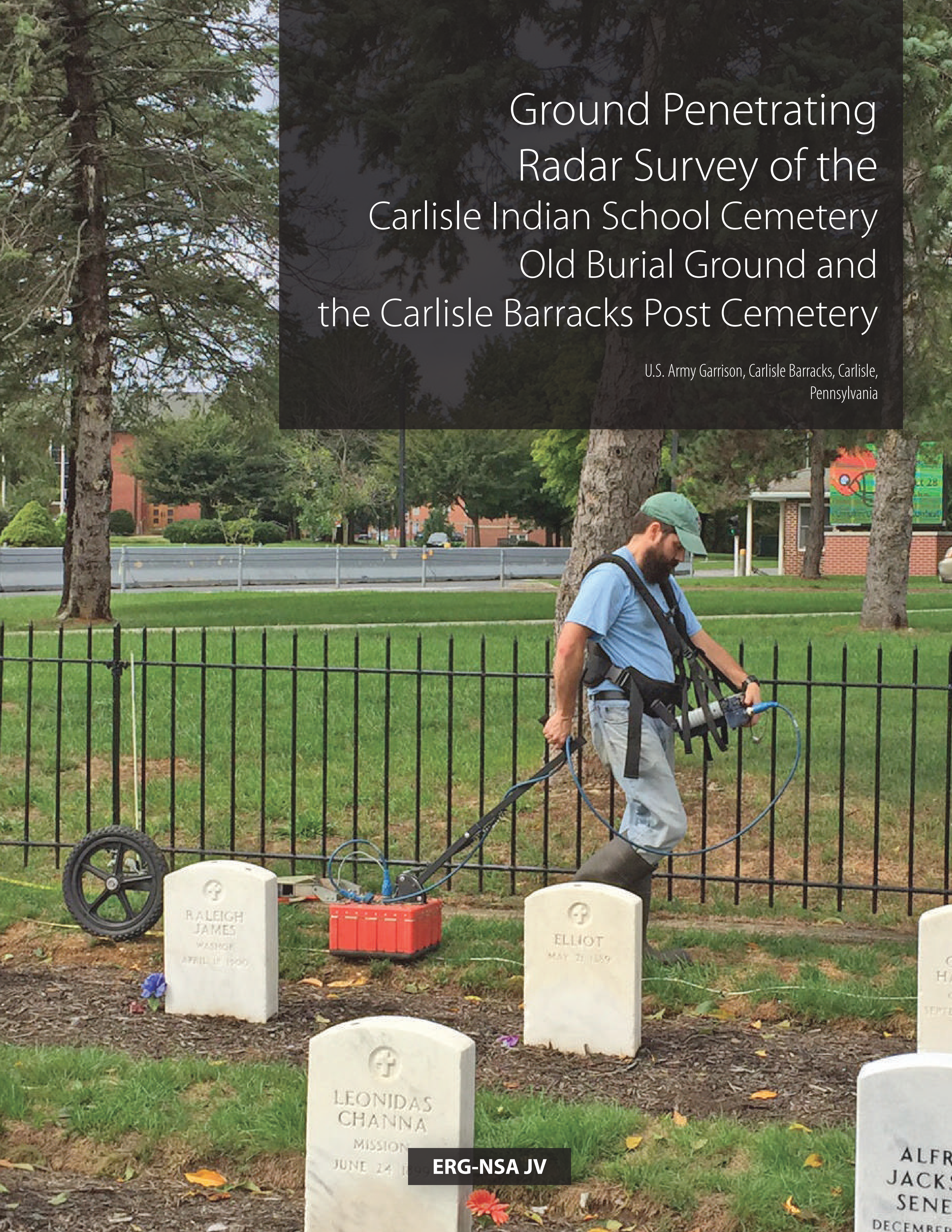
Ground Penetrating Radar Survey of the Carlisle Indian School Cemetery Old Burial Ground and the Carlisle Barracks Post Cemetery

U.S. Army Garrison, Carlisle Barracks, Carlisle, Pennsylvania



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Contract W912P9-16-D-0015, Task Order 10

Report submitted to:

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15 February 2017 • Final Report
New South Associates Technical Report 2660

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EXECUTIVE SUMMARY

The Carlisle Indian Industrial School (Carlisle Indian School) was established at Carlisle Barracks by the Bureau of Indian Affairs (BIA) in 1879 and operated until 1918 when the school was closed and the barracks returned to military use. The Carlisle Indian School Cemetery was established for the burial of Native American students who died while attending the school. Not all of the deceased students were buried in the cemetery; the remains of some were shipped home to their families, tribes, and sponsoring agencies while others who died during "Outings" when they lived with local farming families were buried in local cemeteries.

The Carlisle Indian School Cemetery was established on or adjacent to the "Old Burial Ground," a cemetery that may have originated during the British Encampment of the French and Indian War (1757-1763), which may have been used for the burial of British prisoners of war (POWs) and potentially others during the Revolutionary War, and which became the site of the Holmes family burial ground, and then a U.S. military cemetery following the establishment of the Carlisle Barracks in 1837. The Carlisle Indian School cemetery was relocated to a new burial ground, designated the Carlisle Barracks Post Cemetery, in 1927. This cemetery was subsequently used for the burial of military personnel and their families.

Ground penetrating radar (GPR) survey recorded probable graves in association with 223 of the 228 burial markers in the Post Cemetery. The GPR survey failed to identify anomalies in the locations of five markers. The GPR survey also identified 55 anomalies in the Post Cemetery whose functions could not be determined with the data available. GPR survey of the Old Burial Ground identified a number of utility locations as well as seven indeterminate anomalies.

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I. INTRODUCTION

The U.S. Army Corps of Engineers, St. Louis District, Mandatory Center of Expertise for the Curation and Management of Archaeological Collections (MCX CMAC) is assisting with the disinterment and return of human remains from the Carlisle Indian Industrial School (hereafter referred to as the Carlisle Indian School) Cemetery. MCX CMAC is supporting the Army National Military Cemeteries (ANMC) in this effort. The ANMC reports to the Secretary of the Army and has been tasked with the disinterment and return of tribal members from the Carlisle Indian School Cemetery to their families as requested. The Carlisle Indian School Cemetery, officially the Carlisle Barracks Post Cemetery, contains the graves of Native American children who died while enrolled at the Carlisle Indian School, along with the burials of military and, possibly, non-military personnel. These burials are within the Carlisle Barracks Post Cemetery (hereinafter referred to as the Post Cemetery), which is located at the intersection of Jim Thorpe Road and E. North Street on Carlisle Barracks. Current research indicates it contains 228 burial plots, of which 180 are identified as Native American burials, including 179 students and one non-student. Of the Native American burials, 157 have a known tribal affiliation while the tribal identity of 23 burials is unknown. There are members of 50 tribes in the cemetery. The current Carlisle Indian School Cemetery's burials were relocated to the Post Cemetery from a location known as the Old Burial Ground in 1927. Figure 1 shows the location of the Post Cemetery as well as the Old Burial Ground and both locations are addressed in this report. Historical background on both cemeteries is reported in the archival research report (Matternes et al. 2017).

The Environmental Research Group (ERG) – New South Associates (NSA) Joint Venture (ERG-NSA JV) is supporting MCX CMAC's efforts with task order assignments under an indefinite delivery/indefinite quantity (IDIQ) contract. Work conducted at the Carlisle Barracks involved archival research on the cemetery and a ground penetrating radar (GPR) survey of both the Old Burial Ground and the Post Cemetery.

This report is organized as follows. Chapter II presents the methods employed for this survey. Chapter III provides results of the GPR survey and is illustrated with plan and profile views. References cited follow the text.

Figure 1.
Location of Carlisle Barracks Old Burial Ground and Post Cemetery

Imagery Source: USDA NAIP 2015

II. GROUND PENETRATING RADAR METHODS AND RESULTS

GEOPHYSICAL SURVEY METHODS

The primary goal of geophysical survey is to identify anomalies and make interpretations about their archaeological significance (e.g., feature types) (Kvamme et al. 2006:45). Detecting buried features 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. The resolution of certain instruments (e.g., sensitivity, sampling density, etc.) will determine the size of archaeological features that can be detected. Not surprisingly, larger features (e.g., houses, hearths) are more easily detected than smaller features (e.g., posts). Feature depth is also important because the increased soil volume can degrade signal strength and detection ability.

Clutter/noise 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 prove to be non-archaeological.

The process of an archaeological geophysics survey includes data collection, data processing, Geographic Information System (GIS) organization, identification of geophysical anomalies, and classification of anomalies into potential archaeological feature types (Kvamme et al. 2006:18). Under ideal circumstances the geophysical results would then be used to plan archaeological fieldwork and field validation based on a well-designed testing and sampling plan. Because of significant variations in local soils, geology, and archaeology at each site or within regions, excavation offers significant insight into the results and patterns obtained in a geophysical survey. One of the main goals is to produce clear imagery that looks like buried archaeology.

These types of imagery will be familiar to a non-specialist geophysicist and more meaningful to archaeologists, State Historic Preservation Office (SHPO) staff, managers, and Native American groups (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. Separate maps are produced for each dataset and the results are then displayed together. More advanced methods can be employed that involve statistical and algorithmic operations as a more automated means for data integration (Kvamme et al. 2006:163–164).

GEOPHYSICS IN CEMETERIES

Several factors influence the overall effectiveness of geophysical methods for identifying human graves and associated features. Contrast between the remains, grave shaft, coffin or casket, and the surrounding soils is the single most important variable. Remains that have a chemical or physical contrast from the subsurface materials surrounding them will cause GPR reflections of electromagnetic energy. For graves, the body itself is generally not detected (although there are rare exceptions); it is typically the coffin or casket, burial shaft, or bottom of the grave that causes the reflection (Damaita et al. 2013; 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. Age of the graves is also critical. 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). Relocation can also impact the GPR detection of a burial, particularly in instances where the remains are placed in an informal receptacle or none at all, when the relocated remains are placed in a trench burial, or when relocated remains are buried en masse.

The burial "container" in which the remains were placed is also important. Common types include 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 and then metal caskets in the twentieth century. 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 geophysical method 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 human graves and associated features (Jones 2008; King et al. 1993).

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 burial, 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).

GPR FIELD METHODS

The field survey was conducted using a GSSI SIR-3000 with a 400 MHz antenna. Prior to data collection, the instrument was calibrated to local conditions by walking the survey area and adjusting its 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). 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. Effective depth penetration was approximately 1.4 meters (4.6 ft.). This is an adequate depth penetration for a 400 MHz antenna, with only slight signal attenuation at the bottom of the profile.

GPR data were collected in three separate grids covering a total of approximately 3,650 square meters (Table 1, Figure 2). Two areas were surveyed: the area where the Carlisle Indian School Cemetery was originally located (referred to as the Old Burial Ground) and the current location of the Indian School Cemetery, now known as the Carlisle Barracks Post Cemetery. Grids 1 and 2 were placed in the Old Burial Ground area and Grid 3 was placed in the Carlisle Barracks Post Cemetery. Data collection grids were established using metric tapes. Survey flags and temporary marking paint were used to mark each grid corner. Grid corners were mapped with a Trimble GeoXT global positioning system (GPS) with sub-meter accuracy.

Table 1. Summary of GPR Grids

Grid	Acres	Square Meters
GPR 1	0.66	2,672
GPR 2	0.03	120
GPR 3	0.21	858
Total	0.90	3,650

It is standard practice to orient transects perpendicular to the long axis of suspected features. Data were collected roughly north/northeast as Christian graves are generally oriented east/west. For Grids 1 and 2, transect spacing was 0.5-m given the surface conditions and documented landscape modifications. Transect spacing of 0.5-m is a standard approach for cemetery applications. A three-wheeled survey cart with a sled carrying the antenna was used in this area.

Data collection parameters were changed for Grid 3 because it was located in a known cemetery. First, transect spacing was 0.25-m to provide the maximum possible data resolution. Second, the antenna was attached to a survey wheel for distance calibration rather than the cart so that it could be maneuvered directly against markers and other surface features (Figure 3). And finally, all data were collected in the Y-direction from the baseline rather than alternating (zig-zag) transects. This has the added benefit of more easily working around surface obstacles and minimizing edge-matching exaggeration (i.e., the “zipper effect”).

Figure 2.
Map Showing Locations of GPR Grids

Figure 3.
GPR Data Collection in the Carlisle Barracks Post Cemetery

The locations of major surface features such as grave markers, trees, bushes, utility poles, manhole covers, and concrete planters were recorded with a GPS. Overall accuracy for GPS data collection was very high, with a horizontal position error of no more than 50 centimeters and in most cases no more than 20 centimeters. All data were downloaded from the total station and then imported into ArcMap 10, ESRI's geographic information system (GIS) program. Separate shapefiles were then created for different objects.

GPR DATA PROCESSING

All data were downloaded from the control unit to a computer for post-processing and three-dimensional imaging. 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.

Slicing of the data was done with 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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III. GPR RESULTS

GPR results were based on analysis of the 400MHz data, including individual reflection profiles and amplitude slice maps. Anomalies were sorted into broader interpretive classes based on their presumed origin/function/association (Table 2). Modern utilities and construction features have distinct signatures that allow them to be classified with a high degree of assurance. Within the Post Cemetery, rectangular anomalies associated with burial monuments were classified as likely, but unconfirmed, graves. Indeterminate features were recorded in both cemeteries whose attributes and associations did not permit them to be securely classified. These anomalies could be the products of local geology, construction, plantings, or other activities and cannot be classified with assurance without ground-truthing, i.e. archaeological field evaluation.

Each survey area is discussed in detail below.

