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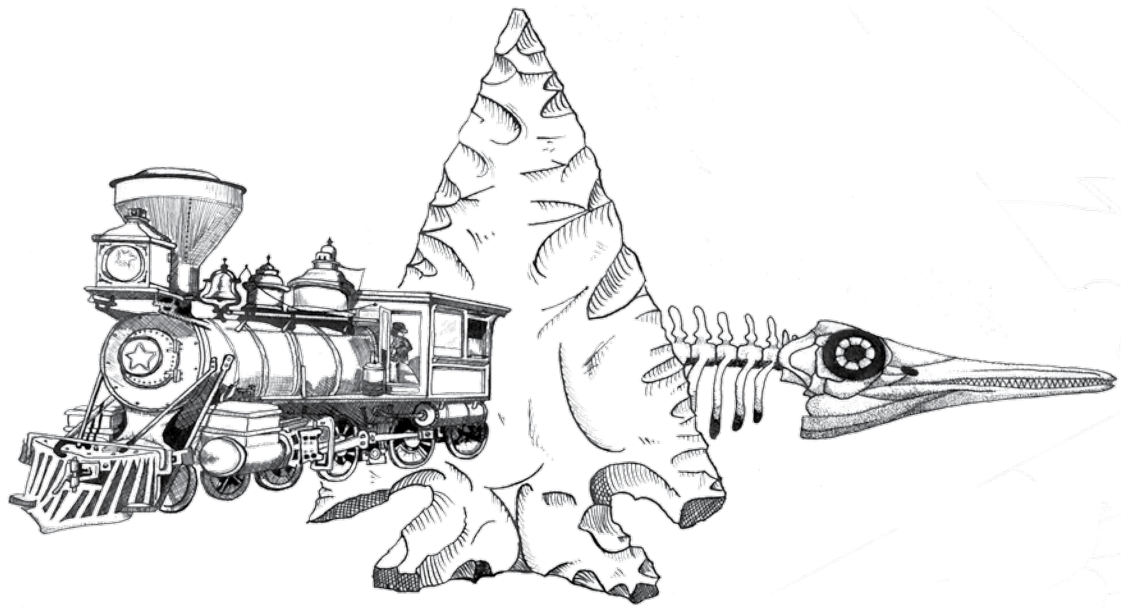

Data Recovery Excavations at Five Prehistoric Archaeological Sites in the Little Boulder Basin, Eureka County, Nevada

Prepared by
Michael D. Cannon

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DATA RECOVERY EXCAVATIONS AT FIVE PREHISTORIC ARCHAEOLOGICAL SITES IN THE LITTLE BOULDER BASIN, EUREKA COUNTY, NEVADA

Prepared for
Barrick Goldstrike Mines, Inc.
P.O. Box 29
Elko, NV 89803

Submitted to
United States Bureau of Land Management–Elko District, Tuscarora Field Office
3900 E. Idaho St.
Elko, NV 89801

Prepared by
Michael D. Cannon

With contributions by
Nicci Barger, Kris Boatman, George Cox, Sarah Creer, Sarah Grant, Sara Meess,
Emily Root-Garey, Amy Spurling, Amber Tews, Allison Twist,
Victor Villagran, and Chester P. Walker

Under the direction of
Michael D. Cannon and Heather K. Stettler

SWCA Environmental Consultants®
257 East 200 South, Suite 200
Salt Lake City, Utah 84111

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ABSTRACT

On behalf of Barrick Goldstrike Mines, SWCA Environmental Consultants implemented a data recovery mitigation plan for five prehistoric archaeological sites: 26EU1533, 26EU1539, 26EU1548, 26EU2064, and 26EU2126. These are the National Register of Historic Places–eligible sites identified within the area of potential effects associated with activities included in the Plan of Operations for the Goldstrike mine, which was submitted to the Elko Field Office of the Bureau of Land Management (now the Tuscarora Field Office of the Elko District) in January 2007. This document reports the results of the data recovery project, which was conducted pursuant to a Historic Properties Treatment Plan (Cannon and Stettler 2007) accepted by the Elko Field Office of the Bureau of Land Management, with concurrence from the Nevada State Historic Preservation Office, in July 2007.

The five sites investigated during the project were determined eligible for the National Register of Historic Places under Criterion D due to their potential to provide information relevant to a variety of research issues. The project focused on collecting data applicable to topics outlined in a research design prepared for the project area in 1991 (Schroedl 1991a) that were both appropriate for the sites involved in the project and of high priority given the current status of archaeological research in the area. Although a variety of specific research questions are addressed in this report, those that were of primary importance in the research design for the project can be grouped into two broad areas: 1) identifying deposits that date to discrete time periods and that can thus provide information about change over time, and 2) documenting and understanding site structure. The project also produced new information about issues such as site formation processes, subsistence, mobility, technological organization, and use of the Tosawihi Quarries chert source. The data recovery process that was implemented to address these issues involved both traditional archaeological methods, such as surface artifact collection and excavation, and cutting-edge remote sensing survey.

The geophysical remote sensing techniques of magnetometry, conductivity survey, and magnetic susceptibility survey were used at all five sites in an effort to locate subsurface archaeological features with the highest potential for providing data applicable to important research questions, particularly thermal features and occupation surfaces that date to relatively discrete time intervals. The types of features that were targeted were not identified in the remote sensing data—primarily because, as manual excavations and mechanical stripping conducted at the end of fieldwork revealed, such features were largely absent from the sites investigated. Thus, the sites investigated could not provide the test case for the use of geophysical methods that was hoped for going into the project. However, the geophysical work conducted during the project did lead to methodological insights that should improve the efficiency and effectiveness of future archaeological remote sensing surveys in the region. In particular, this project makes it clear that more work needs to be done to understand the cause of the "false positives"—apparently the result of geological phenomena—that limited the utility of geophysical methods for archaeological prospection during the project. Steps taken to identify the cause of these false positives during this project included limited auger probing at two sites, which produced inconclusive results, and comparison of geophysical data to the distribution of wildfire-burned vegetation, which does not appear to be responsible for false positives. Recommendations for

future archaeo-geophysical work in the region include pursuing more robust test cases, experimentation with altering survey parameters such as traverse interval and instrument height and orientation, integration with further geoarchaeological research designed to determine what geological factors are reflected in remote sensing data, and use of a "multi-scalar" approach to geophysical survey.

Following completion of remote sensing surveys, a phased approach to excavation was implemented. An initial exploratory phase was intended to locate buried features and obtain chronological information, and when features or areas that appeared to date to discrete time periods were identified in this way, block excavation areas were to be opened in order to collect additional data applicable to project research questions. Results of the exploratory phase of excavation warranted more extensive block excavation at only one site, 26EU2126. The block excavations that were conducted at this site led to the identification of two archaeological features and the recovery of large samples of datable materials, lithic artifacts, and faunal remains, which comprise perhaps the most significant data recovered during the course of the project. As a final step in fieldwork, the surface sediments were mechanically stripped from each site in order to locate any archaeological features that were not encountered during manual excavation and to allow a more thorough evaluation of remote sensing data; an additional feature was identified at 26EU2126 as a result of doing this.

Materials collected during fieldwork underwent a variety of laboratory analyses in order to complete the process of addressing project research questions. These analyses include radiocarbon dating of charcoal and bone samples, X-ray fluorescence and hydration analysis of obsidian artifacts, and studies of faunal remains, macrobotanical remains from flotation samples, ground stone artifacts, and chipped stone tools and debitage.

Occupations at the investigated sites date to a range of chronological phases that span the late Holocene (approximately 4,500 ^{14}C yrs B.P. to present). Despite the project's focus on identifying deposits that date to discrete periods of time, few sites or site loci could be dated to individual phases due to insufficient datable materials and/or palimpsest deposits. An exception to this occurred with one of the areas of 26EU2126 that was explored by block excavation, which produced faunal specimens radiocarbon-dated to the period between A.D. 1230 and 1300, as well as multiple temporally diagnostic projectile points and obsidian hydration measurements that are generally consistent with this age. Geoarchaeological observations made during the course of the project suggest that palimpsest deposits may be the rule in the project area rather than the exception due to low rates of deposition and a lack of clear depositional hiatuses during the last few thousand years.

Faunal remains recovered from 26EU2126 are primarily from artiodactyls, which is consistent with a region-wide pattern of high artiodactyl relative abundance in late Holocene archaeofaunal assemblages. These remains include at least one elk specimen, which represents the first archaeofaunal record of this taxon in the project area. The faunal remains and associated materials are consistent with a logistical settlement pattern in that they suggest an isolated resource processing event. Flotation samples were recovered from four sites (26EU1539, 26EU1548, 26EU2064, and 26EU2126), primarily from charcoal lenses that appear to be the remains of wildfire-burned vegetation and that were investigated in order to develop methods for distinguishing archaeological from non-archaeological lenses. Features that appear based on other evidence to be archaeological contained no plant remains that are clearly the result of human subsistence activities, but this is not surprising given that one is associated with large mammal processing and the other appears to have been the result of hearth cleaning, rather than an actual hearth itself. A limited sample of ground stone artifacts collected during the project, which are primarily expedient in design, suggests that the investigated sites were occupied only periodically by highly mobile individuals and that those individuals did not rely on plant foods as much as on animal foods. Taken together, subsistence data from the project are consistent with a pattern documented previously for the region, in which foraging efficiency was high, and diet breadth narrow, during much of the late Holocene, with a decline in foraging efficiency and corresponding expansion of diet breadth evident after about A.D. 1300.

Lithic data from the project conform with the long-known fact that chert from the Tosawihi Quarries heavily dominates assemblages in the area. A very small amount of obsidian accounts for the remainder of the lithic material recovered during the project. Obsidian sourcing analysis indicates that four sources, located at distances ranging from 110 to 400 km away, are represented at the investigated sites. A pattern of differential source representation between tools and debitage suggests that tools made from obsidian from more distant sources were curated and brought into the LBBA, while material from closer sources was more likely to be used in tool manufacture that actually occurred in the LBBA.

Bifacial reduction appears to have been the dominant strategy used to process Tosawihi chert at the investigated sites, but some evidence of expedient tools and core reduction was also observed. The heavy reliance on bifacial technology suggests that site occupants were highly mobile and required an efficient means of transporting toolstone. Analysis of debitage and tool assemblage composition provides some evidence for functional variability among sites and site loci, though all assemblages appear to be associated primarily with late-stage tool manufacturing, tool rejuvenation, and resource processing activities. Unfortunately, due to limited chronological information from individual site loci, it is not possible to determine whether intra-site spatial variability in debitage assemblages is associated with temporally distinct occupations or whether it reflects functional variability within individual occupations. Overall, however, the lithic data suggest that the individual sites investigated during the project were either short-term camps used by highly mobile foragers or extractive locations that played a role in a larger logistically organized settlement system.

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1. INTRODUCTION

Michael D. Cannon

1.1. PROJECT OVERVIEW

The Little Boulder Basin Area (LBBA) of north-central Nevada has a rich archaeological record that has been the focus of intensive research for more than 15 years. Located north of the Humboldt River and south of the Tosawihi chert quarries, the LBBA is composed of the Little Boulder Basin (LBB) proper—a small valley separated from Boulder Valley by the Tuscarora Spur—as well as small tributary drainages that empty into the LBB (Figure 1).

Much of the archaeological research that has occurred in the LBBA has resulted from the development of several gold mines in the area since the 1980s. Compliance with Section 106 of the National Historic Preservation Act (NHPA) related to this mining activity has led to the cultural resources inventory of large areas in and around the LBBA, the identification of 900 prehistoric archaeological sites in the Carlin Trend, and the excavation of more than 35 of these sites. This work has produced a tremendous amount of information and has substantially improved our understanding of more than 10,000 years of prehistoric occupation in the region.

In continuation of this tradition, and as part of its ongoing efforts to responsibly manage cultural resources, Barrick Goldstrike Mines Inc. (BGMI) contracted SWCA Environmental Consultants (SWCA) to implement a data recovery mitigation plan for five prehistoric archaeological sites. These are the sites that are eligible for the National Register of Historic Places (NRHP) that have been identified within the area of potential effects (APE) associated with activities included in BGMI's Plan of Operations (PoO) for the Goldstrike mine, which was submitted in January 2007 to the Bureau of Land Management Elko Field Office (now the Tuscarora Field Office of the Elko District; hereafter abbreviated BLM-Elko). The BGMI PoO is currently undergoing review under the National Environmental Policy Act (NEPA) (Bureau of Land Management 2008), and compliance with Section 106 of the NHPA is also required. BLM-Elko is responsible for NEPA and Section 106 review of mining activity in the LBB and is a signatory, along with BGMI, the Nevada State Historic Preservation Office (SHPO), and the Advisory Council on Historic Preservation to the 1991 Programmatic Agreement (PA) regarding the treatment of historic properties during mineral development associated with the Goldstrike mine. Implementation of the mitigation plan completes NHPA and corresponding NEPA cultural resource compliance for the five NRHP-eligible sites within the APE associated with the Goldstrike PoO in a manner consistent with the 1991 PA.

This document reports the results of archaeological data recovery performed at the five NRHP-eligible sites within the Goldstrike PoO APE. All five sites were eligible for the NRHP under Criterion D (36 CFR 60.4)—that is, because of their potential to yield information important to our understanding of the region's prehistory or history—and data recovery was therefore an appropriate treatment strategy. The project reported in this document (hereafter termed the 2007 BGMI Data Recovery Project) was conducted pursuant to a Historic Properties Treatment Plan

(HPTP) (Cannon and Stettler 2007) that was accepted by BLM-Elko with Nevada SHPO concurrence in July 2007.

Fieldwork for the project was conducted between July 17 and October 11, 2007, under BLM Cultural Resource Use Permits nos. N-50837 and N-83691 and Nevada Antiquities Permit no. 248. SWCA personnel who participated in the fieldwork included Mike Cannon (Principal Investigator), Derek Heersink (Crew Chief), Brad Leigh, Sara Meess, Pete Morris, Emily Root-Garey, Heather Stettler (Principal Investigator), Amber Tews (Crew Chief), Allison Twist, Claudia Woodman (Crew Chief), and Victor Villagran. Chet Walker and Tony Chapa of Archaeo-Geophysical Associates (AGA) conducted remote sensing work for the project under subcontract to SWCA and under the permits issued to SWCA. Throughout the project, SWCA and AGA personnel consulted closely with members of the BGMI Environmental Division and with Bill Fawcett, Archaeologist, BLM-Elko.

A fieldwork summary and reporting schedule was submitted to BLM-Elko upon completion of fieldwork, in accordance with stipulation G.2.b of the 1991 Goldstrike PA, and BLM–Elko subsequently issued a Notice to Proceed dated October 31, 2007, pursuant to stipulation G of the PA. This final report on the project is submitted in accordance with stipulation H.2 of the PA. All records and materials collected or developed during the course of the project will be curated at the Nevada State Museum (NSM) following procedures outlined in the project HPTP (Cannon and Stettler 2007:41–42); these procedures are consistent with the policies of the NSM and the stipulations of the 1991 PA. SWCA will also provide BLM-Elko with digital copies of all databases, catalogs, and photographs that result from this project.

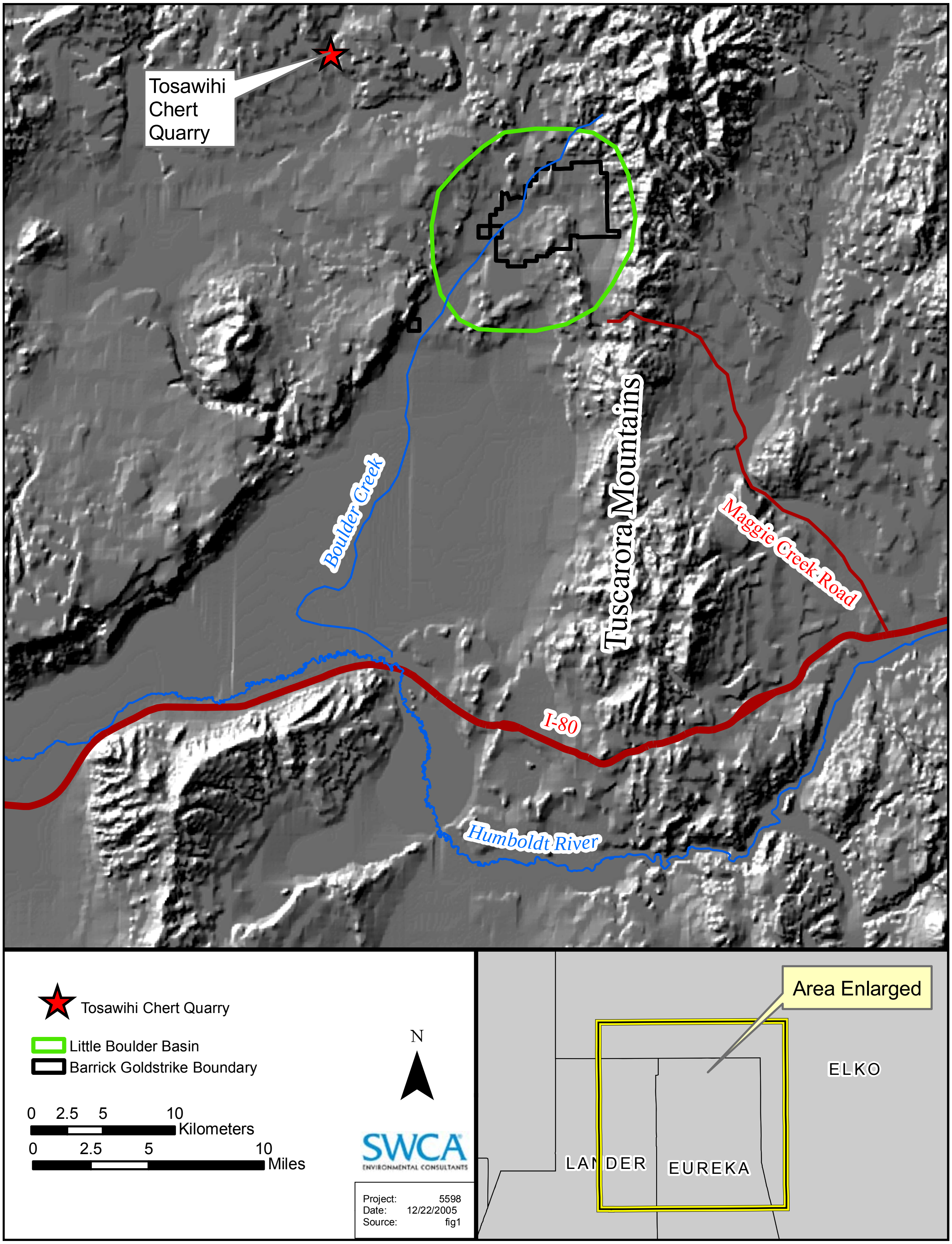

Figure 1. The LBBA, showing the location of the Barrick Goldstrike mine property.

1.1.2. Site Descriptions and Previous Work

The five sites involved in the 2007 BGMI Data Recovery Project are 26EU1533, 26EU1539, 26EU1548, 26EU2064, and 26EU2126. Basic information about each of these sites is provided in Table 1, and their locations are shown in Figure 2. These sites were all originally identified as surface artifact scatters of varying density, consisting primarily of chipped stone debitage with small numbers of chipped stone tools and, in some cases, projectile points and/or grinding stones. As discussed in greater detail in Chapter 5 of this report, occupation of these sites dates to various periods within the late Holocene (ca. 4,500 ^{14}C yrs B.P. to present). The sites were initially determined to be eligible for the NRHP based on their potential to provide information about such issues as land-use patterns, lithic technology, site function, site structure, and subsistence (e.g., Hicks 1988a, 1988b, 1988c, 1989; Newsome 1992; Newsome et al. 1993; Popek 1991a, 1991b; Schroedl 1993; Tipps and Popek 1992a). Since the initial recordations of these five sites, which occurred between 1988 and 1993, four of them (26EU1533, 26EU1548, 26EU2026, and 26EU2126) have experienced mining–related damage, such as the construction of roads, powerlines, or pipelines. However, despite these impacts, it was determined prior to the present project that these sites retained the potential to provide data applicable to important research questions.

Summaries of the work performed at each of these sites prior to the 2007 BGMI Data Recovery Project are provided here. As mentioned in these summaries, SWCA, on behalf of BGMI, conducted limited probing at the five NRHP-eligible sites in the Goldstrike PoO APE as part of a larger probing project in autumn 2006; the results of the 2006 probing at these five sites are incorporated into this report, and probing methods are described in Chapter 3 along with data recovery methods. Updated Intermountain Antiquities Computer System (IMACS) site forms for these five sites, which summarize the results from SWCA's probing and data recovery work, are included in this report as Appendix A.

Table 1. Size and Setting of NRHP-Eligible Sites within the Goldstrike PoO APE

Site	Area (m^2)	Geomorphic Setting
26EU1533 (CrNV 12-7420)	11,114	Ridge above Brush Creek
26EU1539 (CrNV 12-7426)	17,228	Terrace along Boulder Creek
26EU1548 (CrNV 12-7446)	6,143	Slope above Bell Creek
26EU2064 (CrNV 12-10507)	46,609	Ridge above Brush Creek
26EU2126 (CrNV 12-11124)	7,481	Floodplain of Rodeo Creek

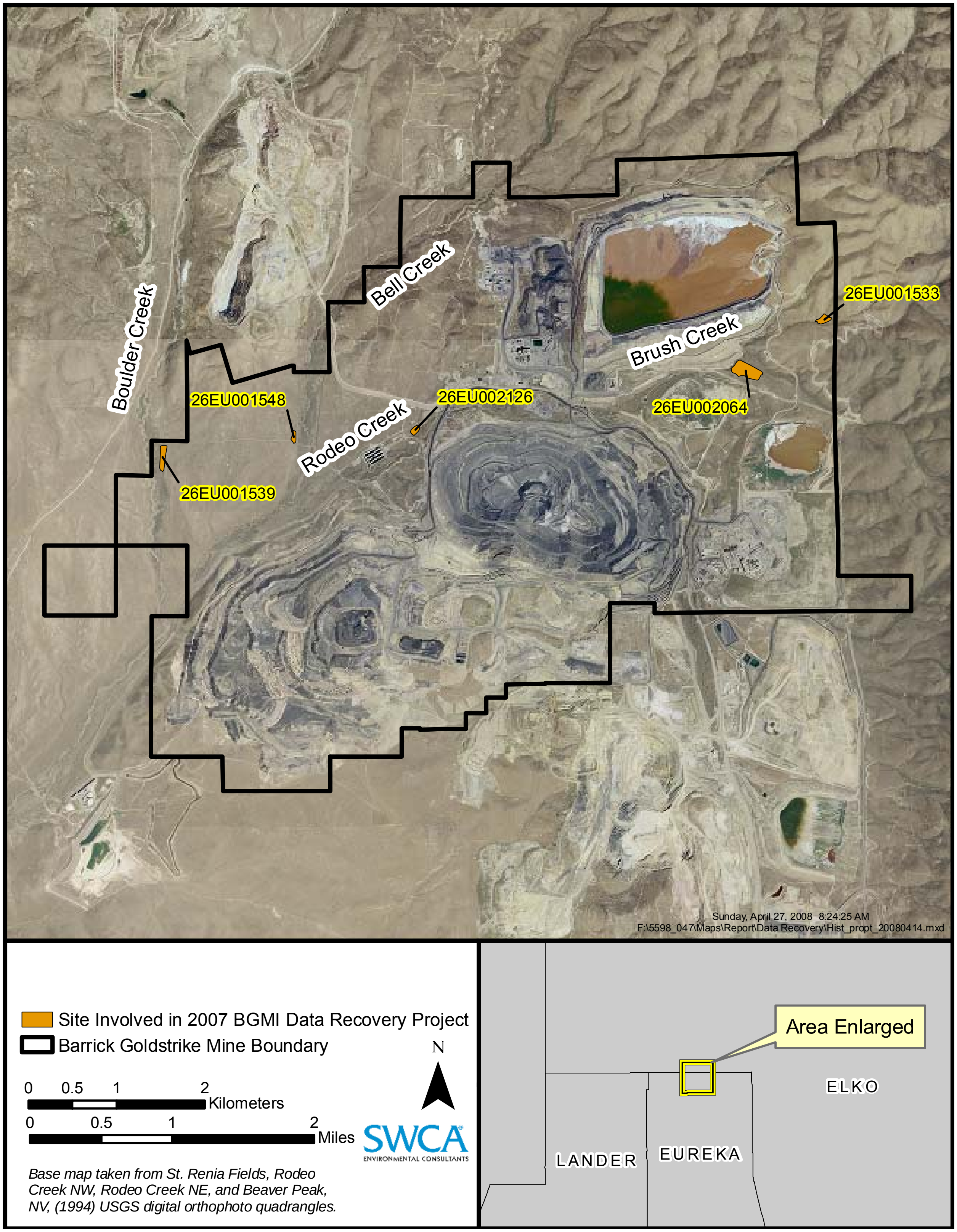

Figure 2. Locations of NRHP-eligible sites within the Goldstrike PoO APE.

26EU1533

Site 26EU1533 (CrNV 12-7420) is located along Brush Creek and straddles a ridge that lies between this creek and a smaller tributary. The site was originally recorded in 1988 by the Desert Research Institute (DRI) as a sparse chipped stone scatter (Hicks 1988c, 1989). P-III Associates Inc. (P-III) revisited the site in 1992 (Newsome 1992; Tipps and Popek 1992b), recording a central concentration of debitage surrounded by a diffuse scatter of flakes. SWCA undertook an additional revisit in September, 2005, and noted that the site had experienced a range fire and subsequent erosion since the time of P-III's visit; SWCA re-established the site's boundaries accordingly. Artifact density appeared much lower in 2005 than was described in the earlier recordations, perhaps due to erosion following the range fire. Other impacts to the site included road construction. In October, 2006, SWCA returned to conduct limited probing, which revealed buried lithic artifacts but no features.

26EU1539

Site 26EU1539 (CrNV 12-7426) is located along a low alluvial terrace on the east side of Boulder Creek. In 1988, DRI documented the site as a low density lithic scatter with some ground stone present (Hicks 1988b, 1989). P-III made two revisits to the site in 1991 and 1993 (Popek and Newsome 1993; Schroedl 1993), identifying additional artifacts and artifact concentrations and expanding the site's boundaries. SWCA revisited the site in September, 2005 and recorded two artifact concentrations, also noting previously unrecorded artifacts, including a small side-notched projectile point. SWCA returned to conduct limited probing in September, 2006. This probing revealed buried lithic artifacts but no features. The site is located in close proximity to an abandoned ranch building and associated corral, and impacts to the site included the construction of a road and a historic ditch across it, as well as more minor impacts from ranching activities (e.g., trash deposition).

26EU1548

Site 26EU1548 (CrNV 12-7446) is located on the slope of a high alluvial terrace on the west side of Bell Creek. The site was originally recorded in 1988 by DRI as a low to moderate density lithic scatter with five localized concentrations (Hicks 1988a, 1989). P-III revisited the site in 1993 and made no changes to the site description but did identify a large biface (Newsome et al. 1993). SWCA revisited the site in September, 2005, and found two artifact concentrations. SWCA returned in September, 2006, to conduct limited probing, which revealed buried lithic artifacts but no features. The site was impacted by the construction of a road through its southern portion.

26EU2064

Site 26EU2064 (CrNV 12-10507) is a very large site located along the top of a ridge that lies to the south of, and high above, the confluence of Brush Creek and a smaller tributary. P-III originally recorded the site in 1991 as a dispersed lithic scatter that included a Humboldt projectile point (Popek 1991a; Tipps and Popek 1992a). SWCA revisited the site in September, 2005, finding four artifact concentrations within the dispersed scatter, and SWCA returned in 2006 to conduct probing. This probing revealed buried lithic artifacts but no features. Impacts to the site included two-track roads through its southern portion and a utility line along its southern edge.

26EU2126

Site 26EU2126 (CrNV 12-11124) is located in the floodplain of Rodeo Creek. The site was originally documented in 1991 by P-III as two lithic concentrations surrounded by a discrete scatter of debitage (Popek 1991b; Tipps and Popek 1992a). Artifacts that P-III recorded and collected include a Cottonwood Triangular projectile point fragment and a basin milling stone fragment. SWCA revisited the site in September, 2005 and relocated the two artifact concentrations. SWCA returned to conduct limited probing in September, 2006, and although no direct indications of features were observed during probing, burned artiodactyl bone and abundant lithic artifacts were found in subsurface context. The site was impacted by construction of an above-ground de-watering pipeline, two-track roads, and dumping of small piles of rock and sediment.

