

**GEOPHYSICAL INVESTIGATIONS AND MONITORING OF THE HVAC REPLACEMENT
PROJECT AREA AT THE TRUMAN FARMHOUSE (SITE 23JA638) WITHIN
THE HARRY S. TRUMAN NATIONAL HISTORIC SITE IN GRANDVIEW,
JACKSON COUNTY, MISSOURI**

By
Steven L. De Vore

Midwest Archeological Center
Technical Report No. 121



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**United States Department of the Interior
National Park Service
Midwest Archeological Center
Lincoln, Nebraska
2009**

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).



ABSTRACT

The National Park Service's Midwest Archeological Center and Harry S Truman National Historic Site staffs conducted geophysical investigations and construction project monitoring at the Truman Farm unit (Site 23JA638) of Harry S Truman National Historic Site in Jackson County, Missouri. The geophysical and archeological investigations were conducted between January 23 and 26, 2008. The archeological investigations were requested by the park staff for the HVAC replacement project at the Truman farmhouse. The project location extended across the side yard on the south side of the farmhouse and in the parking lot.

During the investigations, 337 square meters or 0.08 acres were surveyed with a single fluxgate gradiometer and a dual fluxgate gradiometer system. The magnetic data collected at the selected project areas provided information of the physical properties (magnetic) of the subsurface materials. Several magnetic anomalies were identified, including two clusters of anomalies that appeared to be associated with the original house foundation and a root cellar in the yard. During the trenching activities connecting the geothermal well field with the geothermal pump located in the farmhouse, two features were documented. Both features were mortar lens that were apparently associated with clean up efforts following the destruction of the original farmhouse by fire in 1894. Feature 2 also contained a depression beneath the mortar lens that may be associated with the root cellar entrance. It is recommended that additional geophysical investigations be undertaken at the Truman Farm unit to identify other buried archeological resources associated with the farming activities of the Young and Truman families at the National Park Service unit.

ACKNOWLEDGEMENTS

This project was completed with the support and assistance from the Harry S Truman National Historic Site staff. Sincere appreciation is extended to HSTR Superintendent Larry Villalva, HSTR Facility Manager Alan Dinehart, and HSTR Museum Curator Carol Dage who assisted in the planning and implementation of the archeological and geophysical project. All of the HSTR park staff went out of their way to make me feel welcome and provided assistance in getting the work done efficiently, safely, and as comfortably as possible during the construction phase of the HVAC replacement project in late January in Missouri.

At the Midwest Archeological Center, I would like to thank Dr. Ralph Hartley (MWAC Archeological Assistance and Partnership Program Manager) and Mr. Jeff Richner (MWAC Park Archeology Program Manager) for their direction and leadership during the project. I am also grateful for the support provided by MWAC Manager Dr. Mark Lynott, Administrative Officer Jill Lewis, and the rest of the MWAC staff for all of their help without which this project would not have been completed as smoothly or efficiently as it was. Linda Clarke, Darin Schlake, and Sara Vestecka provided logistical, computer, transportation, and personnel support during the project while Allan Weber and Jeff Larson provided editing and report preparation in the publishing of this document. I am grateful for the review comments of the draft manuscript.

Finally, I would like to acknowledge the contractor Jesse Yoakum of Jesse Yoakum Well Drilling from Cleveland, Missouri, for his extremely helpful attitude throughout the course of the fieldwork. I am particularly thankful to be able to work closely with the Yoakum Well Drilling employees who often had to work around me while I examined archeological features in the trackhoe trench and answer questions about the construction activities.

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1. INTRODUCTION

The National Park Service's (NPS) Midwest Archeological Center (MWAC) and Harry S Truman National Historic Site (HSTR) staffs conducted geophysical investigations and construction monitoring activities at the Truman Farm unit (Site 23JA638) of the Harry S Truman National Historic Site in Grandview, Jackson County, Missouri (Figure 1). The archeological investigations at the park were conducted between January 23rd and 26th, 2008 (De Vore 2008). The geophysical investigations and construction monitoring were requested by the park staff for the archeological investigations of the HVAC replacement construction project associated with the replacement of the Truman farmhouse's furnace, evaporator, and condensing units with a single geothermal heat pump system for the heating, ventilation, and air conditioning (HVAC) of the farmhouse (Alvine Engineering 2007; Bahr Vermeer Haecker 2007). The project corridor extended across the northern portion of the parking lot and across the yard to the south side of the Truman farmhouse next to the southern handicap access and porch (Figure 2).

Established on May 23, 1983 (Public Law 98-23), the Harry S Truman National Historic Site commemorates the life and accomplishments of Harry S Truman (1884-1972), the 33rd President of the United States. Prior to the establishment of the Park, the Truman Home and a surrounding eight block area was designated a National Historic Landmark district in 1971. In 1985, the Truman farm in Grandview was designated a National Historic Landmark. The National Historic Site boundaries were expanded to include the Noland and Wallace Houses in 1989 (Public Law 101-105) and to include the Truman/Young farm in 1993 (Public Law 103-184). The Park contains the Independence unit near the historic downtown area of Independence and the Grandview unit one mile west of U.S. Highway 71 at 12301 Blue Ridge Boulevard in Grandview (National Park Service 1985,1987,1995,1999a,1999b,2000). The 1.41 acre Independence unit contains the Truman Home and carriage house at 219 North Delaware Street (Site 23JA635), the George P. Wallace House and garage at 605 West Truman Road (Site 23JA634), the Frank G. Wallace House at 601 West Truman Road (23JA637), the Joseph T. Noland House at 216 North Delaware Street, and the visitor center at 223 North Main Street (Site 23JA636). The 5.26 acre Grandview unit (Figure 3) contains the Truman farm home, outbuildings, and a portion of the original 600 acre Young/Truman family farm (Site 23JA638).

The purpose of the present archeological project at the park was to provide an evaluation of the buried archeological resources in the construction corridor associated with the replacement of the existing HVAC system with a geothermal well field and heat pump system in compliance with Section 106 of the National Historic Act of 1966, as amended through 1992 (King 2008:109-206; National Park Service 1993:1-41). The project area was located in the primary area of potential effect (APE). The geophysical investigations consisted of magnetic surveys with a single fluxgate gradiometer and a dual fluxgate gradiometer system along the west and south side of the house where the trackhoe excavation trench for the piping connecting the geothermal well field with the geothermal heat pump system inside the basement of the Truman farmhouse was located.

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The magnetic technique offered an inexpensive, rapid, and relatively non-destructive and non-invasive method of identifying buried archeological resources and site patterns, which were detectable and also provided a means for sampling relatively large areas in an efficient manner (Roosevelt 2007:444-445; and Von Der Osten-Woldenburg 2005:621-626). Monitoring of the trackhoe excavation trench provided an exposed view of the subsurface stratigraphy and buried archeological deposits and features. During the course of the geophysical survey, the park facility manager Alan Dinehart assisted in the MWAC geophysical project. Alan Dinehart also served as the Contracting Officer's Representative for the HVAC replacement construction project.

2. ENVIRONMENTAL SETTING

The present project is located in the Osage Plains section (Fenneman 1938:605-630) of the Central Lowlands Province of the Interior Plains. Carl Chapman (1975,1980) further divides the physical environment of Missouri based on his archaeological work in the state into six general physiographic regions. The project area lies in the Lower Missouri Valley locality of the Northwest Prairie Region in the rolling loess mantled hills region of the state (Chapman 1975:1-19' O'Brien and Wood 1998:7-9).

The project area lies on the relatively level ridgetop in an otherwise undulating or rolling topography formed by the erosion of the uplands by numerous drainages feeding into the Little Blue River on the east and the Blue River on the west. Both rivers are tributaries of the Missouri River. The ridgetops are narrow with moderate sloping to steep ridge slopes and narrow valley floors. Bedrock is comprised of Pennsylvanian aged limestones and shales (Branson 1944:282-284; McCourt 1917; Unklesbay and Vineyard 1992). The Truman Farm unit of the Harry S Truman National Historic Site lies at an elevation of approximately 323 meters above mean sea level.

The project areas lie within the Cherokee Prairies resource area of the Central Feed Grains and Livestock Region (USDA 2006:355-357). The soils in western Missouri are dominated by Mollisols and Alfisols (Foth and Schafer 1980:111-175). The Mollisols are formed under grassland vegetation (Foth and Schafer 1980:111) while the Alfisols are formed under forest vegetation (Forth and Schafer 1980:143). The soils are moderately to very deep with loamy or clayey soils with mixed or smectitic mineralogy. The soils range from well to poorly drained with aquic or udic soil moisture and thermic soil temperature regimes. Parent materials consist of loess, alluvium, residuum, or some combination of these materials (Preston 1984:85). The Cherokee Prairies land resource area contains soils that formed under tall prairie grasses. Depth to bedrock ranges from shallow to very deep. The project areas lie within the Macksburg-Sharpsburg-Sampsel soil association of deep, gently sloping and moderately sloping, moderately well drained to poorly drained soils that formed in loess or residuum from shale and limestone; on uplands (Preston 1984:11-12).

The soil within the Truman Farm unit of the Harry S Truman National Historic Site project area is identified as the Sibley-Urban land complex with 2 to 5 percent slopes (Preston 1984:35-36). Urban lands consist of areas covered by buildings and other structures, streets, parking lots, land leveling or excavation, and other man made features that obscure or alternate the native soils to the point where identification is not possible (Preston 1984:35,38). Urban lands tend to be impervious to water where the ground is covered. The Sibley-Urban land complex consists of the deep, well drained, gently sloping Sibley silt loams (Preston 1984:35-36,81) intermixed with Urban land. Developed in very thick silty loess, these soils are found on moderately wide complex ridges. The Sibley soils have a moderate permeability with a very high available water capacity. Surface runoff is medium. Natural fertility of the soil is high with moderate organic matter content. The soil pH ranges from neutral to medium acid. It also has a moderate shrink-swell potential.

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The soil complex is commonly found in yards, parks, gardens, and open areas between buildings.

The project area also lies within the Illinoian biotic province (Dice 1943:21-23). Tall grass prairies and oak woodlands alternate across the landscape although the forests thin as the annual moisture levels decrease. The major native prairie grasses included big bluestem, little bluestem, Indiangrass, and switchgrass (Brown 1985:30-44; Jones and Cushman 2004:24-35; Kricher and Morrison 1998:81-85; Shelford 1963:334-344). A mixed deciduous forest community grows along the bottomlands and side slopes adjacent to the streams (Shelford 1963:334-344; Steyermark 1963; Sutton and Sutton 1985:58-70). These forests consist of medium tall multilayered broadleaf deciduous species (Braun 1944). Dominate species include the red oak, white oak and shagbark hickory (USDA 2006:356). Other minor forest species include dogwood, sycamore, boxelder, mulberry, cedar, and prickly ash. Persimmon, chokeberry, wild plum, wild grapes, and mushrooms are some of the resources used by prehistoric inhabitants of the region, as well as, the historic Euroamerican settlers. The forests have well developed undergrowth vegetation communities of small trees, shrubs, and fords, including redbuds, hornbeam, pawpaw, hawthorne, gooseberry, sumac, sweet haw, blackberry, raspberry, jack-in-the-pulpit, bloodroot, mayapple, wild asters, goldenrods, chenopods, ragweeds, and smartweed (Phillips 1979; Steyermark 1963). They are interrupted by freshwater marshes and prairie communities.

Bison, elk, and wolves inhabited the plains during the prehistoric and early historic periods (Shelford 1963:334-335). Numerous other mammals and rodents also inhabit the region including deer, cottontail rabbit, and fox squirrel (Brown 1985:39-44; Jones and Cushman 2004:42-50; Kricher and Morrison 1998:81; Schwartz and Schwartz 1959; Shelford 1963:334-336; Sutton and Sutton 1985:66-70; USDA 2006:356). Numerous species of birds, including the bobwhite quail and the morning dove, inhabit the grasslands, the shrublands, and wooded areas of the region (Brown 1985:39-44; Jones and Cushman 2004:50-58; Kricher and Morrison 1998:81; Shelford 1963:336; Sutton and Sutton 1985:66-70; USDA 2006:356-357). Reptiles include several species of lizards, turtles, and snakes (Jones and Cushman 2004:58-63; Shelford 1963:336). Fish, including black bullheads, bluegill, channel and flathead catfish, carp, and crappie, and fresh water mussels are found in the streams throughout the region (Buchanan 1980; Jones and Cushman 2004:62; Pfleiger 1971; USDA 2006:356-357). Insects and other invertebrates abound throughout the region (Brown 1985:39-44; Shelford 1963:336-339; Sutton and Sutton 1985:66-70).

