

**GROUND PENETRATING RADAR SURVEY OF PROPOSED ELEVATOR  
SHAFT SITE EXPLORATION (PEPC 47098) IN THE OLD COURTHOUSE AT  
JEFFERSON NATIONAL EXPANSION MEMORIAL, ST. LOUIS, MISSOURI**

Steven L. De Vore



MIDWEST ARCHEOLOGICAL CENTER  
ARCHEOLOGICAL REPORT No. 2

United States Department of the Interior  
National Park Service  
Lincoln, Nebraska

2014



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BY  
STEVEN L. DE VORE

Dates of field work: June 10-12, 2013

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This report has been reviewed against the criteria contained in 43CFR Part 7, Subpart A, Section 7.18 (a) (1) and, upon recommendation of the Midwest Regional Office and the Midwest Archeological Center, has been classified as

*Available*

Making the report available meets the criteria of 43CFR Part 7, Subpart A, Section 7.18 (a) (1).



# TABLE OF CONTENTS

Abstract.....	1
Purpose of archeological work per sow and project design.....	1
Geophysical project location .....	2
Archeological project personnel .....	3
Environmental description of project area.....	3
General description of the geophysical project and methods.....	4
Overall research design.....	4
Culture history and previous work.....	4
Description of investigations.....	5
Field methods .....	6
Ground-penetrating radar survey .....	6
Description of geophysical interpretation of cultural resources located.....	10
National register evaluation of cultural Resources located.....	11
National register recommendations with justifications for eligible, not eligible, need more information from testing, etc .....	12
Site integrity and conservation/stabilization/avoidance recommendations.....	12
Effects of project on resources .....	12
Location of artifactual materials and records from the work .....	13
References cited .....	15
Summary management recommendations .....	23

Figures.....	25
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## LIST OF FIGURES

Figure 1. Location of the geophysical project at the Old Courthouse, Jefferson National Expansion Memorial. ....	25
Figure 2. General view of the Old Courthouse. ....	26
Figure 3. Drawing of the Old Courthouse expansion projects between 1838 and 1852 .....	27
Figure 4. View of the Old Courthouse in 1852 with exterior entry stairs visible on the south side.....	28
Figure 5. Location of the North and South Transept geophysical project areas.....	28
Figure 6. General view of the North Transept.....	29
Figure 7. General view of the South Transept.....	29
Figure 8. Sketchmap of the North Transept geophysical project area. ....	30
Figure 9. Sketchmap of the South Transept geophysical project area. ....	30
Figure 10. Conducting the ground-penetrating radar survey with the GPR cart and 400 MHz antenna in the North Transept geophysical project area. ....	31
Figure 11. Ground-penetrating radar time slice survey data from the North Transept geophysical project area. ....	31
Figure 12. Ground-penetrating radar time slice survey data from the South Transept geophysical project area. ....	32
Figure 13. Image and contour plots of the ground-penetrating radar time slice 3 (6-11 ns) survey data from the North Transept geophysical project area. ....	32
Figure 14. Image and contour plots of the ground-penetrating radar time slice 3 (6-11 ns) survey data from the South Transept geophysical project area. ....	33
Figure 15. Interpretation of ground-penetrating radar data from time slice 3 (6-11 ns) from the North Transept geophysical project area.....	33

Figure 16. Interpretation of ground-penetrating radar data from time slice 3 (6-11 ns) from the South Transept geophysical project area.....	34
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## **ABSTRACT**

The ground-penetrating radar survey at the Old Courthouse was conducted between June 10 and 12, 2013, at the Jefferson National Expansion Memorial (JEFF) in St. Louis, Missouri as part of the Proposed Elevator Shaft Site Exploration project (Planning, Environment and Public Comment [PEPC] document number 47098). The Midwest Archeological Center provided technical assistance for the ground-penetrating radar survey of the two transepts between the rotunda and the North and South wings of the Old Courthouse. The geophysical investigations consisted of a ground-penetrating radar survey with a GPR cart system and 400 MHz antenna. Overall, the geophysical project areas in the two transepts totaled 128 m<sup>2</sup> (1,377.82 ft<sup>2</sup>) or 0.032 ac. The ground-penetrating radar survey resulted in the potential identification of original external stairs in both transepts, additional fill to level the floors, and utility lines located under the stone floors in both transepts. The removal of the stone floor in the vicinity of the proposed elevator shaft site(s) and the excavation of the fill are recommended to meet compliance with Section 106 of the National Historic Preservation Act.

## **PURPOSE OF ARCHEOLOGICAL WORK PER SOW AND PROJECT DESIGN**

Jefferson National Expansion Memorial (JEFF) is located in downtown St. Louis, Missouri, along the Mississippi River. The park consists of the Gateway Arch and grounds, the Old Courthouse, and the Luther Ely Smith Square. The Memorial Drive and the depressed Interstate Highway 70 separate the Gateway Arch and grounds from the Old Courthouse and the Luther Ely Smith Square. The ground-penetrating radar survey is located in the North and South transepts of the Old Courthouse (Figure 1).

The Jefferson National Expansion Memorial was established in 1935 under Executive Order 7253 by President Franklin D. Roosevelt for “a permanent memorial to the men who made possible the territorial expansion of the United States, particularly President Thomas Jefferson and his aides, Livingston and Monroe, and the hardy hunters, trappers, frontiersmen, and pioneers and others who contributed to the territorial expansion and development of the United States” (Brown 1984; BVHA 2013:9; Moore 1994; NPS 2009:1-3,A-1/A-2). The park was the first urban park within the NPS system located outside Washington, D.C. (Moore 1994). The Old Courthouse is part of the Jefferson National Expansion Memorial along with the Luther Ely Smith Square on the west side of Memorial Drive and the depressed Interstate 70 (Figure 2). The courthouse is bounded on the north by Chestnut Street, on the south by Market Street, on the east by 4th Street, and on the west by Broadway in downtown St. Louis.

The Old Courthouse was an important public gathering space for people traveling west. During its lifetime, the Old Courthouse served as the physical and symbolic center of St. Louis (BVHA 2013:215-219). It was the site of the historic Dred Scott case (Swain 2004). Scott, a slave, sued for his freedom from the widow of Dr. John Emerson. The first trial verdict in 1847 favored Mrs. Emerson, but, on appeal in 1850, Scott was awarded his freedom by the St. Louis Court. His freedom was taken away on appeals to the Missouri Supreme Court in 1852 and ultimately, the U.S. Supreme Court in 1857. The 1857 U.S.

Supreme Court decision in the Dred Scott v. Sandford case (Finkelman 1997) resulted in the denial of citizenship to persons of color and that slavery in the territories was a property right that could not be terminated by legislation (Bryan 1937; BVHA 2013:13-14; NPS 2009:3-9).

The Old Courthouse was originally built in phases between 1839 and 1862 (BVHA 2013:23; Lindenbusch 1982). It replaced the original courthouse on the property, which was built in 1826 (BVHA 2013:13-36,169-214). The original 1826 courthouse was built to replace the several courts that were housed in various buildings in St. Louis. By 1838, the original courthouse was too small to meet the demands of the rapidly increasing St. Louis population. The cruciform design of the new courthouse with a central rotunda included the first courthouse as the east wing (Figure 3). Between 1843 and 1857, the north and south entry to the Old Courthouse were located on the exterior of the building (Figure 4). They were enclosed with the addition of the North and South wings between 1857 and 1862. In 1852, the Old Courthouse was expanded with additional wings added to the north and south sides, as well as the demolition of the original courthouse. The courts vacated the building in 1930. The Old Courthouse was acquired by the National Park Service in 1940. Rehabilitation and maintenance of the Old Courthouse by NPS from 1940 to the present has maintained the historic appearance of the Old Courthouse and provided the public with an interpretive center and community center. Accessibility was first addressed in 1987 when an accessibility lift was added to the west portico along with portable interior ramps on the first floor for ease of access to the museum galleries. A new lift was added in the southwest courtyard in 2007 and replaced in 2012. While these lifts provided access to the first floor, the disabled public did not have access to the historic second floor courtrooms. The proposed elevator installation in the transepts will provide access to the second floor.

The National Park Service's (NPS) Jefferson National Expansion Memorial (JEFF) staff proposed the placement of elevators in the North and South transepts at the Old Courthouse to meet accessibility requirements for disabled visitors to the historic courthouse under the Americans with Disabilities Act of 1990 (ADA), as amended by the ADA Amendments Act of 2008. In order to determine the existence of architectural features associated with the original Courthouse, a ground-penetrating radar (GPR) survey was proposed. The Midwest Archeological Center (MWAC) provided technical assistance to the park for the GPR survey of the two transepts where the original exterior stairs to the Courthouse were located. The enclosed transepts connect the original courthouse structure to the North and South wing additions and cover the original exterior stairs. The work is conducted to meet stipulations of the National Historic Preservation Act of 1966 (NHPA), as amended (NPS 2006:35-99), the National Environmental Policy Act of 1970 (NEPA), as amended (NPS 2006:101-104), and Director's Order #28 (NPS 1998).