1.2. RESEARCH OVERVIEW

As noted above, the five sites investigated during the 2007 BGMI Data Recovery Project were determined eligible for the NRHP under Criterion D due to their potential to provide information relevant to a variety of research issues. More specifically, the NRHP eligibility of these sites was evaluated in light of a research design prepared for the LBBA in 1991 (Schroedl 1991a), which has been used as a historic context for purposes of NRHP evaluations since that time. The 2007 BGMI project was focused on collecting data applicable to research topics outlined in that document (hereafter termed the 1991 historic context) in order to recover the NRHP values of the sites involved in the project. The research topics from the 1991 historic context are discussed in detail in Chapter 2 of this report, which also summarizes the current status of research into these topics in the LBBA. Here, those topics that were the primary focus of the 2007 project are briefly reviewed, as are the methods that were employed to explore these topics.

It was recognized from the outset that the NRHP-eligible sites in the Goldstrike PoO APE would not provide data applicable to every research topic outlined in the 1991 historic context; rather, a subset of these topics was pursued, which included topics that were both appropriate for the sites involved in the project and of high priority given the current status of archaeological research in the LBBA (Cannon and Stettler 2007). Although a variety of specific research questions are addressed in this report, those that were of primary importance in the research design can be grouped into two broad areas: 1) identifying deposits that can provide information about change in behavior and material culture over time, and 2) documenting and understanding site structure. Data collected during the course of this project provide important new insights into these topics in the LBBA. The project has also produced new information about issues such as site formation processes, subsistence, mobility, technological organization, and use of the Tosawihi Quarries chert source.

The data recovery process that was implemented to address these topics involved both traditional archaeological methods, such as surface artifact collection and excavation, and cutting-edge remote sensing survey. The geophysical remote sensing techniques of magnetometry, conductivity survey, and magnetic susceptibility survey were used at all five sites in an effort to locate subsurface archaeological features with the highest potential for providing data applicable to important research questions, particularly thermal features and occupation surfaces that date to relatively discrete time intervals. The types of features that were targeted were not identified in the remote sensing data—primarily because, as manual excavations and mechanical stripping conducted at the end of fieldwork revealed, such features were largely absent from the sites investigated. However, the geophysical work conducted during the course of this project has led to methodological insights that should improve the efficiency and effectiveness of future archaeological remote sensing surveys in the region.

Prior to conducting remote sensing surveys, surface artifacts at each of the sites were collected through a close-interval pedestrian survey. Surface artifacts were collected prior to the remote sensing surveys because mowing, which facilitated more accurate spatial control during the geophysical survey, would have disturbed them. In addition, the artifact distribution data that resulted from surface collection were used, along with the remote sensing data, to select locations for excavation. The surface artifact distribution data also provide information that is potentially relevant to resolving issues of chronology, one of the main research emphases for this project.

The surface collections and remote sensing surveys were followed by phased excavations. An initial exploratory phase was intended to locate buried features and obtain chronological information, and when features or areas that appeared to date to discrete time periods were identified in this way, block excavation areas were to be opened in order to collect additional data applicable to project research questions. Results of the exploratory phase of excavation warranted more extensive block excavation at only one site, 26EU2126. The block excavations that were conducted at this site led to the recovery of large samples of datable materials, lithic artifacts, and faunal remains, which comprise perhaps the most significant data recovered during the course of the project.

The final step in fieldwork was to mechanically strip the surface sediments from each site in order to locate any archaeological features that were not encountered during manual excavation. This step served to identify additional features that provided important archaeological information, and it also allowed a more thorough evaluation of the remote sensing data collected during the project.

Finally, materials collected during fieldwork underwent a variety of laboratory analyses in order to complete the process of addressing project research questions. The results of these analyses are reported here, including radiocarbon dating of charcoal and bone samples, X-ray fluorescence and hydration analysis of obsidian artifacts, and studies of faunal remains, macrobotanical remains from flotation samples, ground stone artifacts, and chipped stone tools and debitage.

1.3. Report Organization

Chapter 2 presents background information for the remainder of the report, including an environmental overview, a discussion of the prehistoric culture history of the LBBA and surrounding region, and a summary of the historic context developed for the LBBA in 1991. An evaluation of the 1991 historic context and of work conducted since it was developed provides the research focus for the 2007 BGMI Data Recovery Project, and this research focus is also discussed in Chapter 2.

The field methods used during the project are discussed in Chapter 3, which summarizes both the general fieldwork strategy and the specific tactics that were employed at each site. Chapter 4 provides additional detail about the methods used in the remote sensing surveys and presents the results of these surveys. Chapter 4 also discusses the implications of the remote sensing results from this project for future archaeological research and cultural resource compliance work in the LBBA and surrounding portions of the Great Basin.

Chapter 5 addresses one of the main research foci of this project, that of identifying deposits that can provide information about change over time. This chapter presents chronological information in the form of radiocarbon dates, obsidian hydration measurements, and temporally diagnostic projectile points, as well as observations on geomorphology and site formation processes, in order to resolve the chronology of occupation at each site and to evaluate whether "single-component" deposits are present at them.

Analyses focused on addressing questions about prehistoric adaptations in the LBBA are presented in Chapters 6 and 7. Chapter 6 discusses the subsistence information obtained during the project from faunal remains, macrobotanical remains, and ground stone artifacts. Chapter 7 presents several analyses of the large chipped stone artifact assemblage recovered during the project; these analyses address a range of research questions about topics such as mobility, use of the Tosawihi Quarries, and technological organization.

Finally, Chapter 8 concludes the report with a synthesis of what can be learned from this project, including both methodological insights relating to the application of remote sensing techniques in the region and substantive insights into the prehistory of the LBBA.

2. Background and Research Context

Michael D. Cannon, Sarah Creer, and Kris Boatman

This chapter presents background information for the 2007 BGMI Data Recovery Project, including an overview of the project area environment and a summary of the prehistoric culture history of the LBBA and surrounding region. This chapter also discusses the research emphases for the project. These research emphases derive from the 1991 historic context for the LBBA and from an evaluation of work completed since then. The 1991 historic context and the current status of archaeological research in the LBBA are therefore summarized to provide context for the investigations conducted as part of this project.

2.1. Environment

The LBBA is located just to the northeast of Boulder Valley and north of the Humboldt River in north-central Nevada (Figure 1). The region is characterized by a Basin and Range geomorphologic system, typified by rugged mountain ranges dissected by creeks and drainages. Mining activities in the area have resulted in extensive landscape modification.

2.1.1. Geology

The geology of north–central Nevada consists of rocks laid down from the late Proterozoic through the Triassic age, with sporadic distributions of later Jurassic- and Cretaceous-age rocks (Coats 1987). The majority of these rocks were created from marine deposits that underwent numerous deformations over the millennia. One of the more significant tectonic events in the area was the movement on the Roberts Mountains thrust, which resulted in the eastward movement of silicic and volcanic rocks that were originally deposited on the ocean floor (Coats 1987).

Among the rock formations laid down in the area surrounding the LBBA, several were important to prehistoric inhabitants as sources of raw lithic materials. The Ordovician Vinini Formation makes up the primary bedrock of the Tuscarora Mountains around the LBBA, and is composed of quartzite, limestone, calcareous sandstone, black shale, cherty shale, andesite lava, andesite tuff, interbedded chert, and siltstone (Schroedl 1995a, 1995b, 1996). Two named toolstones can be found in the Vinini Formation: Vinini Silicified Shale and Vinini Chert, both of which are found in archaeological sites in the region (Schroedl 1995b). The Valmy Formation is partly equivalent to the Vinini Formation and consists of vitreous quartzite interbedded with chert and shale (Roberts et al. 1967). Outcrops of the Valmy Formation nearest to the LBBA are located in the Whirlwind Valley, immediately south of Boulder Valley. Both these formations are remnants of the rocks moved eastward by the Roberts Mountains thrust (Roberts et al. 1967). The Roberts Mountain Formation, dating to the Silurian period, consists of dolomite, dolomitic limestone, and siliceous limestone interbedded with chert (Roberts et al. 1967). Outcrops of the formation are exposed in the Tuscarora Mountains (Roberts et al. 1967). This formation's cherts were also used for chipped stone tool production (Schroedl 1995a, 1995b, 1996).

Igneous rock formations in and around the LBBA consist of Jurassic–, Cretaceous–, and Tertiary–aged volcanic episodes in the form of various lava flows and ash layers (Schroedl 1995a, 1995b, 1996). During the Miocene, volcanic deposits of rhyolitic ashes and tuff laid down to the north of the LBBA eventually evolved into the group of cryptocrystalline rocks that includes Tosawihi chert, the toolstone quarried at the Tosawihi Quarries (e.g., Elston and Raven 1992). Later Holocene volcanic episodes are also present in sediment deposition at the LBBA, as represented by the ash layers from the Mount Mazama eruption that occurred around 6,800 radiocarbon years before present (^{14}C yrs B.P.) (Schroedl 1995a, 1995b, 1996). Mazama ash is chemically distinct and distributed throughout northern Nevada, thus creating a temporal marker in the stratigraphy of the region (Elston and Raven 1992). Holocene alluvial activity in the LBBA also contributed to the geologic makeup of the area by transporting numerous rocks into the basin from the surrounding mountains in the form of cobbles and pebbles that may have been used by prehistoric inhabitants in hearths or as ground stone.

2.1.2. HYDROLOGY

Water sources in the LBBA are part of the Boulder Flat hydrographic area and are tributary to the Humboldt River, located south of the LBBA (Maurer et al. 1996). Surface water sources located in the LBBA consist of several ephemeral drainages and creeks, fed by discharge from springs and seeps, such as Sand Dune Spring, Knob Spring, Green Spring, and various other unnamed springs (Maurer et al. 1996). This system of creeks and drainages includes Rodeo Creek, Brush Creek, and Bell Creek, all of which flow into Boulder Creek, the main tributary of Rock Creek, itself a tributary of the Humboldt River. Though Boulder Creek is the largest stream flowing through the LBBA, it is ephemeral over much of its length with the exception of a small section near its headwaters, located in the LBBA, where streamflow is sustained (Maurer et al. 1996). Because water levels in the LBBA are generally low, the current deposition of alluvial sediments in the area is minimal. However, many drainages show signs of past high–energy water flows, as evidenced by the depth of cut–banks (Schroedl 1995a, 1995b, 1996).

2.1.3. FLORA

The LBBA lies within the Big Sagebrush area of the Intermountain Sagebrush vegetation province (Bailey 1978). Along riparian areas such as the various creeks, drainages, springs, and seeps within the LBBA, native vegetation is composed of various willows (*Salix* spp.), bulrush (*Scirpus* spp.), cattails (*Typha latifolia*), and saltgrasses (*Distichlis* spp.). In other areas, native vegetation is dominated by big sagebrush (*Artemisia tridentate)* and rabbitbrush (*Chrysothamnus* spp.). Other native plants include pepperweed (*Lepidium* spp.), wildrye (*Elymus* spp.), wheatgrass (*Agropyron* spp.), Indian ricegrass (*Orysopsis hymenoides*), needle and thread grass (*Stipa* spp.), Idaho fescue (*Festuca idahoensis*), and galleta (*Hilaria jamesii*). Non–native invasive species that would not have occurred prehistorically are also present in the LBBA and include Russian thistle (*Salsola kali*), cheatgrass (*Bromus tectorum*), and crested wheatgrass (*Agropyron cristatum*). An extensive list of the plant species present in north-central Nevada is contained in Appendix 3 in Schroedl (1995b).

2.1.4. FAUNA

The creeks, drainages, and springs within the LBBA provide both a water source for fauna as well as a riparian habitat. Species of animals common in the LBBA include bats (*Myotis lucifugus, Myotis volans*), rodents such as the Townsend's pocket gopher (*Thomomys townsendii*) and the western jumping mouse (*Zapus princeps*), and lagomorphs such as Nuttall's cottontail (*Sylvilagus nuttallii*) and the white-tailed jackrabbit (*Lepus townsendii*) (Bureau of Land Management 1992a). Bird species within the LBBA include the turkey vulture (*Cathartes aura*), the prairie falcon (*Falco mexicanus*), and the red-tailed hawk (*Buteo jamaicensis*), as well as flycatchers (Tyranidae), mockingbirds and thrashers (Mimidae), swallows (Hirundinidae), magpies, jays, crows (Corvidae), and sparrows (Emberizidae), among many others. Non–native upland bird species such as the chukar (*Alectoris chukar*) and the gray partridge (*Perdix perdix*) are also present within the LBBA (Bureau of Land Management 1992b).

The LBBA is part of the mule deer (*Odocoileus hemionus*) migration corridors that run through the region. The Little Boulder Basin itself traditionally served as an intermediate range staging ground, which would accommodate deer prior to their movements along the flanks of the Tuscarora Mountains to and from wintering areas (Bureau of Land Management 2007). However, mule deer are currently not found as commonly in the LBBA due to mining activity (Bureau of Land Management 2007). For greater detail on faunal species present in the LBBA, see Section 6.1 of this report, particularly Table 31.

2.1.5. PALEOENVIRONMENT

The environment of the late Pleistocene across the Great Basin was dominated by large pluvial lakes; however, no pluvial lakes were present in the LBBA or its immediate vicinity. Lake Bonneville, the largest Great Basin pluvial lake, was located to the east, covering much of the eastern Great Basin from approximately the present-day Utah-Nevada border eastward. Lake Lahontan, the second largest Great Basin pluvial lake, sprawled across much of what is currently western Nevada, reaching into central Nevada to the west of the LBBA. Closer to the LBBA, a series of smaller pluvial lakes were present in valleys located south of the Humboldt River, ranging from Goshute, Independence, Clover, Ruby and Diamond Valleys to the southeast of the LBBA, to Crescent and Grass Valleys to the south, to Buffalo Valley to the southwest. Additional pluvial lakes were located in valleys even further south and particularly to the southeast. As is seen in data collected from Lake Bonneville, pluvial lake levels fluctuated dramatically throughout the Pleistocene (Madsen 2000). Vegetation in the central Great Basin at this time consisted mostly of subalpine conifers and sagebrush steppe in the valley bottoms (Grayson 1993). Pleistocene mammals in the Great Basin included ground sloths, horses, camels, mastodons, and mammoths. These, and other species, went extinct as part of the mass extinctions that occurred before the onset of the Holocene (Grayson 1993).

The Holocene saw significant climate changes that divide it into three general periods. Though different names and date ranges have been proposed for these periods (see Antevs 1955; Currey and James 1982), for the purposes of this discussion, the Holocene will be divided into three periods, following Grayson (1993): early (10,000–7,500 ^{14}C yrs B.P.), middle (7,500–4,500 ^{14}C yrs B.P.), and late (4,500 ^{14}C yrs B.P.–present). These divisions are somewhat arbitrary, and dates of major paleoenvironmental changes differ somewhat among different parts of the Great Basin.

The early Holocene is generally characterized by a cooler and moister climate than is present today. The pluvial lakes and large marshes of the late Pleistocene had diminished considerably in size in the early Holocene, but shallow lakes and marshes were still present in many valleys. Pollen data from the early Holocene shows a dominance of sagebrush in areas that are currently dominated by plants in the Cheno–am group (Grayson 1993). Faunal data from early Holocene sites, such as Homestead Cave, suggest that mammals currently only found in higher elevations—pikas (*Ochotona* sp.), yellow-bellied marmots (*Marmota flaviventris*), northern pocket gophers (*Thomomys talpoides*), bushy-tailed woodrats (*Neotoma cinerea*), and voles (*Microtus* sp.), for example—were present in much lower elevations, indicating a cooler climate (Grayson 1993; Madsen 2000). Data from Ruby Valley and Alkali Lake Basin indicate that at the end of the early Holocene, sometime between 8,000 and 7,000 ^{14}C yrs B.P., conditions became much drier, causing lakes to shrink and marshes to retreat (Grayson 1993).

The middle Holocene is characterized by generally hotter and drier conditions throughout the Great Basin (Grayson 1993). Many shallow lakes and marshes in the Great Basin significantly diminished or dried up altogether. Evidence of this drier climate can be seen in data indicating the desiccation of Owens Lake and lowered sedimentation rates in the Ruby Marshes (Benson et al. 2002). Data from tree stumps submerged in Lake Tahoe indicate that the lake remained below its overflow level during much of the middle Holocene (Benson et al. 2002). Even the Great Salt Lake may have almost completely dried up during this period (Madsen 2000). The warmer temperatures of the middle Holocene facilitated the spread of pinyon pine throughout the eastern Great Basin and prompted the expansion of Cheno-am plants, such as shadscale, into areas previously dominated by sagebrush (Grayson 1993).

The climate change that occurred at the end of the early Holocene was also marked by a dramatic reduction in mammalian taxonomic richness (Grayson 2000). Some mammals that had survived in the cooler and moister conditions of the early Holocene diminished dramatically in certain areas of the Great Basin. These mammals include yellow-bellied marmots, pygmy rabbits (*Brachylagis idahoensis*), bushy-tailed woodrats, Ord's kangaroo rats (*Dipodomys ordii*), and Great Basin pocket mice (*Perognathus parvus*) (Grayson 2000; Madsen 2000). The pikas that were present in lower elevations in the early Holocene were compelled to move to the cooler climate of higher elevations (Grayson 1993). Also, the rarity of middle Holocene sites in the Great Basin suggests that human populations may have declined in the region, possibly as a result of decreased surface water sources (Grayson 1993). However, it must be noted that the middle Holocene was not always dry. Evidence for wet periods in the midst of the middle Holocene exists in the Lahontan basin, the Mono Lake basin, and Diamond Pond (Benson et al. 2002).

The late Holocene, dating from around 4,500 ^{14}C yrs B.P. to the present day, is characterized by moister, cooler conditions than the middle Holocene, but not as moist and cool as the early Holocene (Grayson 1993). According to data recovered from James Creek Shelter, increased precipitation began in the middle Holocene and continued to 3,200 ^{14}C yrs B.P. (Elston and Budy 1990). There was then a decrease in precipitation from 3,200 to 2,800 ^{14}C yrs B.P., followed by a short period of flooding activity and leveling out to essentially modern climate conditions a little before 2,300 ^{14}C yrs B.P. (Elston and Budy 1990). As conditions became cooler and moister in the late Holocene, more sagebrush appeared in areas that had been dominated by Cheno–am plants in the middle Holocene (Grayson 1993).

Some mammals that had diminished in areas during the middle Holocene rebounded in the late Holocene. At Homestead Cave, species such as Ord's kangaroo rats and Great Basin pocket mice both increased in abundance in late Holocene and remain to the modern day (Madsen 2000). However, some species that no longer reside in the Great Basin were present during the late Holocene. There is evidence that bison were widespread in the eastern and northern parts of the Great Basin, including the LBBA, in the very late Holocene (Grayson 2006). Bison were also likely present in parts of the Great Basin during the early and middle Holocene periods, but the available data are insufficient to indicate the extent or density of their distribution (Grayson 2006). In contrast to the early and middle Holocene, there is ample evidence of significant human populations throughout the Great Basin during the late Holocene.

2.2. CULTURE HISTORY

The vast majority of archaeological sites identified within the LBBA, and all of the sites investigated in the 2007 BGMI Data Recovery Project, are prehistoric and date to the late Holocene (approximately 4500 ^{14}C yrs B.P. to the present). An overview of the prehistory of the area is provided here to serve as the background for the research design presented below. The culture history sequence developed for the area has undergone numerous revisions since the earliest work conducted in the region (Elston and Budy 1990; McGuire et al. 2004; Schroedl 1995a, 1995b) and indeed, refining the chronology for the region was a component of the original research design for archaeological work conducted here (Schroedl 1991a:78–79; 1991b:78–79). The prehistoric chronology for the LBBA and surrounding region that is used in this report is presented in Table 2; this chronology is based on the cumulative results of previous work from the area as summarized by McGuire et al. (2004).

Table 2. Prehistoric Culture History Sequence for the Little Boulder Basin Area

Period	Phase	Dates (^{14}C yrs B.P.)	Dates (calibrated B.C./A.D.)
Late Prehistoric	Eagle Rock	650–100	A.D. 1300–1850
Late Archaic	Maggie Creek	1450–650	A.D. 600–1300
Middle Archaic	James Creek	3200–1450	1,500 B.C.–A.D. 600
Middle Archaic	South Fork	4500–3200	3,200–1,500 B.C.
Early Archaic	Pie Creek	7000–4500	5,900–3,200 B.C.

2.2.1. Paleoarchaic Period

As is the case throughout much of North America, the earliest compelling evidence for a human presence in the eastern Great Basin dates to just before 11,000 ^{14}C yrs B.P. (Beck and Jones 1997; Graf and Schmitt 2007; see Gilbert et al. 2008, for recently discovered earlier evidence from the western Great Basin). A majority of archaeologists who study the period from this time through the early Holocene (ca. 10,000–8,000 ^{14}C yrs B.P.) in the Great Basin refer to this period as the Paleoarchaic (Beck and Jones 1997; Graf and Schmitt 2007). This contrasts with usage elsewhere in the Americas, where the period of initial human occupation is termed Paleoindian; the difference is warranted by an absence in the Great Basin of evidence for a subsistence focus on the hunting of megafauna, which the term Paleoindian implies (Beck and Jones 1997).

Madsen *et al.* (2005) divide the Great Basin Paleoarchaic into Early and Late sub-periods at approximately the beginning of the Holocene. Diagnostic artifacts of the Early Paleoindian period include both fluted and stemmed projectile point varieties, the precise chronological relationship between which is unclear (e.g., Beck and Jones 1997, 2007; Grayson 1993). Late Paleoarchaic diagnostic artifacts include stemmed points and, after about 9,000 ^{14}C yrs B.P., Pinto points (e.g., Hockett 1995). By far the majority of known Great Basin Paleoarchaic sites are situated in places that would have been adjacent to pluvial lakes or near other wetland settings, suggesting that the types of resources that could be found in such areas were the main focus of subsistence (e.g., Beck and Jones 1997; Duke and Young 2007; Schmitt and Madsen 2005). Faunal remains and human coprolites indicate that small mammals, birds such as waterfowl and sage grouse (*Centrocercus urophasianus*), and wetland plants were important food resources across the Great Basin throughout the Paleoarchaic (e.g., Broughton et al. 2008; Hockett 2007; Madsen et al. 2005; Pinson 2007).

Paleoarchaic materials are rare in the LBBA and surrounding region. Stemmed points are reported to occur only as "scattered" isolates in the LBBA (Schroedl 1995a:55). Outside of the LBBA, stemmed points have been found, also in small numbers, at the Tosawihi Quarries (Ataman and Drews 1992:185; Hockett 2006:Table 2) and along Susie Creek and Maggie Creek (Armentrout and Hanes 1986). Other reports of stemmed points from northeastern Nevada for which provenience information is available (Hockett 1995) are from areas far to the south or east of the Humboldt River. Fluted points are even rarer than stemmed points in the area north of the Humboldt: an artifact described as a "Clovis preform" is reported from the Tosawihi Quarries (Ataman and Drews 1992:183–185), and a "Clovis point" is reported from the Izzenhood Valley

(McGuire et al. 2004:15). The rarity of Paleoarchaic materials in the LBBA and surrounding region, which suggests only a transient human presence in the area during this period (Schroedl 1995a), may be due to the absence, noted above, of terminal Pleistocene/early Holocene pluvial lakes in the region to the north of the Humboldt River and between the Lahontan and Bonneville Basins. Given the clear focus of Paleoarchaic settlement on wetland habitats, the absence of a substantial Paleoarchaic presence in this part of the Great Basin is perhaps not surprising.

2.2.2. EARLY ARCHAIC PERIOD: PIE CREEK PHASE

The shift from the Paleoarchaic to the Early Archaic period occurs around 8000 years ^{14}C yrs B.P. and corresponds to the onset of the middle Holocene period during which the climate of the Great Basin was, as a generalization, warmer and drier than that of today (Madsen et al. 2001). This transition comprised one of the most sudden and dramatic environmental changes in the climatic record for the region.

Due to a lack of well–dated sites or artifact assemblages that date to before 6,800 years ^{14}C yrs B.P. (Schroedl 1995a:55; 1995b:55), much remains unknown about the Early Archaic period in the LBBA. However, significant early deposits at Pie Creek Shelter enabled McGuire et al. (2004) to define a Pie Creek Phase, from 7000–4500 ^{14}C yrs B.P. The Pie Creek Phase appears to be associated with projectile point types such as Gatecliff, Humboldt, Northern Side-notched, Leaf-shaped, and a stemmed variant. Chipped stone assemblages from Pie Creek Shelter suggest that big-game hunting was not a significant component of the subsistence strategy. Small game was taken, and the recovered ground stone and botanical assemblages point to a focus on plant exploitation; this is consistent with a broader Great Basin-wide increase in the use of plant resources and grinding tools that began during the early to middle Holocene transition (e.g., Grayson 1993; Rhode et al. 2006). Overall, the assemblage suggests a group of highly mobile residential foragers who may have been concentrating on the wetland resources found in the Pie Creek Shelter environs (McGuire et al. 2004:123–125). Based as it is on data from a single site, this reconstruction should be considered only tentative, but it does at least provide a workable model for northern Humboldt River occupation in the middle Holocene.

2.2.3. MIDDLE ARCHAIC PERIOD: SOUTH FORK PHASE

The beginning of the Middle Archaic Period, at approximately 4500 ^{14}C yrs B.P., corresponds roughly to the climatic amelioration that occurred throughout the Great Basin at the transition to the late Holocene. In the LBBA, the first phase of the Middle Archaic is the South Fork Phase, which provides evidence for the presence of larger populations in the area as represented by a more visible archaeological record relative to earlier periods. Although Gatecliff points were still used during this period, Humboldt Concave-base points appear to be the dominant type (Schroedl 1995a:56, 1995b:56). McGuire et al. (2004) suggest that subsistence practices were reorganized around the acquisition of large game during this phase, and that settlement systems may have been restructured to promote more logistical exploitation of particular resource localities. Large, diverse assemblages of lithics and other artifacts associated with Gatecliff points may represent residential bases. However, wild-plant procurement did continue, and the exact nature of the settlement strategy has not been well established. Few of these larger sites have been excavated, and many apparently large occupations in the region appear to be palimpsests of repeated occupation.

2.2.4. MIDDLE ARCHAIC PERIOD: JAMES CREEK PHASE

The James Creek Phase, the second Middle Archaic phase defined for the LBBA, is represented by only a few well-excavated components. Elko series projectile points appear to have been common during this phase, but because they also occur in earlier and later phases (Schroedl 1995b:56), they cannot be considered truly diagnostic. The James Creek Phase seems to represent a continuing emphasis on logistical hunting, and faunal assemblages from the Component II occupations at Pie Creek Shelter indicate a continued focus on large game. Evidence for tool stone procurement suggests a reduction in the quantity of exotic lithic material types, interpreted by McGuire et al. (2004:128) as indicating an overall reduction in foraging territory size along with maintenance of significant logistical procurement strategies. Notably, larger residential camps are known from this period, including a site along Dry Susie Creek with evidence of pit structures, strongly suggesting that residential bases were used (Reust et al. 1994; Smith and Reust 1995).

2.2.5. LATE ARCHAIC PERIOD: MAGGIE CREEK PHASE

The Late Archaic Period, represented in the LBBA by the Maggie Creek Phase, is associated with the appearance of bow-and-arrow technology in the region. Arrow point types such as Eastgate, Rose Springs Corner-notched, and Rye Patch Miniature have been recorded both as isolated finds and at archaeological sites throughout the region. The Maggie Creek Phase begins approximately 1250 years ^{14}C yrs B.P., and lasts until approximately 650 years ^{14}C yrs B.P. (Hockett and Morgenstein 2003). James Creek and Pie Creek Shelters were occupied most intensively during this phase, though open sites in the LBBA may have been occupied less intensively than during earlier or later periods (McGuire et al. 2004:16–17, 129–130; Newsome and Tipps 1997). At Pie Creek Shelter, use of exotic tool stone continued to decline, suggesting further settlement and territorial contraction, and more intensive use of plant resources may also have begun (McGuire et al. 2004:129–130). Throughout northeastern Nevada more broadly, characteristics of Fremont assemblages—such as Fremont-like ceramics, Nawthis projectile points, and corn remains—are present in sites or components that date to the Maggie Creek Phase (Hockett and Morgenstein 2003). Most such sites are located some distance to the east and southeast of the LBBA, though maize pollen may be present in samples from James Creek Shelter, which is located just over the Tuscarora Mountains from the LBBA (Madsen 1990:109).

