Geophysical Investigations and Monitoring of Selected Areas Associated with the Dry Prairie Rural Water System Tie-In Construction Project at Fort Union Trading Post National Historic Site, Roosevelt County, Montana, and Williams County, North Dakota

By
Steven L. De Vore

Midwest Archeological Center
Technical Report No. 116

NATIONAL PARK SERVICE
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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 Fort Union Trading Post National Historic Site staffs conducted geophysical investigations and construction project monitoring at the Fort Union Trading National Historic Site in Roosevelt County, Montana, and Williams County, North Dakota. The geophysical and archeological investigations were conducted between October 30 and November 16, 2007. The archeological investigations were requested by the park staff for selected areas within the park along the installation route of the Dry Prairie rural water system tie-in with the park's existing water system in Roosevelt County, Montana, and Williams County, North Dakota. The project location extends across the southern portion of the Mondak townsite, the open prairie between the Mondak townsite and the Fort Union Trading Post site, the open prairie between the Fort Union Trading Post site and the park well near the Garden Coulee site, and the Garden Coulee site to the park's maintenance facility and the well house.

During the investigations, 8,400 square meters or 2.08 acres were surveyed with a fluxgate gradiometer. The magnetic data collected at the selected project areas provided information of the physical properties (magnetic) of the subsurface materials. Several scale magnetic anomalies were identified. During the trenching activities associated with the waterline installation, two anomalies were excavated in Grid Area 5 and Grid Area 2. The feature (Feature 1 within the boundary of Site 32WI17) identified in Grid Area 5 was a small trash filled basin dating to the trading post occupation period between 1829 and 1867. The small charcoal filled pit (Feature 3 within the boundary of Site 32WI17) in Grid Area 2 was also associated with the occupation of the trading post in the mid 1800s. The third feature, found next to the well house during the monitoring of the trench for the installation of waterline hardware (valves), contained materials that dated to the late 1800s and early 1900s. The site was documented and recorded as Site 32WI996. This large trash dump feature may have been associated with the trading post, the Crow-Flies-High village site above Garden Coulee, and the 20th century community of Mondak. It is also possible that the feature represented the disposal of debris from the late 1800s and 1900s agricultural field activities. The presence of numerous magnetic anomalies along the west side of Grid Area 5 suggested the presence of buried materials associated with the occupation of the trading post. It is recommended that additional archeological investigations be undertaken should the park staff decide to construct a fire-suppression vehicle access and parking pad in this area. Due to the successful nature of the magnetic survey, it is also recommended that the park staff develop a plan for the complete magnetic survey of the unsurveyed portions of the park.

ACKNOWLEDGEMENTS

This project was completed with the support and assistance from the Fort Union Trading Post National Historic Site staff. Sincere appreciation is extended to FOUS Superintendent Andy Banta, FOUS Facility Manager Gayle Whittlesey, and FOUS maintenance staff Dennis Borud who assisted in the geophysical project by helping set up the geophysical grid units and laying out, moving, and packing the geophysical survey ropes. All of the FOUS 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 Dry Prairie Rural Water System construction project in early November in North Dakota.

At the Midwest Archeological Center, I would like to 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 Officers Bonnie Farkas and 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 Anna Loach for their editing and report preparation in the publishing of this document. I am grateful for the review comments of the draft manuscript provided by MWAC archeologist Jay Sturdevant and FOUS curator Audrey Barnhart.

Finally, I would like to acknowledge the contractor Neil Iverson of Agri-Industries from Williston, North Dakota, for his extremely helpful attitude throughout the course of the fieldwork. I am particularly thankful to be able to work closely with the Agri-Industries crew members who often had to work around me while I examined archeological features in the backhoe trenches. I would like to thank Bob Norman, Greg Wixon, Chuck Ellis, and Guy Schiessl for their patience while I examined archeological features and asked numerous questions on the operation of the heavy equipment and plumbing activities.

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1. INTRODUCTION

The National Park Service's (NPS) Midwest Archeological Center (MWAC) and Fort Union Trading Post National Historic Site (FOUS) staffs conducted geophysical investigations and construction project monitoring activities at the Fort Union Trading Post National Historic Site in Roosevelt County, Montana, and Williams County, North Dakota (Figure 1). The archeological investigations at the park were conducted between October 30 and November 16, 2007 (De Vore 2007a). The geophysical investigations and construction monitoring were requested by the park staff for the archeological investigations for selected areas within the park associated with the Dry Prairie rural water system tie-in construction project (Figure 2). The project corridor extends across the southern portion of the Mondak townsite, the open prairie between the Mondak townsite and the Fort Union Trading Post site, the open prairie between the Fort Union Trading Post site and the park well next to the Garden Coulee site, and the Garden Coulee site to the park's maintenance facility and the well house. The project corridor crosses several sites with the boundary of the park on the south side of Roosevelt County Road 327 and North Dakota State Highway 1804 (Figure 3).

Fort Union Trading Post National Historic Site was established by Congress of the United States of America on June 20, 1966 (Public Law 89-458) to commemorate the significant role the trading post played in the fur trade on the Upper Missouri River and the expansion of the United States in the Northern Plains in the 19th Century. The trading post was the most important and grandest trading post of an extensive network of trading establishments constructed by the American Fur Company on the upper Missouri (Thompson 1994:1-2). Established in 1828, the post lasted until its purchase by the U.S. Army for materials used in the construction of Fort Buford in 1867. Originally built to capture the trade with the Assiniboine, at least ten tribes traded at the fort during its long history. The Assinboine, Blackfeet, Cree, Crow, Hidatsa, Ojibway, and other tribes traded bison robes and other furs for trade goods (e.g., beads, blankets, cookware, cloth, guns, knives, and other Euro-American goods). A major expansion of the fort occurred in 1833. Numerous other building episodes occurred throughout its history including the rebuilding of the Fort William stockade on the east side of the fort in 1834 after being purchased from the opposition company of Campbell and Sublette (Larpenteur 1989:58-60). The American Fur Company was instrumental in the development of steamboat traffic on the Missouri River with the first steamboat, the Yellowstone, arriving at Fort Union in 1832. Over the years, many notable people visited or worked at the post including company employees Kenneth McKenzie, Charles Larpenteur, James Kipp, Alexander Culbertson, Rudolph Friederich Kurz, and Edwin Thompson Denig, artists George Catlin and Karl Bodmer, naturalist John James Audubon, missionary Pierre Jean De Smet, and adventurers such as Prince Maximilian of Wied and Duke Paul Wilhelm of Württemberg. Maximilian (Thwaites 1906), Audubon (Audubon 1960), Larpenteur (1989), Kruz (1937), and Denig (Ewers 1961) recorded their adventures at the fort and observations of the Native Americans that visited and traded with them.

FORT UNION

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 installation of the Dry Prairie rural water system tie-in and the connection of the rural waterline to the fort facilities in compliance with Section 106 of the National Historic Act of 1966, as amended through 1992. The project area was located in the primary area of potential effect (APE). The geophysical investigations consisted of a magnetic survey with a fluxgate gradiometer of selected areas where the directional boring for the insertion of the waterline would require backhoe excavation pits to access the buried water line in order to make physical connections and for the installation of shutout off vales and other plumbing connections to tie the rural water line into the park's fresh water and fire suppression lines (Figure 4). The magnetic technique offered an inexpensive, rapid, and relatively non-destructive and non-invasive method of identifying buried archeological resources and site patterns that 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 backhoe excavation pits and the backhoe trenches provided an exposed view of the subsurface stratigraphy and buried archeological deposits and features. During the course of the geophysical survey, the park superintendent Andy Banta, and two FOUS maintenance employees, Gayle Whittlesey and Dennis Borud, assisted in the MWAC geophysical project. Gayle Whittlesey, the park's facility manager, also served as the Contracting Officer's Representative for the rural waterline construction project.

2. ENVIRONMENTAL SETTING

The Fort Union Trading Post National Historic Site is located in the glaciated Missouri Plateau section of the Great Plains province of the Interior Plains division (Fenneman 1931:72-79) of the North American continent. The glaciated Missouri Plateau consists of glaciated old plateaus with isolated mountains. This area is located within the Northern Dark Brown Glaciated Plains (USDA 2006:140-142) of the Northern Great Plains Spring Wheat Land Resource Region. The region consists of gently undulating to rolling till plains. The plains are interrupted by more steeply rolling and steep slopes adjacent to major stream valleys, kames, moraines, and kettle holes (Smetana 1985:2-3,115; Sucik 2002:11-12,85-86; USDA 2006:141; Willard 1907). The National Historic Site lies along the high terrace and uplands above the left bank of the Missouri River approximately two miles above the confluence of the Missouri and Yellowstone Rivers.

The area also lies within the mixed prairie grasslands of the Saskatchewan biotic province (Dice 1943:24-26; Jones and Cushman 2004:35-40; Shelford 1963:328-355). The native vegetation is a mixture of short and medium height prairie grasses, including western wheatgrass, sideoats grama, needleandthread, green needlegrass, blue grama, little bluestem, and plains muhly (Brown 1985:45-53; Shelford 1963:344; Sucik 2002:85; USDA 2006:141). Tall and medium grasses (e.g., big bluestem, switchgrass, indiangrass, and little bluestem), prairie cordgrass, northern reedgrass, slough sedge, American mannagrass, reeds, rivergrass, and slim sedge are found in poorly drained areas in depressions and along flood plains (Sucik 2002:85; USDA 2006:141). Western snowberry, prairie rose, echinaccea, stiff goldenrod, berries, and numerous varieties of wild flowers are commonly found throughout the region (Brown 1985:52; Jones and Cushman 2004:40). A narrow strip of deciduous trees (e.g., cottonwoods, elms, ash, willows, and hackberry) occur along the main streams (Brown 1985:53).

During the prehistoric and historic periods, bison, mule deer, wapiti, and pronghorn antelope were present on the grasslands while white-tailed deer were present in the timbered areas along streams and slopes (Brown 1985:52; Jones and Cushman 2004:42-50; Shelford 1963:344). White-tailed jackrabbits were common along with coyotes, badgers, foxes, and wolves (Brown 1985:52; Shelford 1963:344-346; USDA 2006:141). Numerous other mammals and rodents also inhabited the region (Brown 1985:52; Dice 1943:25-26; Jones and Cushman 2004:42-50; Shelford 1963:344-346; Smetana 1985:115). Numerous species of birds inhabited the grasslands, the shrublands, and wooded areas of the region (Brown 1985:53; Jones and Cushman 2004:50-57; Shelford 1963:346). Sharp-tailed grouse, prairie chicken, Hungarian partridge, and pheasant represented some of the regional game birds, as well as migratory waterfowl (e.g., Canadian geese, mallard and pintail ducks, blue-winged teal, and pelicans), in both prehistoric and historic times (Brown 1985:53; Shelford 1963:346; USDA 2006:141). A variety or raptors and numerous grassland and forest species of songbirds were also present (Brown 1985:53; Jones and Cushman 2004:58; USDA 2006:141). Reptiles included several species of lizards, turtles, and snakes (Brown 1985:53; Jones and Cushman 2004:58-63; Shelford 1963:346). Amphibians were found

in the prairies, forests, and wetlands (Brown 1985:53: Jones and Cushman 2004:58-63). Fish, including gar, trout, pike, perch, carp, sturgeon, paddlefish, and suckers along with a variety of sunfish, minnows, shiners, and darters were found in the cool-water streams throughout the region (Jones and Cushman 2004:62-63; North Dakota Game and Fish Department 1986). Insects and other invertebrates were common throughout the region with the grasshopper being one of the most abundant insect groups (Jones and Cushman 2004:64-66; Shelford 1963:346).

The climate is a middle-latitude semiarid or steppe, dry continental climate (Jensen 1972; National Climatic Center 1985:4; Sucik 2002:12; Trewartha and Horn 1980:360-364). The summers are quite hot while the winters are very cold. The annual average temperature ranges between 3 and 7° C (National Climatic Center 1985:4,129; Sucik 2002:12,15; USDA 2006:141). Annual January temperatures average -13° C (Bavendick 1941:1047; Maughan 1941:958; Sucik 2002:12,15). The lowest recorded winter temperature in the region is –52° C (Maughan 1941:958). Annual July temperatures average 34.2° C (National Climatic Center 1985:4,129; Sucik 2002:12,15). The highest recorded summer temperature is 43.8° C (Bavendick 1941:1047; Maughan 1941:958). Annual precipitation averages between 30.5 and 38.0 cm (Bavendick 1941:1047; Maughan 1941:958; USDA 2006:141) with the majority falling from April through September. Snowfall averages 76 cm per year (National Climatic Center 1985:4; Sucik 2002:12). The growing season averages 93 days with killing frosts occurring as late as June 16th in the spring and as early as September 25th in the fall (Bavendick 1941:1047; Maughan 1941:961; National Climatic Center 1985:4,129,132; Sucik 2002:12,16; USDA 2006:141). The sun shines an average of 62 percent of the possible time. The prevailing winds in the summer are from the south and southwest with an average windspeed of 18 kilometers per hour while they are out of the northwest during the winter months (Bavendick 1941:1054; National Climatic Center 1985:5; Sucik 2002:12).

The bedrock geology in the region consists of the Tertiary aged Fort Union Group (Freers 1970:14-15) of the brightly colored (i.e., yellows and tans) Bullion Creek Formation of poorly lithified claystones, mudstones, siltstones, fine-grained sandstones, and lignite formed from fluvial and lacustrine sediments deposited during the Paleocene Epoch (Bluemle 1988). In the uplands along the Missouri River, the gray to grayish brown colored beds of the Tongue River-Sentinel Butte Formations lie on top of the Bullion Creek Formation (Freers 1970:14-15). The Sentinel Butte Formation contains fine-grained sandstone, siltstone, mudstone, claystone, and lignite. The bedrock is covered with the Quaternary aged Wisconsin glacial drift (Bluemle 1977; Freers 1970:25-35). Lying on top of the bedrock in the valleys are deposits of unknown thickness of Quaternary alluvium consisting of unconsolidated clay, silt, sand, and gravel (Freers 1970:35-37).

Soils within the region are dominated by Inceptisols and Mollisols (Foth and Schafer 1980:63-84,111-142; USDA 2006:141). The very deep, moderately well drained or well drained, loamy or clayey soils have ustic soil moisture and frigid soil temperature regimes with mixed or smectitic mineralogy (USDA 2006:141). Parent materials in Roosevelt and Williams County consist of unconsolidated glacial drift (Smetana 1985:115;

Sucik 2002:83). Some of the soils in the county formed in unsorted glacial till while other soils formed in glaciolacustrine deposits, glaciofluvial deposits, eolian deposits over glacial till (Smetana 1985:115; Sucik 2002:83). The soils formed under grassland vegetation consisting of short grasses and midgrasses (Smetana 1985:115; Sucik 2002:85). Depth to bedrock ranges from shallow to very deep. The project area within Montana lies within the protected Havrelon-Lohler-Trembles soil association of *deep, nearly level, well drained and moderately drained, moist soils that are protected from flooding* (Smetana 1985:7-8). The soil within the project corridor consists of the Farland silt loam with two to eight percent slopes (16) soil mapping unit (Smetana 1985:26-27,101) and the Farnuf loam with two to eight percent slopes (18) soil mapping unit (Smetana 1985:28-29,101-102). The Farland silt loam soil in the project area consists of a deep, well drained soil located on the alluvial fans and foot slopes of the uplands above the Missouri River (Smetana 1985:26). Formed in alluvium derived from sedimentary material (Smetana 1985:101), the soil has a moderately slow permeability, a medium surface runoff, and a high available water capacity (Smetana 1985:26). The erosional hazard is moderate (Smetana 1985:26). The soil pH ranges from mildly alkaline in the upper portion of the pedon to moderately alkaline at its base (Smetana 1985:101). The Farnuf loam soil in the project area consists of a deep, well drained soil located on the alluvial fans and terraces on the uplands above the Missouri River (Smetana 1985:28). Formed in alluvium (Smetana 1985:101), the soil has a moderate permeability, a medium surface runoff, and a high available water capacity (Smetana 1985:28). The erosional hazard is moderate (Smetana 1985:28). The soil pH ranges from neutral in the upper portion of the pedon to moderately alkaline at its base (Smetana 1985:101-102). The project area within North Dakota lies within the Havrelon-Lohler soil association of *level and nearly level* (Sucik 2002:28) flood plain soils and the Lawther-Shambo-Savage soil association of *level to undulating* (Sucik 2002:37) alluvial plains soils. The soils within the project corridor consist of the Farland silt loam with one to six percent slopes (669) soil mapping unit (Sucik 2002:43,107) in the open prairie to the north and west of trading post site (32WI17), the Lawther silty clay soil mapping unit (2349) with zero to two percent slopes (Sucik 2002:67-68,116-117) in the open prairie to the east of the trading post site including the Garden Coulee Site (32WI18), and the slightly wet Lohler silty clay soil mapping unit (1178) with zero to two percent slopes next to the maintenance facility and the well house (Sucik 2002:47-48,119-120). The Farland silt loam soil in the project area consists of a very deep, well drained soil located on the flats and rises of alluvial fans and terraces on the uplands above the Missouri River (Sucik 2002:43,107). Formed in alluvium, the soil has a moderately slow permeability, a moderate shrink-swell potential, moderate organic matter level, and a high available water capacity (Sucik 2002:107,331). The soil pH ranges from neutral in the upper portion of the pedon to moderately alkaline at its base (Sucik 2002:107). The Lawther silty clay soil in the project area consists of a very deep, well drained soil located on the alluvial fans and terraces on the uplands above the Missouri River (Sucik 2002:67-68,116-117). Formed in alluvium, the soil has a slow permeability, a high shrink-swell potential, moderate organic matter level, and a high available water capacity (Sucik 2002:116,336). The soil pH ranges from slightly alkaline in the upper portion of the pedon to moderately alkaline at its base (Sucik 2002:116-117). The Lohler silty clay soil in the project area consists of a very

deep, moderately well drained soil located on the flood plains of the river valleys (Sucik 2002:47-48,119-120). Formed in calcareous alluvium, the soil has a slow permeability, a high shrink-swell potential, moderately low organic matter level, and a moderate available water capacity (Sucik 2002:119,332). The soil pH is slightly alkaline throughout the pedon (Sucik 2002:120). These resources provided the basis of the aboriginal subsistence of prehistoric times and the historic and modern Euroamerican farming economy.

3. CULTURAL HISTORY OF THE YELLOWSTONE RIVER REGION

The project area is located in the Yellowstone River archeological study unit in North Dakota (State Historical Society of North Dakota 1990:13.1-33). The cultural sequence for the Yellowstone River region spans the entire range of North American prehistory and history from the earliest Native American occupation to the Euro-American settlement and development in the Plains Archeological Culture Area (Willey 1966:311-329). The project area is located at the edge of the Middle Missouri and the Northwestern Plains subareas (Wedel 1961:156-209,240-277). The sequence is divided into two periods based on the availability of written records: 1) the Prehistoric Period and 2) the Historic Period. The Prehistoric Period is further subdivided into the Paleoindian, the Plains Archaic, the Plains Woodland, the Plains Village, and the Plans Nomadic Traditions. The Historic Period is subdivided into the Protohistoric/Contact, Euro-American Encounters, Fur Trade, Military and Railroad, and Modern Development and Recreation. Summaries of current knowledge regarding the prehistoric cultural history of the North Dakota and the Yellowstone River study unit include Dill (1983), State Historical Society of North Dakota (1990), and Wedel (1961), and Wood (1998). For more detailed discussions of the Historic Period in North Dakota and the Yellowstone River study unit, one is referred to the following sources: Robinson (1966).

Paleoindian (9500 B.C. to 5500 B.C.)

The Paleoindian Period is the earliest confirmed period of human occupation in the Yellowstone River Valley. The Paleo-Indian period is placed between 11,500 and 7,500 years before the present (B.P.). The period is typically divided into three complexes: 1) the Clovis; 2) the Folsom; and 3) the Plano (Bamfort 1988; Dill 1983:4-5; Frison 1991; Irwin-Williams et al. 1973; Irwin and Wormington 1970; State Historical Society of North Dakota 1990:3.22-24; Toom 1996:66). Distinctive artifacts included fluted and unfluted lanceolate points and a diverse toolkit of drills, gravers, burins, knives, and scrapers, most of which continue with little modification into subsequent cultural periods. Viewed as efficient large game hunters, the people of the Clovis complex hunted mammoth, extinct forms of bison, and other Pleistocene animals. The Folsom complex is also recognized by the presence of fluted projectile points and the hunting of extinct forms of bison. The Late Paleo-Indian complex is actually a series of different complexes referred collectively as Plano. The Plano complexes represent the last cultural systems associated with the Pleistocene megafauna. These terminal complexes of the Paleo-Indian period are represented by a number of different projectile point types, including Agate Basin, Alberta, Eden, Hell Gap, Milnesand, Plainview, and Scottsbluff. Plano sites throughout the region consist of kill sites, butchering sites, long term camp sites, and short term camp sites. Most Paleoindian finds reported in the Yellowstone River region have been isolated surface discoveries with no intact features. No sites dating to this period have been excavated. A possible bison kill site with a Scottsbluff point from 32WI102 has been reported in a coulee near the Fort Union National Historic Site (Schneider and Roberson 1981:7).

Plains Archaic (5500 B.C. to A.D. 1)

The Plains Archaic Period is defined by increasing diversity of material culture technology and a change in subsistence behaviors in response to the changing Holocene environment (Dill 1983:5-6; State Historical Society of North Dakota 1990:3.24-26; Toom 1996:66-67). The Plains Archaic period is often further split into three subdivisions: 1) Early Plains Archaic, 2) Middle Plains Archaic, and 3) Late Plains Archaic. Subsistence practices become much more generalized with a shift to smaller game and an increase in the local exploitation of plant foods. A wide diversity in stone tools, both chipped and ground, is a hallmark of the Plains Archaic Period (Frison 1991; Mulloy 1958; Reeves 1973). The mode of hafting of bifaces includes both stemmed and notched points. Complexes include Hanna, Duncan, and Pelican Lake. Plains Archaic sites are rare in the region and tend to be buried in terraces making them difficult to find by traditional archeological survey methods (Toom 1996:67). Their presence in the Yellowstone River archeological study unit is from lithic scatters on terraces, ridges, and other elevated settings.

Plains Woodland (A.D 1-1000)

The Plains Woodland Period is defined by the appearance of pottery and the construction of burial mounds, but otherwise is largely a continuation of trends already seen during the Plains Archaic (Dill 1983:7-10; State Historical Society of North Dakota 1990:3.26-28; Toom 1996:67-68). Regional patterns of cultural activity develop during the period. The bow and arrow also made their appearance. The Plains Woodland Period is divided into the Middle, and Late Plains Woodland. The Early Woodland period as identified in the Eastern Woodlands appears to be lacking in the Plains Woodland period. The innovations appear to be have diffused through the region from the Eastern Woodlands. Middle Plains Woodland sites appear to be more common then Late Plains Woodland sites. Very little information exists for the Woodland Period settlement in the Yellowstone River valley region. Sonota and Besant complexes represent the Middle Plains Woodland manifestations in the region. The Late Plains Woodland period is represented by the wide spread Avonlea complex (Toom 1996:68).

Plains Village (A.D. 1000-1780)

The Plains Village Period is represented by semi-sedentary farmers living in semi-permanent to permanent settlements (Dill 1983:12-16; Lehmer 1971; Lehmer and Caldwell 1971; Toom 1996:69-72; Willey 1966). During this period, a mixed subsistence strategy of bison hunting, garden agriculture consisting of the cultivation of maize, beans, squash, domestic sunflower, and tobacco, and generalized foraging. The Plains Village groups were also active in the long-distance trade networks prior to the Euro-American contact (State Historical Society of North Dakota 1990:13.30). Ceramic technology continued to advance with the production of better pottery due to changes in clay and vessel form. The termination date corresponds to the 1780 smallpox epidemic outbreak on the northern plains (Stearn and Stearn 1945; Trimble 1985). The few sites in the Yellowstone River

study unit associated with the Plains Village tradition lack the residential earthlodges found in the more permanent sites further down the Missouri River and probably represent nomadic field camps associated with resource exploitation (State Historical Society of North Dakota 1990:13.28-31).