## ***GEOPHYSICAL PROJECT LOCATION***

The geophysical project areas are located on the first floor of the Old Courthouse in downtown St. Louis, Missouri (Figure 5). The 19th-century courthouse represents a Greek Revival style building with a central rotunda and four wings. The corner stone

for the Old Courthouse is located on the northwest corner of the North Transept. The two project areas are located in the North and South transepts. Both rooms are elevated above the ground and separate the main part of the courthouse from the newer North and South wings. The original exterior stairs have been enclosed in the two transepts. The transepts have been filled and covered with stone slab flooring.

## **ARCHEOLOGICAL PROJECT PERSONNEL**

MWAC archeologist Steven L. De Vore directed and conducted the ground-penetrating radar survey. Historic Architect Al O'Bright, Midwest Regional Office, and JEFF Park Historian Bob Moore assisted in the GPR investigations. JEFF Chief of Museum Services and Interpretation and NEPA specialist Ann Honious provided background material for the project. MWAC Archeologist Timothy Schilling provided archeological background on the project for the geophysical investigations.

## **ENVIRONMENTAL DESCRIPTION OF PROJECT AREA**

The Jefferson National Expansion Memorial is located in the Dissected Till Plains section of the Central Lowland province of the Interior Plains division (Fenneman 1938:588-605; Hunt 1967:205211) of the North American continent. The Dissected Till Plain section consists of submaturely to maturely dissected till plains. This area is located within the Central Mississippi Valley Wooded Slopes, Western Part major land resource area of the Central Feed Grains and Livestock land resource region (USDA 2006:315-316,365-367). The region consists of deeply dissected, loess covered hills (USDA 2006:366). Nearly level to very steep uplands are dissected by the tributaries of the Mississippi and Missouri rivers. Major streams have numerous stream terraces along the broad flood plains in well-defined valleys. Smaller streams have narrow flood plains. Broad summits range from nearly level to slightly sloping. Uplands are covered with loess. Glacial deposits are underlain by Mississippian, Ordovician, and Pennsylvanian bedrock (USDA 2006:366). The area also lies within the Carolinian biotic province (Dice 1943:16-18). The native vegetation is dominated by deciduous forest vegetation and tall-grass prairies. The upland hardwood vegetation includes oak, hickory, and sugar maple (Shelford 1963:23-35, 89-114; USDA 2006:367). Elm, cottonwood, river birch, ash, silver maple, pin oak, and willow are found on the floodplains. The tall-grass prairies are dominated by big bluestem and little bluestem while sedges occur on the lowlands in addition to the prairie grasses (Shelford 1963:334-344; USDA 2006:367). Wildlife include white-tailed deer, coyote, gray and red fox, beaver, raccoon, skunk, muskrat, opossum, mink, rabbit, squirrels and other small mammals, reptiles, amphibians, fish, insects and spiders, songbirds, raptors, waterfowl, turkey, pheasant and quail (Shelford 1963:23-35,89-114,334-344; USDA 2006:367). The climate is subhumid midcontinental with long hot summers and cold winters (Benham 1982:2, 72-73,88-89; Trewartha and Horn 1980:297-313; USDA 2006:366). The annual average temperature is 13.06° C with a January average temperature of -1.11° C and a July average temperature of 25.94° C (Benham 1982:88; Moxom 1941:947; USDA 2006:366). The annual precipitation for the county averages 85.88 cm with an annual snowfall of 45.21 cm (Benham 1982:88; Moxom 1941:947; USDA 2006:366). Most thunderstorms occur between mid-June and early September. The freeze-free period averages 205 days but ranges between 185 days and 230 days (Benham 1982:89; USDA 2006:366).

Alfisols, Entisols, Inceptisols, and Mollisols dominate the soils of the region (Foth and Schafer 1980; USDA 2006:367). The soils have a mesic soil temperature regime with an udic or aquic soil moisture regime. The soils are dominated by mixed or smectitic mineralogy (USDA 2006:367). The soils range from very shallow to very deep and poorly drained to excessively drained. They are loamy, silty, or clayey. The Old Courthouse is located within Urban land-Harvester-Fishpot soil association with “[u]rban land and nearly level to moderately steep, moderately well drained and somewhat poorly drained, deep soils formed in silty fill material, loess, and alluvium; on uplands, terraces, and bottom lands” (Bedham 1982:8). The soil mapping unit is identified as Urban land (7B), on the upland with 0 to 5 percent slope (Benham 1982:19). The soil mapping unit has more than 85% of surface covered with asphalt, concrete, buildings, or other impervious materials. The areas have been reshaped by cutting and filling episodes in order to produce nearly level surfaces within the urban setting. Cut and fill depths may be as shallow as two meters to as deep as ten meters in order to level the original topography (Benham 1982:19).

## **GENERAL DESCRIPTION OF THE GEOPHYSICAL PROJECT AND METHODS**

The present geophysical inventory project represents the first phase in the architectural/archeological exploration of the proposed elevator locations in the North and South transepts inside the Old Courthouse in St. Louis, Missouri (De Vore 2013). The ground-penetrating radar survey provides a baseline geophysical data set for the identification of buried architectural features under the stone slab floor of the two transepts at the Old Courthouse.

### **Overall Research Design**

The overall research design of the geophysical project was to determine the presence of the original external stairs in the North and South transepts. The collection of GPR profile data follows standard operating procedures used in MWAC GPR projects (De Vore 2013).

### **Culture History and Previous Work**

Jefferson National Expansion Memorial lies within the Central Mississippi Valley subarea of the Eastern Woodland archeological culture area of North America (Wiley 1966:246-341). The geophysical project area is also located within the Middle Mississippi Study Unit (Wright 1987a:B-14-1-B-14-13). The prehistoric archeological resources in Missouri are divided between the Early Man, Paleo-Indian, Dalton, Archaic, Woodland, and Mississippian periods (Chapman 1975, 1980; O’Brien and Wood 1998; Wright 1987b:C-1-1-C-10-8). The prehistoric periods are followed by the Protohistoric and Historic periods. An archeological and historic overview of the Jefferson National Expansion Memorial is provided by Timothy Schilling (2013:2-8). Additional synopsis of the regional prehistory and history may be found in LeeDecker et al. 2013:17-49).

Archeological investigations at the Jefferson National Expansion Memorial have been sporadic since its initial inception. In 1937, the Architectural Research Unit identified 80 potential sites of historic interest including the Old Courthouse, the Old Cathedral, and the Manuel Lisa Warehouse (Schilling 2013:8). The Manuel Lisa Warehouse or Old Rock House was dismantled in the 1940s but before it was dismantled, limited archeological investigations were conducted by Chief Landscape Draftsman Henry Rice (Schilling 2013:8). Rice indicated the lack of intact sediments along the river. During the late 1950s and early 1960s, NPS Archeologist Zorro Bradley undertook archeological investigations to identify and recover historic archeological resources before the construction of the arch monument and museum. He also came to the conclusion that little if any intact archeological resources were present along the river (Schilling 2013:8). The area had been highly disturbed, although, he did find the remains of foundations of buildings that had been demolished by NPS. During the construction of the Parking Ground at the northwestern corner of the JEFF grounds in 1984, a few artifacts were collected during the monitoring of the construction activities (Wells and Williams 1985). They suggested that the material was related to the W. H. Bull medicine factory at was demolished by NPS in the late 1930s. In 1998, MWAC Archeologist Vergil Noble monitored a geotechnical coring project for the construction of the maintenance facility. He indicated that the area was covered with deep fill deposits to a depth of at least three meters (Noble 1999). During the installation of a utility line across the northwest corner of the Old Courthouse lawn in 2007, Noble (2007) documented a late 19th-century brick sewer. In 2012, geoarcheological coring was conducted in association with the CityArchRiver2015 West Entrance project for the proposed new west entrance to the JEFF Gateway Arch and grounds (LeeDecker et al. 2012, 2013). Cores were extracted from the Gateway Arch grounds and the Luther Ely Smith Square. The geoarcheological investigations indicated the presence of deep fill deposits across the project area to a depth averaging more than 4.5 meters. The fill sits on top of weathered Pleistocene loess deposits predating any human presence in the region. The fill contains brick, concrete, and limestone building materials reflecting the 20th-century demolition and reshaping of the 19th-century urban landscape. According to LeeDecker et al (2013:64):

The archeological record at JEFF for the most part reflects events that occurred either (1) more than 12,000 years ago or (2) more recent than 1937. The record of Native American use of the landscape, the early settlement of St. Louis, and the vibrant nineteenth-century commercial district appear to have been destroyed.