Table 2. Summary of GPR Anomalies by Classification and Survey Area

Classification	Carlisle Barracks Post Cemetery	Old Burial Ground	Total
Likely Grave With Marker	223		223
Indeterminate	55	7	62
Rebar Reinforced Concrete		1	1
Utility		12	12
Total	278	20	298

OLD BURIAL GROUND

Soils in the Old Burial Ground area are broadly classified as Hagerstown silt loam, 0 to 3 percent slopes (Soil Survey Staff 2016). This type is found on multiple landforms, including back slopes, foot slopes, summits, side slopes, and interfluves. It is well drained, with depth to water table of more than 80 inches. Parent material is clayey residuum weathered from limestone. A typical profile consists of Ap (0-10 in.) silt loam, Bt1 (10-21 in.) silty clay loam, Bt2 (21-56 in.) silty clay, C (56-73 in.), silty clay loam, and R (73-83 in.) bedrock. Field conditions were quite different from the typical profile as a result of modern construction. The soil descriptions for both Old Burial Ground and Post Cemetery are inconsistent with conditions documented on the ground and they appear to be inverted.

The Old Burial Ground area is in the area of the U.S. Army War College, a highly urbanized setting with modern buildings, parking lots, Forbes Road, curbs, sidewalks, manhole covers, large concrete planters, underground utilities, and small, grassed sections (Figure 4). Aside from surface obstacles, asphalt and concrete are both good mediums for GPR survey. Archival sources indicated that as much as 90 percent of this area has undergone massive disturbance and could contain fill to depths of approximately 15 feet. Two sources provided information on the extent of disturbances in the Old Burial Ground area. Hay et al. (1988) indicated the amount of disturbance, along with narratives regarding the likelihood of intact archaeological resources. Bore logs and profiles indicated the area had been heavily disturbed to depths of up to 15-20 feet and then covered with fill material.

GPR results indicate extensive landscape modification, particularly along Forbes Road and the parking lot (Figures 5-11, Table 3). In this case, there is a long, linear zone of very high amplitude reflections. They were not identified as a specific anomaly. In profile, these reflections appear as linear bands at approximately 30 cmbs that are consistent with materials that are not natural sediments (see Figure 11). In this case, the reflections appear to be a dense layer of fill or other highly compacted material. This compacted material is probably construction fill and does not require further investigation.

Table 3. GPR Anomalies in the Old Burial Ground Area by Depth

Description	Estimated Depth (cm)	Anomaly ID
Utility	35-50	296
Utility	35-55	295
Utility	30-80	294
Utility	0-30	293
Utility	45-90	292
Utility	35-70	291
Utility	35-70	290
Utility	25-50	289
Utility	60-100	288
Utility	120-150	287
Utility	120-150	286
Rebar Reinforced Concrete	0-25	298
Indeterminate	50-90	283
Indeterminate	50-90	282
Indeterminate	50-90	284
Indeterminate	50-90	280

Table 3. GPR Anomalies in the Old Burial Ground Area by Depth

Description	Estimated Depth (cm)	Anomaly ID
Indeterminate	50-90	281
Indeterminate	50-90	285
Indeterminate	85-120	279

UTILITIES (N=12)

Locational data on existing utilities was provided by MCX CMAC. The GPR results confirmed many of these locations and identified additional probable utilities (see Figure 10). In profile, utilities typically have hyperbolic reflections with clearly defined trench walls (Figure 12). Depths vary considerably, from just below the surface to as deep as 120-150 cmbs (see Table 3).

REBAR REINFORCED CONCRETE (N=1)

Anomaly 298 was identified as an area of rebar-reinforced concrete associated with the sidewalk along to Barry Drive (see Figure 10). It was located in Grid 2 on the northwest side of the survey area. In profile, individual sections of rebar are visible as crisp hyperbolic reflections just below the surface (Figure 13).

INDETERMINATES (N=7)

Seven anomalies (279, 280, 281, 282, 283, 284, and 285) were identified as indeterminates (see Figure 10). They were located in the far northeast corner of the survey area beneath a parking lot. Geo-referencing a 1918 map of the Carlisle Indian School cemetery indicated these particular anomalies are just outside or on the northeast boundary of the projected cemetery location.

Anomaly classification was based on their morphology, spatial arrangement, and presence in an area that appeared to be unaltered by modern construction activities. In plan view, these anomalies were loosely arranged in a row that parallels the area of modern construction. Their sizes range in length from 1-4 meters. In profile, they appear as a series of hyperbolic reflections in consecutive profiles (Figure 14). Depths are generally consistent, with six of the seven anomalies located between 50 and 90 cmbs, and the seventh between 85 and 120 cmbs.

The nature of these anomalies cannot be determined based on their configurations and locations. They have potential to represent construction debris scatters associated with the adjoining U.S. Army War College. Alternatively, these anomalies could represent older cultural features that are outside the impact zone of adjacent construction.

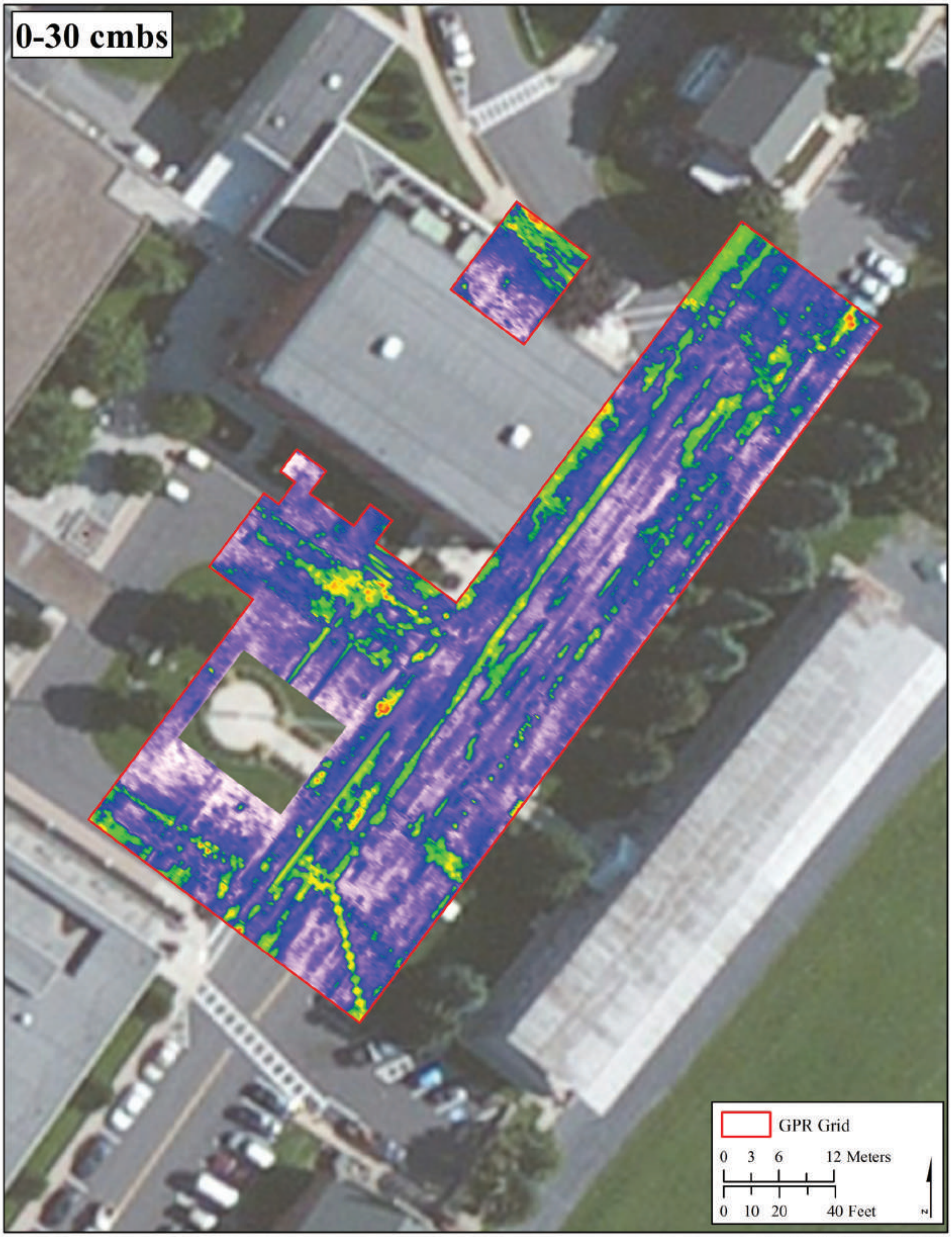
Figure 4.
Photographs Showing Existing Conditions in the Old Burial Ground Survey Area


A. Looking Northwest


B. Looking Southeast


C. Looking Northeast

Figure 5.
GPR Amplitude Slice Map, 0-30 Centimeters Below Surface (cmbs)



Imagery Source: USDA NAIP 2015

Figure 6.
GPR Amplitude Slice Map, 30-60 cmbs

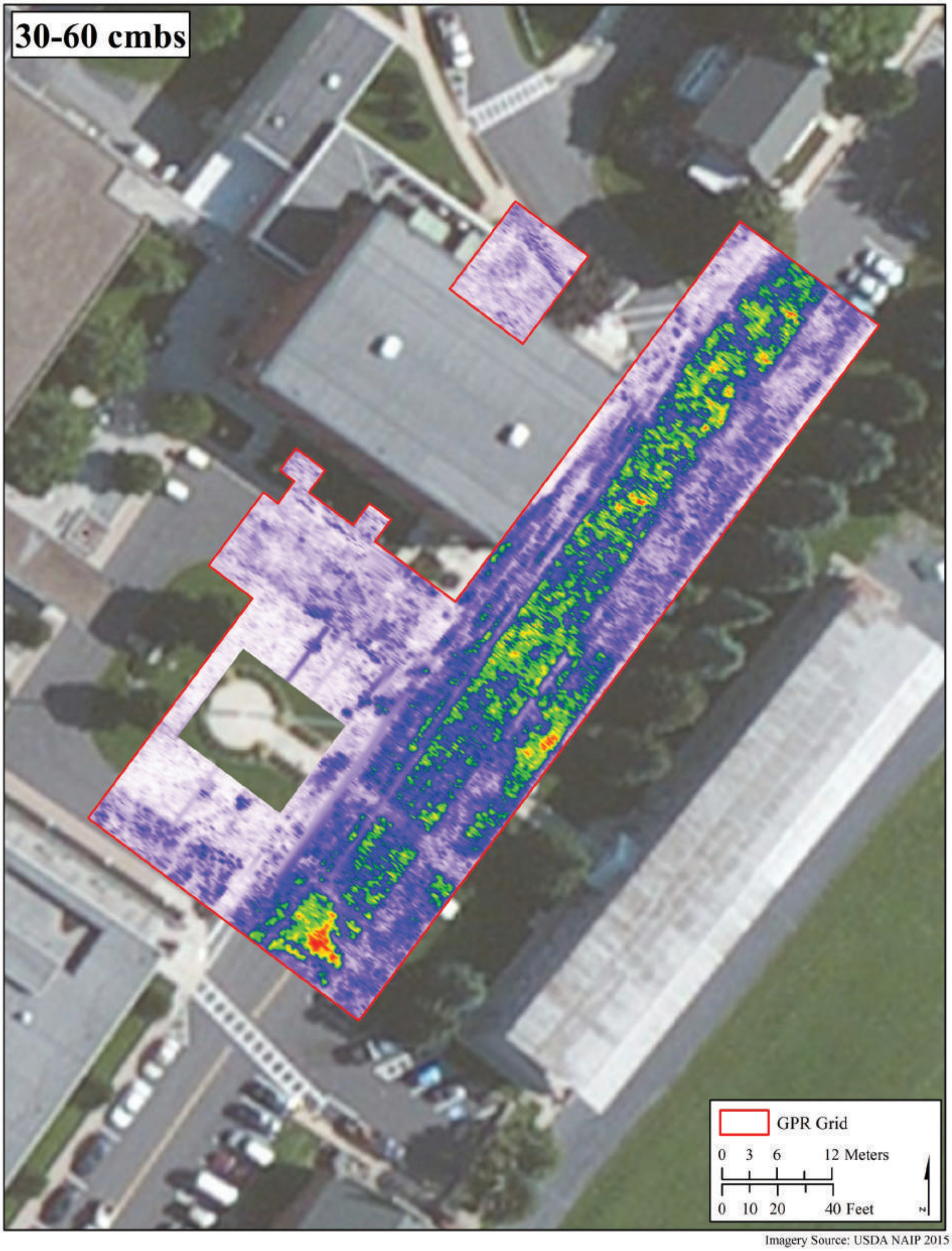
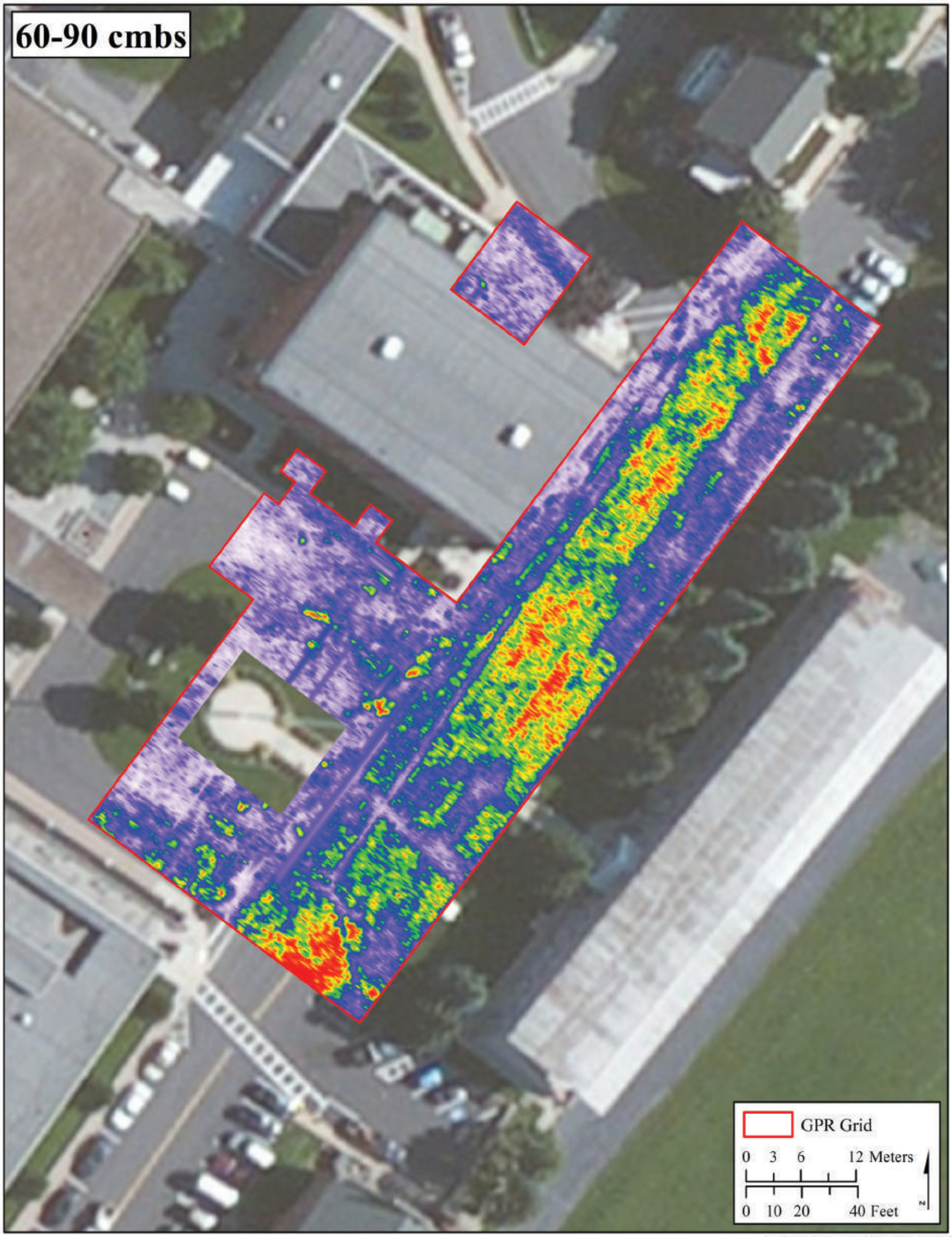


