REMOTE SENSING SURVEY USING GROUND-PENETRATING RADAR AND LIDAR

MT. OLIVE CEMETERY

Jackson State University Campus
Jackson, Hinds County, Mississippi

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RGA | RICHARD GRUBB & ASSOCIATES

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GLOSSARY OF TERMS

Anomaly

Anomalies are the result of a portion of the Ground-Penetrating Radar (GPR) wave's energy reflecting to the antennae due to changes in the electrical properties of the material it is passing through. Anomalies often are caused by buried objects or changes in the subsurface.

Archaeological Features

Archaeological features represent any objects used, modified, or made by human activity that were not meant to be moved and are over 50 years of age. Examples include buildings, firepits, rubbish piles, building remains, or any human made structures.

Concentration

Groups of archaeological material.

Grid

The bounded area where a set of transects were collected as a group, usually collected in a rectangular pattern. Data is collected in grids to allow for the generation of time slice maps.

Human Made Features

Archaeological features that possess qualities suggesting they are made by humans.

Natural Feature

Buried features that possess qualities suggesting they are naturally occurring.

Radargram

Two-dimensional representations of the reflections that a GPR wave experienced as it passed through the ground. Radargrams are the most basic visualizations of GPR data and represent the ground directly underneath the path of the transects.

Likely Burial

Features which show geophysical characteristics typical of human burials. Likely represents a higher degree of confidence that the anomaly represents a human burial. Characteristics typical of human burials include strong hyperbolic reflections that can be identified through a series of two or more radargrams and occur a depth between 50 and 200 centimeters.

Potential Burial

Features which show fewer characteristics typical of human burials, or those which occur in disturbed areas. The term potential represents a lower degree of confidence that the anomaly represents a human burial. Potential burials may still represent human burials.

Feature

In this report, feature refers to any archaeological features.

Resource

In this report the term refers to any archaeological materials.

Surface Feature

Features, like headstones or statues that can be seen on the surface of the ground.

Time Slice Map

Two-dimensional representation of the subsurface that is parallel with the ground, this is generated by forming a composite of multiple radargrams and choosing different wave travel times, which are a proxy for the depth, and displaying them as maps of the subsurface for certain depths.

Transect

The path that the lines of GPR data were collected on; these lines are often collected as part of a grid.

EXECUTIVE SUMMARY

Richard Grubb & Associates, Inc. (RGA) conducted ground-penetrating radar (GPR) and Light Detection and Ranging (LiDAR) surveys at the Mt. Olive Cemetery on the campus of Jackson State University (JSU) located at 1400 John R. Lynch Street, Jackson, Hinds County, Mississippi. The project was managed by Heather Denné, PhD, Director of Community Engagement, Metro Jackson Community Prevention Coalition, JSU, to fulfill requirements of a National Park Service (NPS) Historically Black Colleges and Universities (HBCU) grant that was awarded to JSU in 2023. The surveys identified unmarked burials, other below ground features, and grave depressions in the cemetery.

Mt. Olive Cemetery was listed in the National Register of Historic Places in 2017. The historic cemetery contains over 200 gravemarkers and mausoleums for men and women who contributed to the development of the African American community in Jackson. A database of burials maintained by JSU indicates that there are 1,461 burials at Mt. Olive Cemetery. This number is derived from death certificates dating to between 1909 and 1943 on record at the Mississippi Department of Vital Statistics and data taken from extant headstones at Mt. Olive.

The GPR and LiDAR surveys covered the known area of the Mt. Olive Cemetery, which is an approximately 4.15-acre, rectangular cemetery parcel bounded by fences on the north, east, and south sides, while the western boundary is defined by Bob Carpenter Drive. The GPR survey consisted of 15 continuous GPR survey grids and identified 95 likely burials (with a high degree of certainty), 1,103 potential burials (with grave characteristics but with less certainty), 12 vault covers, and 1,483 grave depressions. The LiDAR survey identified 696 grave depressions which overlap likely/potential graves and/or vault covers or that were identified in the GPR survey. Both likely and potential burial anomalies had radar signatures that were characterized by hyperbolic reflective anomalies that occurred in the size, shape, and orientation expected for human burials. Vault covers were identified by the unique radargram signal caused by scans of metal-reinforced concrete. Death certificates and gravemarker inscriptions confirm that a minimum of 1,461 burials are in the Mt. Olive Cemetery, which roughly aligns with the numbers compiled during RGA's GPR and LIDAR surveys.

GPR and geophysical surveys are not always conclusive on their own but can provide valuable information for planning and for future investigations. As a result of GPR and LiDAR surveys, RGA presents the following recommendations:

1. Trained archaeologists should perform thorough archaeological monitoring of any ground disturbance at or near the cemetery. Should any human remains be encountered, work should be stopped immediately and the appropriate authorities contacted.

2. Consider additional geophysical surveying using magnetometry. A large-scale magnetometer survey could have success mapping the subsurface and locating artifacts associated with burials. Magnetometry surveys are sensitive to metal and certain igneous rocks (such as granite) commonly used in cemetery contexts and could potentially expand upon the data collected

during the present GPR and LiDAR surveys by locating smaller buried headstones, coffin hardware, and/or materials buried with the deceased. Magnetometry has the benefit of covering larger areas more efficiently than GPR and can complement the GPR work already completed.

3. To protect the site's archaeological resources from unauthorized collection RGA recommends placing informational signage asking the public not to collect artifacts and/or take other measures to protect resources.

TABLE OF CONTENTS

APPENDICES

Appendix A: Qualifications of the Authors

Appendix B: GPR Slices at 50, 100, and 150 cm intervals

Appendix C: Annotated Project Data

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

1.0 INTRODUCTION

Richard Grubb & Associates, Inc. (RGA) conducted remote sensing survey using ground-penetrating radar (GPR) and Light Detection and Ranging (LiDAR) at the National Register of Historic Places (NRHP)-listed Mt. Olive Cemetery located at 1400 John R. Lynch Street on the campus of Jackson State University (JSU), Jackson, Hinds County, Mississippi (Figure 1.1 and Figure 1.2). JSU commissioned the remote sensing surveys to locate unmarked burials that historical death certificates indicate are in the cemetery. The project was managed by Heather Denné, PhD, JSU's Director of Community Engagement, Metro Jackson Community Prevention Coalition, to fulfill requirements of a National Park Service (NPS) Historically Black Colleges and Universities (HBCU) grant that was awarded to JSU in 2023. The GPR and LiDAR surveys identified unmarked burials, other below-ground features, and grave depressions in the cemetery.

Mt. Olive Cemetery is a maintained landscape with over 200 headstones and 34 above-ground box mausoleums. The graves are oriented east-to-west as is the tradition in Christian burial practices. The earliest engraved gravemarker dates to 1892, that of Primus Eubank (1814–1892). About 10 mature trees are spread throughout the mowed grounds. JSU's website provides an overview of the cemetery's past, noting there are graves within the cemetery that predate the purchase of the two acres of land by the Jackson Cemetery Association in 1891. The association added two additional acres in 1892 (Wilcox n.d.). The cemetery is thought to have been originally associated with a plantation, but this theory remains unsubstantiated by the archival record (Jackson State University 2025).

Mt. Olive Cemetery contains two prominent and historically important hand-carved statues made from granite and marble. The first statue, erected in 1903, depicts James Hill, a formerly enslaved man who was elected as Mississippi's Secretary of State from 1874–1878. The second statue, erected in 1913, depicts Ida Revels Redmond, who was a teacher and women's issues organizer in Mississippi. She was the daughter of Hiram Revels, the first African American U.S. Congressman to represent Mississippi from 1870 to 8171 (Jackson State University 2025).

The purpose of the remote sensing surveys was to build on previous archival research conducted by JSU to determine the approximate number of burials within the cemetery. Using death certificates from the Mississippi State Department of Health's Vital Records Office and gravemarker inscriptions, JSU's Dr. Heather Denné created a database with the names of 1,461 decedents. Death certificates were not issued by the state prior 1909 and only certificates issued prior to 1943 were available for public review, therefore these death certificates did not tell the complete story. However, Dr. Denné counted 209 gravemarkers with death dates between 1891 and 1908, and 41 with death dates between 1944 and 1997, the year of the last known burial. Dr. Denné added these two figures to the total number of death certificates and placed the total number of burials at a minimum of 1,461. This number does not account for *unmarked* burials that fall outside the 1909 and 1943 time period. It was these *unmarked* burials that the remote sensing techniques hoped to capture.
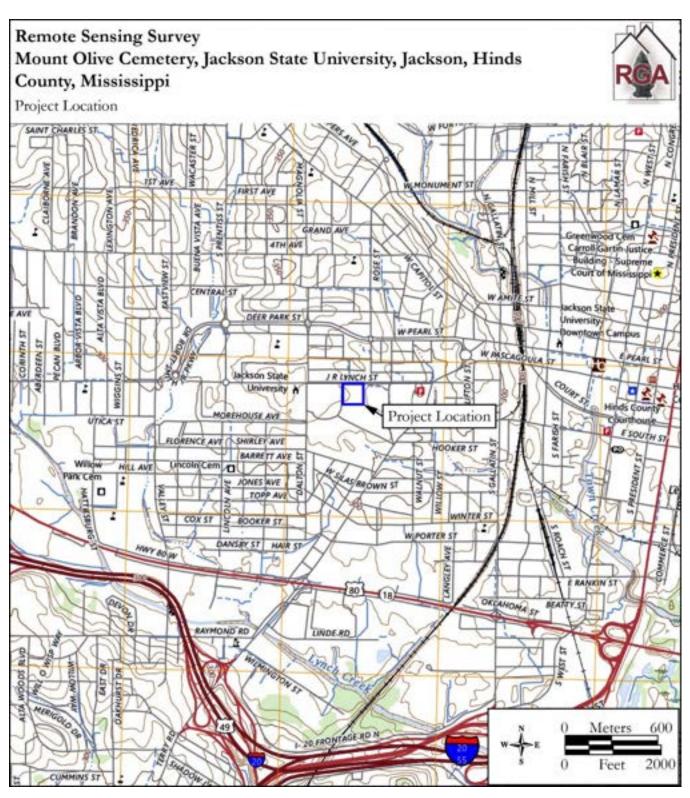
Figure 1.1. USGS topographic map of Mt. Olive Cemetery at 1400 John R. Lynch Street, Jackson, Hinds County, Mississippi
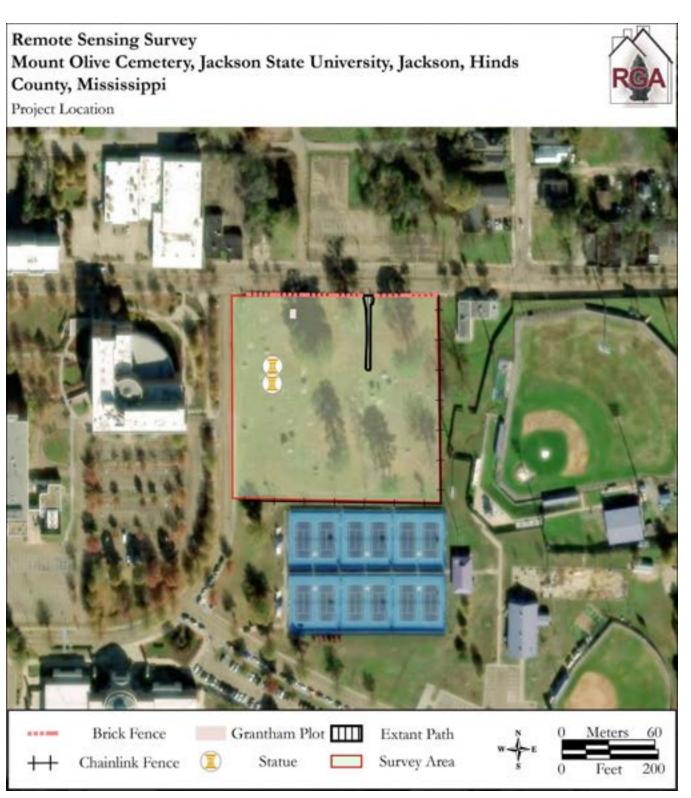(USGS 7.5' Quadrangle: Jackson, MS 2024).