2.2.6. LATE PREHISTORIC PERIOD: EAGLE ROCK PHASE

During the Eagle Rock Phase, the single phase of the Late Prehistoric period in the region, new types of projectile points and new types of pottery appear. Small arrow points such as Desert Side-notched and Cottonwood Triangular points are typical of this phase, as is irregular brownware pottery. Within the LBBA, archaeological finds from the Eagle Rock Phase may date to as late as the 1880s or 1890s (Schroedl 1995b:56). The Eagle Rock Phase and its characteristic artifacts may coincide with an expansion of Numic-speaking peoples out of the Mojave Desert (e.g., Bettinger and Baumhoff 1982; Madsen 1975; Rhode 1994), though the cause of the changes in material culture that occur at this time remains open to debate (e.g., Aikens and Witherspoon 1986; Brewster 2003; Lyneis 1982; Madsen and Rhode 1994). Whatever the cause, however, there is no doubt that significant changes occur in the archaeological record of the region during the Eagle Rock Phase, and the overall pattern appears to represent significant intensification of the use of small game and plant resources relative to earlier periods (Bright et al. 2002; Ugan and Bright 2001).

2.3. Research Context for Data Recovery

As noted in Chapter 1, the 2007 BGMI project addressed a set of research questions that derive from the historic context prepared for the LBBA in 1991 (Schroedl 1991a) and from an evaluation of work conducted under the 1991 historic context. The specific research emphases for the project, adapted from the project treatment plan (Cannon and Stettler 2007), are discussed below, following an overview of the research domains outlined in the 1991 historic context and of the current status of these research domains. This overview provides important background for the research questions that guided data recovery for the 2007 BGMI project.

2.3.1. Research Domains in the 1991 Historic Context

The 1991 historic context discussed many areas in which research was needed, as of the date of its development, in order to better understand the prehistory of the LBBA. Specific research questions were posed for some of these areas, while for others only general needs were mentioned. Likewise, some of these areas were discussed as formal "research domains" in the 1991 historic context, while others were discussed simply as methodological questions or general research issues that could be addressed during work at any site in the region. All of the areas of research need discussed in the 1991 context are treated here as "research domains" for simplicity of presentation. This section summarizes these research domains, grouped into topical categories[1], as well as the results of the work that has been conducted within these domains since 1991. Also noted are the domains that were selected as research emphases for the 2007 BGMI Data Recovery Project.

Chronology and Temporal Change

Chronology

The 1991 historic context discussed a need for a refined projectile point chronology for the LBBA and for greater use of obsidian hydration dating (Schroedl 1991a:79). These issues were soon tackled: Schroedl (1995a) developed both a chronology of projectile point types for the LBBA and a hydration chronology for obsidian from the Paradise Valley source (the most commonly represented obsidian source in the LBBA). The overall culture history of the region is now well understood with the addition of even more recent work (e.g., McGuire et al. 2004), especially for the late Holocene period, to which the overwhelming majority of archaeological

[1] The research domains discussed here are the same as those listed in the project treatment plan (Cannon and Stettler 2007), though they have been rearranged into groups of similar topics.

materials in the LBBA date. For these reasons, issues of refining chronology were not a focus of the 2007 BGMI project, though data from the project are considered in light of earlier research into such issues.

TEMPORAL CHANGE

A general research question posed in the 1991 historic context involved exploring how such things as artifact types, settlement patterns, raw material use, and lithic reduction strategies changed over time (Schroedl 1991a:45). To date, such changes have not been examined in detail. This is due in part to insufficient attention to integrative analyses in previous projects. It is also due in part to too few investigated "single-component" deposits (i.e., deposits containing material that dates to relatively discrete periods of time) and to uneven data from the various time periods. Data compiled from reports on previous excavations in the LBBA indicate that 38 percent (34 of 89) of excavated components are palimpsest "multicomponent" deposits consisting of materials from multiple time periods (see Table 3). This predominance of multicomponent deposits in the LBBA excavated sample may be the result of a past bias towards the excavation of large sites with dense surface manifestations, which may be more likely to contain palimpsest assemblages than smaller, less dense sites (e.g., LaFond et al. 1995). It may also be due to insufficient testing focused on identifying single-component deposits prior to large-scale excavation. Because so many of the excavated sites in the LBBA are multicomponent, and because of the considerable importance of being able to extract temporal change from the archaeological record, a major research emphasis of the 2007 BGMI project was to develop methods to more effectively identify single-component deposits that are useful for addressing research questions about change over time. This issue is discussed in greater detail below (Section 2.3.2).

Table 3. Number of Excavated Components by Phase in the LBBA and Surrounding Area*

Phase	Number of Excavated Components
Protohistoric (Shoshone)	2
Eagle Rock	28
Maggie Creek	11
James Creek	0**
South Fork	5
Pie Creek	0
Multicomponent (palimpsest)	34
Unknown	9
Total	89

*These data were compiled from numerous excavation reports, as summarized in Seddon et al. (2007:Tables 2 and 3)

** Although no single-component James Creek occupation has been excavated, some James Creek material has been recovered from multicomponent occupations.

SITE FORMATION PROCESSES AND PALEOENVIRONMENT

THE EFFECT OF ARTIFACT COLLECTING ON SURFACE ASSEMBLAGES

The 1991 historic context posed the question of whether artifact collecting has biased surface artifact assemblages (Schroedl 1991a:35). This question has since been addressed in several studies (LaFond and Jones 1995; Schroedl 1995b, 1996), although no rigorous statistical analysis has been performed. These studies suggest that surface assemblages differ in composition from subsurface assemblages, a finding consistent with, but not conclusive of, a bias due to artifact collecting. This issue is explored further in Chapter 7 of this report, in which quantitative analyses of chipped stone tool and debitage data from the 2007 BGMI project are used to evaluate whether surface and subsurface assemblages differ in a manner that might be explained by artifact collecting.

EARLY ARCHAEOLOGICAL DEPOSITS IN THE LBBA

In 1991, few single-component archaeological deposits dating earlier than the Maggie Creek Phase had been found in the LBBA, and virtually no archaeological deposits dating to the middle Holocene or earlier had been discovered (e.g., Tipps 1996; see also Table 3). It was thought that such deposits might simply have gone undiscovered as a result of being deeply buried in alluvium along creeks in the area (Schroedl 1991a:34). Since 1991, two studies have been conducted to address this issue (Birnie 1996b; LaFond and Jones 1995), and these studies suggest that early deposits have eroded out of the LBB and are thus unlikely to be preserved. However, these studies are not exhaustive with respect to the full range of geomorphological settings in the area; indeed, exposures of Mazama tephra along Rodeo Creek suggest that Early Holocene sediments are present in at least some places within the LBBA, and there is a corresponding likelihood that Early Holocene archaeological materials are present as well. Thus, there is presently a need for systematic geoarchaeological work to evaluate whether pre-Maggie Creek Phase deposits are left in the LBBA. This would likely require extensive deep testing both at known archaeological sites and in other areas, and during the course of developing and implementing the research design for the 2007 BGMI project, it was determined that such work was beyond the scope of the project.

Comprehensive Understanding of Site Formation Processes

In addition to the specific issues relating to site formation processes discussed above, the 1991 historic context included a more general site formation process research domain, suggesting that excavation methodologies be designed so that the effects of site formation processes could be controlled when making behavioral interpretations (Schroedl 1991a:78). Since 1991, only limited attempts to explore the effects of geomorphological processes on archaeological deposits in the LBBA have been made within this research domain. This work has shown that buried James Creek and South Fork Phase material is present in the LBBA despite little surface indication of such material (Schroedl 1996:214), and that post-depositional processes have likely contributed to the formation of multicomponent deposits (Schroedl 1997:55–56). These important points aside, a synthetic understanding of site formation processes has not been developed for the LBBA. Such an understanding would likely be very useful because it may lead to methods that enable single-component deposits to be located and/or methods that would allow the complex occupational histories of multicomponent sites to be resolved. For this reason, understanding site formation processes is an important part of one of the main research emphases for the 2007 BGMI project (discussed further below), that of identifying single-component deposits. In Chapter 5 of this report, geomorphological observations are used to evaluate the likelihood that single-component deposits are present at the sites involved in this project and, by extension, elsewhere in the LBBA.

Paleoenvironment

The 1991 historic context described a need for understanding environmental change in the LBBA during the course of human occupation in the area (Schroedl 1991a:72), but limited paleoenvironmental data specific to the LBBA have been collected since 1991. Only one geomorphological study, from which a model of paleoenvironmental change was developed, has been conducted (Birnie 1996b). The collection of additional paleoenvironmental evidence (e.g., from packrat middens or from wetland sediments) remains an important need for the LBBA. However, since the most useful types of paleoenvironmental data typically come from settings outside archaeological sites in the LBBA, recovery of such data from the sites investigated during the 2007 BGMI project was not a priority for this project.

Site and Locus Types

Classes of Cultural Properties

It was proposed in the 1991 historic context that sites be classified into types, primarily simple or complex (each with sub-types), that should reflect behavioral variability (Schroedl 1991a:36). Since then, it has become apparent that sites that might be classified as complex under the scheme proposed in the 1991 historic context are complex primarily because they are multicomponent, and that smaller and less dense surface assemblages are more likely to be associated with buried single-component deposits than are larger and denser surface assemblages (e.g., LaFond et al. 1995). In fact, a focus on larger sites with denser surface assemblages may be part of the reason why multicomponent deposits comprise such a large percentage of the excavated localities in the LBBA to date (Table 3). As noted above, and as is discussed in detail below, a major research emphasis of the 2007 BGMI project was to attempt to develop ways of more efficiently identifying single–component deposits.

Activity Locus Type Frequencies

The 1991 historic context asked how common different types of activity loci were in the LBBA (Schroedl 1991a:43). This question was aimed at understanding the function of individual sites or site loci in the area (e.g., lithic reduction areas vs. living areas), information that could be applied to larger research issues. In virtually every project that P-III conducted after the development of the 1991 historic context, sites were classified into various functional categories, but not in a particularly systematic manner. In addition, as noted above, many of the excavated deposits were multicomponent, and these have proven difficult to classify into activity locus types. Issues of site or site locus function are addressed in Chapter 7 of this report.

Spatial Distribution of Locus Types

The 1991 historic context proposed that spatial relationships among locus types should be examined, as should the distribution of locus types in relation to environmental factors such as vegetation type, topography, distance to water, and distance to raw materials (Schroedl 1991a:44). An overall analysis of the distribution of locus types has never been conducted, likely due, at least in part, to the "multicomponent problem" discussed above. More limited aspects of this topic, however, have been examined; for example, a relationship between hunting/processing sites and springs has been demonstrated to some degree (Tipps 1997; Tipps and Miller 1998). Because the small number of sites investigated during the 2007 BGMI project does not provide an adequate sample for addressing questions about locus type distributions, this research domain was not a focus of this project.

Subsistence, Site Function, and Settlement Patterns

Site Structure and Function

It was proposed that analyses of site structure and function could be used to determine where LBBA groups fell along Binford's (1980) forager-collector continuum of settlement systems and how this might have changed over time (Schroedl 1991a:47–50). Since the development of the 1991 historic context, it has been common practice to classify investigated sites in the LBBA into categories that derive from Binford's analysis (e.g., short-term residential base camp, field camp, etc.). However, such classification can be confounded by the problem of multicomponent deposits. Despite the frequency with which sites in the LBBA have been classified into such types, only recently has any synthetic argument about the nature of settlement systems in the region been advanced, and this argument does not actually rely to any great degree on data specific to the LBBA or the surrounding region. McGuire and colleagues (McGuire and Hildebrandt 2005; McGuire et al. 2004) have suggested, based on evidence generalized from across the Great Basin, that the groups who occupied northern Nevada during the late Holocene adopted logistically organized settlement systems. Whether such logistical organization was actually practiced in the LBBA remains to be demonstrated with data from the area. As is discussed further below, documenting site structure for purposes of understanding regional settlement systems was a primary research emphasis for the 2007 BGMI project.

Settlement and Subsistence Patterns

The 1991 historic context argued that models from foraging theory (e.g., Stephens and Krebs 1986) could be used to help understand subsistence and settlement patterns. A "range site" analysis, involving the use of soil types to reconstruct patch return rates (i.e., the amount of calories that could be obtained per unit time from a given area), was proposed as a means of operationalizing such models (Schroedl 1991a:47–50). A range site analysis has not been pursued for the LBBA since 1991, though this approach has proven useful in other Great Basin contexts (e.g., Zeanah 2004; Zeanah et al. 2004). On the other hand, syntheses of subsistence data (including faunal, floral, ground stone, and thermal feature data from the numerous excavated sites in the LBBA) have been completed and have shown changes in subsistence that are understandable in terms of foraging theory (e.g., Birnie 1996a; Bright 1998; see also Bright et al. 2002; Corbeil 1996; Coulam 1996; Ugan and Bright 2001). In particular, although time periods are unevenly covered, these data have clearly demonstrated that diet breadth increased over time in the LBBA, and it appears that technology changed in response to this. The cause of the increase in diet breadth remains incompletely explored, but it is potentially relevant to a recent debate over subsistence change in the Great Basin between McGuire and Hildebrandt (2005) and Byers and Broughton (2004; see also Broughton et al. 2008). The possibility that patterns of subsistence change might have varied among ecological settings (Hockett 2005) also remains to be fully explored in the LBBA. Addressing subsistence-related research questions was not a primary research focus for the 2007 BGMI project; however, some subsistence data were recovered during the course of the project, and these data are considered in light of current research issues in Chapter 6 of this report.

Lithic Technology and Technological Organization

Variability in the Use of Lithic Raw Materials

The 1991 historic context noted a need to understand variability in the use of lithic materials from different sources, including the Tosawihi Quarries (Schroedl 1991a:44). Tosawihi chert overwhelmingly dominates most lithic assemblages in the LBBA. Obsidian also occurs at many sites, and it has likewise become apparent that the frequency of obsidian from various sources changed over time. The causes of these changes, which may be related to larger-scale changes in land-use across northern Nevada (e.g., Hockett 2006), have yet to be explored in detail. Lithic sourcing data from the 2007 BGMI project that are relevant to such issues are discussed in Chapter 7 of this report.

Lithics and Activity Locus Function

It was proposed in the 1991 historic context that lithic analysis could be used to address the interrelated issues discussed above of site function and settlement patterns (Schroedl 1991a:80).

In particular, it was suggested that site or locus function could be inferred from an analysis of the relationship between lithic assemblage diversity and assemblage size. Since 1991, there has been some suggestion from studies conducted in the LBBA that site function cannot be identified based on debitage (e.g., Schroedl 1997). However, no systematic study of this issue has been completed, and the proposed analysis of the relationship between lithic assemblage diversity and assemblage size has not been conducted. Substantial lithic tool and debitage data were collected during the 2007 BGMI project, and are applied to the issue of activity locus function in Chapter 7 of this report.

Lithic Procurement Strategies

In its discussion of lithic procurement strategies (Schroedl 1991a:80), the 1991 historic context primarily considered the use of material from the Tosawihi Quarries chert source. Discussion of the use of this material was largely couched in terms of Elston's economic model of Tosawihi lithic material type procurement (e.g., Elston 1990, 1992). Work conducted in the area since 1991 has suggested that, contrary to a key assumption of Elston's model, not all material obtained from Tosawihi was transported from the quarries in the form of bifaces; rather, it is clear that some was taken away in the form of more costly-to-transport non-bifacial cores (Hockett 2006; LaFond 1996; Schroedl 1997). Recognition that this assumption is problematic (made possible only by application of Elston's very productive model) has led to new questions about how and why the importance of biface reduction and transport relative to core reduction and transport varied over time and space. Chapter 7 of this report presents lithic debitage, biface, and core data collected during the 2007 BGMI project relevant to these new research questions.

Lithic Technology and Mobility

The 1991 historic context presents an insightful discussion of how lithic technology might be influenced by mobility patterns. However, no synthetic study of lithics from the LBBA has since been completed to address this issue. Recently, McGuire and colleagues (McGuire and Hildebrandt 2005; McGuire et al. 2004) have suggested that mobility became increasingly logistical (sensu Binford 1980) between the middle and the late Holocene, not only in northern Nevada but throughout the Great Basin, and such changes in settlement patterns might be reflected in lithic assemblages (e.g., Kelly 1988; Parry and Kelly 1987). However, as noted above, the increase in logistical organization that McGuire et al. (2004) suggest occurred has yet to be demonstrated in the LBBA. Moreover, it is becoming clear that the relationship between lithic technology and mobility is more complex than previously thought (e.g., Prasciunas 2007). Given these points, a thorough analysis, documenting changes in settlement patterns specific to the LBBA and incorporating recent insights into the relationship between lithic technology and mobility, is required in order to fully address this issue. Conducting such an analysis was not a primary emphasis of the 2007 BGMI project; however, lithic data collected during the project are relevant to this research topic and are applied to it in Chapter 7 of this report.

2.3.2. Research Emphases for this Project

As noted in the above overview of the 1991 historic context and of work conducted under it, a subset of the currently important research topics for the area were selected as research emphases for the 2007 BGMI project (Cannon and Stettler 2007). These topics can be summarized as 1) identifying deposits that can provide information about change over time, and 2) documenting and understanding site structure. These research emphases are discussed further here. Chapter 3 of this report gives a detailed description of the field methods that were used to address these research emphases, and subsequent chapters of this report describe the laboratory analyses that were applied both to these research emphases and to other research topics to which data from the project are relevant.

IDENTIFYING DEPOSITS THAT CAN PROVIDE INFORMATION ABOUT TEMPORAL CHANGE

Many of the research domains from the 1991 historic context have been incompletely addressed due to insufficient investigation of deposits that allow documentation of patterns of change over time. Solving this problem requires excavation of single-component deposits that span the area's occupational history, but, as noted above, much of the previous excavation effort in the LBBA had been expended on multicomponent deposits. In response to this situation, the 2007 BGMI project was designed to develop efficient and effective ways of identifying single-component deposits and to extract useful information from any such deposits that could be identified. The research design focused, in particular, on the following specific questions:

- Are single-component deposits (i.e., deposits that date to relatively discrete spans of time) present at the sites involved in the project?
- If so, what is the age of those deposits, and what can we learn from them about their respective time periods and about diachronic change?

As described in greater detail in Chapter 3, the approach that was taken to answer these questions involved first using remote sensing techniques in an attempt to locate subsurface thermal features and activity areas. Then, an initial exploratory stage of excavation focused on identifying single-component deposits by opening small areas, chosen on the basis of remote sensing anomalies or surface artifact characteristics, and by obtaining as much chronological information as possible from them. Later stages of excavation were intended to more fully explore deposits that were identified as single-component in this manner. After manual excavation was completed, surface sediments were mechanically stripped to reveal any remaining subsurface features for documentation and collection of samples for dating. The goal was to obtain data from single-component deposits that could be used to address specific research domains from the 1991 historic context.

Despite a research design focused specifically on identifying single-component deposits, however, it turned out not to be possible to assign most of the sites or site loci investigated during the project to a single one of the temporal phases that have been defined for the LBBA. Rather, most sites or site loci provided evidence for use during at least two phases and therefore cannot be considered to be single-component in the strict sense of "single-phase". On the other hand, it did turn out to be possible to explore change over time at a coarser scale by assigning materials recovered during the project to time periods broader than individual phases. Given that multicomponent deposits are obviously so abundant in the LBBA—as has been demonstrated in much previous work in the area and reconfirmed during this project—it may be useful to adopt this sort of approach more often in the future. That is, future research should perhaps be designed with the degree of chronological resolution that can be achieved in mind.

DOCUMENTING AND UNDERSTANDING SITE STRUCTURE

The research domains from the 1991 historic context that were chosen to be the primary substantive focus of the 2007 BGMI project are those that pertain in some manner to site structure. The issue of site structure is very relevant to many of the research domains from the 1991 historic context, particularly those involving settlement patterns. However, as noted in the above overview of the current status of archaeological research in the LBBA, a complete understanding of site structure, which would include both documentation and explanation of patterns in the organization of entire sites, has not yet been developed for the area. Thus, a major goal of the project was to use any single-component occupations that could be identified to develop a more thorough understanding of site structure. The treatment plan specified the following research questions to focus investigations into this issue:

- How were sites structured during individual time periods?
- How did site structure change over time?
- How does site structure relate to subsistence and mobility adaptations?

The research design for addressing these questions involved first identifying single-component subsurface deposits as described above. Then, if such deposits could be identified, the distribution of different types of features across those occupations would be recorded, thereby revealing the degree to which sites were formally structured. In addition, the degree of activity redundancy among features within an occupation was to be documented in order to infer where settlement practices fell along Binford's (1980) forager-collector continuum. Mechanical stripping (the last stage of fieldwork) was intended to enable site structure to be recorded further. Finally, the site structure data obtained during the project were to be compared to other lines of evidence that relate to, for example, subsistence and mobility, in order to develop an understanding of the factors that influenced site structure patterns.

As is discussed in the following chapters of this report, only one of the five sites investigated during the project (26EU2126) proved to have subsurface deposits that might be understood as activity areas. In addition, the surface archaeological materials documented during the project largely lack the chronological information necessary for identifying single-component site loci or activity areas. Thus, the site structure component of the research design could not be fully implemented: the sample of identifiable, single-component activity areas documented during the project is simply too small.

However, while it is not possible to conduct the thorough analysis of site structure that was hoped for, it is possible to use data from this project to address some of the research domains from the 1991 historic context that are related to this topic. In particular, lithic data collected during the project enable methods for identifying activity locus function specified in the 1991 historic context to be implemented (see Section 7.4.1). Moreover, somewhat serendipitously, the large chipped stone artifact assemblage recovered from surface collection and excavation allowed a wider range of research topics related to stone tool manufacture to be addressed than was anticipated going into the project. In fact, Chapter 7 of this report presents a synthetic, multi-site lithic analysis—focused on issues such as mobility, technological organization, and use of the Tosawihi Quarries—of a sort that has not previously been attempted for the LBBA. Thus, while it turned out not to be possible to conduct the kind of investigation of site structure that was planned, the project did produce data that can advance our understanding of other aspects of prehistoric adaptations in the LBBA in important ways.

3. FIELD METHODS

Michael D. Cannon and Sara Meess

This chapter describes the field methods employed to address the research topics discussed in Chapter 2. The general research design for fieldwork is presented first, followed by a description of how this research design was implemented at each of the sites investigated during the 2007 BGMI project.

3.1. DATA RECOVERY APPROACH

The data recovery process occurred in four stages: surface artifact collection, remote sensing survey, excavation, and mechanical stripping. The procedures followed during each of these stages, and the rationale behind them, are described here. Probing conducted in 2006 at the five NRHP-eligible sites in the Goldstrike PoO APE, which provided a starting point for the 2007 data recovery fieldwork, is also discussed in this section, as are the methods that were used in establishing site grid systems and in mapping during the 2007 BGMI project.

The overall fieldwork approach for the project was designed to be flexible so that data recovery could proceed in as productive and efficient a manner as possible. Information gained in the early stages of fieldwork was used to target subsequent efforts toward those sites or areas of sites that appeared most likely to be single-component and most likely to provide data that could be used to address currently important research questions.

3.1.1. PROBING

In 2005, on behalf of BGMI and in consultation with BLM-Elko, SWCA revisited the 26 NRHP-eligible archaeological sites located either partially or wholly within the Goldstrike Mine boundary. SWCA also revisited 23 of the 96 ineligible sites within the mine boundary that were judged to have potential to provide data relevant to research questions that had become important since the development of the 1991 LBBA historic context. The purpose of the revisits was to update IMACS forms for these sites, many of which had originally been recorded 10–20 years earlier. This process continued in 2006 with probing at 32 of the revisited sites, including the five sites subsequently investigated during the 2007 BGMI project.

Probing involved a combination of shovel tests and 1 × 1–m test excavation units. Shovel tests were approximately 50 × 50 cm in extent and were dug to a depth of 10 cm. The number of shovel tests dug at each of the five sites included in the 2007 BGMI project ranged from 2 to 27. Locations for shovel tests were determined based on factors such as the density and diversity of artifacts within an area and the presence of tools or obsidian artifacts. Based on the results of shovel testing, 1 × 1–m test excavation units were placed in the areas of each site that appeared likely to yield the greatest amount of additional information. Ten test units were excavated at 26EU2064, and one was dug at each of the four other sites involved in the 2007 BGMI project. Each test unit was excavated in 10-cm levels until direct evidence of multicomponent deposits was identified, or until sterile or bioturbated sediments were reached. The depth of the test units excavated at the sites investigated in the 2007 BGMI project ranged from 10 to 35 cm. All sediments excavated from shovel tests and test units were screened through 1/4" mesh. The locations of shovel tests and test units were recorded by Global Positioning System (GPS), and these locations are shown on site maps in Section 3.2 below. No archaeological features were encountered during probing at any of the sites involved in the 2007 BGMI project, though chipped stone artifacts were recovered from buried contexts at all of these sites. In addition, probing at 26EU2126 produced burned large-mammal bone, and the test unit from which this bone came provided the starting point for what turned out to be the most productive block excavation area opened during the 2007 field season. Chipped stone artifacts and faunal remains recovered in 2006 during probing at the sites involved in the 2007 BGMI project are included in the analyses presented in subsequent chapters of this report.

3.1.2. Surface Collection

The first stage of the 2007 data recovery process consisted of systematically collecting artifacts from the surface of each site. One purpose of these surface collections was to produce data on surface artifact distributions that could be used in conjunction with remote sensing data to select locations for excavation. In addition, temporally diagnostic artifacts collected during this stage of the process (as well as diagnostics recorded during earlier work at the sites involved in the project) were used to help determine whether sites or artifact concentrations might be single-component, and thus of higher priority for excavation. Finally, intensive surface collection was warranted by the fact that vegetation was to be cleared from the sites prior to conducting the remote sensing surveys and by the fact that surface sediments were to be mechanically stripped at the completion of fieldwork.

The results of the surface collections are shown in maps in Section 3.2 below. To conduct these surface collections, crews of three to six people walked close (2–3 m) interval transects across the entire area of each site, flagging all observed artifacts or artifact concentrations. In most cases, artifacts discovered during the close interval survey were collected with provenience recorded by GPS, and artifacts found within approximately 1 m of each other (i.e., within the precision of the GPS units that were used) were collected together. Each artifact or group of artifacts of a single artifact type (chipped stone debitage, chipped stone tool, ground stone, etc.) that corresponded to a single GPS shot was treated as an individual field specimen (FS) for cataloging purposes. For three artifact concentrations (one at 26EU1539 and two at 26EU1548), the density of artifacts was high enough that it was more efficient to collect them within 1 × 1–m grids (discussed further in Section 3.2). In these cases, collection grids were laid out with ropes marked at 1-m intervals, and the four corners of each grid were mapped with a total station, enabling the coordinates of each 1 × 1–m unit within the grid to be determined. Each unit within a collection grid was labeled with a letter corresponding to its row (starting with A on the south) and a number corresponding to its column (starting with 1 on the west). All artifacts of a specific type within a given 1 × 1–m unit were treated as a single FS for the grid collections. Artifact densities within some of the 1 × 1–m units in the collection grid at 26EU1539 were so high that, rather than picking up each artifact visible from the surface individually, the upper 1–2 cm of sediment was scraped with a trowel into a bag and artifacts were later collected by screening in the lab. In addition to collecting chipped stone, ground stone, and historic artifacts during the surface collections, the locations of a few fire-cracked rock (FCR) scatters were recorded by GPS, and this information was also considered in selecting excavation areas.