Figure 7.
GPR Amplitude Slice Map, 60-90 cmbs



Imagery Source: USDA NAIP 2015

Figure 8.
GPR Amplitude Slice Map, 90-120 cmbs

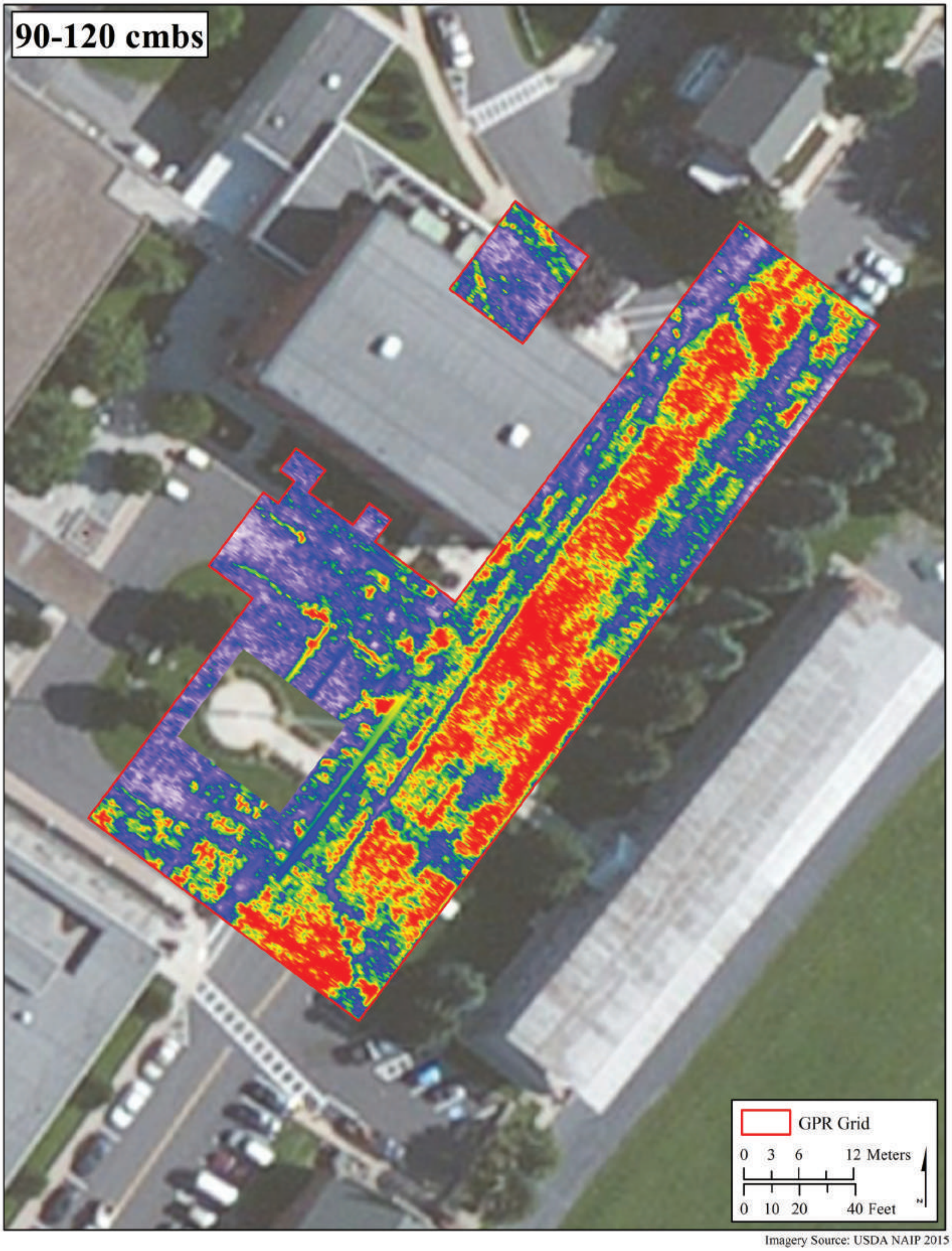
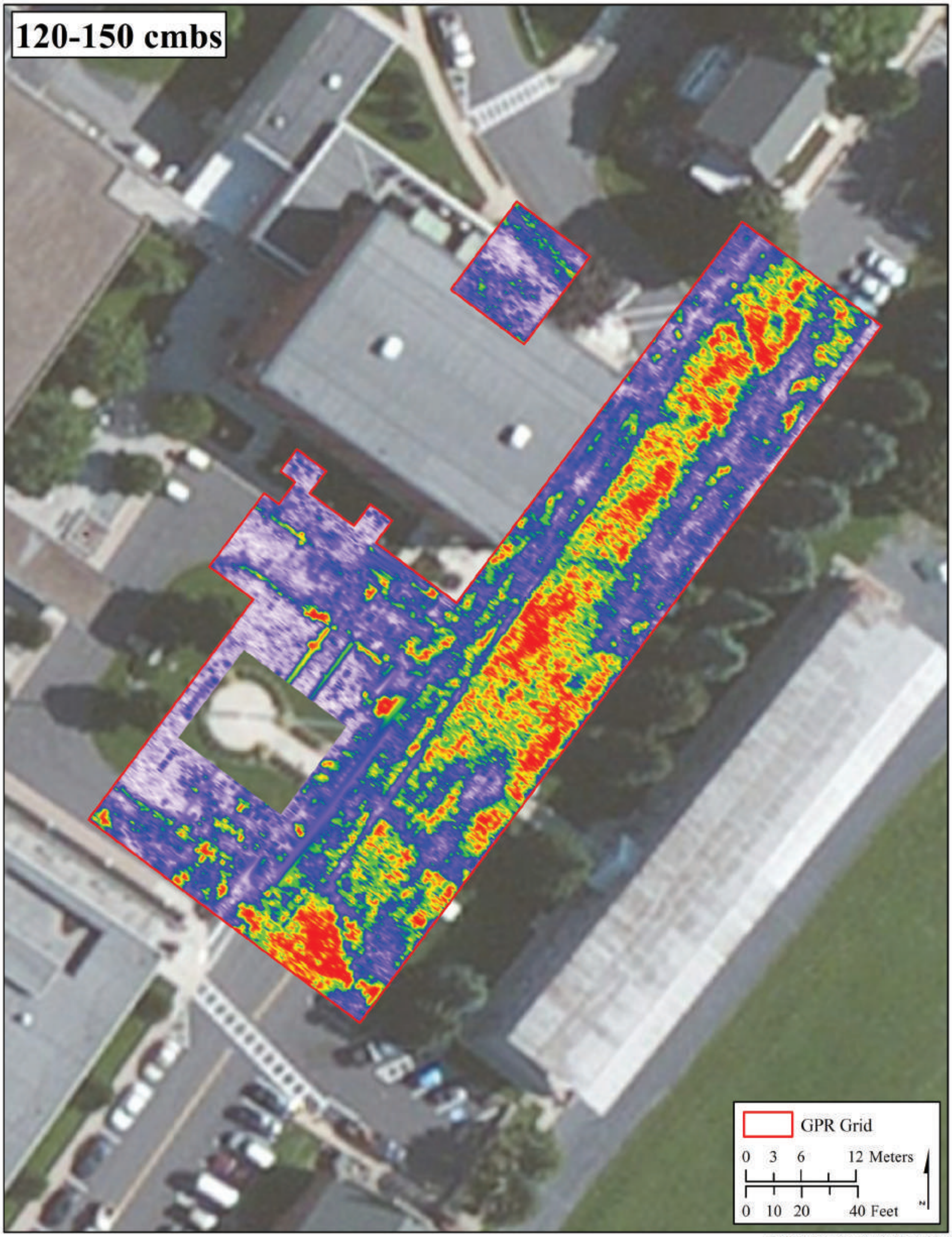
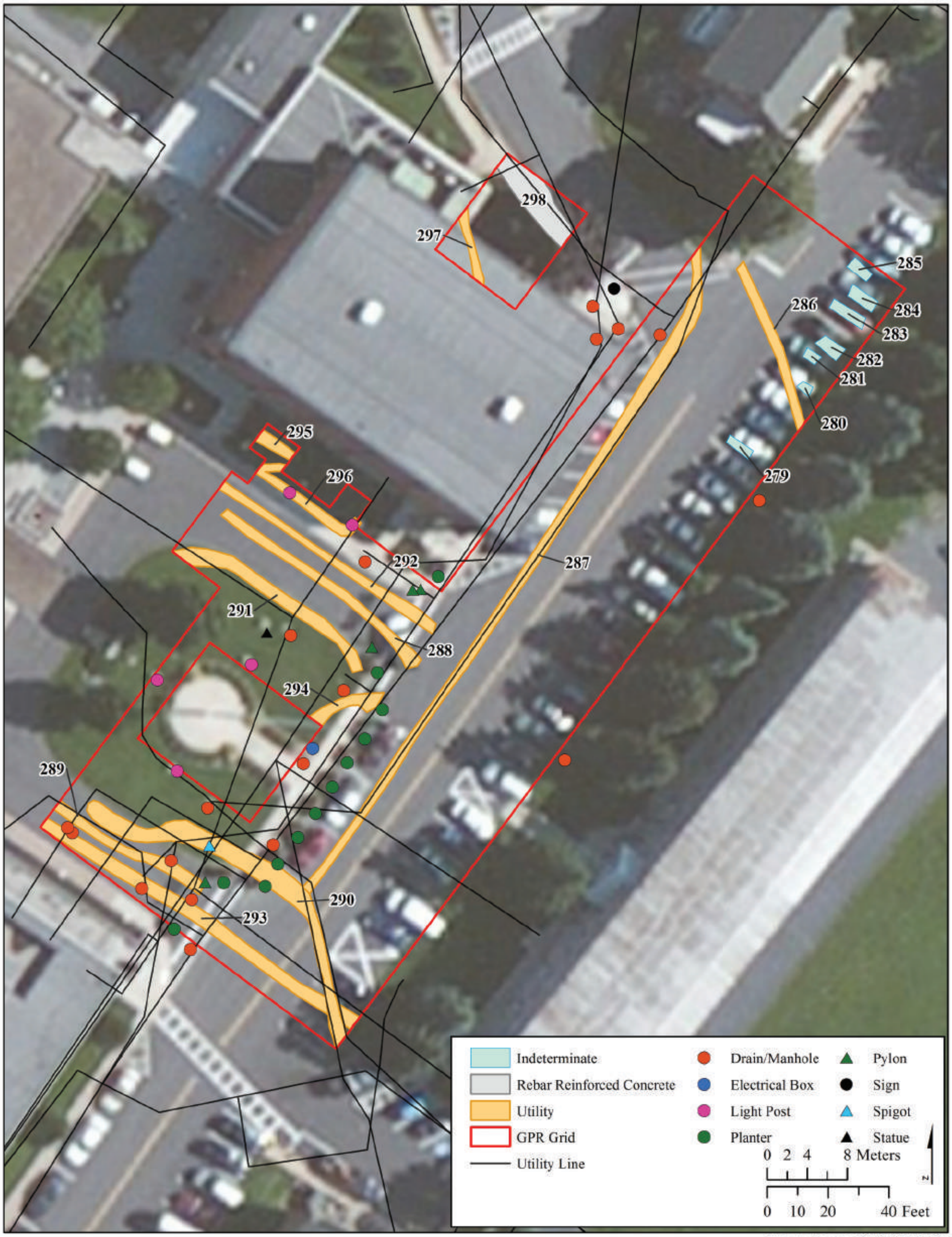


Figure 9.
GPR Amplitude Slice Map, 120-150 cmbs



Imagery Source: USDA NAIP 2015

Figure 10.
Map Showing Interpretive Results for the Old Burial Ground Survey Area