Figure 1.2. Aerial imagery of the project location and Mt. Olive Cemetery
(Esri 2025).

Donny Rowe, MA, RPA, served as Principal Investigator for this study. Mr. Rowe performed the fieldwork, completed the post-fieldwork data processing of the GPR data, produced the graphics, and was the lead report author. Archaeological technicians Mariah Gonzales and Regan Crider assisted with the GPR fieldwork. Ellen Turco, MA, served as Project Manager. The authors meet the Secretary of the Interior's Professional Qualification Standards of 36 CFR 61; their resumes can be found in Appendix A. Catherine Smyrski copyedited and formatted the report. Copies of this report and field data, notes, photographs, and project maps are on file at the RGA office in Wake Forest, North Carolina. Data collection, post-fieldwork data processing, and mapping of the LiDAR data was completed by AAron Edleblute of Drone Nomadix.

Section 1.0 of this report consists of a brief historical background of the site, a summary of previous archaeological and archival studies, and a description of the environmental setting. Section 2.0 presents the theory of remote sensing theory, and Section 3.0 discusses the specific the survey and analytical methods used for this study. The survey results and interpretations are in Section 4.0. The final section, Section 5.0, provides conclusions and recommendations for future work and protection of the site.

1.1 Historical Background

This section was adapted from *Historic Mt. Olive Cemetery: Research Book* by Dr. Heather Denné (nee Wilcox).

Mt. Olive Cemetery was established at least as early as 1891, making the cemetery one of the oldest private African American cemeteries in Mississippi. The cemetery is on the campus of JSU, Mississippi's largest HBCU, which owns and maintains the cemetery today. In June 2017, Mt. Olive Cemetery was listed in the NRHP thanks to the work of JSU's Center for University-Based Development and a grant from the NPS. The National Register designation was bestowed in part due to the cemetery's utilization through four distinct eras in African American history including pre-emancipation, reconstruction, Jim Crow, and the Civil Rights Movement. Mt. Olive is an important reminder of African American life during these temporal periods and one of the most intact historic properties associated with the growth and development of the African American community and business district surrounding John R. Lynch Street. Mt. Olive Cemetery depicts a point of beginning for this community and serves as a final resting place for many prominent African Americans, as well as ordinary citizens.

Jackson College moved to JSU's current location in 1903. The first building occupied was a former farmhouse built in 1880, and the street now named Bob Carpenter Drive was then named "Masters Street." JSU developed from Natchez Seminary which was founded in 1877 in Natchez, Mississippi by the American Baptist Home Mission Society of New York. In 1882, the school moved to Jackson, and in 1899, expanded its curriculum and renamed itself Jackson College. In 1903, the college moved once again to an area just west of Mt. Olive Cemetery (Figure 1.3). Financial support for the school was assumed by the state of Mississippi in 1940, and in 1956, the name was changed to Jackson State College. Finally, in 1979 the college was designated the Urban University of the State of Mississippi and adopted the current name of Jackson State University. Over the years, the University expanded, and in 2005, the College of Business was built along the subject cemetery's western edge.
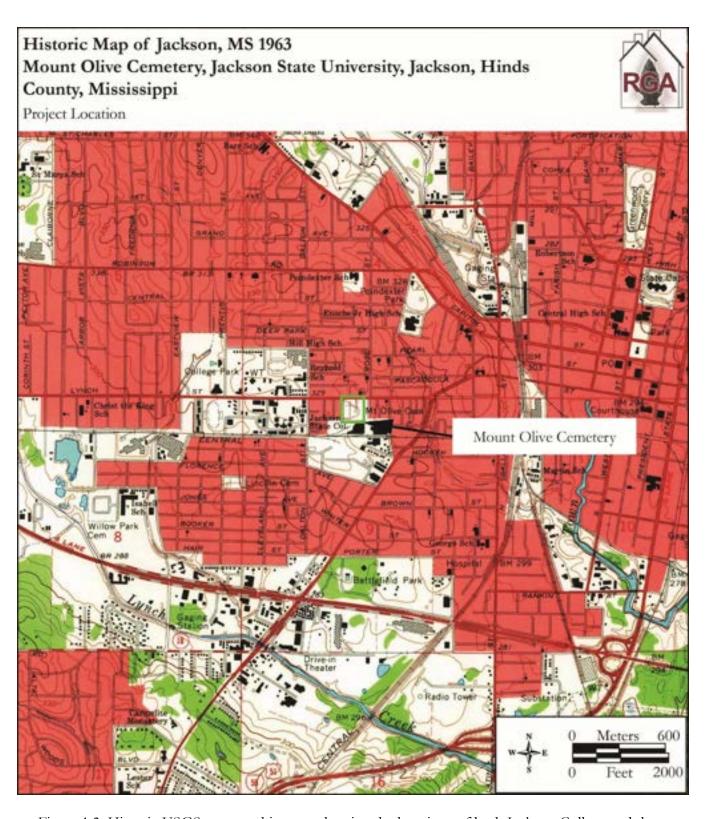
Figure 1.3. Historic USGS topographic map, showing the locations of both Jackson College and the
location of Mt. Olive Cemetery
(USGS 7.5' Quadrangle: Jackson, MS 1963).

The date of the cemetery's earliest burial is unknown; however, death records and gravemarker inscriptions present evidence of freed people being buried at the site, such as Susana Brown (December 25, 1812–September 7, 1904) and Primus Eubank (1814–April 10, 1892), both born before Mississippi acquired statehood in 1817. The earliest inscribed gravemarkers date to the early 1890s. Research compiled by JSU suggests that the land that became Mt. Olive Cemetery was associated with a plantation prior to the purchase of four acres of land by the Jackson Cemetery Association in 1891 and 1892. This assumption has yet to be established with certainty; however, the question is an area for future research. On April 3, 1891, Thomas Darrington sold approximately two acres of land to the Jackson Cemetery Association for $400. The second transaction, involving approximately two additional acres of land, was negotiated between Thomas and Lawrence Darrington and the Jackson Cemetery Association on February 25, 1892, for the sum of $500. During the last decade of the nineteenth century, a private cemetery for African Americans would have been uncommon in Mississippi. African Americans were generally buried on former plantations, churchyards, or in publicly owned cemeteries, such as Greenwood Cemetery in Jackson. Burials at the cemetery that would become the Mt. Olive Cemetery slowed in the mid-twentieth century and it fell into disrepair. The last known burial was of Mrs. Barbara Chris Curry Turner with a date of death of April 18, 1997.

The long history of burials in the Mt. Olive Cemetery provides examples of the various types and styles of burial markers used to memorialize the deceased in historic cemeteries. The graves are oriented east-to-west per Christian burial practices. The cemetery contains granite and concrete tablets set in socketed bases, obelisks, stones flush with the ground masonry, concrete vault covers, mausoleums, some of which sit empty, built for single or multiple burials. It is probable that the mausoleums were emptied as families chose to relocate their loved ones to what they perceived as better maintained cemeteries. The fact that these mausoleums sit empty is another research question that would benefit from investigation. Family plots are delineated by low walls of granite coping, brick, or concrete blocks. A few segments of wrought iron fencing remain. Grave depressions, the evidence of collapsed coffins and burial shafts, are scattered throughout the cemetery. Of note near the cemetery's high point are the statues marking the graves of Ida Revels Redmond and James (Jim) Hill. As the only statues in the cemetery, these reflect the important contributions of these individuals. Ida Revels Redmond was the daughter of Hiram Revels, the first African American to serve in the U.S. Congress to represent Mississippi in 1870 and 1871. Redmond helped organize women's self-improvement efforts through civic, education, and social services. James Hill was a former slave who was elected as Mississippi's Secretary of State from 1874 to 1878.

Dr. Heather Denné (nee Wilcox) conducted research for the subject cemetery on compiled vital statistics drawn from 1,461 death records (both publicly available death certificates and from inscribed gravemarkers). While the death records are incomplete, they still provide context for the burials. Denné's analysis of the raw data revealed vital information about the decedents interred at Mt. Olive Cemetery. Two hundred sixty-eight (268) of the 1,461 burials are marked with above-ground gravemarkers or mausoleums leaving a large number of graves that were either never marked, or which have lost their markers to time. Approximately 23 percent, or 336, of the burials recorded by death certificates are for children under the age of 5 years old. All individuals buried in the cemetery are classified as being of African American descent, either as Black, yellow, Negro, colored, or light. Black, Negro, and colored are interchangeably used depending on who completed the death certificate and

the date of death. Approximately 77 percent of all African American women with death certificates are listed as domestic laborers. Other occupations included, fieldhands, laundress, cook, seamstress, schoolteacher, midwife, and beauty consultant. Thirteen percent of African American men recorded in the death certificates are listed as laborers. Other occupations for men include blacksmith, brick mason, chauffeur, cotton spotter, drayman, farmer, machinist, minister, physician, plasterer, plumber, porter, railroad laborer, waiter, and umbrella repairer. Seventy-nine percent of death certificates list a cause of death. Commonly listed causes are cerebral hemorrhage, chronic nephritis, consumption, dropsy, heart trouble, influenza, pneumonia, malaria, measles, no doctor, pellagra, pulmonary tuberculosis, stillborn, teething, typhoid fever, and whooping cough. The year 1914 was the first time the term "diabetes" is described as a cause of death.

1.2 Previous Research

In 1997, a cemetery survey report was prepared by Thomason and Associates Preservation Planners of Nashville, Tennessee. In 1999, a site survey was completed by Mississippi State University architecture students and was filed with the Mississippi Department of Archives and History (MDAH). The students identified 268 burial sites and transcribed the information legible on the headstones. Now, more than 25 years later, some of the gravemarkers that were identified in 1999 are no longer present due to weather and soil erosion, vandalism, and lack of maintenance and preservation.

In 2004, Marilyn Johnson Luckett prepared a National Register Preliminary Evaluation Questionnaire for the MDAH. This document became the foundation for the NRHP nomination prepared by Heather Denné (nee Wilcox). Mt. Olive Cemetery was listed in the National Register in 2017. Dr. Denné has also prepared *Historic Mt. Olive Cemetery: Research Book* as well as other successful grant applications to the NPS and other funding entities for the restoration of Mt. Olive Cemetery. In 2023, Richard Grubb & Associates, Inc. competed *Cemetery and Gravemarker Conditions Assessment* for Mt. Olive Cemetery. The assessment was funded by a grant made to HBCU's by the NPA, and documented the cemetery's 268 gravemarkers and mausoleums and prescribed treatments for their conservation. This document informed RGA's conservation of the gravemarkers in 2024, and the upcoming conservation of the mausoleums which is anticipated to begin in 2025 and funded by the NPS.

1.3 Environmental Setting

Mt. Olive Cemetery is located at 1400 John R. Lynch Street, Jackson, Hinds County, Mississippi, on the east side of Jackson State University, approximately 2 km west of the State Capitol. The nearest permanent body of water is Town Creek, found approximately 1 km northeast of the cemetery, which is a tributary of the Pearl River. The site is a regularly mowed landscape, sloping gently towards the north and east. The cemetery is directly bordered by chain-link fencing on the east and south sides, as well as a brick and metal fence along the northern boundary. The west side of the cemetery is unfenced and is bounded by Bob Carpenter Drive and associated utilities. The surrounding landscape has been modified by urban development and activity since the late 1800s (Plate 1.1 and Plate 1.2; see Figure 1.2. Aerial imagery of the project location and Mt. Olive Cemetery). The partially fenced site consists of an open, modified landscape with mown grassy areas, mature deciduous trees with visible roots, and various examples of cemetery architecture (Plate 1.3 and Plate 1.4).