The region has a typical continental climate characterized by large daily and annual variations in temperature (Moxom 1941:945-954; Trewartha and Horn 1980:200-302). The project area lies within the subhumid continental climatic zone (Thorntwaite 1948). Winters are fairly brisk and the summers are warm (Moxom 1941:953-954; Trewartha and Horn 1980:200-302). Annual January temperatures average -1.78°C (Preston 1984:2,98). The average daily minimum winter temperature is 0.56°C . The lowest recorded winter temperature is -23.3°C (Preston 1984:2). Annual July temperatures average 26.7°C

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(Preston 1984:98). The average daily maximum temperature in the summer is 25.6° C. The highest recorded summer temperature is 44.4° C (Preston 1984:2). Annual precipitation averages 90.8 centimeters (Preston 1984:2,98) with the majority falling from April through September. The average seasonal snowfall is 55.9 centimeters per year (Preston 1984:2,98). The growing season averages 220 days with killing frosts occurring as late as May 8th in the spring and as early as October 16th in the fall. Severe thunderstorms and tornadoes occur occasionally with hail and high winds. Although these storms are generally local in extent and short in duration, the resulting damage can be severe. Droughts may occur anytime throughout the year, but are most damaging during the crop growing season (Moxom 1941:954). Flooding may occur along smaller streams on the average of one to two times in the spring and early summer months during most years. Occasional severe flooding of the Missouri River can produce heavy losses. The sun shines approximately 75% of the time in summer and 60% of the time in winter (Preston 1984:2). The prevailing winds are from the south with the highest average windspeed of 19.31 kilometers per hour occurring in the spring (Preston 1984:2). These resources provided the basis of the aboriginal subsistence of prehistoric times and the historic and modern Euro American farming economy.

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3. HISTORICAL OVERVIEW OF THE YOUNG-TRUMAN FARM

Since the inception of the Harry S Truman National Historic Site, the National Park Service has completed numerous historic resources, historic structure reports, and cultural landscape studies documenting the history of Park and its association with President Truman and his family. Using these documents (Bahr Vermeer Haecker Architects 2004; Cockrell 1984,1985; Cockrell and Krueger 1989; Evans-Hatch and Evans-Hatch 2001; National Park Service 1985,1987,1995,1999a,1999b,2000; Restoration Associates 1987), the following historic overview has been compiled illustrating the association of the Young and Truman families to the National Park Grandview unit and to the community. The history of the Young and Truman families in western Missouri is closely connected to the general historic trends within the State of Missouri (Missouri Archaeological Society 2006) from the New State Period (1820-1860), the Civil War (1860-1865), the Gilded Age (1865-1900), and the Modern Period (1900-present). The focus of the present overview is on the general history of the Young and Truman families. Additional information concerning the history of Jackson County region may be found in the following publications and references: Foerster (1978), Gallup Map & Supply Company (1931), Hickman (1990), Hopkins (1886), Northwest Publishing Company (1904), Ohman (1983), and Slavens (1976), and the Union History Company (1966). For additional information on the prehistory of the region, the reader should review the summaries of the archeological resources for the State of Missouri by Carl H. Chapman (1975,1980) and by Michael J. O'Brien and W. Raymond Wood (1998).

In the winter of 1841, Truman's grandparents Solomon and Harriet Young left their Kentucky home and headed west with two daughters, Susan and Sara (Ferrell 1991:64). They settled on 80 acres of land in what is now part of Kansas City. Mr. Young filed for ownership under the Preemption Act of 1841. In 1844, the Young's filed a deed to 160 acres of land in southern Jackson County, which they had purchased from Stephen Abston (Evans-Hatch and Evans-Hatch 2001:4). Mr. Young also filed his petition to perfect title to the 80 acres that the family originally settled in 1841. By the end of 1860, the Youngs had procured approximately 1,900 acres through preemption, purchase, or land warrant in the Jackson County region. Capital for the land purchases was acquired in part from Mr. Young's transcontinental freight business (Evans-Hatch and Evans-Hatch 2001:9). Six more children were born to Solomon and Harriet Young in their Missouri home, including Martha Ellen Young, Harry Truman's mother. By the time of Mr. Young's retirement in 1861 from the freighting business and Mrs. Young's purchase of 398 acres just north of Grandview, the family owned almost 5,000 acres of western Missouri farmland (Evans-Hatch and Evans-Hatch 2001:13). On the farm property near Grandview, they built a two-story, frame-construction house with a cellar beneath the kitchen approximately 20 feet (61 meters) in front of an existing log cabin (Evans-Hatch and Evans-Hatch 2001:14-15). The trench for the foundation footings was 20 inches (51 cm) wide and 20 inches (51 cm) deep. They filled the trench with limestone rubble from near-by outcroppings. A foundation of coursed stone blocks mortared with lime was placed on top of the footings. A thirty-foot deep, twenty-four inch diameter well as dug on the south side of the house and lined with

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limestone slabs. They also built a large barn to the east southeast of the house. A large maple grove was planted in front of the house along the entrance lane to the farm. Mr. Young died in 1892 leaving the farm to his wife Harriet. In the fall of 1894, the house burned to the ground. A second, smaller house was built shortly after the original house was destroyed (Evans-Hatch and Evans-Hatch 2001:17).

Anderson Shipp and Mary Jane Holmes Truman, Harry's paternal grandparents, also left Kentucky for western Missouri in 1846 (Evans-Hatch and Evans-Hatch 2001:20). They purchased a 200-acre farm near Westport Landing, the birthplace of Kansas City. The couple had five children including John Anderson Truman, Harry's father. They moved to Platte County, Missouri in 1853. Following the Civil War, the Trumans returned to Jackson County and settled near what would become Grandview, Missouri (Evans-Hatch and Evans-Hatch 2001:20-21). When John Anderson Truman and Martha Ellen Young first met, they were living on neighboring farms. After their marriage in 1881, they moved to Lamar, Missouri. Harry S Truman was born on May 8, 1884. The Trumans left Lamar a year after Harry was born where they briefly lived on a farm southeast of Belton, Missouri. In 1887, the Truman family moved to the Young farm to help Harry's maternal grandparents. The Trumans left the Young farm in 1890 for Independence where their three children including Harry could receive better schooling (Evans-Hatch and Evans-Hatch 2001:24-25). Life in Independence was prosperous for the Truman family until 1903 when the family lost everything in failing wheat futures. While his parents moved to a small farm outside of Clinton, Missouri, Harry stayed in Kansas City working at a bank. By 1906, Harry's parents returned to the Young farm. By 1907, Harry had also returned to his maternal grandparents farm (Evans-Hatch and Evans-Hatch 2001:26-29). Harry worked on the farm until he departed for World War I. After his father's death in 1914, Harry took over as the farm manager (Evans-Hatch and Evans-Hatch 2001:32-54). After Harry left the farm, his sister Mary Jane with the aid of his mother Martha continued farming until 1940 when the farm mortgage was foreclosed and they were forced to move into town (Evans-Hatch and Evans-Hatch 2001:78-89).

During the Young period, several farm buildings were built including two houses (original one built in 1867, burned down in 1894, and second house built on the location of the first house between 1894 and 1895), a large barn, and other farm outbuildings. During the period when the Trumans operated the farm, additional outbuildings were constructed including a small utility building behind the house, a second barn with an outside cistern, and outhouse at the eastern end of the yard; however, some of the buildings present at the farm today have been moved from their original locations. Large square stone posts (thirty inches wide and five feet high) served as corner posts and gate posts around the farm.

In 1945, the County Court sold the Grandview farm (Evans-Hatch and Evans-Hatch 2001:92-93). In 1946, the owners of the farm resold to Harry S Truman. In 1950, Truman began efforts to establish the presidential library on the farm but in 1954 a different site was selected at Independence (Evans-Hatch and Evans-Hatch 2001:93-96). By 1956, the Trumans had sold most of the farm except for the farmhouse and twenty acres of land

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(Evans-Hatch and Evans-Hatch 2001:96-97). The last of the maples planted by Solomon Young were destroyed by a tornado in 1957. In 1966, the large barn was destroyed by fire. In 1965, the Truman family attempted to sell the farmhouse to any organization that would preserve it; however, the first attempt failed. A second attempt was orchestrated in 1976 by members of the Grandview Chamber of Commerce. Although they did not purchase the home, they were able to have the property listed on the National Register of Historic Places in 1978 (Evans-Hatch and Evans-Hatch 2001:96). A third attempt to acquire the Truman farm home was made in the early 1980s by the Harry S Truman Farm Home Foundation, which was instituted by the Grandview Chamber of Commerce and the Grandview City Council (Evans-Hatch and Evans-Hatch 2001:97-99). Restoration of the farmhouse began in the fall of 1983 and was completed by mid-spring in 1984 (Evans-Hatch and Evans-Hatch 2001:99-108). The farmhouse was designated a National Historic Landmark in 1985. In 1994, the National Park Service accepted the farmhouse, related structures, and the 5.2 acres of land through a donation from Jackson County under Public Law 103-184 passed by Congress and signed by President Clinton ((Evans-Hatch and Evans-Hatch 2001:108-109). Today, the remaining five acres of land of the original 600-acre Solomon Young farm is surrounded by modern development. In 2008, the Harry S Truman National Historic Site received a 4.96 acre tract of the original farm on the south side of the Truman farm unit through a donation.

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4. FILE SEARCH AND PREVIOUS ARCHEOLOGICAL DOCUMENTATION AT THE HARRY S TRUMAN NATIONAL HISTORIC SITE

A file search of the Archaeological Survey of Missouri (University of Missouri-Columbia) records was requested in March 2005 for the Noland property (ASM Identification Number 04-5-70), the Truman/Wallace properties (ASM Identification Number 05-3-33), and the Truman Farm (ASM Identification Number 05-3-66). No archeological resources were identified during the Noland, Truman and Wallace properties file search of Sections 2 and 3, Township 49 North, Range 32 West of Jackson County or for the file search associated with the Truman farm in Sections 11, 12, 13, and 14, Township 47 North, Range 33 West of Jackson County. The immediate project area lies within the West Missouri archeological study unit (Wright 1987:B24/1-B24/14). The unit is located on the divide between the Blue and Little Blue River watersheds, which flow into the Missouri River valley.

Limited archeological investigations at the Truman Home property have been related to small restoration projects. In 1988, MWAC archeologist William Sudderth recovered wine bottles from two basement alcoves (68 bottles in the west alcove and 19 bottles in the south alcove) as part of a removal, stabilization, and curation project (Nobel 1988; Sudderth 1988). The wine bottles were packed and removed for permanent storage. In 1992, MWAC archeologist Vergil Noble (1992) monitored excavations to improve the downspout drainage at the rear of the Truman Home. During the monitoring, four pieces of slate roofing were recovered. Limited ground disturbing activities resulted during the 1993 inspection of the coal room in the basement of the Truman Home (Given 1993). A small brick channel or trough was identified beneath the existing dirt floor. Given also noted that an old well or cistern may be present adjacent to the brick trough. Additional excavations in the dirt floor and inspection of several openings in the exterior wall indicated that the brick duct was a fresh air intake for the original coal furnace (Masten 1993). Masten also concluded that there were no known wells or cisterns located in the basement of the house. MWAC archeologist Scott Stadler (2001) conducted archeological investigations beneath the three porches and in the basement of the Truman Home as part of stabilization project of the porches and basement. A small brick feature consisting of three courses of brick was identified under the front porch. Stadler identified the feature as a base for a former support post for the porch. Two features were identified under the kitchen porch including a cistern dating to ca. 1867 and a small brick retaining wall at the east end of the 1867 porch. Excavations in the basement suggested that the basement floor had been excavated into culturally sterile subsoil. Artifacts recovered from the porch excavations included cut and wire nails, slate roofing fragments, glass marble, wooden die, plastic beads, ferrous wheel of child's toy, a toy trail car, a golf club head, a child's leather shoe, a KC and I Line (Kansas City Railways company) ticket, whiteware, and window glass. A few badly rusted pieces of ferrous metal were recovered from the basement excavations.

In order to determine the foundation depth for the rehabilitation of the Noland House basement foundation, Archeologist John Peterson (2003) of the Jackson County

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Parks and Recreation Department assisted the Harry S Truman staff in monitoring three exploratory holes in the Noland House basement. The purpose of the excavations was to determine the depth of the foundation beneath construction joints and collect data on the chronology of the house additions. Three small exploratory excavations were placed near the southeast corner of the south wall (Hole 1), near the intersection of the crawl space foundation and an addition to the south side of the house (Hole 2), and at the base of the western basement foundation wall (Hole 3). Hole 1 bisected a construction joint in the south brick wall. This area of the basement was partially excavated and contained a concrete cap over the subsoil. Peterson noted that a builder's trench may be present but the size of the excavation precluded any further examination. The excavation of Hole 2 in the crawl space revealed a 10 cm wide builder's trench along the south wall. Artifacts from the feature included cut nails, a redware rimsherd from an unglazed flower pot and a shoe heel fragment. Hole 3 was located along the west wall of the basement in the north room of the "root cellar" area. Three courses of brick were identified below the basement's concrete floor. A mixed layer of sand and coal clinkers below the concrete floor suggested that the room may have functioned as a dump for the coal furnace. Two soil cores were removed from the yard at the exterior northwest corner and the northeast corner of the house to explore the engineering properties of the soil (Terracon 2003).