Imagery Source: USDA NAIP 2015

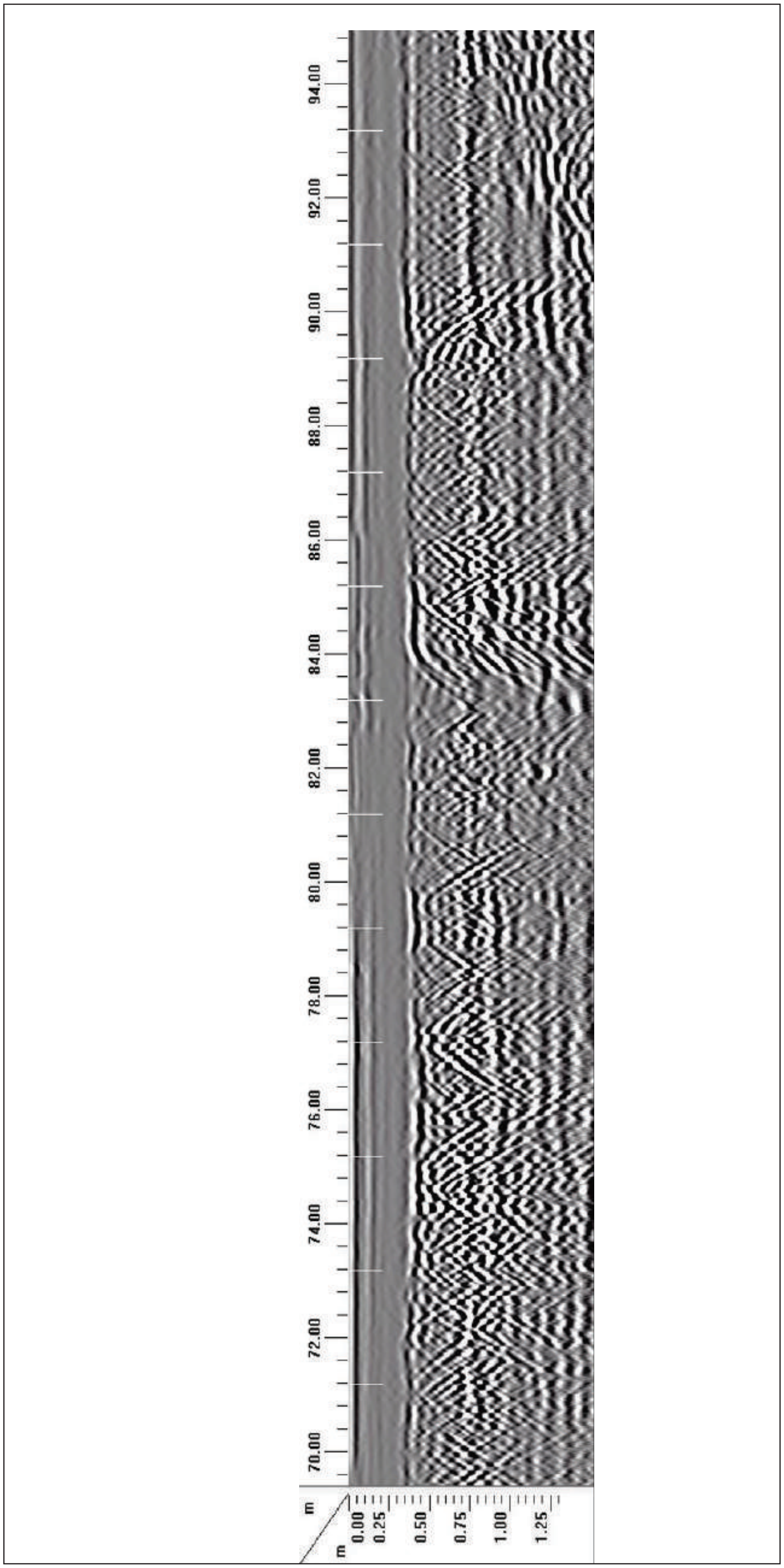
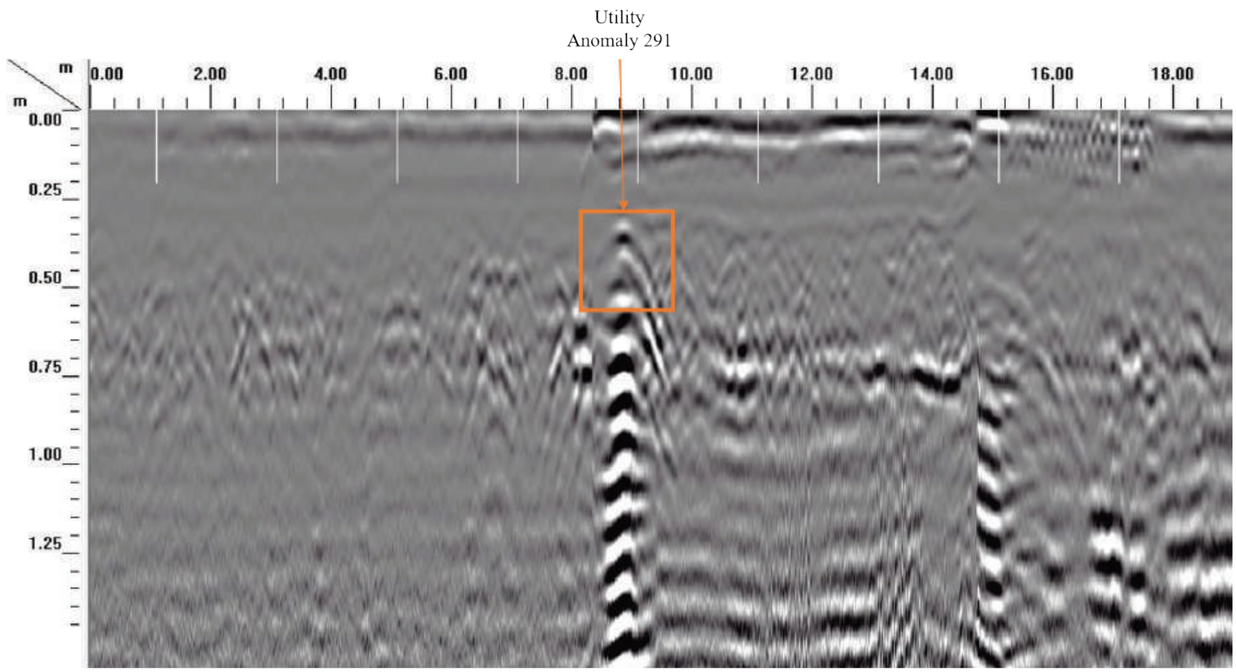


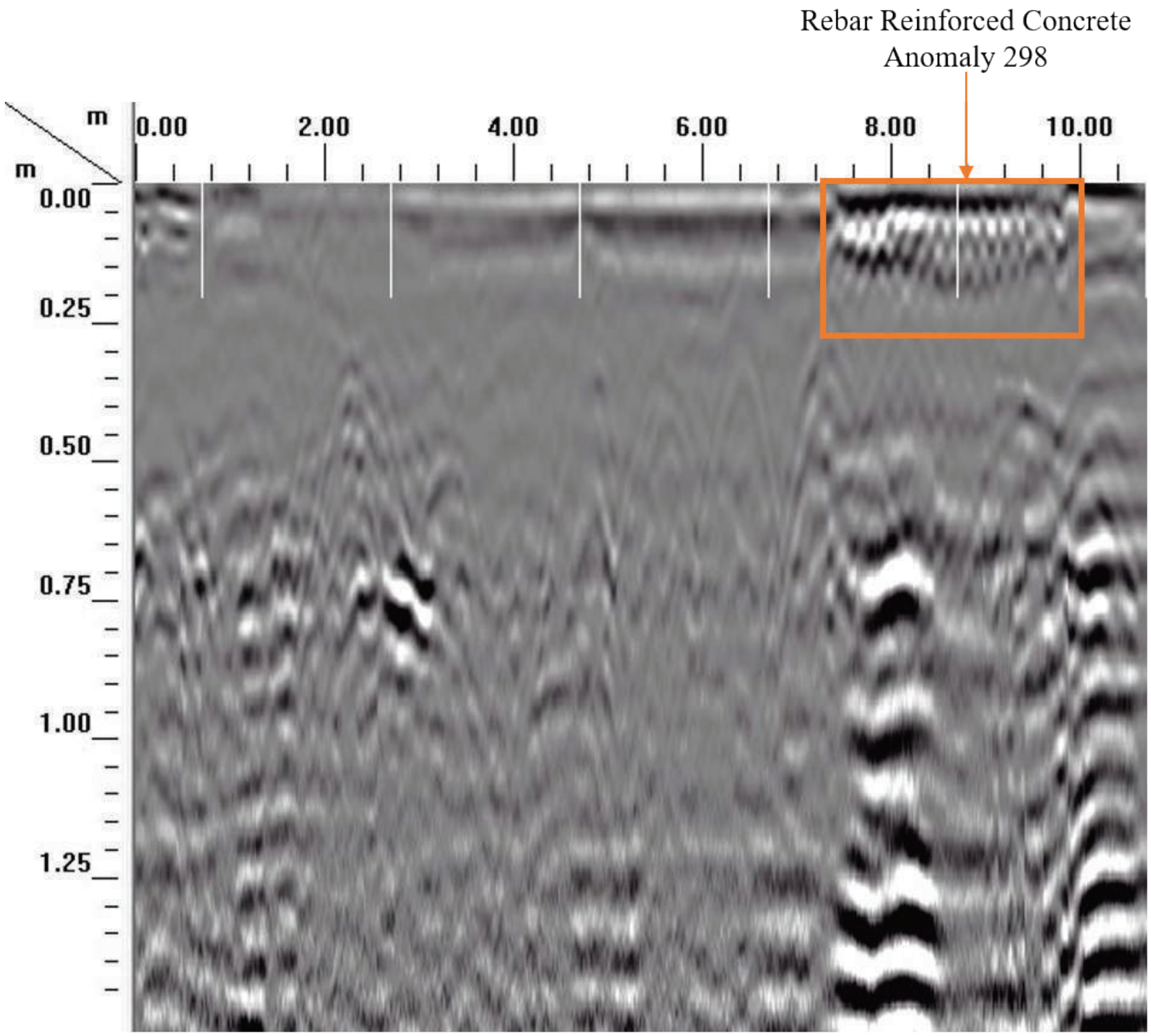
Figure 11.
Profile Showing Dense Fill Layer Along Forbes Road

Figure 12.
Profile Showing Utility Reflections



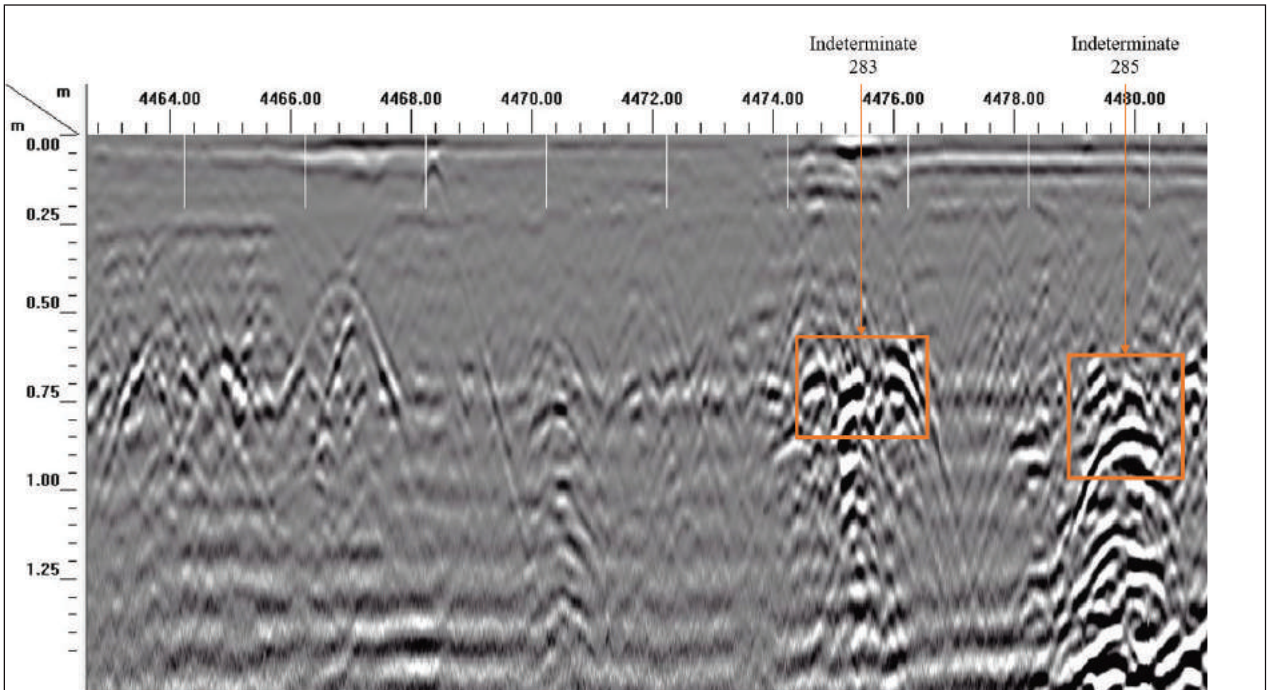
Grid 1 – Profile 84, 18.5 meters in the x-direction

Figure 13.
Profile Showing Rebar-Reinforced Concrete Or Asphalt



Grid 2 – Profile 14, 3.5 meters in the x-direction

Figure 14.
Profile Showing Indeterminate Anomalies



Grid 1 – Profile 143, 39 meters in the x-direction

These features are protected beneath the parking lot pavement and are not threatened by any known construction event. Ground-truthing through archaeological testing and trenching would be needed to determine their shape, content, and cultural association. However, such testing would require the use of a backhoe to penetrate the parking lot pavement.

CARLISLE BARRACKS POST CEMETERY

Soils in the Carlisle Barracks Post Cemetery are classified as Urban land and Udorthents (Soil Survey Staff 2016). This type consists of pavement, buildings, and other artificially covered areas. It has very high runoff and measures approximately 10 inches in thickness. However, as was found with the Old Burial Ground, conditions documented at the time of the survey are not consistent with the published description.