Plains Nomadic (A.D. 1000-1780)

The Plains Nomadic groups coexisted with the Plains Villagers in the region (Dill 1983:10-12). Prior to the arrival of the Europeans and the introduction of the horse, these native inhabitants of the region were pedestrian nomads relying on themselves and their camp dogs to move their materials goods across the landscape. Unlike the Plains Villagers that resided in permanent earthlodges, except on their hunting excursions, the Plains Nomads lived in skin tipis. They relied on hunting small and large game animals and gathering wild plant resources. Sites identified with the Plains nomads consist of tipi rings or stone circles with a few lithic artifacts.

Protohistoric/Contact (A.D. 1500 to A.D. 1738)

The Protohistoric and Contact Periods mark the transition from a strictly archeological record to one augmented by ethnographic, enthohistoric, and historic records. Until the advent of Euro-American culture was felt here, there would be little to distinguish a protohistoric site from an earlier Plains Nomadic or Plains Woodland site. European influences began to arrive on the northern plains in the 1600 and 1700s with trade goods from the northeast and horses from the southwest (State Historical Society of North Dakota 1990:B38). During the protohistoric period, native inhabitants of the region were establishing the cultural traits that would later in the historic period be represented by identified tribal groups throughout the region. Typically, observations made by the first visitors are used to establish a baseline and to project back in time the locations and characteristics of native societies. The contact period begins with the 1738 French foray in the region by Pierre Gaultier de Varennes, Sieur de la Vérendrye (Burpee 1927; Smith 1980). During his journey, he maintained a journal of his travels and of the native peoples he encountered. With a contingent of some 600 Assinboine and 30 Mandan, he arrived at the main Mandan village in North Dakota on December 3, 1738.

Euro-American Encounters (A.D. 1738 to A.D. 1806)

The period consisted of European exploration and exploitation by traders and trappers (Ritterbush 1991). The trade between the Europeans (French, English, and Spanish) and village tribes (Mandan, Hidatsa, and Arikara) developed during the 1700s with the village tribes controlling the flow of goods from the Europeans to the nomadic tribes in the region (Dill 1983:16-20; Nasatir 1952). It is during this time that the nomadic tribes developed an equestrian culture and the reliance on the horse as transportation and a beast of burden. Eastern tribes from the Great Lakes region moved out on the plains and rapidly adapted to the equestrian lifestyle that was to epitomize the Plains Indians

of the 19th century, as well as indigenous Plains Nomadic groups. These included the Lakota and Dakota Sioux, the Cheyenne, the Assiniboine, the Blackfeet, and the Crow. Although surrounding area had gradually become known during the prior century, it was not really until the early nineteenth century that the region entered the historic record to any significant extent. Included as part of the 1803 Louisiana Purchase, Arkansas became part of the territory controlled by the fledgling United States of America. A number of expeditions were conducted to explore this new land purchase: Meriwether Lewis and William Clark into the northern regions along the Missouri River (Moulton 1983-2004; Thwaites 1969), Zebulon Pike into the Rocky Mountains (Coues 1895; Hart and Hulbert 2007), Thomas Freeman and Peter Custis along the Red River (Flores 1986), and William Dunbar and George Hunter to the Washita River and "hot springs" in Arkansas and Louisiana (Berry 2003; Berry et al. 2006). The Lewis and Clark expedition reached the Mandan villages in October 1804 where they spent the winter at Fort Mandan. In 1805, they traveled up the Missouri River from the Mandan villages to the Pacific coast in Oregon. They passed by the Yellowstone and Missouri River confluence on their way to the Rocky Mountains. On their return trip on 1806, they spent time exploring the Yellowstone River and surrounding region.

Fur Trade (1806-1865)

With the return of the Lewis and Clark expedition to St Louis, a period of exploration and exploitation followed on the Upper Missouri region including the project area within the Yellowstone River study unit (Toom 1996:72-73). The development of the fur trade on the Upper Missouri also had a major impact on the native cultures in the region. Euro-American trade goods were incorporated into the existing material culture of the sedimentary and the equestrian inhabitants of the region. The fur trade had developed in the 1700s between the Native American groups, especially the Middle Missouri village tribes who served as middlemen in the trading between the Europeans and other tribes in the region, until smallpox epidemics and other European diseases for which they lacked immunity resulted in the catastrophic decline in population in the 1780s and the 1830s (State Historical Society of North Dakota 1990;13.31-33); Trimble 1985). The equestrian Sioux, Cheyenne, Assiniboine, Crow, and Blackfeet became the primary native groups in the Upper Missouri fur and bison robe trade. Numerous publications on the fur trade commerce provide an extensive history of the interactions between the Europeans, the Americans, and the Native American tribes (Chittenden 1986; Phillips 1961; Sunder 1965; Wishart 1979; Wood and Thiessen 1985).

In 1807, Manuel Lisa led the first American trading venture up the Missouri River. John Colter, one of Lewis and Clark's men with knowledge of the Upper Missouri region, joined Lisa. Lisa established a trading port at the confluence of the Bighorn River with the Yellowstone River. Although Lisa had originally planned to open trade with the Blackfeet, he ended up in the hearth of Crow territory where he established the first American trading post in the region (Chittenden 1986:114-125). He was also the founder of the Missouri Fur Company, which was the earliest of the three major companies to operate on the Upper

Missouri River in the vicinity of the project area (Chittenden 1986-126-159). The Rocky Mountain Fur Company, founded by William H. Ashley, followed on the success of the Missouri Fur Company (Chittenden 1986:246-312). Although his early ventures were not successful, he managed a lucrative business during the 1820s. On his 1822 expedition, he and his group reached the mouth of the Yellowstone River. Many of his employees became famous traders, trappers, and explorers of the western frontier. The third and most successful of the major fur trade companies was the American Fur Company, which was originally incorporated by John J. Astor in 1808 (Chittenden 1986:313-394). Beginning in the Great Lakes region, the American Fur Company conducted operations in the Great Lakes, the upper Mississippi, along the Northwest Coast of the Pacific Ocean, and the Great Plains including the Upper Missouri region. The American Fur Company and its various regional divisions, including the Upper Missouri Outfit, controlled the fur trade for nearly thirty years from ca. 1830 to the 1860s when it went out of business (Chittenden 1986:328-329).

In 1828, the American Fur Company sought to advance its operations along the Upper Missouri region by establishing a trading post near the confluence of the Missouri and Yellowstone Rivers. The trading post was the most important and grandest fort of an extensive network of trading establishments established by the American Fur Company on the upper Missouri (Hunt 1986:2-5; Thompson 1994:1-2). Established in 1828, the post lasted until its purchase by the U.S. Army for materials used in the construction of Fort Buford in 1867. The site became part of the Dakota Territory in 1861. Originally built to capture the trade with the Assiniboine, at least ten tribes traded at the fort during its long history. A major expansion of the fort occurred in 1833. Numerous other building episodes occurred throughout its history including the rebuilding of the Fort William stockade on the east side of the fort in 1834 after being purchased from the opposition company of Campbell and Sublette (Larpenteur 1989:58-60). The American Fur Company was instrumental in the development of steamboat traffic on the Missouri River with the first steamboat, the Yellowstone, arriving at Fort Union in 1832 (Mattison 1962). Over the years, many notable people visited or worked at the post including company employees Kenneth McKenzie, Charles Larpenteur, James Kipp, Alexander Culbertson, Rudolph Friederich Kurz, and Edwin Thompson Denig, artists George Catlin and Karl Bodmer, naturalist John James Audubon, missionary Pierre Jean De Smet, and adventurers such as Prince Maximilian of Wied and Duke Paul Wilhelm of Württemberg. Maximilian (Thwaites 1906), Audubon (Audubon 1960), Larpenteur (1989), Kruz 1937), and Denig (Ewers 1961) recorded their adventures at the fort and observations of the Native Americans that visited the trading post.

The Military and the Railroad (1866-1895)

Following the Civil War, the U.S. Army focused on the subjugation of the plains, southwestern, and western tribes. Military campaigns in 1864 and 1865 in the Dakota Territory resulted in the construction of a number of military posts in the Dakota Territory. Although the old trading post was originally considered as a location of a military post,

the Army chose to build a new fort, Fort Buford, next to the confluence of the Yellowstone and Missouri Rivers in 1866 (Robinson 1966:101-103; Warner 1986). Fort Buford was established to protect the overland and river routes along the northern portion of the Great Plains. Originally consisting of a palisaded stockade housing a single company of soldiers, the fort was expanded in 1867 to accommodate four additional companies. The ruins of the nearby Fort Union Trading Post were purchased by the Army and the materials were used in the expansion of Fort Buford (Thompson 1994:94). Between 1871 and 1872, the fort was increased in size to house ten companies of soldiers but ultimately housed six. During its early years, Fort Buford was under attack from Sitting Bull's Hunkpapa Sioux warriors. Following the Sioux Wars of 1876-1879, Sitting Bull finally surrendered at Fort Buford following his flight into Canada in 1881. During the next fifteen years, Fort Buford's garrison protected survey and construction crews of the Great Northern Railway company, patrolled the international border with Canada, and policed the regions against outlaws. By 1895, the fort had deteriorated to the point where repairs were deemed too expensive and the fort was determined to be not necessary for the army's changing mission. It was abandoned on October 1, 1895. The military reservation was transferred to the Department of the Interior for disposition of the land and buildings to the General Land Office. The buildings served as residences and businesses for a number of years following Fort Buford's abandonment and sale until its demise in the early twentieth century.

Following a number of events at the Fort Berthold reservation, a band of Hidatsa under their leader Crow Flies High, left the reservation and settled between the old Fort Union Trading Post site (32WI17) and Fort Buford between the late 1860s or early 1870s and 1884 (Fox 1988:1-19). The band settled on the eastern edge of the terrace next to the old trading post site above Garden Coulee a couple of miles west of Fort Buford (Fox 1988:20-68). During their stay at the Garden Coulee Site (32WI18), the Hidatsa farmed, hunted, and traded at the fort. In addition, the men often served as Indian Scouts for the Army. By 1884, the increase in the size of the band had become a nuisance for the Army at Fort Buford. The band was requested to leave. They moved to a new village near the mouth of the Little Knife River, where they stayed until their forced return to the Fort Berthold reservation (Fox 1988:16-19).

Originally, this region of the Dakota Territory was identified as Buffalo County. It was subdivided into several counties over ten years. In 1873, Wallette County, which included the Fort Buford military reservation and the old Fort Union Trading Post site, was formed but was never organized due to the lack of settlers. In 1883, Wallette County was divided into two unorganized counties with Buford County on the west and Flannery County on the east side of Wallette County. In 1889, North Dakota was admitted to the Union as the 39th state (Robinson 1966:199-203). Williams County was formed in 1891 by recombining Buford and Flannery Counties into a single county (Williams County Historical Society 1975-1976).

The Great Northern Railway was very active in the promotion of settlement in the Dakota Territory and the State of North Dakota during the 1880s (Kraenzel 1955;

MacDonald 1963; Robinson 1966). The railroad companies operated model farms during the 1880s, offered special rates for settlers, and operated emigrant trains. They also directed settlement of the new territories by creating towns along the rail lines along which new settlers concentrated their farms along the railroad in a linear fashion. The emigrants aboard the trains were often deposited in unsettled areas resulting in an ethnic checkerboard along the rail lines. Cattle ranching also developed on the Northern Plains during this period (MacDonald et al. 1982:27-30).

Modern Development and Recreation (1895 to present)

In 1901 the Fort Buford military reservation was opened for settlement (MacDonald et al. 1982:25). Homesteading in the early 20th century was aided by the passage of the Enlarged Homestead Act of 1909, which double the allowable homestead claim from 160 acres to 320 acres (MacDonald et al. 1982:30). During the boom period between 1900 and 1920, the cattle industry also recovered from the late 19th century decline. In 1904, the townsite of Mondak was established in 1904 on the Montana side of the Montana/ North Dakota state line. This not only provided a rail point for the transit of local livestock and crops to the national market but supplied liquor to the residents of dry State of North Dakota (MacDonald et al. 1982:33-45). In 1910, Williams County was divided between Divide on the north and Williams on the south after a vote of the residents. Prohibition took its toll on Mondak with the closure of the Mondak station by the Great Northern Railway, the introduction of the automobile, and construction of an improved road network, and an area-wide drought (MacDonald et al. 1982:42-45). Fires in 1928 resulted in the final destruction of the Mondak community. Agriculture continued to be the primary industry in the region through the 20th and into the 21st century. Although oil exploration began in the early 20th century in North Dakota, the first oil was discovered in 1951 (Robinson 1966:458-461). The Williston Basin has been a major producer of oil since the 1970s.

The decade of the 1920s saw an increased interest in the fur trade period in America (Hunt 1986:5). Interest in the Fort Union Trading Post site coincided with the threat of its destruction by a gravel mining operation (Matzko 1998:69-70). The President of the Great Northern Railway showed interest in the site and promoted a series of public relation events exemplifying its national importance (Hunt 1986:5-6). As a result of increased interest in the historic site, the State of North Dakota purchased the old trading post site as an addition to its state park system (Matzko 1998:79-98). The trading post site was recognized in 1961 as a National Historic Landmark for its role in history of the nation's expansion. In 1966, the U.S. Congress established the old trading post site as the Fort Union Trading Post National Historic Site (Public Law 89-458). The National Park Service was charged with preserving the site, as well as interpreting its history to the American public (Matzko 1998:99:254).

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4. PREVIOUS ARCHEOLOGICAL INVESTIGATIONS AT FORT UNION TRADING POST NATIONAL HISTORIC SITE

Fort Union Trading Post National Historic Site lies within the boundary of the Yellowstone River archeological study unit (State Historical Society of North Dakota1990:13.1-33). Archeological research at Fort Union Trading Post National Historic Site was initiated in 1968-1972 with investigations of the trading post site directed towards the *location and delineation of architectural features which were considered to be the prerequisites for the partial reconstruction of the fort* (Hunt 1986:6). Most of the archeological activity was centered on the proposed reconstruction of the fur trading post beginning in the late 1960s and concluding in the late 1980s (Cabak and Groover 2002; Gillio 1973; Hunt 1986; Hunt and Peterson 1988; Husted 1970,1971; Loendorf 1971; Moore 1968; Peterson 2002a,2002b; Peterson and Hunt 1990; Scott 1986; Sturdevant 2001; Thiel 2003). Other inventory and compliance projects have occurred in the years since the establishment of the Fort Union Trading Post as a National Park Service unit in 1966 (Anderson 1973; Anderson and Galley 1976; Hunt 2000; Hunt and Bauermeister 2002; Stadler 2002; Thiessen 1977).

The archeological investigations yielded a significant number of artifacts associated with the fur trade period from 1828 to 1867 at the Fort Union Trading Post National Historic Site. Initially, series of student papers were prepared for the classroom assignments at the University of Nebraska-Lincoln. These research papers were related to the early excavations in the late 1960s and early 1970s (Brown 1974; Carillo 1970,1971; Galley 1975a,1975b; McClure 1972; Pfeiffer 1975; Wolf 1975). There was an attempt to fully describe the artifact inventory between 1979 and 1981 by NPS archeologists Dick Ping Hsu and Leslie Perry; however, in-house review of the manuscript identified several inherent problems (Hunt 1986:43-45). The completed systematic study of the Fort Union Trading Post National Historic Site artifacts was continued by William J. Hunt, Jr., and others in a series of reports analyzing the archeology and artifacts from the 1968-1972 excavations (Angus and Falk 1986; De Vore 1987,1992; De Vore and Hunt 1993,1994, 1996; Hunt 1986a,1986b,1986c, 1986d,1986e). The 1986-1988 excavations associated with the trading post's reconstruction yielded additional artifacts; however, the artifact inventory from these excavations has not been completely analyzed or described. Selected categories of artifacts have served the basis for Master's theses, Doctoral dissertations, journal articles, and reports (Bauermeister 2000; Cannon 1992; Hunt 1989; Ross 2000; Thiel 1992,1995,1998).

The park has also been the focus of a number of archeological prospection projects using geophysical and aerial photographic methods (Figure 5). Aerial photographs of the park were taken in 1977 using both black and white panchromatic and false color infrared imagery (Snow 1978). Ms. Snow analyzed the imagery with a mirror stereoscope and identified several anomalies. She was able to ground truth several anomalies to the east of the fort ruins. Anomalies appeared to be associated with the historic activities at the trading post, with the Fort William stockade, and with the Hidatsa Crow-Flies-High

village site. She also identified a wagon trail exiting the trading post and heading to the northwest. Several features to the northwest of the fort ruins were identified with the historic community of Mondak.

One of the early magnetic surveys in the National Park Service, conducted by the University of Nebraska-Lincoln (UNL) and MWAC, occurred at the location of the trading post site (32WI17) and the Fort William stockade site (Weymouth 1979,1989, 1991,1994). The UNL/MWAC crew utilized two Geometrics G-826A proton magnetometers: one as a stationary base station for recording diurnal changes, and the second one as the rover for collection data across the site. Sixteen 20 m by 20 m geophysical survey blocks or grid units were placed over the ruins of the trading post. An additional nine grid units were surveyed in the region east of the fort ruins identified as a possible location for the Fort William stockade. A second survey of the suspected Fort William location was carried out in 1978 with the addition survey of nine more grid units (Coles 2004:34-36; Weymouth 1991:2). The crew used a sampling density of one sample per meter along one-meter traverses. The survey effort required eight days to complete (Weymouth 1979:3-4). Parts of two grid units in the southwest quadrant were resurveyed at two samples per meter along 0.5-meter traverses. At the time of the survey, most of the data were recorded by hand; however, the data from two grid units were recorded with a newly developed data logger. The survey produced a large number of magnetic anomalies that appeared to be correlated with known archeological features (Weymouth 1979:4-12,1989,1991). Re-analysis of the magnetic data collected at the possible Fort William site location *resulted in the identification of four major localized anomalies and at least 10 linear anomalous features* (Weymouth 1994:7).

In 1999, archeologists from MWAC conducted a magnetic survey of the existing waterline alignment as part of a compliance project for the replacement of the existing waterline (Nickel and Hunt 2000). The geophysical survey included twenty-eight 20 m by 20 m grid units that extended from the edge of the terrace above Garden Coulee to the reconstructed Fort Union Trading Post. A Geoscan Research FM36 fluxgate gradiometer was used to collect the magnetic data. Initially, the magnetic survey data were collected at four samples per meter along 0.5-meter traverses in a parallel or unidirectional mode. After the survey of a number of grid units between the maintenance facility and the well in the middle of the field, the data acquisition was changed to a zigzag mode. The survey corridor passed through the Garden Coulee Site (32WI18) and the Fort Union Trading Post Site (32WI17). Over 53 anomalies were documented during the waterline survey, which were identified as high probable archeological features.

In 2002, Archaeo-Physics LLC (Jones and Maki 2003) conducted a geophysical survey at the Garden Coulee Site (32WI18). The investigations included a magnetic survey with a Geoscan Research FM36 fluxgate gradiometer and a limited resistance survey with a Geoscan Research RM15 resistance meter and PA5 twin probe array. The magnetic survey was conducted over one hundred fifty-four contiguous 20 m by 20 m survey grid units (Jones and Maki 2003:1-2). At first, the magnetic data were collected at four samples per meter along 0.5-meter traverses in a zigzag mode. It was changed to eight samples

per meter along one-meter traverses near the end of the survey to speed up the survey efforts in anticipation of inclement weather. Archaeo-Physics LLC staff also conducted a resistance survey with a Geoscan Research RM15 resistance meter and PA5 twin probe array. The probe spacing on the mobile frame was 0.5 meters for an approximate depth penetration of 0.5 meters. Two samples were collected along one-meter traverses on 84 contiguous grid units (Jones and Maki 2003:2).

During 2006, the Midwest Archeological Center and Fort Union Trading Post National Historic Site staffs conducted geophysical investigations at four selected areas within the boundary of the park (De Vore 2007b). The geophysical survey was conducted in order to address the park staff's concerns about locating a geophysical and archeological quiet area for the construction of a corral area for the Fort Union Muzzleloaders during events at the fort, the evaluation of the area surrounding the park's service road for a possible re-alignment for potential buried archeological resources, the identification of the location of the park's sewage leach field, the area along the terrace edge south and east of Archaeo-Physics LLC survey block at the Garden Coulee Site (32WI18), and the location identified by the park staff as the Larpenteur's trading post near the park's main visitor parking lot. The geophysical survey techniques included a magnetic survey with a Geoscan Research FM36 fluxgate gradiometer, a conductivity survey with a Geonics EM38 ground conductivity meter, and a ground penetrating radar survey with a Geophysical Survey Systems Inc. (GSSI) TerraSIRch SIR System-3000 ground penetrating radar cart system with a 400 mHz antenna gpr cart system and 400 mHz antenna. Ninety-five complete 20 m by 20 m grid units and twenty-three partial 20 m by 20 m grid units were surveyed during the geophysical investigations at the Fort Union Trading Post National Historic Site. A total of 40,350 m2 or 9.97 acres were surveyed during the geophysical investigations of the four survey areas. The use of geophysical survey techniques at the historic trading post location indicated their usefulness in collecting basic background archeological data concerning the nature and extent of the archeological resources. Four sites were identified and documented during the geophysical project including the Fort William stockade (32WI988), three trash dumps (32WI989, 32WI990, and 32WI991), and the Larpenteur trading post (32WI992). The magnetic survey data indicated that the sites contained intact archeological deposits and features related to the 19th century activities at the trading post. Evaluation of the data suggested that the sites will yield significant archeological information on the local and regional historic activities of the fur trade on the Upper Missouri.

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5. PRESENT ARCHEOLOGICAL MONITORING AND GEOPHYSICAL PROSPECTION PROJECT

The October/November 2007 project sought to determine the nature and extent of subsurface features and disturbance within the areas of potential effect (APE) associated with the excavation of directional boring pits and backhoe trenches for the installation of the waterline and its connection to the park's administrative offices, visitor center, and museum located in the reconstructed Bourgeois House and existing waterline and well house (De Vore 2007b). The project extends from the neighboring private property on the northwest side of the main park unit located on the south side of Roosevelt County Road 327 and North Dakota State Highway 1804. The waterline route crosses the restored native prairie to the park's entrance road and from the entrance road to a point northeast of the reconstructed trading post to the existing waterline on the north side of the park's maintenance service road. In addition to the installation of the rural water tie-in system to the Dry Prairie Rural Water System through directional underground boring, rerouting of the existing park waterline around the 500-gallon fire suppression tank on the north side of the reconstructed trading post, connecting of the waterline to the Bourgeois House, bypassing the park's well between the reconstructed trading post, and revamping the connection of the waterline to the park's well house required the backhoe excavation of trenches for the installation of new water pipe, plumbing fittings, valves, and hydrants (National Park Service 2006). The condition of the project area at the time of the survey was stable. The project area around the reconstructed fort and the maintenance facility consisted of mown prairie and domestic grasses. The open areas were planted in native prairie grasses. The geophysical equipment used in the survey efforts consisted of a fluxgate gradiometer (Heimmer and De Vore 1995). The geophysical prospection inventory was to be used to identify undisturbed or minimally disturbed areas that would be impacted by the construction related activities for the installation of the Dry Prairie rural water tie-in system to the park's existing water system. The archeological monitoring of the construction boring insertion pits and backhoe trenches was conducted in order to detect, evaluate, and document buried archeological features uncovered by the construction activities.