3.1.3. Remote Sensing Survey

Following surface collection, each site was surveyed using both a magnetometer and an electromagnetic (EM) instrument that simultaneously collects sediment conductivity and magnetic susceptibility readings. The goal of the magnetometer survey was to locate buried thermal features, while the goal of the EM survey was to identify subsurface occupational surfaces or activity areas. These geophysical techniques were chosen because, as discussed in Chapter 4, they are sensitive to the kinds of archaeological features that were of interest. They are also relatively unaffected by the uneven ground surface conditions that characterize the sites involved in this project, which would have posed a problem for other techniques such as ground-penetrating radar. Anomalies in the remote sensing data that appeared likely to indicate thermal features and occupational surfaces were targeted during the initial exploratory phase of excavation. It was hoped that remote sensing would enable such features to be located more efficiently than typically occurs when traditional testing methods are used so that the focus of excavation could quickly turn from locating features to evaluating whether deposits were single-component.

In addition to helping identify single-component deposits, a secondary goal of the remote sensing surveys was to evaluate whether the geophysical techniques that were used are effective in the first place at locating buried thermal features and occupational surfaces in the LBBA. However, as discussed further below, few such features were encountered during excavation, and the mechanical stripping that was conducted as the final stage of the data recovery process revealed that such features are rare or non-existent at the sites involved in this project. Thus, this project cannot provide a thorough evaluation of the utility of geophysical survey for locating the kinds of features that were the target of the remote sensing surveys at sites in the LBBA as hoped. However, the project does provide insights into steps that might be taken to ensure more productive use of remote sensing methods in the future. These insights are discussed in the concluding chapter of this report. Moreover, despite the rarity of the types of features that were targeted at the investigated sites, it was still possible to implement the general fieldwork strategy of using information gained early in the fieldwork to focus later efforts toward those sites or areas of sites that appeared most useful in relation to the project research emphases.

The remote sensing surveys were conducted by Archaeo-Geophysical Associates LLC (AGA), working under subcontract to SWCA. Details of remote sensing data collection and processing procedures, as well as remote sensing results, are discussed in Chapter 4 of this report, which is coauthored by Chester P. Walker of AGA.

Before conducting the remote sensing surveys, but after the surface collections were complete, vegetation was cleared from the sites with a rotary mower (a "brush hog") to allow systematic coverage of the sites with near-surface geophysical instruments. Remote sensing data collection grids of 20 × 20–m units were then staked out across the sites using a total station; the methods used to establish these site grids are discussed in greater detail in Section 3.1.6 below. Portions of each site were omitted from the remote sensing survey due to steep slopes, obstacles (e.g., deep channels), or metal mine infrastructure that would interfere with results (e.g., a pipeline). At 26EU1548, the remote sensing survey area extended approximately 20–30 m west of the site boundary to explore the possibility that hearth features were located uphill from the surface artifact concentrations on which the site boundary was based.

3.1.4. EXCAVATION

Excavation began following the completion of the remote sensing survey at all five sites and preliminary analysis of the geophysical data. As noted above, excavation proceeded in a phased manner. Initial excavation efforts targeted the locations of selected remote sensing anomalies and/or the locations of surface artifact concentrations or notable surface materials. One purpose of these initial exploratory excavations was to locate buried features and to identify single-component deposits so that such deposits could be explored further through subsequent excavation. Given this purpose, recovery of datable materials and temporally diagnostic artifacts was a major goal of the exploratory excavations. Work conducted during this phase of the project proceeded in a "rolling" manner among sites: while the results of dating analyses from the initial phase of excavation at some of the sites were pending, work continued at other sites.

Another purpose of the initial phase of excavation was to evaluate the relationship between different types of geophysical anomalies and different types of archaeological features. The plan was that, as it became clear what types of features were reflected by what types of anomalies, subsequent excavation efforts would focus on the types of anomalies that reflected the features with the greatest data potential. However, as noted above, excavation of geophysical anomaly locations revealed few archaeological features: in fact, 29 anomalies were specifically targeted during the initial phase of excavations, and among these anomaly locations, only one archaeological feature was discovered, an FCR concentration with small amounts of associated charcoal (Feature 1 at 26EU2126, which, as is discussed further below and in Chapter 4, was found in an area of high conductivity). Potential causes of the geophysical anomalies other than archaeological features are discussed in Chapter 4. For present purposes, the important point is that once it became apparent that most anomalies did not reflect archaeological features, exploratory excavations began to focus on the locations of surface artifact concentrations or notable surface materials to a greater degree than on the locations of geophysical anomalies. Nonetheless, the general approach of using exploratory excavations to identify deposits that might merit more extensive block excavation continued to be followed.

The basis for the placement of each area excavated during the 2007 BGMI project is described in Section 3.2, and excavation unit locations are shown on maps in that section. In general, the location of each excavation unit was determined by geophysical data, surface artifact data, and/or findings in other excavation units. Nearly all excavation areas were placed at locations selected during consultation between Mike Cannon and Heather Stettler, SWCA Principal Investigators, and Bill Fawcett, BLM-Elko archaeologist, often also involving Chet Walker, the AGA principal, and one or more BGMI representatives, particularly Darek Huebner and Andy Cole. However, a few areas (specified in Section 3.2) were placed based solely on the field judgment of a SWCA Principal Investigator (Cannon) when other locations proved unproductive.

In order to implement the phased approach to excavation, fieldwork during the excavation stage of the project took place in three sessions of seven to nine days, separated by breaks of five to seven days. These breaks allowed radiocarbon and obsidian hydration dating samples to be submitted, and they also enabled the next session to be planned based on previously obtained dating results and on further inspection of geophysical and surface artifact data.

The first excavation session focused primarily on magnetometer anomalies, 16 of which were excavated during the session, along with one conductivity anomaly. These excavation locations were selected in an initial excavation planning meeting held at the BLM-Elko office on August 22, 2007. At this meeting, several remote sensing anomalies at each site were chosen for excavation pending field inspection of anomaly locations (which occurred on August 30), and additional anomalies were selected as "backups" to be excavated in the event that field inspection suggested that any of the primary locations should not be excavated (for example, because there was evidence of bioturbation at the location or because metal was found on the surface that could have been the cause of the magnetometer anomaly that was observed at the location). No archaeological features were discovered at any of the magnetometer anomaly locations excavated during the first session, but buried FCR was abundant at the location of the single conductivity anomaly that was excavated (Operation C at 26EU2126), which also corresponded with the location of a surface artifact concentration. Thus, the emphasis for the second excavation session shifted from magnetometer anomalies to conductivity anomalies and areas of high surface artifact density. In addition, excavation units were opened around the test unit dug at 26EU2126 during the 2006 probing project in which artifacts and burned bone were abundant (an area labeled Operation F in 2007). When the 11 conductivity anomaly locations opened during the second session revealed no archaeological features, the focus of work conducted during the third excavation session shifted to locations dictated by surface materials or by findings in other excavation units; mechanical stripping also began during the third session.

The general excavation methods that were used at all sites are described next, and the details of the excavation process at each site are summarized in Section 3.2. The numbers of 1 × 1–m excavation units dug at each site during the 2007 BGMI project are listed inTable 4, along with the number of shovel tests and test units excavated during the probing conducted in 2006[2].

[2] The data recovery plan for the project specified estimated amounts of area to be excavated at each site (Cannon and Stettler 2007:Table 3). These estimates were intended to be maximum values that would enable BGMI to plan adequately for the project; actual excavation amounts were to be determined based on results from surface collection, remote sensing, and early stages of excavation (Cannon and Stettler 2007:31). At four of the sites involved in the project, the actual amount of area excavated was lower than the estimated maximum amount because archaeological features were not encountered in the quantities anticipated. At the fifth site, 26EU2126, the actual amount excavated was nearly three times the maxiumum estimated amount; this was done because it was agreed that the best use of project resources was to focus on the one site that appeared after exploratory excavations to be able to provide data applicable to project research questions. Overall, the coupled use of remote sensing and initial exploratory excavations likely did result in considerable savings of effort compared to the type of strategy used in the LBBA in the past, which relies heavily on extensive block excavation.

Table 4. Number of 1 × 1–m Excavation Units Dug at Each Site

Site	2006 Probing	2007 Data Recovery	Total
26EU1533	1 (+ 2 shovel tests)	14	15
26EU1539	1 (+ 3 shovel tests)	22	23
26EU1548	1 (+ 5 shovel tests)	11	12
26EU2064	10 (+ 27 shovel tests)	13	23
26EU2126	1 (+ 3 shovel tests)	56	57
Total	14	116	130

Excavation proceeded by digging 1 × 1–m units, either individually or in blocks. Each block of contiguous 1 × 1–m excavation units (including isolated individual units) was termed an "operation" and designated with a letter (e.g., "Operation B"), while each 1 × 1–m unit within an operation was designated with the operation letter followed by a number (e.g., "Unit B3"). Excavation units were not necessarily staked out with reference to site grid systems (which were established as described below in Section 3.1.6); rather, their locations and orientations were determined by other, more relevant factors. Operations intended to explore remote sensing anomalies were centered over the estimated centers of those anomalies, following methods described in greater detail below, and they were oriented along the cardinal directions of site grid systems at an "eyeball" level of approximation (as noted in Section 3.1.6, site grid systems were not oriented to true north for reasons related to the remote sensing surveys). The locations and orientations of other operations were determined by such factors as landforms (in the case of Operations F and G at 26EU1539, which are discussed below) or test units excavated in a previous year prior to the establishment of site grid systems (the case for Operation F at 26EU2126, also discussed below). In lieu of staking out excavation units with reference to site grid systems, absolute spatial control was maintained by mapping the corners of excavation units with a total station (see Section 3.1.6 for details).

Excavation was conducted by a crew of four to six people. Units were excavated by shovel skimming and troweling, and all excavated sediments were screened through 1/4" mesh (with the exception of bulk samples of feature fill, discussed further below). All units were dug in 10–cm arbitrary levels to a depth of 20 cm below surface except for two, discussed in Section 3.2, that were dug to 30 cm below surface. Vertical control was maintained in most cases through an arbitrary sub-datum established for this purpose, though in a few cases the natural ground surface at a corner of the unit was used. In either situation, the location and elevation of the reference point relative to the site datum were recorded with the total station so that absolute elevations for excavation levels could be calculated. The floors of most units were kept level, and if the ground surface was sloping, the depth to the top and bottom of excavation levels was measured from the corner of the unit at which the ground surface was highest. In two instances involving units dug on a steep slope (Operations D and E at 26EU1533), the floors of units were dug parallel to the ground surface; the surface at the lowest sides of the units in these operations was more than 20 cm below the surface at the highest sides, and had floors been dug level in these units, a portion of them would have remained unexcavated after digging two 20 cm levels.

Recovered archaeological materials were bagged by 10-cm level and 1 × 1–m unit, and each artifact type (chipped stone debitage, faunal remains, etc.) within a given unit and level was collected as a separate FS. For each level within each unit, a unit-level form was filled out that provided detailed information about such things as the depth of the level, sediment characteristics, types of artifacts and other materials encountered, features (if present), disturbances, and other important observations. To assist in understanding site formation processes, a representative sample of the excavation units at each site was selected for stratigraphic description and profiling. All units were photographed both prior to and after excavation.

When a thermal feature was exposed in an excavation unit, it was first drawn in plan view and photographed. It was then sectioned, and approximately half of the feature was excavated following its internal stratigraphy; this produced a profile that was drawn and photographed. Finally, the remainder of the feature fill was excavated, and a photograph of the feature depression was taken after excavation. Feature fill sediments were collected as bulk samples for flotation analysis. Features were assigned arbitrary sequential feature numbers by site, and a form was filled out for each feature describing its morphology, contents, and context.

As noted above, excavation occurred both at the locations of a sample of remote sensing anomalies and at locations selected based on surface artifact data or on findings from other excavation units. Further detail about specific procedures followed for excavation of remote sensing anomaly locations is provided below, as is a description of methods used in auger probing, which was conducted during the excavation of two sites to help evaluate the causes of remote sensing anomalies.

REMOTE SENSING ANOMALY EXCAVATIONS

For the purposes of this project, a remote sensing anomaly is defined as any feature in the geophysical data that was judged likely to reflect an archaeological feature of interest. These judgments were made during consultations among the individuals specified above on p. 31. The locations of 29 such anomalies were specifically targeted for excavation during the exploratory phase of the project, including 17 magnetometer anomalies and 12 EM anomalies[3].

Remote sensing anomaly locations were found in the field by triangulation from the corners of 20 × 20–m site grid units. Distances for triangulation were calculated from to-scale remote sensing images by measuring from the center of an anomaly to the closest two grid unit corners. Then, in the field, tape measures were used to triangulate from the appropriate grid corner stakes to the anomaly center, and the spot found by triangulation was marked with a pin flag. Subsequent mapping of excavation units with the total station showed that excavation units were placed precisely over targeted anomalies, indicating that this method for finding anomaly locations was highly accurate. It is likely that this method for finding anomaly locations resulted

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[3] This number includes one anomaly that was excavated during the third excavation session, after the initial round of magnetometer anomaly testing. Operation I at 26EU2126 was part of a line of systematic test units dug at this site, and happened to be placed near the location of one of the magnetometer anomalies selected as a "backup" excavation location during the initial excavation planning meeting. The location of for this unit determined by the systematic sampling scheme was adjusted slightly so that it would encompass the anomaly location.

in far greater accuracy than might have been obtained from using GPS units, which (with the exception of survey-grade GPS units) have an average error on the order of 50–100 cm.

It was initially unknown how precisely anomaly locations could be found in the field, so a 2 × 2–m block area was staked out at each of the anomaly locations (with the exception of two locations, for reasons discussed in Section 3.2). This size of area—much larger than the diameter of the thermal features that were expected to be encountered—allowed for some error in identifying the physical locations of the sources of anomalies from the remote sensing data images. The center of each 2 × 2–m block was located at the center of the anomaly as found by triangulation. For the first few anomaly locations excavated during the course of the project, all four 1 × 1–m units within a 2 × 2–m block were excavated. However, once it became clear that anomaly locations were being found precisely, only one or two of the 1 × 1–m units within a 2 × 2–m block were initially excavated. Diagonally opposed units were excavated in these cases, and the remainder of the units in the 2 × 2–m block were not excavated if a feature was not discovered by that point.

Before excavation at magnetometer anomalies, the ground surface within a radius of several meters around the flagged anomaly location was swept with a metal detector. In a few instances, pieces of metal were found and were determined to be the cause of the magnetometer anomaly that was being targeted. These locations were not excavated, and one of the "backup" excavation locations selected during the initial excavation planning meeting was excavated instead.

AUGER PROBING

Limited auger probing was conducted at 26EU1533 and 26EU1539 as part of efforts to evaluate the causes of patterns in the remote sensing data, and it also provided important information about site formation processes. A 4" bucket auger was used to bring up samples of sediments. Sediment texture and color were described on an auger probing form, and the depth at which any sedimetological changes occurred was recorded. Auger probe holes were dug to a maximum depth of approximately 80 cm, unless impenetrable sediments prevented the auger from going any deeper. At both of the sites where augering was done, auger probes were taken at intervals along linear transects that crossed features of interest in the remote sensing data.

3.1.5. MECHANICAL STRIPPING

The final stage of the data recovery process was to mechanically strip (or "blade") the surface sediments from each site, as has been done during many previous data recovery projects in the LBBA (e.g., Schroedl 1995b). One purpose of the mechanical stripping was to locate any archaeological features that may have been missed in the manual excavations, thereby potentially providing additional information about site structure. Another purpose was to allow further evaluation of the geophysical data through comparison of the distribution of remote sensing anomalies to the distribution of archaeological features and/or site sedimentological characteristics.

Blading was performed with a road grader (operated by a BGMI contractor) and involved skimming the upper 10–15 cm of sediment from transects across a site in two successive passes.

The first pass skimmed 5–8 cm from a transect and the second skimmed an additional 5–8 cm (the depth of the grader cut varied slightly due to topography). The sediment from each transect was left in a "windrow" on top of the previous transect. The grader was followed at all times by two SWCA monitors who flagged the locations of all possible archaeological features, and these flagged locations were avoided in subsequent passes by the grader. Each flagged feature was carefully inspected to determine if it was archaeological or natural (such as the remains of vegetation that had burned in a wildfire). Archaeological features were recorded and collected as described in Section 3.1.4. A few features that were clearly not archaeological were also recorded and collected in the same manner for comparison to archaeological features, and the results of this comparison are presented in Chapter 6.

Chipped stone tools, ground stone artifacts, and other notable artifacts exposed during blading were collected as described above for the surface collections, though in some cases the provenience of these artifacts was recorded by total station rather than by GPS. Lithic debitage exposed during blading was not collected because sufficient debitage samples had already been recovered during surface collection and manual excavation[4]. Artifacts collected during blading are shown on maps in Section 3.2, as is the extent of the area bladed at each site.

3.1.6. Site Grid Systems and Mapping

The grid system that was established on each site for remote sensing data collection was also used for mapping purposes during the excavation stage of the project. The grid systems were laid out using a Topcon GTS-603AF total station with a single-prism range rod, and the same instrument was used for maintaining spatial control during excavation. To lay out the grid system at a site, a total station datum and one or more backsight points were first established. The grid was oriented so that the site could be covered in the fewest possible number of 20 × 20–m units, thereby maximizing the efficiency of remote sensing data collection. As a result, grid north for some sites deviated substantially from true north. However, the locations of all datum and backsight points were recorded using a Trimble GeoXT GPS unit that provides data with sub-meter precision when post-processed, and these GPS data enabled the total station data to be georeferenced and expressed in Universal Transverse Mercator (UTM) coordinates, rather than solely in arbitrary grid coordinates with an arbitrary grid north.

After the datum and backsight point(s) were established at a site, a grid of 20 × 20–m units was staked out using the total station. Grid unit corners were found to within a precision of approximately 5 cm, and a piece of lath, marked with the grid coordinates, was placed in the ground at each. In a few cases, units smaller than 20 × 20 m were staked out; this occurred when a full 20 × 20–m unit could not be staked out due to a steep slope or some other obstacle. In addition to being used for remote sensing data collection, the grid stakes were also used for triangulating to the locations of remote sensing anomalies, as discussed above, and for general navigation around each site.

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[4] Exceptions to this occurred at 26EU1539, where one piece of debitage that appeared in the field to be a tool was collected during blading and where seven pieces of debitage were present in the fill of a charcoal lens feature that was collected.

The maps presented in this report are based on a combination of GPS and total station data. Excavation units, surface collection grids, auger probes, and most features found during mechanical stripping (whether archaeological or natural) were mapped with the total station, whereas surface collection artifacts (except for those from surface collection grids) and most artifacts found during mechanical striping were mapped by GPS (exceptions to these procedures are noted in Section 3.2). Site boundaries and features such as roads, creeks, and mine infrastructure were mapped by GPS, in many cases during SWCA's 2005 or 2006 field seasons, or were obtained from CAD data provided by BGMI.

Each time the total station was set up at a site, shots to control points (such as backsight points) were taken to ensure set-up accuracy. These repeated control point shots indicate that total station mapping precision is approximately 2–5 cm for horizontal measurements and approximately 5–10 cm for vertical measurements. The GPS data collected with the Trimble GeoXT units during this project, when differentially corrected, have a precision of 1 m or less for the overwhelming majority of the position taken. A variety of base stations were used to differentially correct the GPS data; in general, the base station closest to the project area with useable data for a given day was selected to post-process the data from that day. UTM coordinates for Zone 11 N relative to the NAD 1983 datum were used throughout the project, and data are presented in the Zone 11 N, NAD 1983 coordinate system throughout this report.

3.2. SITE-SPECIFIC FIELDWORK SUMMARIES

3.2.1. 26EU1533

SWCA conducted probing at 26EU1533 in October 2006, excavating two shovel tests and one 1 × 1–m test unit. The placement of these units was determined by SWCA's observations of surface artifacts during a 2005 site revisit, which led to the identification of one artifact concentration, C-1. Shovel Test 1 (ST1) was placed in C-1 and ST2 was placed outside of C-1; each was excavated to an approximate depth of 10 cm below surface (cmbs). ST1 was located on the northern boundary of C1, and ST2 was located down-slope of the southern boundary of C-1. Test Unit 1 (TU1) was placed in C-1 at the area with the highest quantity of flakes on the surface. TU1 was located down-slope and south of ST1 and was excavated to a depth of 10 cmbs. The unit was discontinued on the basis of a marked decrease in the quantity of cultural material. No archaeological features were observed during probing, and chipped stone artifacts were the only type of archaeological material recovered. During the course of the 2006 probing, an Elko Corner-notched point was recorded approximately 30 m east of C-1 at the edge of one of the two-track roads that crosses the site; this point was relocated and collected during the 2007 BGMI project.

The results of the surface collection conducted at 26EU1533 as part of the 2007 BGMI project are shown in Figure 3. The densest artifact concentration found in the 2007 surface collection (in the central-southern portion of the site) corresponds to the concentration identified as C-1 in 2005. The surface collection also revealed a sparser distribution of artifacts surrounding this concentration, primarily to the east and northeast.

During excavations for the 2007 BGMI project, SWCA dug fourteen 1 × 1–m excavation units at 26EU1533 in five areas (Operations A through E); the locations of these excavation areas are shown in Figure 4, as are the locations of the shovel tests and the test unit dug in 2006. Operations A and B were placed at the locations of magnetometer anomalies (Figure 25), while Operations C, D, and E were placed in areas of high conductivity (very strong conductivity anomalies in the case of Operations C and D) (Figure 31). Operations D and E were also located within or downhill of surface artifact concentrations. No archaeological features were encountered in excavation, and in all excavation units, subsurface artifacts were either not present or were rare and occurred only in the uppermost few centimeters (artifact counts by excavation unit and level for all of the sites involved in the project are provided in Appendix B).

Each operation at this site consisted of a 2 × 2–m area that was divided into four 1 × 1–m excavation units. The 1 × 1–m units were assigned numbers, starting with Unit 1 at the southwestern corner of an operation and moving clockwise. In Operations A and B, all four 1 × 1 –m units in each block were excavated. Based on the negative results of excavation in these two operations and on similar results from other sites involved in the project, it was determined that excavation of full 2 × 2–m blocks was not necessary for the remainder of the operations at 26EU1533. In Operations C and D, two 1 × 1–m units were excavated in each block: one 1 × 1–m unit in the southwestern quadrant and one in the northeastern quadrant. In Operation E, one 1 × 1–m unit in the northwestern quadrant and one in the southeastern quadrant were excavated. All units were all excavated in two arbitrary 10-cm levels.

Since no sign of archaeological features were found in the fifteen 1 × 1–m units and two shovel tests dug at 26EU1533 in 2006 and 2007, and because only two potentially datable artifacts had been recovered from the site (an Elko Corner-notched point and an obsidian flake with a problematic hydration band; see Chapter 5), it was determined after excavation of these units that further excavation at the site would likely not provide additional data relevant to the research emphases for the project. Thus, excavation was discontinued after completion of these units.

In addition to this excavation, limited auger probing was conducted at 26EU1533 in order to evaluate the possible causes of patterning in the remote sensing data. Twenty-two probes were dug with a 4-inch-diameter bucket auger to depths averaging approximately 50 cmbs; these probes were spaced approximately one meter apart along three linear transects in the central-eastern part of the site (Figure 4). Transect A was oriented south to north and consisted of five auger holes. Transects B and C were both oriented south-southeast to north-northwest. Transect B consisted of seven auger holes while Transect C consisted of ten auger holes. The auger probing revealed two soil horizons that were also observed in excavation units at all sites: a pale brown calcic B horizon underlain by a dark yellowish brown C horizon (soil profiles observed at the sites involved in this project are discussed in detail in Chapter 5). The implications of the augering that was conducted at this site for understanding remote sensing results are discussed in Chapter 4.

As the final stage of fieldwork at 26EU1533, most of the surface of the site was mechanically stripped (see the "bladed area" in Figure 4). Due to the two-track roads in the southern portion of the site, as well as the steep slope along the site's southeastern edge and the creek along its southwestern boundary, these areas of the site were not stripped. Blading revealed no archaeological features at 26EU1533. As was the case at all the sites involved in this project, numerous small charcoal stains were exposed, but all of these appear to be the remains of vegetation burned by wildfire; in fact, BGMI personnel reported that 26EU1533 was within an area that burned in the late 1990s. A sample of these charcoal stains was photographed. Blading at this site did uncover a ground stone artifact, which was collected.

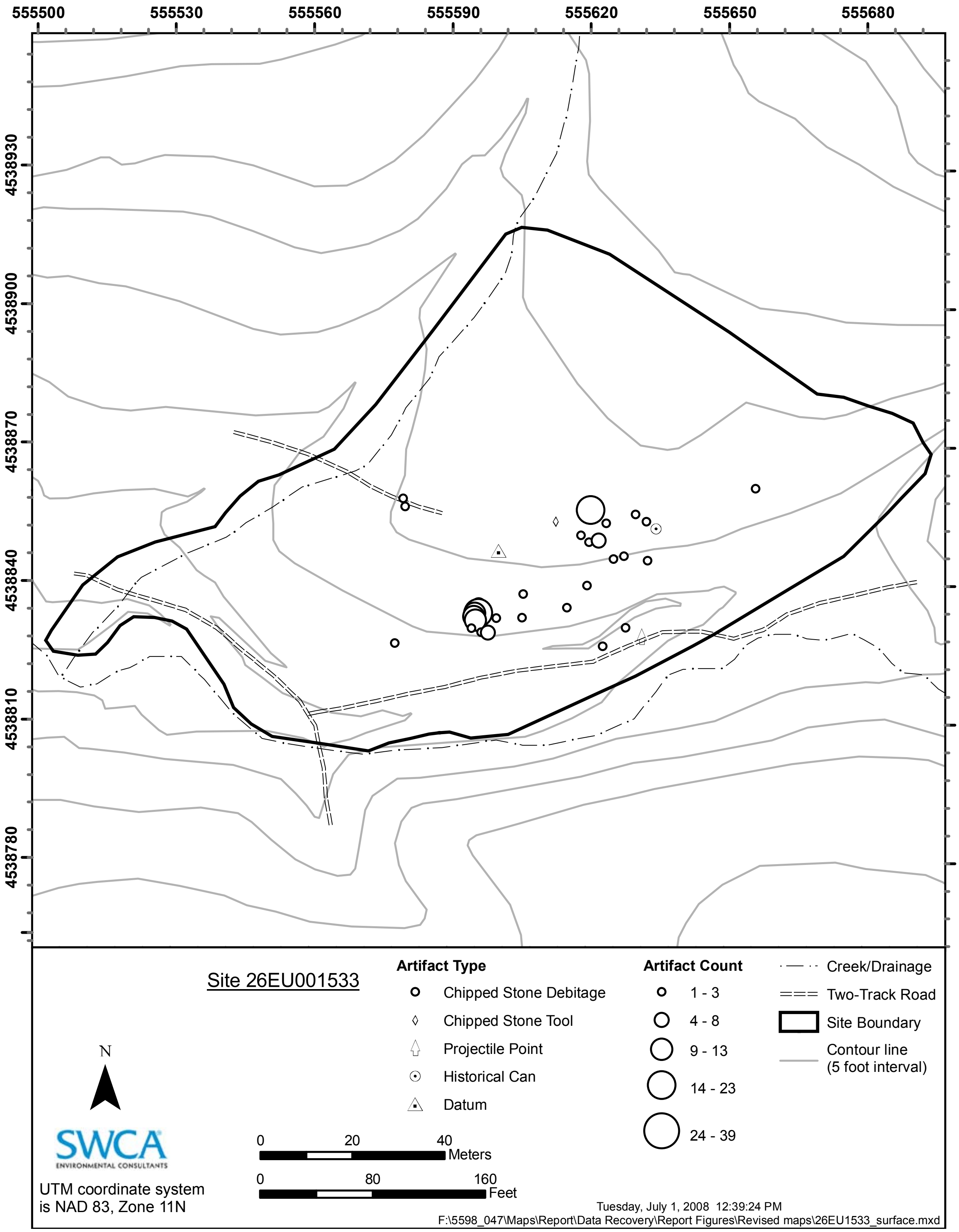

Figure 3. Results of surface artifact collection at 26EU1533.