Additional coring was conducted at the Truman Farm House and at the Frank and George Wallace Houses in order to assess the engineering properties of the soils for proposed rehabilitation projects at the Frank Wallace House and the Truman Farm House (Peterson 2004). The stratigraphy of three pits excavated by Park staff at the Truman Farm House and the Carriage House at the Truman Home were also examined during this monitoring project. Cores at the Truman Farm House were located in the yard near the southwest corner of the house and near the northeast corner of the house. No artifacts were noted during the coring. The excavations were located along the south side of the building next to the southwest corner and the north side of the northeast corner of the building. A small whiteware sherd was recovered from the southwestern excavation pit. The brick foundation in the southwest pit extended to 96 cm below the surface while the brick foundation on the northeast corner only extended to a depth of 67 cms below the surface where it was found resting on a concrete footing. Two cores were drilled at the Frank Wallace House: one in the yard outside the south wall of the house and one inside the basement. Three cores were drilled at the George Wallace House: one in the yard between the two houses near the southeast corner of the building, one in the front yard near the northwest corner of the building, and one in porch fill. Two blue transfer print earthenware and porcelain sherds and a plain white porcelain sherd were recovered from the two cores in the yards of the Frank and George Wallace Houses. A plain whiteware sherd was recovered from the core in the George Wallace porch. The excavation pit along the east side of the Truman Home Carriage House near the northeast corner revealed a feature that may have been a builder's trench. Four artifacts were recovered from the ash, coal, clinker, limestone mixed fill, including a polychrome floral decorated whiteware plate rim sherd, a plain whiteware sherd, and two clear container glass fragments. Peterson suggested that the artifacts dated the fill to the late 19th or early 20th century. The foundation wall

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consisted of rough blocks of limestone with a sandy mortar that extended to a depth of 65 cm below the surface.

In 2005, the archeological and geophysical investigations of the Noland property, the Truman Home yard, and the George and Frank Wallace lots, were conducted as part of the foundation rehabilitation projects for the Noland House and the Frank Wallace House in 2005 (De Vore 2005a,2005b,2005c; De Vore et al. 2009; Peterson 2005; Thiessen 2005). The magnetic, ground conductivity, resistance, and ground-penetrating radar data collected at the Noland property provided information of the physical properties (i.e., magnetic gradient, and conductance, the resistance, and ground-penetrating radar reflections) of the subsurface materials. Numerous small scale magnetic, conductivity, resistance, and ground-penetrating radar anomalies are identified in the four data sets. Buried utility lines to the house, including the water and gas lines, were also identified in the data sets. A concentration of magnetic, and resistance anomalies in the southwest corner was identified and confirmed with the shovel tests and excavation units as a gravel parking pad. A cistern off of the southwest corner of the Noland House was uncovered during the monitoring of the construction trench surrounding the house. Excavations including shovel tests and formal excavation units indicated the presence of a light scatter of historic artifacts in the Noland yard associated with the late 19th century construction of the house and subsequent 19th and 20th century modifications and additions to the main house unit, as well as the National Park Service activities after the Noland property was incorporated into the Harry S Truman National Historic Site. The magnetic, ground conductivity and ground penetrating radar data collected at the Truman/Wallace properties also provided information of the physical properties (i.e., magnetic, soil conductance, soil resistance, and dielectric permittivity) of the subsurface materials. Numerous small scale magnetic, conductivity, resistance, and ground-penetrating radar anomalies were identified in the three data sets. Buried utility lines to the Truman Home including the water and gas lines were identified along with the security lighting system surrounding the Truman Home. A buried ceramic storm water drainage tile pipe was identified in the eastern portion of the Frank Wallace property. A midden deposit associated with a filling or multiple filling episodes in the lower part of the original Gates property (i.e., the location of the Frank Wallace property and house) was uncovered during the monitoring of the construction trench surrounding the Frank Wallace House. The recovery of artifacts and the documentation of features in the demolition trench indicated the presence of a late 19th century midden deposit, which was probably used as a disposal area for refuse from the Gates occupation and to fill the low area in this portion of the property. Fill inside the front porch foundation of the Frank Wallace House appeared to be materials discarded from furnace and stove cleaning episodes, as well as other activities, to provide a base for the raised front porch.

Archeological investigations at the Truman Farm near Grandview, prior to the 2004 coring activities mentioned above, included an archeological survey and testing project conducted at the farm grounds in 1983 (Bray 1983). The project was part of the restoration efforts by the Truman Farm Home Foundation (Evans-Hatch and Evans-Hatch 2001:97-

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108). Above ground structures, buildings, and features were mapped and described. Additional probing with a tile probe and limited exploratory excavation pits to examine the target revealed numerous features around the house and in the barn yard. In 1994, four small areas of ground disturbances related to the installation of outdoor security lamps were examined (Richner 1994). The backfill from the small installation pit southeast of the house contained several artifacts that were viewed as associated with the 19th century backyard midden. On the northeast side of the house, a shallow access trench for the new electrical line conduit contained a 10 cm thick fill zone over the natural soil matrix. A single whiteware ceramic sherd was observed in the backfill.

5. GEOPHYSICAL FIELD METHODOLOGY

The geophysical investigations at the Truman Farm property (23JA638) called for magnetic survey of the yard associated with the proposed HVAC replacement project and the trackhoe trench for the installation of the piping from the geothermal wells in the parking lot to the geothermal pump inside the Truman farmhouse in order to identify the extent of the site and location of buried archeological resources (Figure 4). The geophysical survey covered an area of 337 m² (0.08 acres).

The geophysical grid was established with a portable Ushikata S-25 Tracon surveying compass (Ushikata 2005) and 100-meter tape. The surveying compass was used to sight in two perpendicular base lines and the geophysical grid unit corners. Wooden hub stakes (2" x 2" wooden hub stakes) were placed at the 20-meter grid corners with additional stakes placed at intersection points of the grid unit and the Truman farmhouse. The geophysical grid was aligned parallel to the parking lot sidewalk on its south side. With the surveying compass on the southeast corner point of the grid unit, the southern base line extended 20 meters west of the corner of the parking lot sidewalk and the sidewalk to the farmhouse. The grid was oriented on Magnetic North. The northeast corner stake along the eastern baseline was placed at 14 meters north of the southeast corner of the grid unit next to the porch and handicap accessible ramp to the house. From the southwest corner stake, the northwest corner stake was shot in with the surveying compass at 20 meters north of the southwest corner. A grid corner stake was placed at nine meters east of the northwest corner of the grid. Additional stakes were placed at the ten meter marks north of the southern baseline on the east and west baselines.

Global positioning system (gps) coordinates were collected at the geophysical grid corner stakes, at the ends of the geothermal well locations in the parking lot, and along the trackhoe trench lines from the farmhouse to the parking lot sidewalk with a Trimble GeoXH handheld 2005 series gps unit (Trimble Navigation 2007a). The positional data was collected as Universal Transverse Mercator (UTM) coordinates in Zone 15 North using the North American Datum of 1983 (NAD-83) as the horizontal reference (Trimble Navigation 2002). Once the coordinates were collected, the rover files were downloaded to a field laptop computer using the TerraSync software (Trimble Navigation 2007b,2007c) for differentially correcting the data in the Trimble Pathfinder Office software (Trimble Navigation 2007d). The National Geodetic Survey continuously operating reference station (CORS) 50 miles away at Lathrop, Missouri, was selected as the provider for the base station gps data. The field gps data was differential corrected using the CORS Lathrop base station data. The corrected data files were then exported to an EXCEL spreadsheet. The corrected data was added to the park's geographic information system (gis) as a layer illustrating the location of the geophysical project grid.

Before the start of the geophysical survey of the grid area, yellow nylon ropes were laid out on the grid unit (Figure 5). These ropes served as guide ropes during the actual data acquisition phases of the project. Twenty-meter ropes were placed along the

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top and bottom base lines connecting the grid corners. The survey ropes formed the boundaries of grid during the data collection phase of the survey. Additional traverse ropes were placed a one-meter intervals across the grid at a perpendicular orientation to the base lines beginning with the line connecting the two wooden hubs on the left side of the grid unit. The ropes serve as guides during the data acquisition and in the development of the sketch map of the surface features. The 20-meter lengths of ropes are divided into 0.5 meter increments by different colored tape. One color (blue) is placed every meter along the rope with a different colored (red) tape placed at half-meter intervals. The use of different colored tape on the ropes provides a simple way to maintain one's position within the geophysical survey grid unit as data are being collected. The geophysical data were therefore recorded in a series of evenly spaced parallel lines with measurements taken at regular intervals along each line resulting in a matrix of recorded measurements (Kvamme 2001:356; Scollar et al. 1990:478-488). Beginning in the lower left-hand corner of the grid, data collection occurred in a parallel (unidirectional) or zigzag (bi-directional) mode across the grid(s) until the survey was completed for each technique. During the magnetic survey while the survey ropes were in place in each grid unit, a sketch map was also made of relevant surface features for the grid area (Figure 6).

6. GEOPHYSICAL PROSPECTION TECHNIQUES

Various geophysical instruments have been used by archeologists to locate evidence of past human activity. Magnetometers and soil resistance meters began to be employed on Roman sites in England during the late 1940s and early 1950s (Aitken 1961), and their use was the focus of considerable research in the 1960s and 1970s. During this period, the archeological applications of additional instruments were also explored (Aitken 1974, Clark 2000, Scollar et al. 1990, Tite 1972). While many of the early studies in England and Europe were very successful, it was some time before improvements in detector sensitivity and data processing techniques allowed a wide range of New World sites to be mapped. Virtually all the instruments used in non-invasive mapping of historic sites originated as prospecting devices for geological exploration. In general, cultural resource applications using geophysical instruments focus on weaker anomalies or smaller anomalies. It is important to emphasize that instruments employed in archeological geophysical surveys do not respond only to the desired cultural targets, and consequently, feature detection depends greatly on the recognition of patterns that match the anticipated form of the cultural target. The challenge in archeological geophysics is to recognize the anomalies produced by the target features and sort them out from the “noise” produced by the responses from the surrounding matrix. The amount of data collected in any given area and the method of collection both affect one’s ability to recognize the specific anomaly type or “signature” of the feature being sought.

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

The passive geophysical prospection technique used during this project is the magnetic survey. As indicated above, passive techniques measure existing physical properties of the earth. Other passive geophysical techniques include the measurement of earth’s natural electrical fields, gravitational fields, radiometric measurement of radioactive

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elements, and thermal measurements of soil temperature changes. These passive methods with limited archeological applications include self-potential methods, gravity survey techniques, and differential thermal analysis. Active methods were not used due to the time limitations of the project and the winter weather.

Magnetic Survey Methodology

A magnetic survey is a passive geophysical prospection technique used to measure the earth's total magnetic field at a point location. Magnetometers depend upon sensing subtle variation in the strength of the earth's magnetic field in close proximity to the archeological features being sought. Variation in the magnetic properties of the soil or other buried material induces small variations in the strength of the earth's magnetic field. Its application to archeology results from the local effects of magnetic materials on the earth's magnetic field. These anomalous conditions result from magnetic materials and minerals buried in the soil matrix. Ferrous or iron based materials have very strong effects on the local earth's magnetic field. Historic iron artifacts, modern iron trash, and construction material like metal pipes and fencing can produce such strong magnetic anomalies that nearby archeological features are not detectable. Other cultural features, which affect the earth's local magnetic field, include fire hearths, and soil disturbances (e.g., pits, mounds, wells, pithouses, and dugouts), as well as, geological strata.

Magnetic field strength is measured in nanoteslas (nT; Sheriff 1973:148). In North America, the earth's magnetic field strength ranges from 40,000 to 60,000 nT with a inclination of approximately 60° to 70° (Burger 1992:400; Milsom 2003:55; and Weymouth 1986:341). The project area has a magnetic field strength of approximately 57,600 nT with an inclination of approximately 73.4° (Peddie 1992; Peddie and Zunde 1988; and Sharama 1997:72-73). Magnetic anomalies of archeological interest are often in the ± 5 nT range, especially on prehistoric sites. Target depth in magnetic surveys depends on the magnetic susceptibility of the soil and the buried features and objects. For most archeological surveys, target depth is generally confined to the upper one to two meters below the ground surface with three meters representing the maximum limit (Clark 2000:78-80; and Kvamme 2001:358). Magnetic surveying applications for archeological investigations have included the detection of architectural features, soil disturbances, and magnetic objects (see Aspinall et al. 2008; Bevan 1991,1998:29-43; Breiner 1973,1992:313-381; Burger 1992:389-452; Clark 2000:92-98,174-175; David 1995:17-20; Dorin and Savit 1988:633-749; Gaffney and Gater 2003:36-42,61-72; Gaffney et al. 1991:6,2002:7-9; Heimmer and DeVore 1995:13,2000:55-56; Kvamme 2001:357-358,2003:441,205, 434-436,2006a:205-233,2006b:235-250; Lowrie 1997:229-306; Milson 2003:51-70; Mussett and Khan 2000:139-180; Nishimura 2001:546-547; Robinson and Çoruh 1988:333-444; Scollar et al. 1990:375-519; Telford et al. 1990:62-135; Weymouth 1986:343; and Witten 2006:73-116 for more details on magnetic surveying).

Two modes of operation for magnetic surveys exist: 1) the total field survey and 2) the magnetic gradient survey. The instrument used to measure the magnetic field strength

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is the magnetometer (Bevan 1998:20). Three different types of magnetic sensors have been used in the magnetometer: 1) proton-free precession sensors, 2) alkali vapor (cesium or rubidium) sensors, and 3) fluxgate sensors (for a detailed description of the types of magnetometers constructed from these sensors see Aitken 1974; Aspinall et al. 2008:29-56; Clark 2000:66-71; Milsom 2003:58-62; Scollar et al. 1990:450-469; and Weymouth 1986:343-344).

The total field magnetometer is designed to measure the absolute intensity of the local magnetic field. This type of magnetometer utilizes a single sensor. Due to diurnal variation of the earth's magnetic field, the data collected with a single sensor magnetometer must be corrected to reflect these diurnal changes. One method is to return to a known point and take a reading that can be used to correct the diurnal variation. A second method is to use two magnetometers with one operated at a fixed base station collecting the diurnal variation in the magnetic field. The second roving magnetometer is used to collect field data in the area of archeological interest. The diurnal variation in the rover data is then corrected using the base station results. Common magnetometers of these types used in archaeological investigations include the proton precession magnetometer, the Overhauser effect magnetometer (a variation of the proton precession magnetometer), and the cesium magnetometer.