Initially, the construction plans called for the underground water line installation to proceed along the park's boundary fence next to the county road and the state highway (National Park Service 2006; Sturdevant 2005). A casing containing the waterline was to be installed under the park's entrance road. At a point north of the reconstructed trading post and visitor center, the new waterline route was to be redirected and connected to the existing park waterline near the park's service road from the reconstructed trading post to the park's maintenance facility located in Garden Coulee. Concerns about damage to known archeological sites in the path of the buried waterline from unforeseen future repairs to the waterline resulted in a slight modification of the new waterline route across the open prairie. Instead of proceeding near the park's boundary fence, the waterline route was redirected to pass on the north side of Site 24RV593, under the least dense portion of Site 24RV592 next to the park entrance road, and south of Site 32WI902 (Sturdevant

2005). This revised waterline installation route placed the corner of the waterline where it would be directed to the park's existing waterline in the middle of the open prairie field to the northeast of the reconstructed trading post and the park's outside interpretive teepee display area. This proposed directional drilling route would also avoid the park's sewage leach field north of the visitor center and reconstructed trading post. The proposed directional drilling route was marked with lath stakes and colored flagging tape. The archeological sites in the proposed route corridor were also marked with lathe stakes and flagged with a different color of flagging tape to differentiate the site boundaries from the drilling route. The locations of the directional boring pits were identified and geophysical prospection grid units were placed over these locations.

Seven geophysical grid areas (Grid Areas 5-11) were established at the project location continuing with the 2006 geophysical designations for the geophysical grid areas (De Vore 2007b). The wooden hub stakes for the corners of the 20-m by 20-m grid units (gu) were sighted in with a surveying compass with a portable Ushikata S-25 Tracon surveying compass (Ushikata 2005) and 100 meter tape. Grid Area 5 was placed on the north side of the North Palisade Wall of the reconstructed trading post (Figure 6). Grid Area 5 connected to Grid Area 2 on its east side at grid units 3 and 7 from 2006. It also connected to Grid Area 1 on its north side at grid units 1 and 2 from 2006. Grid Area 5 consisted of ten 20 m by 20 m grid units measuring 40 m n-s by 100 m east-west for an area of 4,000 m2 or 1.0 acre. Grid North for Grid Area 5 was oriented on Magnetic North. Grid Area 5 also included the area of a proposed access and parking location for the park's firefighting vehicle next to the reconstructed trading post. Grid Area 5 also consisted of the site coordinate system established during the 2002 geophysical survey of the Garden Coulee Site (32WI18) by Archaeo-Physics (Jones and Maki 2003) and utilized during the NPS 2006 geophysical surveys (De Vore 2006a,2006b,2007b). Grid Area 6 was located at the northwest corner of the main park unit on the south side of the county road and railroad tracks (Figure 7). The grid area consisted of one grid unit with an area of 400 m2 or 0.1 acre. Grid North for Grid Area 6 was oriented eight degrees west of Magnetic North. Grid Area 7 was located across the park's entrance road on the Montana side of the park (Figure 8). Three grid units were established with the center unit located across the asphalt pavement and the adjacent drainage ditches. Grid Area 7 was oriented on Magnetic North. The center grid unit was not surveyed with the fluxgate gradiometer. The eastern grid unit contained the insertion point for the bit and drill rod of the directional boring route to the northwest corner of the main park unit and the Dry Prairie rural water tie-in point on the neighboring private property in Montana. The distance between insertion point for the new waterline on the east side of Grid Area 7 and its egress point on the west side of Grid Area 6 was approximately 433 meters. The total area surveyed in the two outside grid units was 800 m2 or 0.2 acre. Grid Area 8 was located in the open prairie east of the park's entrance road on the North Dakota side of the park (Figure 9). It was approximately half way between Grid Area 7 and Grid Area 9. The distance between Grid Area 7 and the junction point in Grid Area 9 was 523 meters. The center of Grid Area 8 was located approximately 256 meters from the junction point in Grid Area 9. Grid Area 8 consisted of two 20 m by 20 m grid units oriented on Magnetic North. The eastern grid

unit contained the insertion point for the bit and drill rod. The directional drilling was back towards Grid Area 7. Grid Area 8 consisted of 800 m2 or 0.2 acre. Grid Area 9 was located at the turning point for the east-west section of rural waterline (Figure 10). Grid Area 9 consisted of four 20 m by 20 m grid units measuring 40 meters by 40 meters on a side. The grid units were oriented on Magnetic North and contained a total area of 1,600 m2 or 0.4 acre. The location of Grid Area 9 represented the junction of the new waterline from the neighboring private property to the west of the park and new waterline hookup with the park's existing waterline on the north side of the park's maintenance service road near the northeast corner of the reconstructed trading post. The distance between Grid Area 9 and the park's existing waterline was approximately 100 meters. It also utilized the site coordinate system from Grid Area 5 in order to express the results into the mapped site coordinate system established during the 2002 geophysical survey of the Garden Coulee Site (32WI18) by Archaeo-Physics (Jones and Maki 2003) and used during the NPS 2006 geophysical surveys (De Vore 2006a,2006b,2007b). During the course of the construction project, two additional grid areas were added to the geophysical survey portion of the overall project. During the insertion of the new waterline pipe on the east side of the park's entrance road in the boring hole created by the between Grid Area 7 and Grid Area 8, the 3-inch PVC water pipe broke at one of the couplings connecting the 20-foot sections of PVC pipe. As a result of the breakage and the need for additional boring pits to extract the broken pipe, two additional grid areas were established. Grid Area 10 was located approximately 55 meters west of Grid Area 8 (Figure 11), and Grid Area 11 was located approximately 56 meters east of Grid Area 7 (Figure 12). Both grid areas consisted of a single grid unit, which were oriented on Magnetic North and contained an area of 400 m2 or 0.1 acre for each grid unit. The selected geophysical project areas contained 21 grid units for a total of 8,400 square meters or 2.08 acres. Due to the relative positions of Grid Area 6-8 and 10-11, the coordinate systems for these grid areas used the arbitrary N0/E0 coordinates for the lower left hand corner or southwest corner of the grid areas as their coordinate nomenclature. All of the grid units within the 2007 grid areas were identified a unique grid unit number that was continued from the 2006 geophysical investigations of FOUS (De Vore 2006a,2006b,2007b).

Global positioning system (gps) coordinates were collected along the projected waterline route, the location of the geophysical grid unit corners at the boring pit locations, and identified archeological features unearthed during the backhoe trenching operations 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 13 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 Navigations 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) 83 miles away at Medora, North Dakota, was selected as the provider for the base station gps data. The field gps data was differential corrected using the CORS Medora 3 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. 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.

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

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.

The active geophysical prospection techniques used during this project included conductivity, resistivity, and ground-penetrating radar. As indicated above, active techniques transmit electrical, electromagnetic, or acoustic signals into the ground. The interaction of these signals and buried materials produces an altered return signal, which is measured by the appropriate geophysical instrument. The ground-penetrating radar and ground conductivity meter utilize electromagnetic signals. The resistivity meter injects an electric current into the ground.

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 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; 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 survey was conducted with a Geoscan Research FM36 fluxgate gradiometer with a ST1 sample trigger (Figure 13). 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 where no noticeable localized magnetic variations were located. The magnetic reference point for Grid Area 5 was located at N1120/E700. The magnetic reference point for Grid Area 6 was located at the southeast corner of grid unit 129. The magnetic reference point for Grid Area 7 was located at the southeast corner of grid unit 131. The magnetic reference point for Grid Areas 8, 10, and 11 were located at the southwest corner Of Grid Area 8 in grid unit 132. The magnetic reference point Grid Area 9 was located at N1240/E740. The readings should vary less than 2 to 3 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.

Before the start of the geophysical survey at each grid area, yellow nylon ropes were laid out on the grid units. These ropes served as guide ropes during the actual data acquisition phases of the project. Twenty-meter ropes were placed along the top and bottom base lines connecting the grid corners. The survey ropes formed the boundaries of each 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.

The survey of each traverse was conducted in a zigzag or bidirectional mode beginning in the southwest corner or lower left-hand corner of each 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 each 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 a 20m by 20 m grid unit. At the end of the data acquisition of four grid units, the instrument's memory was full and the magnetic data from the survey were downloaded into the Geoscan Research GEOPLOT software (Geoscan Research) on a field laptop computer. It took approximately 26 minutes to download the data from memory of the gradiometer when it was full. The grid files identified as to their relative positions in the GEOPLOT mesh file. A composite data file created in GEOPLOT was reviewed in the field prior to the clearing of the gradiometer's memory.

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. 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.

Due to the limited memory capacity and changes in the instrument setup of the FM36 fluxgate gradiometer, the data were downloaded into a laptop computer after the completion of two grid units at 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). Each grid file contained the magnetic raw data obtained during the survey of the individual grids. The grid files were 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 and methodology and make appropriate survey decisions or modifications while still in the field.

In order to process the magnetic data, the grid files 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 files oriented in the correct position in the overall survey of the site (Geoscan Research 2003:3/15-21). Once the grid files have 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 may have been the effects of cultivation (e.g., plow marks, ridge and furrow) 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 “scan to scan instrument and operator bias defects” (Jones and Maki 2002:16). 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 –220.4 to 257.7 nT with a mean of 0.35 nT and a standard deviation of 19.707 nT after the application of the zero mean traverse algorithm in Grid Area 5. The magnetic data ranged from –189.0 to 165.0 nT with a mean of -1.33 nT and a standard deviation of 18.785 nT after the application of the zero mean traverse algorithm in Grid Area 6. The magnetic data ranged from –16.2 to 52.0 nT with a mean of 0.13 nT and a standard deviation of 1.932 nT after the application of the zero mean traverse algorithm in Grid Area 7. The magnetic data ranged from –13.8 to 31.9 nT with a

mean of 0.04 nT and a standard deviation of 1.271 nT after the application of the zero mean traverse algorithm in Grid Area 8. The magnetic data ranged from –44.4 to 28.4 nT with a mean of 0.05 nT and a standard deviation of 1.179 nT after the application of the zero mean traverse algorithm in Grid Area 9. The magnetic data ranged from –5.2 to 27.5 nT with a mean of 0.06 nT and a standard deviation of 0.976 nT after the application of the zero mean traverse algorithm in Grid Area 10. The magnetic data ranged from –35.9 to 39.2 nT with a mean of -0.19 nT and a standard deviation of 7.741 nT after the application of the zero mean traverse algorithm in Grid Area 11. The data set is interpolated to produce a uniform and evenly spaced data matrix (Geoscan Research 2003:6/53-56). Increasing or decreasing the number of data measurements creates a smoother appearance to the data. The original matrix is an 8 x 1 matrix. The interpolate function requires three parameters: direction, interpolation mode and interpolation method. In the Easting direction, the number of data measurements are expanded to yield an 8 x 4 data matrix. In the Northing direction, the number of data measurements are shrunk yielding a 4 x 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 is bipolar 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).

In SURFER 8 (Golden Software 2002), the initial step was to view the xyz data file. Adjustments to the x and y coordinates were made to the data files for Grid Area 5 and 9. The x or Easting and the y or Northing coordinates was divided by four to yield the sample interval position at every 0.25 meters across the magnetic data set. The value 1120 was added to the Northing coordinate and the value 600 was added to Easting coordinate values in Grid Area 5 in order to express the results into the mapped site coordinate system established during the 2002 geophysical survey of the Garden Coulee Site (32WI18) by Archaeo-Physics (Jones and Maki 2003) and utilized during the NPS 2006 geophysical surveys (De Vore 2006a,2006b,2007b). The value 1220 was added to the Northing coordinate and the value 700 was added to Easting coordinate values in Grid Area 9 in order to express the results into the mapped site coordinate system established during the 2002 geophysical survey of the Garden Coulee Site (32WI18) by Archaeo-Physics (Jones and Maki 2003) and utilized during the NPS 2006 geophysical surveys (De Vore 2006a,2006b,2007b). Grid Areas 6-8 and 10-11 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 rastor representation of 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 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 form Grid Area 5 (Figure 14), Grid Area 6 (Figure 15), Grid Area 7 (Figure 16), Grid Area 8 (Figure 17), Grid Area 9 (Figure 18), Grid Area 10 (Figure 19), and Grid Area 11 (Figure 20).

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 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 contract 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 affects 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 in 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. 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 numerous dipole and monopole magnetic anomalies in the data sets from the magnetic survey of selected geophysical grid areas at FOUS. Grid Area 5 contains several strong magnetic anomalies associated with the modern utilities, including the electrical and telephone lines, the park's fresh waterline and fire suppression system, and the sewage disposal lines, as well as the effect of ferrous materials (e.g., nails, bolts, rebar,

etc.) used in the reconstruction of the trading post's palisade line and foundation (Figure 21). During the 1986 reconstruction excavations at Fort Union Trading Post National Historic Site (Hunt and Peterson 1988:12-13), area outside of the North Palisade Wall was excavated in the area of the proposed utility lines, sewer line, waterline, and associated hardware, including electrical meters, air conditioner units, 500 gallon water storage tank, water hydrant, and gate and shutoff valves. The area consisted of approximately 600 m^2 or 0.14 acres. The 1987 excavations (Peterson and Hunt 1990:2-4) of the remainder of the North Palisade line included an additional 550 m^2 or 0.13 acres. Concentrations of magnetic anomalies within the boundary of the 1986 excavations may represent artifact laden backfill used to fill in the excavation units or they may represent dropped or lost modern building hardware (i.e., nails, screws, washers, nuts, bolts, wire, etc.) or items from park vehicles. To the east of the 1986 excavated area, there is a light scattering of magnetic anomalies which may represent historic period artifacts. The one magnetic anomaly identified as Feature 1 during the construction trenching (see next section) is a faint positive monopole anomaly, which measures 4.3 nT. Other faint anomalous measurements under 5 nT may also represent historic features, although they are not identified on the interpretative map of the eastern portion of Grid Area 5. The area on the west side of Grid Area 5 lies next to or in the drainage to the northwest and west of the reconstructed trading post. There appears to be a moderately dense scatter of magnetic anomalies in this area. The area may represent a trash midden outside the trading post. A proposed fire suppression staging area is planed for this portion of the project area. Due to the density of the scatter, archeological investigations of the proposed fire suppression staging area are warranted.

Grid Area 6, located in the northwest corner of the main park unit, contains two linear series of magnetic anomalies associated with the park's barbed wire boundary fences (Figure 22). A few isolated magnetic anomalies in the grid unit may represent ferrous items (e.g., nails, fencing staples, wire, etc.) associated with the construction of the park boundary fences or agricultural implement parts from farm machinery prior to the establishment of the park or by park equipment.

Grid Area 7, located across the park's entrance road, contains a very light scatter of magnetic anomalies on both sides of the road with the western grid unit containing approximately three times the number of magnetic anomalies as the eastern grid unit (Figure 23). The western grid unit is located within the boundary of Site 24RV592. The site is located on the southern margin of the Mondak townsite, which dated to the early 20th century. Hunt and Bauermeister (2002:7-8) suggested that the site represented the location of former taverns on the Montana site of the North Dakota-Montana state line. The small concentration of magnetic anomalies in the northwest corner of grid unit 130 on the west side of Grid Area 7 may be associated with a Mondak structure. The park's entrance road follows the route of Yellowstone Street on the south side of the Great Northern Railway tracks. The First & Last Chance Saloon was located in the northeast corner of the lot near the modern entrance to the park. The eastern grid unit is located within an empty lot to the north of the Swobodee's Sporting House. The magnetic anomalies represent an extremely light scattering of ferrous materials associated with the Mondak period in the early 20th century.

Grid Area 8, located o the North Dakota side of the main park unit northwest of the reconstructed trading post approximately half way between Grid Area 7 and Grid Area 9, contains an extremely light scatter of magnetic anomalies (Figure 24). With a concentration of magnetic anomalies along the southern edge of the grid area, it is possible that the location of the grid area is the northern limit of an undocumented archeological site. The anomalies might also be associated with items lost from farming equipment.

Grid Area 9, located to the northeast of the reconstructed trading post, lies at the junction of the route of the rural water and its connecting line to the park's existing waterline (Figure 25). A few isolated magnetic anomalies are present within the grid area. The southern portion of the grid area is also located within the park's campground and living history demonstration area used during the annual rendezvous event. Two fire hearths from the 2007 rendezvous event were noted during the preparation of the grid area's sketch map. It is possible that a few of the magnetic anomalies are associated with the modern camp hearths. Other anomalies may be associated with items lost off of farming equipment during their use associated with agricultural activities in the field.

Grid Area 10, located west of Grid Area 8, contains a few magnetic anomalies (Figure 26). No noticeable discard pattern is observable in the data set. It is possible that the anomalies may also be associated with items lost off of farming equipment or with material from the historic fur trade period of the 19th century. The 1860s Larpenteur trading post, 32WI992, is located along the gravel quarry containing the park's main visitor parking lot to the southwest of the grid area (De Vore 2006b,2007b).

Grid Area 11, located to the east of Grid Area 7, contains a few magnetic anomalies, which may be associated with the Mondak townsite from the early 20th century (Figure 27). Near the middle of the grid area, there is a massive high intensity magnetic anomaly that spans the length of the grid unit. This atypical anomaly is larger and more complex than magnetic anomalies generally associated with archeological features and artifacts. It is probable that this anomaly represents a lightning induced remanent magnetization episode (Jones and Maki 2005; Maki 2005).

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7. RESULTS OF THE SITE MONITORING OF THE CONSTRUCTION TRENCHING

The construction project at Fort Union Trading Post National Historic Site called for the hook-up to the Dry Prairie Water System and the installation of the new waterline into the park's existing fresh water and fire suppression system. The construction project included horizontal directional drilling for the installation of the new water line, the excavation of bore pits for connecting the segments of the waterline, and the excavation of trenches for the placement of bypass waterlines and plumbing hardware. The horizontal directional drilling (HDD) or boring, the excavation of the bore pits for the connection of the buried waterline segments, the excavation of trenches for the rural water bypass around the park's buried 500 gallon fire suppression tank, the excavation of the bypass of the park's well, and the connection of the waterline with new valves and hydrants at the well house was conducted by Agri Industries, Inc. of Williston, North Dakota.

During the project, several Agri Industry employees were present at the construction site. Neil Iverson was the project manager. Bob Norman and Greg Wixon operated the heavy equipment used to excavate the trenches and boring pits. Norman and Wixon also performed the exterior plumbing installation of PVC and copper water pipe, flush hydrants and values, gate valves, check valves, and the double check valve vault with assistance from Cory Zueger and Sean Forthun. The excavation of the boring pits and the trenches at the rerouted waterlines at the reconstructed fort, and the park's well and well house were conducted with a Caterpillar 420D backhoe loader (Figure 28). In more restricted areas around the palisade wall and on the interior of the fort between the Bourgeois House and the Palisade Wall bracing, a Caterpillar 303 CR mini hydraulic excavator was used to dig the rerouted waterline trenches (Figure 29). The excavation of the vault pit and the placement of the reinforced concrete vault in Grid Area 6 utilized a Volvo EC330BLC tracked excavator (Figure 30). The use of the HDD system allowed for a steerable, trenchless method of installing the new underground rural water pipe with minimal impact to the surrounding area and minimal environmental disruption. Once the drilling was completed the drill bit was removed and a reamer was attached to the drill rod and the PVC water pipe. The PVC pipe was then pulled back through the drill hole. The horizontal directional drilling was conducted with a Ditch Witch JT 4020 all-terrain directional drill and associated Ditch Witch MM9 fluid management system mounted on a flat bed truck (Figure 31). The directional drilling team consisted of Chuck Ellis, the drilling machine operator and foreman, and Guy Schiessl who operated the Ditch Witch 752 electronic guidance system for the directional drill. Sean Forthun also assisted Chuck Ellis when Guy Schiessl was working on other company projects.

Grid Area 5, Site 32WI17/Feature 1, and Interior of Reconstructed Trading Post

The initial excavations included the removal of fill around the park's existing water line and 500 gallon water and fire suppression tank on the north side of the North Palisade in Grid Area 5 (Figure 32). The bypass line connected into the Bourgeois House basement

plumbing. During the monitoring of the excavation trench, a single archeological feature was identified within the boundary of the Fort Union Trading Post Site, 32WI17 (Figure 33). It was exposed during the backhoe trenching of the bypass route of the new waterline around the park's buried 500 gallon water storage tank. It was located 1.10 meters north and 3.32 meters east of the northeast corner of the fire hose box. Excavation of the backhoe trench was halted during the identification and documentation of the feature. Designated as Feature 1 for the 2007 archeological and geophysical project, the feature was identified as a small basin shaped trash disposal or dump feature (Figure 34). It was centered at N1122.9/E666.3 and located at a depth of 10-30 cm below the surface (bs). The feature measured 90 cm along the backhoe exposure and extended back into the trench wall. It extended approximately 60 cm across the width of the backhoe trench. The fill consisted of a mixture of ash, charcoal, wood, and soil. In the mixed matrix, two bison rib bones and on metapodial bone fragment, a cut nail, and a bottle glass fragment were noted in the disturbed backhoe backdirt pile but were not collected. The northern end of the feature contained a cylindrical area that might represent a refilled post hole. The feature corresponds to a magnetic anomaly identified during the magnetic survey. The bypass trench extended under the North Palisade wall and foundation. On the interior of the fort, the bypass trench went through the top of the well (Feature 18) identified and partially excavated in 1986 (Hunt and Peterson 1988:25-28). The trench ended at the north foundation wall of the Bourgeois House by the Bell Tower steps. Although a dark layer of soil containing bone fragments was noted around the cement support footing for the steps, it was apparent that it was excavated soil from the 1986 excavations of the Bourgeois House and the Kitchen that had been backfilled in the excavation unit.

Grid Areas 6, 7, 8, 10, and 11

Monitoring activities continued with the excavation of the boring pits associated with connecting the new water pipe and the installation of the casing under the park's entrance road in Grid Area 7. No archeological features were noted in the excavation areas on the east and west side of the road bed. A large area was excavated in Grid Area 6 for the installation of the concrete vault in the corner of the park property. No archeological features were observed during the excavation. Due to the break in the new PVC water pipe as it was pulled from the park's entrance road to the drill insertion point next to Grid Area 8, boring pits were excavated in Grid Area 10 and Grid Area 11 to locate the buried pipe. No archeological features were observed in either bore area.

Well House, Site 32WI996, and Feature 2

The contractor excavated a trench on the west side of the well house in the park's maintenance facility in the Garden Coulee drainage at the east end of the main park unit in order to install new valves on the existing waterline and new plumbing on the interior of the well house (Figure 35). During the excavation of the trench, a large basin-shaped feature was observed at the south end of the excavation (Figure 36). The trench excavation halted while the feature was identified and documented. The feature, identified as Feature

2 for the present project, was located approximately one meter west of the well house and its cement pad at the base of the high terrace on the floodplain above the Missouri River. The feature consisted of a mixed artifact- and soil-filled matrix. The feature was approximately 30 cm thick and the top of the feature was located 10 cm bs (Figure 37). The feature extended beyond the southern edge of the excavation next to the park's graveled service road on the north side of the maintenance shop and to the west of the excavation area. The excavated portion of the feature measured approximately 2 meters in width and 2.5 meters in length. The feature fill contained bone, bottle grass, window glass, metal fragments, a metal loop handle, and a bent cut nail. During the continued excavation of the waterline pit, the existing waterline pipe was uncovered along with an older abandoned waterline pipe and power line to the park's well. The area was highly mottled from the disturbed backfill. Artifacts were noted in the disturbed backfill but were not collected. The area was designated as Site FOUS 6 following the terminology used in the 2006 geophysical investigations at the park (De Vore 2006a,2006b,2007b). It was later recorded with the State Historical Society of North Dakota and designated as Site 32WI996.

Grid Area 9, Park Well, Grid 2 Tie-in, and Feature 3 (32WI17)

Grid Area 9 was located at the junction of the new waterline from the northwest corner of the main unit of the park and the section of new waterline that connected to the park's existing waterline near the reconstructed trading post. The boring pit was excavated to expose both segments of the new waterline in order to join the two segments of the PVC pipe together. The southern half of the grid area was located within the area used for camping and fur trade period demonstrations during the park's annual rendezvous event. No buried archeological resources were identified during the excavation of the bore pit in the grid unit.

The fill around the park's well located in the open prairie east of the reconstructed trading post was excavated to provide working space for the installation of a bypass to the well along the existing waterline between the maintenance and park housing facilities and the reconstructed trading post and visitor center. During the excavation of the existing waterline, observation of the disturbed soil indicated that the fill was loosely packed compared to the surrounding undisturbed soil. No buried archeological resources were observed during the excavation of the well trench.