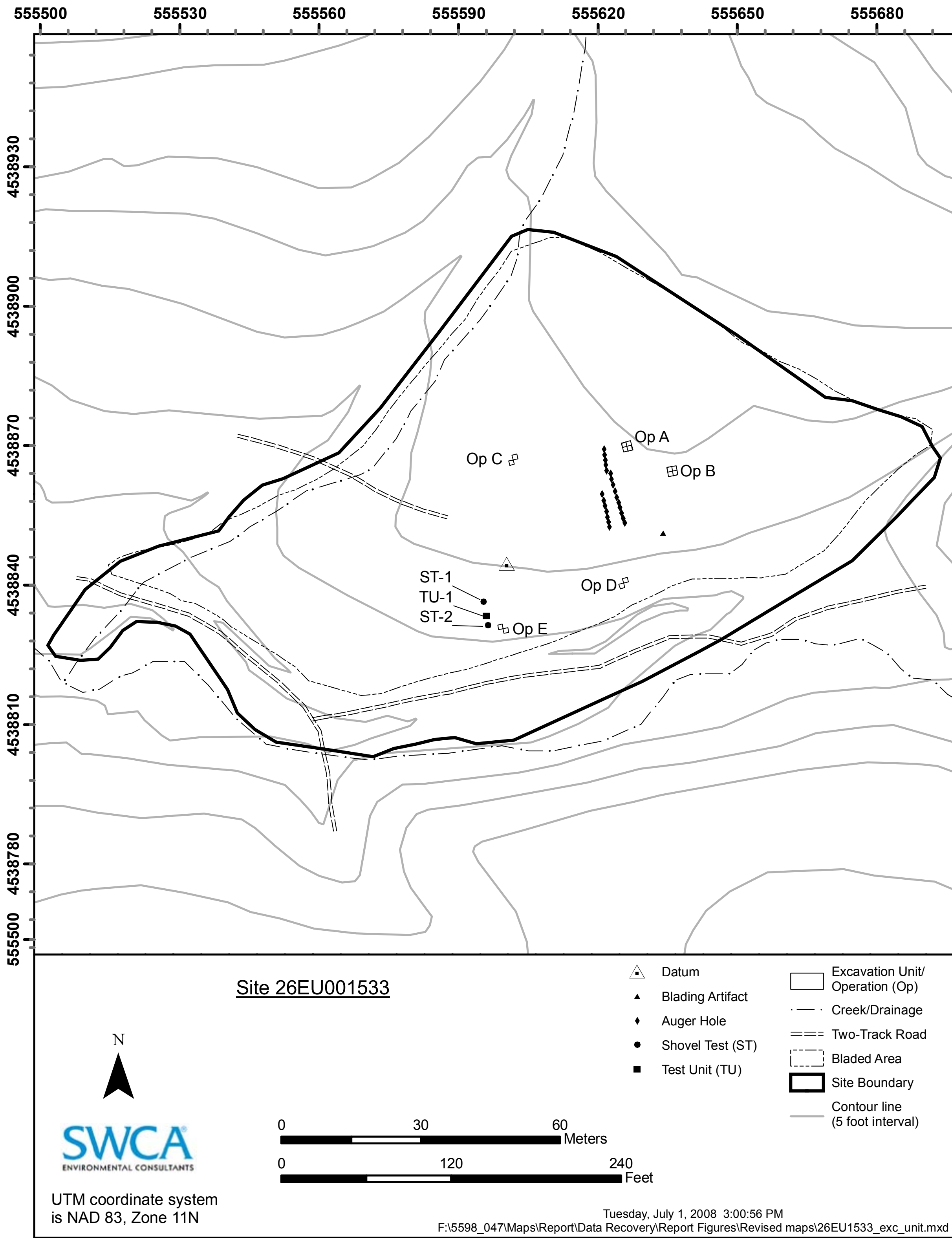

Figure 4. Locations of excavation units and extent of mechanical stripping at 26EU1533.

3.2.2. 26EU1539

SWCA conducted probing at 26EU1539 in September 2006, excavating three shovel tests and one test unit. The placement of these units was determined by observations of surface artifacts made by SWCA during a 2005 site revisit, which led to the identification of two areas of increased artifact density, C-1 and C-2. The three shovel tests, ST1, ST2, and ST3, were placed in C-1, and each was excavated to an approximate depth of 10 cmbs. To better understand the distribution of cultural material within C-1, the shovel tests were placed around the boundary of the concentration. TU1 was placed in C-1 over the area with the highest quantity of flakes on the surface, and was excavated to a depth of 20 cmbs. The unit was discontinued on the basis of a marked decrease in cultural material. Most of the debitage recovered from TU1 was found in the first 10 cm level. No archaeological features were observed in probing, and chipped stone artifacts were the only type of archaeological material recovered. A small side-notched point was recorded on the site but not collected during the 2005 revisit, and this point was not relocated during the 2006 or 2007 field seasons.

The results of the surface collection conducted at 26EU1539 as part of the 2007 BGMI project are shown in Figure 5. The artifact concentrations identified as C-1 and C-2 in 2005 correspond to the relatively dense concentrations shown in this figure in the north-central (just north of the road) and far northeastern portions of the site, respectively. The 2007 surface collection also revealed a sparser distribution of artifacts throughout the northern and central parts of the site and an extremely large and dense concentration located in alluvial gravels adjacent to a stream channel near the southern tip of the site. A surface collection grid (Collection Grid 1, or CG1) of 1 × 1–m units was established in the densest part of this southern artifact concentration, abutting the low alluvial terrace northeast of the gravels in which the concentration was located (Figure 5). This grid was 5 × 4 m in size, with the long axis oriented from northwest to southeast (Figure 6). Artifact density in some of the 1 × 1–m units within this grid was extremely high, and these units were collected by scraping surface sediments into bags for screening in the lab. Two collector's piles, each approximately 20 cm in diameter and consisting of well over 100 artifacts, were present within one of the units in the collection grid (Unit D2); the artifacts in these piles were collected along with the rest of those from the unit. The grid was laid out such that it encompassed the location of an obsidian artifact (sample number 1539-159-1) found during the initial survey that was conducted as part of the surface collection.

During the excavations conducted in 2007, SWCA dug twenty-two 1 × 1–m excavation units at 26EU1539 in eight areas (Operations A–H); the locations of these excavation areas are shown in Figure 7, along with the locations of the shovel tests and the test units dug in 2006. Operations A and B were placed at the locations of magnetometer anomalies (Figure 26), Operations C and D were placed in areas of high conductivity (Figure 32) in or near surface artifact concentrations, Operation E was placed at a location within a surface artifact concentration where FCR was recorded during the surface collection, Operations F and G were placed within the dense surface artifact concentration at the south end of the site, and Operation H was placed just uphill from the location of a ground stone artifact that was recovered during the surface collection. A very small ash lens was found in Operation G on the alluvial terrace just above the gravels in which the dense southern artifact concentration was located. This feature, located in Unit G4, Level 2, was recorded and collected following the procedures for excavation of archaeological features outlined in Section 3.1.4, but, as discussed in Section 6.2, flotation analysis provides no clear evidence that it is archaeological. All units excavated at the site were dug to a depth of 20 cm. Artifacts were very dense in the upper 10-cm level of most of the units in Operations F and G, and less so in the lower level of these units. In all excavation areas other than Operations F and G, subsurface artifacts were either not present or were rare and occurred only in the uppermost few centimeters.

Operation A consisted of a 4 × 1–m area with its long axis oriented east-west. This area was divided into four 1 × 1–m excavation units, each of which was assigned a number, starting with Unit A1 at the eastern end of the operation. Operation A deviated from the standard 2 × 2–m block that was staked out for most remote sensing anomaly excavations due to the nature of the anomaly that it was being used to investigate. This anomaly was a circular feature, approximately 3–5 meters in diameter, that was evident in the magnetometer data for this site and that appeared as though it might correspond to a pit structure (see Figure 26 in Chapter 4). Field inspection of this location also showed a shallow circular depression consistent with a buried pit structure. Operation A was therefore configured as a 4 × 1–m trench that started outside the circular depression to the east and then moved westward toward its center. Excavation revealed no signs of a prehistoric structure; rather, dung was observed in the upper level of one of the units within the depression, suggesting that the depression is the remains of a cattle wallow associated with the historic ranch building and corral located just to the west of the site.

Operations B through E each consisted of a 2 × 2–m area divided into four 1 × 1–m units. The 1 × 1–m units are designated in the same manner described for 26EU1533. All four 1 × 1–m units in Operation B were excavated. Based on the negative results of excavation in this operation, and on similar results from other sites involved in the project, it was determined that excavation of full 2 × 2–m blocks was not necessary for the remainder of the operations at this site that were intended to explore remote sensing anomalies. Thus, two 1 × 1–m units were excavated in Operations C and D: one in the southwestern quadrant and one in the northeastern quadrant. Operation E, though placed to explore an FCR concentration recorded during surface collection rather than a remote sensing anomaly, was excavated in the same manner.

Operations F and G were intended to explore the area in and around the dense surface artifact concentration located in the southern portion of the site. Given the location of this concentration in alluvial gravels, it is likely that the artifacts within it were redeposited, but it was thought that intact archaeological features might be present on the low terrace above the concentration. Operation F consisted of a single 1 × 1–m unit dug in the gravels to the south of the CG1 surface collection grid, while Operation G consisted of a 5 × 1–m trench that ran northwards from a location in the gravels on the northeast side of the collection grid (near where the obsidian artifact was found) up onto the terrace. Operation G was divided into five 1 × 1–m units numbered from 1 through 5 starting at the south.

Finally, Operation H consisted of a 2 × 1–m trench oriented west-east and divided into two 1 × 1–m units, with Unit H1 located to the west of Unit H2. These units were the only ones excavated at 26EU1539 based solely on the field judgment of the SWCA Principal Investigator, and they were intended to explore whether subsurface archaeological materials were present uphill from the location of a ground stone artifact that was recovered during surface collection.

Because no signs of archaeological features were found in the twenty-three 1 × 1–m units and three shovel tests dug at 26EU1539 in 2006 and 2007, and because only one temporally diagnostic artifact had been recorded at the site (the small side-notched point recorded in 2005) and no datable materials had been recovered (see Chapter 5; the obsidian artifact that was collected from the site had no measurable hydration band), it was determined after excavation of the units described above that further excavation at the site would likely not provide additional data relevant to the research emphases for the project. Excavation was thus discontinued after completion of these units.

As at 26EU1533, limited auger probing was conducted at 26EU1539 to evaluate the causes of patterning in the remote sensing data. Fourteen auger probes averaging approximately 50 cmbs in depth were spaced at 5-m intervals along two transects in the northeast corner of this site (Figure 7). One transect was oriented southwest to northeast up the slope of the alluvial terrace in this part of the site, and the second transect began at the first and proceeded to the southeast across a shallow channel. The implications of the augering that was conducted at this site for understanding remote sensing results are discussed in Chapter 4 of this report.

Fieldwork at 26EU1539 concluded with the blading of virtually the entire surface of the site (Figure 7). The two-track road that runs across the site was excluded from blading, as was the area in the southwestern corner of the site, which was inaccessible due to the stream channel that crossed this part of the site. Blading revealed no archaeological features at 26EU1539, though many small charcoal stains were exposed, all of which are likely the remains of wildfire-burned vegetation. One of these charcoal stains was recorded and collected as described in Section 3.1.4, and Chapter 6 presents an analysis of this and similar features from other sites that is intended to provide a firmer basis for distinguishing archaeological charcoal lenses from non-archaeological ones in the future. In addition, to evaluate whether such features might be reflected in remote sensing data, all of those found to the north of the two-track road that crosses the site were mapped with a total station so that their distribution could be plotted on the remote sensing images; the distribution of these features in relation to the remote sensing data is discussed in Chapter 4. An Eastgate Expanding-stem projectile point, a chipped stone tool, a core, and two pieces of ground stone were exposed during blading and were collected; the projectile point was found in the vicinity of the dense surface artifact concentration in the southern part of the site. One piece of chipped stone debitage that appeared in the field to be a tool was also collected during blading, and the fill of the charcoal lens that was collected contained an additional seven flakes.

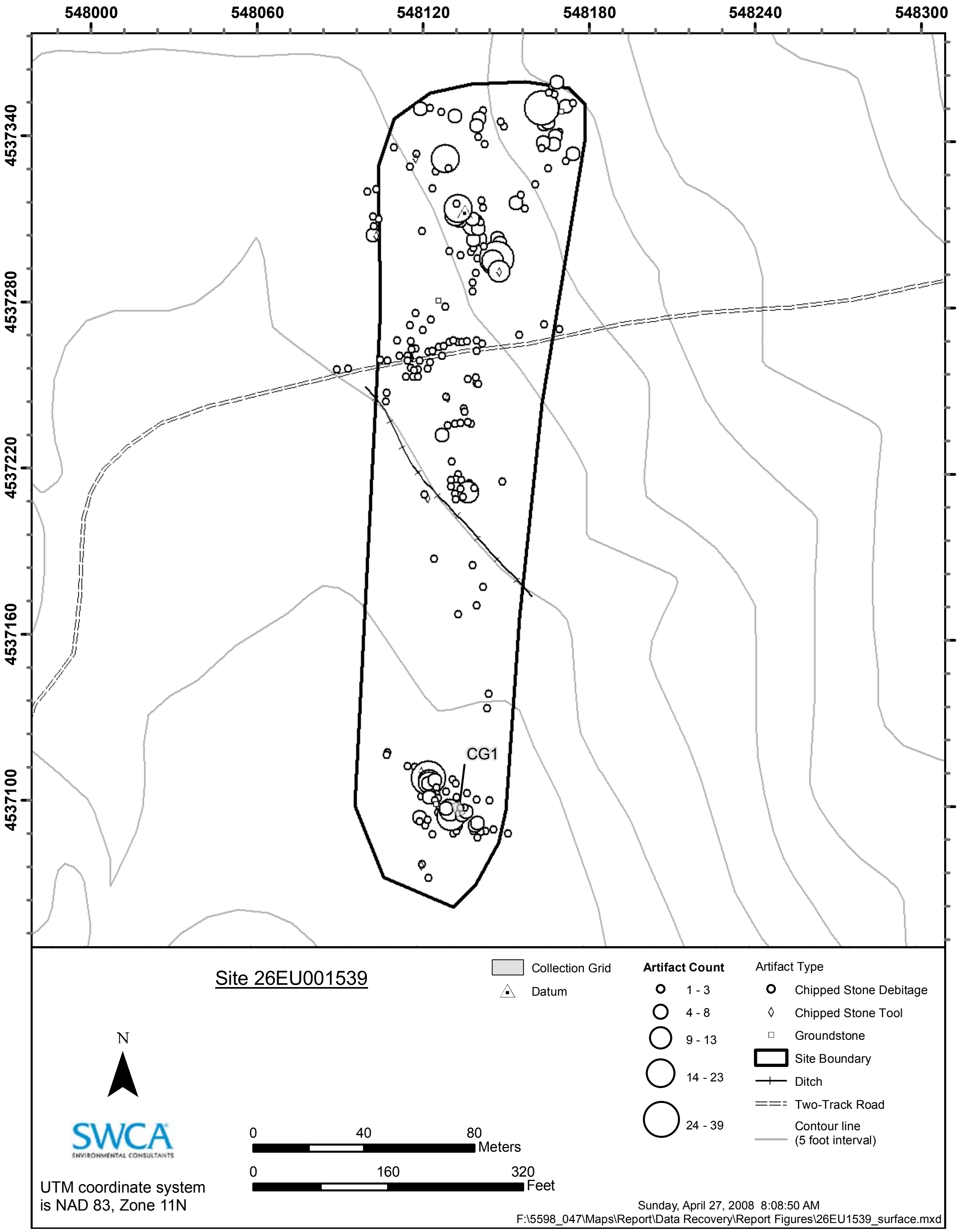

Figure 5. Results of surface artifact collection at 26EU1539.

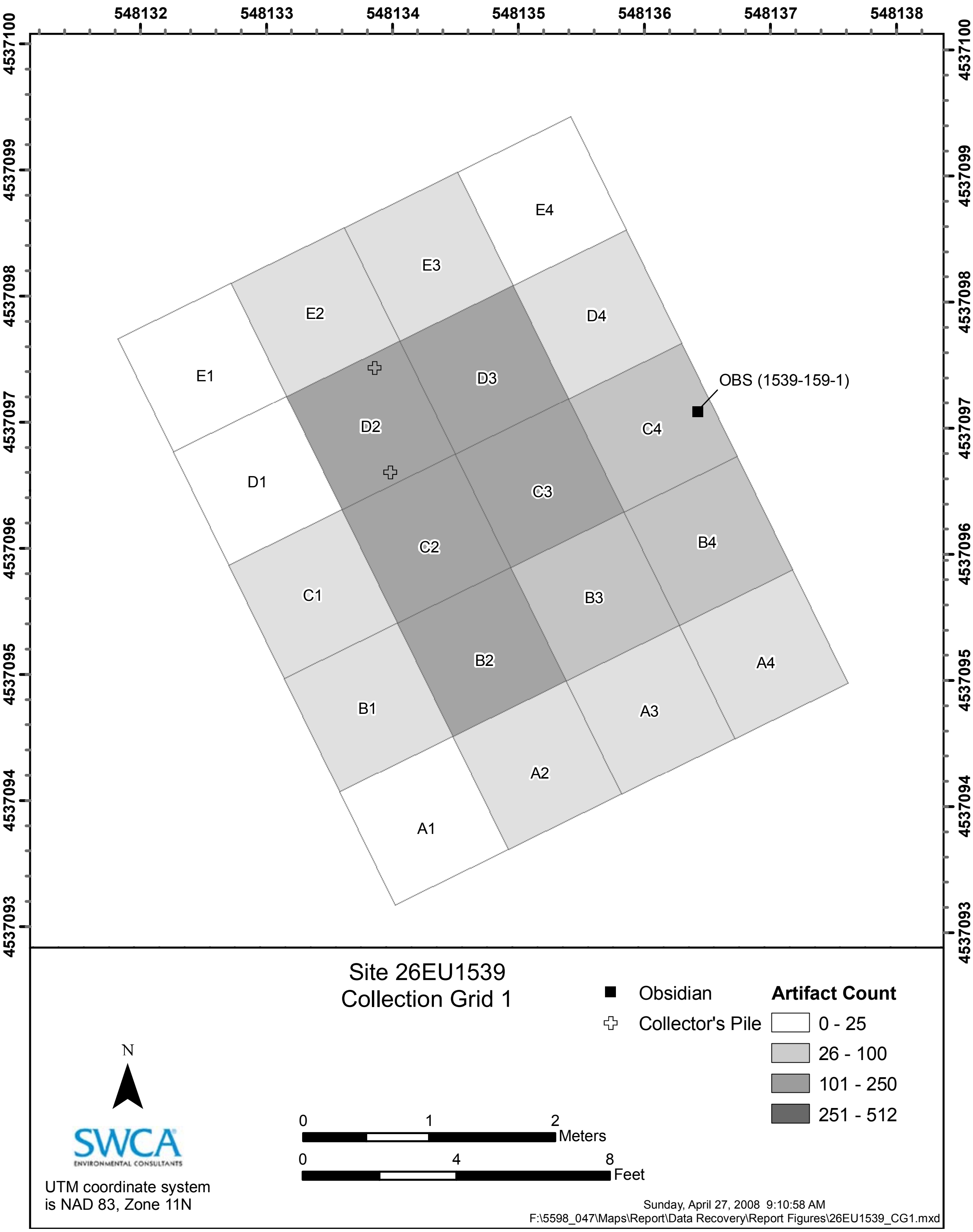

Figure 6. Collection Grid 1 at 26EU1539.

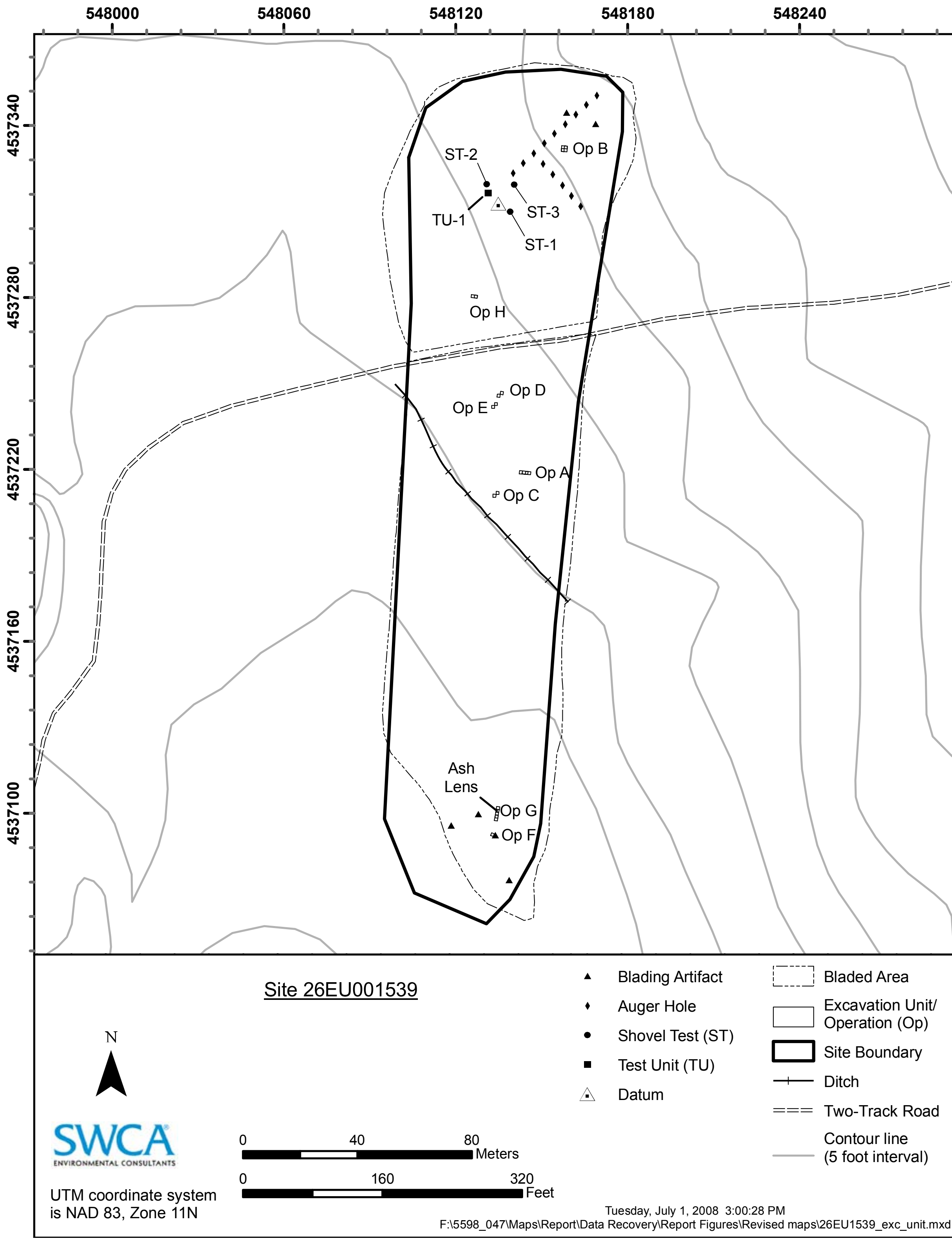

Figure 7. Locations of excavation units and extent of mechanical stripping at 26EU1539.

3.2.3. 26EU1548

SWCA conducted probing at 26EU1548 in September 2006, excavating five shovel tests and one test unit. The placement of these units was determined by observations of surface artifacts made by SWCA during a 2005 site revisit, which led to the identification of a small, discrete concentration (C-1) and a larger, more dispersed concentration (C-2). ST1 was placed within C-1, and the remainder of the shovel tests were distributed across the rest of the site; each was excavated to an approximate depth of 10 cmbs. TU1 was placed in C-1 over the area with the highest quantity of flakes on the surface and was excavated to a depth of 30 cmbs. Excavation of this unit was discontinued at this depth on the basis of a marked decrease in the quantity of cultural material. Most of the debitage recovered from TU1 was from 0–10 cmbs. No archaeological features were observed during probing, and chipped stone artifacts were the only archaeological material recovered. SWCA recorded no temporally diagnostic artifacts at the site during the 2005 or 2006 field seasons.

The results of the surface collection conducted at 26EU1548 as part of the 2007 BGMI project are shown in Figure 8. The artifact concentration identified as C-1 in 2005 is the one located in the southeastern part of the portion of the site that lies north of the two-track road that crosses the site, and the concentration identified as C-2 in 2005 is the one in the northeastern part of the site. The 2007 surface collection revealed additional concentrations to the west of both C-1 and C-2, as well as an extensive scatter of artifacts within a shallow channel that crosses the central portion of the site from west to east. Two of the artifact concentrations (the one identified as C-2 in 2005 and the concentration to the west of the one identified as C-1 in 2005) were dense enough to warrant the establishment of collection grids. The southern grid, CG1, was 6 × 4 m in size, with its long axis oriented from northwest to southeast (Figure 9), and the northern grid, CG2, was 14 × 5 m in size, with its long axis oriented from northeast to southwest (Figure 10). CG1 encompassed ST5, one of the shovel tests excavated in 2005.

During excavations for the 2007 BGMI project, SWCA dug eleven 1 × 1–m excavation units at 26EU1548 in seven areas (Operations A through G); the locations of these excavation areas, and of the shovel tests and test unit dug in 2006, are shown in Figure 11. Operations A, B and C were placed at the locations of magnetometer anomalies (Figure 28), and Operations D, E and F were placed in areas of high conductivity (Figure 34). The location for Operation G was chosen on the basis of surface artifact density, and it was placed within the area of the artifact concentration encompassed by CG1. In addition, the magnetometer anomaly that was the target of Operation C fell within CG2. Operation B was located outside of the site boundary recorded on IMACS forms for the site, but it was near the head of the shallow channel in which surface artifacts were very abundant. The magnetometer survey of this site was extended west of the site boundaries in order to explore whether buried features might be located uphill of the surface artifact concentrations at the site, and Operation B was a test of a magnetometer anomaly in this area. No archaeological features were encountered during excavation. Subsurface artifacts were moderately dense in the upper 10-cm level of excavation units that were located in or near areas of surface artifact concentration, but were otherwise rare.

Each operation at 26EU1548 consisted of a 2 × 2–m area that was divided into four 1 × 1–m excavation units. The 1 × 1–m units are designated in the same manner described for 26EU1533.

Full excavation of each 2 × 2–m block was determined to be unnecessary based on the results of full block excavation at other sites involved in the project. At Operations A, B and C, only the northwestern 1 × 1–m unit was excavated in each operation. In Operation D, two 1 × 1–m units were excavated in the 2 × 2–m block: one in the northwestern quadrant and one in the southeastern quadrant. In Operations E and F, one 1 × 1–m unit in the southwestern quadrant and one in the northeastern quadrant were excavated. The units were all excavated in two arbitrary 10-cm levels.

Because no signs of archaeological features were found in the twelve 1 × 1–m units and five shovel tests dug at 26EU1548 in 2006 and 2007, and because no temporally diagnostic artifacts and few datable materials had been recovered from the site (only two obsidian artifacts with measurable hydration bands; see Chapter 5), it was determined after excavation of the units described above that further excavation at the site would likely not provide additional data relevant to the research emphases for the project. Thus, excavation was discontinued after completion of these units.

Blading was conducted at 26EU1548 across the portion of the site that lies to the north of the two-track road and was extended to the west of the site, where artifacts were observed on the ground surface and where Operation B had been excavated. It was also extended beyond the northeastern and southeastern portions of the site, where additional surface artifacts were observed. The portion of the site located to the south of the two-track road was not bladed due to a deep ditch than runs along the southern edge of the road, which made this part of the site inaccessible to the grader.

The blading exposed several charcoal stains that appear to be the result of natural wildfire. Eight of the 15 charcoal stains were recorded and collected as described in Section 3.1.4, and Chapter 6 presents an analysis of these features that is intended to provide a firmer basis for distinguishing archaeological charcoal lenses from non-archaeological ones in the future. As was done in the northern part of 26EU1539, all of the charcoal lenses/stains that were exposed at 26EU1548 were mapped with a total station so that their distribution could be compared to the remote sensing data. A total of 15 such features were mapped at this site, including the eight mentioned above that were recorded and collected. The distribution of these features in relation to the remote sensing data is discussed in Chapter 4. No artifacts other than lithic debitage were discovered during blading at this site.