Plate 1.1. General overview of Survey Grid 1, showing topography.
Photo View: East; Photographer: Donald Rowe; Date: November 22, 2024.

Plate 1.2. Example of surface features within the cemetery, including mausoleums, headstones, concrete barriers, and trees.
Photo View: East; Photographer: Donald Rowe; Date: November 22, 2024.

Plate 1.3. View of a depression that is likely associated with a burial.
Photo View: North; Photographer: Donald Rowe; Date: November 22, 2024.
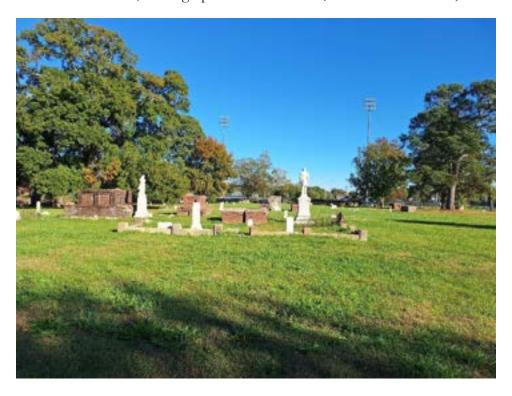
Plate 1.4. View of Mt. Olive Cemetery, showing the statue of James Hill and Ida Revels Redmond.
Photo View: East; Photographer: Donald Rowe; Date: November 22, 2024.

RGA's remote sensing survey area falls on the southwestern edge of the Jackson Prairie physiographic province (MARIS 2013). The province lies primarily in Central Mississippi extending from the Alabama border in the east to the area just northwest of Jackson, Mississippi. It is surrounded by North Central Hills physiographic province to the north, the Loess Hills physiographic province to the west, and the Southern Pine Hills physiographic province to the south. The Jackson Prairie province is characterized by very gently rolling land, with slopes as gentle as 10 feet of raise per mile. The soil is dominated by calcareous clays that are the weathered product of the Yazoo clay (Monroe 1954). The underlying geology for the site consists of the Jackson group, a sedimentary layer consisting primarily of Yazoo clay, green and gray calcareous clay, and the Moodys Branch formation at the base with shells embedded in glayconitic clayey quartz sand (Mercury Maps Inc. 1969).

Soils in the survey area consist of Loring-Urban land complex. Loring soils, 2 to 8 percent slopes are moderately well drained with moderately low to moderately high permeability (NRCS 2025; Table 1; Figure 1.4). Urban soils are characterized as those consisting of human transported material (NRCS 2025). Knowing the soil type and conditions at the time of the survey is important in optimizing the collection, processing, and interpreting of GPR surveys as variations can greatly affect the electrical properties of the subsurface. GPR surveys detect changes in the electrical properties of the subsurface, and because of this, the type of soil present in the survey area affects the results of the survey. Soils have different electrical properties as well as different abilities to drain water, which can further alter the electrical properties.

Table 1. Typical soil profiles within the survey area.

Name:	Soil Horizon: Depth in Inches	Texture, Inclusions	Slope	Drainage	Landform
Loring-Urban (LuC)	H1: 0–5 H2: 5–21 H3: 21–66 H4: 66–72	Silt loam Silty clay loam Silt loam Silt loam	2–8%	Moderately well drained	Urban settings

Figure 1.4. Soil map of survey area
(Source: NRCS 2025 and Esri 2025).

2.0 BACKGROUND ON REMOTE SENSING IN ARCHAEOLOGY

Remote sensing survey methods, including GPR and LiDAR, are non-invasive approaches to identifying and mapping below-surface objects and for visualizing the current topography of the ground surface in relation to these underground anomalies (Conyers 2006). These methods of remote sensing allow a glimpse into what may lie underground and can serve as one of many bases from which archaeological data can be collected. Remote sensing survey methods are also used to identify graves, pre-Contact earthworks and monuments, fortifications and trenches on battlefield sites, and spatial organization of early historic settlements, trading posts, farmsteads, and tavern sites, among other kinds of features and resources (Cornett and Ernenwein 2020; Ewen 2019; Heckman 2005; Horsley et al. 2014; Kvamme 2003).

It is important to note that: "The results and subsequent interpretations of remote sensing surveys should not be treated as an absolute representation of the underlying features. It is normally only possible to prove the nature of anomalies through intrusive means, such as trial excavations" (Horsley et al. 2014:10). Therefore, geophysical and LiDAR anomalies must be subjected to ground-truthing methods to determine whether they represent cultural features or other subsurface manifestations (Ewen 2016; Hargrave 2006). A recent literature review indicates that there has been a general lack of ground truthing to test geophysical anomalies (WSP, Inc. and New South Associates, Inc. 2018).

2.1 Ground-Penetrating Radar Theory

Ground-penetrating radar has been successfully utilized on historic and pre-Contact archaeological sites for several decades in the eastern United States. GPR accurately maps the spatial extent of near-surface objects and features.

The antenna of a GPR unit transmits into the ground an electromagnetic wave that operates in the microwave range of frequencies. The frequency of an antenna, such as the 350 MHz used in this survey, represents the center frequency of the antenna while the actual transmission is made up of a wide range of frequencies, in this case ranging from 125 MHz to 700 MHz. This wave of energy is emitted from a transmitter in the shape of a cone and reflects off sediment, rock, or buried materials and back to a receiver in the antenna. The reflected waves continually bounce between the subsurface and the receiver at the speed of light until the energy has dissipated due to a loss of heat and energy (Balanis 1997). As a result, the GPR antenna gathers a log of positive and negative amplitude reflections measured in deciBels (dB) as well as a measurement of radar travel time in nanoseconds (ns). Across a GPR transect, each individual line scan is divided into 512 or 1024 samples, depending on the unit's settings, displaying the change in the amplitude of a reflection as depth, or time, increases (Evans 2003). These changes in amplitude of reflection and the changing speed of the radar wave as it moves through the subsurface are due to changes in the dielectric constant of the materials or sediments of the subsurface. For instance, radar waves travel fastest through air, which has a dielectric constant of 1, and slowest through water, which has a dielectric constant of 81. The dielectric constant of soils ranges from 10 to 40 given changes in clay, silt, and sand content as well as conductivity and moisture content (Daniels 2004).

Given this knowledge, GPR application and data interpretation rely on identifying anomalies which represent strong reflections of such changes in the ground during a survey. These black-white-black (negative-positive-negative amplitude reflections) and white-black-white (positive-negative-positive amplitude reflections) series of reflective bands represent significant changes in the dielectric constant of materials and potential anomalies such as utilities, storage tanks, buried features, structures, or graves.

The results from GPR and other remote-sensing methods do not usually involve the identification of specific features, but rather the data provide differences in reflections from radar energy pulsed into the ground from the GPR antenna. As the pulses encounter varying subsurface features, they are reflected back to the GPR unit in varying degrees of strength and transmission time. Thus, changes in soil compaction and chemistry may transmit a contrasting signature that is different from the surrounding matrix. Transmission time is the amount of time it takes for the radar pulse to be reflected back to the receiving antenna and is interpreted as depth (i.e., the longer the transmission takes the deeper the object lies). The shape of the reflection may also give clues to the nature of a below-surface object. A hyperbolic shape in the profile usually suggests a single object, while a planar reflection may indicate a flat surface such as a floor or a change in stratigraphy (Conyers 2006).

Ground-penetrating radar units vary by antenna frequency. While soil properties, surface condition (for example, obstacles such as trees and shrubs or surface treatments such as hardscaping), and water retention may affect transmission and data resolution, in general there is a relationship between antenna frequency and resolution. Low-range frequency antennas (50–100 MHz) may penetrate as much as 15 m below surface under certain conditions. High-range frequency antennas (800–1000 MHz) may penetrate only 1 m but have extremely high resolution and are often used to locate buried utilities or items buried in concrete. Medium-range frequency antennas such as the 350 or 400 MHz are typically used in archaeology and are reliable to a depth of up to 3 m below the surface, depending on the surface conditions (Conyers 2006). The 350 MHz HyperStacking (HS) antenna is known to reduce noise via high-speed interpolated sampling (Kruske 2020).

Limitations include surveys in urban areas where buried and overhead utilities can produce too much "noise" to effectively identify archaeological features. Moist or waterlogged clay can impede GPR penetration or survey results (Kvamme 2003). Other limiting factors include natural anomalies such as iron deposits, soil composition and burn episodes, and wooded areas or large trees with extensive root systems that could trigger false positives (Chadwick and LaVigne 2019:104).

2.2 Ground-Penetrating Radar in Cemeteries

In comparison with other archaeological features, human burials can be a challenging target for geophysical survey methods. In some cases, burials may provide too little contrast to permit detection. Human remains (i.e., bones) are likely to evade detection due to their small size. Potential burials are identified by GPR prospection methods when disruptions appear in the natural stratigraphy of the soil, for example, air-filled cavities or less-compact soils, or through the presence of associated objects or structures.

Since contrast in soils is reduced over time, older burials may be difficult, and sometimes impossible, to identify (Horsley et al. 2014). Contrast in soils is important for detecting subsurface anomalies, including burials. Identifying potential graves in historic cemeteries through GPR does not usually involve the identification of physical human remains (i.e., skeletons) (Lowry 2016), but rather the difference in reflections from radar energy pulsed into the ground from the GPR antenna (Conyers 2006b). For example, when using GPR to delineate cemeteries, usually a grave shaft, casket or coffin, spaces/voids, vaults, or burial goods are detected as dissimilar to the surrounding natural strata (Lowry 2016).

2.3 LiDAR Theory and Use in Cemeteries

Laser Imaging, Detection, and Ranging, or LiDAR, operates on the principle of emitting laser pulses towards a target and then measuring the time it takes for the reflected light to return to the sensor. This time-of-flight measurement, combined with the known speed of light, allows for the precise calculation of the distance to the target. By rapidly firing these laser pulses and recording the reflections, a dense three-dimensional point cloud of the scanned environment is generated. The intensity of the returned light can also provide valuable information about the surface characteristics of the objects being scanned. Different wavelengths of light can be employed depending on the specific application, allowing for varying levels of penetration through vegetation or the detection of specific material properties.

In the context of cemeteries, LiDAR technology offers a non-invasive and highly efficient method for surveying and documenting burial sites. Traditional surveying techniques can be time-consuming and potentially disruptive to the often delicate and historically significant landscape of a cemetery. LiDAR, however, can rapidly capture detailed topographic data, creating accurate 3D models of gravestones, mausoleums, and the surrounding terrain. This information can be used for a variety of purposes, including creating detailed maps for cemetery management, monitoring the condition of monuments over time, and identifying unmarked graves through subtle ground surface variations. The ability to collect data remotely and non-destructively makes LiDAR an invaluable tool for preserving and understanding these important cultural heritage sites.

3.0 APPLICATIONS OF GROUND-PENETRATING RADAR AND LIDAR

3.1 GPR Field Methodology

In November 2024, RGA conducted a GPR survey at Mt. Olive Cemetery. The GPR data was collected using a Geophysical Survey Systems, Inc. (GSSI) SIR 4000 control unit with a 350 MHz digital HyperStacking (HS) antenna (transmitter and receiver) mounted on a three-wheeled cart with a survey wheel for distance calibration. The GPR was calibrated on-site, using a relative dielectric permittivity (RDP) of 14. Grid corners, and surface features were mapped and recorded with a Trimble R12i RTK rover paired with a rugged Trimble field controller running Trimble Access 2020 for centimeter-level GPS accuracy, along with measuring tapes, plastic stakes, and pin flags.

