies in GIS. The end product is a series of interpretive maps depicting the locations of likely cultural features.

## GEOPHYSICS IN CEMETERIES

Several factors influence the overall effectiveness of geophysics for identifying individual graves. Contrast between the remains, grave shaft, coffin, or casket and the surrounding soils is the most important variable. Remains that have a chemical or physical contrast from the subsurface materials surrounding them will cause GPR reflections of electromagnetic energy. Age of the graves is critical to this contrast. Older graves typically have less contrast and are more difficult to detect because they have had more time to decompose and are less likely to have intact coffins or caskets (if these were present to begin with).

The burial “container” that the remains may have been placed in is also important and includes simple linen or cloth shrouds, pine boxes or wooden coffins, lead or other metal caskets, and burial vaults. In certain cases, hardware such as nails, hinges, and handles may be present, but not necessarily all the time. Although there is a high degree of variation in specific container types among different geographical regions, each of these tends to have been used at certain times throughout history and correlates with the presumed age of the grave. For example, burial shrouds were common throughout the seventeenth and early eighteenth centuries before being replaced by wooden coffins. It must also be noted that cultural trends and patterns tended to persist much longer in rural and/or economically depressed areas than in urban centers.

## GROUND PENETRATING RADAR (GPR)

GPR is a remote sensing technique frequently used by archaeologists to investigate a wide range of research questions. In archaeological applications, GPR is used to prospect for potential subsurface features. Because GPR is a remote sensing technique, it is non-invasive, non-destructive, relatively quick, efficient, and highly accurate when used in appropriate situations. In cemeteries, GPR is commonly used to identify anomalies consistent with the expectations for human graves (Jones 2008; King et al. 1993).

The use of GPR for identifying potential historic graves is based on the concept of contrast, which may include differences in physical, electrical, or chemical properties between an object or feature and its surrounding matrix (Conyers 2004a). For graves, the body itself is generally

not detected; it is typically the coffin or casket, grave shaft, or bottom of the grave that causes the reflection (Jones 2008; King et al. 1993). Not surprisingly, greater contrast generally equates to better detection and resolution. For example, a metal casket in a concrete vault is much easier to see with GPR than a body buried in a wooden coffin only.

GPR data are acquired by transmitting pulses of radar energy into the ground from a surface antenna, reflecting the energy off buried objects, features, or bedding contacts, and then detecting the reflected waves back at the ground surface with a receiving antenna (Conyers 2004a). When collecting radar reflection data, surface radar antennas are moved along the ground in transects, typically within a survey grid, and a large number of subsurface reflections are collected along each line. As radar energy moves through various materials, the velocity of the waves will change depending on the physical and chemical properties of the material through which they are traveling (Conyers and Lucius 1996). The greater the contrast in electrical and magnetic properties between two materials at an interface, the stronger the reflected signal, and, therefore, the greater the amplitude of reflected waves (Conyers 2004b).

When travel times of energy pulses are measured, and their velocity through the ground is known, distance (or depth in the ground) can be accurately measured (Conyers and Lucius 1996). Each time a radar pulse traverses a material with a different composition or water saturation, the velocity will change and a portion of the radar energy will reflect back to the surface and be recorded. The remaining energy will continue to pass into the ground to be further reflected, until it finally dissipates with depth.

The depths to which radar energy can penetrate, and the amount of resolution that can be expected in the subsurface, are partially controlled by the frequency (and therefore the wavelength) of the radar energy transmitted (Conyers 2004b). Standard GPR antennas propagate radar energy that varies in frequency from about 10 megahertz (MHz) to 1,000 MHz. Low frequency antennas (10-120 MHz) generate long wavelength radar energy that can penetrate up to 50 meters in certain conditions but are capable of resolving only very large buried features. In contrast, the maximum depth of penetration of a 900 MHz antenna is about one meter or less in typical materials, but its generated reflections can resolve features with a maximum dimension of a few centimeters. A trade-off therefore exists between depth of penetration and subsurface resolution.

The success of GPR surveys in archaeology is largely dependent on soil and sediment mineralogy, ground moisture, subsurface material moisture retention, the depth of buried features, feature preservation, and surface topography and vegetation. Electrically conductive or highly magnetic materials will quickly attenuate radar energy and prevent its transmission to

depth. Depth penetration varies considerably depending on local conditions. Subsurface materials that absorb and retain large amounts of water can effect GPR depth penetration because of their low relative dielectric permittivity (RDP). In practical applications, this generally results in shallower than normal depth penetration because the radar signal is absorbed (attenuated) by the materials regardless of antenna frequency (Conyers 2004a; 2012; Conyers and Lucius 1996). Differential water retention can also positively affect data when a material of interest, such as a grave, retains more water than the surrounding soils and, therefore, presents a greater contrast.

The basic configuration for a GPR survey consists of an antenna (with both a transmitter and receiver), a harness or cart, and a wheel for calibrating distance. The operator then pulls or pushes the antenna across the ground surface systematically (a grid) collecting data along transects. These data are then stored by the receiver and available for later processing.

The “time window” within which data were gathered was 45 nanoseconds (ns). This is the time during which the system is “listening” for returning reflections from within the ground. The greater the time window, the deeper the system can potentially record reflections. To convert time in nanoseconds to depth, it is necessary to determine the elapsed time it takes the radar energy to be transmitted, reflected, and recorded back at the surface by doing a velocity test. Hyperbolas were found on reflection profiles and measured to yield a relative dielectric permittivity (RDP), which is a way to calculate velocity. The shape of hyperbolas generated in programs is a function of the speed at which electromagnetic energy moves in the ground, and can therefore be used to calculate velocity (Conyers and Lucius 1996). The RDP for soils in the cemetery area was approximately 17, which, when converted to one-way travel time, (the time it takes the energy to reach a reflection source), is approximately 7 centimeters/nanosecond. All profiles and processed maps were converted from time in nanoseconds (ns) to depth in centimeters using this average velocity.

## GPR FIELD METHODS

The field survey was conducted using a GSSI SIR-3000 using a 400 MHz antenna over the selected areas. The first step was to calibrate the antenna to local conditions by walking the survey area and adjusting the instrument’s gain settings. This method allows the user to get an average set of readings based on subtle changes in the RDP (Conyers 2004b). Field calibration was repeated as necessary to account for changes in soil and/or moisture conditions (Conyers 2004a). Effective depth penetration was approximately 1.5 meters (4.9 ft.). This is an adequate depth penetration for a 400 MHz antenna, with only slight signal attenuation at the bottom of the profile.

A single grid was established over the cemetery boundary that measured approximately 3,851 square meters (0.95-ac) in size (Figure 3). Survey flags and temporary marking paint were used to mark each grid corner. Grid corners were also mapped a Trimble GeoXT global positioning system (GPS) with sub-meter accuracy.

It is generally standard practice to orient transects perpendicular to the long axis of suspected features. In this case, data were collected roughly north-south as Christian graves are generally oriented east-west. Transect spacing was 50 centimeters, an interval that has been demonstrated to generate the best resolution possible while still maintaining field efficiency (Pomfret 2005). Transects were collected in a zig-zag pattern, alternating starting direction, and started in the southwest grid corner.

## GPR DATA PROCESSING

All data were downloaded from the control unit to a laptop computer for post-processing. Radar signals are initially recorded by their strength and the elapsed time between their transmission and reception by the antenna. Therefore, the first task in the data processing was to set “time zero”, which tells the software where in the profile the true ground surface was. This is critical to getting accurate results when elapsed time is converted to target depth. A background filter was applied to the data, which removes the horizontal banding that can result from antenna energy “ringing” and outside frequencies such as cell phones and radio towers. Background noise can make it difficult to visually interpret reflections. Hyperbolic reflections are generated from the way the radar energy reflects off point targets. In cemeteries, graves are often visible as hyperbolic reflections.

The next data processing step involved the generation of amplitude slice-maps (Conyers 2004b). Amplitude slice-maps are a three-dimensional tool for viewing differences in reflected amplitudes across a given surface at various depths. Reflected radar amplitudes are of interest because they measure the degree of physical and chemical differences in the buried materials. Strong, or high amplitude reflections often indicate denser (or different) buried materials. Such reflections can be generated at pockets of air, such as within collapsed graves, or from slumping sediments. Amplitude slice-maps are generated through comparison of reflected amplitudes between the reflections recorded in vertical profiles. Amplitude variations, recorded as digital values, are analyzed at each location in a grid of many profiles where there is a reflection recorded. The amplitudes of all reflection traces are compared to the amplitudes of all nearby traces along each profile. This database can then be “sliced” horizontally and displayed to show the variation in reflection amplitudes at a sequence of depths in the ground. The result is a map that shows amplitudes in plan view, but also with depth.

Figure 3.  
GPR Grid



Source: USDA NAIP Imagery 2014

Slicing of the data was done using the mapping program *Surfer 8*. Slice maps are a series of x,y,z values, with x (east) and y (north) representing the horizontal location on the surface within each grid and z representing the amplitude of the reflected waves. All data were interpolated using the Inverse Distance Weighted method and then image maps were generated from the resulting files.

From the original .dzt files (raw reflection data), a series of image files was created for cross-referencing to the amplitude slice maps that were produced. Two-dimensional reflection profiles were also analyzed to determine the nature of the features identified on the amplitude slice maps. The reflection profiles show the geometry of the reflections, which can lend insight into whether the radar energy is reflecting from a flat layer (seen as a distinct band on profile) or a single object (seen as a hyperbola in profile). Individual profile analysis was used in conjunction with amplitude slice maps to provide stronger interpretations about possible graves.