The Carlisle Barracks Post Cemetery is well maintained, with an iron boundary fence set in concrete, orderly rows of markers set in mulch, and grass strips between the markers (Figure 15). Ornamental vegetation is limited to a large weeping cherry tree near the center and shrubs in three of the four corners. Official records indicate the cemetery contains 228 graves, including 180 Native American graves and 48 graves of veterans, dependents, and others.

Amplitude slice maps for the Carlisle Barracks Post Cemetery are shown in Figures 16-20. The cemetery contains 228 known, marked graves. Some graves included more than one interment. GPR data show 278 distinct anomalies in two classes: probable graves with associated markers (n=223) and indeterminates (n=55). Table 4 provides the attributes of these anomalies, while Figure 21 provides sample profiles.

LIKELY GRAVES WITH ASSOCIATED MARKERS (N=223)

Two hundred and twenty-three anomalies were identified as probable graves because they are directly associated with existing markers (Figures 22 and 23, Table 4). Five of the 228 markers in the Post Cemetery do not have a corresponding GPR anomaly (Table 5). Possible reasons for the lack of an associated anomaly may include low contrast remains (i.e., present but not detected – this is likely the case for the infant burial in F30), a complete lack of remains, or a marker that was displaced from another location that has an indeterminate anomaly.

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
11	Indeterminate	40-90	3	N	4,453,046.46402	315,235.71713	0.75	1.19	0.89
42	Indeterminate	40-80	3	N	4,453,053.85742	315,245.62642	0.65	1.55	1.01
43	Indeterminate	40-70	3	N	4,453,057.16326	315,245.43871	0.66	1.16	0.77
48	Indeterminate	70-100	3	N	4,453,060.27457	315,249.16892	0.52	0.72	0.37
52	Indeterminate	70-100	3	N	4,453,060.60181	315,253.66678	0.75	1.20	0.90
62	Indeterminate	60-100	3	N	4,453,069.27757	315,260.93099	0.57	0.94	0.54
65	Indeterminate	40-90	3	N	4,453,054.68516	315,246.76700	0.63	1.44	0.91
70	Indeterminate	70-110	3	N	4,453,057.17210	315,250.27045	0.59	1.37	0.81
79	Indeterminate	40-60	3	N	4,453,063.73983	315,258.60919	0.47	1.07	0.50
87	Indeterminate	40-80	3	N	4,453,068.79355	315,265.46456	0.69	1.27	0.88
88	Indeterminate	50-90	3	N	4,453,069.31876	315,266.04710	0.54	1.44	0.78
89	Indeterminate	40-60	3	N	4,453,035.25234	315,228.12281	0.51	0.95	0.49
90	Indeterminate	40-100	3	N	4,453,036.42498	315,229.26853	0.83	1.59	1.32
102	Indeterminate	50-80	3	N	4,453,045.68155	315,239.15791	0.83	1.26	1.04
108	Indeterminate	50-80	3	N	4,453,048.46335	315,244.92591	0.60	1.28	0.78
109	Indeterminate	40-90	3	N	4,453,034.19882	315,229.63258	0.69	1.58	1.09
119	Indeterminate	50-80	3	N	4,453,040.41062	315,239.38589	0.49	1.12	0.55
128	Indeterminate	70-100	3	N	4,453,048.77245	315,247.38601	0.72	1.36	0.99
130	Indeterminate	40-60	3	N	4,453,052.97081	315,250.29919	0.70	1.48	1.04
142	Indeterminate	40-80	3	N	4,453,061.29421	315,261.60227	0.49	0.86	0.42
143	Indeterminate	60-100	3	N	4,453,062.98094	315,261.07281	0.65	1.61	1.04
145	Indeterminate	100-120	3	N	4,453,063.83988	315,262.75420	0.60	1.42	0.86
150	Indeterminate	100-120	3	N	4,453,066.59212	315,265.83010	0.59	1.03	0.60
151	Indeterminate	60-100	3	N	4,453,065.46398	315,267.04288	0.45	0.91	0.41
153	Indeterminate	40-90	3	N	4,453,049.58314	315,250.15109	0.70	1.01	0.71
154	Indeterminate	15-60	3	N	4,453,051.25341	315,250.67697	0.72	1.08	0.79
155	Indeterminate	40-80	3	N	4,453,051.12087	315,252.30807	0.66	1.32	0.88
156	Indeterminate	40-60	3	N	4,453,051.56143	315,252.92654	0.61	1.13	0.68

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
159	Indeterminate	40-100	3	N	4,453,052.71681	315,255.24619	0.77	1.76	1.35
166	Indeterminate	80-100	3	N	4,453,056.73268	315,261.22988	0.52	1.29	0.67
175	Indeterminate	60-100	3	N	4,453,064.67170	315,269.18403	0.43	1.40	0.60
176	Indeterminate	40-60	3	N	4,453,064.99236	315,269.73206	0.50	0.97	0.48
177	Indeterminate	60-100	3	N	4,453,065.38606	315,270.31122	0.73	1.18	0.86
178	Indeterminate	40-80	3	N	4,453,031.08389	315,231.47952	0.70	1.48	1.03
197	Indeterminate	40-90	3	N	4,453,046.60479	315,248.23806	0.71	1.51	1.06
205	Indeterminate	60-100	3	N	4,453,033.35622	315,238.40982	0.47	1.26	0.59
228	Indeterminate	60-90	3	N	4,453,051.15657	315,257.54734	0.61	0.87	0.53
229	Indeterminate	70-100	3	N	4,453,051.98804	315,258.29804	0.37	0.87	0.32
234	Indeterminate	60-90	3	N	4,453,054.92617	315,261.87795	0.66	1.02	0.67
243	Indeterminate	40-60	3	N	4,453,063.29386	315,270.41866	0.64	1.06	0.67
255	Indeterminate	60-100	3	N	4,453,053.11748	315,263.26574	0.40	1.17	0.47
256	Indeterminate	40-100	3	N	4,453,053.41581	315,263.85400	0.52	1.14	0.59
264	Indeterminate	40-100	3	N	4,453,059.22127	315,269.11661	0.57	1.33	0.76
267	Indeterminate	40-90	3	N	4,453,061.97010	315,271.34285	0.74	0.90	0.66
268	Indeterminate	40-80	3	N	4,453,031.06611	315,237.57580	0.67	0.94	0.63
269	Indeterminate	70-100	3	N	4,453,032.68981	315,239.22141	0.54	0.91	0.49
270	Indeterminate	40-90	3	N	4,453,034.24066	315,241.00527	0.60	1.06	0.64
271	Indeterminate	40-90	3	N	4,453,039.45475	315,248.04138	0.84	1.16	0.97
272	Indeterminate	70-100	3	N	4,453,040.74012	315,249.98486	0.62	0.87	0.53
273	Indeterminate	40-80	3	N	4,453,044.68073	315,253.95820	1.00	1.78	1.78
274	Indeterminate	40-60	3	N	4,453,047.27863	315,256.37189	0.85	1.29	1.10
275	Indeterminate	40-60	3	N	4,453,047.61286	315,258.28435	0.62	1.09	0.68
276	Indeterminate	50-100	3	N	4,453,049.26680	315,260.46553	0.63	1.24	0.79
277	Indeterminate	50-100	3	N	4,453,053.68602	315,266.30051	0.54	1.20	0.64
278	Indeterminate	40-90	3	N	4,453,058.11437	315,270.37792	0.64	1.38	0.89
1	Probable Grave	50-80	3	A1	4,453,040.48786	315,227.00154	0.42	1.52	0.64

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
2	Probable Grave	50-80	3	A2	4,453,041.28135	315,227.95640	0.56	1.69	0.94
3	Probable Grave	50-90	3	A3	4,453,042.01354	315,228.83422	0.58	1.69	0.98
4	Probable Grave	40-90	3	A4	4,453,042.76453	315,229.60279	0.54	1.11	0.60
5	Probable Grave	50-90	3	A5	4,453,043.41952	315,230.68816	0.65	1.43	0.93
6	Probable Grave	50-90	3	A6	4,453,044.20147	315,231.49374	0.51	1.36	0.69
7	Probable Grave	50-90	3	A7	4,453,044.89133	315,232.53632	0.63	1.48	0.93
8	Probable Grave	50-80	3	A8	4,453,045.53559	315,233.33227	0.46	1.39	0.64
9	Probable Grave	50-80	3	A9	4,453,046.05868	315,234.27892	0.69	1.23	0.85
10	Probable Grave	40-70	3	A10	4,453,047.51402	315,234.56012	1.00	1.06	1.06
12	Probable Grave	40-90	3	A11	4,453,047.26887	315,236.53233	0.84	1.21	1.01
13	Probable Grave	40-90	3	A32	4,453,048.04709	315,237.22962	0.65	1.91	1.25
14	Probable Grave	60-80	3	A12	4,453,049.16601	315,236.56268	0.64	0.94	0.60
15	Probable Grave	40-90	3	A13	4,453,048.96797	315,237.94001	0.74	1.27	0.94
16	Probable Grave	50-80	3	A14	4,453,049.76407	315,238.76455	0.73	1.49	1.09
17	Probable Grave	50-90	3	A15	4,453,050.42875	315,239.58459	0.71	1.69	1.19
18	Probable Grave	40-90	3	A16	4,453,051.12809	315,240.32958	0.69	1.53	1.05
19	Probable Grave	50-80	3	A17	4,453,051.85742	315,241.43701	0.78	1.50	1.17
20	Probable Grave	40-90	3	A38	4,453,051.99788	315,242.87740	0.73	1.25	0.92
21	Probable Grave	50-80	3	A21	4,453,039.28531	315,228.52062	0.54	1.33	0.71
22	Probable Grave	50-100	3	A22	4,453,039.84921	315,229.16418	0.51	1.42	0.73
23	Probable Grave	50-90	3	A23	4,453,040.78491	315,230.18069	0.56	1.51	0.85
24	Probable Grave	50-90	3	A24	4,453,041.58871	315,231.00172	0.41	1.83	0.75
25	Probable Grave	40-80	3	A25	4,453,042.01832	315,232.02552	0.55	1.42	0.79
26	Probable Grave	40-90	3	A26	4,453,042.90124	315,232.88548	0.62	1.37	0.84
27	Probable Grave	40-80	3	A27	4,453,043.82571	315,233.47093	0.69	1.02	0.70
28	Probable Grave	40-90	3	A28	4,453,044.46630	315,234.32153	0.40	0.81	0.33
29	Probable Grave	50-80	3	A29	4,453,044.92350	315,235.45397	0.66	1.52	1.00
30	Probable Grave	50-80	3	A30	4,453,045.43956	315,236.75165	0.57	1.19	0.67

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
31	Probable Grave	40-90	3	A31	4,453,046.15011	315,237.64514	0.67	1.58	1.06
32	Probable Grave	40-90	3	A32	4,453,046.91540	315,238.88020	0.65	1.66	1.07
33	Probable Grave	70-100	3	A33	4,453,048.15584	315,239.02036	0.62	0.84	0.52
34	Probable Grave	40-90	3	A34	4,453,048.35162	315,240.39854	0.60	1.19	0.71
35	Probable Grave	50-90	3	A35	4,453,049.45971	315,241.30680	0.63	1.66	1.05
36	Probable Grave	40-90	3	A36	4,453,049.89711	315,242.16515	0.44	1.14	0.50
37	Probable Grave	70-100	3	A37	4,453,050.43730	315,243.30930	0.59	1.13	0.67
38	Probable Grave	40-90	3	A19	4,453,053.11041	315,242.92534	0.58	0.97	0.57
39	Probable Grave	40-90	3	A20	4,453,053.97179	315,243.63205	0.55	1.44	0.79
40	Probable Grave	50-90	3	A39	4,453,051.94887	315,244.11310	0.68	1.29	0.88
41	Probable Grave	40-90	3	A40	4,453,053.08273	315,244.64845	0.51	1.11	0.56
44	Probable Grave	40-90	3	F1	4,453,056.20626	315,246.81115	0.70	1.53	1.08
45	Probable Grave	40-90	3	F2	4,453,057.10809	315,247.93714	0.59	1.30	0.77
46	Probable Grave	70-100	3	F3	4,453,057.98839	315,248.28893	0.64	1.37	0.88
47	Probable Grave	50-80	3	F4	4,453,058.49255	315,248.99348	0.65	1.29	0.83
49	Probable Grave	70-80	3	F5	4,453,059.52086	315,250.34773	0.35	0.81	0.29
50	Probable Grave	70-90	3	F6	4,453,059.86889	315,251.12241	0.55	1.07	0.59
51	Probable Grave	40-90	3	F8	4,453,060.76039	315,252.00400	0.50	1.39	0.70
53	Probable Grave	70-100	3	F9	4,453,061.59530	315,253.17908	0.46	0.79	0.36
54	Probable Grave	70-100	3	F10	4,453,061.99331	315,253.81380	0.54	1.21	0.66
55	Probable Grave	50-80	3	F11	4,453,063.28576	315,254.27695	0.56	1.43	0.80
56	Probable Grave	40-80	3	F12	4,453,064.50661	315,256.59760	0.49	1.27	0.62
57	Probable Grave	40-80	3	F13	4,453,064.97407	315,257.30372	0.54	1.44	0.78
58	Probable Grave	40-80	3	F14	4,453,065.50047	315,258.02207	0.64	1.25	0.80
59	Probable Grave	50-80m	3	F15	4,453,066.47247	315,259.22412	0.48	0.73	0.35
60	Probable Grave	70-100	3	F16	4,453,066.89442	315,259.82883	0.49	0.97	0.47
61	Probable Grave	60-90	3	F17	4,453,067.33329	315,260.40444	0.56	0.91	0.51
63	Probable Grave	60-100	3	F19	4,453,068.75318	315,262.31049	0.58	0.91	0.53