Additional synopsis of the previous archeological and cultural resource investigations may be found in Schilling (2013) and LeeDecker et al. (2013:8-9, 13-17).

### **Description of Investigations**

Geophysical prospection techniques available for archeological investigations consist of a number of techniques that record the various physical properties of the earth, typically in the upper couple of meters; however, deeper prospection can be utilized if necessary (David 1995). Geophysical techniques are divided between passive and active techniques. Passive techniques are primarily ones that measure inherently or naturally occurring local or planetary fields created by earth-related processes (Heimmer and De Vore 1995:7, 2000:55; Kvamme 2001:356). The primary passive method utilized in



archeology is magnetic surveying. Other passive methods with limited archeological applications include self-potential methods, gravity survey techniques, and differential thermal analysis. Active techniques transmit an electrical, electromagnetic, or acoustic signal into the ground (Heimmer and De Vore 1995:9,2000:58-59; Kvamme 2001:355-356). The interaction of these signals with buried materials produces alternated return signals that are measured by the appropriate geophysical instruments. Changes in the transmitted signal of amplitude, frequency, wavelength, and time delay properties may also be observable. Active methods applicable to archeological investigations include electrical resistivity, electromagnetic conductivity (including ground-conductivity and metal detectors), magnetic susceptibility, and ground-penetrating radar. Active acoustic techniques, including seismic, sonar, and acoustic sounding, have very limited or specific archeological applications.

### Field Methods

In order to determine the presence of the original external stair case located under the stone floor in the North and South transepts, NPS staff utilized a ground-penetrating radar cart system with a 400 MHz antenna to collect subfloor GPR data. In order to collect the GPR profile data, the geophysical project areas in the North and South transepts were outlined and marked off with blue painter's masking tape to establish a geophysical project grid on the floor of the two rooms between the rotunda and the newer wings. The length and width of the rooms were measured and the masking tape was placed on the floor at intervals, which provided the maximum coverage with the GPR cart and 400 MHz antenna. Additional strips of tape were placed at 0.5-meter intervals along the guide tapes to provide placement of the GPR cart during the collection of the profile data. The North Transept measures approximately 17.6 meters (57 ft, 8 in) east-west by approximately 4.0 meters (13 ft, 1 in) north-south (Figure 6). The room is also slightly tapered along its length and width. The geophysical grid in the North Transept measures 16 meters east-west by 4.0 meters north-south. The South Transept measures approximately 17.6 meters (57 ft, 8 in) east-west by approximately 4.0 meters (13 ft, 1 in) north-south (Figure 7). The room is also slightly tapered along its length and width. The geophysical grids in the North and South transepts each measure 16 meters east-west by 4.0 meters north-south. The geophysical grids in each transept paralleled the interior walls of the transepts next to the rotunda with approximately a meter offset from the east and west walls. Sketch maps were made of the North (Figure 8) and South (Figure 9) transepts after the grids were established in each one. The geophysical project area within the North Transept measures 64 m<sup>2</sup> (688.91 ft<sup>2</sup>) or 0.016 ac. The geophysical project area within the South Transept also measures 64 m<sup>2</sup> (688.91 ft<sup>2</sup>) or 0.016 ac. The total area covered by the ground-penetrating radar survey in both transepts total 128 m<sup>2</sup> (1,377.82 ft<sup>2</sup>) or 0.032 ac.

#### Ground-Penetrating Radar Survey

**Instrument** Geophysical Survey Systems Inc. (GSSI) TerraSIRch SIR System-3000 ground-penetrating radar cart system with a 400 megahertz (MHz) antenna (GSSI 2003).

**Specifications:** SIR 3000: System hardware contains a 512-mb compact flash memory card as its internal memory. It accepts industry-standard compact flash

memory cards up to 2 gb. Processor is a 32-bit Intel StrongArm PISC 206 MHz processor with enhanced 8.4" TFT display, 800 x 600 resolution, and 64k colors. The processor also produces linescan and O-scope displays. The GPR system uses one channel. It also uses the GSSI Model 623 survey cart with survey wheel for mounting the antenna and control unit. The 400 MHz Model 5103 ground-coupled antenna has a depth of view of approximately 4 m assuming a ground dielectric constant of 8 with a range of 50 ns, 512 samples per scan, 16-bit resolution, 5 gain points, 100 MHz vertical high-pass filter, 800 MHz vertical low-pass filter, 64 scans per second, and 100 KHz transmit rate.

*Survey type:* ground-penetrating radar

*Operators:* Steven De Vore

The ground-penetrating radar (GPR) survey is an active geophysical technique that uses pulses of radar energy (i.e., short electromagnetic waves) that are transmitted into the ground through the surface transmitting antenna (see Annan 2005:357-438; Bevan 1991, 1998:43-57; Clark 2000:118-120, 183-186; Conyers 2004, 2006:131-159, 2007:329-344; Conyers and Goodman 1997; Davenport 2001:89-103; David 1995:23-27; David et al. 2008:28-34; Gaffney and Gater 2003:47-51, 74-76; Gaffney et al. 1991:5-6, 2002:9-10; Goodman et al. 2007:375-394; Heimmer and DeVore 1995:42-47, 2000:63-64; Kvamme 2001:363-365, 2003:442-443, 2005:436-438; Lowrie 1997:221-222; Milsom and Eriksen 2011:185-209; Mussett and Khan 2000:227-231; Nishimura 2001:547-551; Scollar et al. 1990:575-584; Weymouth 1986:370-383; and Witten 2006:214-258 for more details on GPR surveys). The radar wave is reflected off buried objects, features, or interfaces between soil layers. These reflections result from contrasts in electrical and magnetic properties of the buried materials or reflectors. The contrasts are a function of the dielectric constant of the materials (Sheriff 1973:51). The depth of the object or soil interface is estimated by the time it takes the radar energy to travel from the transmitting antenna and for its reflected wave to return to the receiving antenna. The depth of penetration of the wave is determined by the frequency of the radar wave. The lower the frequency, the deeper the radar energy can penetrate the subsurface; however, the resulting resolution, or the ability to distinguish objects, features, and soil changes decreases. The low-frequency antennas generate long wavelength radar energy that can penetrate several tens of meters under certain conditions, but can only resolve larger targets or reflectors. The higher the radar wave frequency, the higher the resulting resolution, but the penetration depth decreases. High frequency antennas generate much shorter wavelength energy, which may only penetrate a meter into the ground. The generated reflections from these high frequency antennas are capable of resolving objects or features with maximum dimensions of a few centimeters. A resulting tradeoff exists between subsurface resolution and depth penetration: the deeper the penetration then the resulting resolution is less, or the higher the resolution then the resulting depth penetration is much shallower.

As the radar antenna system (transmitting and receiving antennas) is moved along the survey line, a large number of subsurface reflections are collected. The various subsurface materials affect the velocity of the radar waves as they travel through the ground (Conyers and Goodman 1997:31-40). The rate at which these waves move through the ground is affected by the changes in the physical and chemical properties

of the buried materials through which they travel. The greater the contrast in electrical and magnetic properties between two materials at the interface results in a stronger reflected signal. As the radar pulse travels through the ground, changes in material composition or water saturation cause changes in the velocity of the pulse with a portion of the energy reflected back to the surface where it is detected by the receiving antenna and recorded by ground-penetrating radar unit. The remaining energy continues to pass into the subsurface materials where it can be reflected by deeper reflectors until the energy finally dissipates with depth. The radar system measures the time it takes the radar pulse to travel to a buried reflector and return to the unit. If the velocity of the pulse is known, then the distance to the reflector or the depth of the reflector beneath the surface can be estimated (Conyers and Lucius 1996).

The success of the survey is dependent on soil and sediment mineralogy, clay content, ground moisture, depth of the archeological resource, and surface topography and vegetation. The ground-penetrating radar signal can be lost or attenuated (i.e., quickly dissipated) in soils that have high moisture content, high electrical conductivity, highly magnetic materials, or high clay content. Dry soils and sediments, especially those with low clay content, represent the best conditions for energy propagation. A ground-penetrating radar survey, with its capability for estimating the depth and shape of buried objects, may be an extremely valuable tool in the search for grave shafts and trenches. At times, radar cannot profile deep enough or the strata may be so complex as to render the trenches, graves, and other types of excavations indistinguishable from the surrounding soil profile.