The final step in the data processing was to integrate the depth slices with other spatial data. This was done using ArcGIS 10, which can display and manipulate all forms of spatial data created for this project, including GPR results, cemetery features, grid data, and base graphics such as aerial photography and topographic maps. The resulting anomalies were digitized as individual features and referenced to the coordinate system.

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# V. RESULTS AND RECOMMENDATIONS

## CEMETERY MAPPING RESULTS

As part of this project, all existing grave markers were mapped with a Trimble GPS system (Figure 4). This was done to correlate known markers with GPR anomalies and help assess the extent and distribution of unmarked graves. Recorded information included a broad assessment of the marker type (e.g., headstone, ledger, funeral home marker) and death date. Marker materials included granite, marble, and concrete, as well as iron and PVC pipes. Depressions and mounds were also recorded.

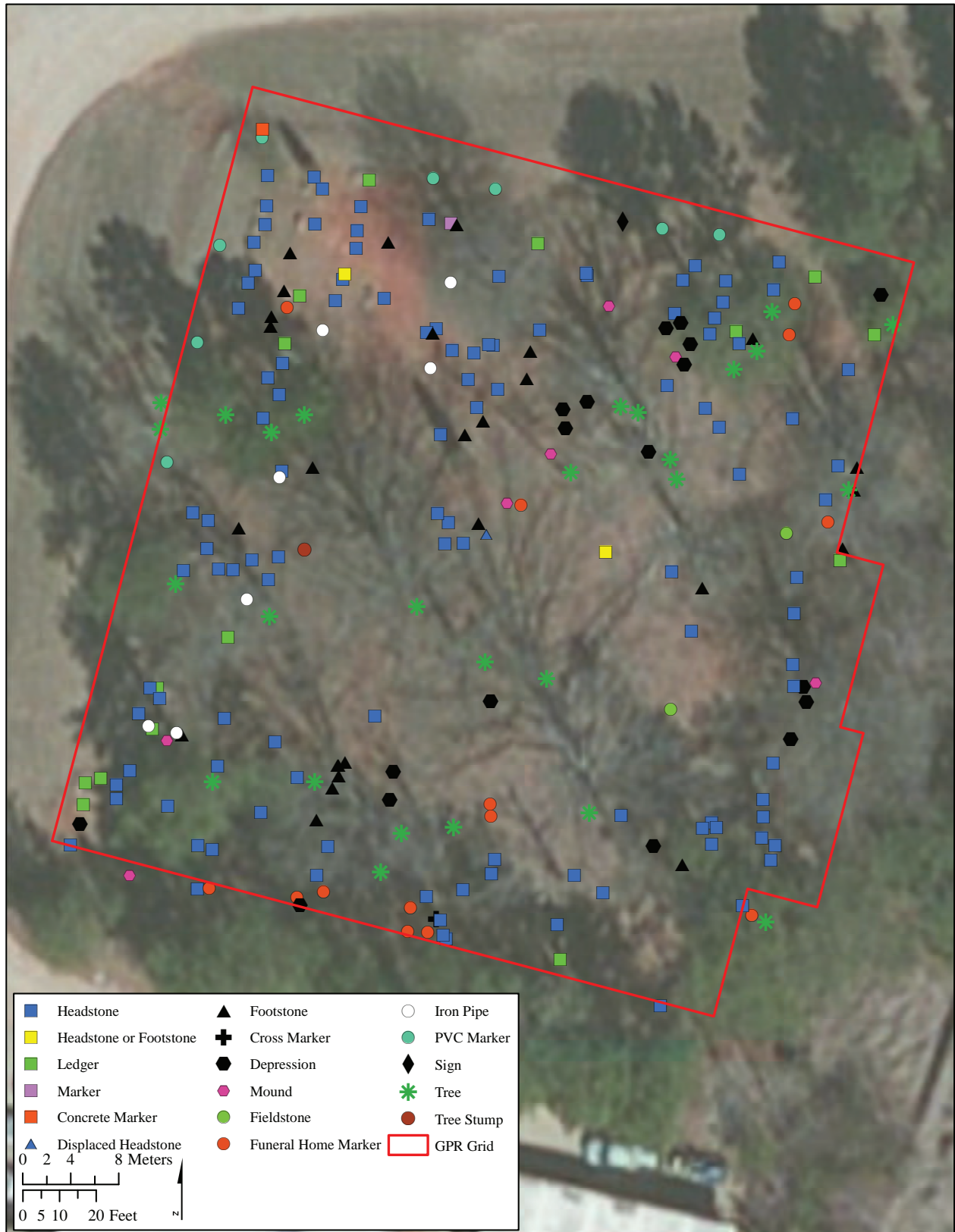
There is a survey map of Oak Grove cemetery prepared by Carroll Mann, Jr., dated 1938 (Figure 5). The dimensions listed are approximately 190 feet east/west by 200 feet north/south. At that time, the cemetery contained numbered plots with regular dimensions located primarily around the perimeter. Walkways were also present between many of the plots. It also contained other plots of irregular size and configuration, almost all of which were closer to the center. This patterning suggests that the irregular plots may have been the earliest and more organic in terms of their layout. It appears that by 1938, an attempt was made to establish formal plots of consistent size and orientation. The internal portion of the cemetery was demarcated as “occupied space”, but there is no indication what this meant. Perhaps there was information suggesting additional unmarked graves.

Comparison of the Mann map with current conditions shows a strong correlation. In general, existing markers follow the layout and organization of plots around the perimeter with a noticeable void in the center. Consistency in patterning suggests the community members followed the plots established in 1938.

## GPR RESULTS

The primary purpose of this survey was to identify marked and unmarked graves. New South takes a conservative approach to the identification of graves based on geophysical data. Emphasis was placed on their size, shape, depth, orientation, and overall characteristics in both plan and profile. As noted earlier, many factors influence the overall effectiveness of geophysics for detecting anomalies consistent with graves including soil type and acidity, moisture and precipitation, soils magnetic properties, age of probable graves, likely burial depth, and burial container (e.g., shroud, wood coffin, metal casket, and concrete vault). In general, if an anomaly has any of the characteristics of a grave it is marked as such. However, the potential for false positives always exists and the results should be viewed as an estimate of the total number of graves.

Figure 4.  
Map of Existing Markers and Other Features



Source: USDA NAIP Imagery 2014



GPR results were based on analysis of the 400MHz data, including individual reflection profiles and amplitude slice maps (Figures 6-10). Overall, the data quality and resolution is very high in the slice maps, particularly at depths greater than 30 centimeters. Grave features were generally high contrast and visible in both plan and profile views. In profile, graves are seen as hyperbolic reflections and range in depth from approximately 25 to 75 centimeters below surface (cmbs) (Figure 11). Appendix A includes a table of GPR anomalies along with UTM coordinates for their center points.

The GPR survey identified approximately 403 graves (Figure 12, Appendix A). Of this number, approximately 152 are associated with an existing marker and 251 are completely unmarked. The graves are distributed throughout the cemetery in dense clusters. Marked graves tend to be clustered around the perimeter, which fits well with the 1938 Mann map (Figure 13). Unmarked graves are found throughout the cemetery, but with a noticeable cluster in the center. This corresponds to the “occupied space” identified on the Mann map and suggests unmarked graves were present at a very early date. The few void spaces correspond to mature tree locations and the appearance of space may not reflect reality on the ground.

Grave markers are often, but not always, a reasonable estimate of interment numbers. The 251 unmarked graves is a relatively high number compared to the 152 marked graves, but not unusual. The anomaly patterns show that the unmarked graves fall within rows and clusters as would be expected in an organized community cemetery. Rows of marked graves often continue with several unmarked graves. Burial placement seems to be orderly throughout the cemetery. The presence of unmarked graves is a common occurrence in almost all historic cemeteries, regardless of their location, association, or condition. There are a number of factors that might lead to this result, most of which are not intentional. First, markers may not have been placed at the time of death. In these situations, the family may have fully intended to return at a later date and place a marker. Second, temporary markers of perishable materials or other objects may have been placed that have since been lost to the elements. In certain African American cemeteries, in particular, there is a tradition of placing household objects on the surface of a grave. To outsiders, this pattern is often misinterpreted as trash and the items are sometimes removed. Though the intentions may have been well placed, the result is removal of associated burial objects. Third, markers get dislodged or moved accidentally and then cannot be replaced in their original locations. Fourth, records of interments and maps are often incomplete or fragmentary. And finally, and rarely, there is vandalism or other deliberate attempts to remove grave markers.