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
64	Probable Grave	50-80	3	F20	4,453,071.05494	315,263.22673	0.64	1.05	0.66
66	Probable Grave	60-100	3	F21	4,453,054.86080	315,247.89012	0.62	1.28	0.79
67	Probable Grave	60-80	3	F22	4,453,055.59620	315,248.71515	0.47	1.10	0.52
68	Probable Grave	70-90	3	F23	4,453,055.68700	315,249.36450	0.46	1.36	0.63
69	Probable Grave	60-100	3	F24	4,453,055.92167	315,250.16738	0.63	1.19	0.75
71	Probable Grave	40-100	3	F25	4,453,057.58667	315,251.06890	0.57	1.73	0.98
72	Probable Grave	40-100	3	F26	4,453,056.98523	315,252.79981	0.65	1.96	1.27
73	Probable Grave	50-100	3	F27	4,453,058.32719	315,253.12855	0.64	1.25	0.80
74	Probable Grave	40-80	3	F28	4,453,059.08373	315,253.62156	0.56	1.22	0.68
75	Probable Grave	80-100	3	F29	4,453,059.79181	315,254.83494	0.64	0.77	0.49
76	Probable Grave	40-100	3	F31	4,453,061.68599	315,255.78513	0.65	0.81	0.53
77	Probable Grave	40-80	3	F32	4,453,062.12797	315,256.85996	0.59	1.21	0.72
78	Probable Grave	50-100	3	F33	4,453,062.85861	315,257.82193	0.69	1.20	0.82
80	Probable Grave	40-100	3	F34	4,453,064.31484	315,259.09970	0.61	1.31	0.80
81	Probable Grave	40-100	3	F35	4,453,064.76283	315,260.21901	0.68	1.27	0.87
82	Probable Grave	40-80	3	F36	4,453,065.31946	315,261.59501	0.70	1.53	1.08
83	Probable Grave	40-100	3	F37	4,453,066.26901	315,262.43608	0.60	1.48	0.88
84	Probable Grave	60-80	3	F38	4,453,067.33374	315,262.92098	0.69	0.72	0.50
85	Probable Grave	50-80	3	F39	4,453,067.67204	315,264.12733	0.54	1.01	0.54
86	Probable Grave	40-100	3	F40	4,453,068.22866	315,264.88798	0.55	1.18	0.65
91	Probable Grave	60-100	3	B1	4,453,036.83890	315,230.00348	0.70	1.44	1.01
92	Probable Grave	60-100	3	B2	4,453,037.29695	315,230.80953	0.59	1.89	1.11
93	Probable Grave	40-90	3	B3	4,453,038.23324	315,232.26824	0.76	1.53	1.16
94	Probable Grave	40-90	3	B4	4,453,038.94441	315,233.13402	0.60	1.48	0.88
95	Probable Grave	60-100	3	B5	4,453,039.69452	315,234.05362	0.65	1.71	1.12
96	Probable Grave	40-90	3	B6	4,453,040.39396	315,234.93301	0.71	1.62	1.16
97	Probable Grave	40-100	3	B7	4,453,040.95157	315,236.02255	0.55	1.89	1.05
98	Probable Grave	40-100	3	B8	4,453,041.41371	315,236.99161	0.55	1.56	0.86

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
99	Probable Grave	40-90	3	B9	4,453,042.66024	315,237.54491	0.74	1.65	1.22
100	Probable Grave	60-100	3	B10	4,453,043.24094	315,238.58432	0.58	1.45	0.84
101	Probable Grave	60-100	3	B11	4,453,043.89669	315,239.47250	0.69	1.50	1.03
103	Probable Grave	60-100	3	B12	4,453,044.51215	315,240.37124	0.77	1.75	1.35
104	Probable Grave	40-100	3	B13	4,453,045.14636	315,241.45195	0.62	1.90	1.18
105	Probable Grave	60-100	3	B15	4,453,046.16181	315,242.25161	0.63	1.75	1.10
106	Probable Grave	60-80	3	B16	4,453,046.90459	315,243.03032	0.73	1.31	0.95
107	Probable Grave	50-100	3	B17	4,453,047.63226	315,244.04202	0.58	1.56	0.90
110	Probable Grave	50-90	3	B18	4,453,035.41559	315,231.50034	0.76	2.03	1.54
111	Probable Grave	40-90	3	B19	4,453,035.65890	315,232.76601	0.78	1.82	1.42
112	Probable Grave	60-100	3	B20	4,453,036.40951	315,233.59712	0.74	1.67	1.24
113	Probable Grave	50-80	3	B21	4,453,037.31237	315,234.34149	0.65	1.81	1.18
114	Probable Grave	40-100	3	B22	4,453,037.83846	315,235.26255	0.43	1.45	0.62
115	Probable Grave	50-80	3	B23	4,453,038.26980	315,236.62147	0.66	1.64	1.08
116	Probable Grave	50-90	3	B24	4,453,039.18186	315,237.23687	0.58	1.39	0.81
117	Probable Grave	50-90	3	B25	4,453,039.66393	315,238.23029	0.48	1.34	0.65
118	Probable Grave	50-90	3	B26	4,453,039.97887	315,238.81327	0.54	1.42	0.76
120	Probable Grave	50-100	3	B27	4,453,040.84303	315,240.06317	0.60	1.65	0.98
121	Probable Grave	50-100	3	B28	4,453,042.38848	315,240.45390	0.67	1.29	0.86
122	Probable Grave	50-80	3	B29	4,453,042.86621	315,241.51132	0.53	1.46	0.77
123	Probable Grave	50-80	3	B30	4,453,043.53069	315,242.65438	0.45	1.18	0.53
124	Probable Grave	40-80	3	B31	4,453,044.40141	315,243.26259	0.65	1.10	0.72
125	Probable Grave	40-80	3	B32	4,453,045.18169	315,244.38481	0.47	1.31	0.61
126	Probable Grave	40-100	3	B33	4,453,045.99124	315,245.11348	0.65	1.68	1.09
127	Probable Grave	40-60	3	B34	4,453,046.87241	315,245.75639	0.63	1.32	0.83
129	Probable Grave	50-80	3	Y	4,453,050.82846	315,249.06197	0.75	1.61	1.21
131	Probable Grave	70-100	3	E1	4,453,053.70103	315,251.01410	0.60	1.60	0.96
132	Probable Grave	40-80	3	E2	4,453,055.38471	315,251.92660	0.81	1.04	0.85

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
133	Probable Grave	60-90	3	E18	4,453,054.20128	315,252.73581	0.53	0.93	0.50
134	Probable Grave	40-90	3	E4	4,453,055.59208	315,254.50971	0.74	1.83	1.35
135	Probable Grave	40-90	3	E5	4,453,056.51299	315,255.29639	0.58	1.52	0.89
136	Probable Grave	40-80	3	E6	4,453,057.32479	315,256.13245	0.72	1.72	1.24
137	Probable Grave	50-100	3	E7	4,453,058.11940	315,257.10389	0.54	1.32	0.70
138	Probable Grave	40-100	3	E8	4,453,058.65966	315,257.92161	0.96	1.69	1.63
139	Probable Grave	60-100	3	E9	4,453,059.43788	315,258.84521	0.68	1.36	0.92
140	Probable Grave	50-90	3	E10	4,453,060.17339	315,259.79602	0.48	1.34	0.64
141	Probable Grave	40-80	3	E11	4,453,060.86675	315,260.74746	0.59	1.27	0.75
144	Probable Grave	40-100	3	E12	4,453,062.30789	315,262.84968	0.53	1.81	0.96
146	Probable Grave	40-80	3	E13	4,453,062.77004	315,263.76657	0.75	0.99	0.74
147	Probable Grave	40-90	3	E14	4,453,063.59325	315,264.70253	0.61	0.97	0.59
148	Probable Grave	40-90	3	E15	4,453,064.63362	315,265.43315	0.60	1.47	0.88
149	Probable Grave	40-90	3	E16	4,453,065.06167	315,266.16230	0.56	1.50	0.84
152	Probable Grave	40-90	3	E17	4,453,065.99503	315,267.63353	0.56	1.83	1.02
157	Probable Grave	60-80	3	E18	4,453,052.25286	315,253.77061	0.55	1.02	0.56
158	Probable Grave	40-90	3	E19	4,453,053.86454	315,253.83221	0.60	1.34	0.81
160	Probable Grave	40-100	3	E20	4,453,053.75827	315,255.30629	0.74	1.38	1.02
161	Probable Grave	40-90	3	E21	4,453,054.07444	315,256.84351	0.80	1.49	1.19
162	Probable Grave	60-100	3	E22	4,453,055.46348	315,257.17939	0.72	1.45	1.04
163	Probable Grave	40-90	3	E23	4,453,055.50347	315,258.82795	0.68	1.85	1.26
164	Probable Grave	70-100	3	E24	4,453,056.16120	315,259.53185	0.63	1.63	1.03
165	Probable Grave	70-100	3	E25	4,453,056.60695	315,260.22875	0.63	1.64	1.03
167	Probable Grave	70-100	3	E26	4,453,057.74364	315,261.36090	0.60	1.59	0.95
168	Probable Grave	60-100	3	E27	4,453,059.04394	315,261.60994	0.58	1.70	0.99
169	Probable Grave	60-100	3	E28	4,453,060.05583	315,262.70495	0.74	1.51	1.12
170	Probable Grave	80-100	3	E29	4,453,060.83827	315,263.50389	0.64	1.70	1.09
171	Probable Grave	60-100	3	E30	4,453,060.71530	315,264.98168	0.65	1.35	0.88

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
172	Probable Grave	20-60	3	E31	4,453,062.22922	315,266.12097	0.45	1.47	0.66
173	Probable Grave	20-40	3	E32	4,453,063.32314	315,266.28004	0.65	1.23	0.80
174	Probable Grave	60-100	3	E34	4,453,064.05532	315,267.71291	0.66	1.67	1.11
179	Probable Grave	50-80	3	C1	4,453,033.24908	315,233.27218	0.71	1.64	1.16
180	Probable Grave	50-80	3	C2	4,453,033.06687	315,234.98835	0.67	1.46	0.99
181	Probable Grave	60-90	3	C3	4,453,034.20091	315,235.13581	0.50	1.02	0.51
182	Probable Grave	40-100	3	C4	4,453,034.87297	315,236.26523	0.43	0.86	0.37
183	Probable Grave	70-100	3	C5	4,453,035.48868	315,236.94091	0.56	1.03	0.58
184	Probable Grave	40-100	3	C6	4,453,036.46936	315,237.79826	0.71	1.36	0.96
185	Probable Grave	50-80	3	C7	4,453,037.33632	315,238.00986	0.58	1.40	0.82
186	Probable Grave	40-80	3	C8	4,453,037.47352	315,239.94879	0.40	0.89	0.35
187	Probable Grave	40-80	3	C9	4,453,038.02155	315,241.46047	0.49	1.19	0.58
188	Probable Grave	40-100	3	C10	4,453,039.09220	315,241.44831	0.54	0.99	0.53
189	Probable Grave	50-80	3	C11	4,453,039.57163	315,242.82672	0.48	0.86	0.41
190	Probable Grave	60-80	3	C12	4,453,040.54840	315,243.36158	0.53	0.90	0.48
191	Probable Grave	50-90	3	C13	4,453,041.02948	315,244.43631	0.52	1.40	0.72
192	Probable Grave	50-100	3	C14	4,453,041.54799	315,245.36246	0.52	1.76	0.92
193	Probable Grave	40-100	3	C15	4,453,042.76899	315,246.19430	0.52	1.38	0.72
194	Probable Grave	60-100	3	C16	4,453,043.13034	315,247.20847	0.57	1.00	0.57
195	Probable Grave	40-80	3	C17	4,453,044.33981	315,247.77193	0.56	1.25	0.70
196	Probable Grave	60-90	3	C18	4,453,044.81290	315,248.61517	0.51	1.08	0.55
198	Probable Grave	30-60	3	C19	4,453,045.44348	315,249.55657	0.71	1.10	0.78
199	Probable Grave	60-110	3	C20	4,453,046.61253	315,249.97273	0.56	0.96	0.53
200	Probable Grave	40-100	3	C21	4,453,031.15249	315,234.55126	0.75	1.89	1.41
201	Probable Grave	50-80	3	C22	4,453,031.58322	315,235.69716	0.51	0.86	0.44
202	Probable Grave	60-90	3	C23	4,453,032.17564	315,236.62936	0.58	1.03	0.60
203	Probable Grave	50-80	3	C24	4,453,033.84806	315,236.43145	0.46	0.99	0.46
204	Probable Grave	50-80	3	C25	4,453,034.38246	315,237.48046	0.55	1.07	0.58