The tie-in point of the new waterline with the existing waterline was located on the north side of the park's maintenance service road to the north east of the reconstructed trading post (Figure 38). The tie-in point was located within the boundary of grid unit 3 in Grid Area 2 from the 2006 geophysical investigations (De Vore 2006a,2007b). The bore hole was excavated to expose the existing waterline and to provide working room to connect the two lines. During the excavation of the area, a small charcoal stain was observed. Construction activities were halted until the feature was identified and documented. The feature contained charcoal and burned wood. It was designated Feature 3 for the 2007 archeological and geophysical project (Figure 39). It was located near the

northeastern boundary of the Fort Union Trading Post Site, 32WI17. It was located below the plowzone at a depth of 40 cm bs (Figure 40). It was approximately 22 cm in diameter and 8 cm thick. The feature resembled other small features noted in the 1988 excavations next to the Southwest Bastion and the South Palisade foundation wall (Cabak and Groover 2002; Sturdevant 2001). The feature apparently was associated with hide smoking and processing.

8. ARTIFACT DESCRIPTIONS FROM FEATURE 2, 32WI996

Artifacts from the trash dump feature at Site 32WI996 were divided into several material categories consisting of glass (i.e., bottle glass and window glass) metal (i.e., can fragments, strap metal, loop pot or can handle, wire, and a machine cut nail), bone (i.e., faunal remains), wood, and stone (i.e., coal and shale). Using a functional classification developed by Roderick Sprague (1980-81) for 19th and 20th century artifacts, the artifacts from the Feature 2 fill at Site 32WI996 consist of personal items, domestic items, architecture, and unknowns. Within the personal items, the medical and health items consists of the bottle glass that were apparently from patent medicine bottles, while the bottle glass from the whiskey or bourbon bottles are classified under the indulgences (Sprague 1980:225). The can fragments are retail merchandizing items under manufacturing in the commerce and industry functional category (Sprague 1980:257). The metal loop handle probably represents a wash boiler handle which is classified as a laundry item within the cleaning and maintenance group under the domestic items (Sprague 1980:256). The window glass and wire are identified as construction materials under the category of architecture (Sprague 1980:256). The machine cut nail is identified as construction hardware under the functional category of architecture (Sprague 1980:256). The strap metal pieces, the coal, and the shale are identified as unknowns (Sprague 1980:258). The faunal remains represent subsistence ecofacts that are part of the gustatory group within housewares and appliances under the domestic items (Sprague 1980:256).

Bottle glass fragments (Table 2) recovered from the Feature 2 fill at Site 32WI996 includes alcohol and patent medicine bottles (Figure 41). The bottle glass from Feature 2 was divided between Class I intoxicants (Hunt 1986b:36-72) and Class II medicinal bottles (Hunt 1986b:73-90). A clear glass neck and finish bottle fragment appeared to represent a Whiskey or Bourbon bottle. The neck finish is identified as a double oil or mineral finish (Fike 1987:8). This bottle was apparently manufactured in a two-piece mold before the finish was hand applied. The two-piece mold technique for bottle manufacturing generally dated between ca. 1750 and ca. 1880 (Jones and Sullivan 1985:26-28). It was similar to Hunt's (1986b:58-59) variety 2, type C, subclass Id whiskey or bourbon bottles. Two other clear glass fragments, including a base and a body fragment, were also recovered from the feature fill. Clear glass bottles had a general application including use for alcoholic beverages such as whiskey, especially after 1875 (Fike 1987:13). Two amber neck and finish fragments mend together. The finish was also hand applied to this bottle and represented an oil or ring neck finish (Fike 1987:8). A shoulder fragment and two curved body fragments were also identified with this category. The amber colored glass had a general application for alcoholic beverages and bitters. It was used widely after 1860 (Fike 1987:13). A small light green body fragment from an intoxicant bottle was also recovered from the feature. The medicinal bottle fragments consisted of one body panel and two base fragments of a rectangular type P, subclass IIb patent medicine (Hunt 1986b:82-90). All of the bottle fragments exhibited patination resulting from the decomposition or weathering of the glass.

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Three pieces of window glass were recovered from the feature fill (Table 3). Two of the fragments were clear glass while the third piece had a light greenish tint when viewed in cross-section. The pieces were between 47.8 and 16.4 mm in diameter while their thicknesses ranged between 2.5 and 2.4 mm. The window glass represented the construction materials category Class VIII artifacts (De Vore 1987:46-47).

A variety of ferrous metal artifacts (Table 4) recovered from the feature fill include a ring handle, a machine cut nail, several can fragments, and wire (Figures 42 and 43). An oval shaped ferrous metal ring measures 7.03 cm along the long axis and 3.16 cm along the short axis. The diameter of the wire used in making the ring is 0.4 cm (U.S. standard gauge No. 12 wire). The ferrous ring is similar to handles found on wash boilers or other household domestic items. Two ferrous wire fragments which appear to mend together are constructed from U.S. standard gauge No. 13 wire. Both segments are slightly curved. Two pieces of bent strap metal are approximately 2.38 cm wide and exhibit nail holes approximately 0.31 cm in diameter. Their purpose is presently unknown but they may have been used to bind or fasten the wooden slats of shipping crates together. The machine cut nail is a 20d box or flooring nail (Nelson 1968) representing the subclass Ic machine cut nail (De Vore 1987:90-93). The shear marks or burrs on the sides of the nail are located on opposite sides indicating the nail had been cut from opposite sides of the nail plate. The head of the nail is a perfected machine made head. This type of nail was made from the late 1830s to the present time; however, machine cut nails were generally replaced by the wire nail during the late 1880s (De Vore 1987:93). The machine cut nail is bent at a 90 degree angle indicating that it had been clinched. Thirteen can fragments recovered from the feature fill include two lids and ten body fragments. Two of the lid fragments mend together. The lid appears to be from a sanitary can, which would date after 1895 (Busch 1981:97-100; Rock 1980,1989:55). It measures approximately 11.44 cm in diameter. The other small lid fragment is the cap from a hole-and-cap can. It measures approximately 4.77 cm in diameter. This would be comparable to a No. 3 size can (Rock 1989:190). The body fragments also appear to be from hole-and-cap style cans. This type of can was manufactured between 1810 and the early 1900s (Busch 1981:96-97; Rock 1980,1989:50-52). Eleven of the fragments including the lid fragments appear to be from round or cylindrical cans, while two of the fragments appear to be from square or rectangular shaped cans. The body fragments appear to be from the hole-in-cap style can and are classified as Type A, Hole-and-Cap cans by Hunt (1986b:15-29). The square or rectangular style cans were often used for canned meats including corned beef, roast beef, etc. (Rock 1980). In 1875, the rounded corner and tapered rectangular can was commercially used for canned meats by the Wilson Packing Company and the Libby, McNeill and Libby Company (Rock 1980).

One piece of wood, two pieces of coal, and one piece of shale were also recovered from the feature fill (Table 2). The wood was D-shaped and slightly tapered on the rounded side. It is possible that the wood artifact represented a wooden peg. The coal pieces may have been intended for fuel. The shale piece may have been associated with coal used for fuel. A small area on the rock appeared to be the remnant of some coal.

Faunal remains recovered from Feature 2 at Site 32WI996 (see Appendix) consisted of twelve bone and tooth elements (Table 6). Bison and mule deer are represented by a minimum number of one individual each for the two plains herbivores. The remaining faunal elements could only be classified to the category of unidentified large mammals. Green bone breaks on the bison metacarpal and femur strongly suggested human processing of the animal. Saw marks were also identified on a bison rib element. The occurrence of these wild animals as food sources was consistent with documented subsistence patterns during the fur trade period (Angus and Falk 1986:11-17).

9. CONCLUSIONS AND RECOMMENDATIONS

During the period from October 30 to November 16, 2007, the Midwest Archeological Center and Fort Union Trading Post National Historic Site staffs conducted geophysical investigations and construction monitoring of selected areas along the installation route of the Dry Prairie rural water system tie-in to the park's existing water system in Roosevelt County, Montana, and Williams County, North Dakota. The project was conducted in response to the park's request for the archeological compliance activities associated with the installation of the Dry Prairie rural water system tie-in construction project. The project location extended across the southern portion of the Mondak townsite, the open prairie between the Mondak townsite and the Fort Union Trading Post site, the open prairie between the Fort Union Trading Post site and the park's well at the Garden Coulee site, and the Garden Coulee site to the park's maintenance facility and the well house. During the investigations, 8,400 square meters or 2.08 acres were surveyed with a fluxgate gradiometer.

This report has provided an analysis of the geophysical data and construction monitoring collected during three weeks of archeological investigations at the Fort Union Trading Post National Historic Site. The magnetic data collected at the selected project areas provided information of the physical properties (magnetic) of the subsurface materials. Several small scale magnetic anomalies were identified. During the trenching activities associated with the waterline installation, two anomalies were excavated in Grid Area 5 and Grid Area 2. The feature (Feature 1 within the boundary of Site 32WI17) identified in Grid Area 5 was a small trash filled basin which probably dated to the trading post occupation period between 1829 and 1867. The small charcoal filled pit (Feature 3 within the boundary of Site 32WI17) in Grid Area 2 was also associated with the occupation of the trading post in the mid 1800s. The third feature found next to the well house during the monitoring of the trench for the installation of waterline hardware (valves) contained materials that dated to the late 1800s and early 1900s and the site was documented and recorded as Site 32WI996. This large trash dump feature may have been associated with the trading post, the Crow-Flies-High village site above Garden Coulee, or the 20th century community of Mondak. It is also possible that the feature represented the disposal of debris from the late 1800s and 1900s agricultural field activities. The presence of numerous magnetic anomalies along the west side of Grid Area 5 suggested the presence of buried materials associated with the occupation of the trading post. It is recommended that additional archeological investigations be undertaken should the park staff decide to construct a fire-suppression vehicle access and parking pad in this area. The success of the magnetic survey efforts of the present project along with previous geophysical investigations at the park indicated the high potential for the identification and evaluation of buried archeological resources within the park boundary. It is also recommended that the park staff develop a systematic plan for the complete geophysical investigations, especially a magnetic survey, of the unsurveyed portions of the park on the high terrace between the highway and the Missouri River including the Garden Coulee drainage. This portion of the park consists of 148.65 acres or 601,554.32 m^2. To date, 26.18

acres (105,950 m^2) of the park's main unit on the high terrace between the highway and the Missouri River have been surveyed with the fluxgate gradiometer. Since this portion of the park has a high potential for future development activities, a magnetic survey of the remaining 122.47 acres or 495,594.32 m^2 of the terrace is recommended. The resulting geophysical data would be essential baseline data for the park and any future development and interpretative activities.

Finally, refinement of the archeological and geophysical interpretation of the survey data is dependent on the feedback of the archeological investigations following geophysical survey (David 1995:30). Should additional archeological investigations occur at the site investigated during this project, the project archeologist is encouraged to share additional survey and excavation data with the geophysical investigators for incorporation into the investigators' accumulated experiences with archeological problems. Throughout the entire geophysical and archeological investigations, communication between the geophysicist and the archeologist is essential for successful completion of the archeological investigations. It is also important for the investigators to disseminate the results of the geophysical survey and archeological investigations to the general public. It is through their support in funds and labor that we continue to make contributions to the application of geophysical techniques to the field of archeology.

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TABLES

Table 1. Acquisition and instrumentation information for the gradiometer survey used in the grid input template.

GENERAL Acquisition	value	Instrumentation	value
Sitename	FOUS	Survey Type	Gradiometer
Map Reference		Instrument	FM36
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	2400
Traverse Interval (y)	1.0 m	Averaging	Off
Traverse Mode	ZigZag	Averaging Period	16

Table 2. Bottle Glass from Feature 2, Site 32WI996.

Item	Dimensions (mm)	Color	Weight (g)	Description
neck & finish	orifice ext. – 28.1 orifice int. – 18.4 length – 115.0 thickness – 4.9 finish height – 26.1	clear	81.54	broken at neck; 2 piece mold marks; double oil or mineral finish
body	length – 19.2 width – 13.7 thickness – 4.2	clear	1.18	curved
base	length – 35.5 width – 25.5 thickness – 5.4	clear	4.50	
body	length – 22.7 width – 12.1 thickness – 2.9	light green	1.32	curved
neck & finish	length – 41.1 width – 26.2 thickness – 6.3 finish height – 20.8	amber	13.07	oil or ring finish; mends to other piece
neck & finish	length – 44.4 width – 16.2 thickness – 6.3 finish height – 20.8	amber	5.31	oil or ring finish; mends to other piece
shoulder	length – 52.3 width – 40.2 thickness – 3.4	amber	12.18	curved
body	length – 27.7 width – 21.4 thickness – 3.6	amber	3.77	curved
body	length – 36.8 width – 24.6 thickness – 4.4	amber	5.49	curved
body	length – 25.9 width – 20.4 thickness – 3.8	amber	4.06	panel; flat; corner
base	length – 50.3 width – 22.8 thickness – 4.5	amber	6.70	panel; flat
base	length – 42.6 width – 25.8 thickness – 5.1	amber	6.89	panel; flat

Table 3. Window Glass from Feature 2, Site 32WI996.

Item	Dimensions (mm)	Color	Weight (g)
window glass	length – 47.8 width – 31.1 thickness – 2.5	clear	5.95
window glass	length – 24.8 width – 22.3 thickness – 2.3	clear	1.62
window glass	length – 16.4 width – 12.1 thickness – 2.4	light green	1.04

Table 4. Metal from Feature 2, Site 32WI996.

Item	Dimensions (mm)	Weight (g)	Description
wire	length – 72.2 diameter – 3.8	5.34	ferrous; standard gauge 13
wire	length – 109.1 diameter – 3.7	10.05	ferrous; standard gauge 13
oval ring	long axis: length, ext. – 70.3 length, int. – 61.5 short axis: length, ext. – 31.9 length, int. – 23.9 diameter – 4.0	13.28	ferrous; standard gauge 12
machine cut nail	20 d (penny)	16.31	clinched; machine formed head; shear alternating sides
strap metal	width – 23.4 thickness – 1.4	16.72	ferrous, bent, nail holes (3.1 mm diameter)
strap metal	width – 23.8 thickness – 1.0	4.26	ferrous, bent, nail holes (3.2 mm diameter)
hole-and-cap lid	diameter – approx. 47.73 thickness – 1.0	2.34	ferrous fragment
sanitary can lid (2 fragments)	diameter – approx. 114.35 thickness – 1.0	9.54	ferrous; ribbed; smooth cut along lid edge; No. 3 can size
hole-and cap can body fragments (9 pieces)			
Rectangular can body fragments (2 pieces)			one contains seam

Table 5. Floral and stone materials from Feature 2, site 32WI996.

Item	Dimensions	Weight	Description
wood	length – 46.2 diameter – 16.6	2.18	possible wooden peg fragment
coal (2 pieces)	diameters – 25.0 and 23.11	4.72	
shale	diameter – 40.9	9.52	

Table 6. Faunal remains from Feature 2, site 32WI996 (adapted from Appendix).

Taxonomic Group	Common name	Element	Description
Bison bison	bison	incisor	worn
Bison bison	bison	rib	saw marks
Bison bison	bison	left metacarpal	green bone break
Bison bison	bison	femur	green bone break
Bison bison	bison	left calcaneum	tuber calcis portion
Odocoileus hemionus	mule deer	2nd thoracic vertebrae	body portion
Odocoileus hemionus	mule deer	7th cervical vertebrae	body portion
Odocoileus hemionus	mule deer	thoracic vertebrae	body fragment
Odocoileus hemionus	mule deer	left rib	head portion
Odocoileus hemionus	mule deer	right rib	neck portion
	Unidentified large mammal	long bone	shaft fragment
	Unidentified large mammal	indeterminate	

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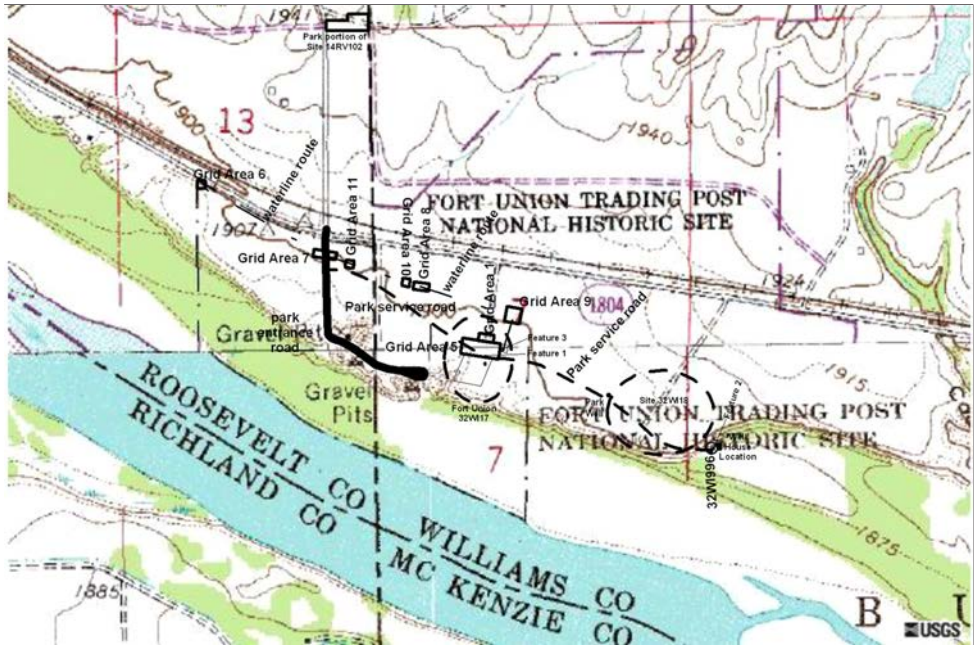
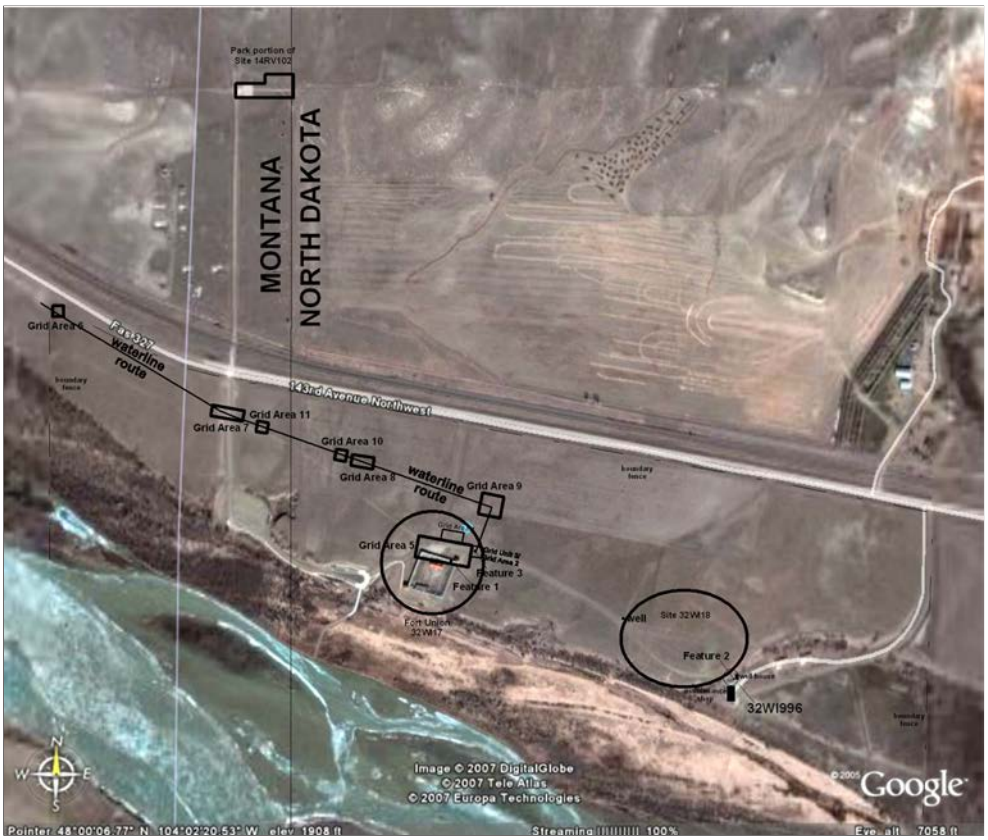
FIGURES



a) USGS 7.5 minute topographic map (3 km W of Buford, North Dakota, United States, dated 01 July 1989)



b) GOOGLE EARTH aerial photograph (3 km W of Buford, North Dakota, United States, dated 2007).

Figure 1. Location of the Fort Union Trading Post National Historic Site, Roosevelt County, Montanta, and Williams County, North Dakota.

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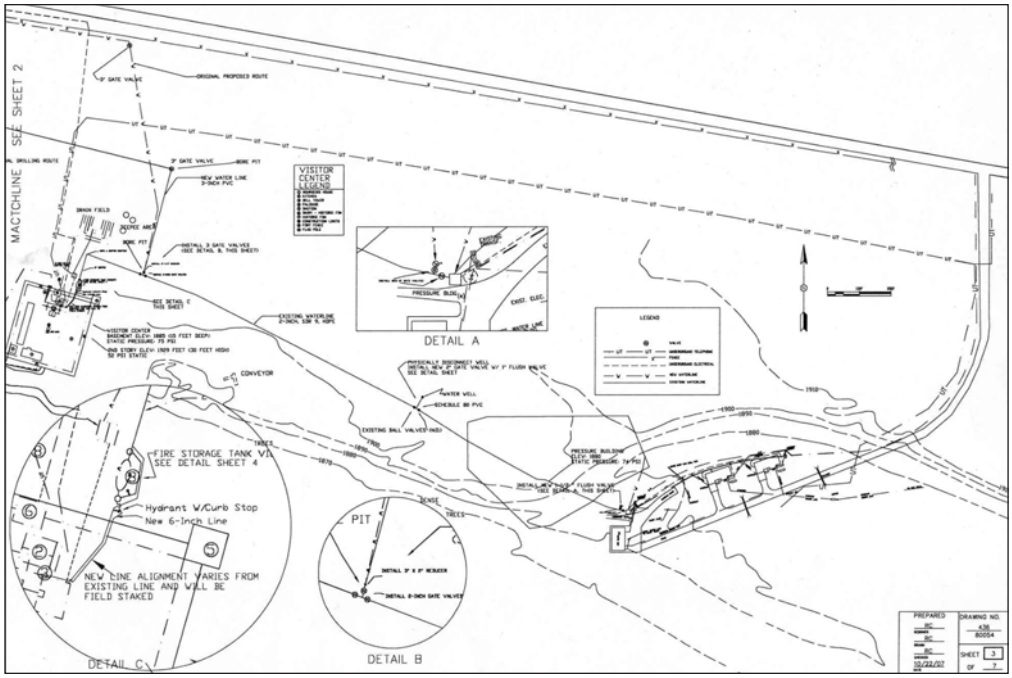
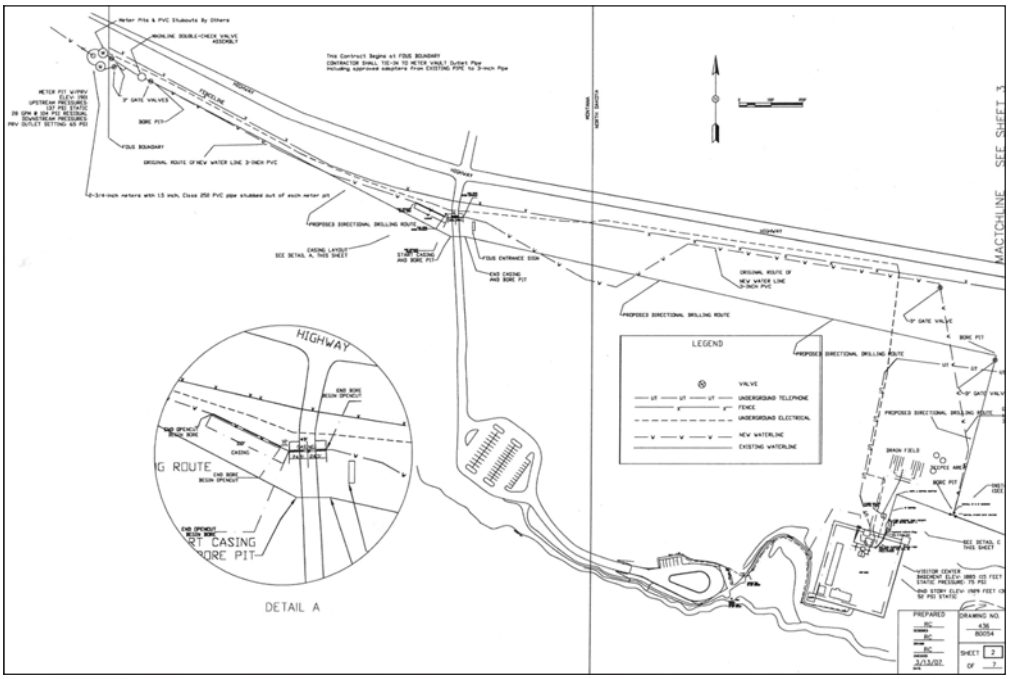


a) western half of construction project



b) eastern half of construction project

Figure 2. Dry Prairie rural water system tie-in construction at Fort Union Trading Post National Historic Site.