The survey area consists of a maintained approximately 4.15-acre cemetery. The cemetery grounds are comprised of manicured lawns with some mature trees, mausoleums, bushes, headstones, concrete barriers, and two prominent statues. Preceding fieldwork, the survey area had undergone regular mowing (Plate 3.1–Plate 3.4). Numerous surface features remained, including trees, bushes, and cemetery materials, which posed some impediments to survey in those areas. Survey transects were collected as close to them as possible.

Survey grids denoted as 1 through 15 were set up over the survey area to cover the cemetery as completely as possible. A series of 2,876 GPR transects were collected across 15 grids (Table 2; Figure 3.1). All 15 grids were collected at a 0.25-m parallel interval customarily used on cemetery sites (Leach 2021:48). Transects were oriented north–south in the Y-direction and were collected bi-directionally. Obstacles to survey, such as trees, bushes, and surface features, caused some unintended gaps in the data. Transects in Grids 1, 5, 8, and 12 terminated at the northern fence line. Transects in Grids 4, 7, 11, and 15 terminated at the southern fence line.

Table 2: GPR grid collection parameters.

Grid	Size (Meters [M])	Transects	Direction
1	31 × 36	164	North / South
2	30 × 35	235	North / South
3	31 × 35	179	North / South
4	30 × 24	145	North / South
5	30 × 36	146	North / South
6	30 × 35	195	North / South
7	30 × 58	246	North / South
8	30 × 35	174	North / South
9	30 × 35	147	North / South
10	30 × 35	201	North / South
11	30 × 22	135	North / South
12	39.5 × 35	236	North / South
13	39.75 × 35	276	North / South
14	39.5 × 35	225	North / South
15	40 × 22	172	North / South

Plate 3.1. Survey area from the west side of Grid 2. The eastern chain link boundary fence is visible in the image.
Photo View: East; Photographer: Donald Rowe; Date: November 22, 2024.

Plate 3.2. Survey area from the center of Grid 4. The southern chain link boundary fence is visible with the adjacent tennis courts.
Photo View: South; Photographer: Donald Rowe; Date: November 22, 2024.

Plate 3.3. Survey area from the western edge of Grid 5 where the northern brick and metal fence is visible. Photo View: East; Photographer: Donald Rowe; Date: November 22, 2024.
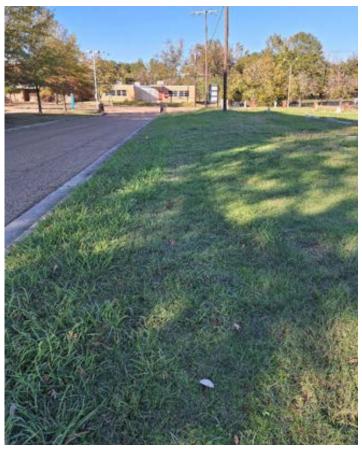

Plate 3.4. Bob Carpenter Drive along the western side of Grid 12. Utilities and land modifications associated with their installation can be seen to the east of the road. Photo View: North; Photographer: Donald Rowe; Date: November 22, 2024.
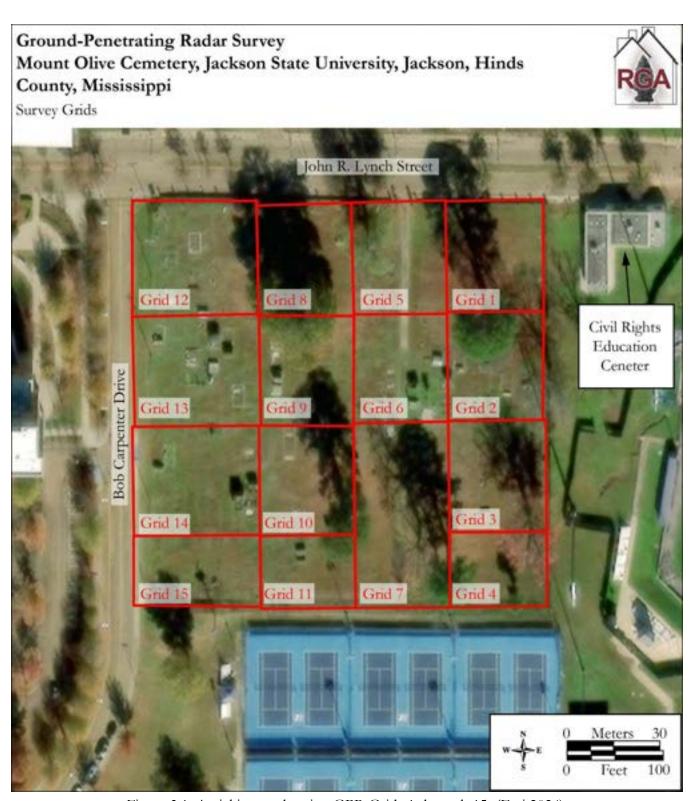
Figure 3.1. Aerial image showing GPR Grids 1 through 15 (Esri 2024).

Following the fieldwork, the GPR data was copied onto a GSSI SIR 4000 flash drive, processed using GPR-SLICE v7.MT imaging software, and mapped in ArcPro v3.3.2.

Using GPR-SLICE, the GPR data was appended into a 2D batch of files. File information was then created and edited based on collection parameters set in the field. The manufacturers' data was gained and converted to GPR-SLICE format and dc-drift and wobble noise were removed from the converted radargrams. Transects were reversed when applicable. Navigation was set to artificial markers since the survey wheel was employed. A time-zero adjustment was performed to remove the direct wave and some horizontal banding associated with the surface conditions. A vertical high pass/low pass filter was performed to remove horizontal banding and reduce graininess in the reflection profiles or radargrams. A background removal filter was then applied to further remove banding associated with surface conditions. A range gain was applied to the radargrams to compensate for the signal attenuation, amplifying the appearance of the hyperbolic anomalies, and reducing contrast near the surface and bottom of the profiles outside the area of focus. Hyperbola matching was performed to calculate velocity and identify the true dielectric constant, increasing the accuracy of depth. Data was reviewed between filters to account for the analysis of anomalies which may appear differently when post-processed using varied methods. After filtering, the data was sliced, gridded, and interpolated to create time slice grids which were downloaded as GRD files.

GRD files from the GPR grids were then imported into ArcPro and georeferenced using the grid corners which were collected using the RTK. After the grids were imported, the symbology of the layers was changed to better visualize the differences between areas with high reflection values and those with lower values. The visualization style chosen results in areas with higher values being represented with warmer colors, red being the highest, and lower values being represented by the cooler colors, blue being the lowest.

The results of the GPR survey are best viewed in selected radargram profiles associated with transects and in an interpolated 3D grid of all transects which displays time slices by depth. While viewing the radargrams, it became clear that the strongest positive and negative reflections appear roughly 0.20–1.50 m (0.66–4.92 ft) below surface. Radar waves were received from a maximum depth of 3.0 m (9.84 ft). A time-variable range gain was applied to amplify these areas of interest and minimize contrast near the surface and bottom of the radargram profiles. A variety of color palates and transformations were used to display the anomalies identified.

3.2 LiDAR Methodology

In November 2024, AAron Edelblute of Drone Nomadix recorded orthophotography and LiDAR data over the Mt. Olive Cemetery using a DJI M300RTK quadcopter (drone) with LiDAR payload. Prior to the quadcopter flight, RTK GPS points were recorded manually utilizing a Carlson BRx7 GNSS base station and rover. 3D ground control points targets (GCPs) were recorded across the cemetery along with ground shots that would be utilized to georeference and correct LiDAR contour data. Horizontal GPS data was collected in NAD83 (2011) Mississippi State Plane. Vertical data was collected in NADV88 Mississippi State Plane. All data was collected in US Survey Feet. The altitude of the drone survey was approximately 170 feet (52 m) above the ground level.

Orthophotography of the cemetery and surrounding landscape was collected with a 46MP camera along parallel transects oriented north to south. RTK GNSS data was used to ensure locational accuracy. Photographs were collected with 85 percent frontal and 75 percent side overlap in order to create high resolution 3D imagery.

LiDAR data was collected using a sensor capable of 80 percent reflectivity at 450 m (0klx) and 10 percent reflectivity at 90 m (100klx). For this survey, the sensor utilized a maximum point rate return of 480,000 points per second (pts/s) and a 4.5° vertical field of view (FoV). LiDAR collects individual points of data by pulsing lasers at the ground surface and receiving their reflections from surfaces. The speed of their return measures the distance from the unit. The collected data is processed to develop overall contour information for the area of survey. Several pulses are necessary over a given distance to record point locations that may not be visible from all angles, such as areas under tree cover. For this survey, data was collected at a 90° angle to the ground along a grid pattern at 4.5 mph.

Following the fieldwork and data collection, post-processing of both orthophotography and LiDAR data was necessary to ensure data accuracy. Field photography was processed utilizing Pix4Dmatic and Pix4Dsurvey software in order to stitch individual images into an orthomosaic tied to the collected GCPs. Data from the orthomosaics were utilized to create a dense 3D point cloud and achieve a ground sampling distance (GSD) of 1.41 cm/pixel (0.05 ft/pixel). This data was used to manually trace landscape features into Esri shapefiles as horizontal linework for analytical usage.

LiDAR data was post-processed utilizing GeoCue LP360, which georeferenced the collected LiDAR data to the GCPs and utilized a strip alignment process to assemble individual transects into an overall dataset as both points and contours. Contours were produced at 0.1-foot (3-cm) distance. Data was manually cleaned to remove data artifacts and a ground-only model (also known as a bare earth model) was created by removing above-ground structures and vegetation. A triangulated irregular network (TIN) was created from this data on a 0.3-foot (9-cm) grid spacing. An accuracy report was generated at this point in order to check for any unforeseen data processing or collection issues. After post-processing, this data was determined to have a horizontal and vertical accuracy within 0.9–4.5 cm (0.03–0.15 ft) of the GCPs.

Once the initial processing of both datasets was complete, the horizontal linework created from orthophotography was conflated with TIN data to account for increased vertical accuracy. The TIN was then manually analyzed for small elevation differences matching the approximate size of human burials. Known and potential graves were marked accordingly in a shapefile.

Once all analysis was complete, contours, known and potential grave locations, and relevant landscape features were exported as shapefiles and AutoCAD files.

4.0 SURVEY RESULTS AND INTERPRETATIONS

RGA performed the remote sensing surveys between November 13 and November 22, 2024. Geophysical Specialist Donald Rowe directed the survey with assistance from Archaeological Technicians Mariah Gonzales and Regan Crider. Aaron Edleblute operated the drone and collected LiDAR data. The weather was clear with one day having a significant amount of precipitation. The temperatures ranged from 50°F in the mornings to 75°F during the day. The GPR survey's purpose was to locate unmarked burials within the cemetery (Figure 4.1). The data and interpretations presented herein were influenced by the local conditions at the time of the survey.

4.1 GPR Survey Results

The maximum GPR penetration of radar for this survey was 3.0 m (9.84 ft) below the ground surface. The majority of the anomalies identified during GPR survey were buried between 50 and 100 cm (1.64 and 3.28 ft) below the surface. This depth of burial is relatively shallow compared to other cemeteries but is within the range that is expected in historic cemeteries. Data used to make the interpretations was extracted from time slice maps which can be viewed in Appendix B.

The GPR survey identified 95 likely burials, 1,103 potential burials, 12 buried vault covers, 5 linear features: 2 carriage paths, 1 buried fence line and 1 buried utility line and associated land modifications; and a modern sidewalk. The likely and potential burials are arranged in rows that run north to south, and the graves are oriented east to west as it typically seen in Christian burials. On the cemetery's western edge, buried modern utilities and the modern sidewalk between the cemetery and Bob Carpenter Drive appear in the GPR data as a linear anomaly (Table 3; Figure 4.3 through Figure 4.6).

Table 3. Identified anomalies.