Table 4. GPR Anomalies in the Post Cemetery

Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
206	Probable Grave	40-100	3	C26	4,453,034.76171	315,239.11162	0.57	1.12	0.64
207	Probable Grave	50-100	3	C27	4,453,035.48465	315,240.06990	0.50	1.41	0.70
208	Probable Grave	40-100	3	C28	4,453,036.18047	315,240.23663	0.50	1.02	0.52
209	Probable Grave	50-80	3	C29	4,453,036.84296	315,242.03446	0.55	1.32	0.72
210	Probable Grave	40-90	3	C30	4,453,037.47801	315,242.88910	0.53	1.44	0.76
211	Probable Grave	40-100	3	C31	4,453,038.14893	315,243.41483	0.62	1.76	1.10
212	Probable Grave	80-100	3	C32	4,453,039.19984	315,244.04362	0.50	0.84	0.42
213	Probable Grave	60-100	3	C33	4,453,039.58200	315,245.30890	0.53	1.38	0.74
214	Probable Grave	60-100	3	C34	4,453,039.87232	315,246.59369	0.52	0.82	0.43
215	Probable Grave	40-90	3	C35	4,453,040.76963	315,247.62770	0.47	0.89	0.42
216	Probable Grave	40-100	3	C36	4,453,041.65780	315,248.08020	0.57	1.80	1.03
217	Probable Grave	60-80	3	C37	4,453,042.51832	315,248.83003	0.57	1.33	0.76
218	Probable Grave	40-80	3	C38	4,453,043.19668	315,249.82954	0.64	1.36	0.87
219	Probable Grave	40-80	3	C39	4,453,044.00522	315,250.48122	0.74	1.45	1.07
220	Probable Grave	40-100	3	C40	4,453,044.59198	315,251.42565	0.67	1.56	1.04
221	Probable Grave	60-100	3	D1	4,453,047.78471	315,252.73304	0.83	0.96	0.79
222	Probable Grave	40-60	3	D2	4,453,049.52403	315,252.36648	0.68	1.26	0.86
223	Probable Grave	40-80	3	D3	4,453,049.73703	315,253.78327	0.55	1.48	0.81
224	Probable Grave	90-110	3	D4	4,453,050.43970	315,254.62456	0.72	1.29	0.92
225	Probable Grave	90-110	3	D5	4,453,050.81769	315,255.57187	0.59	1.16	0.69
226	Probable Grave	60-90	3	D6	4,453,051.33196	315,256.36538	0.44	1.10	0.48
227	Probable Grave	60-90	3	D7	4,453,052.30006	315,257.23924	0.60	1.03	0.61
230	Probable Grave	60-90	3	D8	4,453,053.05339	315,258.25324	0.43	0.95	0.41
231	Probable Grave	60-90	3	D9	4,453,053.81187	315,259.20437	0.59	0.91	0.54
232	Probable Grave	60-90	3	D10	4,453,054.14951	315,259.93631	0.50	1.26	0.63
233	Probable Grave	60-80	3	D11	4,453,054.21078	315,261.04132	0.51	0.97	0.50
235	Probable Grave	60-80	3	D12	4,453,055.72202	315,262.97592	0.63	1.02	0.64
236	Probable Grave	70-100	3	D13	4,453,056.36300	315,263.76221	0.53	1.24	0.66

Table 4. GPR Anomalies in the Post Cemetery

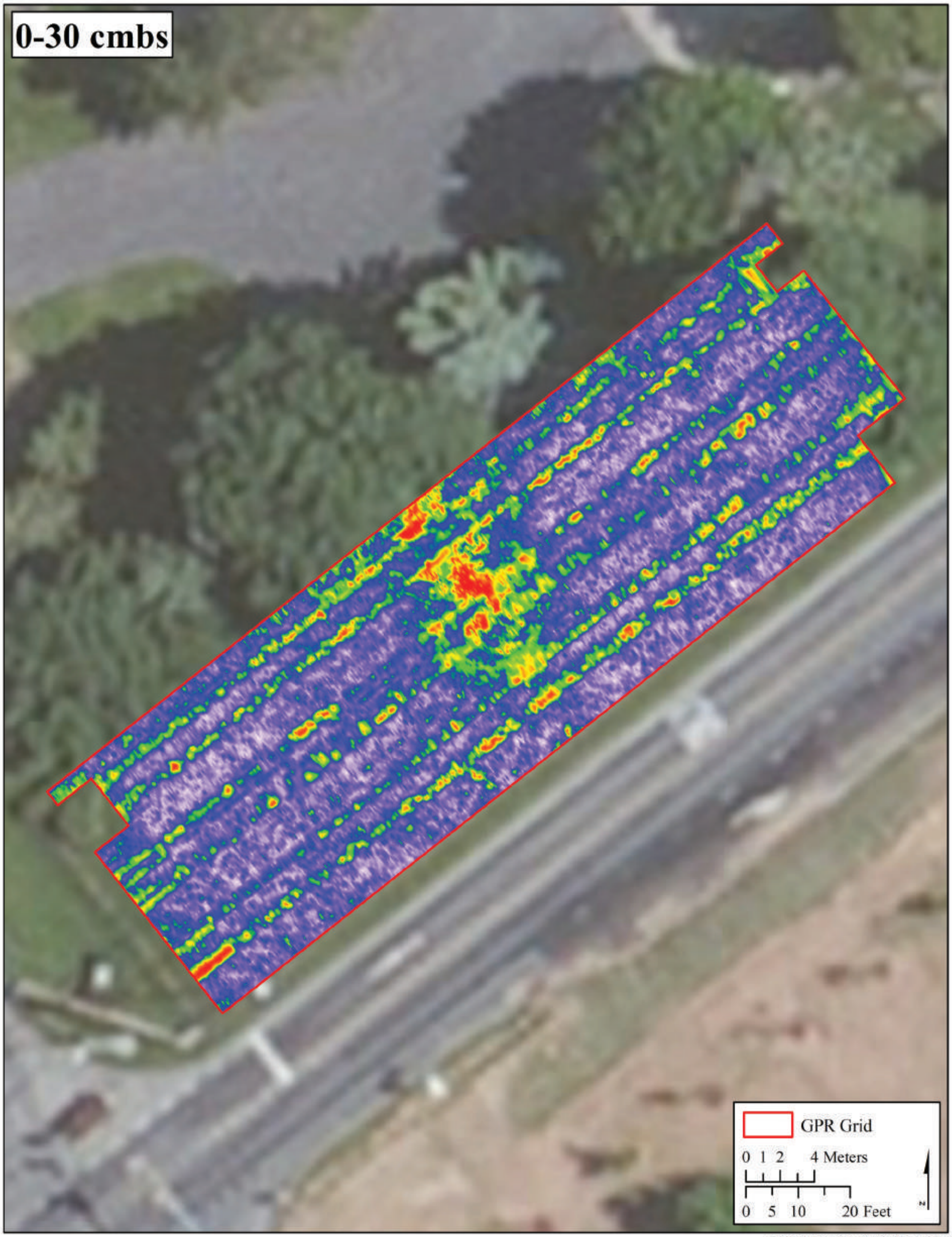
Anomaly ID	Description	Estimated Depth (cm)	GPR Grid	Marked	UTM Northing	UTM Easting	Width (meters)	Length (meters)	Area (square meters)
237	Probable Grave	70-100	3	D14	4,453,057.65237	315,263.46802	0.56	1.21	0.68
238	Probable Grave	40-90	3	D15	4,453,057.54519	315,264.56793	0.51	1.38	0.71
239	Probable Grave	60-100	3	D16	4,453,057.82288	315,265.65524	0.66	0.95	0.63
240	Probable Grave	40-80	3	D17	4,453,058.99073	315,266.13902	0.51	1.81	0.93
241	Probable Grave	40-60	3	D19	4,453,061.41668	315,268.36994	0.61	1.03	0.62
242	Probable Grave	40-60	3	D20	4,453,062.42188	315,269.13689	0.70	1.40	0.98
244	Probable Grave	40-90	3	D21	4,453,046.49355	315,253.74990	0.70	1.48	1.03
245	Probable Grave	40-90	3	D22	4,453,047.98582	315,254.17801	0.74	1.05	0.78
246	Probable Grave	40-90	3	D23	4,453,048.56117	315,255.05593	0.50	1.30	0.65
247	Probable Grave	30-70	3	D24	4,453,048.64329	315,256.46575	0.67	1.18	0.80
248	Probable Grave	40-80	3	D25	4,453,049.29214	315,257.33675	0.81	1.48	1.21
249	Probable Grave	40-100	3	D26	4,453,049.79148	315,258.28021	0.64	1.27	0.81
250	Probable Grave	40-100	3	D27	4,453,050.43081	315,259.25321	0.68	1.68	1.15
251	Probable Grave	60-100	3	D28	4,453,051.30947	315,259.88032	0.74	1.54	1.13
252	Probable Grave	40-100	3	D29	4,453,051.94685	315,260.92088	0.86	1.36	1.17
253	Probable Grave	40-100	3	D30	4,453,052.57649	315,261.67902	0.81	1.33	1.08
254	Probable Grave	40-90	3	D31	4,453,053.08285	315,262.55477	0.46	1.20	0.55
257	Probable Grave	30-90	3	D32	4,453,054.34067	315,264.04496	0.59	1.62	0.95
258	Probable Grave	40-80	3	D33	4,453,055.13644	315,264.57162	0.69	1.40	0.96
259	Probable Grave	40-90	3	D34	4,453,055.11484	315,266.15403	0.64	1.62	1.03
260	Probable Grave	40-60	3	D35	4,453,056.27344	315,265.92769	0.60	1.71	1.02
261	Probable Grave	40-90	3	D36	4,453,057.00296	315,266.39598	0.57	0.90	0.51
262	Probable Grave	40-90	3	D37	4,453,057.29698	315,267.42768	0.64	1.35	0.86
263	Probable Grave	40-100	3	D38	4,453,058.29178	315,268.06757	0.62	1.96	1.22
265	Probable Grave	40-100	3	D39	4,453,060.31226	315,269.61176	0.88	1.21	1.06

Figure 15.
Photographs Showing Existing Conditions in the Carlisle Barracks Post Cemetery Area