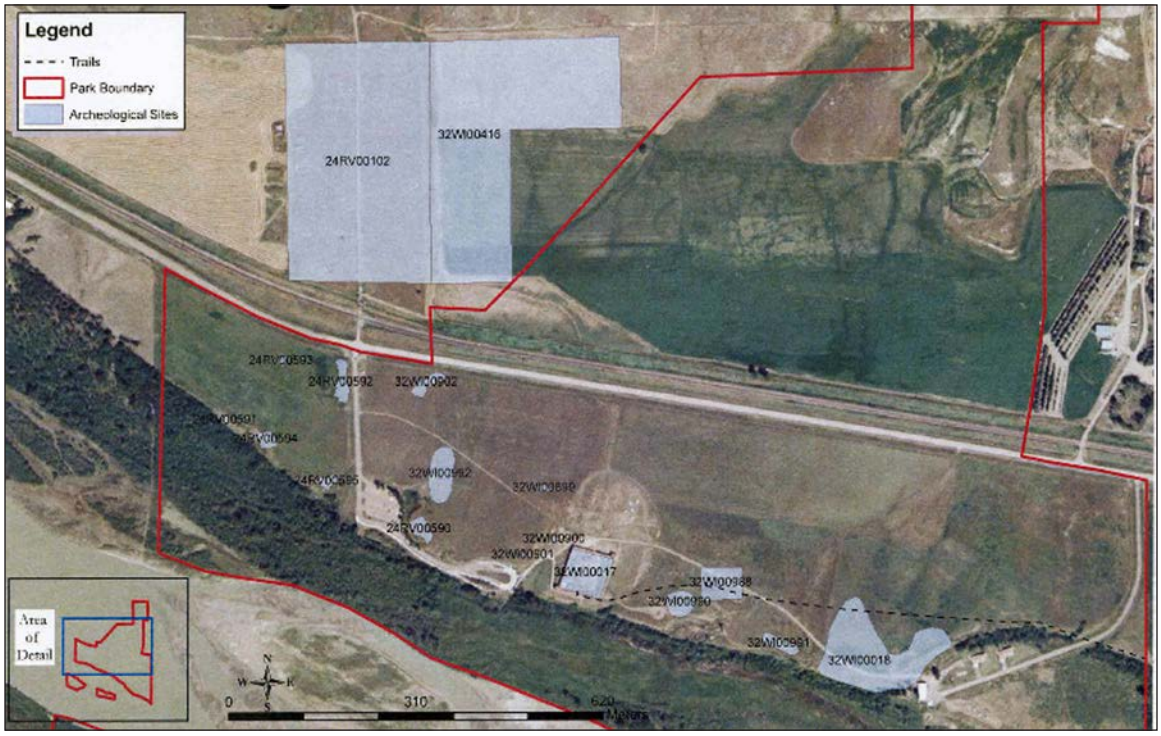


Figure 3. Location of documented sites within the Fort Union Trading Post National Historic Site.

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Figure 4. Geophysical project areas at the Fort Union Trading Post National Historic Site, Montana and North Dakota (adapted from Google Earth).

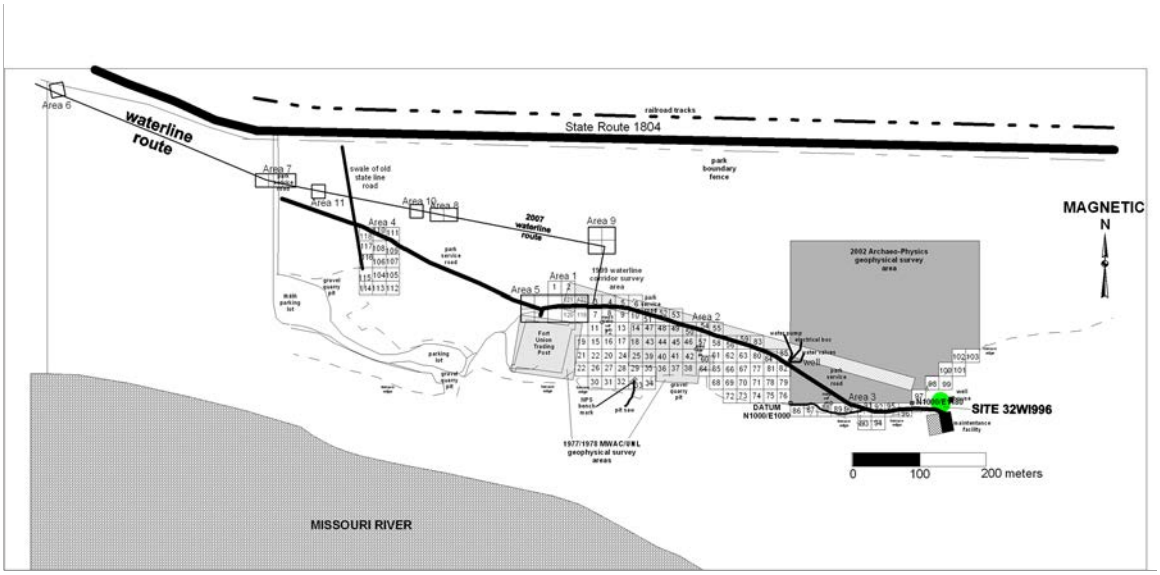
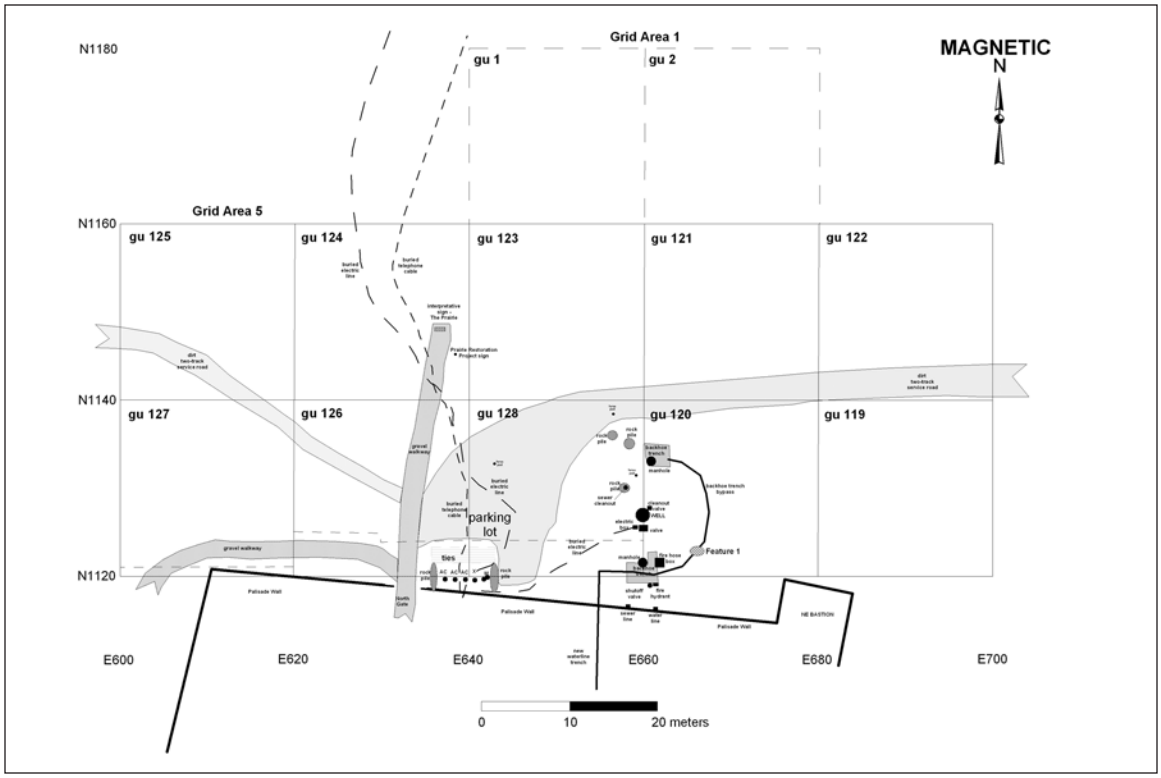


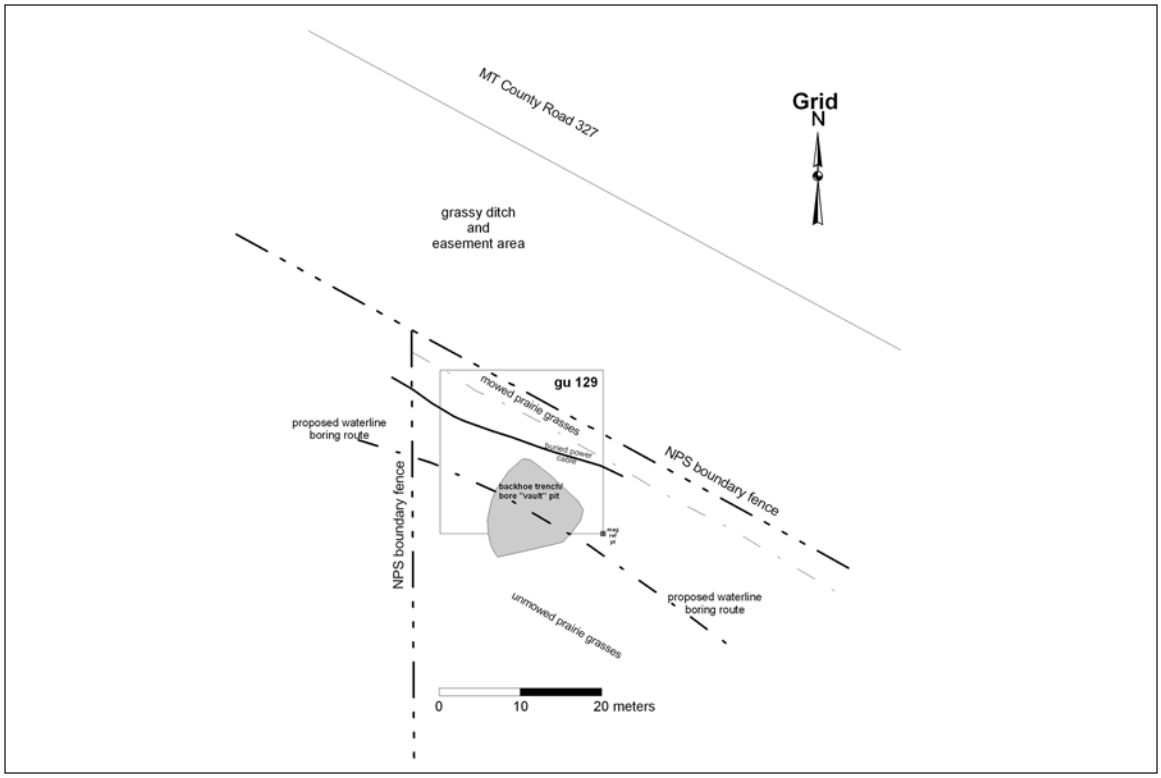
Figure 5. Geophysical project areas associated with present project and previous archeological investigations.



a) sketch map of Grid Area 5

b) general view of middle of Grid Area 5 (view to the west)

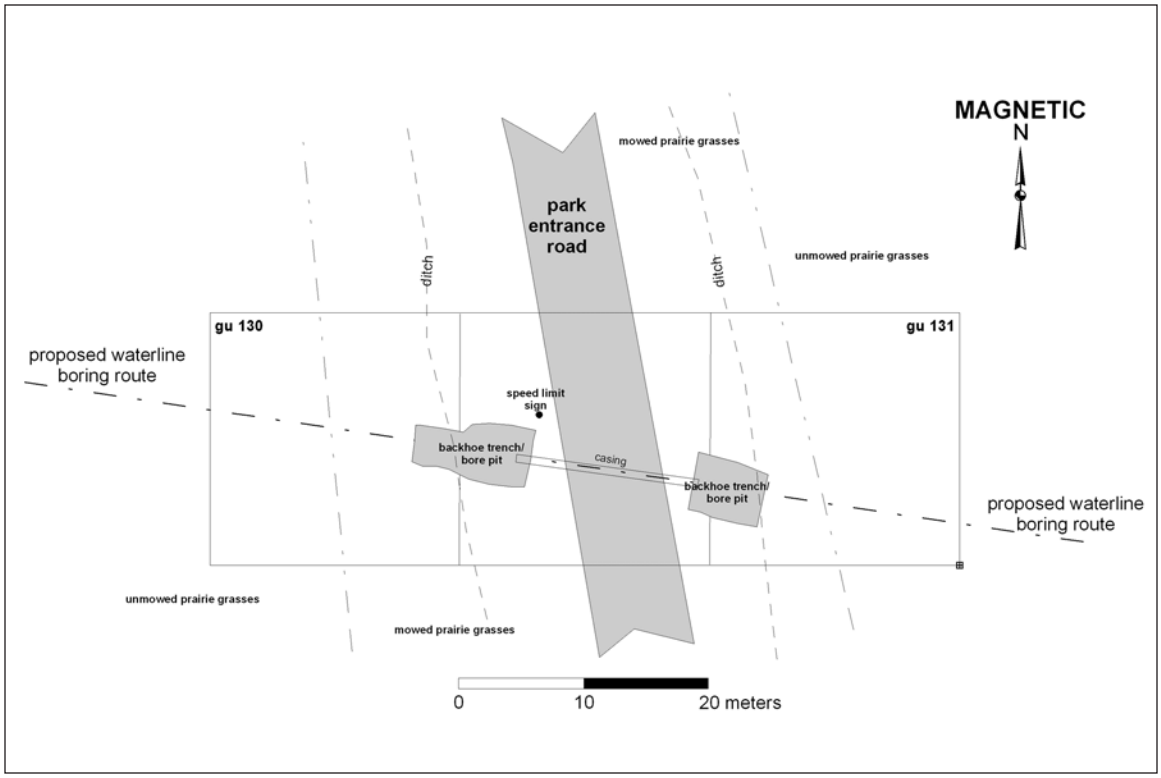
Figure 6. Grid Area 5 geophysical project area on north side of reconstructed trading post.



a) sketch map of Grid Area 6

b) general view of Grid Area 6 (view to the west southwest)

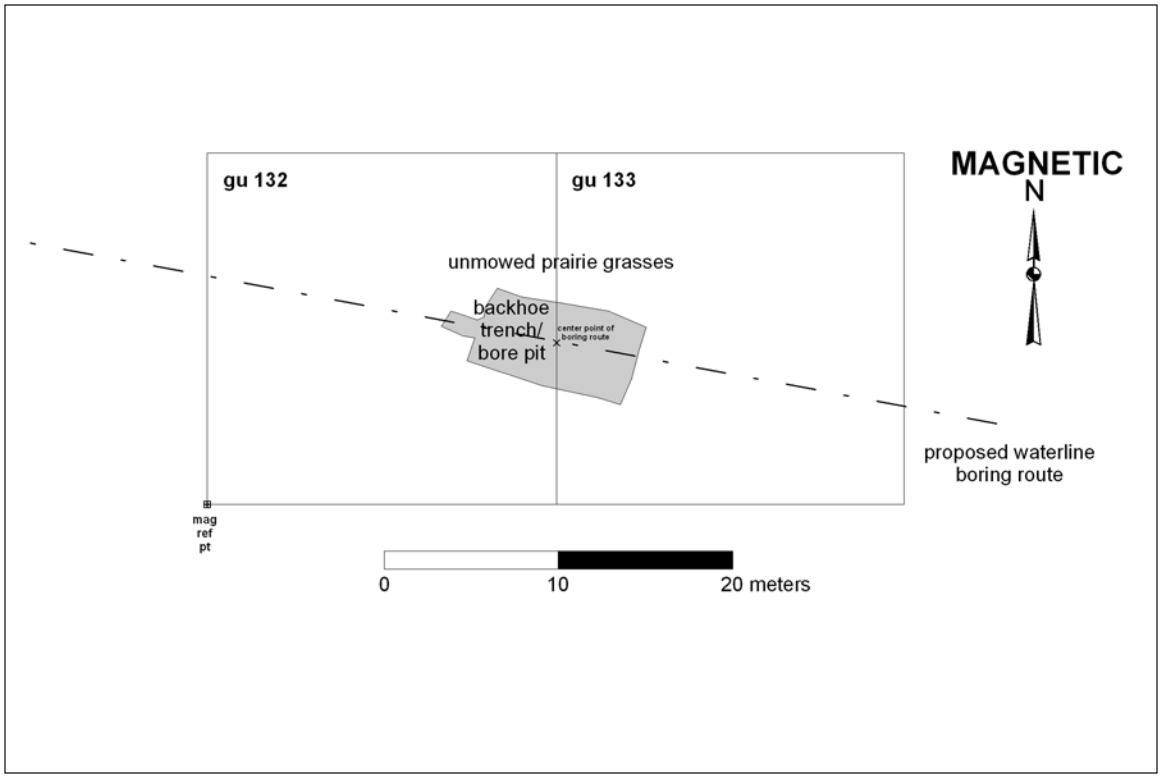
Figure 7. Grid Area 7 in northwest corner of main park unit.



a) sketch of map Grid Area 7

b) general view of Grid Area 7 (view to the east)

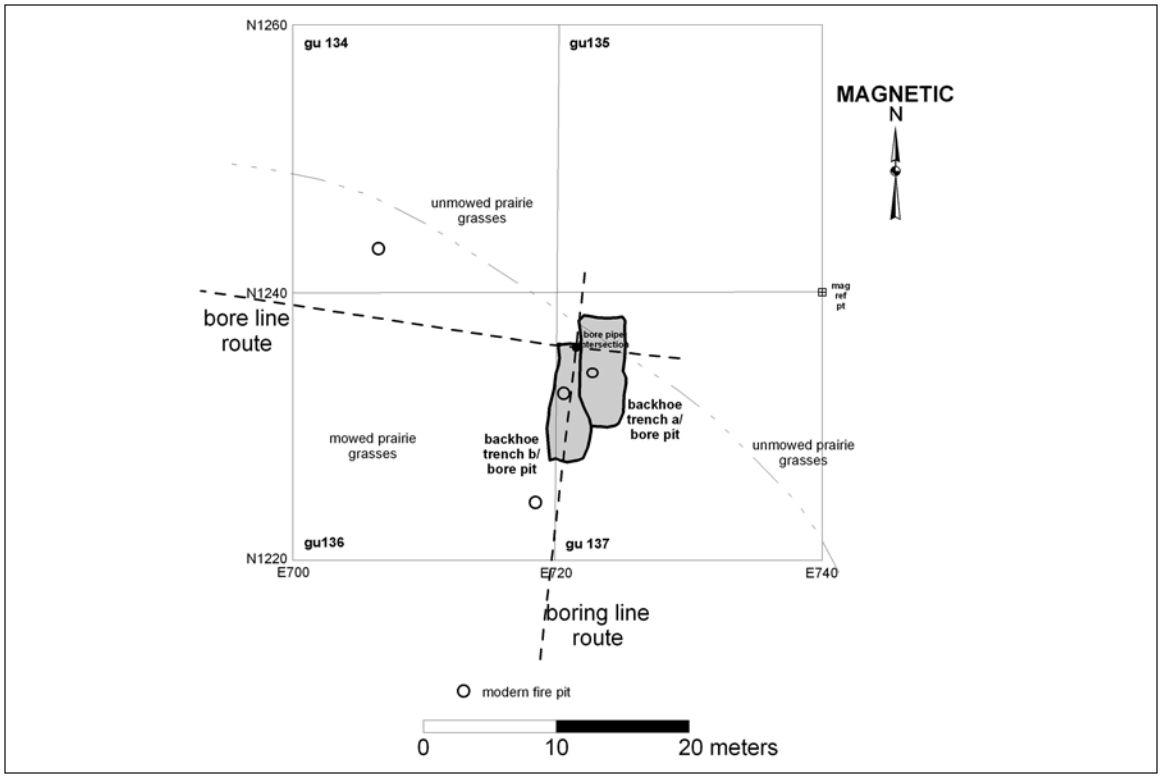
Figure 8. West side of Grid Area 7 at the park entrance road.



a) sketch map of Grid Area 8

b) general view of Grid Area 8 (view to the southeast)

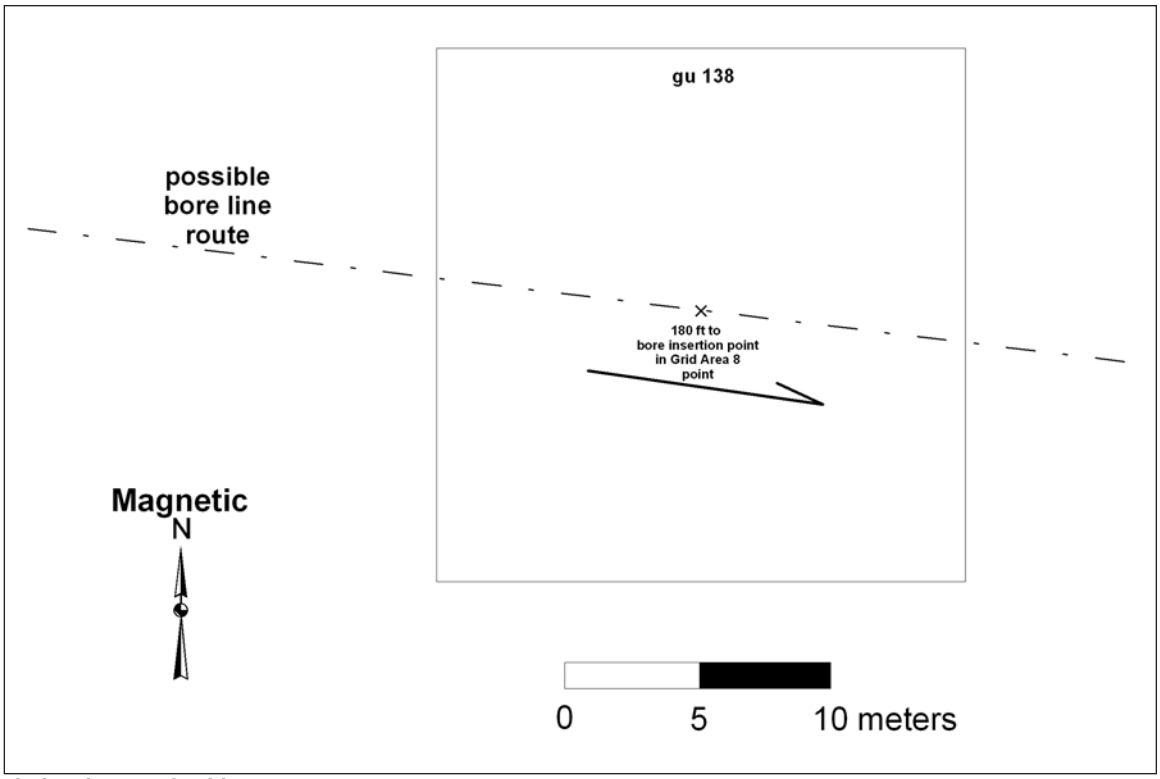
Figure 9. Grid Area 8 approximately half way between Grid Area 7 and Grid Area 9



a) sketch map of Grid Area 9

b) general view of Grid Area 9 (view to the southwest)