Anomaly Type	GPR Count	Number of GPR-Identified Anomalies Corresponding with LiDAR Identified Depressions (Total Depressions = 1,483)
Likely Burials	95	45
Potential Burials	1,103	641
Vault Covers	12	10
Linear Features/Carriage Paths	5	28 depressions intersect with linear anomalies anomalies (multiple depressions overlay individual linear features). (Features identified include buried utilities and associated land modifications, one buried section of fence, and two potential carriage paths-one extending from the south end of the current east path used in the cemetery and a second one on the cemetery's west side.)
Modern Sidewalk	1	0

The identified historic anomalies represent burials that have been divided into two categories: *likely burials*, which show geophysical characteristics typical of human burials or are clearly associated with burial markers; and *potential burials*, which show fewer characteristics of human burial or occur in areas with no marker. The designation of "likely" in this text represents a higher degree of confidence that the anomaly represents a human burial.
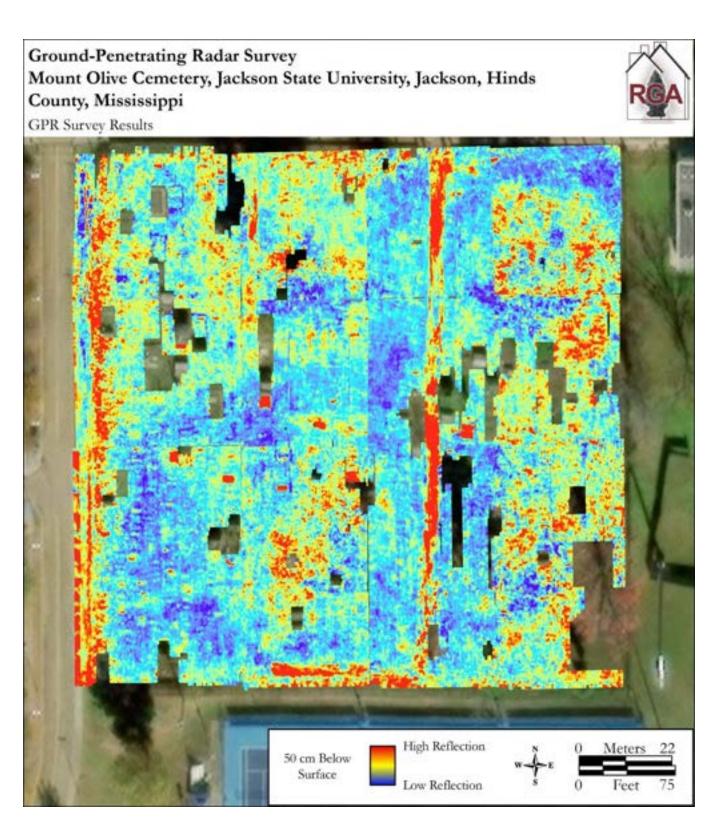
Figure 4.1. Plan view time slice map showing 50 cm depth GPR data without interpretation at Mt. Olive Cemetery (Esri 2024).
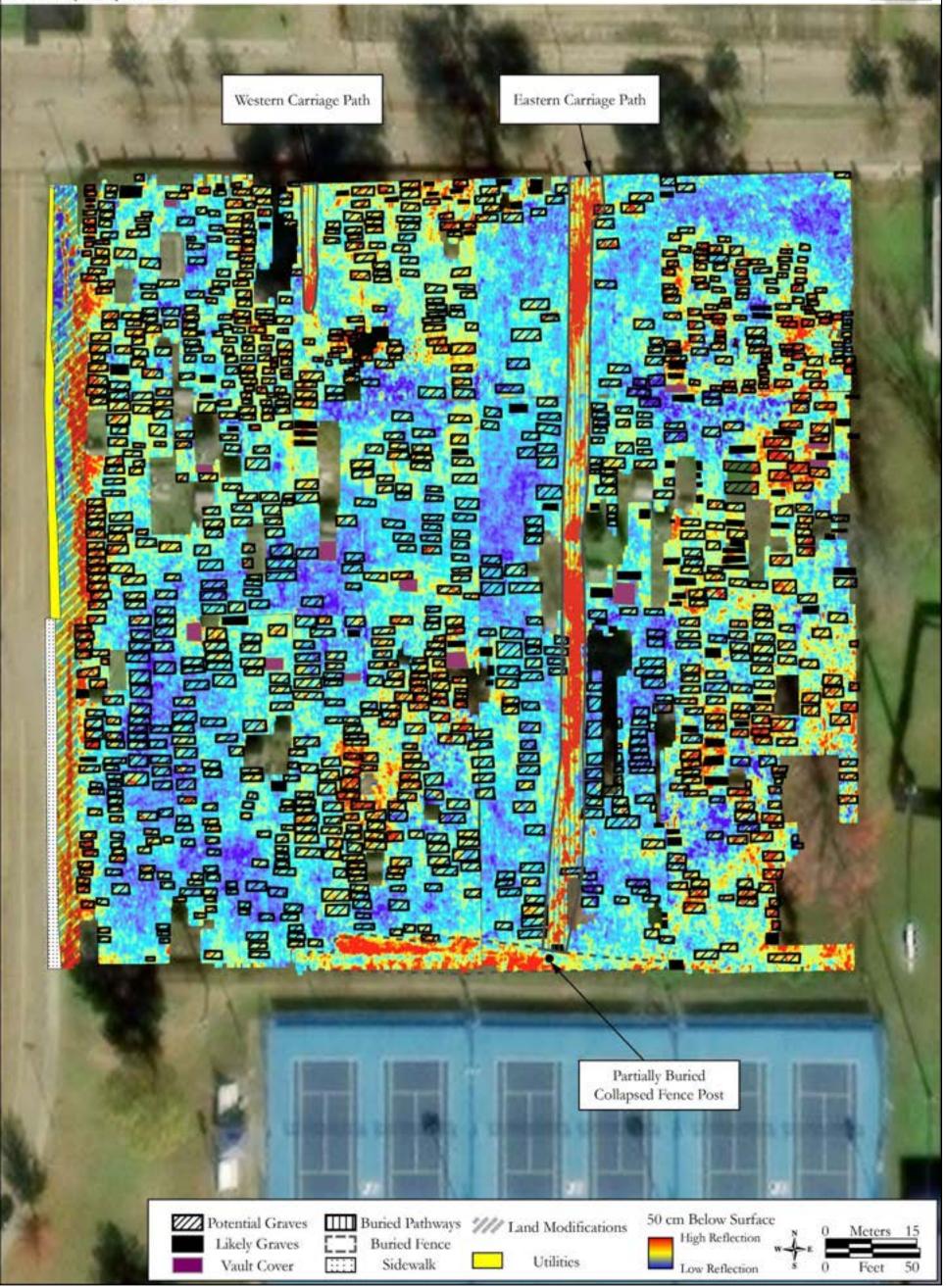
Figure 4.2. Plan view time slice map showing all GPR survey anomalies found at full radar depth range, which extends from the surface to 300 cm below the surface (Esri 2024).
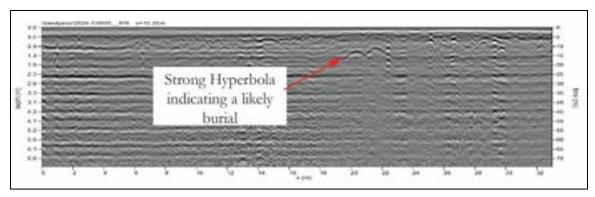
Figure 4.3. Radargram 076_1 from Grid 1 shows radar reflections of likely burials; the strong reflection seen in the radargram suggests that the coffin or vault of the burial is likely intact.
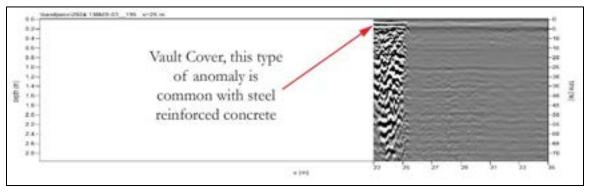
Figure 4.4. Radargram 195_3 from Grid 9 shows large high reflection anomaly representing a slab of steel or iron reinforced concrete. Note: This transect was partially collected due to obstructions which caused white space on the left side of the radargram.
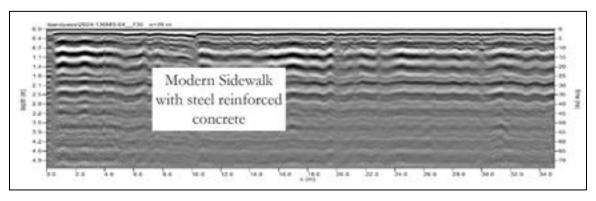
Figure 4.5. Radargram 736_4 from Grid 14 shows a high reflection anomaly covering the entire radargram; this transect was taken along the modern sidewalk and the radargram is the result of the steel-reinforced sidewalk.
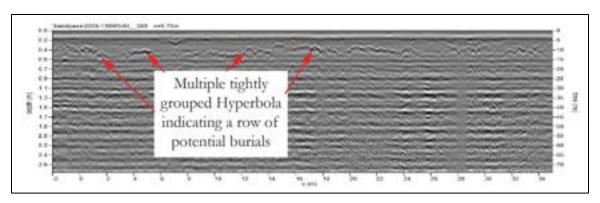
Figure 4.6. Radargram 048_4 from Grid 12 shows tightly grouped hyperbolic anomalies; these anomalies suggest the presence of burials, but the proximity of the anomalies causes them to appear weaker in time slice images.

When the descriptor "potential" is used, the degree of confidence is lower. Lower confidence in the type of anomaly may be attributable to its geophysical characteristic, the presence of overlying or nearby visible features, or the environmental conditions at the time of the survey. Likely burials identified in this survey represent those anomalies that are clearly associated with markers or show a clear hyperbolic high reflection signal across three or more radargrams. These anomalies represent either marked burials or they display radargram signals that are expected when coffins or burial vaults are detected in GPR data. Potential burials are those that lack such clear indicators as likely burials but appear as high reflection anomalies that occur in the size, shape, and orientation that is expected of human burials in historic cemeteries in the southern United States. Features other than graves that were identified in the data are likely naturally occurring features such as tree roots, buried rocks, changes in stratigraphy, or soil disturbances associated with natural flora or fauna.

Burial anomalies designated as either likely or potential burials were determined based on the degree of confidence that the anomaly indicated the presence of a burial. Vault covers are reinforced concrete slabs used as capstones for some graves in Mt. Olive Cemetery. Nine of the 12 vault covers identified are buried. The vault covers were designated independently from other types of capstones, either at the surface or buried, due to the unique signature that metal-reinforced concrete slabs display in GPR results. The modern sidewalk located on the southwest edge of the cemetery, was also constructed using reinforced concrete and the same unique signature was visible in the GPR data (see Figure 4.5). The east and west carriage paths extend from the northern edge of the cemetery to the south (see Figure 4.2). The west path is approximately 20 m in length and runs south from the north fence line past the large cinder block wall-enclosed, Grantham family plot. It is not visible from the ground surface. The concrete-covered east path extends south from the entry gate on the south side of John R Lynch Street. Presently, the east path extends approximately 45 m south of the gate and terminates; however, the GPR showed that at one time this path extended through the cemetery, around 125 m in length, to the current south fence line. This historic path is evidenced by the high reflectivity of the GPR signature and the absence of GPR signatures indicative of graves in the path's alignment.