The TerraSIRch SIR System-3000 survey cart (Figure 10) contained a data-logger with a display that allowed the results to be viewed almost immediately after they were recorded (GSSI 2003). The SIR 3000 was set to collect GPR data with the 400 MHz antenna at an antenna transmission rate of 100 MHz and the distance mode selected for use of the survey wheel on the cart. The scan menu was set with 512 samples; 16-bit format; 60 ns range or window; a dielectric constant of 8; a scan rate of 100; and 50 scans per meter for the project area. In the gain menu, the gain was set to manual with a default value of 1. The GPR system was moved around the grid prior to the start of the survey to adjust the gain. If a location caused the trace wave to go off the screen, the gain was set to auto and then back to manual. The position was set to the manual mode with the offset value at the factory default and the surface display option set to zero. The filters were left at the default settings. With the setup completed, the run/stop button at the bottom of the display screen was selected and the collect mode was initiated. The GPR unit was moved across the grid, and at the end of the traverse the next file button was selected and data acquisition was halted. The GPR unit was placed at the start of the next line before saving the profile. Once the profile data were saved, the GPR unit was ready to collect the next profile line. The GPR data were recorded on a 512-mb compact flash card and transferred to a laptop computer at the end of the survey of the two transects.

The TerraSIRch SIR System-3000 survey cart system (GSSI 2003) operated an antenna at a nominal frequency of 400 MHz. The antenna was mounted in a cart that recorded the location of the radar unit along the grid line. The GPR profiles were collected along 0.5-m traverses beginning in the lower right hand corner of the grid for the first traverse oriented to the east. The data were collected in a zigzag or bidirectional



fashion with the surveyor alternating the direction of travel for each traverse across the grid. At each survey grid location, the GPR file was identified with an alpha designation: the North Transept project area was designated OCHN and the South Transept project area was designated OCHS. Sixteen radar profiles were collected across OCHN for a linear distance of 98 m. Fourteen radar profiles were collected across OCHS for a linear distance of 86 m. Overall, thirty radar profiles were collected in the two transept geophysical project areas for a total linear distance of 184 m.

Ground-penetrating radar surveys generally represent a tradeoff between depth of detection and detail. Lower frequency antennas permit detection of features at greater depths but they cannot resolve objects or strata that are as small as those detectable by higher frequency antennas. Actual maximum depth of detection also depends upon the electrical properties of the soil. If one has an open excavation, one can place a steel rod in the excavation wall at a known depth and use the observed radar reflection to calibrate the radar charts. When it is not possible to place a target at a known depth, one can use values from comparable soils. Reasonable estimates of the velocity of the radar signal in the site's soil can be achieved by this method (Conyers and Lucius 1996). Using one of the hyperbolas on a radargram profile from the OCHN project area (Goodman 2012:194-199), the velocity was calculated to be approximately 9.8 cm per nanosecond (ns) with a dielectric constant of 10.4. For a time slice between 5 and 15 ns with the center at 10 ns (two-way travel time), the approximate depth to the center of the GPR slice would be 49 cm. With a time window of 60 ns, the GPR profiles extended to a depth of 2.67 m. The signal velocity for the OCHS project area was calculated to be 0.089 m/ns with a dielectric constant of 11.36 based on the hyperbola matching routine in the GPR-SLICE software. The GPR profiles extended to a depth of 2.36 m.

The GPR radargram profile line data from the two geophysical project areas were imported into GPR-SLICE (Goodman 2012) for processing. The first step in GPR-SLICE was to create a new survey project for each area using the file name for the survey project name (Goodman 2012:16). This step identified the file name and folder locations (Goodman 2008:13). The second step was to transfer the raw GPR profile data from its original location on the computer hard drive to the GPR-SLICE project folder (Goodman 2012:17). The next step was to create the information file (Goodman 2012:18-21). The information file included the number of profiles collected for the area, along with the file identifier name, extension identifier for GSSI radargrams, the profile naming increment, the first radargram name, direction of profiling, x and y beginning and ending coordinates, units per marker, the time-window opening in nanoseconds, samples per scan, the number of scans per meter, and the type of data. The information file was edited, if necessary, to correct profile lengths (Goodman 2012:21-26). The 16-bit GSSI data were then converted to remove extraneous header information, to regain the data to enhance the signal, and to remove any DC drift in the profile data. Once the conversion process was completed, the next step was to reverse the profile data (Goodman 2012:29-31). Since the radargrams were collected in the zigzag mode, every half-meter profile line or odd interval needed to be reversed (Goodman 2012:29-30). The next step was to insert navigation markers into the resampled radargrams (Goodman 2012:31-32, 59-67). These markers assign xyz locations to the radargrams and to all time-slice images. The next step was to create the time slices of the profile data (Conyers and Goodman 1997; Goodman 2012:32-40; Goodman et al. 1995). The time-

slice analysis included the search for the 0 ns location of the ground surface reflection, setting the number of time slices and determining the slice thickness, setting the cut parameters, setting the cuts per mark, and finally conducting the slice, resampling, and xyz processing. Once the time-slice data files were created, the next step was to create the grid and time-slice data files (Goodman 2012:41-50, 68-88). The gridding process interpolated between the xyz data in order to create the time slices and pixel maps. Twenty time slices were generated for each geophysical project area GPR data set. Once the initial gridding process was completed, a low-pass filter was applied to the dataset to smooth noisy data in the time slices. Two-dimensional time-sliced radar data were generated in the pixel map menu (Goodman 2012:46,89-101) for the survey grids at OCHN (Figure 11) and OCHS (Figure 12). In addition, the original processed grid slices and the low-pass filtered grid slices can be exported in the Surfer grid format. The low-pass filtered surfer grid files are transformed into image and contour plots in Surfer. The final step in processing the GPR data was to create the 3D binary files from the 2D grid files for the generation of a 3D volume display of the GPR data (Goodman 2012:51-58).

Generally, one time slice is selected for further display and analysis for each survey grid since the animated 3D view of the radar data does not translate to the report document format. Time slice 3, from 6 to 11 ns (Figure 13), is selected as the representative slice for further analysis of the GPR data from the North Transept geophysical project area. The amplitude strength of the GPR data from OCHN, before the application of the low-pass filter, ranges from 773,176 to 92,043,583 with a mean of 11,468,339 and a standard deviation of 10,924,393. Time slice 3, from 6 to 11 ns (Figure 14), is selected as the representative slice for further analysis of the GPR data at the OCHS geophysical project area. The amplitude strength of the GPR data from OCHS, before the application of the low-pass filter, ranges from 3,161,056 to 76,497,891 with a mean of 18,085,129 and a standard deviation of 10,806,037. The gain may be readjusted for any time slice or for the entire time-slice dataset (Goodman 2008:41-47). In order to create a three-dimensional display of the GPR time-sliced data, the existing time slices are interpolated to create normalized grids (Goodman 2008:48-49). The interpolations value is set to 5 and the new interpolated grids are all normalized. The next step is to create the 3D time-slice dataset. The number of grids is now equal to 96  $((20-1)*5)+1$ . The 3D data may be displayed as a series of z slices in the creation of a 3D cube with a jpeg output for animating the 3D cube (Goodman 2008:50).

## **DESCRIPTION OF GEOPHYSICAL INTERPRETATION OF CULTURAL RESOURCES LOCATED**

Andrew David (1995:30) defines interpretation as a “holistic process and its outcome should represent the combined influence of several factors, being arrived at through consultation with others where necessary.” Interpretation may be divided into two different types: the geophysical interpretation of the data and the archaeological interpretation of the data. At a simplistic level, geophysical interpretation involves the identification of the factors causing changes in the geophysical data. Archeological interpretation takes the geophysical results and tries to apply cultural attributes or causes. In both cases, interpretation requires both experience with the operation of geophysical equipment, data processing, and archeological methods; and knowledge of

the geophysical techniques and properties, as well as known and expected archeology. Although there is variation between sites, several factors should be considered in the interpretation of the geophysical data. These may be divided between natural factors, such as geology, soil type, geomorphology, climate, surface conditions, topography, soil magnetic susceptibility, seasonality, and cultural factors, including known and inferred archeology, landscape history, survey methodology, data treatment, modern interference, etc. (David 1995:30). It should also be pointed out that refinements in the geophysical interpretations are dependent on the feedback from subsequent archeological investigations. The use of multiple instrument surveys provides the archeologist with very different sources of data that may provide complementary information for comparison of the nature and cause (i.e., natural or cultural) of a geophysical anomaly (Clay 2001; Kvamme et al. 2006). Each instrument responds primarily to a single physical property: magnetometry to soil magnetism, electromagnetic induction to soil conductivity in the quadrature phase component and magnetic susceptibility in the in-phase component, resistivity to soil resistance, and ground-penetrating radar to dielectric properties of the soil (Weymouth 1986:371).