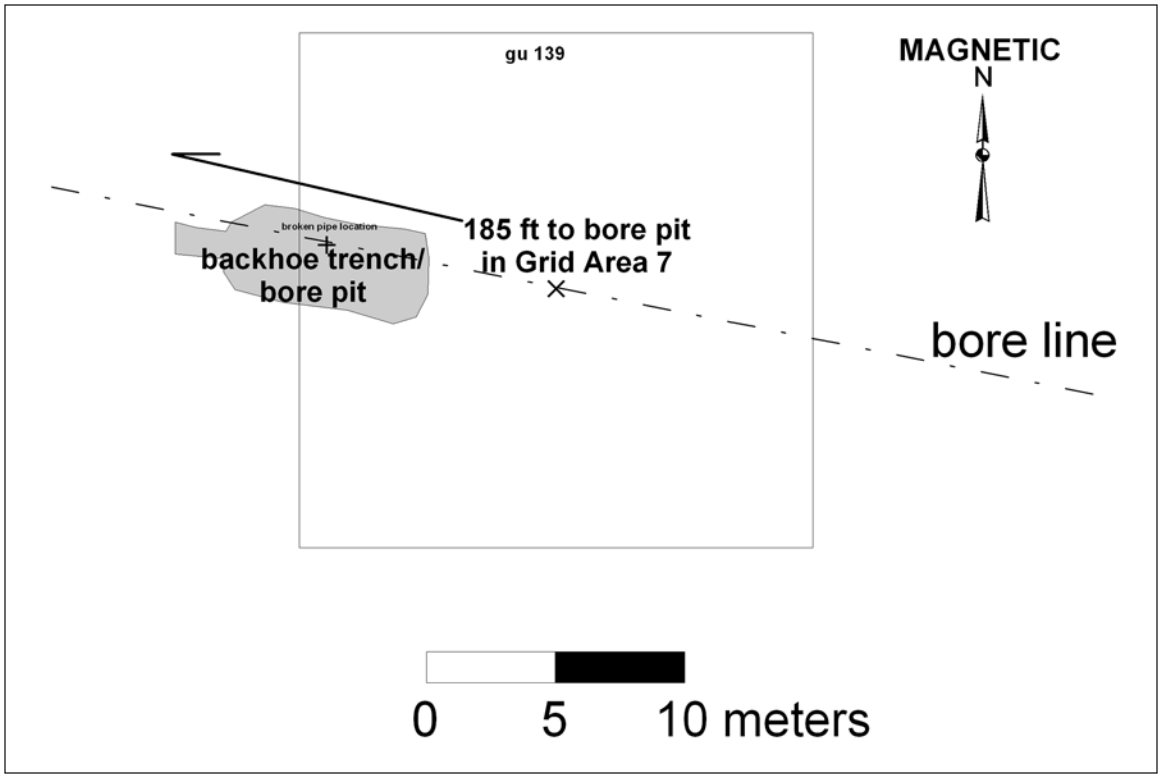
Figure 10. Grid Area 9 northeast of reconstructed trading post



a) sketch map of Grid Area 10

b) general view of Grid Area 10 (view to the northeast)

Figure 11. Grid Area 10 to the west of Grid Area 8.



a) Sketch map of Gird Area 11

b) general view of Grid Area 11 (view to the west)

Figure 12. Grid Area 11 to the east of Grid Area 7.

Figure 13. Conducting the magnetic survey with a Geoscan Research FM36 fluxgate gradiometer in Grid Area 7 (view to the north northwest).

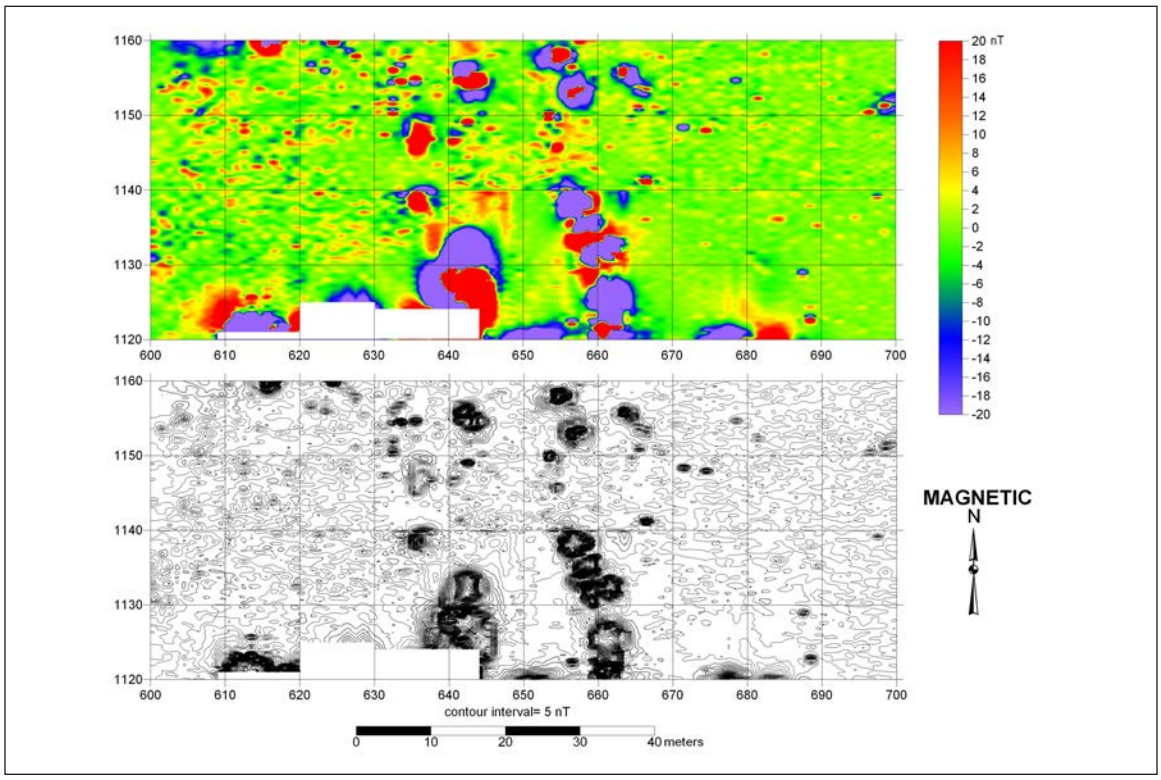


Figure 14. Magnetic image and contour data plots of Grid Area 5.

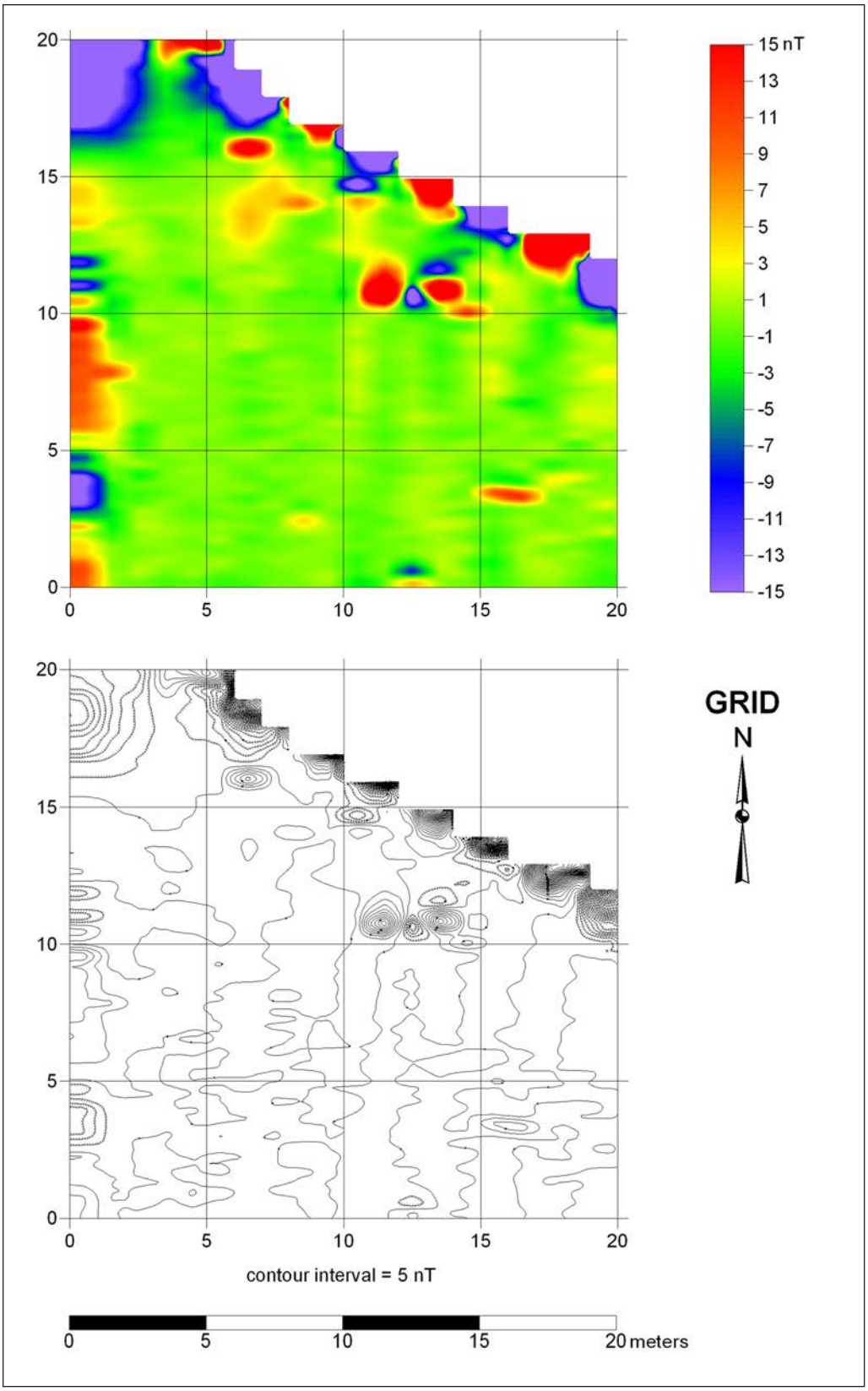


Figure 15. Magnetic image and contour data plots of Grid Area 6.

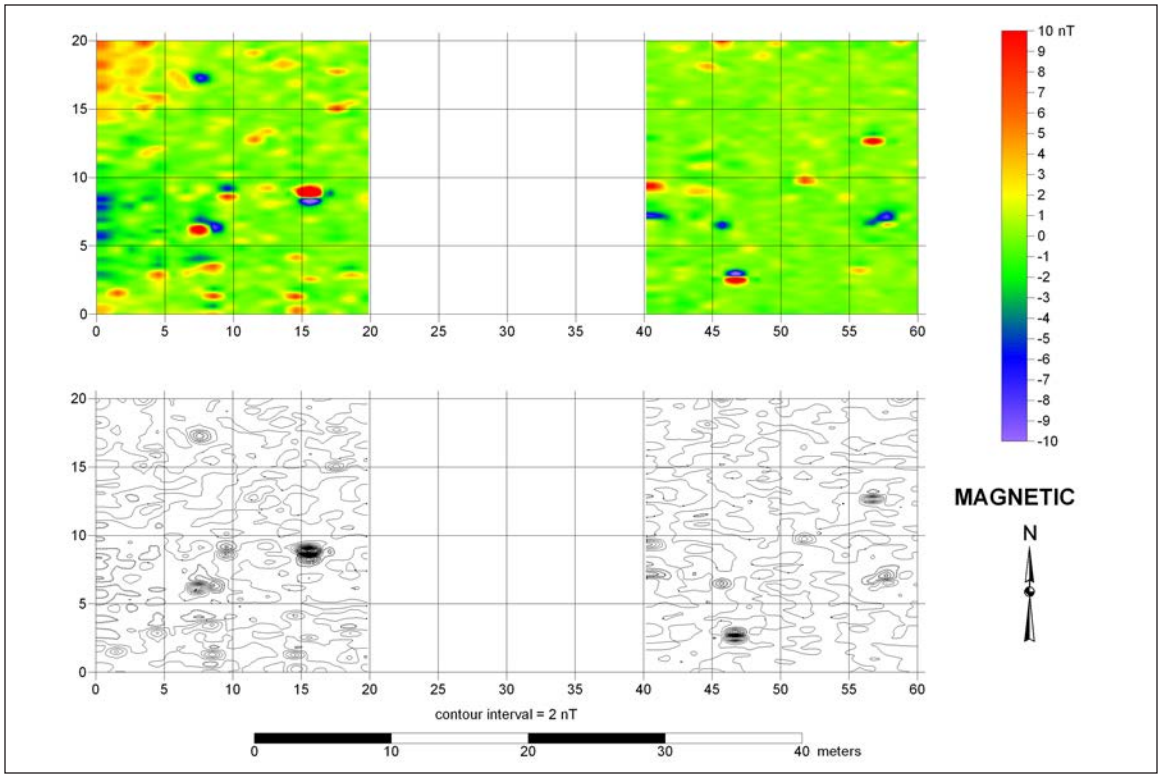


Figure 16. Magnetic image and countour data plots of Grid Area 7.

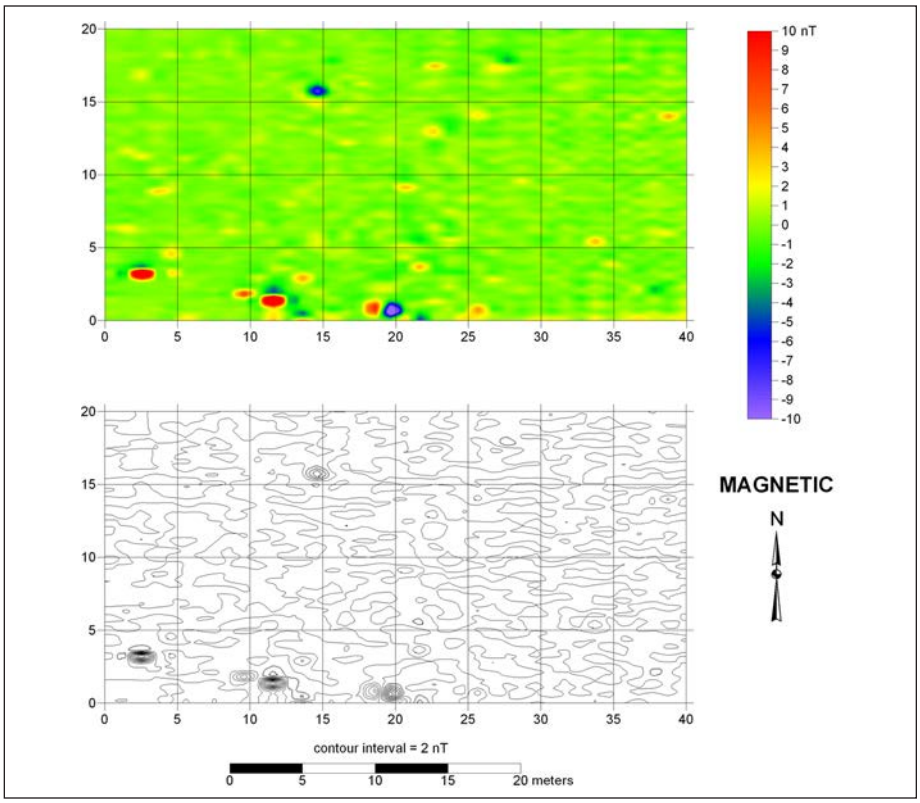


Figure 17. Magnetic image and countour data plots of Grid Area 8.

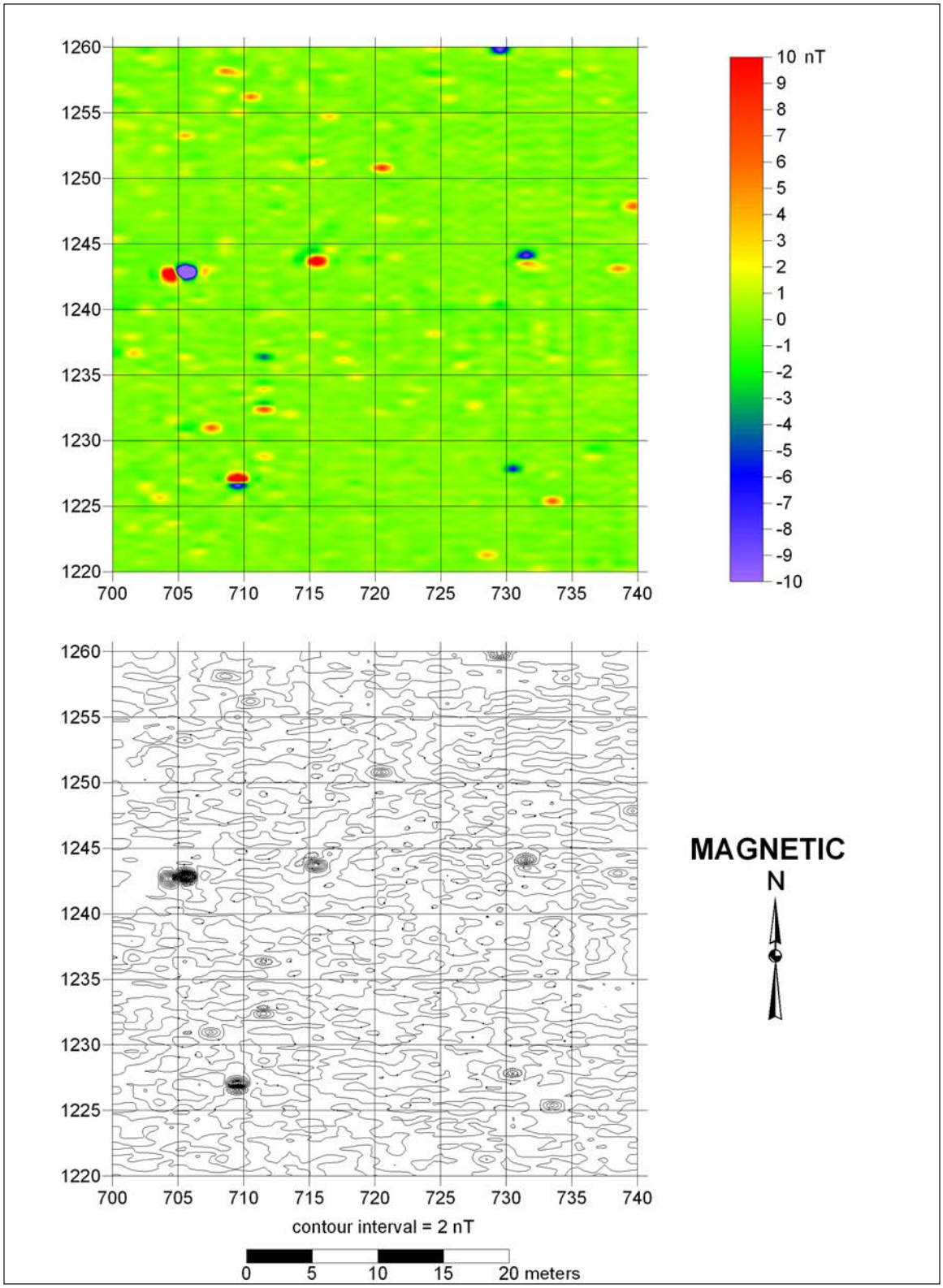


Figure 18. Magnetic image and contour data points of Grid Area 9.

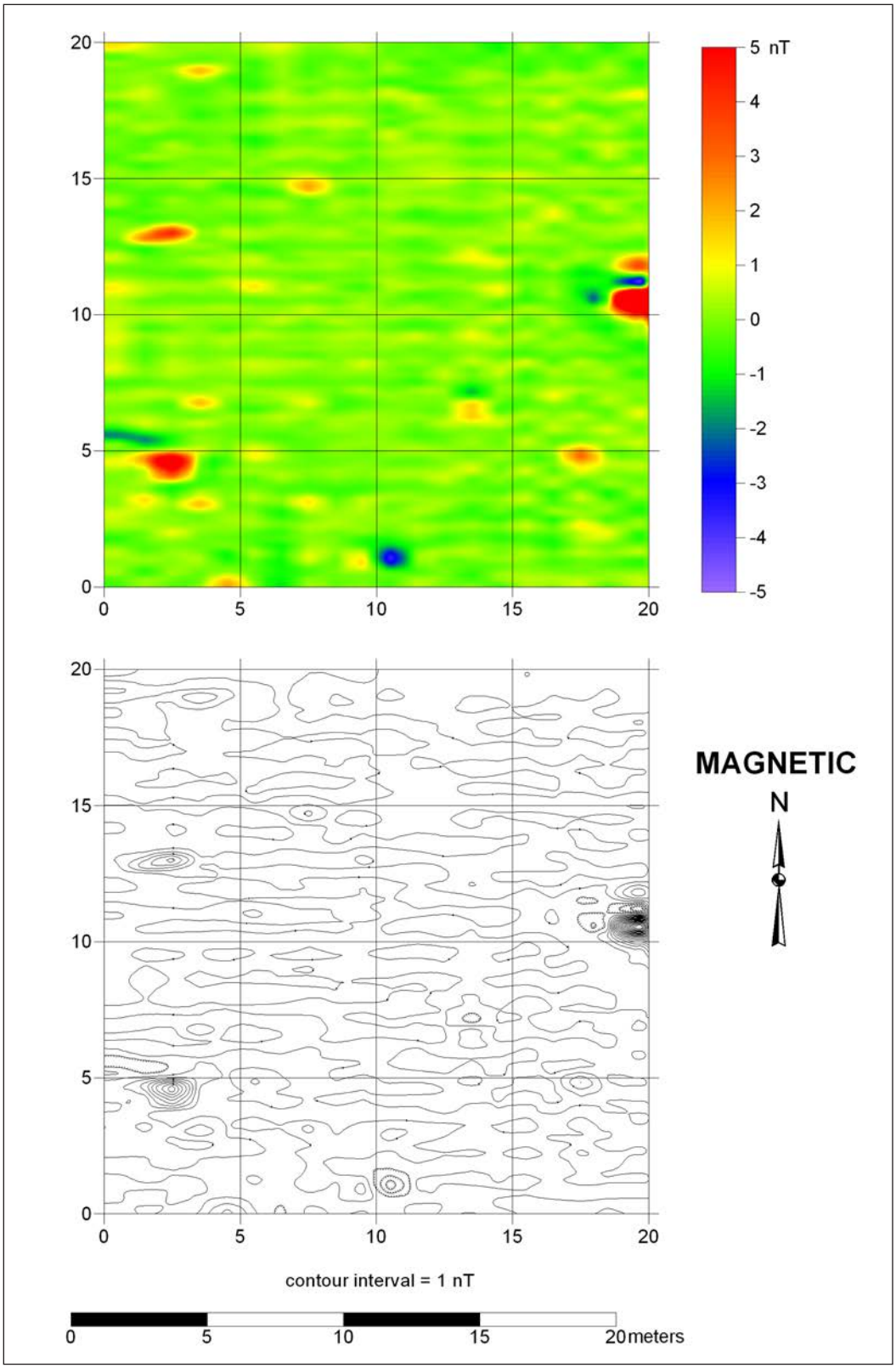


Figure 19. Magnetic image and contour data plots of Grid Area 10.