Figure 6.  
GPR Amplitude Slice Map, 0-30 Centimeters Below Surface (cmbs)

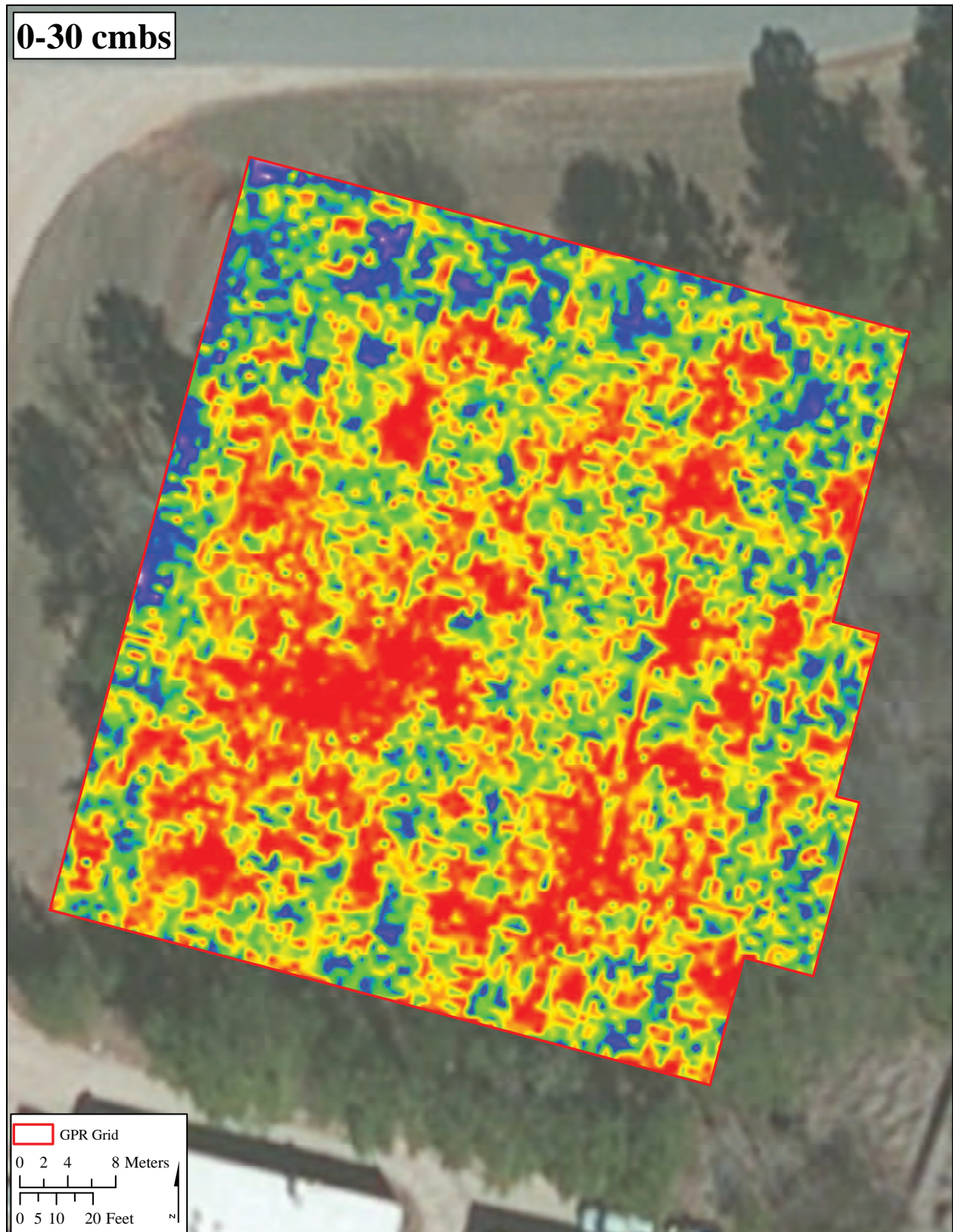


Figure 7.  
GPR Amplitude Slice Map, 30-60 cmbs

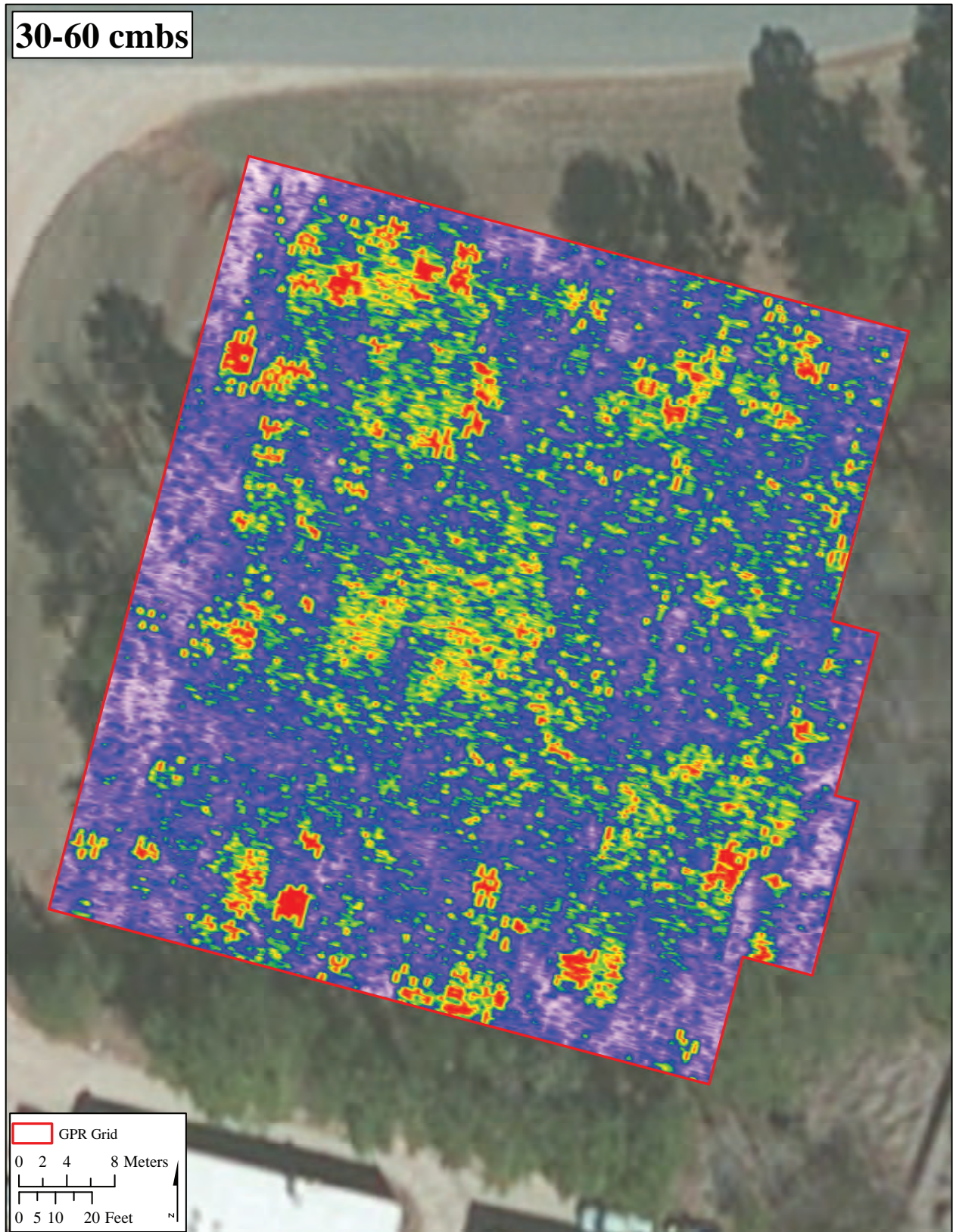