4.2 LiDAR Survey Results Compared with GPR

The LiDAR survey completed concurrently with the GPR survey found a total of 1,483 depressions that were identified as potential burials (Figure 4.7). The total number of likely and potential burials
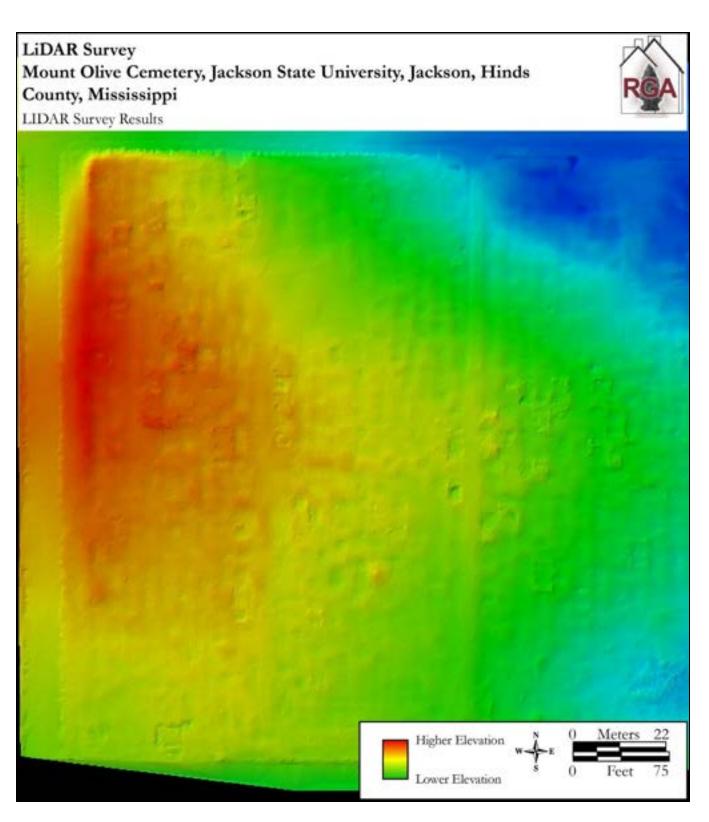
Figure 4.7. Plan view of LiDAR survey results showing elevation variations within the cemetery (DroneNomadix 2024).

and vault covers indicated through GPR is 1,210. Both the likely and potential burial anomalies are suspected to be human burials which appear as hyperbolic high GPR reflection anomalies, suggesting most of the burials included some type of container, either a coffin or vault, for example. The anomalies that have the clearest hyperbolic shape in the data likely represent burials that are either more intact or utilized more concrete, masonry, or metal in the burial containers. High GPR reflection anomalies that extend vertically throughout the entire radargram are typical of metal-reinforced concrete. The metal content of the concrete reflects almost all the radar energy back to the antenna resulting in an anomaly that appears in the data as a repeating high reflection anomaly that extends through the entire radargram. Linear features, such as paths, appear in the time slice maps as continuous high or low reflection anomalies that occur in lines. The linear features in the data are usually identified through associations with features visible on the surface. For example, the buried fence line that delineates the cemetery's south boundary was identified by a partially buried collapsed fence pole located within the area covered by the corresponding anomaly (Figure 4.8; see Figure 5.2). The exception to this is the west carriage path located in the northwest part of the cemetery which is not visible from the ground surface and was identified through its GPR signature alone.

Finally, some of the hyperbolic anomalies that appear throughout the GPR data represent isolated buried objects such as rocks, roots, possible isolated building materials, and various other buried objects. These anomalies are distinguished from the burial anomalies primarily by either their size, shapes, or orientations. Anomalies that are smaller or larger than an average human, are not oval or rectangular, or are not orientated in the prevailing east–west direction, are less likely to represent human burials.

It is important to note that the size of the anomalies created by burials can vary due to a variety of factors. The size of the anomaly can be affected by the size of the burial (juvenile versus adult burials), the integrity of the burial, the type of burial (no burial container, wooden coffins, or metal/concrete vaults), and soil or environmental conditions at the time of the survey. This multitude of variables makes estimating the size, condition, or type of burial difficult with GPR data alone. For example, small GPR anomalies can be the result of juvenile burials, partially collapsed burial containers, burial urns, or potentially the result of the GPR equipment failing to detect a portion of a larger burial. Figures 4.3, 4.4 and 4.6 show the radar reflections which display the characteristics listed in this report. These characteristics include strong hyperbolic shaped high reflection anomalies, high reflection anomalies that extend vertically through the radargram typical of metal-reinforced concrete, and multiple weaker hyperbolic anomalies occurring in tight rows representing multiple potential burials.

Ninety-five (95) anomalies were identified by GPR as likely burials with a higher degree of certainty. Forty-five (45) of the anomalies identified by the GPR survey as likely burials overlap with LiDAR-indicated depressions. The likely burials were found throughout the cemetery, being evenly spread across the 15 GPR grids (see Figure 5.2). Likely burials were identified by their proximity to extant burial markers or the presence of strong hyperbolic reflections in the size, shape, and orientation expected of a human burial. Radargram identification was made by strong hyperbolic reflections that could be identified through a series of two or more radargrams with a depth between 50 and 200 cm.
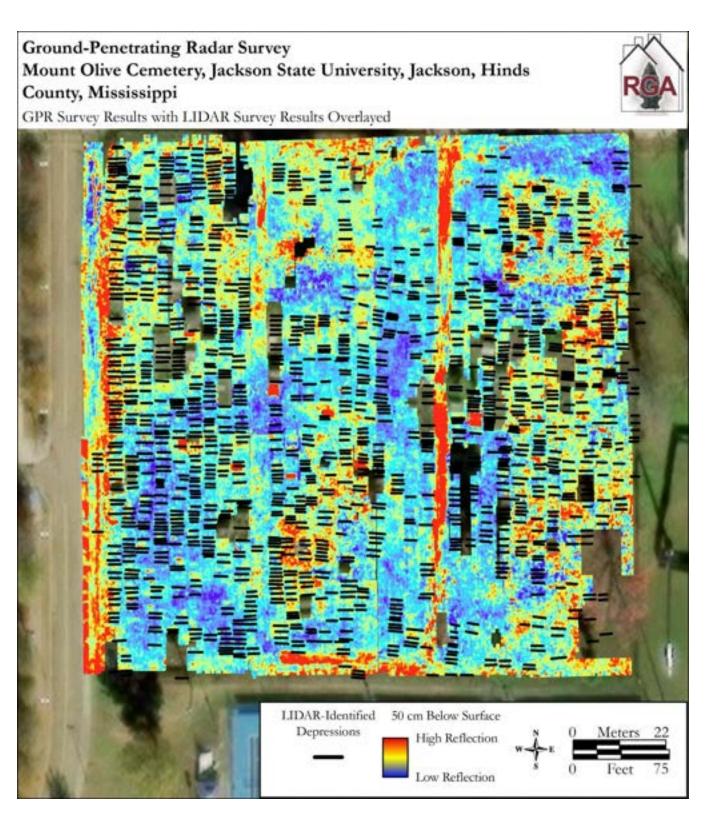
Figure 4.8. Plan view time slice map showing GPR survey results with the LiDAR-identified depressions overlayed (Esri 2025).

One-thousand, one-hundred and three (1,103) anomalies were identified with less certainty as potential burials, 641 of which overlap with LIDAR identified depressions. Similarly to the likely burials, the potential burials appear as high reflection anomalies that are identified through a series of two or more radargrams with a depth between 50 and 200 cm. The primary difference between likely and potential burials is either the presence of an associated marker or a strong hyperbolic signature in the radargram reflection.

Twelve (12) anomalies were identified as vault covers; these were identified by the unique GPR signature caused by metal-reinforced concrete. Of the 12 vault covers, 10 overlap with depressions seen in the LiDAR data and 3 of them are visible at the surface. Vault covers were separated from the likely burials as they have unique geophysical signatures and are almost certain to represent a burial.

4.3 Results Summary

Both the GPR and LiDAR surveys suggest that there are more than 1,000 unmarked burials at Mt. Olive Cemetery. The burials are positioned in rows that run from north to south with the individual graves oriented east-west, as is typical in Christian burial places. The results of both surveys show that the cemetery was extensively utilized with the areas to the west and south showing dense concentrations of anomalies. The northeast corner of the cemetery appears to be the least utilized section of the cemetery in both the GPR and LiDAR data. However, it is important to note that the absence of anomalies does not guarantee this portion of the cemetery is unoccupied. Older burials or those with no container (coffins or vaults) can be difficult to locate with remote sensing or geophysical techniques.

5.0 CONCLUSIONS AND RECOMMENDATIONS

RGA conducted GPR and LiDAR surveys at the Mt. Olive Cemetery on the campus of Jackson State University, in Jackson, Hinds County, Mississippi. The GPR survey identified 95 likely burials, 1,103 potential burials, and 12 vault covers marking 1,210 likely and potential burials. The GPR survey also identified 2 likely carriage paths, 1 likely buried utilities, 1 likely buried fence line, 1 linear feature likely caused by land modifications, and a modern sidewalk. The LiDAR survey identified 1,483 depressions as possible graves. A total of 686 likely and potential burial anomalies identified by GPR corresponded with the grave depressions identified in the LiDAR survey. JSU maintains a database of 1,461 burials in the cemetery. This figure aligns closely with 1,483 grave depressions identified by the LiDAR.

The 1,210 likely burials, potential burials, and vault covers identified in the GPR survey as well as the and the 1,483 depressions identified in the LiDAR survey show that the cemetery's 268 gravemarkers and mausoleums represent a fraction of its burials. The burials are positioned in rows that run from north to south with the individual graves oriented in the traditional Chirstian east-west alignment, a pattern that is not clearly visible on the ground due to the loss of gravemarkers over time. The survey establishes that The GPR anomalies identified as likely or potential burials show hyperbolic reflections in the radargrams and match the size, shape, and orientation expected of human burials in the time slice maps (see Appendix B).

Two linear anomalies were identified as likely carriage paths: one 20-m-long path to the west that is not evident at the surface; and one 45-m-long path in the east which appears to be a continuation of the extant concrete path visible today. Additionally, the vault covers, and the modern sidewalk identified along the cemetery's southwest edge have the unique geophysical signal that is seen when GPR data is collected over metal-reinforced concrete.

Both the GPR survey and the LiDAR survey identified anomalies throughout the cemetery (see Figure 5.8). The greatest concentration of anomalies can be found in the west and south portions of the cemetery. The portion of the cemetery with the lowest concentration of anomalies is the northeast corner. Both surveys identified fewer anomalies in the northeast corner suggesting that this portion of the cemetery is less extensively utilized. It is important to note that the presence of geophysical or LiDAR anomalies does not definitely identify the presence or absence of human burials. Burials, especially older historic burials, can be challenging to locate with these methods as the characteristics of burials that can be identified typically decay over time.

Geophysical surveys are not always conclusive on their own but can provide valuable information for future investigations. Considering this, RGA presents the following recommendations:

1. Archaeologists should perform thorough archaeological monitoring of any ground disturbance at the cemetery. Should any human remains be encountered, work should be stopped immediately and the appropriate authorities contacted.

2. Consider additional geophysical surveying using magnetometry. A large-scale magnetometer survey could have success mapping the subsurface and locating artifacts associated with burials. Magnetometry surveys are sensitive to metal and certain igneous rocks (such as granite) commonly used in cemetery contexts and could potentially expand upon the data collected during the present GPR and LiDAR surveys by locating smaller buried headstones, coffin hardware, and/or materials buried with the deceased. Magnetometry has the benefit of covering larger areas more efficiently than GPR and can complement the GPR work already completed.

3. To protect the site's archaeological resources from unauthorized collection RGA recommends placing informational signage asking the public not to collect artifacts and/or take other measures to protect resources.

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Appendix A: Qualifications of the Authors

ELLEN TURCO
PRINCIPAL SENIOR HISTORIAN (36 CFR 61)

Ellen Turco has over 20 years' experience in cultural resources management across multiple industries such as transportation, telecommunications, oil and gas infrastructure, and land development. Her experience includes historical research and writing, architectural surveys and analysis, National Register of Historic Places evaluations for individual resources, districts, and landscapes, both state and federal Historic Preservation Tax Credit applications, and the preparation of both Memorandum of Agreement and Programmatic Agreement documents. She has conducted and directed cultural resources surveys in accordance with Sections 106 and 110 of the National Historic Preservation Act, as amended, NEPA, and other municipal and state cultural resource regulations. Ms. Turco exceeds the qualifications set forth in the Secretary of Interior's Standards for an Historian and Architectural Historian [36 CFR 61].