The magnetic gradient survey is conducted with a gradiometer or a magnetometer with two magnetic sensors separated by a fixed vertical distance. The instrument measures the magnetic field at two separate heights. The top sensor reading is subtracted from the bottom sensor reading. The resulting difference is recorded. This provides the vertical gradient or change in the magnetic field. Diurnal variations are automatically canceled. This setup also minimizes long range trends. The gradiometer provides greater feature resolution and potentially provides better classification of the magnetic anomalies. Two commonly used gradiometers in archeological investigations are the cesium gradiometer and the fluxgate gradiometer. They are capable of yielding 5 to 10 measurements per second at an accuracy resolution of 0.1 nT (Kvamme 2001:358). Cesium gradiometers record the absolute total field values like the single sensor magnetometers. The fluxgate sensors are highly directional, measuring only the component of the field parallel to the sensor's axis (Clark 2000:69). They also require calibration (Milsom 2003:2003:61-62). Both cesium and fluxgate gradiometers are capable of high density sampling over substantial areas at a relatively rapid rate of acquisition (Clark 2000:69-71; and Milsom 2003:60-62).

The magnetic gradient survey in the Truman farm yard at Site 23JA638 was conducted with a single fluxgate gradiometer system and with a dual fluxgate gradiometer system. The use of both systems provided an opportunity to compare the magnetic data sets from both instruments. The dual system was a new addition to the MWAC inventory of geophysical instruments that includes fluxgate, cesium, and overhauser gradiometers; proton precession magnetometers; resistance meters with twin probe arrays; resistivity meters; conductivity meters; metal detectors; and ground penetrating radar cart system with a 400 MHz antenna.

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Single Fluxgate Gradiometer Survey

The single gradiometer survey was conducted with a Geoscan Research FM36 fluxgate gradiometer with a ST1 sample trigger (Figure 7). The instrument is a vector magnetometer, which measures the strength of the magnetic field in a particular direction (Geoscan Research 1987). The two fluxgate magnetic sensors are set at 0.5 meters apart from one another. The instrument is carried so the two sensors are vertical to one another. Height of the bottom sensor above the ground is relative to the height of the surveyor. In the carrying mode at the side of the body, the bottom sensor is approximately 0.30 meters above the ground. Two readings are taken at each point along the survey traverse, one at the upper sensor and one at the lower sensor. The difference or gradient between the two sensors is calculated (bottom minus top) and recorded in the instrument's memory. Each sensor reads the magnetic field strength at its height above the ground. The gradient or change of the magnetic field strength between the two sensors is recorded in the instrument's memory. This gradient does not measure absolute field values but voltage changes, which are calibrated in terms of the magnetic field. The fluxgate gradiometer does provide a continuous record of field strength. With a built-in data logger, the gradiometer collects survey data quickly and efficiently.

The gradiometer sensors must be accurately balanced and aligned along the direction of the field component to be measured. The zero reference point was established at a quiet area in the front yard of the Truman Farm where no noticeable localized magnetic variations were located. The magnetic reference point for the project was located 20 meters west of the front porch along the N20 line. The preliminary readings in the area varied less than 2 nT. The balancing and alignment procedures were oriented to magnetic north. The balance control on the instrument was adjusted first. The balancing the instrument was conducted in the 1 nT resolution range to within a range of ± 1 nT. The magnetic sensors were then aligned to within a range of ± 1 nT. If the observed display readings went over the acceptable range, the balancing and alignment procedures were repeated until successful. The instrument was returned to the 0.1 nT resolution operating range and then zeroed at arm's length over the operator's head. The operator's manual (Geoscan Research 1987:29-31) illustrates the steps involved in preparing the instrument for actual field data collection.

The survey of each traverse was conducted in a zigzag or bidirectional mode beginning in the southwest corner or lower left-hand corner of the grid unit (Table 1). During the survey, data were collected at 8 samples per meter (0.125 m) along each traverse and at one-meter traverses across each individual grid unit resulting in 8 samples per square meter. A total of 3,200 measurements were recorded during the magnetic survey for a complete 20 m by 20m grid unit. With eight samples per meter and one-meter traverses in the zigzag mode, it took approximately 15 minutes to complete the 20-m by 20-m grid unit. At the end of the survey of the grid unit, the magnetic data from the survey were downloaded into the Geoscan Research GEOPLOT software (Geoscan Research) on a field laptop computer. The grid file was identified as to its relative position in the

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GEOPLOT mesh file. A composite data file created in GEOPLOT was reviewed in the field prior to the clearing of the gradiometer's memory.

Dual Fluxgate Gradiometer System

The dual fluxgate gradiometer system used on the project was a Bartington Grad 601-2 single axis magnetic gradiometer (Figure 8), which is also a vector magnetometer, which measures the strength of the magnetic field in a particular direction. The dual fluxgate gradiometer sensor configuration of the instrument uses two fluxgate gradiometer sensor tubes separated by a distance of one meter. The dual gradiometer records two lines of data during each traverse reducing the distance walked and the survey time by half compared to the time and distance covered with a single gradiometer system. The sensors must be accurately balanced and aligned along the direction of the field component to be measured. The reference point for balancing and aligning the gradiometer is located approximately forty meters west of the northwest corner of the geophysical grid unit and aligned on Magnetic North.

The fluxgate gradiometer sensor tubes in the dual gradiometer are spaced 1.0 meters apart with the two tubes also spaced at one meter apart (Table 2). The instrument is carried so the two sensors in each tube are vertical to one another with the bottom sensors approximately 30 cm above the ground. Each sensor reads the magnetic field strength at its height above the ground. The gradient or change of the magnetic field strength between the two vertical sensors is recorded in the instrument's memory for both sensor tubes. These gradients are not in absolute field values but rather voltage changes, which are calibrated in terms of the magnetic field. The dual fluxgate gradiometer provides a continuous record of the magnetic field strength across each line for each traverse across the grid unit.

The magnetic survey was designed to collect eight samples per meter along 1.0-meter lines or 8 data values per square meter. The data were collected in a zigzag fashion with the surveyor alternating direction of travel for each traverse across the grid. A total of 3,200 data measurements were collected during the survey of a complete grid unit. The magnetic data were recorded in the memory of the gradiometer and downloaded to a laptop computer at the completion of the survey. The magnetic data were imported as individual grid files into DW Consulting's ArcheoSurveyor software (DW Consulting 2008). The grid files were combined into a site composite file for processing. Both shade relief and trace line plots were generated in the field before the instrument's memory was cleared.

Magnetic Data Processing

Processing of geophysical data requires care and understanding of the various strategies and alternatives (Kvamme 2001:365; Music 1995; Neubauer et al. 1996). Drs.

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Roger Walker and Lewis Somers (Geoscan Research 2003) provide strategies, alternatives, and case studies on the use of several processing routines commonly used with the Geoscan Research instruments in the GEOPLOT software manual. Dr. Kenneth Kvamme (2001:365) provides a series of common steps used in computer processing of geophysical data:

Concatenation of the data from individual survey grids into a single composite matrix;

Clipping and despiking of extreme values (that may result, for example, from introduced pieces of iron in magnetic data);

Edge matching of data values in adjacent grids through balancing of brightness and contrast (i.e., means and standard deviations);

Filtering to emphasize high-frequency changes and smooth statistical noise in the data;

Contrast enhancement through saturation of high and low values or histogram modification; and

Interpolation to improve image continuity and interpretation.

It is also important to understand the reasons for data processing and display (Gaffney et al. 1991:11). They enhance the analyst's ability to interpret the relatively huge data sets collected during the geophysical survey. The type of display can help the geophysical investigator present his interpretation of the data to the archeologist who will ultimately use the information to plan excavations or determine the archeological significance of the site from the geophysical data.

Single Fluxgate Gradiometer Data Processing

The magnetic data from the single fluxgate gradiometer instrument were downloaded into a laptop computer after the completion of survey of the site. On the laptop computer, the GEOPLOT software was initialized and the data from the instrument was downloaded as grid data files on the laptop computer (Geoscan Research 2003:4/1-29). The grid file contained the magnetic raw data obtained during the survey of the individual grid unit. The grid file was reviewed as a shade plot display (Geoscan Research 2003) for data transfer or survey errors. If no data transfer errors were observed, a composite of the data file(s) was created for further data processing. Generally, while in the field, the composite file was processed with the zero mean traverse routine and viewed on the laptop computer before the memory in the gradiometer was cleared. From this preliminary review of the collected data, the geophysical investigator could analyze his survey design

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and methodology and make appropriate survey decisions or modifications while still in the field.

In order to process the magnetic data, the grid file from the survey must be combined into a composite file. The first step in creating a composite file is to create a mesh template with the grid file oriented in the correct position of the magnetic survey of the site (Geoscan Research 2003:3/15-21). Once the grid file has been placed in the correct position in the mesh template, the composite file is generated. The master grid or mesh template is saved as a file for later modification as necessary.

After the creation of the composite file for the magnetic data collected at the site, the data may be viewed either as the numeric data values or as a graphic representation of the data (Geoscan Research 2003:5/2-3). The shade plot represents the data in a raster format with the data values assigned color intensity for the rectangular area at each measurement station. Data may be presented as absolute numbers, in units of standard deviation, or as a percentage of the mean. Several color and monochrome palettes provide different visual enhancements of the data. Trace plots of the data represent the data in a series of side by side line graphs, which are helpful in identifying extreme highs and lows in the data. The trace plots show location and magnitude.

Up to this point, we have been collecting the data and preparing it for processing and analysis. Inspection of the background should show the data as bipolar and centered on zero. There should be a broad range in the archeological anomalies with weak anomalies less than 1 nT, typical 1 nT to 20 nT anomalies, strong anomalies greater than 20 nT. If the anomalies are weak then reset the clip plotting parameter to a minimum of -2, a maximum of 2, and units to absolute. Then one should identify weak and strong ferrous anomalies, which often represent modern intrusions into the site such as localized surface iron trash, wire fences, iron dumps, pipelines, and utility lines. Geological trends in the data set should also be identified. Since gradiometers provide inherent high pass filtering, broad scale geological trends are already removed from the data set. If such trends appear to exist, there may be changes in the topsoil thickness, natural depressions, igneous dikes or other geomorphologic changes in the landscape. Final step prior to processing the data is to identify any defects in the data. These can range from periodic errors appearing as linear bands perpendicular to the traverse direction, slope errors appearing as shifts in the background between the first and last traverses, grid edge mismatches where discontinuities exist between grids, traverse striping consisting of alternating stripes in the traverse direction which most commonly occurs during zigzag or bi-directional surveys, and stager errors resulting in the displacement of a feature on alternate traverses (Geoscan Research 2003:Reference Card 3).

Initially, the spectrum function (Geoscan Research 2003:6/87-95) was applied to the data. The spectrum function provided analysis of the frequency spectrum of the data, splitting it into amplitude, phase, real, or imaginary components. The amplitude component was selected for the analysis to identify any periodic defects. These defects

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may have been the effects of cultivation (e.g., plow marks, ridge and furrow, etc.) or operator induced defects during data acquisition). It operated over the entire site data set. No periodic defects were noted in the data set.

The magnetic data were “cleaned up” using the zero mean traverse algorithm (Geoscan Research 2003:6/107-115). This algorithm was used to set the background mean of each traverse within a grid to zero, which removed any stripping effects resulting from instrument scan and/or operator bias defects. It also was useful in removing grid edge discontinuities between multiple grids. The algorithm utilized the least mean square straight line fit and removal default setting over the entire composite data set. The statistics function (Geoscan Research 2003:6/101-102) was then applied to the entire magnetic data composite file for the southern portion of the site. The mean, standard deviation, and variance were used to determine appropriate parameters for the subsequent processing steps. The magnetic data ranged from -208.7 to 212.0 nT with a mean of -7.78 nT and a standard deviation of 39.894 nT after the application of the zero mean traverse algorithm. The data set was interpolated to produce a uniform and evenly spaced data matrix (Geoscan Research 2003:6/53-56). Increasing or decreasing the number of data measurements created a smoother appearance to the data. The original matrix was an 8×1 matrix. The interpolate function required three parameters: direction, interpolation mode and interpolation method. In the Easting direction, the number of data measurements was expanded to yield an 8×4 data matrix. In the Northing direction, the number of data measurements was shrunk yielding a 4×4 matrix. The low pass filter was then used to remove high-frequency, small scale spatial details over the entire data set (Geoscan Research 2003:6/57-60). It was also used to smooth the data and to enhance larger weak anomalies. The resulting data had a normal distribution with a mean near zero representing the background value. The composite data files were then exported to xyz data files for use in the SURFER 8 contouring and 3d surface mapping program (Geoscan Research 2003:5/4-7; Golden Software 2002).