Figure 8.  
GPR Amplitude Slice Map, 60-90 cmbs

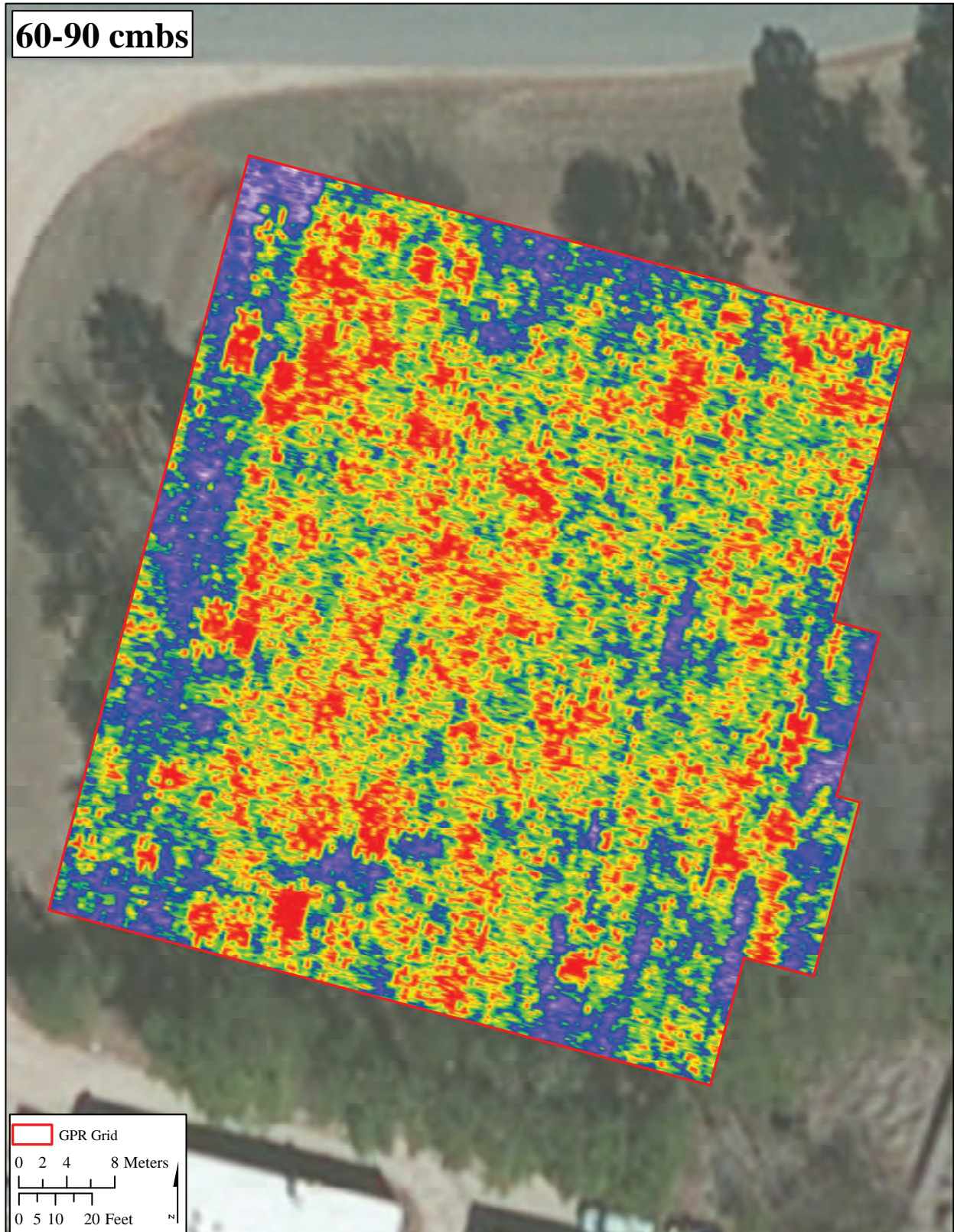


Figure 9.  
GPR Amplitude Slice Map, 90-120 cmbs

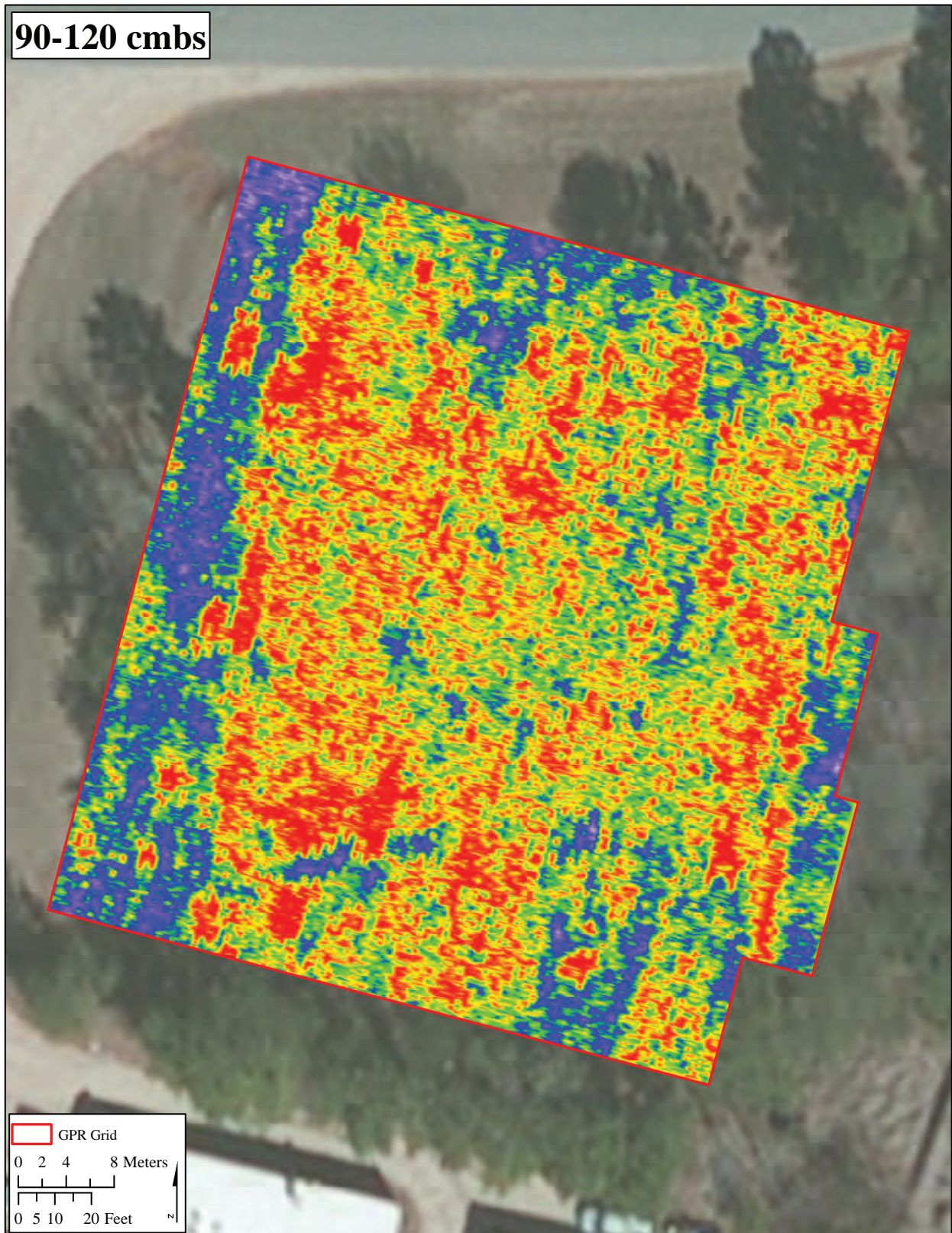