A. Cemetery Looking Northeast

B. Cemetery Looking Southwest

Figure 16.
GPR Amplitude Slice Map, 0-30 cmbs

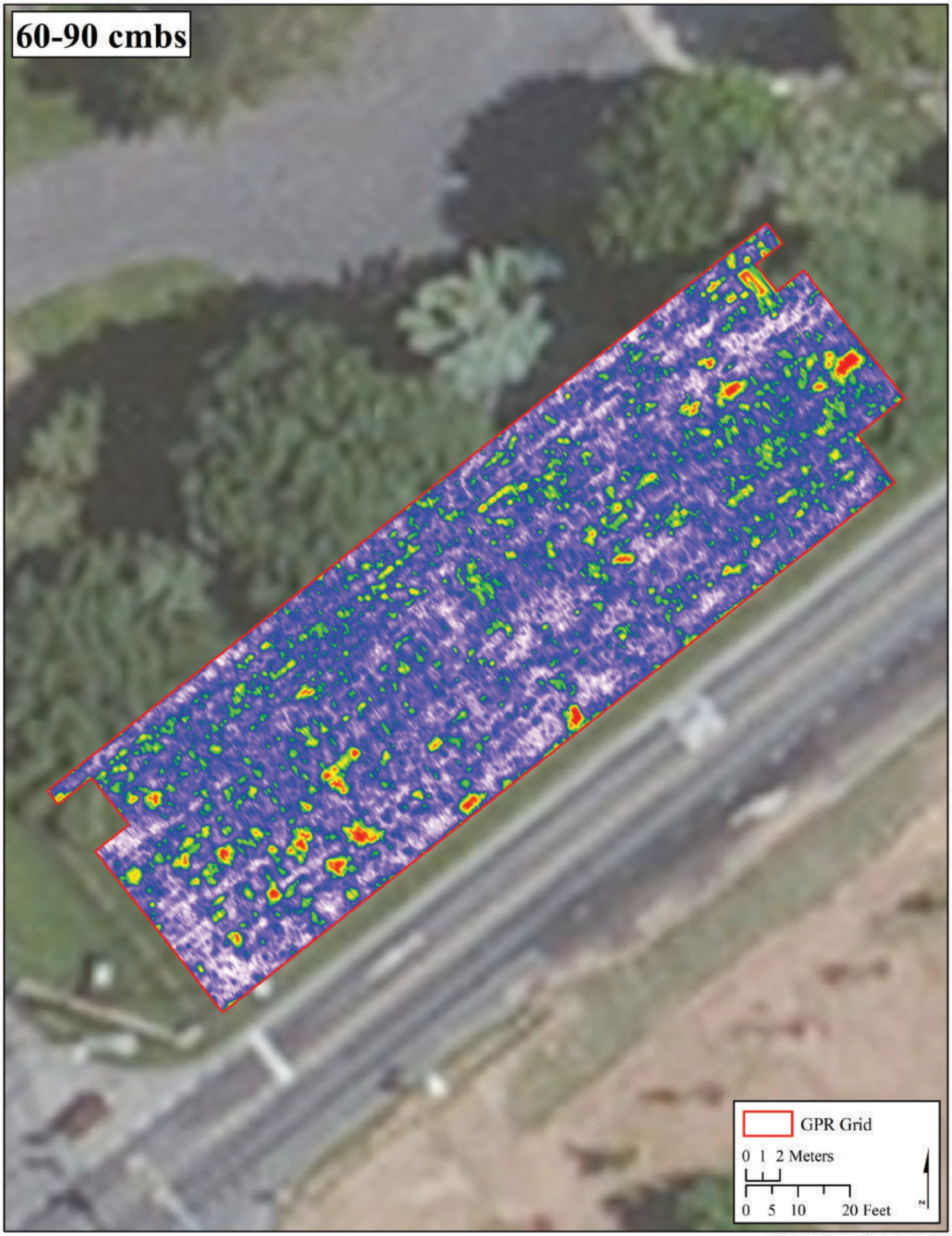


Imagery Source: USDA NAIP 2015

Figure 17.
GPR Amplitude Slice Map, 30-60 cmbs

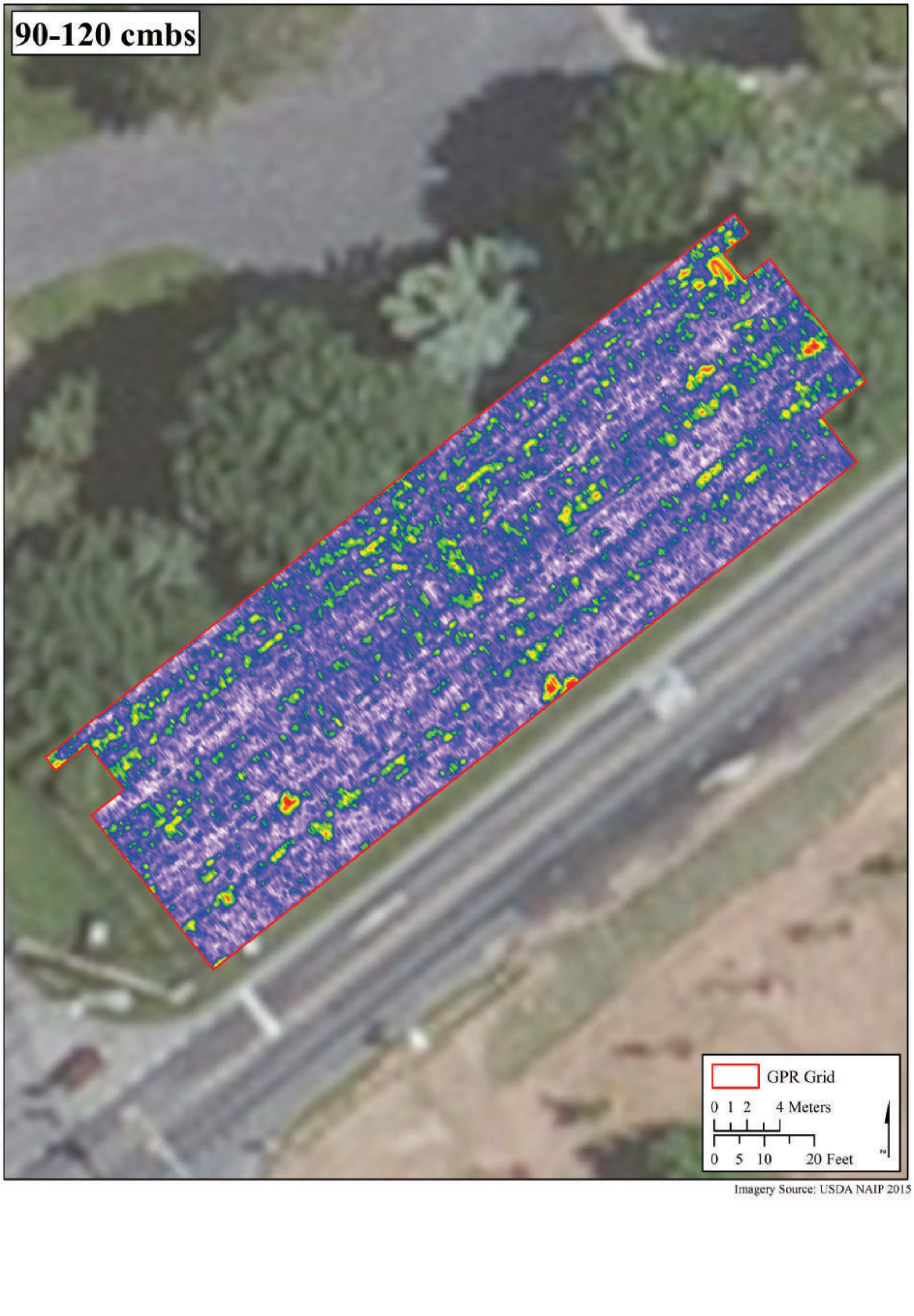
Imagery Source: USDA NAIP 2015

Figure 18.
GPR Amplitude Slice Map, 60-90 cmbs



Imagery Source: USDA NAIP 2015

Figure 19.
GPR Amplitude Slice Map, 90-120 cmbs

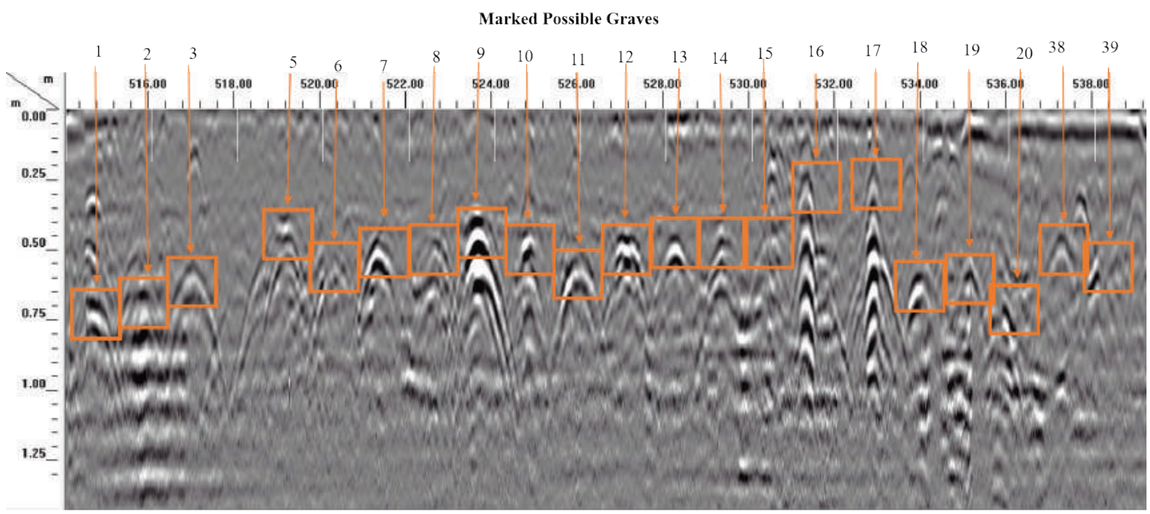


Imagery Source: USDA NAIP 2015

Figure 20.
GPR Amplitude Slice Map, 120-150 cmbs

Imagery Source: USDA NAIP 2015

Figure 21.
GPR Profile of Probable Graves



Grid 3 – Profile 11, 2.5 meters in the x-direction

Figure 22.
Map Showing Carlisle Barracks Post Cemetery Grave Markers and Anomalies

Imagery Source: USDA NAIP 2015

Figure 23.
Map Showing Carlisle Barracks Post Cemetery Anomalies without Associated Markers

Imagery Source: USDA NAIP 2015

Table 5. Grave Markers with No Associated GPR Anomaly

Number	Last Name	First Name	GPR Anomaly (Y/N?)
D18	Bytzolay	John	N
E33	Unknown		N
E3	Hensley	Edward	N
F30	Bird	Infant	N
A18	Painter	Warren	N

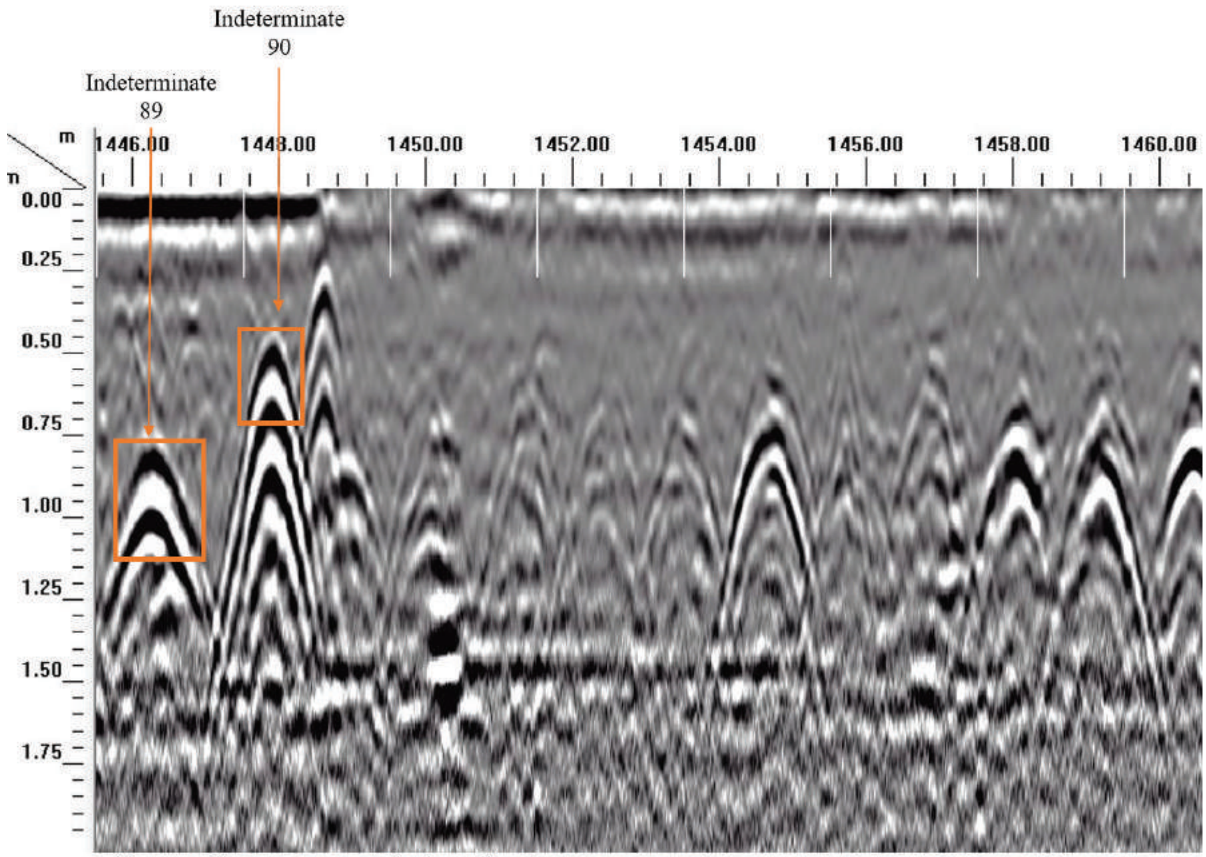
INDETERMINATE (N=55)

Fifty-five anomalies were classified as indeterminates (Figure 24, see Figures 22 and 23). These anomalies were not associated with known, marked, burials; were found in varying locations; and varied in dimensions. There was considerable variation in the length, width, and depth of these anomalies. Depths ranged between 0.40 and 1.0 cmbs. Lengths ranged between 0.72 and 1.78 cm; most are between 1.0 and 1.5 meters. Widths range between 0.40 and 1.00 cm.

The nature of these anomalies cannot be determined with the information recovered to date. Some located along the cemetery's edges as well as in other locations may reflect historic plantings. Others may reflect disturbances associated with the relocation of burials to the Post Cemetery as well as the excavation of grave shafts. Finally, it is possible that some indeterminate anomalies near burial markers without an associated anomaly (see Table 5) may reflect the burials associated with those markers.

The nature of the Indeterminate anomalies within the Post Cemetery cannot be determined without archaeological testing. Field-testing is recommended to determine the function and cultural affiliation of these.

Figure 24.
GPR Profile of Indeterminate Anomalies



Grid 3 – Profile 30, 7.25 meters in the x-direction

IV. SUMMARY AND CONCLUSIONS

GPR results indicated that the accessible portions of the Old Burial Ground have been significantly impacted by cut-and-fill activities associated with the construction of the U.S. Army War College. GPR survey identified utility and construction features as well as seven indeterminate anomalies on the edge of the construction zone. The nature of these cannot be determined with the data at hand. These indeterminate anomalies may be debris scatters generated by the War College's construction, or alternatively may be older cultural features. Geo-referencing of historic maps indicates they fall outside, but in proximity to, the boundaries of the Carlisle Indian School Cemetery. Ground-truthing through archaeological testing would be needed to determine the association of these anomalies. They are currently preserved beneath the pavement of a parking area.

GPR survey of the Post Cemetery identified anomalies associated with 223 of the 228 burial markers in the cemetery. Based on the attributes of these anomalies they are recorded as probable burials. Five markers did not have an associated anomaly. One of these, F30, the burial of an infant, may not have been identified due to its size. The others may have anomalies present that were not recognized with the GPR. Alternatively, the burials associated with these four markers may be recorded as indeterminate anomalies, with the marker offset from the burial shaft. Fifty-five indeterminate anomalies were identified within the Post Cemetery. The function of these cannot be determined with the information recorded to date, although it is likely that some reflect the locations of plantings while others may be indications of reburial construction activities. Ground-truthing through archaeological testing would be needed to determine the function of these anomalies.

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REFERENCES CITED

Conyers, Lawrence

2004a *Moisture and Soil Differences as Related to the Spatial Accuracy of GPR Amplitude Maps at Two Archaeological Test Sites*. Paper presented at the Tenth International Conference on Ground Penetrating Radar, The Netherlands.

2004b *Ground-Penetrating Radar for Archaeology*. AltaMira Press, Walnut Creek, California.

Conyers, Lawrence B.

2012 *Interpreting Ground-Penetrating Radar for Archaeology*. Left Coast Press, Walnut Creek, California.

Conyers, Lawrence and Jeffery Lucius

1996 Velocity Analysis in Archaeological Ground Penetrating Radar Studies. *Archaeological Prospection* 3(1):25–38.

Damaita, Brian N., John M. Steinberg, Douglas J. Boender, and Guðný Zoëga

2013 Imaging Skeletal Remains with Ground-Penetrating Radar: Comparative Results over Two Graves from Viking Age and Medieval Churchyards on the Stóra-Seyla Farm, Northern Iceland. *Journal of Archaeological Science* 40:268–278.

Hay, Conran A., Christopher E. Hamilton, and Christina Schmidlapp

1988 *A Cultural Resource Overview and Management Plan for the United States Army Carlisle Barracks, Cumberland County, Pennsylvania*. Archaeological and Historical Consultants, Inc., Centre Hall, Pennsylvania.

Jones, Geoffrey

2008 Geophysical Mapping of Historic Cemeteries. Paper presented at the Conference on Historical and Underwater Archaeology, Albuquerque, New Mexico.

King, Julia A., Bruce W. Bevan, and Robert J. Hurry

1993 The Reliability of Geophysical Surveys in Historic-Period Cemeteries: An Example from the Plains Cemetery, Mechanicsville, Maryland. *Historical Archaeology* 27(3):4–16.

Kvamme, Kenneth L., Eileen G. Ernenwein, Michael L. Hargrave, Thomas Sever, Deborah Harmon, and Fred Limp

2006 *New Approaches to the Use and Integration of Multi-Sensor Remote Sensing for Historic Resource Identification and Evaluation*. Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville, Arkansas.

Matternes, Hugh B., Matthew Rector, and J.W. Joseph

2017 *Archival Research of the Carlisle Indian Cemetery, U.S. Army Garrison, Carlisle Barracks, Carlisle, Pennsylvania*. Prepared for the U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri. Environmental Research Group, Baltimore Maryland and New South Associates, Inc., Stone Mountain, Georgia.

Soil Survey Staff

2016 Web Soil Survey. *Natural Resources Conservation Service, United States Department of Agriculture*. Electronic document, http://websoilsurvey.nrcs.usda.gov/app/homepage.htm, accessed 22 December 2016.