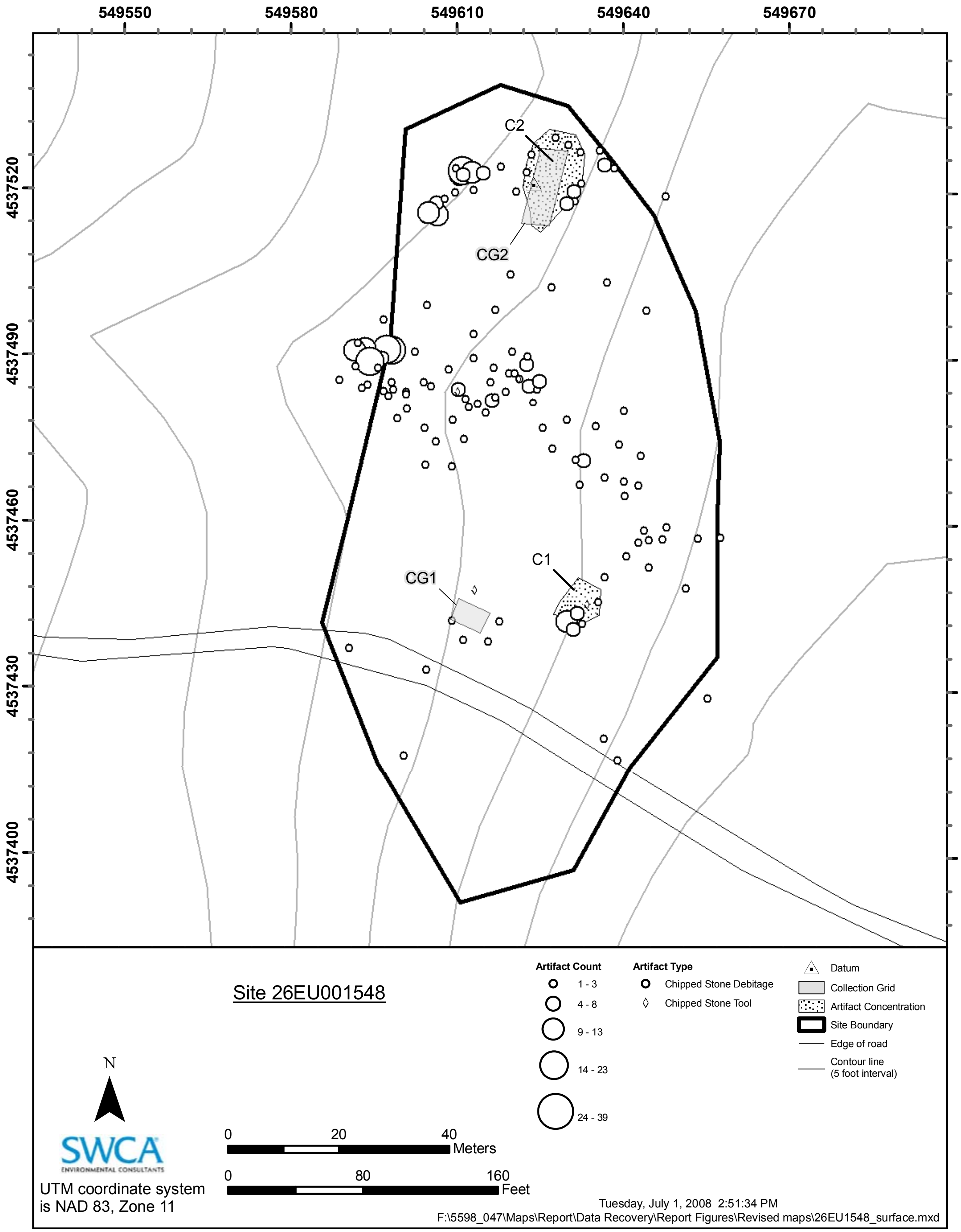

Figure 8. Results of surface artifact collection at 26EU1548.

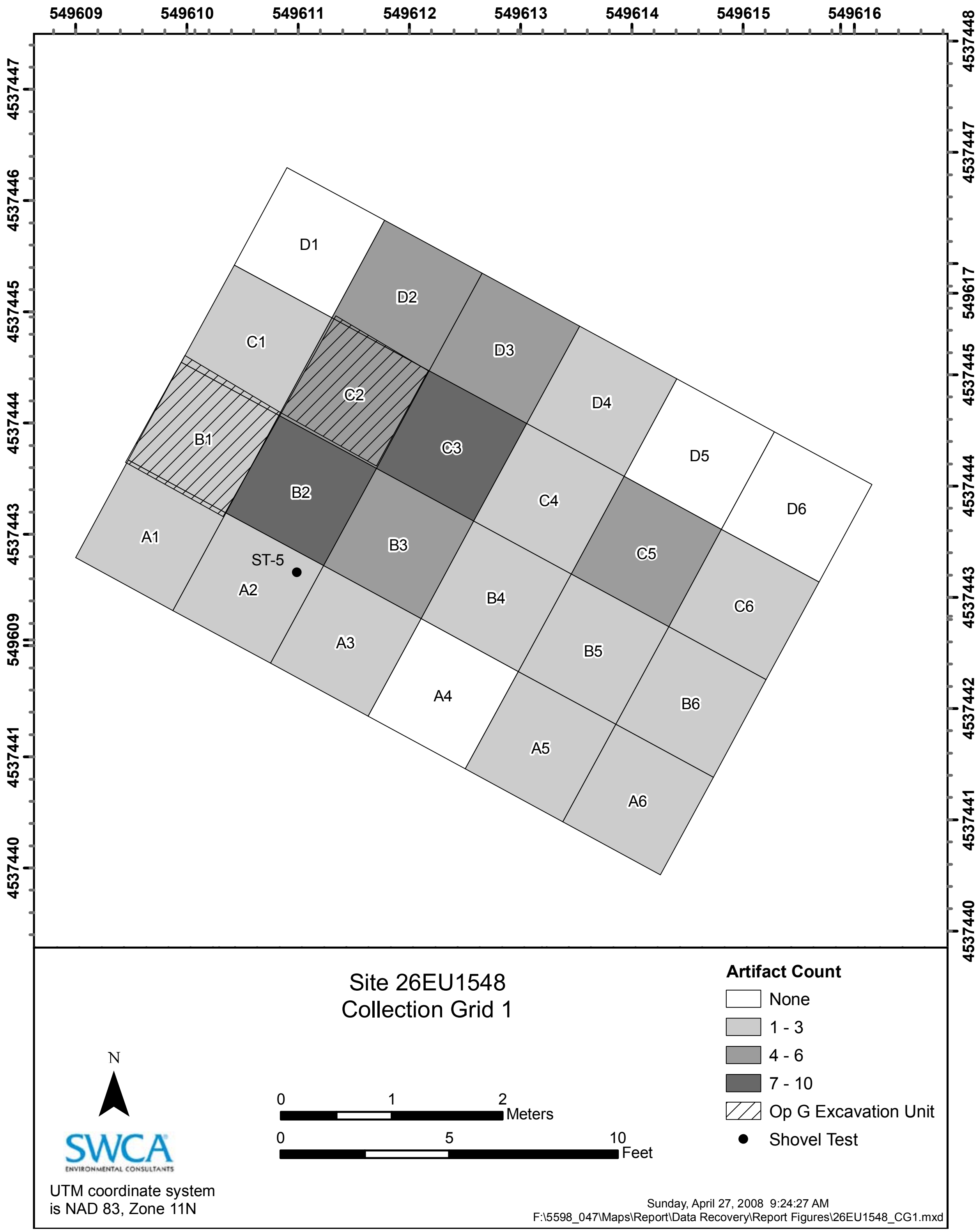

Figure 9. Collection Grid 1 at 26EU1548.

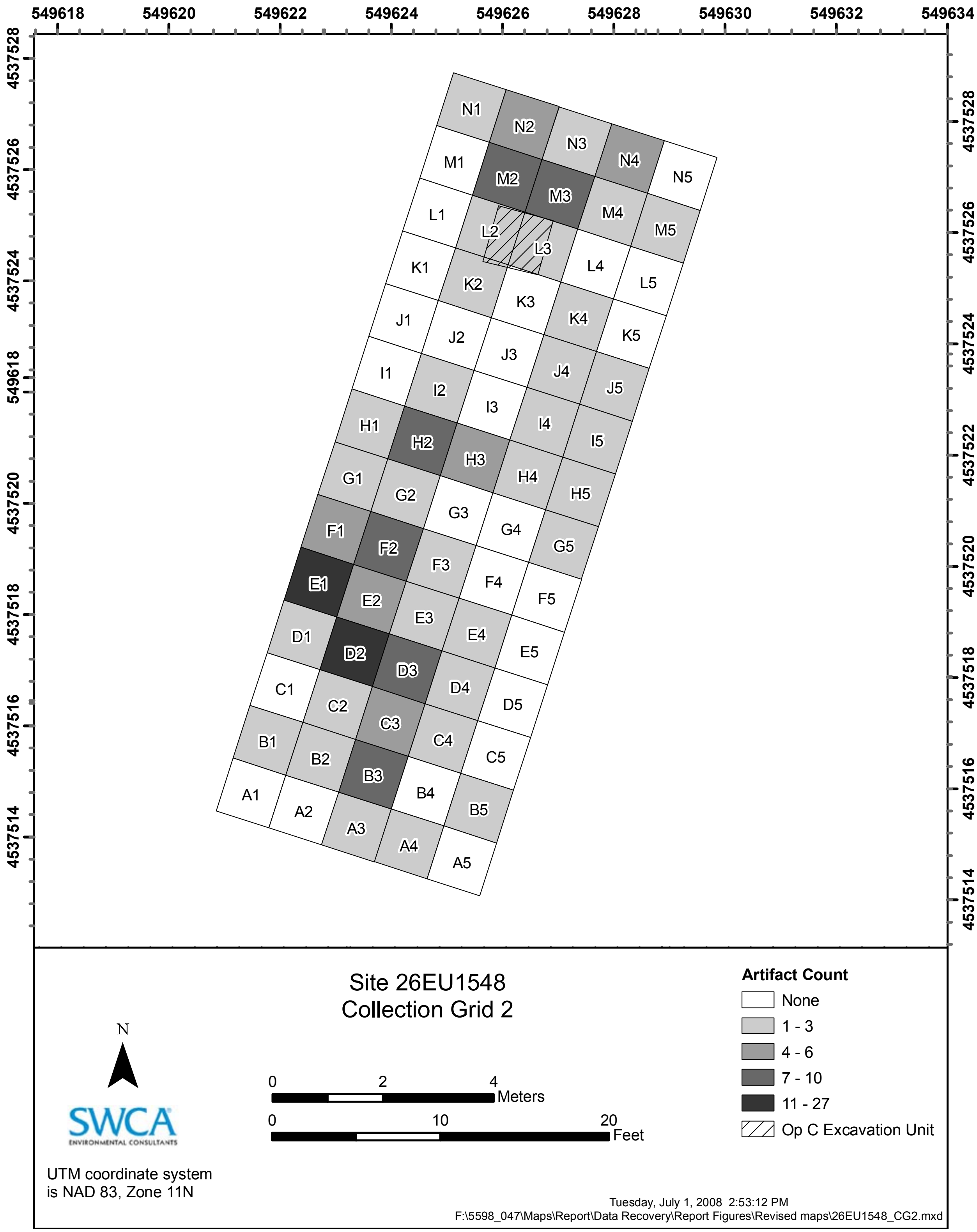

Figure 10. Collection Grid 2 at 26EU1548.

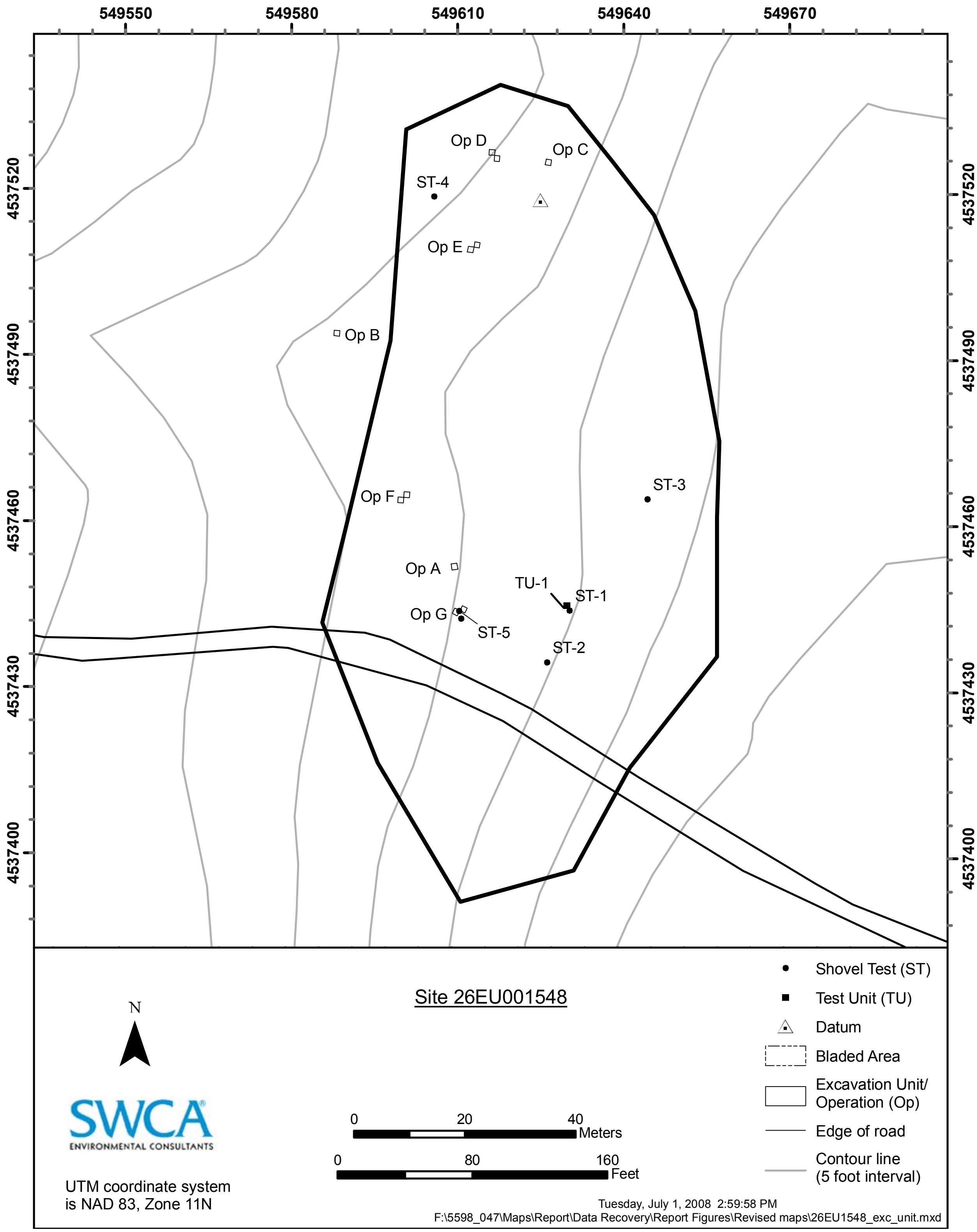

Figure 11. Locations of excavation units and extent of mechanical stripping at 26EU1548.

3.2.4. 26EU2064

SWCA conducted probing at 26EU2064 in the fall of 2006, excavating 27 shovel tests and 10 test units throughout the site. The placement of these units was determined by observations of surface artifacts made by SWCA during a 2005 site revisit, which led to the identification of three areas of increased artifact density (C-1 through C-3) and one artifact concentration (C-4). Four shovel tests and two test units were excavated in each of C-1, C-2 and C-3 (ST1 through ST4 and TU1 and TU1 in C-1, ST5 through ST8 and TU3 and TU4 in C-2, and ST9 through ST12 and TU5 and TU6 in C-3). Eight shovel tests (ST13 through ST20) and two test units (TU7 and TU8) were excavated in C-4, and an additional seven shovel tests (ST21 through ST27) and two test units (TU9 and TU10) were excavated across the rest of the site outside of the identified artifact concentrations. The shovel tests were dug to a depth of 10 cmbs, and the test units were dug to depths ranging from 10 to 35 cmbs. All but five of the shovel tests and two of the test units produced subsurface artifacts, and it was noted in many of the shovel tests and test units that most if not all of the artifacts came from the top 5 cmbs. No archaeological features were observed in probing, and chipped stone artifacts were the only type of archaeological material recovered. SWCA recorded no temporally diagnostic artifacts at the site during the 2005 or 2006 field seasons.

The results of the surface collection conducted at 26EU2064 as part of the 2007 BGMI project are shown in Figure 12. This surface collection revealed an extensive but discontinuous scatter of artifacts along the ridge that runs the length of the northeastern boundary of the site, as well as a relatively discrete artifact concentration in the southwestern portion of the site. The concentrations identified as C-1 through C-4 in 2005 correspond to relatively small artifact clusters within the much more extensive scatter that lies along the northeastern ridge.

During the 2007 excavations, SWCA dug thirteen 1 × 1–m excavation units at 26EU2064 in nine areas (Operations A through I); the locations of these excavation areas are shown in Figure 13, along with the locations of the shovel tests and test units dug in 2006. Operations A through G were placed at the locations of magnetometer anomalies (Figure 29) and, in the case of Operations A, B and G, in or near large surface artifact concentrations. Operation H was placed near a surface artifact concentration and Operation I was placed at the location of a very strong conductivity anomaly (Figure 35). As was the case in the extensive testing that took place at this site in 2006, no archaeological features were encountered in excavation during 2007. In addition, in the units dug in 2007, subsurface artifacts were either rare and occurred only in the uppermost few centimeters or, particularly in the case of units dug away from surface concentrations, they were not recovered at all.

Each operation at this site consisted of a 2 × 2–m area that was divided into four 1 × 1–m excavation units. The 1 × 1–m units are designated in the same manner described for 26EU1533. Full excavation of each 2 × 2–m block was determined to be unnecessary based on the results of full block excavation at other sites involved in the project. In Operations A, B, H and I, two 1 × 1–m units were excavated in each block: one 1 × 1–m unit in the southwestern quadrant and one in the northeastern quadrant. At Operations C through G, only the southwestern 1 × 1–m unit was excavated in each operation. The units were all excavated in two arbitrary 10-cm levels.

Because no signs of archaeological features were found in the twenty-three 1 × 1–m units and twenty-seven shovel tests dug at 26EU2064 in 2006 and 2007, and because the projectile points discovered at the site (discussed in Chapter 5), all of which are from surface contexts, span virtually all of the late Holocene and show no clear spatial patterning by time period, it was determined after excavation of the units described above that the site was unlikely to contain single-component deposits that could provide data relevant to the research emphases for the project. Thus, excavation at the site was discontinued after completion of these units.

Most of the surface of 26EU2064 was bladed at the conclusion of fieldwork, with the exception of portions that were inaccessible due to steep slopes and a portion in the vicinity of a utility pole (Figure 13). Blading revealed no archaeological features at 26EU2064. Several small charcoal stains were observed, but all appeared to be the remains of vegetation burned by wildfire. One of these was recorded and collected for comparison to archaeological features, the results of which are presented in Chapter 6. One chipped stone tool was recovered from this site during blading.

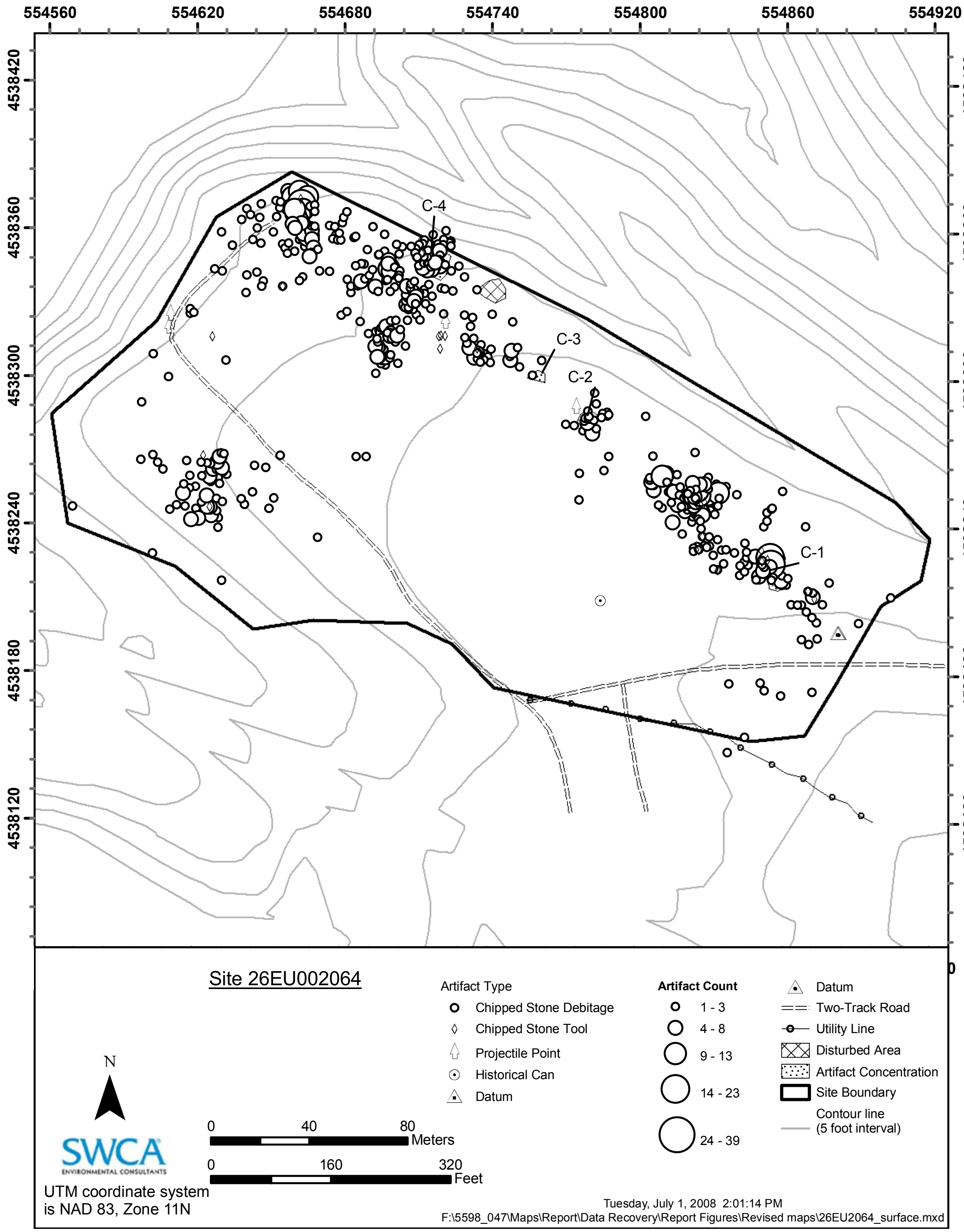

Figure 12. Results of surface artifact collection at 26EU2064.

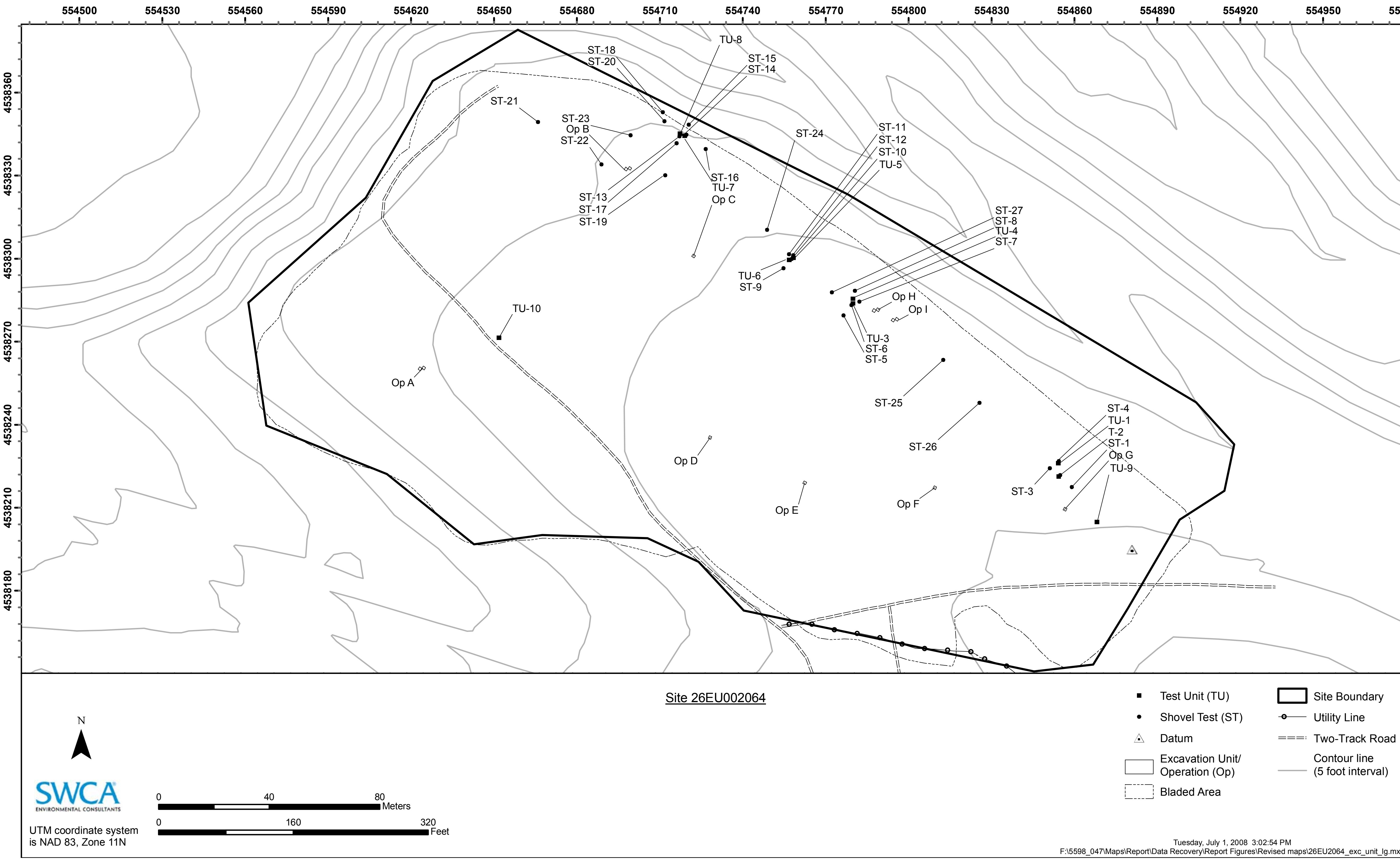

Figure 13. Locations of excavation units and extent of mechanical stripping at 26EU2064.

3.2.5. 26EU2126

Probing was conducted by SWCA at 26EU2126 in September 2006 with the excavation of three shovel tests and one test unit. The placement of these units was determined by observations of surface artifacts made by SWCA during a 2005 site visit, which led to the identification of two concentrations, C-1 and C-2. The shovel tests ST1 through ST3 were placed within concentration C-2 and were excavated to an approximate depth of 10 cm. To better understand the distribution of cultural material within C-2, ST1 and ST2 were placed on the concentration's western boundary, and ST3 was placed near its center. TU1 was placed in C-2 over the area with the highest quantity of flakes on the surface, very close to ST3. TU1 was excavated to a depth of 30 cmbs and was discontinued on the basis of a marked decrease in the quantity of cultural material. Debitage, most of which was recovered from 0–10 cmbs, was abundant in TU1. A small number of faunal specimens, many of which were burned, were also recovered from ST3 and TU1. No archaeological features were observed in probing, and chipped stone artifacts and faunal remains were the only type of archaeological material recovered.

The results of the surface collection conducted at 26EU2126 as part of the 2007 BGMI project are shown in Figure 14. In addition to a few artifacts scattered across the site, two concentrations are apparent in the surface collection data: the one in the northeastern portion of the site corresponds to the concentration identified as C-1 in 2005, and the one in the southeastern portion of the site corresponds to the concentration identified as C-2 in 2005. Approximately half of the northeastern concentration falls within an area that was cleared for construction of the dewatering pipeline that crosses the site; it appears that 10–20 cm of sediment was scraped from the surface in this area for pipeline construction.