Figure 10.  
GPR Amplitude Slice Map, 120-150 cmbs

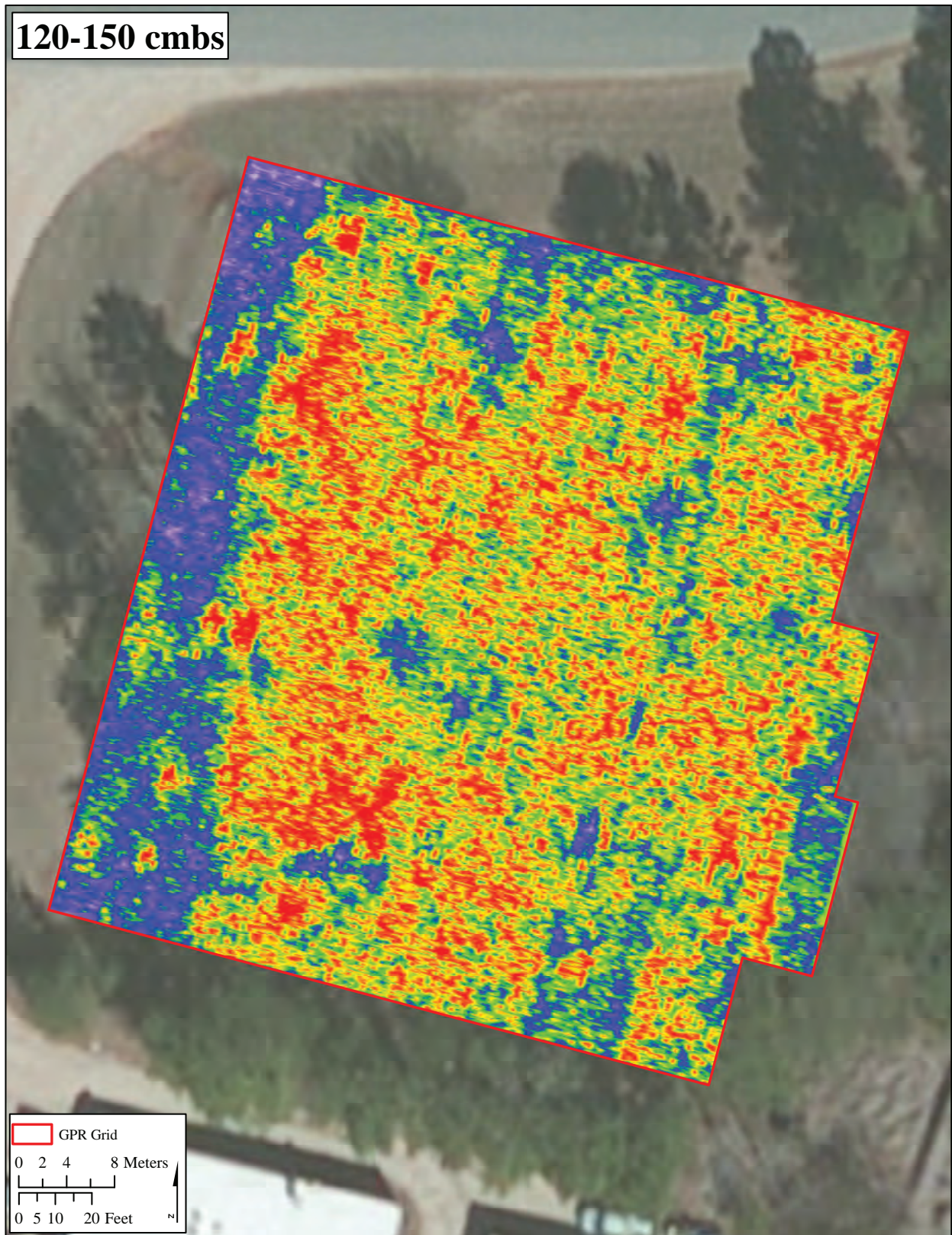
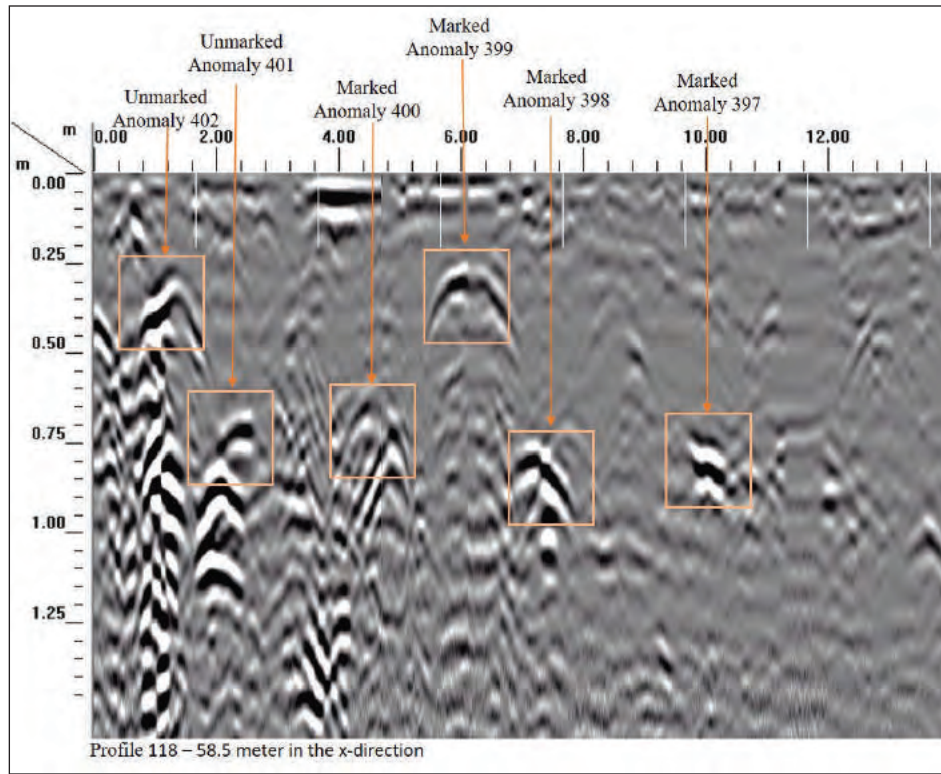
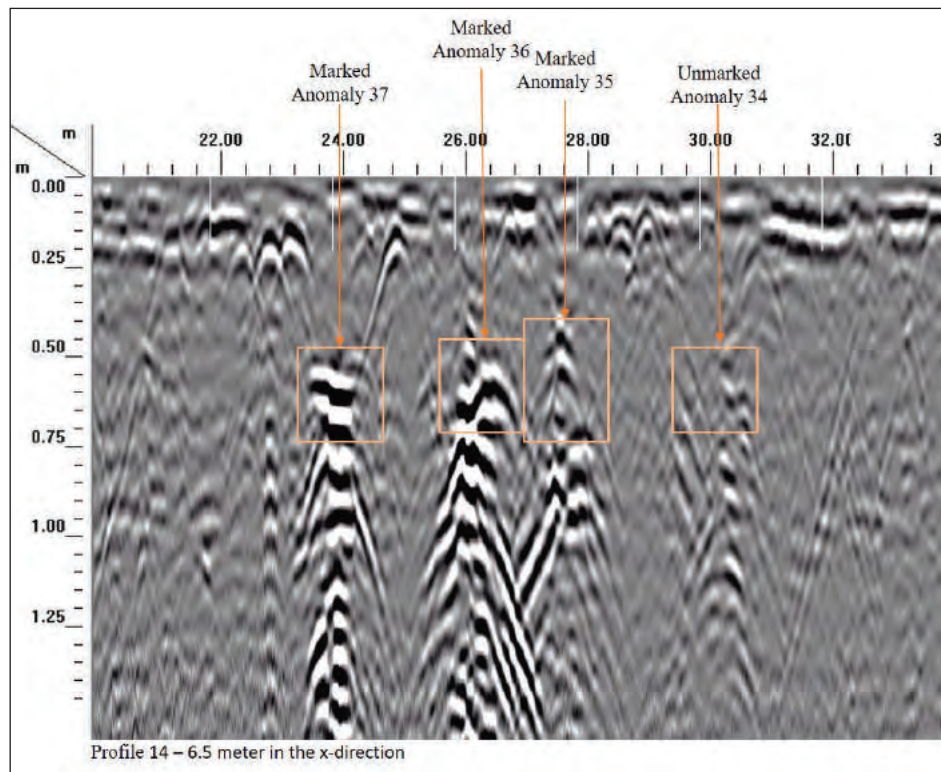