Analysis of the ground-penetrating radar data from the two transept geophysical project areas indicates the presence of numerous GPR targets. In the North Transept, a series of strong or high amplitude planar reflections along the south side of the room suggests the presence of the original exterior stairs, which are intact beneath the stone slab floor (Figure 15). In addition, a strong hyperbolic reflection in the center of the room represents a utility line running between the original part of the Old Courthouse and the North Wing. The GPR data from the north side of the transept suggest the area under the stone floor is filled with non-reflective material such as soil or sand. In the South Transept, a series of strong or high amplitude planar reflections along the north side of the room also suggests the presence of the original exterior stairs, which are intact beneath the stone floor (Figure 16). In addition, two areas of strong hyperbolic reflections appear to represent utility lines running beneath the stone floor between the original part of the Old Courthouse and the South Wing. Two additional areas on the south side of the transept are identified as strong or high-amplitude hyperbolic reflections. It is possible that the strong GPR reflection near the center of the room represents a utility corridor, but both may indicate larger rubble used in the fill to level the floor.

## **NATIONAL REGISTER EVALUATION OF CULTURAL RESOURCES LOCATED**

The Jefferson National Expansion Memorial was established in 1935 under Executive Order 7253 by President Franklin D. Roosevelt, which included the old Courthouse although it was not acquired until 1940 (NPS 2009:A-1/A-2). The Old Courthouse was listed on the National Register of Historic Places in 1966 as part of the nomination package for The Gateway Arch, the Old Courthouse, and the Old Cathedral National Register of Historic Places Inventory – Nomination (AECOM 2010: D-1/D-10; Bellavia 1996:231-239). The Old Courthouse derived its significance from its architecture, art, engineering, and law.

The geophysical survey of the two transepts in the Old Courthouse was conducted as part of the National Park Service's archeological investigations associated with the proposed locations for ADA compliant elevator(s) to provide disabled access to the upper floors in the building. The ground-penetrating radar data strongly suggest the presence of the original exterior stairs on the north and south side of the Old Courthouse building.

This report has provided a review and analysis of the geophysical data collected during the ground-penetrating radar survey of the two transepts located on the first floor of the Old Courthouse at Jefferson National Expansion Memorial in St. Louis, Missouri. The use of geophysical survey techniques at the Old Courthouse indicates the usefulness in collecting basic background geophysical data concerning the nature and extent of the architectural features and modifications to historic structures. Based on the information provided by the geophysical survey methods, it is apparent that the geophysical data set yielded useful information for the determination of the integrity and significance of the buried architectural resources associated with the Old Courthouse building at JEFF. While the ground-penetrating radar survey results provided data on the nature of the buried architectural resources, ground-truthing through archeological excavation will provide definitive information on the nature of these geophysical anomalies.

#### **National Register Recommendations with Justifications for Eligible, Not Eligible, Need More Information from Testing, Etc**

The geophysical survey of the North and South transepts on the first floor of the Old Courthouse at JEFF yielded baseline data for the evaluation of the architectural features buried under the stone floors in the two transepts. The ground-penetrating radar survey data indicate that remains of the original exterior stairs to the Old Courthouse are present under the existing stone floors in the two transepts along with subfloor utility lines. The geophysical data collected in the Old Courthouse indicate the architectural features identified in the GPR data add further support to the existing National Register of Historic Places listing under Criterion C.

#### **Site Integrity and Conservation/Stabilization/Avoidance Recommendations**

The geophysical project areas contain intact architectural remains of the original 1839 Old Courthouse. The resulting architectural integrity of buried architectural resources is extremely high. Additional archeological investigations are needed to determine the nature and cause of the geophysical anomalies noted in the ground-penetrating radar surveys conducted during this project.

### **EFFECTS OF PROJECT ON RESOURCES**

The geophysical project has identified numerous buried architectural resources that appear as intact features in the data beneath the transept floors on the first floor of the Old Courthouse. The project represents a positive effect for the identification and

location of the original exterior stairs associated with the 19th-century construction of the Old Courthouse between 1839 and 1864.

## **LOCATION OF ARTIFACTUAL MATERIALS AND RECORDS FROM THE WORK**

No artifacts were collected during the project. The geophysical data and associated documentation are part of the JEFF accession number 1294. The materials are also temporarily curated under MWAC accession number 1537 until the entire collection is returned to JEFF.



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## SUMMARY MANAGEMENT RECOMMENDATIONS:

☐ CLEARANCE NOT RECOMMENDED (explain):

☐ CLEARANCE RECOMMENDED (explain):

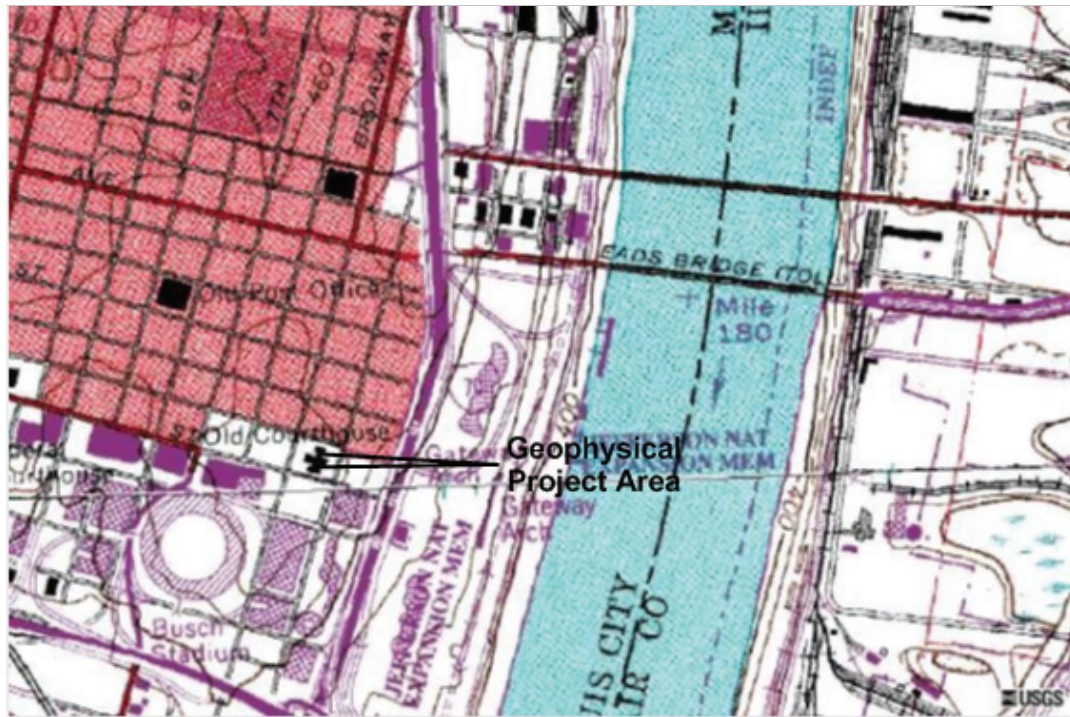
☒ CLEARANCE RECOMMENDED WITH CONDITIONS (explain):

The present ground-penetrating radar survey of the North and South transepts indicate that the original exterior stairs appear to be intact beneath the stone slab floor. The survey data also suggests that fill was added to level the present transept floors before the stone slab flooring was placed in the two transepts. It is recommended that ground-truthing is needed to determine the nature, extent, and significance of the GPR reflections in the two transepts before the proposed ADA elevator shafts are constructed.

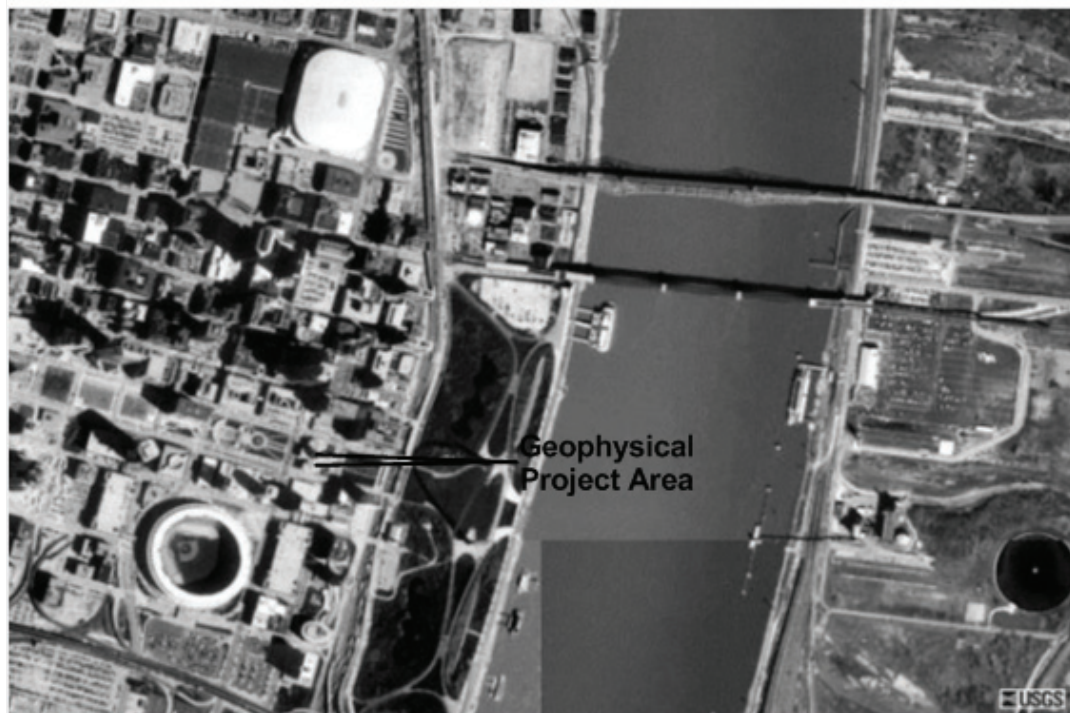




## FIGURES



a) St Louis, Missouri (USGS topographic map, dated 1 July 1996)