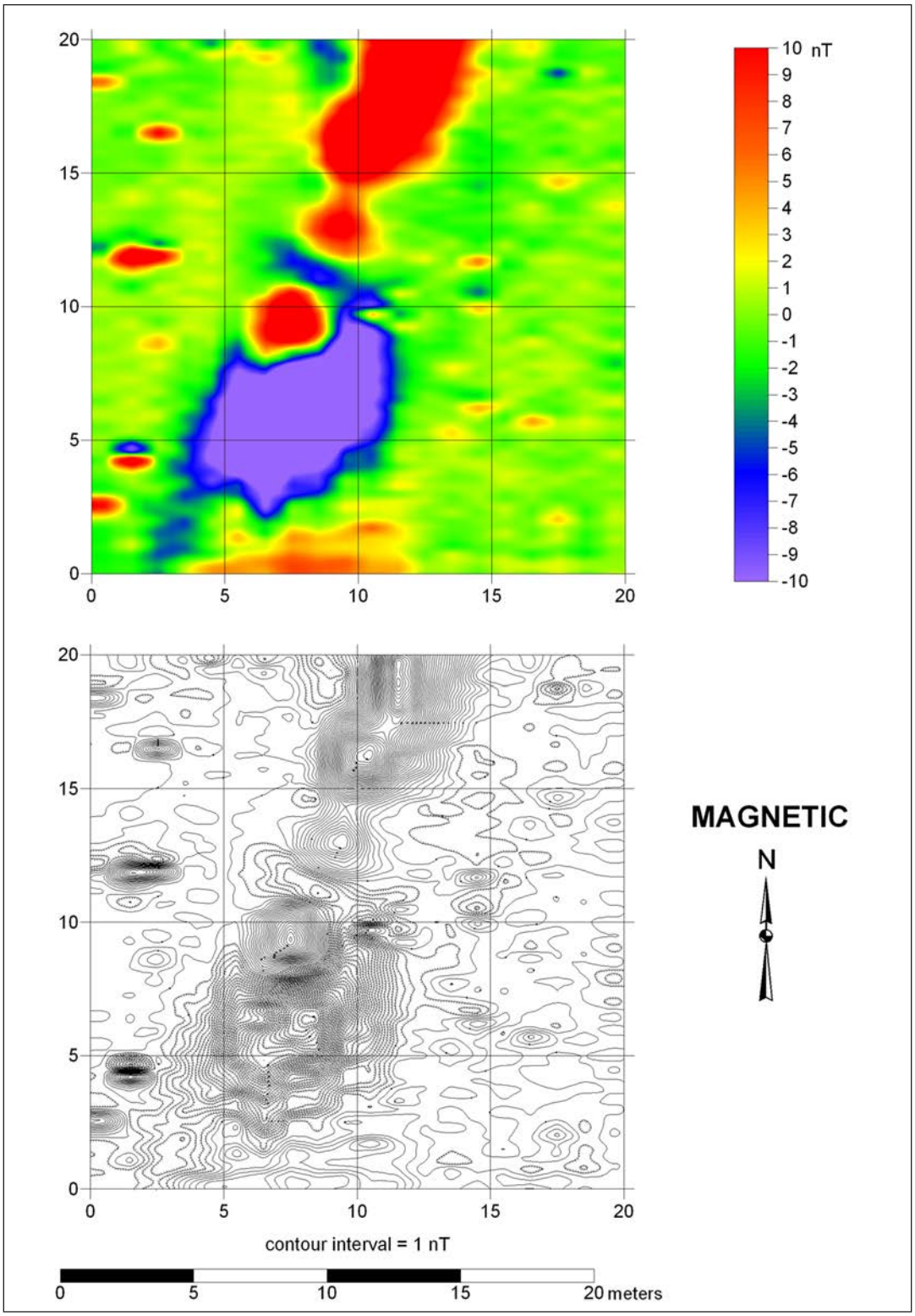


Figure 20. Magnetic image contour data plots of Grid Area 11.

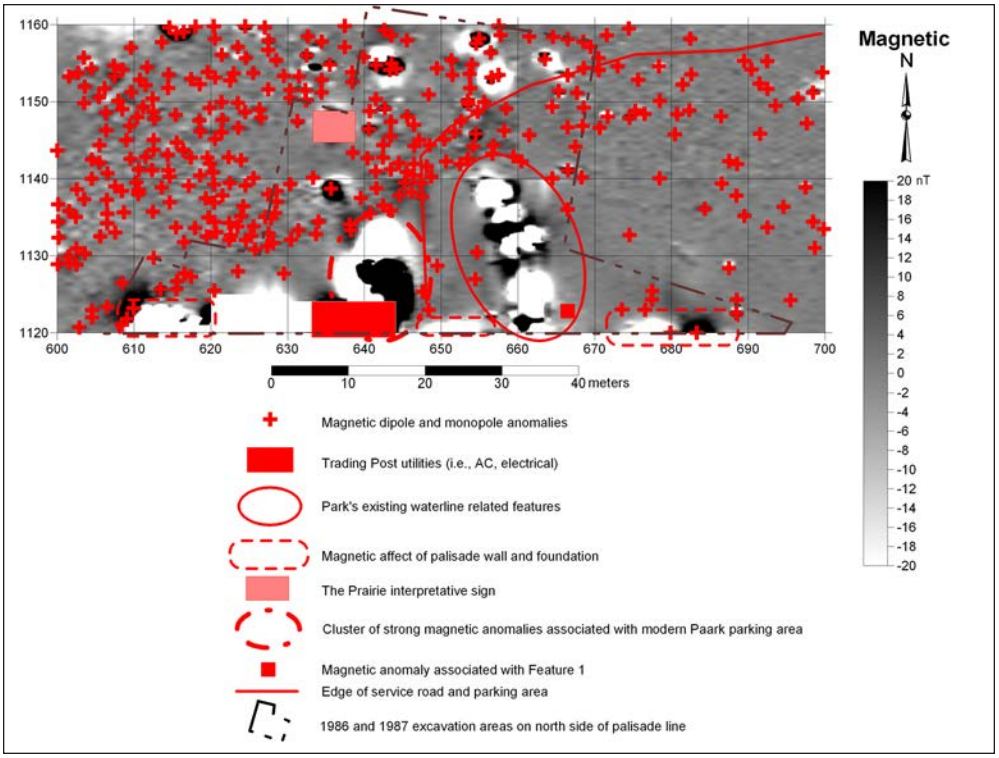


Figure 21. Interpretation of the magnetic data from Grid Area 5.

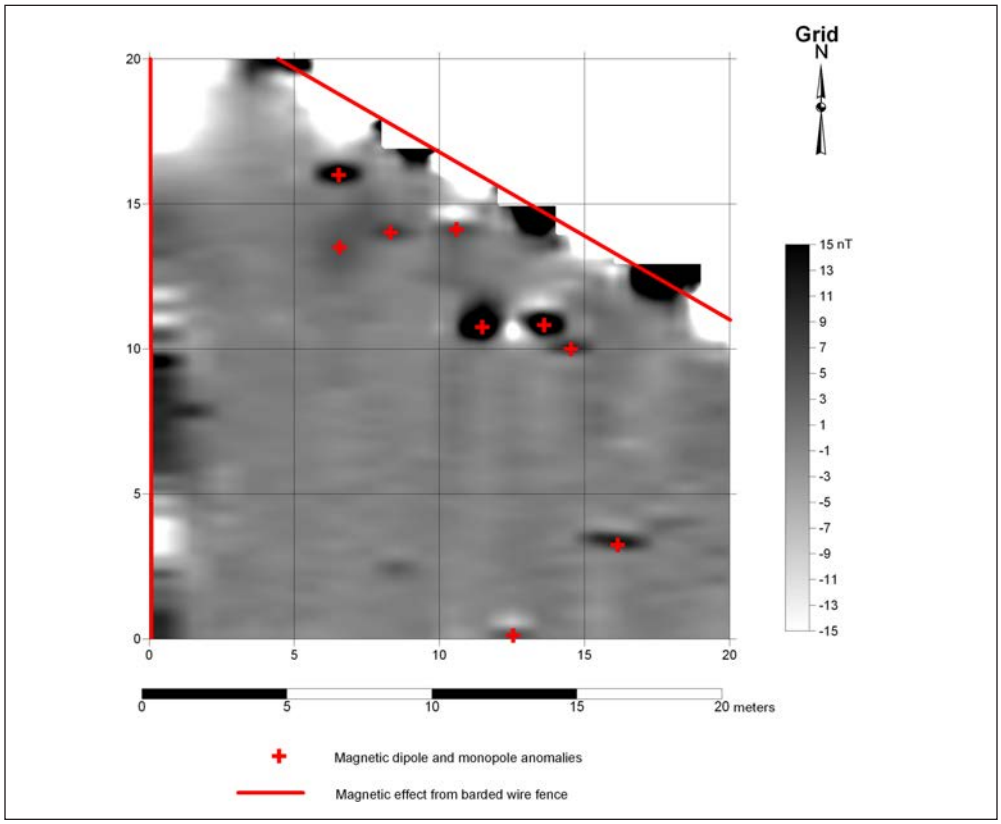


Figure 22. Interpretation of the magnetic data from the Grid Area 6.

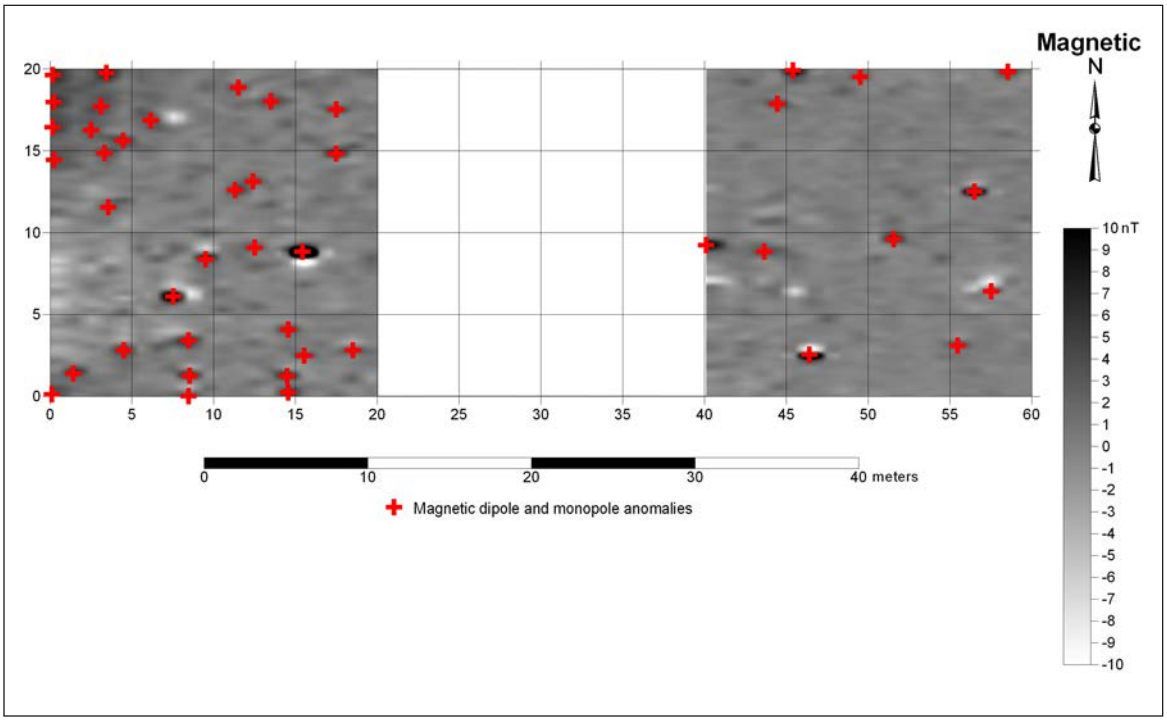


Figure 23. Interpretation of the magnetic data from the Grid Area 7.

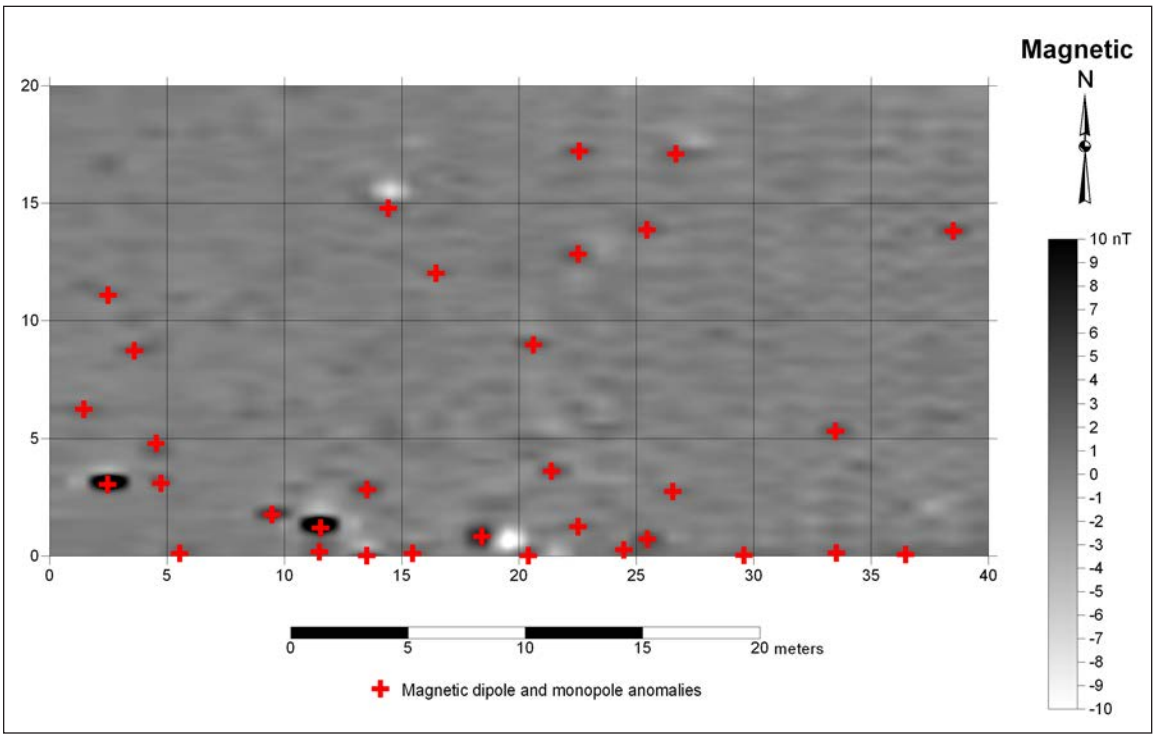


Figure 24. Interpretation of the magnetic data from the Grid Area 8

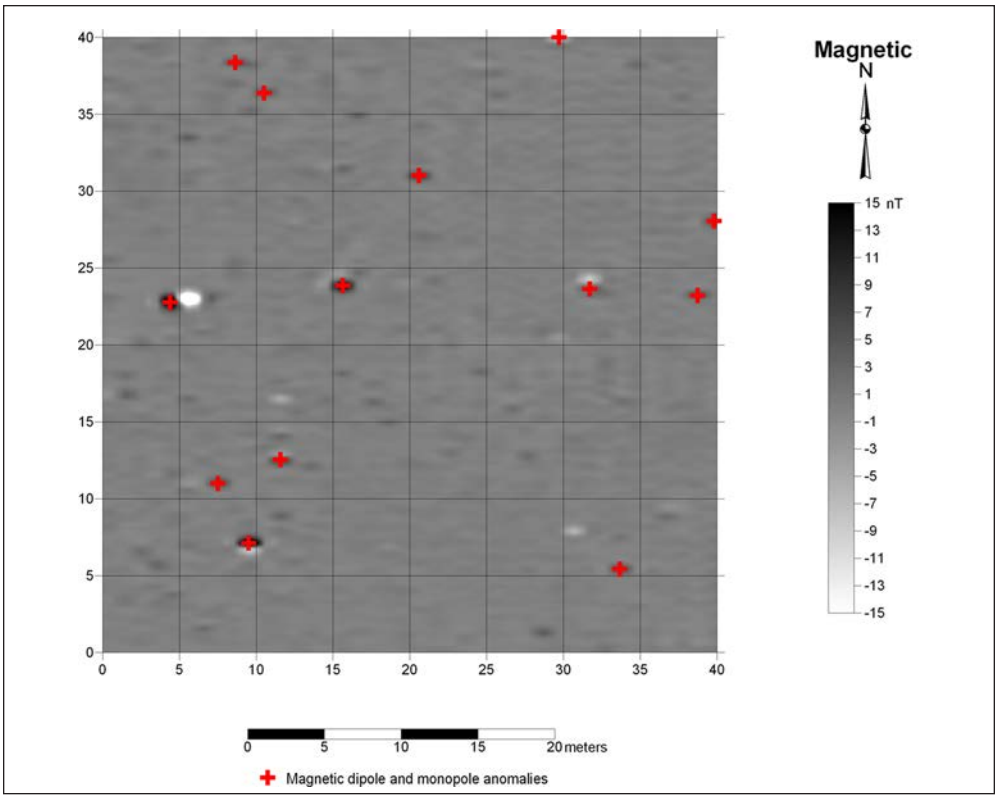


Figure 25. Interpretation of the magnetic data from the Grid Area 9.

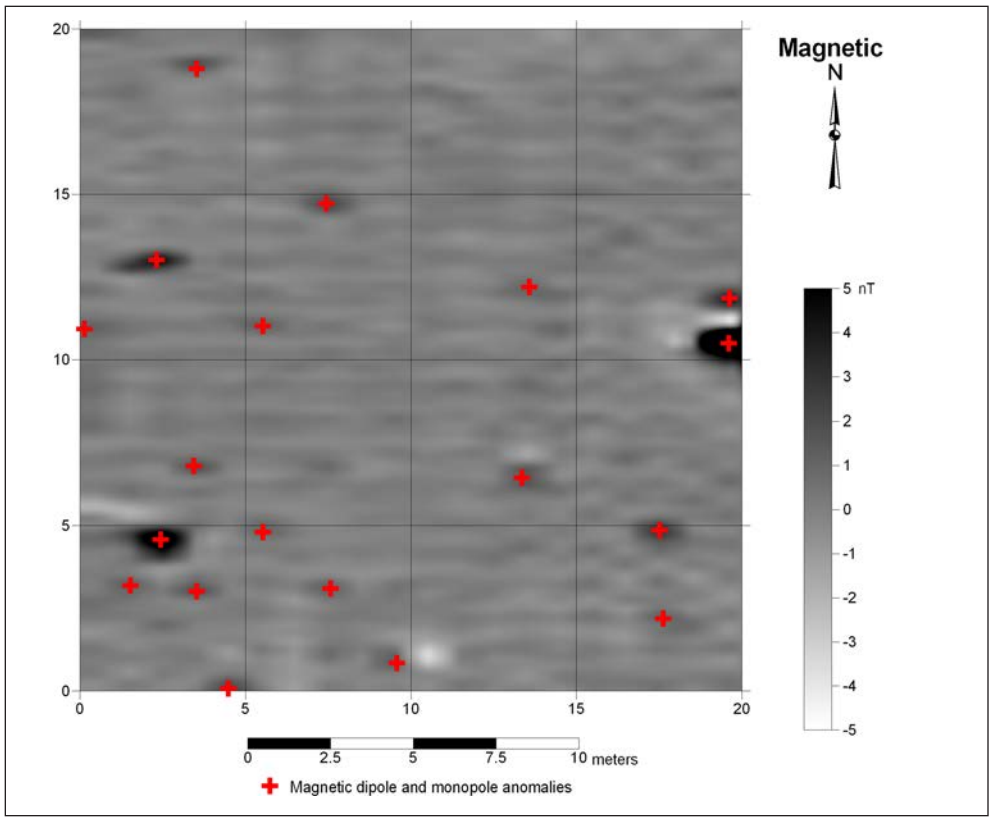


Figure 26. Interpretation of the magnetic data from the Grid Area 10.

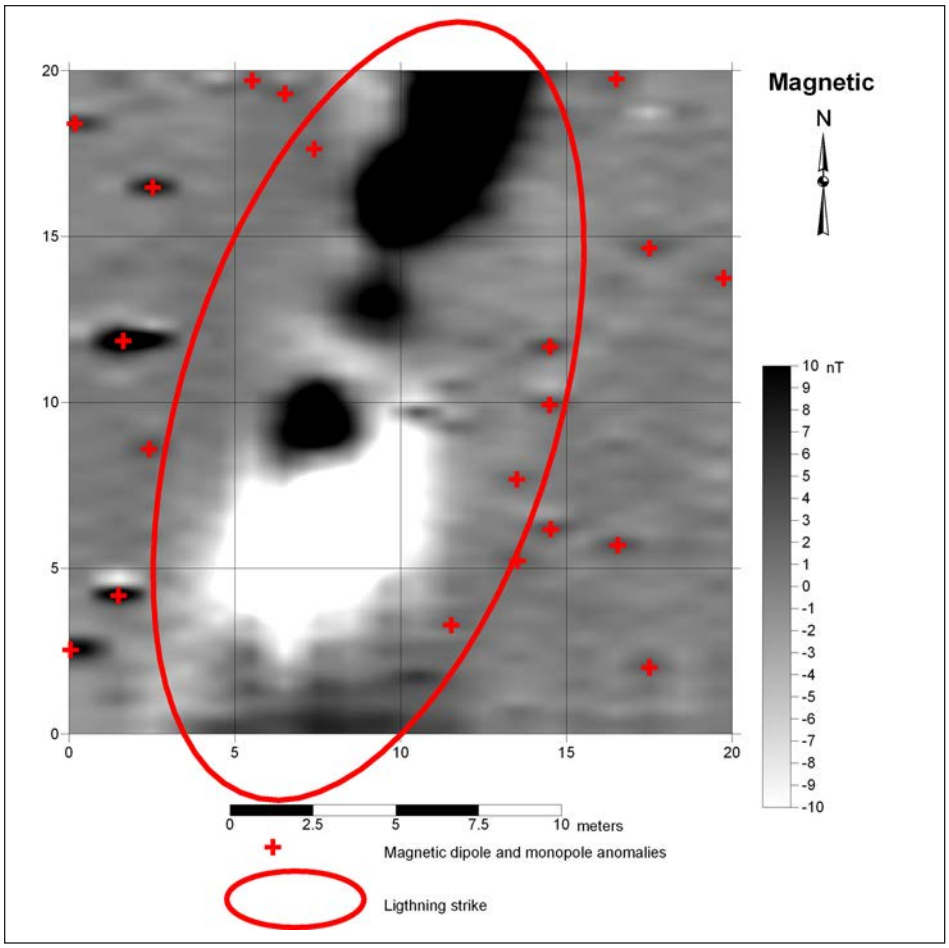


Figure 27. Interpretation of the magnetic data from Grid Area 11.

Figure 28. Caterpillar 420D backhoe loader in operation along outside of North Palisade Wall (view to southwest).

Figure 29. Caterpillar 303 CR mini hydraulic excavator in operation next to the east side of the kitchen (view to the southeast).

Figure 30. Volvo EC330BL$_{LC}$ tracked excavator in operation in Grid Area 6 near corner of park boundary fence (view to the north northeast).

a) view of Ditch Witch JT 4020 all terrain directional drilling rig (view to the southwest

b) view of drilling operation in progress (view to the east)

Figure 31. Ditch Witch JT 4020 all terrain directional drilling rig in operation on east side of park entrance road.

Figure 32. Excavation of the trench for bypass of the 500 gallon fire suppression storage tank (view to the southwest).

Figure 33. Feature 1 located in backhoe trench at Site 32WI17 (view to southwest).