Figure 11.  
Example of Graves in Profile

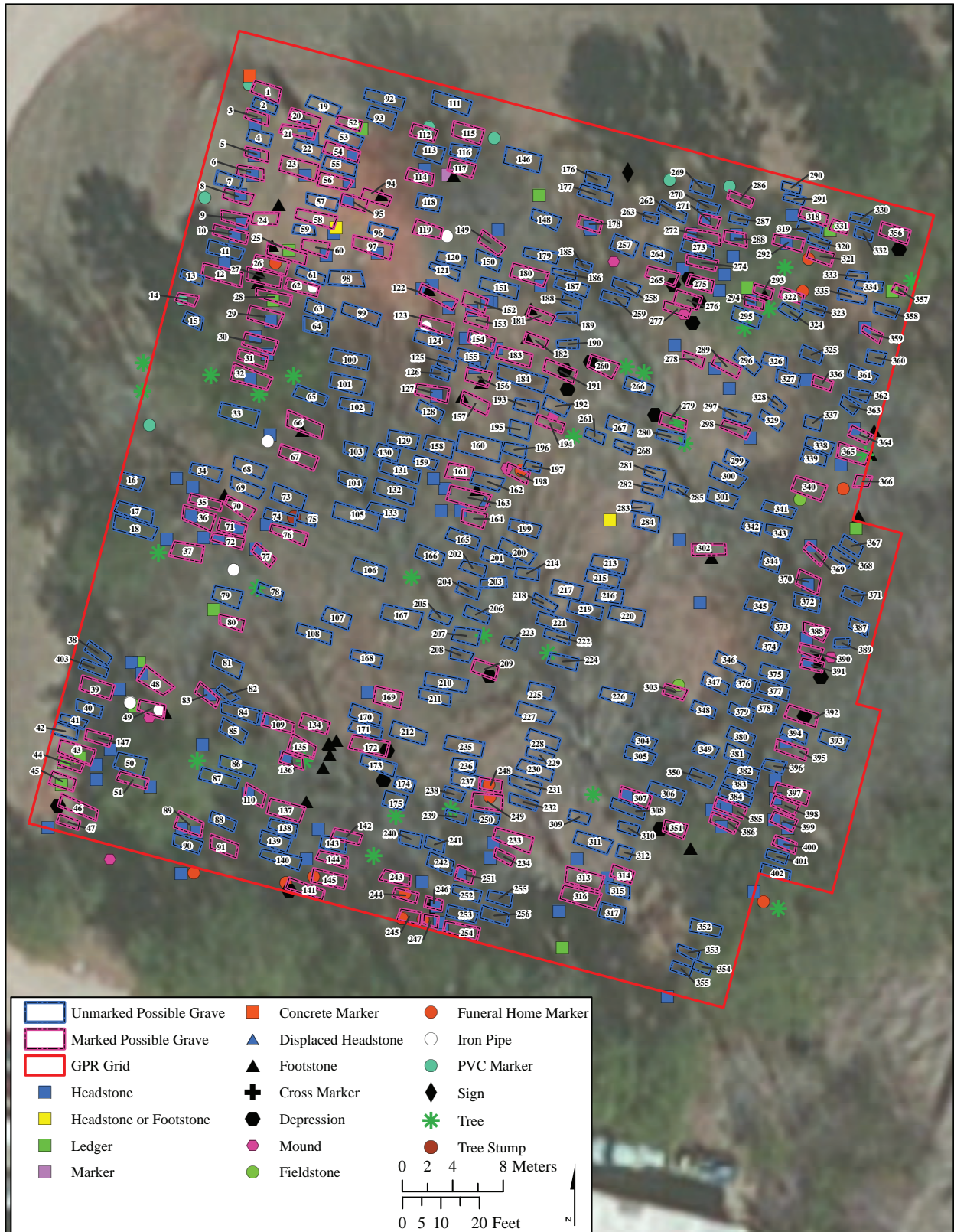


A. Profile 118



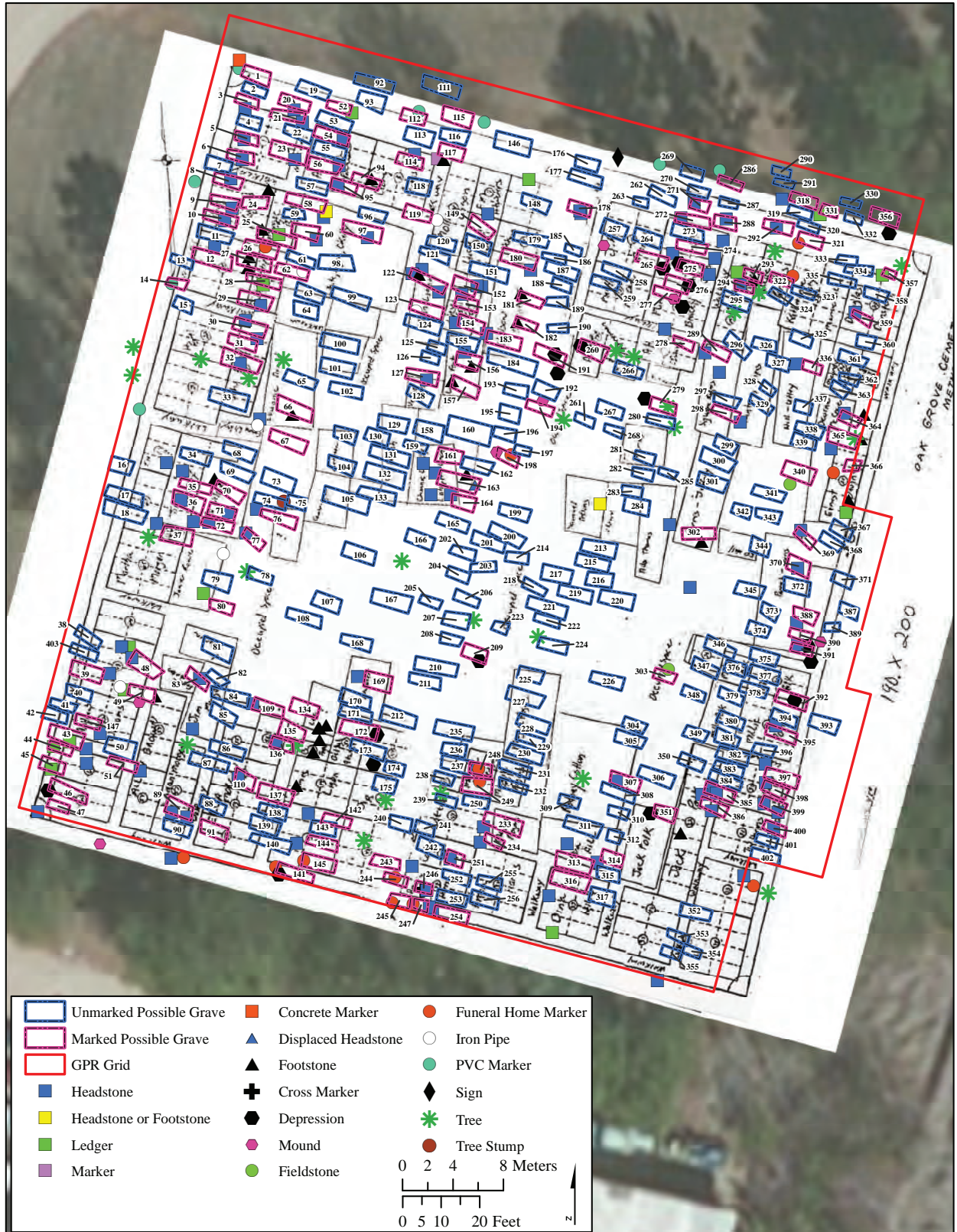
B. Profile 14

Figure 12.  
GPR Results Showing Marked and Unmarked Graves



Source: USDA NAIP Imagery 2014

Figure 13.  
GPR Results on 1938 Mann Map



Source: USDA NAIP Imagery 2014

## RECOMMENDATIONS

New South recommends that the markers and geophysical anomalies identified as probable graves should be treated as such. The GPR data suggest that Oak Grove Cemetery is essentially full, although there are isolated pockets with limited open space. Any future interments should be planned carefully, both to avoid the graves identified in this survey and to consider any unmarked graves that might have been missed.

Future preservation efforts should consider placing markers on all grave locations to commemorate those individuals. That effort would also provide a long-term visual record of grave locations and could be recorded as part of an updated cemetery map prepared by a professional surveyor. A more comprehensive marker inventory is also recommended that would photograph each marker and make a conditions assessment. This could be completed as a part of a cemetery master plan.

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# APPENDIX A: GPR ANOMALIES

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**Appendix A  
GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
1	Possible Grave	Yes	3962972.48563	707991.42032
2	Possible Grave	No	3962971.32533	707991.25117
3	Possible Grave	Yes	3962970.44779	707990.66301
4	Possible Grave	No	3962968.81543	707990.85716
5	Possible Grave	Yes	3962967.49228	707990.64424
6	Possible Grave	Yes	3962966.05159	707990.17499
7	Possible Grave	No	3962965.43150	707988.35451
8	Possible Grave	Yes	3962964.13407	707989.15674
9	Possible Grave	Yes	3962962.42355	707988.91919
10	Possible Grave	Yes	3962961.16631	707988.56564
11	Possible Grave	No	3962959.88770	707988.07135
12	Possible Grave	Yes	3962957.92886	707987.90227
13	Possible Grave	No	3962957.73869	707985.50212
14	Possible Grave	Yes	3962956.00181	707985.11867
15	Possible Grave	No	3962954.31089	707985.61126
16	Possible Grave	No	3962941.54490	707980.66735
17	Possible Grave	No	3962939.13955	707980.96427
18	Possible Grave	No	3962937.88526	707980.91938
19	Possible Grave	No	3962971.31295	707995.89637
20	Possible Grave	Yes	3962970.32337	707994.40491
21	Possible Grave	Yes	3962969.30217	707993.93413
22	Possible Grave	No	3962967.91047	707994.77311
23	Possible Grave	Yes	3962966.39813	707993.98583
24	Possible Grave	Yes	3962962.40157	707991.30664
25	Possible Grave	Yes	3962959.60756	707992.96970
26	Possible Grave	Yes	3962958.73109	707991.78902
27	Possible Grave	Yes	3962957.70907	707991.20656
28	Possible Grave	Yes	3962956.18983	707992.03074
29	Possible Grave	Yes	3962954.62787	707991.28887
30	Possible Grave	Yes	3962952.50361	707990.88356
31	Possible Grave	Yes	3962951.31040	707990.31979
32	Possible Grave	Yes	3962949.81561	707990.09378
33	Possible Grave	No	3962946.86061	707989.25593
34	Possible Grave	No	3962942.30003	707986.63675
35	Possible Grave	Yes	3962939.90697	707986.58621
36	Possible Grave	Yes	3962938.66838	707986.03358
37	Possible Grave	Yes	3962935.98677	707985.13504
38	Possible Grave	No	3962927.92492	707978.04429
39	Possible Grave	Yes	3962925.20209	707977.94501
40	Possible Grave	No	3962923.53924	707977.33532
41	Possible Grave	No	3962922.53975	707976.09112
42	Possible Grave	No	3962921.75084	707975.43562
43	Possible Grave	Yes	3962920.10324	707976.34479
44	Possible Grave	Yes	3962919.12744	707975.86327
45	Possible Grave	Yes	3962917.77124	707975.20528
46	Possible Grave	Yes	3962915.70783	707976.42176
47	Possible Grave	Yes	3962914.54327	707975.68976
48	Possible Grave	Yes	3962925.69933	707982.51816

**Appendix A  
GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
49	Possible Grave	Yes	3962923.52569	707982.31136
50	Possible Grave	No	3962919.14486	707980.64088
51	Possible Grave	Yes	3962917.87330	707980.81692
52	Possible Grave	Yes	3962969.95734	707997.98059
53	Possible Grave	No	3962968.81563	707997.60209
54	Possible Grave	Yes	3962967.68478	707997.37098
55	Possible Grave	No	3962966.54578	707997.19505
56	Possible Grave	Yes	3962965.31806	707996.73812
57	Possible Grave	No	3962963.71900	707995.85903
58	Possible Grave	Yes	3962962.42211	707995.36901
59	Possible Grave	No	3962961.48582	707994.37673
60	Possible Grave	Yes	3962960.11479	707995.31069
61	Possible Grave	No	3962957.89377	707994.92300
62	Possible Grave	Yes	3962956.93032	707994.22721
63	Possible Grave	No	3962955.18461	707995.59612
64	Possible Grave	No	3962953.86694	707995.32377
65	Possible Grave	No	3962948.35490	707994.86277
66	Possible Grave	Yes	3962946.03750	707994.39934
67	Possible Grave	Yes	3962943.46714	707993.93964
68	Possible Grave	No	3962942.65836	707990.06617
69	Possible Grave	No	3962941.04286	707989.83546
70	Possible Grave	Yes	3962939.44415	707989.32897
71	Possible Grave	Yes	3962937.87003	707988.64779
72	Possible Grave	Yes	3962936.86931	707988.38110
73	Possible Grave	No	3962940.34389	707993.13142
74	Possible Grave	No	3962938.72886	707992.44886
75	Possible Grave	No	3962938.63270	707994.58915
76	Possible Grave	Yes	3962937.34956	707993.28660
77	Possible Grave	Yes	3962935.70178	707991.16513
78	Possible Grave	No	3962932.78568	707991.65677
79	Possible Grave	No	3962932.42666	707988.31475
80	Possible Grave	Yes	3962930.35351	707988.65198
81	Possible Grave	No	3962926.98070	707988.31634
82	Possible Grave	No	3962924.68115	707988.25344
83	Possible Grave	Yes	3962924.63040	707986.68882
84	Possible Grave	No	3962923.22797	707989.37183
85	Possible Grave	No	3962921.74940	707988.75247
86	Possible Grave	No	3962918.97573	707989.08333
87	Possible Grave	No	3962918.00983	707987.59234
88	Possible Grave	No	3962914.58959	707987.92574
89	Possible Grave	Yes	3962914.34596	707985.24629
90	Possible Grave	No	3962912.85400	707985.13346
91	Possible Grave	Yes	3962912.63116	707988.02945
92	Possible Grave	No	3962971.87148	708000.77212
93	Possible Grave	No	3962970.45321	708000.56565
94	Possible Grave	Yes	3962964.06986	708000.07151
95	Possible Grave	Yes	3962963.68149	707998.32816
96	Possible Grave	No	3962961.43677	708000.60884