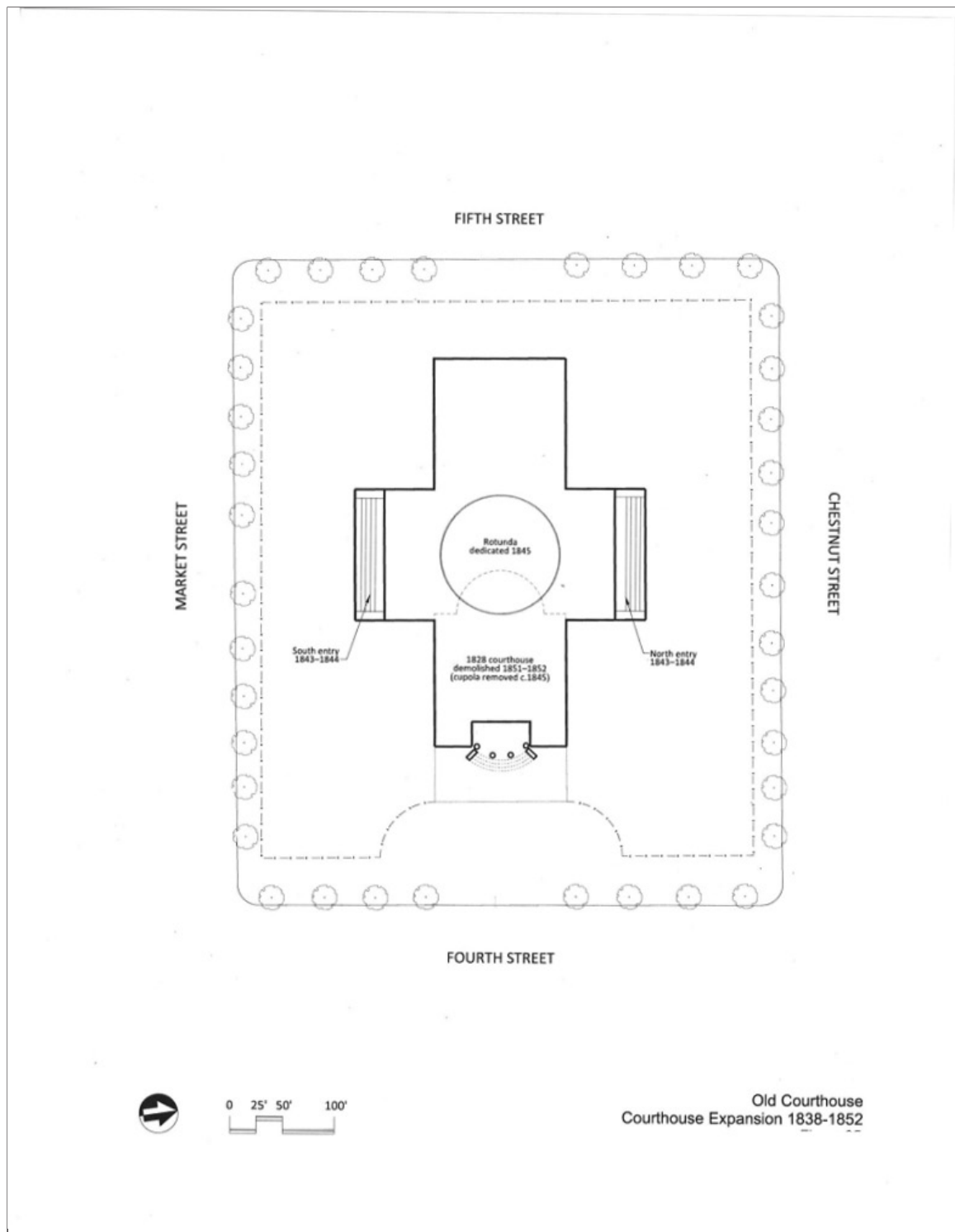


b) St Louis, Missouri (USGS aerial photograph, dated 2 April 1998)

**Figure 1.** Location of the geophysical project at the Old Courthouse, Jefferson National Expansion Memorial, St. Louis, Missouri.



**Figure 2.** General view of the Old Courthouse in St. Louis, Missouri (view to the northwest).



**Figure 3.** Drawing of the Old Courthouse expansion projects between 1838 and 1852 showing location of exterior entry stairs (BVHA 2013: Figure 35)





Figure 4. View of the Old Courthouse in 1852 with exterior entry stairs visible on the south side (from the Missouri History Museum collection, reference n17030).

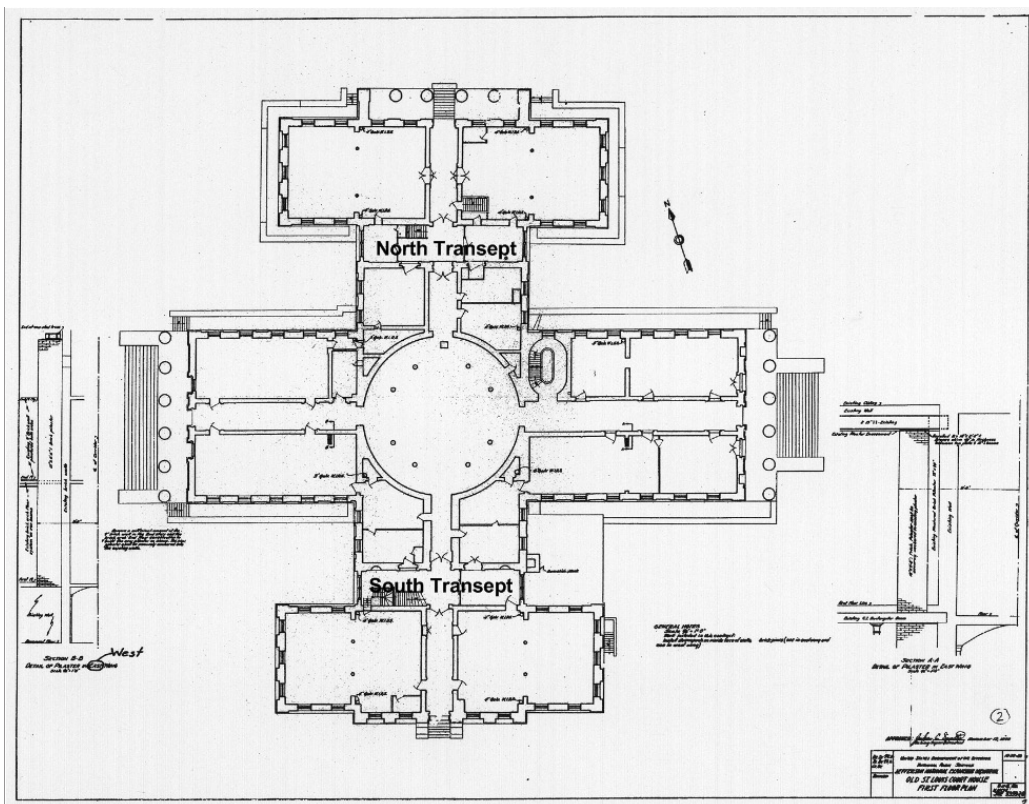


Figure 5. Location of the North and South Transept geophysical project areas.