Dual Fluxgate Gradiometer Data Processing

The magnetic data were imported as individual grid files into DW Consulting's ArcheoSurveyor software (DW Consulting 2008). The grid files were combined into a site composite file for processing (DW Consulting 2008:3-4). Both shade relief and trace line plots were generated in the field before the instrument's memory was cleared. Upon completion of the survey, the data were processed in ArcheoSurveyor. Initially, a replace routine was applied to the composite data set to remove the extreme positive and negative values over 205 nT and under -205 nT by assigning the dummy value to these extremes (DW Consulting 2008:64). A destripe routine was then applied to remove any traverse discontinuities that may have occurred from operator handling or heading errors (DW Consulting 2008:48). Upon completion of the destripe function, the data were interpolated by expanding the number of data points in the traverse direction and by reducing the number of data points in the sampling direction to provide a smoother appearance in the data set and to enhance the operation of the low pass filter (DW Consulting 2008:49).

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This changed the original 8 x 1 data point matrix into 4 x 4 data point matrix for the survey area. The low pass filter was then applied over the entire data set to remove any high frequency, small scale spatial detail (DW Consulting 2008:59). This transformation resulted in the improved visibility of larger, weak archeological features. The magnetic data from Site 23JA638 after the application of the destripe function ranged from -151.6 nT to 219.4 nT with a mean of -4.84 nT and a standard deviation of 32.660 nT. The resulting data had a normal distribution with a mean near zero representing the background value. The composite data files were then exported to xyz data files for use in the SURFER 8 contouring and 3d surface mapping program (DW Consulting 2008:28; Golden Software 2002). An image and contour plot of the magnetic data was also generated for the survey area.

Final Magnetic Data Processing and Presentation

In SURFER 8 (Golden Software 2002), the initial step was to view the xyz data file from the single and the dual fluxgate gradiometer data sets. The grid area utilized the arbitrary coordinate system beginning with N0/E0 for the lower left hand corner of the southwest corner of the grid. The data were sorted, using the data sort command to check for GEOPLOT dummy values (i.e., 2047.5). The rows of data containing these values were deleted from the file. The data was saved as a new file containing the corrections.

In order to present the data in the various display formats (e.g., contour maps, image maps, shaded relief maps, wireframes, or surfaces), a grid must be generated (Golden Software 2002). The grid represents a regular, rectangular array or matrix. Gridding methods produce a rectangular matrix of data values from regularly spaced or irregularly spaced XYZ data. The geometry is defined for the project area. The minimum and maximum values for the X and Y coordinates are defined. These values represent the beginning and ending coordinates of the surveyed geophysical grid. The sample interval and traverse spacing are defined in the distance between data units under spacing. The number of lines should correlate with the number of traverses and samples per traverse. The Kriging gridding method was selected for processing the data. The Kriging method is very flexible and provides visually appealing displays from irregularly spaced data. The Kriging variogram components are left in the default values. The next step in the formation of the visual display of the data from the site is to apply the spline smoothing operation to the grid file. The operation produces grids that contain more round shapes on the displays. Due to the presence of unsurveyed areas along the edges of the rectangular survey area, a blanking file was constructed and applied to the grid file. The blanking file contains the X and Y coordinates used to outline the blanked portion of the grid, as well as, the number of parameter points and whether the blanking operation is located on the interior of the parameter points or on the exterior of these points.

At this point in the process, maps of the data may finally be generated (Golden Software 2002). Typically for geophysical surveys, contour maps, image maps, shaded relief maps, and wireframes may be generated. The image map is a raster representation of

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the grid data. Each pixel or cell on the map represents a geophysical data value. Different color values are assigned to ranges of data values. The image map is generated. The map may be edited. The color scale is set with the minimum value assigned the color white and the maximum value assigned the color black. The data are also clipped to a range between -20 and 20 nT for the single fluxgate gradiometer data and between -10 and 10 nT for the dual fluxgate gradiometer for better visual presentation of the image. The scale is a graduated scale flowing from white through several shades of gray to black. SURFER 8 has a several predefined color scales including the rainbow scale which is often used for the presentation of geophysical data or the investigator may create an color spectrum suitable for the project data. To complete the image map, descriptive text is added along with a direction arrow, a color scale bar, and map scale bar. Another way to represent geophysical data is with contour maps. Contour maps provide two dimensional representations of three dimensional data (XYZ). The North (Y) and East (X) coordinates represent the location of the data value (Z). Lines or contours represent the locations of equal magnetic value data. The distance or spacing between the lines represents the relative slope of the geophysical data surface. The contour map may be modified by changing the mapping level values in the levels page of the contour map properties dialog controls. Contour maps are useful in determining the strength of the magnetic anomalies as well as their shape and nature. The various types of maps can be overlain on one another and different types of data can be illustrated by stacking the displays within a single illustration. Both the image and contour maps were generated for the magnetic data from the project area for the single fluxgate gradiometer (Figure 9) and the dual fluxgate gradiometer system (Figure 10).

Magnetic Data Interpretation

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 consisting of 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 methodology; 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

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of the nature and cause (i.e., natural or cultural) of a geophysical anomaly (Clay 2001). Each instrument responds primarily to a single physical property: magnetometry to soil magnetism, electromagnetic induction to soil conductivity, resistivity to soil resistance, and ground penetrating radar to dielectric properties of the soil to (Weymouth 1986b:371).

Interpretation of the magnetic data (Bevan 1998:24) from the project requires a description of the buried archeological feature of object (e.g., its material, shape, depth, size, and orientation). The magnetic anomaly represents a local disturbance in the earth's magnetic field caused by a local change in the magnetic contrast between buried archeological features, objects, and the surrounding soil matrix. Local increases or decreases over a very broad uniform magnetic surface would exhibit locally positive or negative anomalies (Breiner 1973:17). Magnetic anomalies tend to be highly variable in shape and amplitude. They are generally asymmetrical in nature due to the combined effects from several sources. To complicate matters further, a given anomaly may be produced from an infinite number of possible sources. Depth between the magnetometer and the magnetic source material also affect the shape of the apparent anomaly (Breiner 1973:18). As the distance between the magnetic sensor on the magnetometer and the source material increases, the expression of the anomaly becomes broader. Anomaly shape and amplitude are also affected by the relative amounts of permanent and induced magnetization, the direction of the magnetic field, and the amount of magnetic minerals (e.g., magnetite) present in the source compared to the adjacent soil matrix. The shape (e.g., narrow or broad) and orientation of the source material also affects the anomaly signature. Anomalies are often identified in terms of various arrays of dipoles or monopoles (Breiner 1973:18-19). A magnetic object is made of magnetic poles (North or positive and South or negative). A simple dipole anomaly contains the pair of opposite poles that relatively close together. A monopole anomaly is simply one end of a dipole anomaly and may be either positive or negative depending on the orientation of the object. The other end is too far away to have an effect on the magnetic field.

Magnetic anomalies of archeological objects tend to be approximately circular in contour outline. The circular contours are caused by the small size of the objects. The shape of the object is seldom revealed in the contoured data. The depth of the archaeological object can be estimated by half-width rule procedure (Bevan 1998:23-24; Breiner 1973:31; Milsom 2003:67-70). The approximations are based on a model of a steel sphere with a mass of 1 kg buried at a depth of 1.0 m below the surface with the magnetic measurements made at an elevation of 0.3 m above the ground. The depth of a magnetic object is determined by the location of the contour value at half the distance between the peak positive value of the anomaly and the background value. With the fluxgate gradiometer, the contour value is half the peak value since the background value is approximately zero. The diameter of this contour (Bevan 1998:Fig. B26) is measured and used in the depth formula where **depth = diameter – 0.3 m** (Note: The constant of 0.3 m is the height of the bottom fluxgate sensor above the ground in the Geoscan Research FM36 were I carry the instrument during data acquisition. This value needs to be adjusted for each individual that carries the instrument.). The mass in kilograms of the object (Bevan 1998:24, Fig.

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B26) is estimated by the following formula: **mass = (peak value - background value) * (diameter)³/60**. It is likely that the depth and mass estimates are too large rather than too small, since they are based on a compact spherical object made of iron. Archeological features are seldom compact but spread out in a line or lens. Both mass and depth estimates will be too large. The archaeological material may be composed of something other than iron such as fired earth or volcanic rock. Such materials are not usually distinguishable from the magnetic data collected during the survey (Bevan 1998:24). The depth and mass of features comprised of fired earth, like that found in kilns, fireplaces, or furnaces could be off by 100 times the mass of iron. If the archeological feature were comprised of bricks (e.g., brick wall, foundation, or chimney), estimates could be off by more than a 1000 times that of iron. The location of the center of the object can also be determined by drawing a line connecting the peak positive and peak negative values. The rule of thumb is that the center of the object is located approximately one third to one half of the way along the line from the peak positive value for the anomaly. One should also be cautious of geophysical anomalies that extend in the direction of the traverses since these may represent operator-induced errors. The magnetic anomalies may be classified as three different types: 1) dipole, 2) monopole, and 3) linear.

There are several dipole and monopole magnetic anomalies in the single fluxgate gradiometer data set (Figure 11). Some of them are grouped in clusters while others appear as individual occurrences. Most noticeable are the negative and positive anomalies along the southern portion of the survey area and those around the farmhouse. The cluster of magnetic anomalies along the southern edge of the survey grid represent the magnetic affect of rebar in the concrete sidewalk adjacent to the survey grid and the buried ferrous pipe next to the sidewalk identified during the excavation of the trackhoe trench. The effect of the magnetic field associated with ferrous materials in the house (i.e., nails, lightning guide wires, galvanized steel downspouts, window and door screens, etc.) and the porch and handicap access ramp is also noticeable in the magnetic data. One very strong negative anomaly located near N5/E17 is associated with a water hydrant in the yard. Other isolated magnetic dipole anomalies may represent buried ferrous objects, such as nails, bolts, or tools, lost in the yard. A relatively strong cluster of magnetic anomalies in the center of the yard appears very close to the location of the root cellar identified during the 1983 archeological inventory of the farm site (Bray 1983:16,29). A second area of rather strong magnetic anomalies is located to the east of the area that may represent the location of the root cellar. Although there is nothing identified during the 1983 archeological inventory of the property, the area is suspicious and bears closer examination with traditional archeological excavation techniques. The area west of the house contains several anomalies along with some linear anomalous areas that appear to be associated with the remains of a portion of the original house foundation (Bray 1983:15-29). Two very strong magnetic anomalies southwest of the house also need further archeological investigation to determine their true nature. It should be noted that several of the anomalies and clusters overlap. This is due in part to the combined magnetic effect from multiple causes.

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There are several dipole and monopole magnetic anomalies in the single fluxgate gradiometer data set (Figure 12). Although there are difference in the relative strengths of the magnetic anomalies in data sets from the single fluxgate gradiometer survey and the dual fluxgate gradiometer survey, the differences are due in part to the different separations between the two instruments. The single gradiometer system has a sensor separation of 0.5 meters while the dual system has the sensors separated by one meter.

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7. RESULTS OF THE SITE MONITORING OF THE CONSTRUCTION TRENCHING

The construction project at the Truman Farm unit of the Harry S Truman National Historic Site called for the replacement of the farmhouse heating, ventilation, and air conditioning units (HVAC) with a geothermal heat pump and well field (Bahr Vermeer Haecker 2007). The construction project included vertical drilling of several geothermal wells in the parking lot south of the farmhouse, the excavation of a trench from the well field to the farmhouse for the installation of the supply and return hydronic piping from the geothermal heat pump inside the house and the well field, and the installation of the heat pump and other associated supply and return ducts, wiring, and plumbing fixtures inside the house. The exterior trench and the geothermal wells were excavated by employees of the Jesse Yoakum Well Drilling of Cleveland, Missouri.

During the project, several Yoakum Well Drilling company employees were present at the construction site. The excavation of the trench from the house to the parking lot was conducted with a Caterpillar 304.5 mini hydraulic excavator with a digging bucket attachment or trackhoe (Figure 13). The construction crew started the excavation trench neat the porch on the south side of the house. They excavated a diagonal trench across the yard to the parking lot sidewalk. The finished trackhoe excavation trench was approximately 16.75 meters long and was excavated to a depth of approximately 1.3 meters (Figure 14). The west wall of the trench was profiled and described (Figure 15). The upper portion of the trench contained a mottled fill. Portions of the truncated dark brown silt loam B horizon were present with the underlying C horizon comprised of a yellowish brown silty clay loam. Two features were identified, documented, and mapped. The features appeared to be shallow mortar lens. Modern utility trenches were also uncovered along the concrete parking lot sidewalk. One utility trench was apparently excavated with a backhoe and two other utility lines were placed within the earlier backhoe trench with a small trenching machine. One utility trench contained a 1" diameter copper pipe while the other trench contained a 1½" diameter steel pipe (Figure 16). Both lines appeared to have been abandoned. The construction crew also tried to remove the reinforced concrete sidewalk slab where they had cut through the sidewalk to reach the parking lot. They were unable to pull the concrete out of the way with the bucket on the excavator and had to replace the bucket with a hammer attachment in order to remove the reinforced concrete sidewalk slab. They also removed the asphalt from the parking lot where the geothermal wells were going to be located with the Caterpillar 304.5 mini hydraulic excavation and a Caterpillar 246c skid steer loader (Figure 17). The construction crew drilled the four wells with a Reichdrill T-690-w truck mounted overhead water well drilling rig (Figure 18). The well holes were bored to a depth of approximately 91 meters (300 feet).

Feature 1, a mortar lens, was located at 1.3 to 3.5 meters south of the starting edge of the trench next to the farmhouse (Figure 19). It was identified approximately 32 cm below the ground surface and extended to a depth of 40 cm below the ground surface (Figure 20). The mortar lens extended across the trench and into the walls of the trench.