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GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
97	Possible Grave	Yes	3962960.14524	707999.85623
98	Possible Grave	No	3962957.63283	707997.72005
99	Possible Grave	No	3962954.80049	707998.92410
100	Possible Grave	No	3962951.24216	707998.01261
101	Possible Grave	No	3962949.28909	707997.81415
102	Possible Grave	No	3962947.53662	707998.54017
103	Possible Grave	No	3962944.00089	707998.46109
104	Possible Grave	No	3962941.59712	707998.18869
105	Possible Grave	No	3962938.79958	707998.53040
106	Possible Grave	No	3962934.58043	707999.53215
107	Possible Grave	No	3962930.70425	707996.97865
108	Possible Grave	No	3962929.48743	707995.21888
109	Possible Grave	Yes	3962922.35374	707992.28969
110	Possible Grave	Yes	3962916.64176	707990.46449
111	Possible Grave	No	3962971.57121	708006.08092
112	Possible Grave	Yes	3962969.20257	708003.84497
113	Possible Grave	No	3962967.62754	708004.33267
114	Possible Grave	Yes	3962965.70087	708003.56937
115	Possible Grave	Yes	3962969.19816	708007.35517
116	Possible Grave	No	3962967.68027	708007.12665
117	Possible Grave	Yes	3962966.40925	708006.86780
118	Possible Grave	No	3962963.66244	708004.27643
119	Possible Grave	Yes	3962961.51241	708004.13757
120	Possible Grave	No	3962959.16065	708006.07956
121	Possible Grave	No	3962958.23525	708005.61488
122	Possible Grave	Yes	3962956.17509	708005.02387
123	Possible Grave	Yes	3962953.92419	708004.92495
124	Possible Grave	No	3962952.74860	708004.65641
125	Possible Grave	No	3962950.91805	708005.72527
126	Possible Grave	No	3962950.09315	708005.16351
127	Possible Grave	Yes	3962948.60119	708004.60262
128	Possible Grave	No	3962947.11092	708004.37961
129	Possible Grave	No	3962944.87952	708002.24318
130	Possible Grave	No	3962943.83912	708000.98735
131	Possible Grave	No	3962942.32610	708002.01587
132	Possible Grave	No	3962940.76149	708001.59707
133	Possible Grave	No	3962939.19921	708001.01868
134	Possible Grave	Yes	3962922.32367	707995.19345
135	Possible Grave	Yes	3962920.49380	707994.17582
136	Possible Grave	Yes	3962919.42469	707993.41451
137	Possible Grave	Yes	3962915.48151	707992.90838
138	Possible Grave	No	3962914.13038	707992.72880
139	Possible Grave	No	3962913.02045	707992.07103
140	Possible Grave	No	3962911.62677	707992.67165
141	Possible Grave	Yes	3962909.23874	707994.41923
142	Possible Grave	Yes	3962913.39140	707997.75135
143	Possible Grave	No	3962912.81455	707996.71580
144	Possible Grave	Yes	3962911.61848	707996.66399

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GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
145	Possible Grave	Yes	3962910.03503	707996.32689
146	Possible Grave	No	3962967.06723	708011.74034
147	Possible Grave	Yes	3962921.22627	707978.05074
148	Possible Grave	No	3962962.34942	708013.56615
149	Possible Grave	Yes	3962960.42847	708009.20998
150	Possible Grave	No	3962959.06537	708008.99050
151	Possible Grave	No	3962956.88768	708009.89563
152	Possible Grave	Yes	3962955.78207	708007.89941
153	Possible Grave	Yes	3962954.36338	708008.07229
154	Possible Grave	Yes	3962952.75785	708008.42585
155	Possible Grave	No	3962951.35232	708007.81308
156	Possible Grave	Yes	3962949.84698	708008.19652
157	Possible Grave	Yes	3962947.75531	708007.96649
158	Possible Grave	No	3962944.32546	708005.10720
159	Possible Grave	No	3962943.07619	708004.05478
160	Possible Grave	No	3962944.31239	708008.27856
161	Possible Grave	Yes	3962942.30366	708006.67379
162	Possible Grave	No	3962941.55337	708008.91004
163	Possible Grave	Yes	3962940.26312	708007.41957
164	Possible Grave	Yes	3962938.62441	708007.82831
165	Possible Grave	No	3962937.02998	708006.96825
166	Possible Grave	No	3962935.68673	708004.35705
167	Possible Grave	No	3962930.86186	708002.13517
168	Possible Grave	No	3962927.53724	707999.37808
169	Possible Grave	Yes	3962924.42028	708001.03768
170	Possible Grave	No	3962923.03568	707999.22862
171	Possible Grave	No	3962921.88991	707999.27461
172	Possible Grave	Yes	3962920.60347	707999.56451
173	Possible Grave	No	3962919.05659	708000.30501
174	Possible Grave	No	3962917.54212	708002.36414
175	Possible Grave	No	3962916.26091	708001.56945
176	Possible Grave	No	3962965.48910	708017.62357
177	Possible Grave	No	3962964.30630	708017.52454
178	Possible Grave	Yes	3962961.95247	708017.01990
179	Possible Grave	No	3962959.48203	708013.23275
180	Possible Grave	Yes	3962957.93240	708012.22530
181	Possible Grave	Yes	3962954.68201	708013.12145
182	Possible Grave	Yes	3962952.73642	708012.73917
183	Possible Grave	Yes	3962951.46127	708011.03622
184	Possible Grave	No	3962949.73616	708011.68585
185	Possible Grave	No	3962958.64565	708016.53066
186	Possible Grave	No	3962958.01151	708015.04612
187	Possible Grave	No	3962956.99712	708015.61610
188	Possible Grave	No	3962955.85136	708015.59958
189	Possible Grave	No	3962954.54293	708015.26115
190	Possible Grave	No	3962952.44192	708015.33121
191	Possible Grave	Yes	3962950.31765	708014.67706
192	Possible Grave	No	3962947.51818	708014.34479

**Appendix A  
GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
193	Possible Grave	No	3962947.50701	708012.01972
194	Possible Grave	Yes	3962946.12356	708013.88548
195	Possible Grave	No	3962945.66543	708011.48464
196	Possible Grave	No	3962944.06046	708011.11345
197	Possible Grave	No	3962942.75486	708012.48066
198	Possible Grave	Yes	3962942.19418	708011.31673
199	Possible Grave	No	3962937.84765	708011.88816
200	Possible Grave	No	3962936.01647	708011.24526
201	Possible Grave	No	3962935.48722	708009.74193
202	Possible Grave	No	3962934.64847	708007.82803
203	Possible Grave	No	3962933.48881	708009.41861
204	Possible Grave	No	3962932.88794	708007.40197
205	Possible Grave	No	3962930.74013	708005.20878
206	Possible Grave	No	3962930.99280	708008.03879
207	Possible Grave	No	3962929.30340	708007.27218
208	Possible Grave	No	3962927.76195	708006.79515
209	Possible Grave	Yes	3962926.66440	708008.72011
210	Possible Grave	No	3962925.60046	708005.61883
211	Possible Grave	No	3962924.47951	708004.79224
212	Possible Grave	No	3962921.59037	708002.61835
213	Possible Grave	No	3962934.99941	708018.60653
214	Possible Grave	No	3962934.24808	708012.08710
215	Possible Grave	No	3962933.83962	708018.05925
216	Possible Grave	No	3962932.51152	708018.62211
217	Possible Grave	No	3962932.91842	708015.18833
218	Possible Grave	No	3962931.90520	708013.40709
219	Possible Grave	No	3962931.38214	708016.70682
220	Possible Grave	No	3962930.93868	708020.00277
221	Possible Grave	No	3962930.29012	708014.46844
222	Possible Grave	No	3962929.29557	708014.46942
223	Possible Grave	No	3962928.72028	708010.76054
224	Possible Grave	No	3962927.27388	708014.93305
225	Possible Grave	No	3962924.96749	708013.14114
226	Possible Grave	No	3962924.51312	708019.23391
227	Possible Grave	No	3962923.19887	708012.66572
228	Possible Grave	No	3962921.08155	708013.36463
229	Possible Grave	No	3962919.84677	708013.09902
230	Possible Grave	No	3962918.68922	708012.73997
231	Possible Grave	No	3962917.54183	708011.92519
232	Possible Grave	No	3962916.14263	708011.74008
233	Possible Grave	Yes	3962913.14028	708011.01818
234	Possible Grave	Yes	3962911.77617	708010.24093
235	Possible Grave	No	3962920.56526	708007.06930
236	Possible Grave	No	3962919.02584	708007.08371
237	Possible Grave	No	3962917.84015	708007.25549
238	Possible Grave	No	3962916.74677	708006.25766
239	Possible Grave	No	3962914.96705	708006.45837
240	Possible Grave	No	3962913.17517	708002.83575