**Figure 6.** General view of the North Transept (view to the east).



**Figure 7.** General view of the South Transept (view to the east).

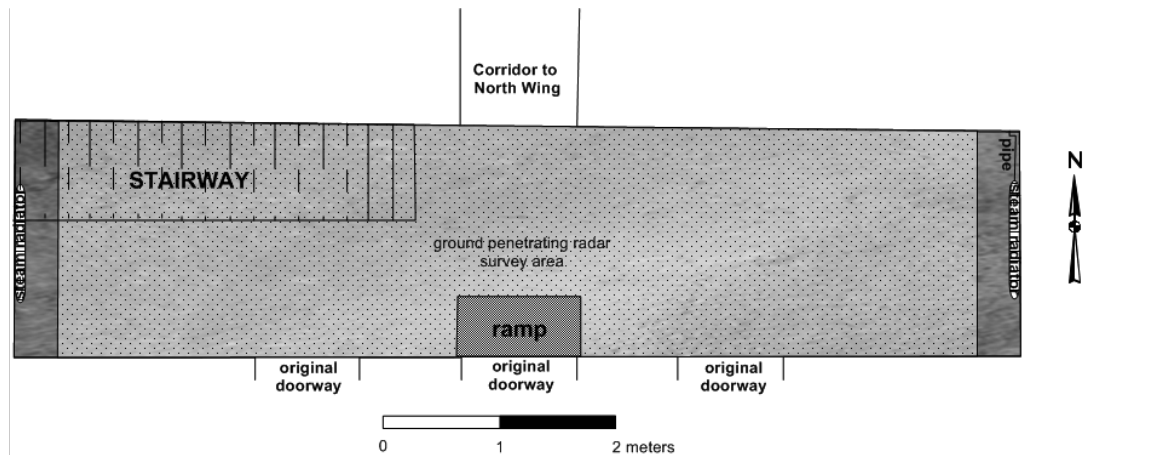


Figure 8. Sketchmap of the North Transept geophysical project area.

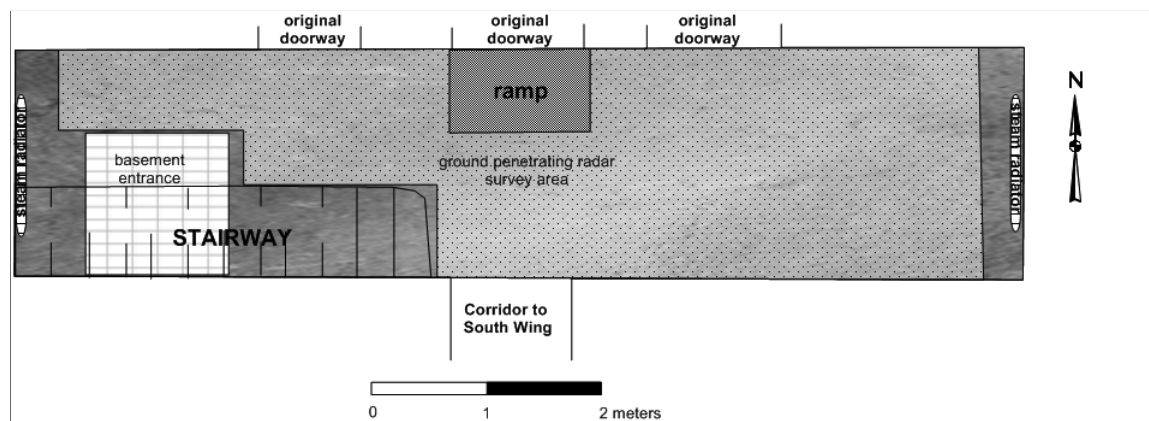
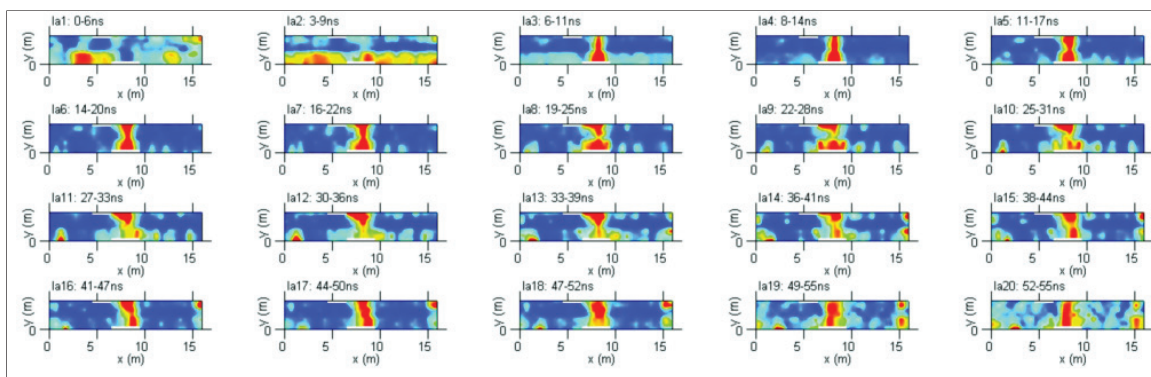


Figure 9. Sketchmap of the South Transept geophysical project area.

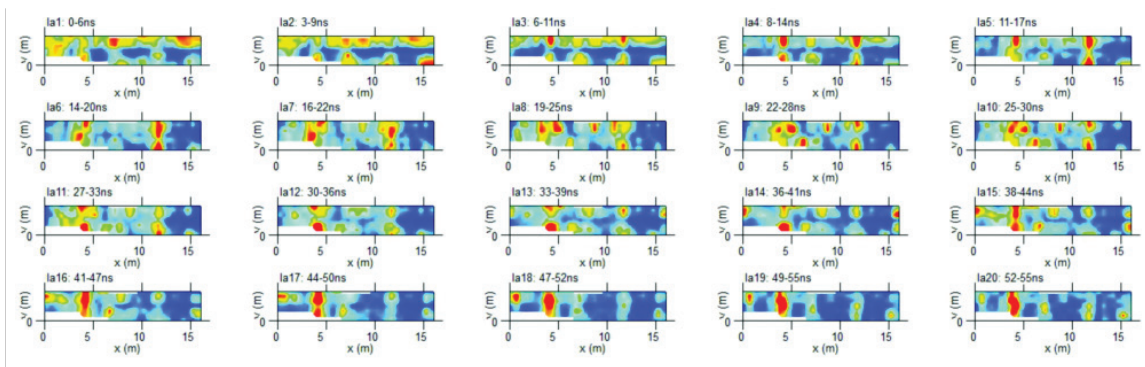




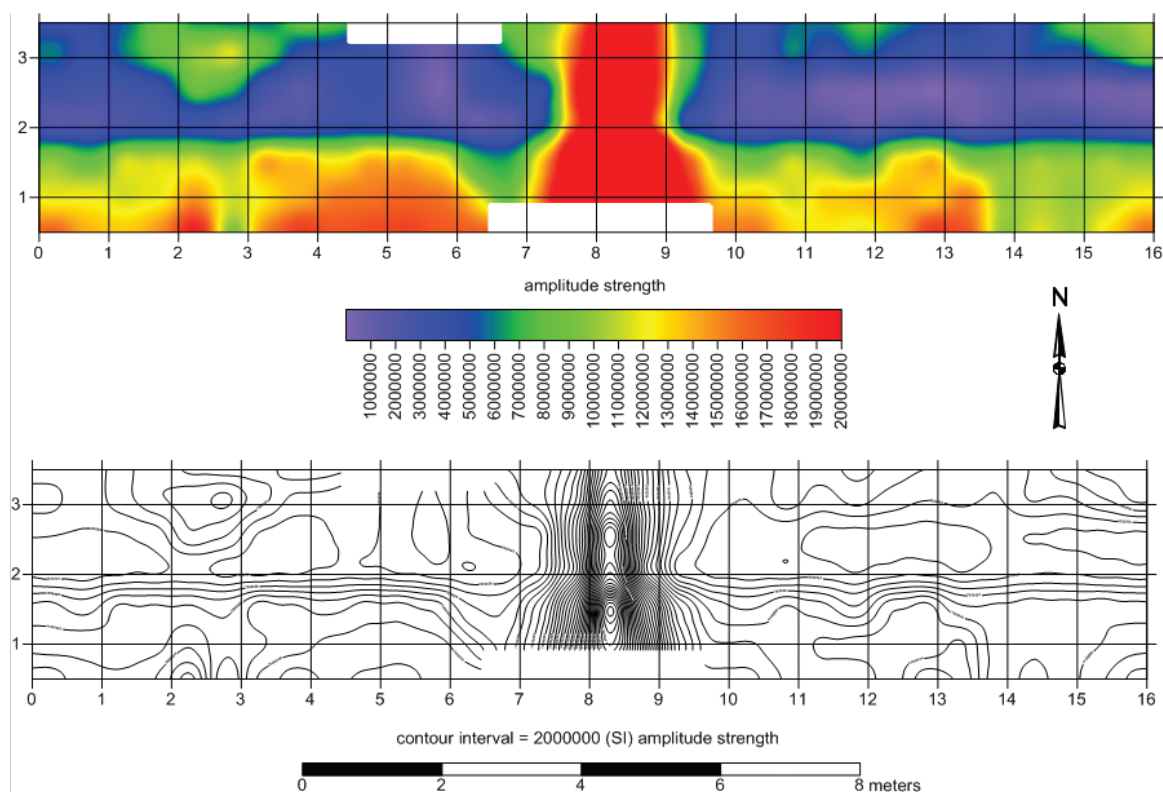
**Figure 10.** Conducting the ground-penetrating radar survey with the GPR cart and 400 MHz antenna in the North Transept geophysical project area (view to the west southwest).