REPRESENTATIVE PROJECT EXPERIENCE

Cemetery Relocation, Town of Wendell, Wake County, North Carolina (Sponsor: Wake Technical Community College) Served as project manager for a multicomponent project to relocate 16 nineteenth-century graves. The burials were on the site of the proposed new Wake Tech campus and were relocated to a perpetual care cemetery in Raleigh. This project required knowledge of, and strict adherence to, state grave removal laws, the preparation of a successful grave removal petition for presentation to the county Board of Commissioners, and coordination with multiple parties including the county health department, the county planning department, a licensed funeral director, and the grave removal contractor.

Friendship Chapel Cemetery, Town of Wake Forest, Wake County, North Carolina (Sponsor: Wake Forest Historical Society) Researched the hidden history of this former slave cemetery through deeds, oral histories, genealogies, and church and personal family records. Developed a context for area folk cemeteries and burial practices. This information, along with collected documentary and current photos, was compiled into a GIS-based interactive Storymap hosted on the website of a local museum. This project won a North Carolina Museum's Council's Award of Excellence for 2018.

Local Landmark Designation Report for Seth Jones Cemetery and Walled Cemeteries of Wake County Context, Town of Rolesville, Wake County, North Carolina (Sponsor: Capital Area Preservation) Served a project manager for a report on the Seth Jones Cemetery that included a context statement on walled cemeteries.

Improvements to NC 42 Interchange with I-40, Johnston County, North Carolina (Sponsor: North Carolina Department of Transportation) Principal Investigator and Historian for a Phase I Historic Architectural Resource Inventory of a formerly rural but now heavily developed 5-mile-long corridor. The Phase I work eliminated 25 resources from intensive study and identified 4 resources that required Phase II National Register evaluations. The phased approach allows project planning and design to proceed in areas without historic sensitivity.

Mount Ararat African American Episcopal Church, City of Wilmington, New Hanover County, North Carolina (Sponsor: North Carolina Department of Transportation) Principal Investigator and Historian for this multi-part mitigation of a Reconstruction-era African American church and cemetery. Authored NRHP nomination text for the church, former school site, and adjacent cemetery. Provided background on folk burial practices in the eastern Coastal Plain for the ground-penetrating radar cemetery survey and authored an illustrated public history booklet about the history of the Middle Sound community entitled "Kin, Kindred, Relatives and Friends." Work on this project identified a potentially eligible resource, the Nixon Oyster Plant, that had been omitted in previous planning surveys. The Oyster Plant was treated in a subsequent document to ensure that all Section 106 and NEPA requirements were met.

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DONNY ROWE
GEOPHYSICAL ARCHAEOLOGIST (36 CFR 61)

Donny Rowe is a Principal Investigator and RGA's geophysical archaeologist based in the firm's North Carolina office. His prior experience includes working for the Bureau of Land Management, where he conducted Phase I and Phase II archaeological investigations and prepared technical reports for compliance with the National Environmental Policy Act and Section 106 of the National Historic Preservation Act. At RGA, Mr. Rowe specializes in the use of non-invasive geophysical techniques such as ground-penetrating radar, magnetometry, electrical resistivity, and conductivity for archaeological investigations. He specializes in the use of geophysics in cemeteries and provides expertise in post-fieldwork processing and interpretation of data. Mr. Rowe also provides GIS support to the company, creating map graphics for both field use and in final reports. His educational and professional background exceed the *Secretary of the Interior's Professional Qualification Standards* for Archaeology (36 CFR 61).

REPRESENTATIVE PROJECT EXPERIENCE

Zion Union Cemetery GPR Survey, Borough of Mercersburg, Franklin County, Pennsylvania (Sponsor: Zion Union Cemetery Association) Geophysical Specialist who assisted the ground-penetrating radar survey efforts to identify buried anomalies in the historic African American Zion Union Cemetery. The survey identified 27 anomalies, with 25 of them likely corresponding to gravestones. The remaining anomalies suggested that older sections of the cemetery would be more likely to contain unmarked burials.

Mount Olive Cemetery GPR and LiDAR Survey, Jackson State University (JSU), Jackson, Mississippi (Sponsor: JSU and the National Park Service) Served as the lead geophysical archaeologist for multi-disciplinary project funded by an HBCU Grant from the NPS. GPR data was collected over two weeks on a 4-acre site. The goal of the study was to locate and map over 1,200 unmarked burials, which are known to exist through death certificates and other records. Mr. Rowe will process the data collected in the field and blend it with a drone LiDAR survey to create maps with the locations of unmarked burials.

Carter Finley Stadium GPR Survey, Raleigh, North Carolina (Sponsor: North Carolina State University) Conducted a GPR survey of a 0.25-acre cemetery to facilitate the relocation of burials for a construction project. The site's wooded topography and the impacts of a previous effort to remove the graves provided challenges to data collection and post fieldwork data processing. The results of the survey will allow the graves to be relocated to a safe location with perpetual care.

East Yuma Cemetery District, East Yuma County, Colorado (Sponsor: East Yuma County Cemetery District) Planned and conducted a multi-instrument geophysical survey of two rural cemeteries and one rural community center in Eastern and Western Colorado. Managed a team of field assistants. Processed and interpreted GPR data as both time slices and radargrams using Geophysical Archaeometry Laboratory's GPR-Slice MT software. The final report was accepted by Colorado State University in fulfilment of Mr. Rowe's Masters in Anthropology.

Ailey Young Park GPR Survey, Wake Forest, North Carolina (Sponsor: Town of Wake Forest) The Ailey Young House may be the oldest remaining building associated with Wake Forest's African American community. The house was one of a number of no longer extant Black-owned houses known as "Simmons Row." Mr. Rowe directed a geophysical survey of

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the Young House and Simmons Row site the results of which are being used to inform the public engagement and planning process for a town-owned park.

Singleton Family Cemetery GPR Survey, Wedgefield, Sumter County, South Carolina (Sponsor: Sumter Museum) Geophysical Specialist/Archaeologist, conducted a GPR survey of the Singleton Family Cemetery to investigate potential burials on the 0.15-acre plot. The survey results suggested that twenty-seven likely and thirty-two potential burials were present in the survey area. RGA recommended monitoring if any ground disturbance will be conducted within 10-15 meters of the cemetery boundary. Should any human remains be encountered, RGA recommended that work should stop immediately, and the appropriate authorities contacted.

Rock Hill Cemetery GPR Survey, Lake James State Park, Burke County, North Carolina (Sponsor: Foothills Conservancy of NC) Geophysical Specialist/Archaeologist, conducted a GPR survey of the Rock Hill Cemetery to investigate potential burials on the 0.25-acre plot. The survey results suggested that twenty-one likely burials were present in the survey area. RGA recommended monitoring if any ground disturbance will be conducted within 10-15 meters of the cemetery boundary. Should any human remains be encountered, RGA recommended that work should stop immediately, and the appropriate authorities contacted.
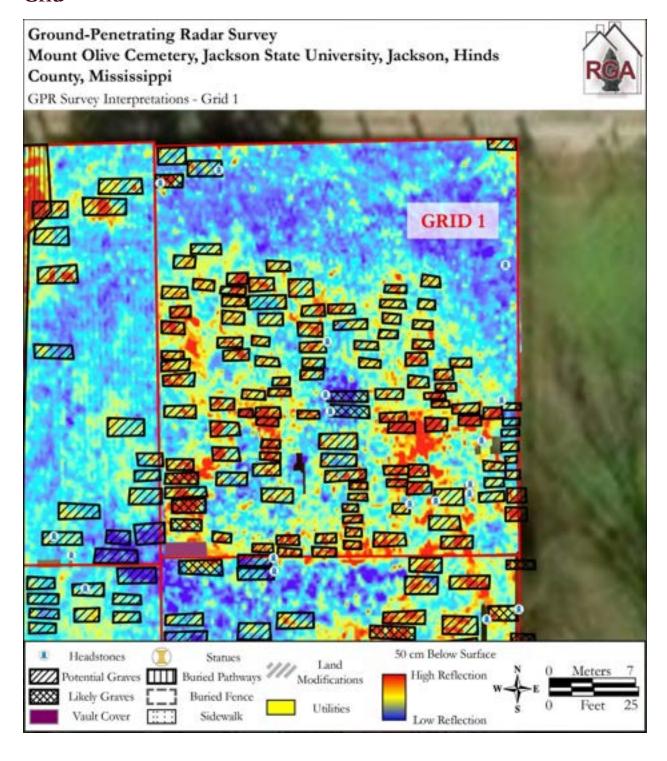
Apex Peakway Right-of-Way Survey, Apex, Wake County, North Carolina (Sponsor: Private Sponsor) Geophysical Specialist/Archaeologist, conducted a GPR survey of the Apex Peakway right-of-way on the north side of Apex Peakway east of its intersection with Tingen Road. The GPR survey investigated an area measuring 0.16 acres. Geophysical evidence from a GPR survey of the Apex Peakway right-of-way in Apex, North Carolina, suggested that no unmarked burials are present in the survey area. The concentration of anomalies throughout the survey area and the appearance of the survey area suggest that the area has been disturbed in the recent past. The lack of archaeologically relevant anomalies and the evidence of modern subsurface disturbances strongly suggested that the survey area contains no unmarked burials. RGA recommended monitoring if any ground disturbance will be conducted near the cemetery boundary. Should any human remains be encountered, RGA recommended that work should stop immediately, and the appropriate authorities contacted.

Marvin Road Apartments, Charlotte, Mecklenburg County, North Carolina (Sponsor: North Carolina Housing Finance Agency) Archaeologist and Principal Investigator for archaeological monitoring conducted survey for the Marvin Road Apartments project located at the intersection of Marvin Road and Billigsley Road. The project area lies immediately north and west of the St. Lloyd's Presbyterian Church Cemetery. Due to the limitations of GPR technology on the type of uneven and heavily wooded terrain present at the edge of a fence apparently marking the cemetery limits, the North Carolina Office of State Archaeology (OSA) recommended construction monitoring within a 10-meter buffer at the western and northern edges of the cemetery parcel. During the mechanical and manual stripping, no indications of a continuation of the cemetery were noted within or outside the 10-meter buffer. RGA recommended no further monitoring or other archaeological investigation as the project is currently designed.

Goss Family Cemetery, Cary, White Oak Township, Wake County, North Carolina (Sponsor: Private Sponsor) Archaeologist for ground probing survey of the Goss Family Cemetery. The survey, covering 0.04 acres within the 0.37-acre cemetery, aimed to identify potential locations of unmarked burials using a metal tile probe. The metal tile probe survey found two areas with the potential for unmarked graves. A third area displayed ornamental plants which can mark burials. RGA recommended this area should be treated with caution during any excavation activities at the site.

Byrd Farm Cemetery Reserve, New Light Township, Wake County, North Carolina (Sponsor: Private Sponsor) Archaeologist and Principal Investigator for a due diligence archaeological assessment and records review of a potential cemetery on a private property in Wake County. The due diligence study looked for the presence or absence of graves at the site in anticipation of applying for a septic permit. Visual inspection and pedestrian survey did not reveal the presence of graves, gravemarkers, grave depressions, plot enclosures, funerary plantings or any other indicators of abandoned graves on the property. Judgmental probing with a tile probe was negative for soil conditions associated with grave shafts. RGA recommended no additional archaeological investigations for this project; however, due to the increased sensitivity of sites with the potential to contain human remains, it was recommended that archaeological monitoring be conducted during the installation of the septic infrastructure.