**Appendix A  
GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
241	Possible Grave	No	3962912.77021	708004.72232
242	Possible Grave	No	3962911.26965	708005.19127
243	Possible Grave	Yes	3962910.11522	708001.64134
244	Possible Grave	Yes	3962908.73052	708002.44427
245	Possible Grave	Yes	3962907.03755	708002.75289
246	Possible Grave	Yes	3962908.07410	708004.65029
247	Possible Grave	Yes	3962906.70867	708004.44920
248	Possible Grave	Yes	3962917.47560	708009.17508
249	Possible Grave	Yes	3962916.17055	708008.92394
250	Possible Grave	No	3962914.89530	708008.82493
251	Possible Grave	Yes	3962910.37429	708007.12456
252	Possible Grave	No	3962908.90287	708007.32674
253	Possible Grave	No	3962907.25852	708006.90383
254	Possible Grave	Yes	3962905.92837	708006.89123
255	Possible Grave	No	3962908.48222	708009.90882
256	Possible Grave	No	3962907.12105	708009.46447
257	Possible Grave	No	3962960.25914	708019.76454
258	Possible Grave	No	3962956.98949	708019.93665
259	Possible Grave	No	3962956.05186	708019.02361
260	Possible Grave	Yes	3962950.69283	708018.09510
261	Possible Grave	No	3962945.15820	708017.44241
262	Possible Grave	No	3962962.92407	708023.57504
263	Possible Grave	No	3962962.44639	708021.89229
264	Possible Grave	No	3962959.57818	708022.43597
265	Possible Grave	Yes	3962957.85586	708022.78195
266	Possible Grave	No	3962949.11084	708020.86852
267	Possible Grave	No	3962945.96888	708019.41517
268	Possible Grave	No	3962944.32858	708019.75601
269	Possible Grave	No	3962964.77816	708025.94036
270	Possible Grave	No	3962963.27627	708026.44768
271	Possible Grave	Yes	3962962.18720	708026.56705
272	Possible Grave	Yes	3962960.97642	708026.06310
273	Possible Grave	No	3962960.00987	708025.56479
274	Possible Grave	Yes	3962958.90654	708025.91416
275	Possible Grave	Yes	3962957.24262	708025.81202
276	Possible Grave	Yes	3962955.93456	708024.76253
277	Possible Grave	Yes	3962955.19328	708023.95205
278	Possible Grave	Yes	3962951.23049	708025.30902
279	Possible Grave	Yes	3962946.25502	708023.64732
280	Possible Grave	No	3962945.08264	708023.49654
281	Possible Grave	No	3962942.17618	708022.22564
282	Possible Grave	No	3962940.90275	708022.07411
283	Possible Grave	No	3962939.49813	708021.15872
284	Possible Grave	No	3962938.34619	708021.55531
285	Possible Grave	No	3962940.95509	708024.00480
286	Possible Grave	Yes	3962963.94234	708028.99394
287	Possible Grave	No	3962962.36638	708028.82272
288	Possible Grave	Yes	3962960.83014	708028.57260



**Appendix A  
GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
289	Possible Grave	Yes	3962950.66717	708027.87904
290	Possible Grave	No	3962964.85090	708033.01072
291	Possible Grave	No	3962963.93983	708033.27080
292	Possible Grave	Yes	3962960.49980	708032.82395
293	Possible Grave	Yes	3962956.63154	708030.79324
294	Possible Grave	Yes	3962955.70792	708030.05175
295	Possible Grave	No	3962954.57028	708029.43128
296	Possible Grave	No	3962951.05477	708029.51348
297	Possible Grave	No	3962946.70503	708028.67425
298	Possible Grave	Yes	3962945.69748	708028.63126
299	Possible Grave	No	3962943.19985	708028.57966
300	Possible Grave	No	3962941.98870	708027.92146
301	Possible Grave	No	3962940.21301	708027.52463
302	Possible Grave	Yes	3962936.15558	708026.45778
303	Possible Grave	Yes	3962924.86686	708023.76914
304	Possible Grave	No	3962920.95693	708021.36231
305	Possible Grave	No	3962919.85791	708020.97933
306	Possible Grave	No	3962916.89567	708023.12811
307	Possible Grave	Yes	3962916.47562	708020.63513
308	Possible Grave	No	3962915.59341	708020.04558
309	Possible Grave	No	3962914.93251	708016.20711
310	Possible Grave	No	3962914.05198	708020.09980
311	Possible Grave	No	3962912.95363	708017.29884
312	Possible Grave	No	3962912.14466	708019.78692
313	Possible Grave	Yes	3962910.03761	708016.56022
314	Possible Grave	Yes	3962910.41617	708019.60001
315	Possible Grave	No	3962909.16638	708019.29065
316	Possible Grave	Yes	3962908.60786	708016.28703
317	Possible Grave	No	3962907.35749	708018.82279
318	Possible Grave	Yes	3962962.58212	708034.83960
319	Possible Grave	No	3962961.62214	708034.50222
320	Possible Grave	No	3962960.54384	708035.18161
321	Possible Grave	Yes	3962959.40359	708035.33931
322	Possible Grave	Yes	3962956.26286	708033.02976
323	Possible Grave	No	3962955.27270	708034.78602
324	Possible Grave	No	3962954.99129	708032.91333
325	Possible Grave	No	3962951.59945	708034.60222
326	Possible Grave	No	3962951.14756	708031.69136
327	Possible Grave	No	3962949.71135	708032.76489
328	Possible Grave	No	3962947.64380	708031.94794
329	Possible Grave	No	3962946.38223	708031.42156
330	Possible Grave	No	3962962.37834	708038.50869
331	Possible Grave	Yes	3962961.74790	708036.80816
332	Possible Grave	No	3962961.18334	708038.74199
333	Possible Grave	No	3962957.82427	708038.24876
334	Possible Grave	No	3962957.06849	708039.21228
335	Possible Grave	No	3962956.20030	708037.78592
336	Possible Grave	Yes	3962949.33947	708035.46254

**Appendix A  
GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
337	Possible Grave	No	3962946.17866	708034.73683
338	Possible Grave	No	3962944.40166	708035.29724
339	Possible Grave	No	3962943.46649	708034.78884
340	Possible Grave	Yes	3962941.00106	708034.41096
341	Possible Grave	No	3962939.33776	708032.02249
342	Possible Grave	No	3962937.97553	708029.89686
343	Possible Grave	No	3962937.61269	708032.03244
344	Possible Grave	No	3962935.10522	708031.31267
345	Possible Grave	No	3962931.69554	708030.49319
346	Possible Grave	No	3962927.11113	708028.13072
347	Possible Grave	No	3962925.50040	708026.96696
348	Possible Grave	No	3962923.46864	708026.04029
349	Possible Grave	No	3962920.28146	708026.22480
350	Possible Grave	No	3962918.03868	708025.90772
351	Possible Grave	Yes	3962913.99785	708023.81095
352	Possible Grave	No	3962906.12611	708026.18071
353	Possible Grave	No	3962904.19694	708024.86424
354	Possible Grave	No	3962903.03542	708025.92710
355	Possible Grave	No	3962902.92450	708024.29099
356	Possible Grave	Yes	3962961.25399	708041.22858
357	Possible Grave	Yes	3962956.76271	708041.58993
358	Possible Grave	No	3962955.13194	708040.52621
359	Possible Grave	Yes	3962953.25190	708039.45185
360	Possible Grave	No	3962951.38392	708039.71183
361	Possible Grave	No	3962950.02637	708038.63171
362	Possible Grave	No	3962948.41379	708038.44031
363	Possible Grave	No	3962947.58172	708037.63112
364	Possible Grave	Yes	3962945.24428	708038.43334
365	Possible Grave	Yes	3962943.71004	708037.87653
366	Possible Grave	Yes	3962941.55701	708038.63660
367	Possible Grave	No	3962936.42732	708037.77659
368	Possible Grave	No	3962935.50770	708036.95895
369	Possible Grave	Yes	3962935.80922	708034.88527
370	Possible Grave	Yes	3962933.58988	708034.38378
371	Possible Grave	No	3962932.51294	708037.88353
372	Possible Grave	No	3962931.95997	708034.25821
373	Possible Grave	No	3962929.96889	708032.12152
374	Possible Grave	No	3962928.55807	708031.15835
375	Possible Grave	No	3962926.37622	708031.65195
376	Possible Grave	No	3962925.49433	708029.37612
377	Possible Grave	No	3962924.99892	708031.66152
378	Possible Grave	No	3962923.79364	708030.80872
379	Possible Grave	No	3962923.24441	708029.00957
380	Possible Grave	No	3962921.33229	708029.02365
381	Possible Grave	No	3962919.93083	708028.66712
382	Possible Grave	No	3962918.53456	708029.18247
383	Possible Grave	No	3962917.50928	708028.88231
384	Possible Grave	No	3962916.60969	708028.57363

**Appendix A  
GPR Anomalies**

Anomaly ID	Label	Marked	UTM Northing	UTM Easting
385	Possible Grave	Yes	3962915.65058	708028.13583
386	Possible Grave	Yes	3962914.49797	708027.68268
387	Possible Grave	No	3962930.04145	708038.37134
388	Possible Grave	Yes	3962929.67213	708034.94487
389	Possible Grave	No	3962928.73843	708037.04370
390	Possible Grave	Yes	3962928.11114	708034.56527
391	Possible Grave	Yes	3962926.99490	708034.66102
392	Possible Grave	Yes	3962922.96487	708033.85108
393	Possible Grave	No	3962921.07475	708036.43339
394	Possible Grave	No	3962921.52445	708033.25067
395	Possible Grave	Yes	3962920.26095	708033.01202
396	Possible Grave	No	3962918.99346	708031.65328
397	Possible Grave	Yes	3962916.79603	708033.08567
398	Possible Grave	Yes	3962915.84902	708032.52849
399	Possible Grave	Yes	3962914.60654	708032.40628
400	Possible Grave	Yes	3962912.77965	708032.51122
401	Possible Grave	No	3962911.81707	708031.88850
402	Possible Grave	No	3962910.54951	708031.74730
403	Possible Grave	No	3962926.75038	707977.71991