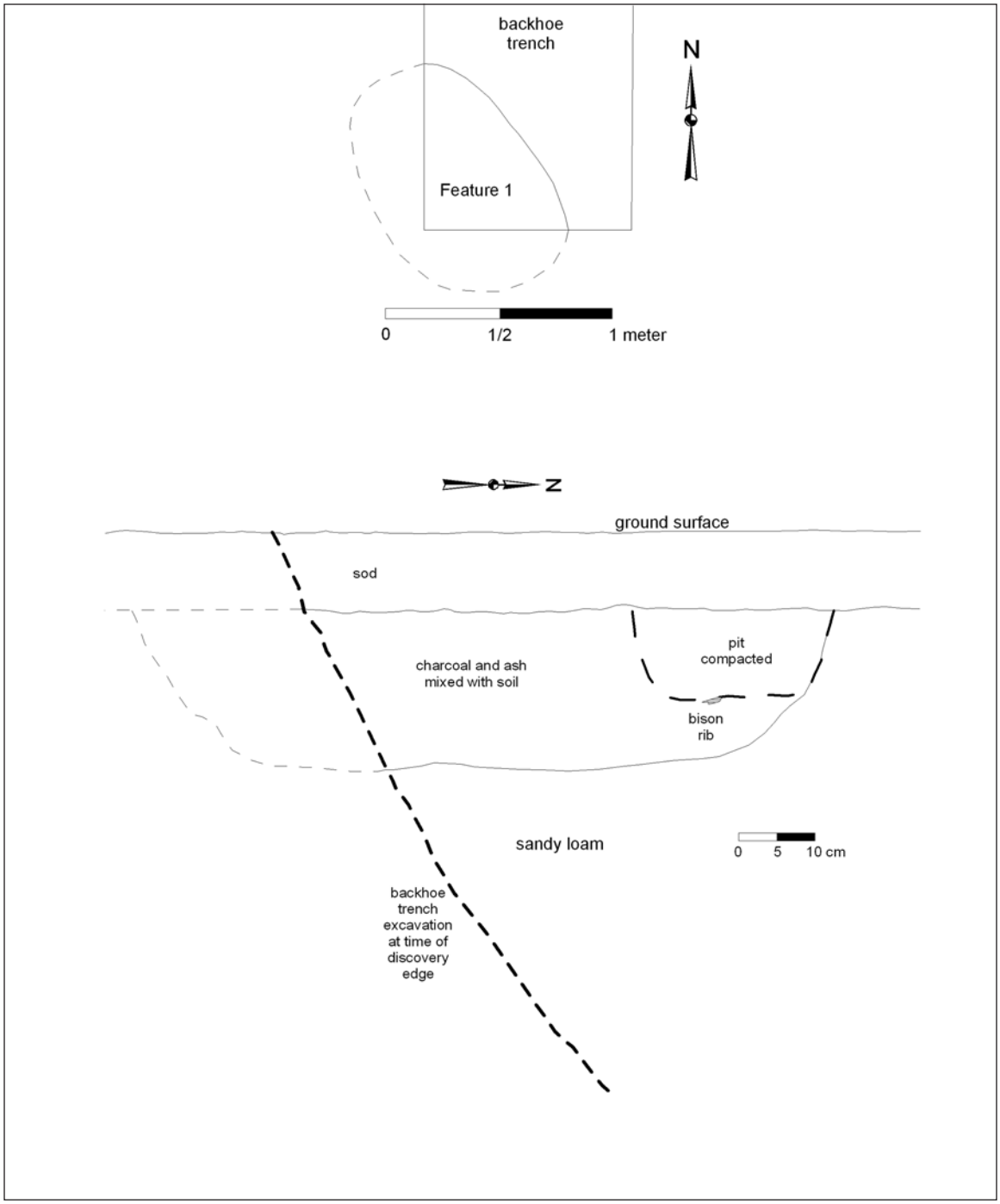


Figure 34. Drawing of Feature 1 at Site 32WI17.

Figure 35. Excavation of trench next to west side of well house at Site 32WI996 (view to the east).

Figure 36. South side of Feature 2 at Site 32WI996 (view to the south).

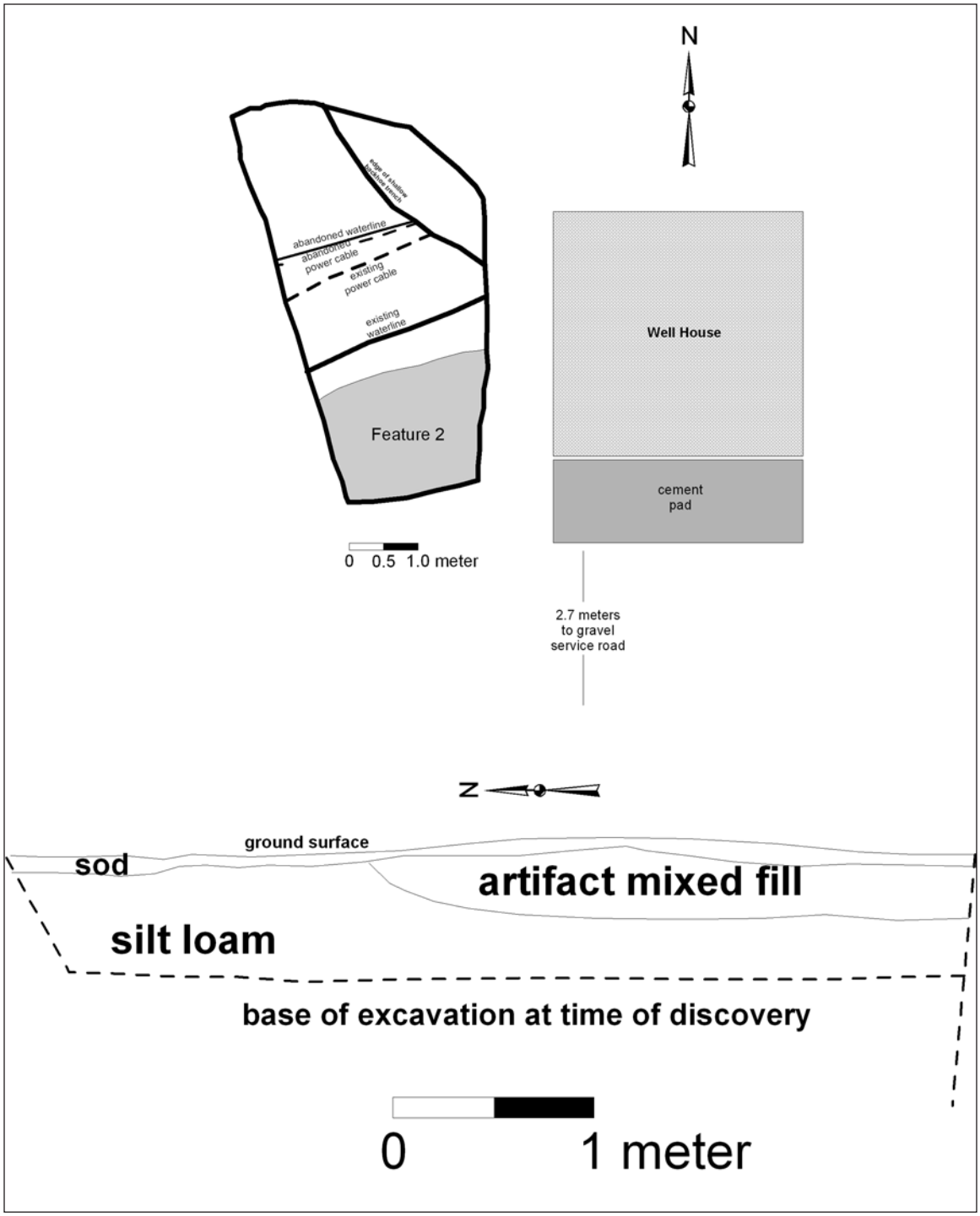


Figure 37. Drawing of Feature 2 at Site 34WI996 next to west side of well house.

Figure 38. Excavation of existing waterline trench in Grid Area 2 next to park service road (view to the east).

Figure 39. Feature 3 at Site 32WI17 in trench wall (view to the north).

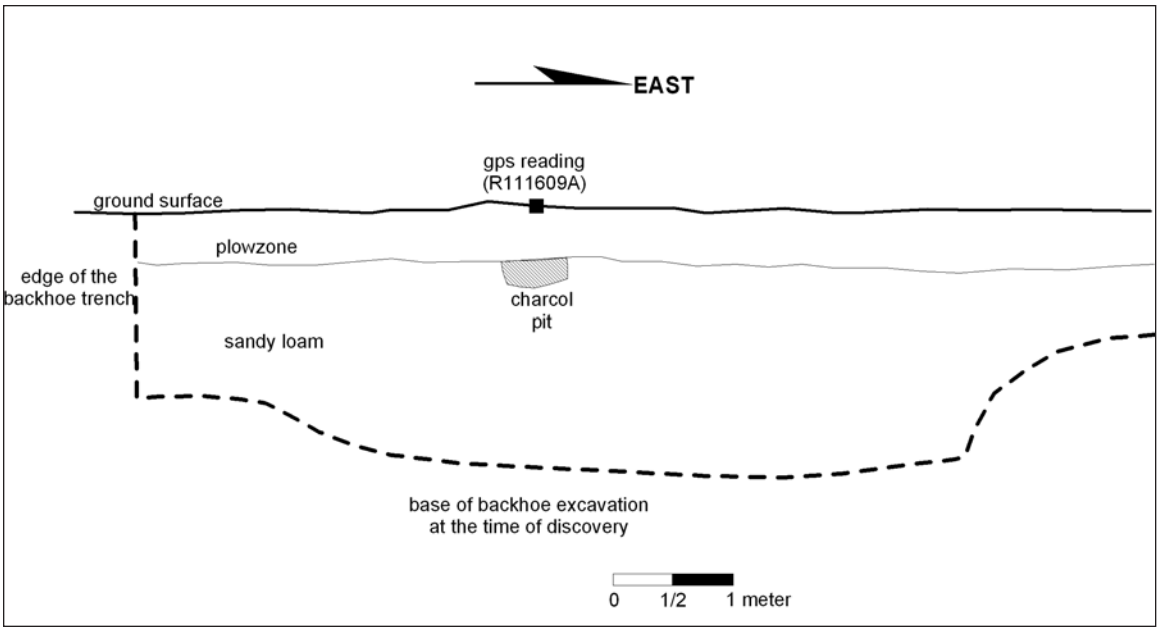


Figure 40. Drawing of Feature 2 at Site 32WI17.

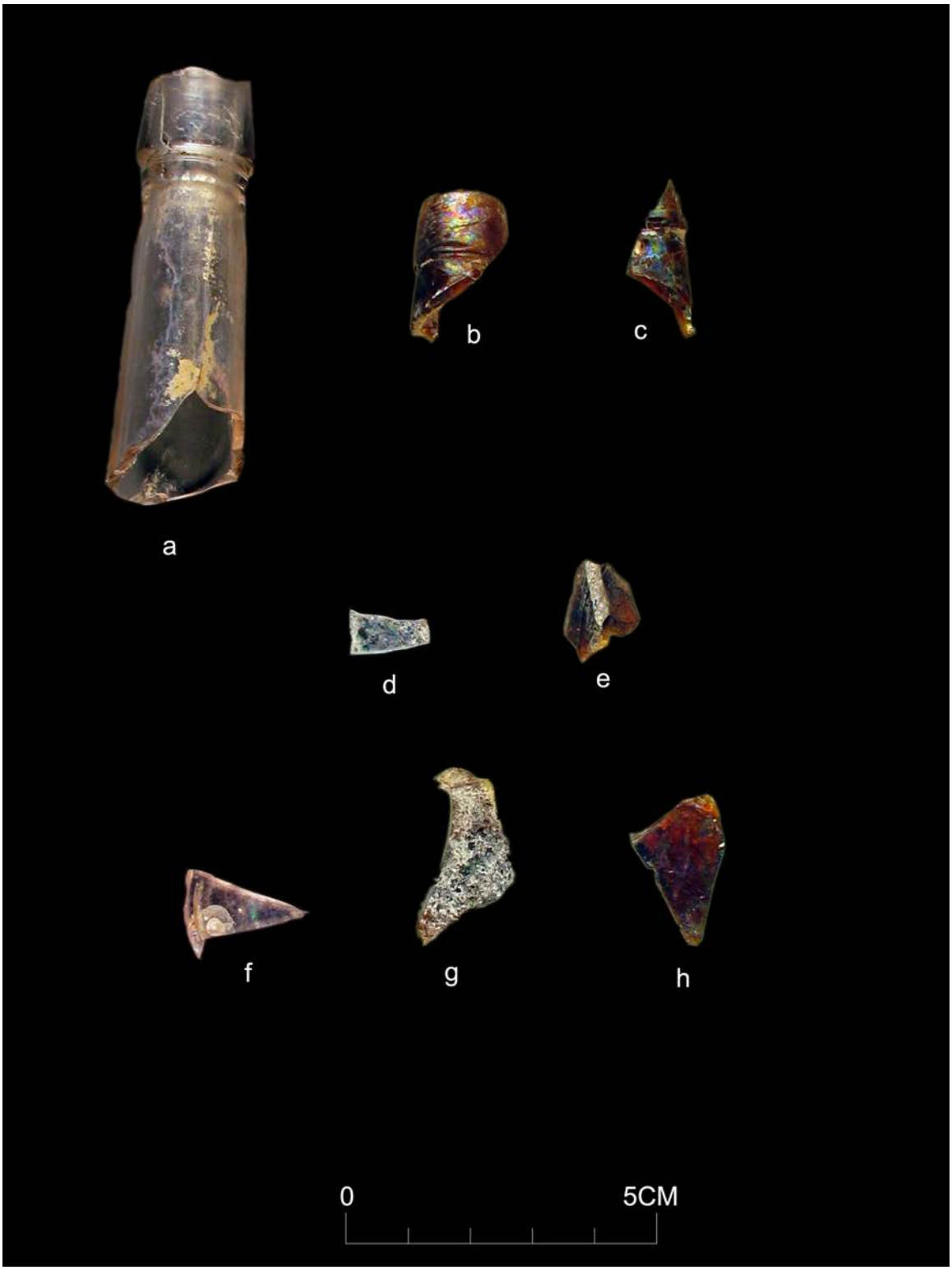


Figure 41. Bottle glass artifacts from Feature 2 at Site 32WI996 (a: a clear neck and finish, b: amber neck and finish, c: amber neck and finish, d: light green body, e: amber panel body corner, f: clear base, g: amber base, h: amber base --- b and c mend together).

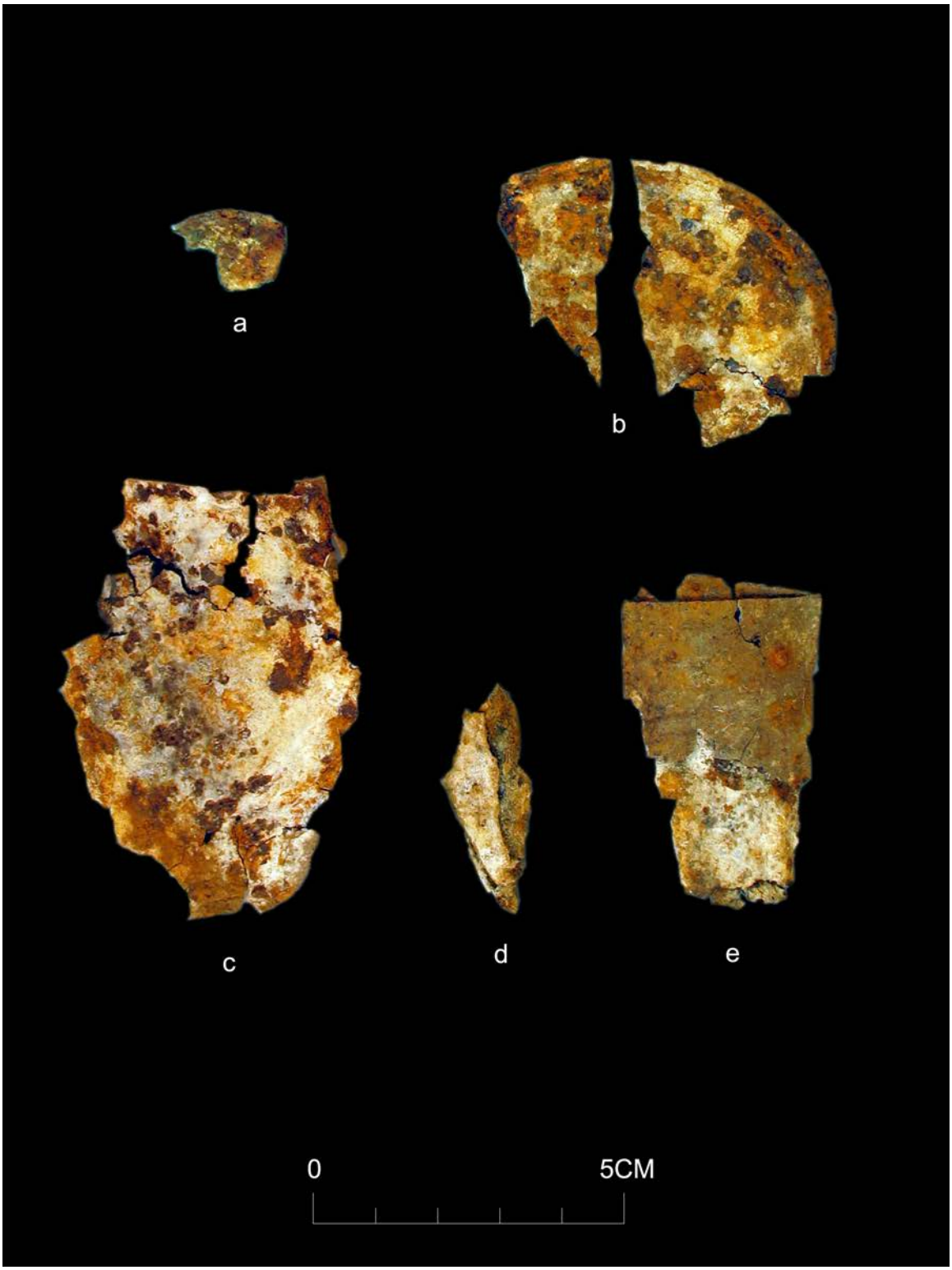


Figure 42. Can artifacts from Feature 2 at Site 32WI996 (a: hole-and-cap lid, b: sanitary can lid fragments which mend together, c: hole-in-cap can body, d: rectangular can side seam, e: hole-in-cap body).

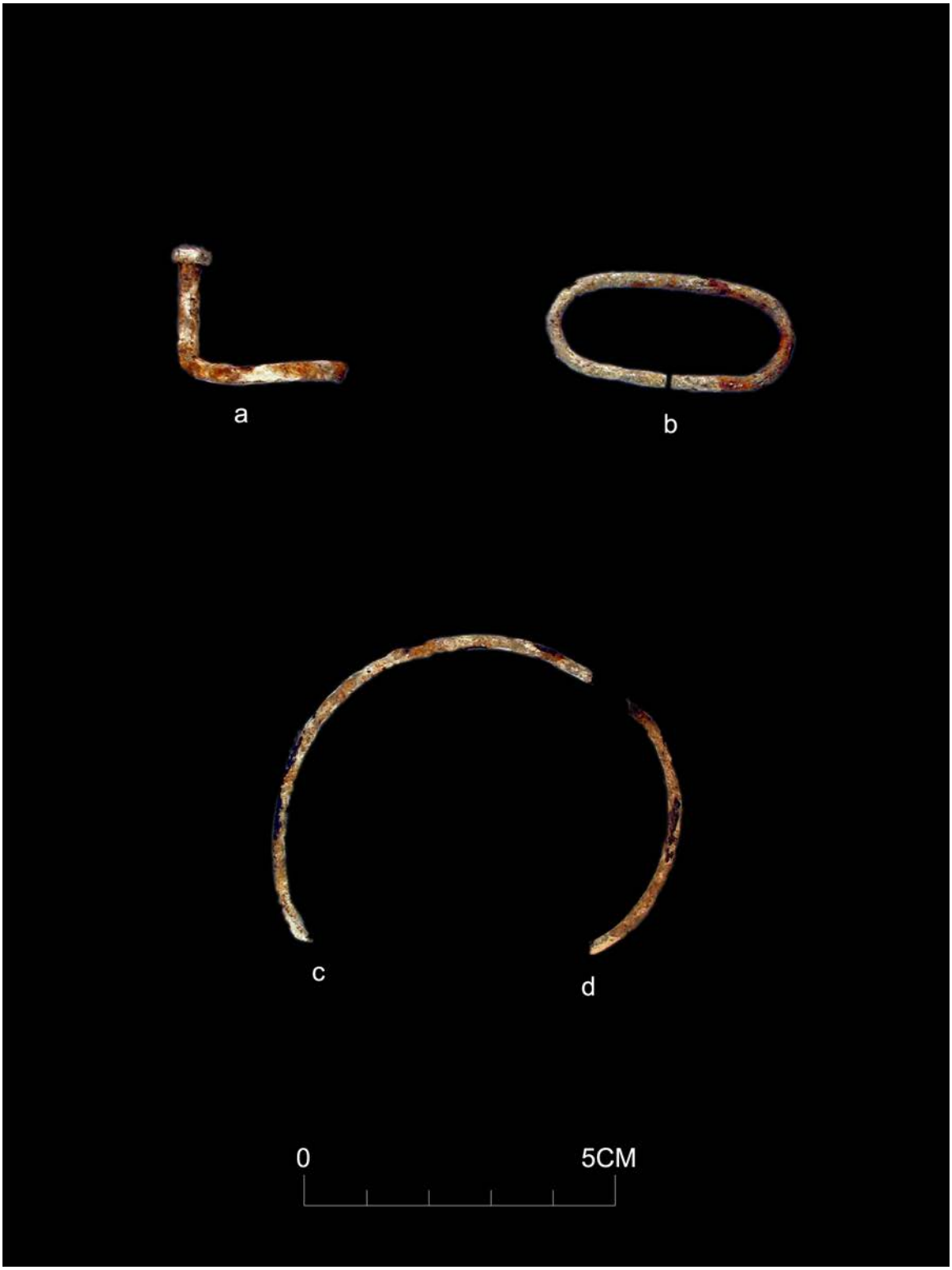


Figure 43. Metal artifacts from Feature 2 at Site 32WI996 (a: 20d machine cut nail, b: metal loop handle, c and d standard guage no. 13 wire which mend together).

APPENDIX:
FAUNAL REMAINS FROM WELL HOUSE, FORT UNION NATIONAL HISTORIC SITE

by
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Midwest Archeological Center
Lincoln, Nebraska
8 May 2008

Twelve bone and tooth specimens were recovered by Steven De Vore on 11 November 2007 during trench monitoring at Fort Union National Historic Site (FOUS). The specimens were recovered from a depth of 10-40 cm below surface. Three taxonomic groups are recognized in the assemblage, unidentified large mammal (n=2), mule deer (*Odocoileus hemionus*, n=5), and bison (*Bison bison*, n=5). Table 1 provides a description of each element.

Table 1. Description of faunal remains recovered from Well House monitoring at FOUS.

Taxonomic Group	Element	Comment
Unidentified large mammal	Long bone	Shaft fragment
Unidentified large mammal	Indeterminate	
Odocoileus hemionus	Second (?) thoracic vertebrae	Body portion
Odocoileus hemionus	Seventh (?) cervical vertebrae	Body portion
Odocoileus hemionus	Thoracic vertebrae	Body fragment
Odocoileus hemionus	Left rib	Head portion
Odocoileus hemionus	Right rib	Neck portion
Bison bison	Incisor	Worn, old individual
Bison bison	Unsided rib	Sawn
Bison bison	Left metacarpal	Green bone break
Bison bison	Unsided femur	Green bone break
Bison bison	Left calcaneum	Tuber calcis portion

Analysis of the faunal remains was conducted at the Midwest Archeological Center using the Center's comparative faunal collection. Brown and Gustafson' (1979) guide was also consulted. Taxonomy of the species follows Banks et al. (1987). All faunal materials are currently being curated by the Midwest Archeological Center under MWAC Accession Number 1197.

Modification of the specimens is limited, but the green bone breaks of the bison metacarpal and femur suggest human processing. The perpendicular saw cut across the rib body is the only conclusive evidence for butchering.

REFERENCES

Banks, R.C., R.W. McDiarmid, and A.L. Gardner
1987 *Checklist of Vertebrates of the United States, the U.S. Territories, and Canada*. United States Department of Interior, Fish and Wildlife Service, Resource Publication 166. Washington D.C.

Brown, C.L., and C.E. Gustafson
1997 A Key to Postcranial Skeletal Remains of Cattle/Bison, Elk, and Horse. Washington State University Laboratory of Anthropology, Reports of Investigations No. 57. Pullman.