**Figure 11.** Ground-penetrating radar time slice survey data from the North Transept geophysical project area.

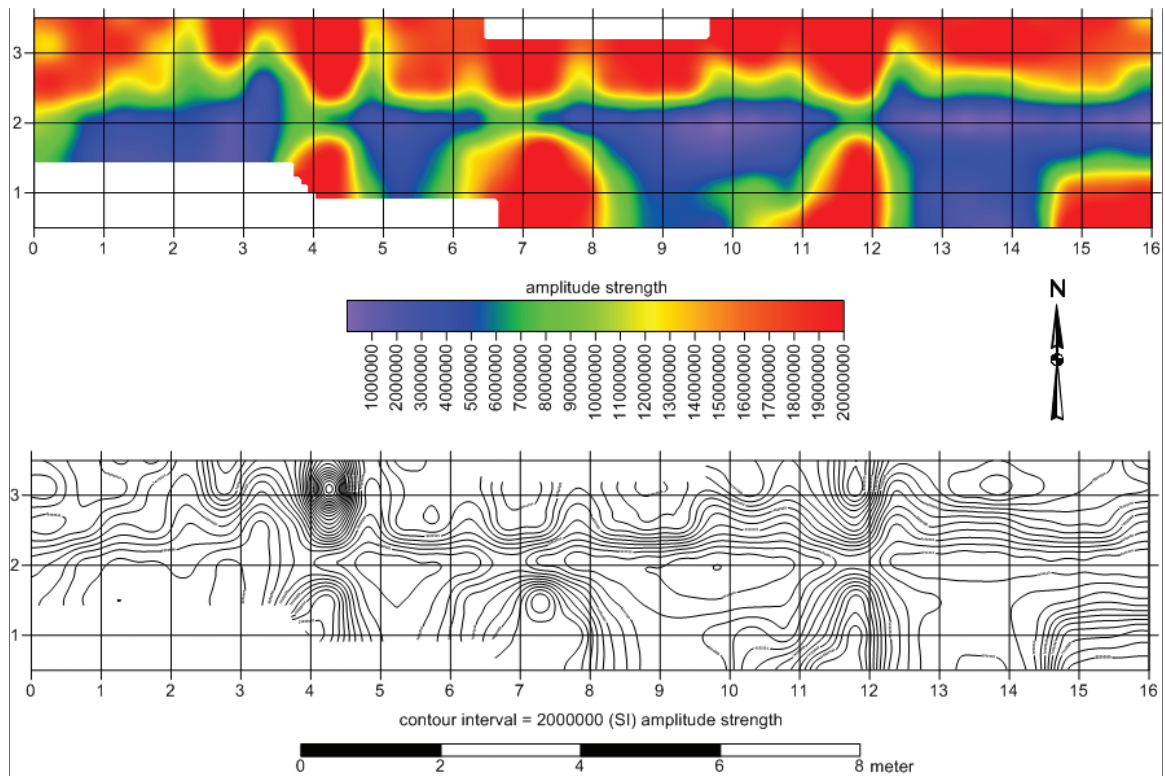


**Figure 12.** Ground-penetrating radar time slice survey data from the South Transept geophysical project area.

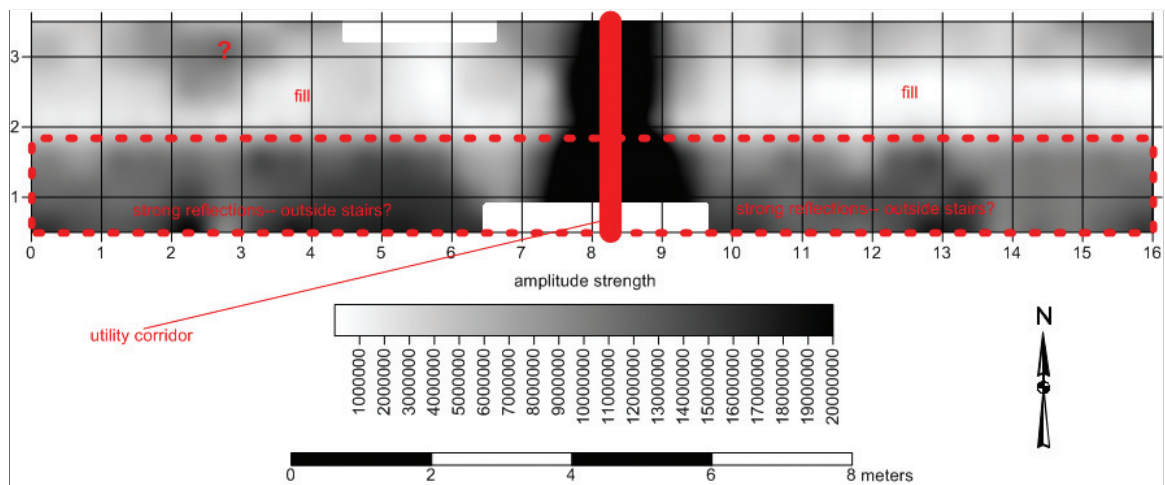


**Figure 13.** Image and contour plots of the ground-penetrating radar time slice 3 (6-11 ns) survey data from the North Transept geophysical project area.

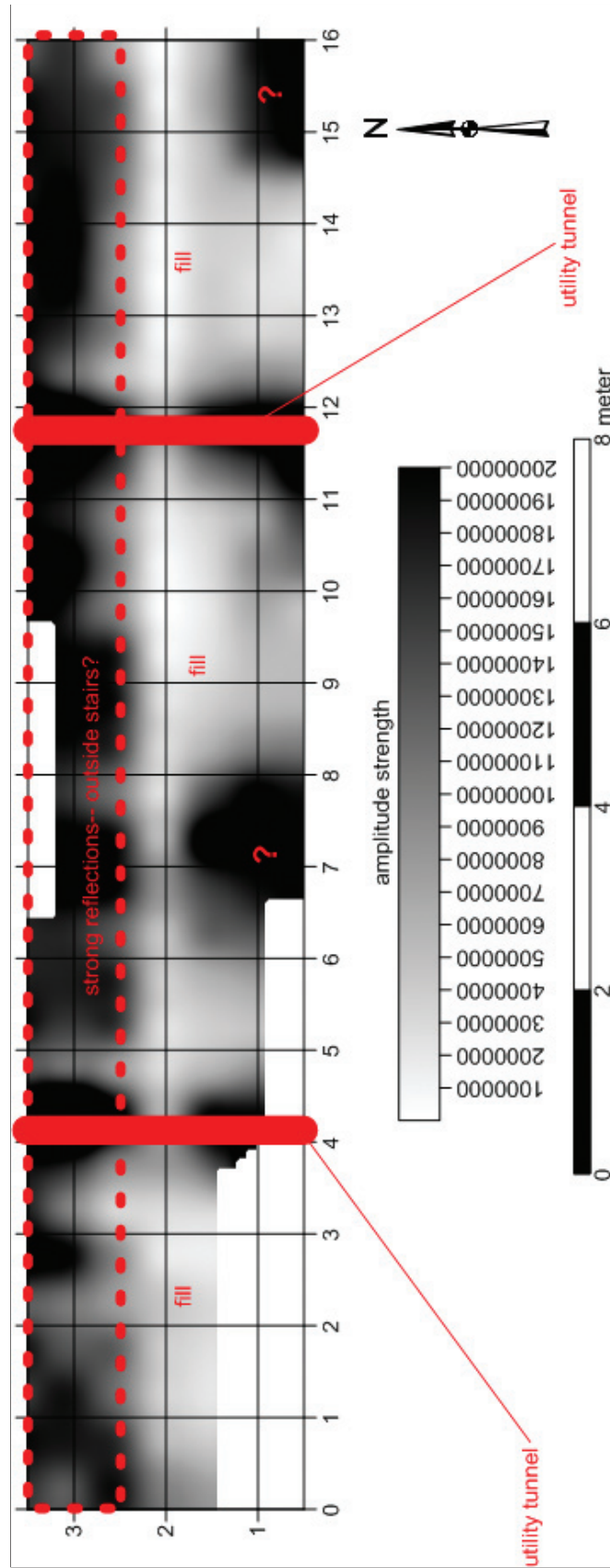




**Figure 14.** Image and contour plots of the ground-penetrating radar time slice 3 (6-11 ns) survey data from the South Transept geophysical project area.



**Figure 15.** Interpretation of ground-penetrating radar data from time slice 3 (6-11 ns) from the North Transept geophysical project area.



**Figure 16.** Interpretation of ground-penetrating radar data from time slice 3 (6-11 ns) from the South Transept geophysical project area.