More excavation effort was expended at 26EU2126 than any other site involved the 2007 BGMI project. This was because this site proved to be most productive in terms of providing data applicable to the research emphases for the project. Fifty-six 1 × 1–m excavation units were dug in 15 areas (Operations A through O); the locations of these units and of the shovel tests and test unit dug in 2006 are shown in Figure 15. Operations A and B were placed at the locations of magnetometer anomalies (Figure 30), Operation C was placed in an area of high conductivity (Figure 36) near the location of the surface artifact concentration in the northeastern part of the site, and Operations D and E were placed at the locations of very strong conductivity anomalies (Figure 36). Operation F was centered on the test unit from 2006 (TU1), which had produced abundant artifacts and burned artiodactyl bone, and Operations G through N were a series of units intended to explore the area between Operations F and C. Finally, Operation O was placed at a location where burned jackrabbit bone was found on the surface; this was the sole operation excavated at 26EU2126 based entirely on the field judgment of the SWCA Principal Investigator, and it was intended to evaluate whether a subsurface thermal feature might have been the source of the faunal remains.

Archaeological features were encountered in Operations C and F during excavation, as described below. In addition, these two operations were located within artifact concentrations identified during surface collection, and subsurface artifacts were reasonably abundant in these two operations; they were, in fact, very dense in some of the units in Operation F. In the remaining operations, subsurface artifacts were either not present or were rare and occurred only in the uppermost few centimeters (though one notable artifact, a Cottonwood Triangular point, was recovered in Operation B). Consequently, none of the operations other than C and F was expanded into large excavation blocks. All units dug at this site in 2007 were excavated in two 10-cm levels with the exception of two, discussed below, that were dug in three 10-cm levels.

Operations A and B each consisted of a 2 × 2–m area that was divided into four 1 × 1–m excavation units. The 1 × 1–m units are designated in the same manner described for 26EU1533. All four 1 × 1–m units in Operations A and B were excavated. Based on the negative excavation results in these two operations and on similar results from other sites involved in the project, it was determined that excavation of full 2 × 2–m blocks was not necessary for Operations D and E, the other two operations at this site for which such blocks were originally planned. In Operations D and E, only two 1 × 1–m units were excavated in the 2 × 2–m blocks staked out for these operations: one unit was excavated in the southwestern quadrant and the other in the northeastern quadrant.

Operation C was a block of ten 1 × 1–m units (Figure 16 and Figure 17). The block started as a 2 × 1–m trench, an exception to the standard practice for the project of staking out 2 × 2–m blocks to explore remote sensing anomalies. A 2 × 1–m block was considered adequate in this case because the operation was intended to explore a large area of high conductivity that was assumed to reflect an occupation surface rather than a small thermal feature; thus, the issue of locating small features, the reason for staking out 2 × 2–m blocks for most remote sensing anomaly locations, was not a concern here. The 2 × 1–m trench started to the southeast of the surface artifact concentration located in this part of the site, and the initial plan was to proceed to the northwest toward the center of the concentration area.

Scattered FCR was abundant in the initial two 1 × 1–m units excavated in Operation C, particularly in the northwestern unit, Unit C2. Unit C3 was then excavated to the northwest of Unit C2, and more FCR was discovered on the northeastern side of this unit. Due to this discovery, the next unit, Unit C4, was excavated to the northeast of Unit C3. A discrete cluster of FCR was discovered in Unit C4, extending from the lower portion of the first 10-cm level to the bottom of the second 10-cm level. This FCR cluster, designated Feature 1, consisted of 20 to 30 blackened, angular, fist-sized cobbles and was approximately 20 cm in diameter. The FCR concentration was not associated with any apparently fire-altered sediments, ashy material, or hearth-like basin-shaped feature; this, together with the fact that additional FCR was found scattered throughout the surrounding deposit, suggests that the feature is the result of an episode of FCR dumping. Because the FCR concentration had no fill, it could not be collected following the feature collection procedures outlined in Section 3.1.4, but it was photographed. Figure 18 is a photograph of Feature 1 taken at the bottom of the second 10-cm level; additional pieces of FCR found in the sediments surrounding Feature 1 are shown piled at the far left of this photograph. No other excavation block at any site involved in the 2007 BGMI project produced FCR in nearly the abundance in which it was found in Operation C at 26EU2126.

Because the FCR concentration extended to the bottom of the second level in Unit C4, a third 10-cm level was dug in this unit (one of the two units for which this was done during the 2007 BGMI project). After removing the FCR cobbles at the top of the third level, three separate small pieces of charcoal were discovered directly underneath the feature. These three charcoal samples were collected individually, and they produced statistically contemporaneous radiocarbon results, with a pooled mean that has an inclusive calibrated 2-sigma age range of A.D. 380–530 (these radiocarbon dates are discussed in greater detail in Chapter 5). The fact that the three radiocarbon dates are contemporaneous suggests that they are associated with the same prehistoric event, which, as noted above, was evidently an FCR dumping episode. Artifact density dropped considerably in the third level of Unit C4, and Feature 1 did not continue below the elevation at which the charcoal specimens were found. Thus, formal excavation of this unit stopped with completion of the third level, though a "window trench" was dug on the northeast side of the unit prior to excavation of adjacent units in order to record a soil profile (this profile and profiles of other units excavated during the course of the project are presented and discussed in Chapter 5). This window trench was dug in sterile sediments to a depth of approximately 40 cm.

In order to explore whether additional FCR concentrations and/or a hearth feature that might have been the source of the FCR were located nearby, it was decided to expand Operation C to the northwest, northeast, and southeast of Unit C4. Unit C5 was placed to the southeast of Unit C4, Units C6 and C7 were placed to the northwest of Units C3 and C4, respectively, and Units C8, C9, and C10 were placed to the northeast of Units C7, C4, and C5, respectively. No additional features or signs of features were found in the remainder of the units dug in Operation C, and excavation of the Operation C block was halted at this point. It should be noted that the Operation C excavation block extended all the way to the disturbed area adjacent to the pipeline to the northwest, and it is possible that additional features were once present in this disturbed area. Artifacts recovered from the excavations in Operation C include a large sample of debitage, a ground stone artifact, a chert scraper, and two untypable chert projectile point fragments (classified in Chapter 7 as Stage 5 bifaces); two pieces of unidentified large mammal bone were also collected.

Operation F was the largest excavation block dug at 26EU2126 (or, in fact, at any of the sites involved in the 2007 BGMI project). This block ultimately consisted of 24 1×1–m units including the test unit from 2006 (TU1), which it encompassed (Figure 19, Figure 20). Operation F began as an expansion of TU1, which, as noted above, produced burned faunal remains in addition to lithic artifacts in 2006. The presence of burned bone in TU1 and in the nearby ST3 suggested that a hearth feature might be located in the vicinity. In addition, by the time it was decided to expand around TU1, most of the remote sensing anomaly locations that had been targeted for the initial phases of excavation had been dug and only one archaeological feature had been found (Feature 1 in Operation C at 26EU2126). Thus, it was decided that the area around TU1 at 26EU2126 provided the best opportunity of any area of any site involved in the project for locating archaeological features and recovering data applicable to project research questions.

Five 1 × 1–m units, Units F1 through F5, were initially excavated around TU1 during the second excavation session of the 2007 BGMI project (see Figure 19 for locations). Chipped stone artifacts and faunal remains, many of which were burned, were abundant in these units, but particularly so in Unit F2, where they continued to appear in abundance throughout the second 10-cm level. Because artifacts were so abundant in the second level of Unit F2—well over 500 artifacts were found in this level, far more than were recovered in the second level of any other unit in Operation F—a third level was dug in this unit (making this the second of the two units for which this was done during the 2007 BGMI project). Artifact density dropped considerably in the third level (to fewer than 100 artifacts), and excavation of Unit F2 was then stopped. Units F4 and F5 were located to the north and south of F2, respectively, and were put into place to determine whether the extent and depth of the artifact density observed in Unit F2 continued into adjacent units. However, this was not the case; while artifacts were abundant in these units, they were not nearly as numerous as in F2.

The remaining 18 units in Operation F were dug during the third and final excavation session of the 2007 BGMI project. Units F6 through F11 were first dug to the west of the F4-F2-F5 row of units in order to explore a feature that was evident in the magnetometer data from this area (a feature that was not selected as an anomaly to explore during the initial planning for the excavations). Excavation in Unit F7 revealed a shallowly buried piece of metal wire that was likely the cause of the feature in the magnetometer data (for which reason this magnetometry feature is not considered here to be one of the magnetometer anomalies that was evaluated through excavation), but the remainder of the units on the west side of Operation F continued to be excavated to thoroughly explore whether archaeological features might be present in this area. No features were found in these units, but artifacts were abundant, particularly in Units F6, F7, and F8 (the units adjacent to F2). Operation F was then expanded to the south and southeast of TU1 (with the excavation of Units F12 and F13, respectively) and to the northeast (with the excavation of Unit F14). Unit F12 encompassed a portion of ST3 from 2006. Again, no features were found in these units, though artifacts were recovered and were particularly abundant in Units F12 and F13.

The next step in the excavation of Operation F was to search for features further north, east, and south of TU1. To do this, 2 × 1–m trenches were dug east of Unit F3 (Units F15 and F16), south of Unit F5 (Units F17 and F18), and north of Unit F1 (Units F19 and F20). A thick ash lens was observed in second level of Unit F17. This lens, designated Feature 2, is clearly a hearth and is illustrated in Figure 19, Figure 21, and Figure 22 (the feature is mislabled as "Feature 1" in Figure 21; Zones I and II depicted in Figure 22 are described in Section 5.3). Feature 2 evidently also extended to the north into the area encompassed by Unit F5 and was not recognized as being part of an archaeological feature during excavation of that unit. Charcoal collected from the fill of this hearth produced a radiocarbon date with a calibrated 2-sigma age range of A.D. 770–980 (discussed in greater detail in Chapter 5). No features were discovered in the other units excavated at this step of the process. Artifacts were recovered from all of these units, but were abundant only in F17, the unit in which Feature 2 was found.

Excavation of Operation F concluded with the excavation of Units F21 and F22, located in the northeastern corner of the excavation block to the east of Units F19 and F20, and of Unit F23, located to the west of F17. Sediments throughout Operation F were ashy and exhibited a texture characteristic of midden deposits, but this was most pronounced in the units located in the northeastern portion of the operation, such as F14, F19, and F20. Thus, Units F21 and F22 were excavated further northeast to explore whether a feature might be present there; however, none was found, and artifacts were not particularly abundant. Unit F23 was excavated adjacent to F17 to determine if additional features or subsurface artifacts associated with Feature 2 were present. Although no additional features were found in this unit, a sizable sample of lithic debitage was recovered. An excavation unit was not placed to the east of Unit F17 because this was the area in which ST3 from 2006 was located.

At this point it became clear that the single feature (Feature 2) found in Operation F could account for all of the burned bone recovered from the excavation block, which was most abundant in the units closest to it, and that artifact density was highest in the vicinity of Unit F2 and declined with distance from this unit (Figure 23, Figure 24). It also appeared that Feature 2 could account for the ashy sediments in Operation F, which were most obvious in the units located to the northeast of the feature, or downwind of it given the region's prevailing southwesterly winds. Thus, it was decided that additional features were likely not present in the area and that the most useful information that the area could provide had been recovered. As such, Operation F was not expanded further. Archaeological materials recovered from excavations in Operation F include very large samples of chipped stone debitage (including seven pieces of obsidian, six of which have measurable hydration bands; see Chapter 5), faunal remains (the density of which correlates spatially with that of debitage; see Figure 23 and Figure 24), several chipped stone tools, three Cottonwood Triangular projectile points, and one Desert Side-notched point. Moreover, in addition to the radiocarbon date on charcoal from Feature 2 mentioned above, two large mammal bone specimens recovered in close proximity to this feature produced statistically contemporaneous radiocarbon dates with a pooled mean that has a calibrated 2-sigma age range of A.D. 1230–1300.

The purpose of Operations G through N was to evaluate whether occupation might have been continuous in the area between Operations C and F. Each of these operations started as a single 1 × 1–m unit placed at 5-m intervals along a straight line between the centers of Operations F and C. The location for Operation I along the line of test units was very close to the location of a magnetometer anomaly that was selected as a "backup" excavation location during the initial excavation planning meeting, and the placement of this operation was adjusted slightly so that it would encompass this magnetometer anomaly and provide an additional anomaly test. Operation M was expanded into a 2 × 1–m unit to explore whether a large rock found in the southwest wall of the initial unit might be associated with an archaeological feature, but the second unit revealed that it was not. No features and very few artifacts were found in any of the Operation G through N units, suggesting that Operations F and C are discrete occupation areas. Because of the lack of archaeological materials in these operations, none of them other than Operation M was expanded beyond 1 × 1 m in size.

Finally, Operation O was excavated to the northwest of Operation F as a 2 × 1–m trench divided into two 1 × 1–m units. Operation O was put into place because calcined jackrabbit bone was observed on the surface of this location, and the two units were opened to evaluate whether a hearth feature might be present. Additional bone was found subsurface, but no direct evidence of an archaeological feature was encountered, and only one chipped stone artifact was recovered.

Fieldwork at 26EU2126 concluded with mechanical stripping of the portion of the site that lies to the southeast of the pipeline (Figure 15; two debris piles in the southwestern part of the site were avoided by the grader). Blading in this area exposed an FCR concentration, designated Feature 3, located to the northwest of Operation F and southwest of Operation C. Feature 3 was similar to Feature 1 from Operation C, but it contained a small amount of ashy fill, which was collected.

Charcoal recovered from this fill returned a radiocarbon date with a calibrated 2-sigma age range of A.D. 600–680 (discussed further in Chapter 5). In addition to this feature, a few small charcoal stains that appeared to be the result of natural burning were also observed, none of which were recorded or collected. Notably, no additional archaeological features were found during blading in the vicinity of Operations C or F. However, one chipped stone core was collected during blading just southwest of Operation F.

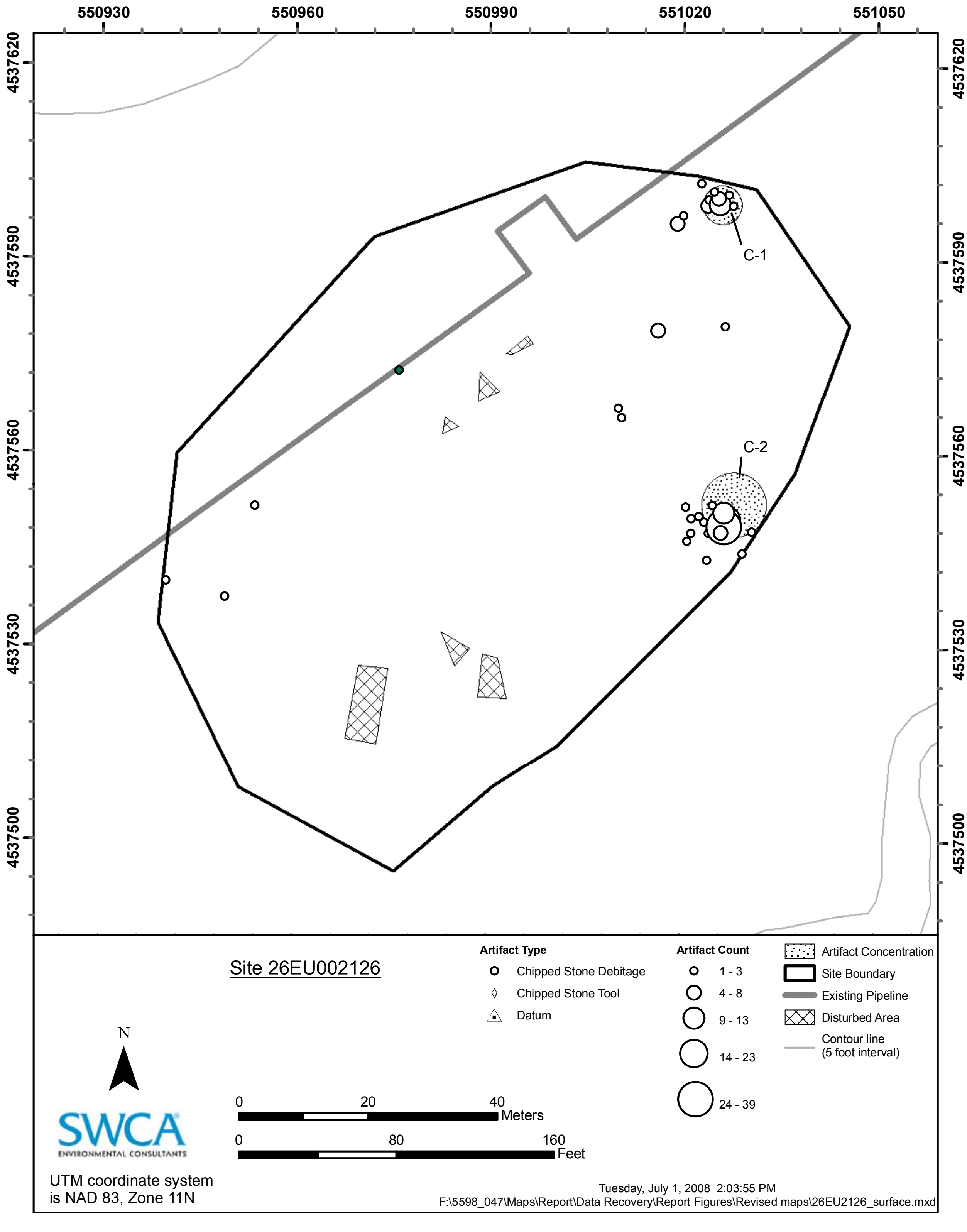

Figure 14. Results of surface artifact collection at 26EU2126.

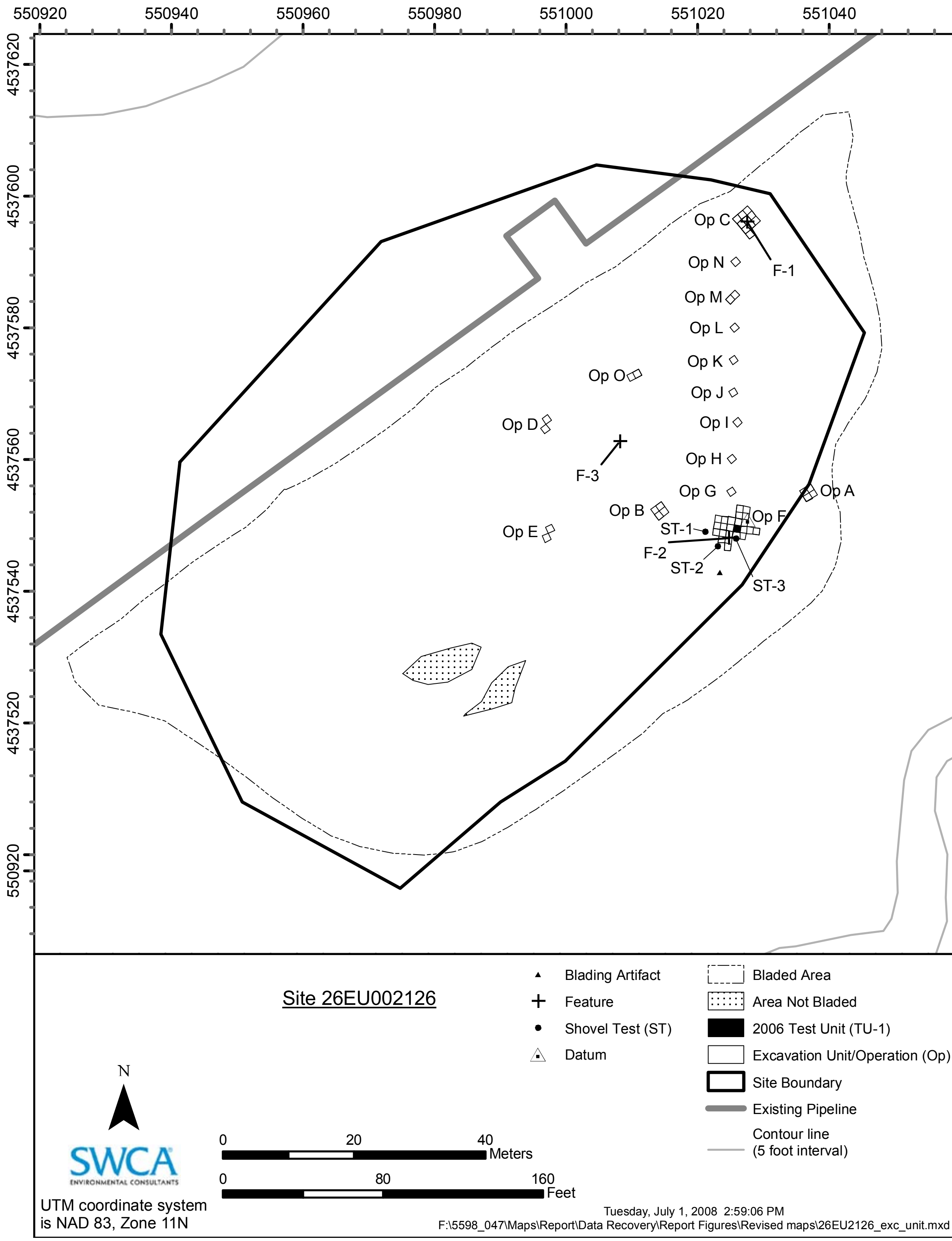

Figure 15. Locations of excavation units and extent of mechanical stripping at 26EU2126.

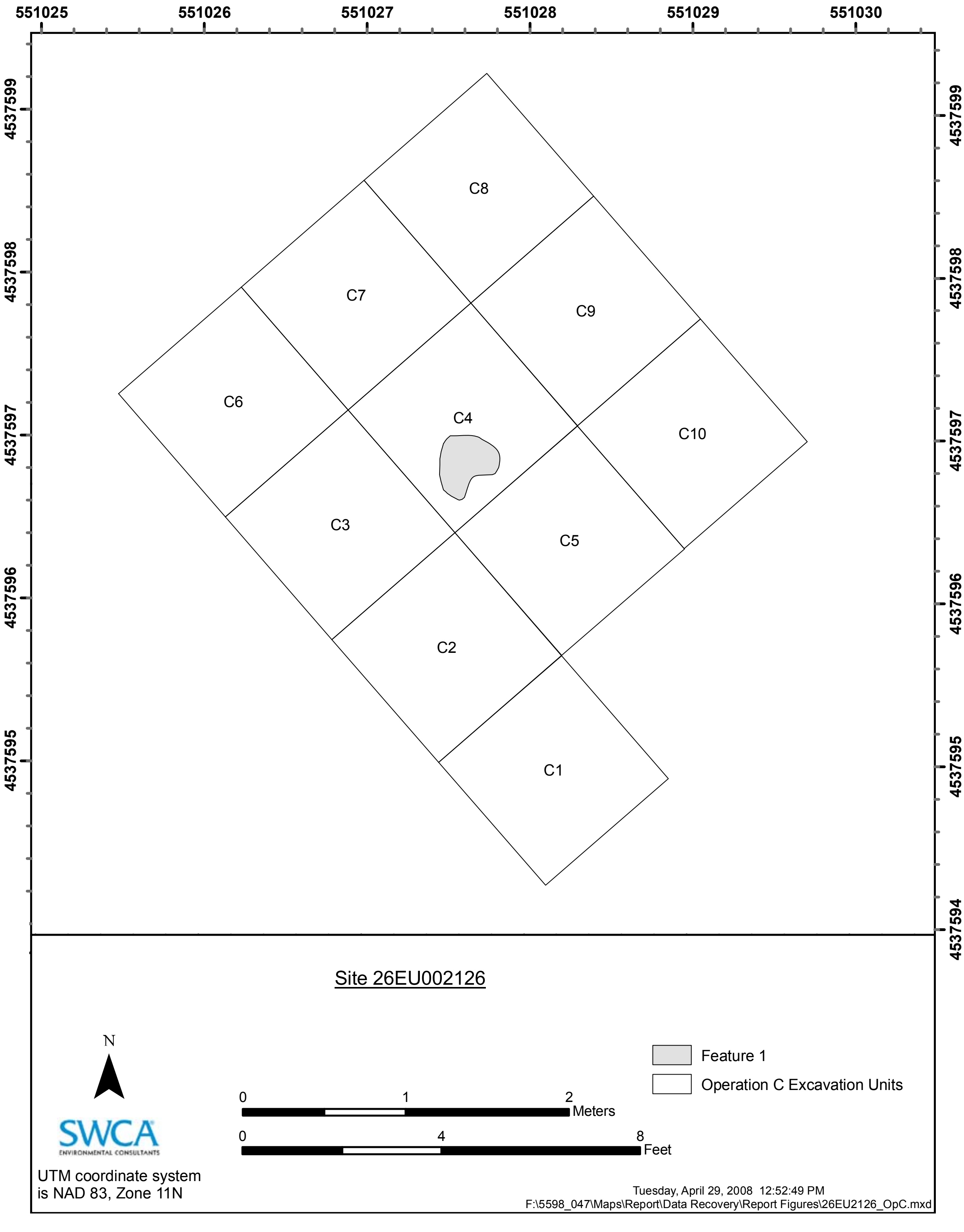

Figure 16. Excavation units in Operation C at 26EU2126, showing the location of Feature 1.

Figure 17. Photograph of Operation C at 26EU2126 after completion of excavation; facing southeast.

Figure 18. Photograph of Feature 1 at 26EU2126, taken at a depth of 20 cm in Unit C4; facing northeast.

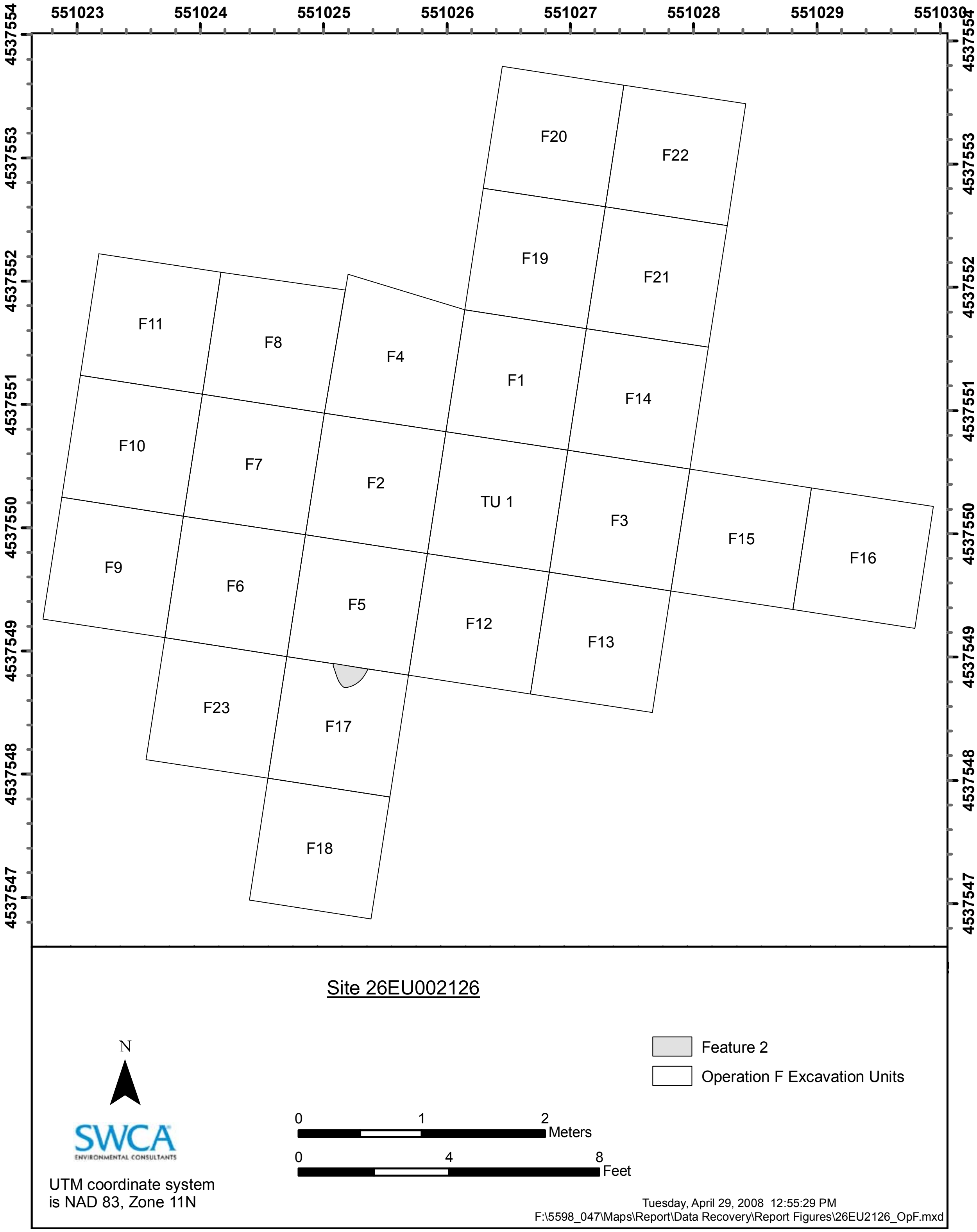

Figure 19. Excavation units in Operation F at 26EU2126, showing the location of Feature 2.