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It was estimated to be approximately 2.2 meters in diameter. The mortar was light gray in color and some of the mortar appeared to have been burned. The mortar lens may be associated with the clean up efforts following the fire that destroyed the original farmhouse in 1894. Feature 2, a mortar lens, was located 5.97 m to 7.25 m from the starting edge of the trench next to the farmhouse (Figure 21). The feature was located at a depth of 44 cm and extended to a depth of 53 cm (Figure 22). The mortar lens extended across the trench and into the trench walls. It thinned out on the east side of the trench. The feature was approximately 1.28 m long and varied from one cm to 9 cm in thickness. Beneath the mortar lens, there was a slight depression that contained several tree roots and was originally believed to be the root ball of a planted tree; however, after the review of the original archeological investigations (Bray 1983:16,29), it is possible that the depression associated with Feature 2 may be related to the filled root cellar that was identified in the side yard. In the 1983 archeological report, Robert Bray (1983:29) described the root cellar as the following:

... Filled Root Cellar. Both the presence and identification were detected visually and substantiated by remote sensing. The feature is about 10 feet long east-west and 8 feet wide north-south. It has a downramp entryway some 6 feet long attached to the east end. If the identification is correct, depth of the cellar would be between 6 and 6.5 feet. No subsurface tests were done. Excavation would be required to verify the identification and to fix the construction and use periods. It would have been equally congruous with the present house or with the earlier one...

The slight depression may correlate to the east end of the entrance to the root cellar. Mortar identified in the feature was light gray in color with some of the mortar discolored from the heat of a fire. The mortar lens may also be associated with the clean up efforts following the 1894 fire that destroyed the original farmhouse. No artifacts were identified with either feature; however a metal gutter ferrule was noted in the trench backdirt during the excavations. It measured 13 cm (5 inches) in length. It was not collected since it was identified as modern and not related to the historic period associated with the house construction and usage by the Young and Truman families.

8. CONCLUSIONS AND RECOMMENDATIONS

During the period from January 23 to January 26, 2008, the Midwest Archeological Center and Harry S Truman National Historic Site staffs conducted geophysical investigations and construction monitoring of the HVAC replacement project in Jackson County, Missouri. The project was conducted in response to the park's request for the archeological compliance activities associated with the installation of the geothermal wells, connecting piping from the well field to the Truman farmhouse, and the geothermal pump inside the farmhouse. The project location extended across northern portion of the parking lot and side yard to the Truman farmhouse. During the investigations, 337 square meters or 0.08 acres were surveyed with a single fluxgate gradiometer and with a dual fluxgate gradiometer system.

This report has provided an analysis of the geophysical data and construction monitoring collected during week of archeological investigations at the Truman Farm unit of Harry S Truman National Historic Site. The magnetic data collected at the selected project areas provided information of the physical properties (magnetic) of the subsurface materials. Several magnetic anomalies were identified. Two of the anomalies appeared to have been associated with the original foundation of the first house built by Solomon Young and a root cellar. Additional ground truthing should be conducted to verify the actual nature of these anomalies. During the trenching activities associated with the connecting piping installation, two features were excavated in the trackhoe trench. Both features were mortar lens, which appeared to be associated with the clean up efforts following the destruction of the original house during a fire in 1894.

The project area contained a high degree of integrity based on the analysis of the geophysical data, the excavation results, and the monitoring activities. Based on the successful results of the present project to identify buried archeological resources associate with the Truman family at Site 23JA638, it is recommended that the park staff pursue the development and implantation of a geophysical survey of the entire 5.2 acres of the Truman Farm unit to provide baseline geophysical and archeological information about the core area of the Young/Truman farm site. While the 1983 archeological investigations provided a reconnaissance level survey of the site, it did not provide thorough archeological coverage of buried archeological resources associated with the Young and Truman family activities at the farm from 1861 to 1940. With the advent of modern geophysical instruments, including the fluxgate gradiometer, the resistance meter and twin probe array, the conductivity meter, and ground penetrating radar; and high speed, large memory storage personal computers, the ability of an archeological geophysical survey to collect data for the identification of buried archeological resources and disturbances affecting the integrity of the site has been greatly improved over the past two decades. The geophysical survey with a well prepared survey design can provide nearly 100 percent areal coverage of an archeological site and its associated buried archeological resources.

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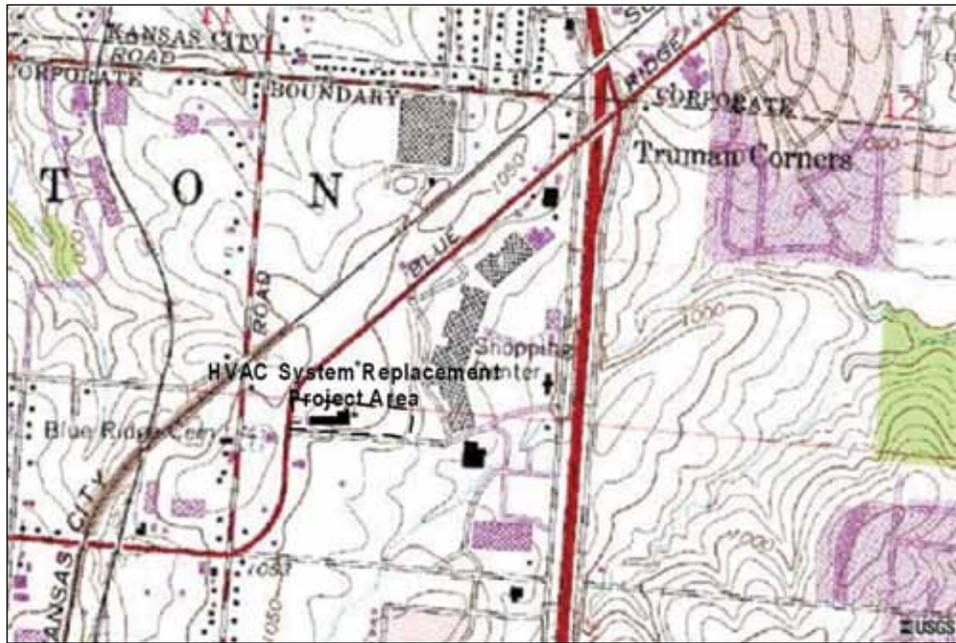
Table 1. Acquisition and instrumentation information for the single fluxgate gradiometer survey used in the grid input template at the Truman Farm (Site 23JA638).

| GENERAL | | | |
|--------------------------|-----------------|------------------------------|-----------------------|
| Acquisition | Value | Instrumentation | Value |
| Sitename | HSTR2008 | Survey Type | Gradiometer |
| Map Reference | | Instrument | FM256 |
| Dir. 1st Traverse | N | Units | nT |
| Grid Length (x) | 20 m | Range | AUTO |
| Sample Interval (x) | 0.125 m | Log Zero Drift | Off |
| Grid Width (y) | 20 m | Baud Rate | 19200 |
| Traverse Interval (y) | 1.0 m | Data Format | HEX D+R |
| Traverse Mode | ZigZag | Computer Buffer Size | 32767 |
| FILE NOMINCLATURE | Raw Data | Processed Data | Corrected Data |
| Processing Software | GEOPLOT | | |
| Grid | tfg1 | | |
| Mesh | tfg | | |
| Composite | tfgc | tfgcz,tfgczi,tfgczil,tfgcilr | |

Table 2. Acquisition and instrumentation information for the dual fluxgate gradiometer survey used in the grid input template at the Truman Farm (Site 23JA638).

| GENERAL | | | |
|--------------------------|-----------------|-----------------------------|-----------------------|
| Acquisition | Value | Instrumentation | Value |
| Sitename | 23JA638 | Survey Type | Dual Gradiometer |
| Map Reference | | Instrument | Bartington Grad601-2 |
| Dir. 1st Traverse | N | Units | nT |
| Grid Length (x) | 20 m | Range | AUTO |
| Sample Interval (x) | 0.125 m | Log Zero Drift | Off |
| Grid Width (y) | 20 m | Baud Rate | 19200 |
| Traverse Interval (y) | 1.0 m | Number of Sensors (tubes) | 2 |
| Traverse Mode | ZigZag | Download Software | Bartington GRAD601 |
| FILE NOMINCLATURE | Raw Data | Processed Data | Corrected Data |
| Processing Software | Archeosurveyor | | |
| Grid | tfg01 | | |
| Composite | tfgc | tfgci,tfgcz,tfgczil,tfgcilr | |

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a) topographic map of the Truman farm, Grandview, Missouri (USGS topo map dated 01 Jul 1995).



b) aerial photograph of the Truman farm, Grandview, Missouri (USGS aerial photo dated 22 March 1997).

Figure 1. Location of the Truman Farm unit of the Harry S Truman National Historic Site in Grandview, Missouri.

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a) general view of the project area from the eastern edge of the parking lot (view to the north).



b) general view of the southern portion of the project area in the parking lot (view to the east).

Figure 2. General views of the geophysical and construction project area at the Truman Farm.



Figure 3. Truman farmhouse and outbuildings (view to the east).



Figure 4. Geophysical project area at the Truman Farm unit of Harry S. Truman National Historic Site (view to the east).

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Figure 5. Geophysical survey ropes on the grid at the Truman Farm unit (view to the northeast).

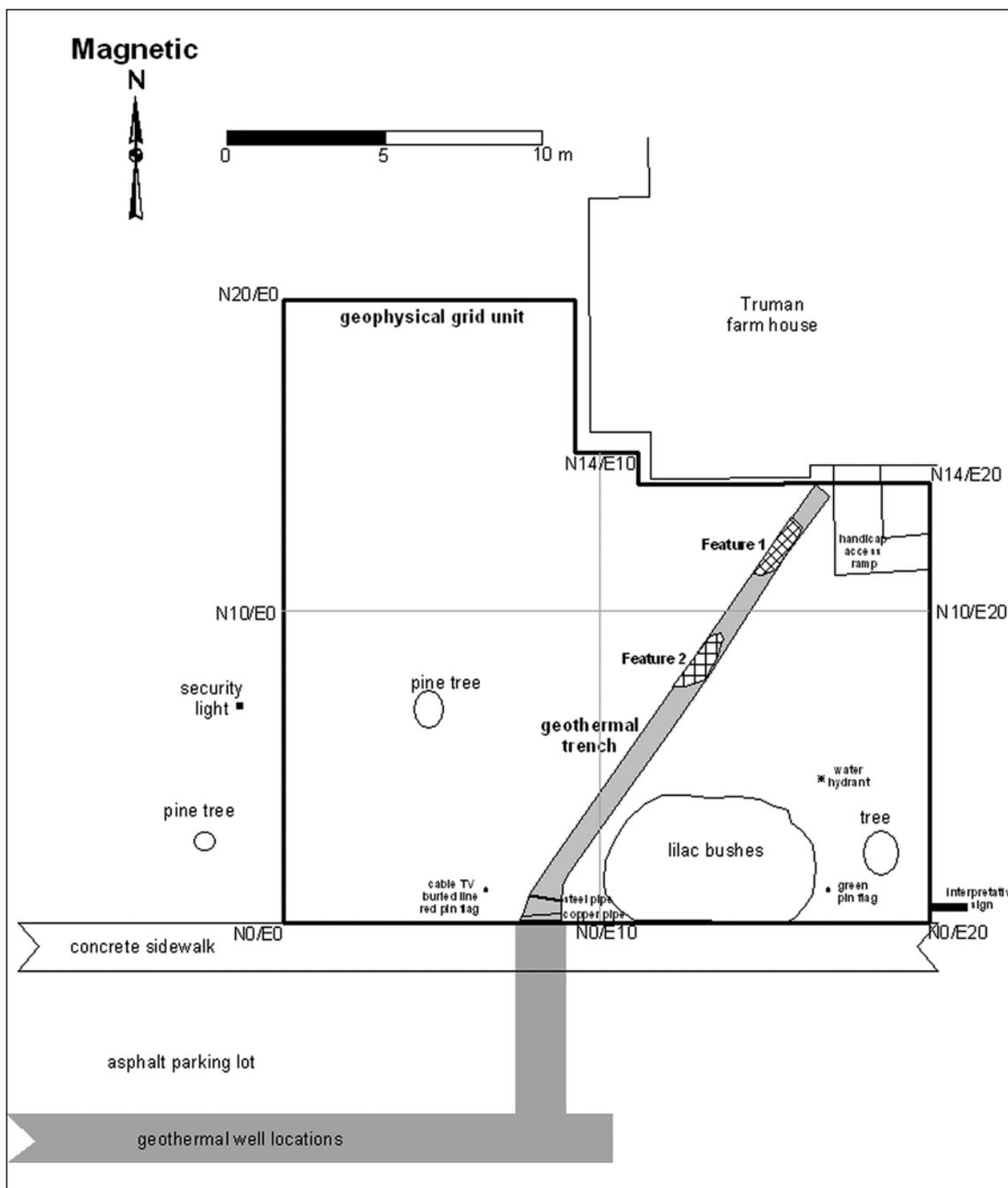


Figure 6. Geophysical and construction project area.



Figure 7. The single fluxgate gradiometer braced against the handicap accessible porch (view to the east).



Figure 8. The dual fluxgate gradiometer system next to the handicap accessible porch (view to the north).