Appendix B: Detailed View of Interpreted GPR Slices at 50 cm by Grid

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi
GPR Survey Interpretations - Grid 1

GRID 1

Legend:
- Headstones
- Potential Graves
- Likely Graves
- Vault Cover
- Statues
- Buried Pathways
- Buried Fence
- Sidewalk
- Land Modifications
- Utilities
- 50 cm Below Surface
- High Reflection
- Low Reflection
- 0 Meters 7
- 0 Feet 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 2

GRID 2

	Headstones		Statues		Land Modifications	50 cm Below Surface				
	Potential Graves		Buried Pathways			High Reflection			Meters	7
	Likely Graves		Buried Fence		Utilities			0		
	Vault Cover		Sidewalk			Low Reflection		0	Feet	25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 3

GRID 3

				50 cm Below Surface		
🔵 Headstones	⚱ Statues	🖊 Land Modifications		High Reflection		N
▨ Potential Graves	▦ Buried Pathways					W → E
▩ Likely Graves	⬚ Buried Fence	🟨 Utilities				S
🟪 Vault Cover	⬚ Sidewalk			Low Reflection		

0 Meters 7
0 Feet 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 4

GRID 4

50 cm Below Surface

🔵 Headstones	⚱ Statues	▨ Land Modifications	High Reflection
▨ Potential Graves	⊞ Buried Pathways		
▨ Likely Graves	⊡ Buried Fence	🟨 Utilities	
🟪 Vault Cover	⊡ Sidewalk		Low Reflection

Meters 0 — 7
Feet 0 — 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 5

GRID 5

Headstones	Statues	Land Modifications
Potential Graves	Buried Pathways	
Likely Graves	Buried Fence	Utilities
Vault Cover	Sidewalk	

50 cm Below Surface

High Reflection

Low Reflection

N
W E
S

0 Meters 7
0 Feet 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 6

GRID 6

Legend

Headstones	Statues	Land Modifications	**50 cm Below Surface**	
Potential Graves	Buried Pathways		High Reflection	
Likely Graves	Buried Fence	Utilities		
Vault Cover	Sidewalk		Low Reflection	

0 Meters 7
0 Feet 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 7 North

GRID 7
North

Legend

Headstones	Statues	Land Modifications	**50 cm Below Surface**	
Potential Graves	Buried Pathways		High Reflection	
Likely Graves	Buried Fence			
Vault Cover	Sidewalk	Utilities	Low Reflection	

Meters 0 — 7
Feet 0 — 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 7 South

GRID 7
South

Headstones	Statues	Land Modifications	50 cm Below Surface
Potential Graves	Buried Pathways		High Reflection
Likely Graves	Buried Fence	Utilities	
Vault Cover	Sidewalk		Low Reflection

	Meters	7
0	Feet	25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds
County, Mississippi

GPR Survey Interpretations - Grid 8

GRID 8

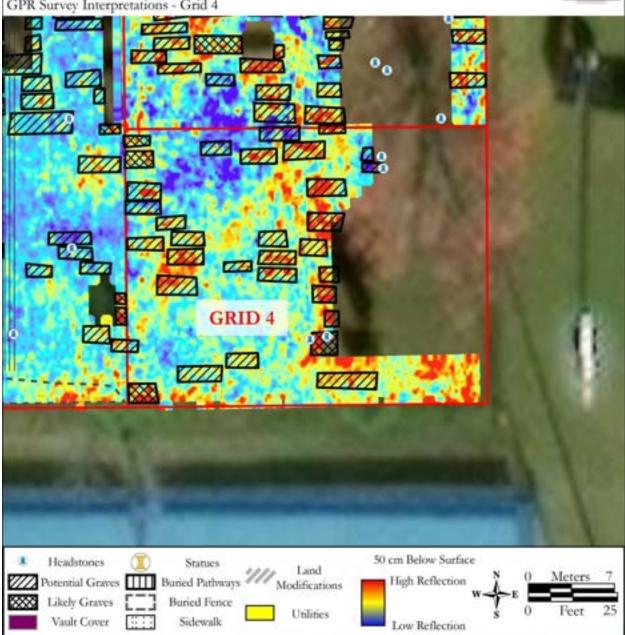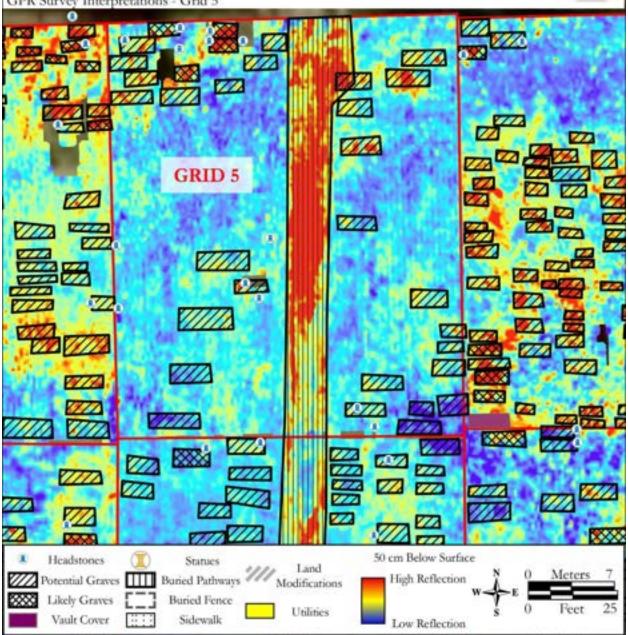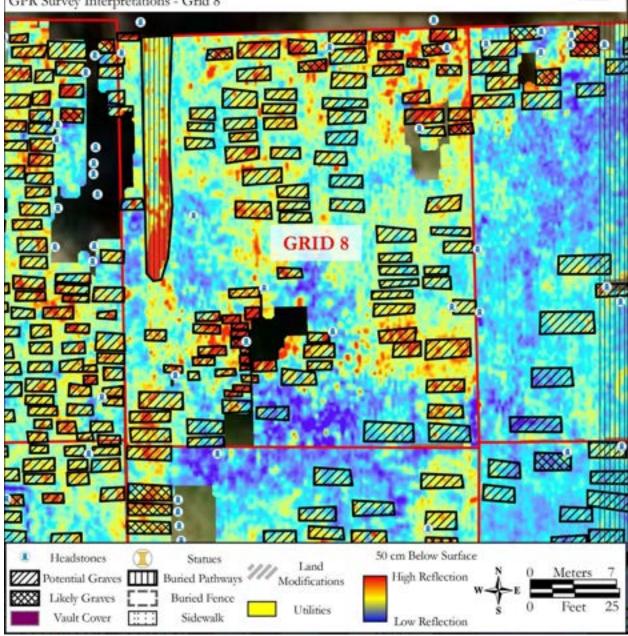|	Headstones		Statues		Land Modifications	50 cm Below Surface		
▨	Potential Graves	⊞	Buried Pathways			High Reflection		Meters 7
▩	Likely Graves	⊡	Buried Fence					
■	Vault Cover	⊡	Sidewalk		Utilities	Low Reflection		Feet 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 9

GRID 9

Legend:

Symbol	Description	Symbol	Description	Symbol	Description
	Headstones		Statues		Land Modifications
	Potential Graves		Buried Pathways		Utilities
	Likely Graves		Buried Fence		
	Vault Cover		Sidewalk		

50 cm Below Surface

High Reflection

Low Reflection

Meters 0 — 7
Feet 0 — 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 10

GRID 10

Symbol	Description	Symbol	Description	Symbol	Description
	Headstones		Statues		Land Modifications
	Potential Graves		Buried Pathways		
	Likely Graves		Buried Fence		Utilities
	Vault Cover		Sidewalk		

50 cm Below Surface

High Reflection

Low Reflection

N W E S

Meters 0 — 7
Feet 0 — 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds
County, Mississippi

GPR Survey Interpretations - Grid 11

GRID 11

	Headstones		Statues		Land Modifications	50 cm Below Surface				
	Potential Graves		Buried Pathways			High Reflection			Meters	7
	Likely Graves		Buried Fence		Utilities				Feet	25
	Vault Cover		Sidewalk			Low Reflection				

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 12

GRID 12

Legend

Symbol	Description
Headstones	
Potential Graves	Statues
Likely Graves	Buried Pathways
Vault Cover	Buried Fence
	Sidewalk
Land Modifications	
Utilities	

50 cm Below Surface

High Reflection

Low Reflection

N
W — E
S

Meters 0 — 7
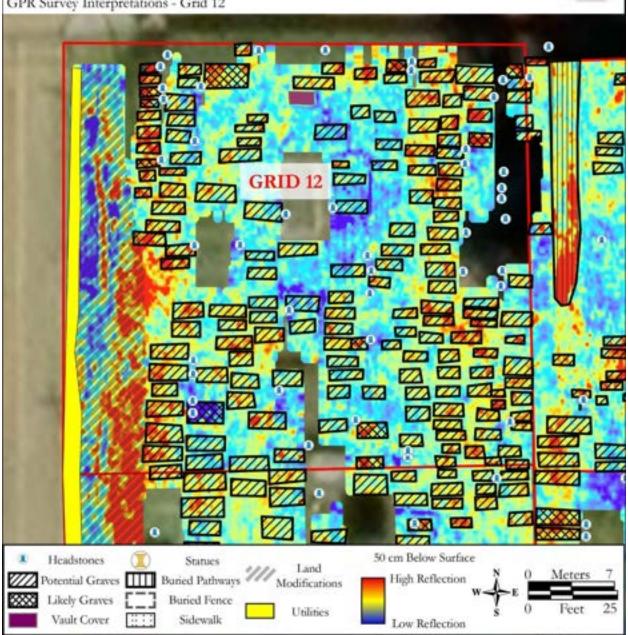Feet 0 — 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 13

GRID 13

Legend:

50 cm Below Surface
High Reflection
Low Reflection

- 🛆 Headstones
- ⚱ Statues
- ▨ Potential Graves
- ⦀⦀⦀ Buried Pathways
- ⧄ Land Modifications
- ▩ Likely Graves
- ⌐⌐ Buried Fence
- ■ Vault Cover
- ⋯ Sidewalk
- ▮ Utilities

Meters 0 – 7
Feet 0 – 25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds County, Mississippi

GPR Survey Interpretations - Grid 14

GRID 14

Headstones
Potential Graves
Likely Graves
Vault Cover

Statues
Buried Pathways
Buried Fence
Sidewalk

Land Modifications
Utilities

50 cm Below Surface
High Reflection
Low Reflection

Meters
0   7
Feet
0   25

Ground-Penetrating Radar Survey
Mount Olive Cemetery, Jackson State University, Jackson, Hinds
County, Mississippi

GPR Survey Interpretations - Grid 15

GRID 15

	Headstones		Statues		Land Modifications	50 cm Below Surface		
	Potential Graves		Buried Pathways			High Reflection		N
	Likely Graves		Buried Fence		Utilities			W E
	Vault Cover		Sidewalk			Low Reflection		S

0 Meters 7
0 Feet 25

Appendix C: Annotated Project Data

Principal Investigator:	Donald Rowe
Project Manager:	Ellen Turco
Authors:	Donald Rowe, Ellen Turco
Title:	Ground-Penetrating Radar Survey of the Mt. Olive Cemetery
Date:	July 2025
RGA Database Title:	Mt. Olive Cemetery GPR
RGA Project No.:	2024-136MS
State:	Mississippi
County:	Hinds County
USGS Quad:	Jackson, MS
Drainage Basin:	Town Creek, Pearl River, Mississippi River, Gulf of Mexico
Regulation:	N/A
Project Type:	Historic Preservation Planning
Project Sponsor:	Jackson State University
Client:	Jackson State University
Level of Survey:	Historical Research; Geophysical Survey (GPR)
Cultural Resources:	Historic Cemetery site, site of historic African American cemetery
Geophysical Anomalies:	95 likely burials, 1,103 potential burials, 12 vault covers, 5 linear features, and 1 modern sidewalk