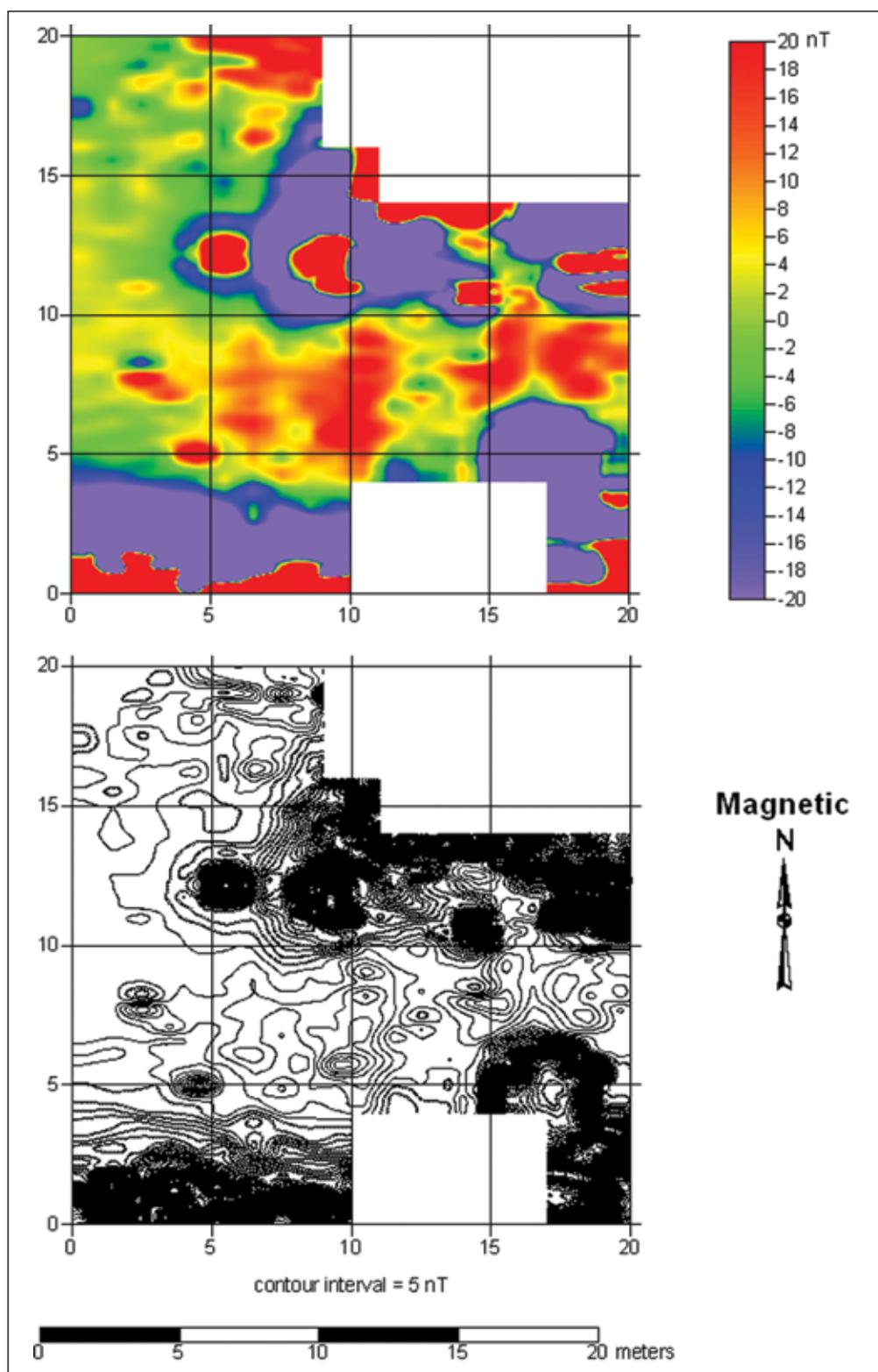


Figure 9. Image and contour plot of magnetic data from the single fluxgate gradiometer survey.

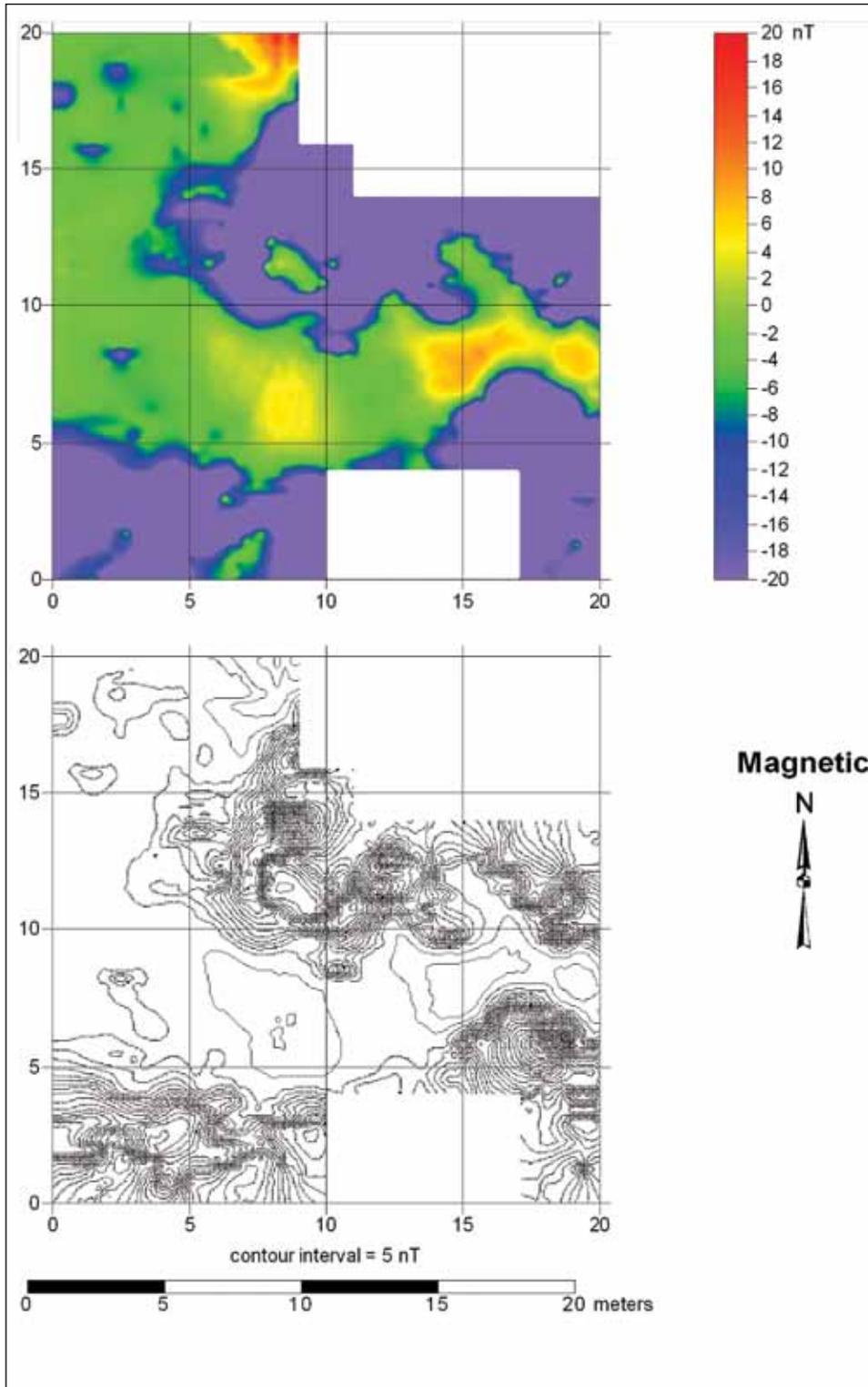


Figure 10. Image and contour plot of magnetic data from the dual fluxgate gradiometer survey.

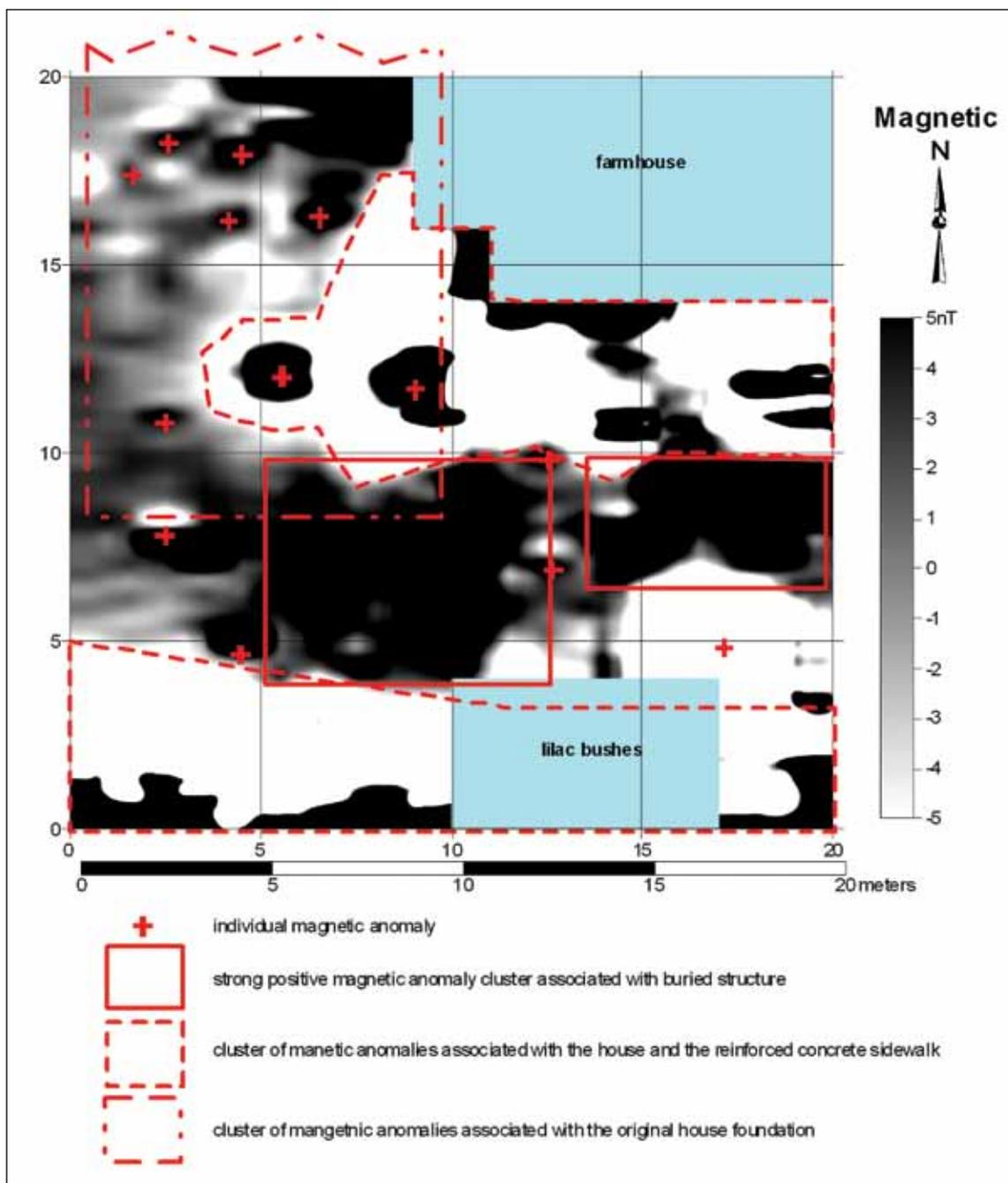


Figure 11. Interpretation of the magnetic data from the single fluxgate gradiometer.

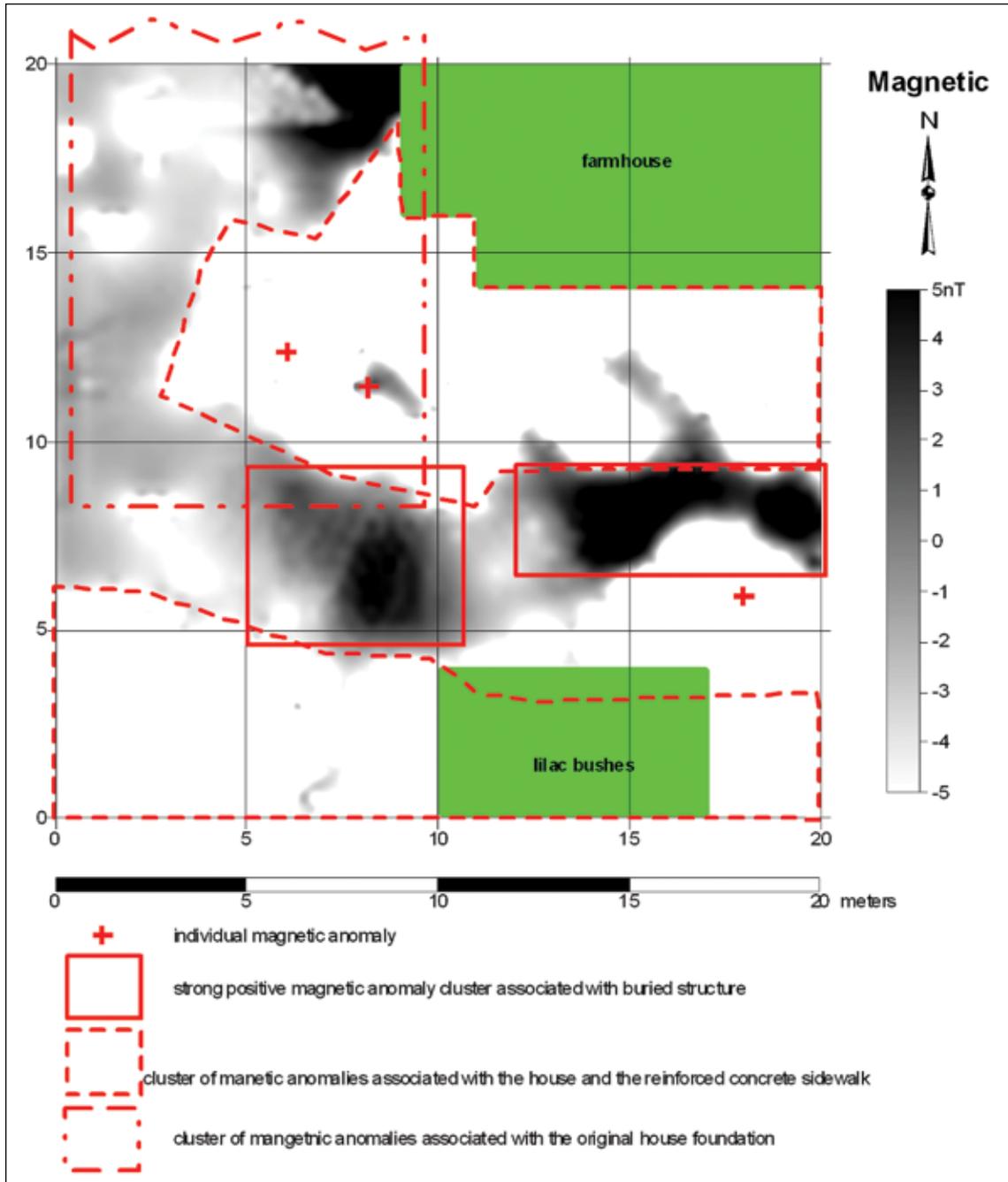


Figure 12. Interpretation of the magnetic data from the dual fluxgate gradiometer.



Figure 13. Excavation of the connecting piping trench with a mini hydraulic excavator (view to the west).



Figure 14. General view of the excavated trackhoe trench from the house (view to the southwest).

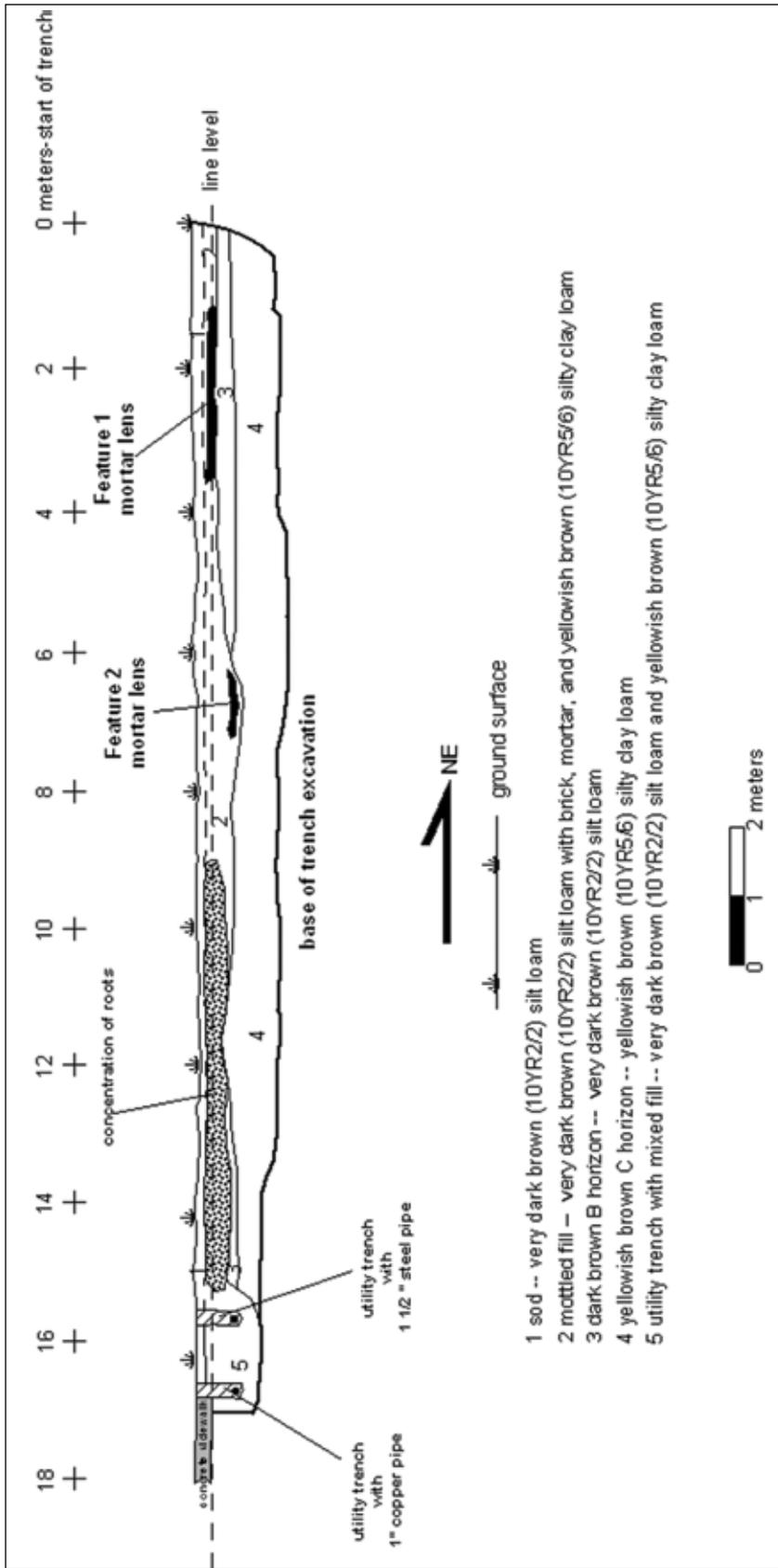


Figure 15. Profile of the west side of the trackhoe trench.



Figure 16. Copper and steel utility pipes in the utility trench along the parking lot sidewalk (view to the east).



Figure 17. Mini hydraulic excavator and skid steer loader removing asphalt from parking lot and location of the geothermal well field (view to the west).



Figure 18. Drilling the geothermal well with a truck mounted drilling rig (view to the north).



Figure 19. West wall profile of Feature 1 (view to the northwest).

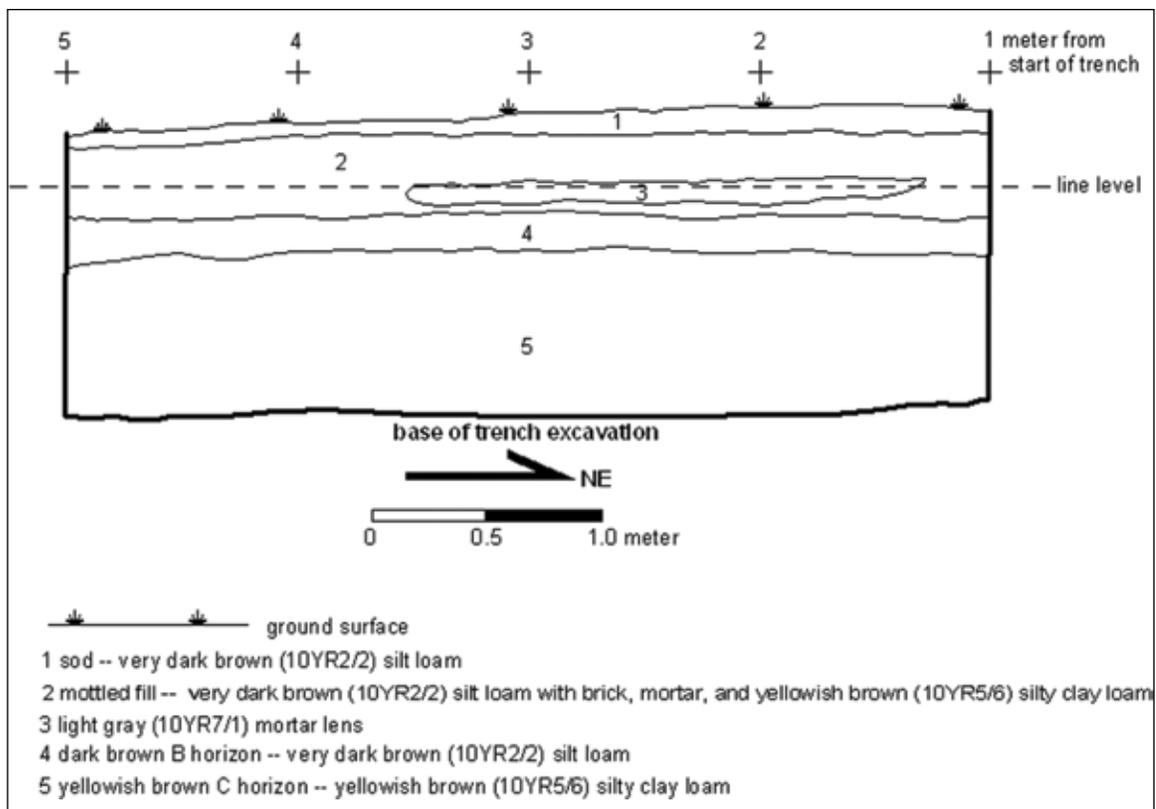


Figure 20. Profile drawing of Feature 1.



Figure 21. West wall profile of Feature 2 (view to the northwest).

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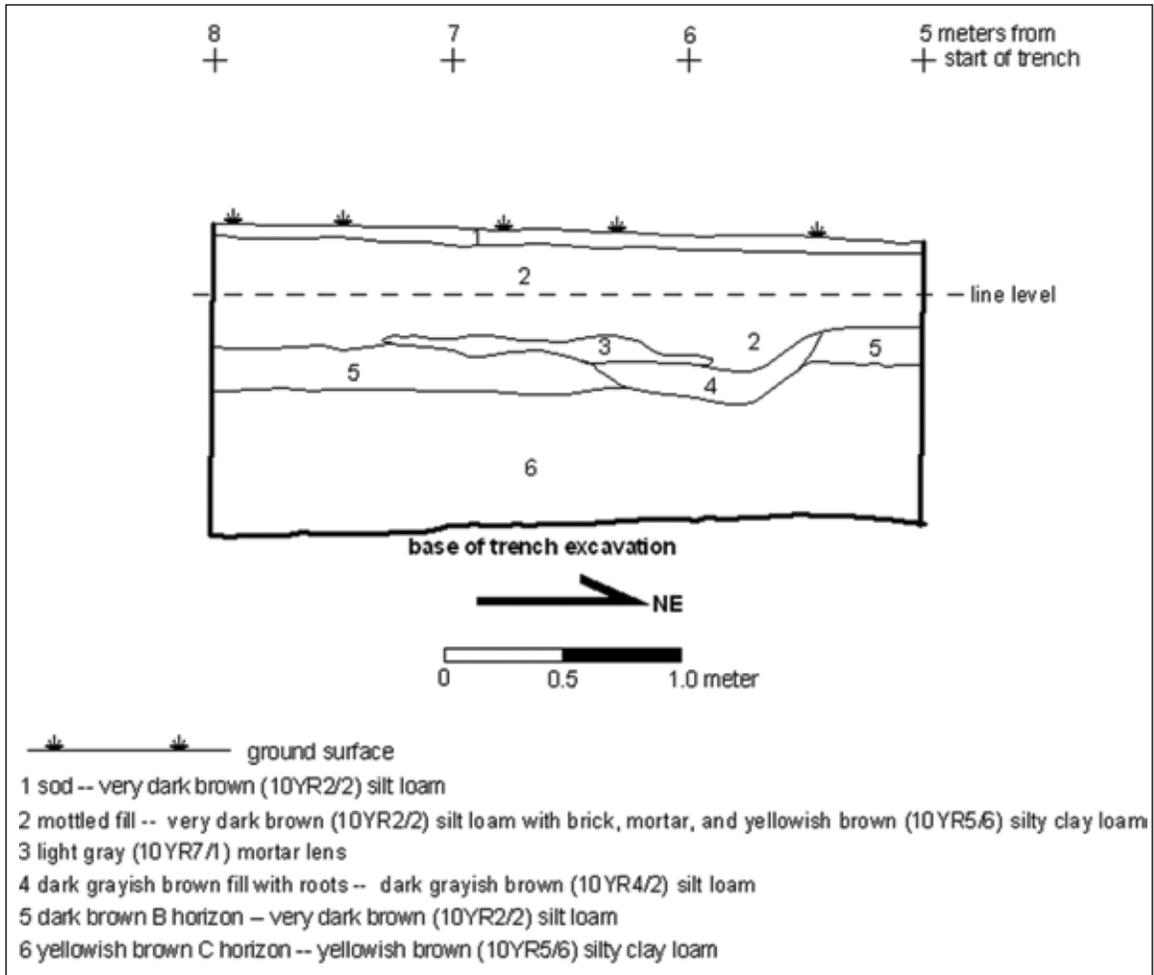


Figure 22. Profile drawing of Feature 2.