Figure 20. Photograph of Operation F at 26EU2126 after completion of excavation; facing west.

Figure 21. Photograph of Feature 2 at 26EU2126, taken at a depth of approximately 15 cm in Unit C4; facing south.

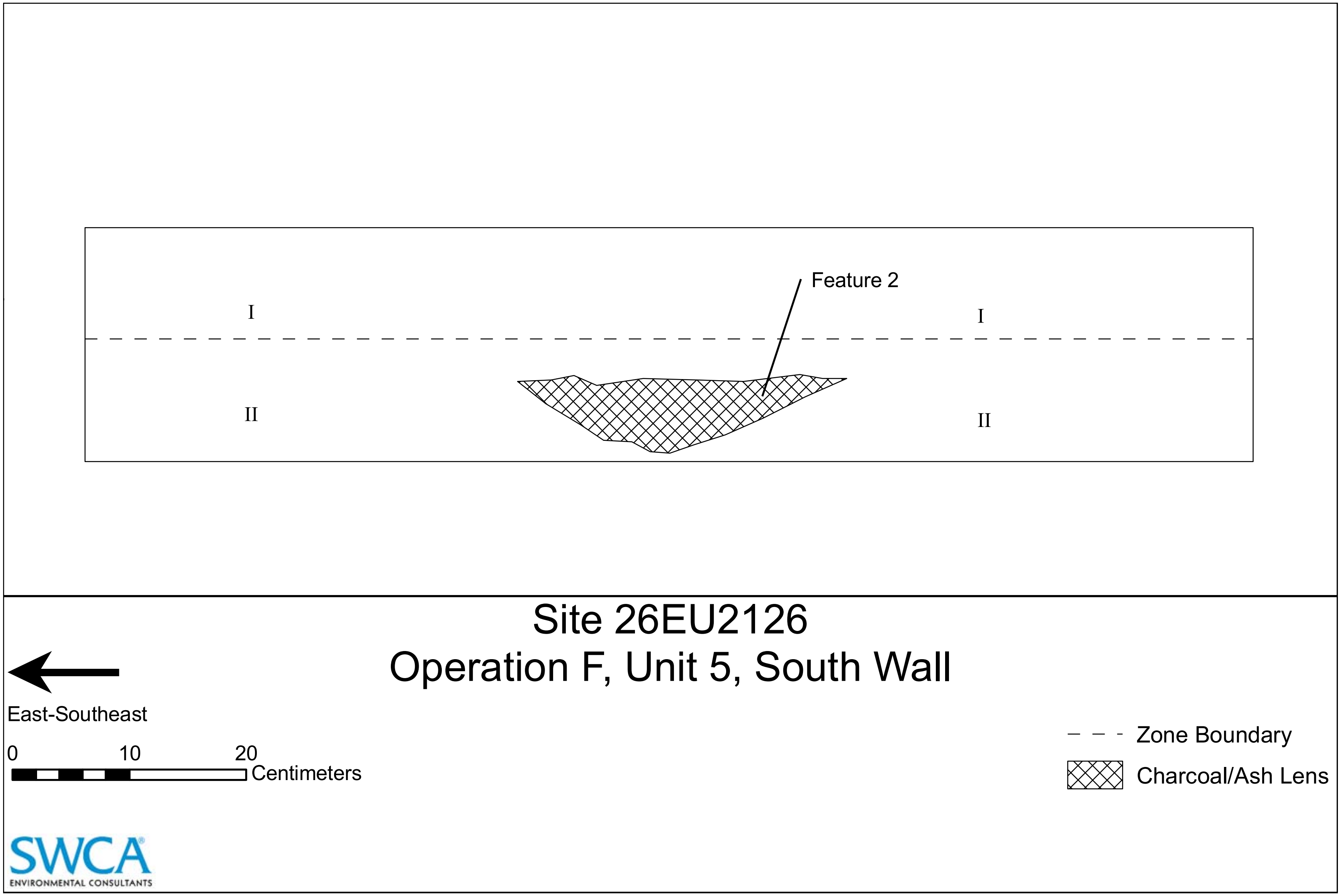

Figure 22. Profile of the south wall of Unit F5, 26EU2126, showing Feature 2.

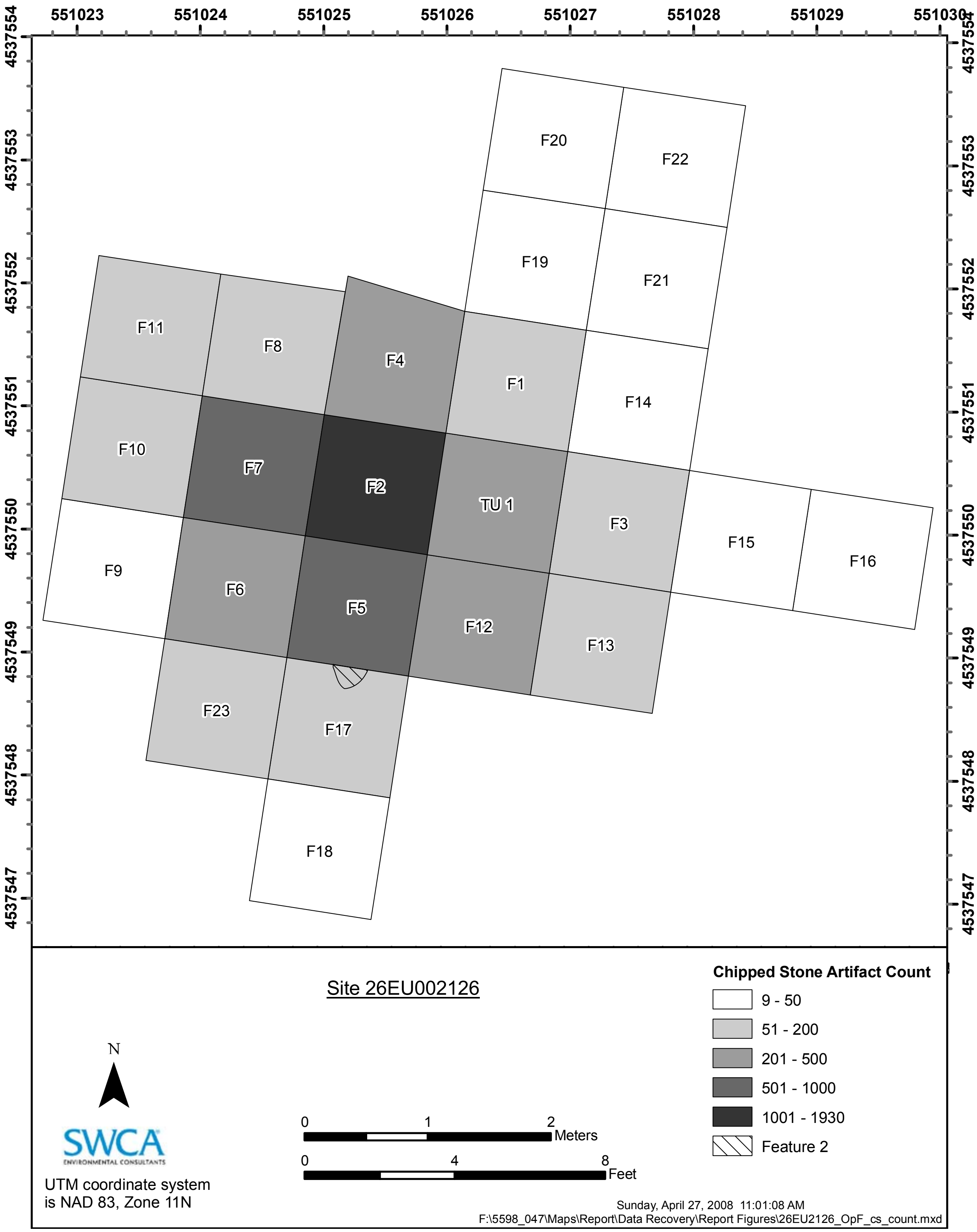

Figure 23. Chipped stone artifact density in Operation F at 26EU2126.

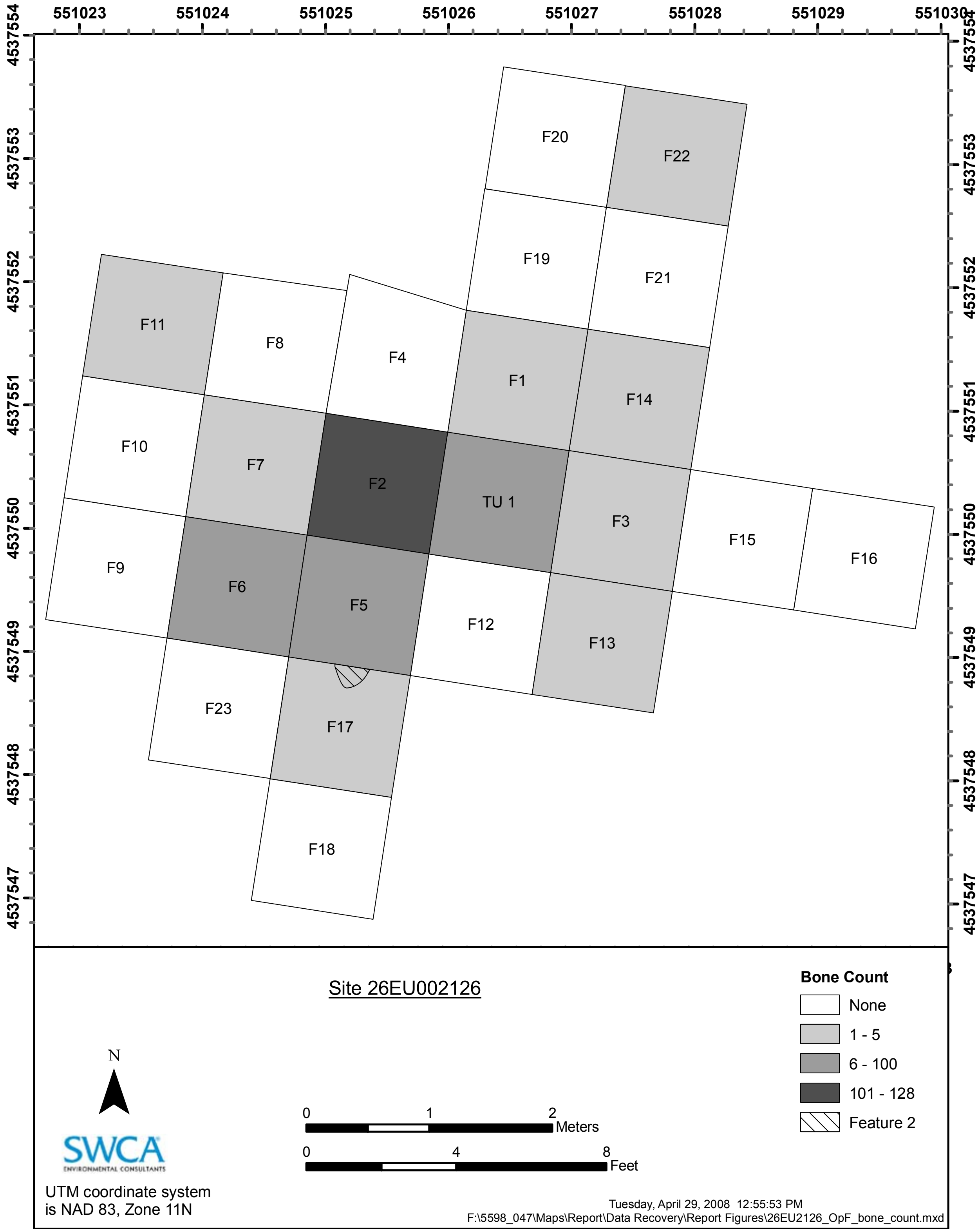

Figure 24. Faunal bone density in Operation F at 26EU2126.

4. REMOTE SENSING

Michael D. Cannon and Chester P. Walker

As described in the previous chapters, collection of geophysical remote sensing data played an integral role in the research design for the 2007 BGMI Data Recovery Project. This chapter discusses in greater detail the goals of the remote sensing data collection for the project and the methods that were used to collect the data. It also describes the data processing steps that were carried out, presents the resulting data in the form of two-dimensional images, and evaluates potential causes of patterns observed in the data. Finally, the chapter addresses the remote sensing results in relation to the project goals and presents suggestions for more efficient and effective use of remote sensing techniques in future archaeological work in the LBBA and other parts of the Great Basin.

4.1. GOALS

Three geophysical remote sensing techniques were used during this project: magnetometry, conductivity survey, and magnetic susceptibility survey. These techniques were used in surveys covering as much of the surface of each of the five sites involved in the project as possible. The primary goal of using these techniques was to locate subsurface archaeological features with the highest potential for providing data applicable to important research questions, particularly thermal features and occupation surfaces that date to relatively discrete time intervals. For reasons discussed below, magnetometry was used to attempt to locate thermal features, while conductivity and magnetic susceptibility were used to attempt to locate occupation surfaces. It was hoped that these techniques would enable the types of features that were sought to be located more efficiently than is possible using traditional testing methods so that the focus of excavation could quickly turn from finding features to evaluating whether deposits were single-component. Features identified in the remote sensing data were to undergo limited excavation so that temporally diagnostic artifacts and/or datable materials could be recovered; those deposits that appeared to be single-component based on the limited excavations were then to be explored more extensively through block excavations.

A secondary goal of the remote sensing surveys was, by necessity, to evaluate whether the techniques that were used are effective at locating the types of features that were targeted in the first place. In essence, the project was intended to serve as a test case for the usefulness of geophysical methods in archaeological research and cultural resource management (CRM) in the LBBA and other parts of the Great Basin. While magnetometry was used without success to locate thermal features during one project conducted in the LBBA in the early 1990s (Schroedl 1996:521), the technology and survey methodology of magnetometry has since advanced, and it was determined that the utility of the method should be reevaluated. In addition, the techniques of conductivity and magnetic susceptibility survey had never previously been used in archaeological investigations in the LBBA and were thus completely unevaluated. It was recognized that, if successful, this test case involving these methods would likely lead to substantial methodological advances, enabling data recovery projects such as the 2007 BGMI project to be both more productive and more cost-effective than is the case when only traditional methods of archaeological testing are used.

Unfortunately, the project turned out not to be able to provide the sort of test case that was hoped for. This was because, as manual excavations and the mechanical stripping conducted at the end of fieldwork revealed, the types of features that were targeted were rare or absent at the sites investigated. Despite this fact, however, the geophysical work conducted during the course of this project leads to methodological insights that should improve the efficiency and effectiveness of future archaeological remote sensing surveys in the region. These insights come in part from a preliminary evaluation of the causes of patterns observed in the geophysical data, something that was not attempted in the first application of remote sensing in the LBBA. They also come in part from an evaluation of different remote sensing survey strategies. These issues are addressed below, following a discussion of the methods that were used and presentation of the results.

4.2. METHODS

Geophysical survey was conducted by Archaeo-Geophysical Associates, LLC (AGA), with field support from SWCA, and AGA performed all post-field data processing. For the project as a whole, data were collected over an area totaling 87,200 m^2. This was divided up among the five sites as follows: 7,200 m^2 at 26EU1533; 16,000 m^2 at 26EU1539; 8,800 m^2 at 26EU1548; 41,200 m^2 at 26EU2064; and 14,000 m^2 at 26EU2126.

4.2.1. TECHNICAL BACKGROUND

Archaeological applications of geophysics ("archaeo-geophysics") employ a range of techniques for the nondestructive prospection of archaeological deposits (Gaffney and Gater 2003). These techniques have been developed for a variety of applications, mostly geological in nature, but they have been adapted for use in archaeological investigations through the development of archaeology-specific field collection techniques and data processing programs. Archaeo-geophysical data have a long history of success in helping to focus archaeological excavations to specific locations within sites. Under the right conditions, archaeo-geophysics can also be used by itself as a primary source of archaeological data (Kvamme 2003a).

In general, all geophysical techniques map, record, or sense different variables or properties of sediments. However, geophysical instruments are differentially affected by other variables such as moisture, metal trash or debris, and transmission of signals such as those of cell phones and transmission lines. Data collection is also impacted differently for each geophysical instrument by physical impediments such as trees, pavement, fences, and vegetation. Archaeologists have found that the first line of defense against this complex matrix of variables is to come to the field prepared to collect data with several different instruments. The "multiple-technique" approach not only increases the likelihood of success in detecting archaeological features of interest, but it can often enhance the visibility of the archaeological targets that may be present and preserved at archaeological sites (Kvamme 2006b:57–58; Kvamme et al. 2006:251). This is the approach that was taken in the 2007 BGMI project.

The specific techniques that were used in the project are described in greater detail next. These techniques—magnetometry, conductivity survey, and magnetic susceptibility survey—were chosen for their potential to find the types of features that were targeted in the project, as discussed below. The other near-surface geophysical technique that has also received considerable use in archaeology—ground–penetrating radar (GPR)—was not employed primarily for logistical reasons. While GPR does have the potential to locate the kinds of features that were of interest for the project—particularly thermal features, especially if they are rock-lined—previous experience in other Great Basin settings has shown that the rough ground surfaces that are typical of the region introduce considerable noise into the data. For a GPR survey to produce "clean" data, the radar antenna must maintain a constant ground coupling (i.e., it must remain in continued contact with the ground) as it is moved along the surface (Conyers 2004:68–71), and this is not possible at sites such as those involved in this project where, even after vegetation removal, the ground is very uneven.

MAGNETOMETRY

Magnetometer and magnetic gradiometer surveys are noninvasive and passive methods that measure slight variations in the magnetic properties of sediments. Magnetometers have become the primary tool for archaeo-geophysicists working on prehistoric archaeological sites in part because magnetic data can be collected and processed rapidly and efficiently, but also because when sediments have properties that are favorable, magnetometers have proven useful in locating negative relief features such as pits and post holes as well as thermally altered features such as fire hearths and burned structures (Gaffney et al. 2000; Kvamme 2003b; Walker and Perttula 2007a, 2007b).

Magnetometers record two types of magnetism: induced and remnant. Induced magnetism involves the minute fluctuations in the earth's magnetic field that sediments and other objects create. It is known as induced magnetism because the objects causing the fluctuations do not maintain their own magnetic field. If the effects of induced magnetism are strong enough compared to the magnetism of surrounding deposits, features such as pits or post holes can be identified or resolved in the geophysical data. Remnant magnetism occurs when an object maintains its own magnetic field. In prehistoric archaeological examples, this can be the case when objects are thermally altered, thus creating a magnetic state called thermoremnant magnetism (Kvamme 2006c:207). Locating thermal features such as hearths was one of the primary goals of the 2007 BGMI project, and magnetometry is useful for locating such features due to the thermoremnant magnetism that they often possess.

The magnetometer used in this study was a Bartington Grad 601-2 dual sensor fluxgate gradiometer, which is discussed in detail by Bartington and Chapman (2004). This instrument is equipped with a filter that eliminates the effects on the data that are collected of most power lines, an important point given that power lines are located very close to some of the sites involved in this project. The dual gradiometer sensors, spaced 1 m apart, enable survey of a given area to be completed in half the time required by a single sensor instrument.

CONDUCTIVITY

Conductivity surveys measure the ability of sediments to conduct an electric current (Clay 2006:79). Conductivity is a function of, among other things, sediment porosity (McNeill 1980b). Thus it can, in theory, reflect contrasts between disturbed areas, such as human occupation areas, and surrounding undisturbed sediments; this was the purpose for which conductivity survey was used in the 2007 BGMI project.

Conductivity is the theoretical inverse to resistivity, but measuring conductivity entails a much more complex set of procedures than does measuring resistivity (Bevan 1983:51; Clay 2006:79). Conductivity instruments differ greatly from resistivity instruments in that no probes are inserted into the ground; rather, they consist of a set of two wire coils, one of which transmits a low-frequency signal that the other receives. Because of this, a conductivity meter can simply be carried above the ground surface while data are logged automatically, making conductivity surveys relatively time and labor efficient.

Conductivity data for this project were collected using a Geonics EM38B electromagnetic (EM) instrument, which also simultaneously records magnetic susceptibility data (discussed next). Conductivity meters can resolve data at different depths by changing the separation of the transmission and receiving coil and by transmitting its signal at different frequencies. Some instruments allow for these variables to be changed and others, like the EM38B (the most popular conductivity meter used in American archaeology), are not adjustable. However, the EM38B has a maximum effective depth of 1.5 m (measured from the height of the instrument, approximately 50 cm above the ground surface in this case), which is more than sufficient for the depth at which subsurface archaeological deposits typically occur at sites in the LBBA.

MAGNETIC SUSCEPTIBILITY

Magnetic susceptibility is a measurement of a material's ability to be magnetized (Dalan 2006:161). Changes or contrasts in the magnetic susceptibility of sediments are the result of a conversion of weakly magnetic oxides and hydroxides to more strongly magnetic forms (Dalan 2006:162). This magnetic enhancement can be caused by burning episodes, both natural and human–caused, as well as by organic and inorganic pedogenic processes (Dalan 2006:162–163). Magnetic susceptibility data were recorded during this project because it was hoped that they would reflect prehistoric occupational surfaces, which should, in theory, be magnetically enhanced due to organic enrichment.

Similar to other geophysical methods, magnetic susceptibility has become increasingly useful for archaeological investigations. Magnetic susceptibility instruments differ from magnetometers in that they only measure fields resulting from induced magnetism, whereas magnetometers record the net effect of induced and remnant magnetism (Dalan 2006:162; Kvamme 2006c:207–210). The differences between these two instruments produce datasets that are both complementary and unique. They are complementary in that magnetic susceptibility data can aid in the interpretation of magnetometer data (Dalan 2006:162–163), whereas magnetic susceptibility data are unique in that they can be used to address entirely different research questions involving, for example, the tracking of broad magnetic changes across the landscape (David 1995:20).

4.2.2. FIELD METHODS

The specific settings used for the geophysical instruments employed in this study differ greatly; however, there are a few concepts of data collection that apply to all three technologies. In general, the density of a geophysical dataset is controlled by two factors: 1) traverse interval, or the distance between the passes that the instrument makes as it is carried back and forth across the grid collection area, and 2) sample interval, or the distance between the readings that the instrument records as it moves along each traverse. The optimal traverse and sample intervals depend on many factors, including the size and depth of the target features, the nature of the sediment matrix, present-day uses of the collection area, the length of time available for the survey, and the research goals of the project. For this project, magnetometer data were collected using a 0.500-m traverse interval and a 0.125-m sample interval (8 readings per linear meter), resulting in a data density of 16 readings per square meter. This high degree of resolution is appropriate for locating thermal features that may be a meter or less in diameter. Conductivity and magnetic susceptibility data were collected using a 1.0-m traverse interval and a sample interval of five readings per second; given the pace of the surveyor, this amounts to a 0.25-m sample interval (four readings per linear meter), and this combination of traverse and sample intervals resulted in a data density of four readings per square meter. This lower degree of resolution is appropriate for the larger occupation surfaces that were the target of conductivity and susceptibility survey.

As noted, spatial control was maintained by collecting the geophysical data in grids of 20 × 20–m units. AGA has found that this size of collection unit results in an optimal balance between dataset quality and speed of data collection. Following stake-out of the grid units (as described in Section 3.1.6), PVC pin flags were placed at 2-m intervals on two sides of each grid square. These pin flags provided geophysical surveyors with targets to aim for as they traversed the grids, ensuring that the traverse intervals discussed above were maintained. The EM38B instrument used to collect the conductivity and susceptibility datasets was integrated with a Sokkia 2650 dual frequency GPS receiver with OmniStar correction service, which provides sub-decimeter spatial precision to these datasets. This GPS integration for the EM datasets was in addition to the use of the 20 × 20–m grid units; these datasets were collected in 20 × 20–m units to ensure that data densities remained consistent and that the EM data covered the same areas as the magnetometer data. Both the magnetometer and the EM instrument were passed over the grids in a bidirectional pattern.

4.2.3. DATA PROCESSING

After collection, all data were processed and filtered to remove false readings (spikes and drop-outs). Processing also leveled the datasets so that adjacent 20 × 20–m grids could be combined into a single image with no "grid lines". And finally, datasets were processed to enhance the visibility of target features both through statistical manipulation of the recorded data and through image processing of the image file output.

The general goal of this last form of data processing is to lessen the effects of background "noise" and to enhance the quality of the "signal" or "target" in the geophysical data. In field geophysics in general, and archaeo-geophysics in particular, the term "noise" is used to refer to any return that is not a direct result of the object under investigation, which is referred to as the "target" or "signal". Hence, what is considered to be noise in one case can in another case be the signal or target (Milsom 2005:13–14). It is also important to note that absolute accuracy of the geophysical readings is less important for resolving targets in the geophysical data than is the relative contrast between the target and its surrounding matrix.

The major data processing techniques that were used for this project are discussed next, with details on the specific data processing workflow that was followed for each of the five sites. Because the workflow for processing differs greatly between magnetometer and EM data, the processing steps used for each type of data are discussed separately. The general approach to data processing followed Kvamme (2006a:236) and involved computer processing of the data to identify regular and culturally interpretable patterns using pattern recognition principles. As Kvamme (2006a:236) notes, "In general, anomalies exhibiting regular geometric shapes (lines, circles, squares, rectangles) tend to be of human origin". After each processing step, the results were closely compared to the previous processed state to ensure that manipulation was not decreasing the clarity and quality of the data, thus avoiding the creation of processed images that are primarily products of the data processing itself.

MAGNETOMETRY

All magnetometer data from the 2007 BGMI project were processed using ArcheoSurveyor 2.0 software produced by DW Consulting. The processing steps used for the data from each of the five sites involved in the project are presented in Table 5 through Table 9.

The magnetometer datasets were first de-striped. De-striping is a process used to equalize the underlying differences between grids caused by instrument drift, inconsistencies during setup, delays between surveying adjacent grids, or heading error. De-striping was done by subtracting the median for each traverse from the values in that traverse.

Next, the datasets were clipped. Clipping replaces all values outside a specified minimum and maximum range. These minimum and maximum values are specified in either absolute values or as ± standard deviations (SD). This process is used to remove extreme data point values, and it aids in normalizing the histogram of the magnetic data. Archaeological details in magnetometer data are subtle, and fine details show through more clearly when data are normally distributed.

When necessary, the data were de-staggered. De-staggering corrects for the minor inconsistencies in a surveyor's gait as they walk back and forth across the collection area. In de-staggering, the data in a traverse are simply moved up or down by a specified interval.

Finally, low pass filtering was also used when necessary. Low pass filters remove low frequency components in geophysical data and lessen the effects of background noise. They operate by calculating the mean of the values within a window of a specified size and by then replacing the window's center value with the mean. Either a uniform or a Gaussian weighting can be used to replace the center value. With uniform weighting, all values within the window are given equal weight. With Gaussian weighting, which was used for all datasets produced during this project, a higher weight is given to values closer to the center of the window.

Table 5. Processing Steps for Magnetometer Data from 26EU1533

Step	Processing Task
1	Base Layer
2	De-stripe Median Traverse: Grids: All
3	Clip from -20 to 20
4	De-stagger: Grids: All Mode: Both By: -4 intervals
5	De-stagger: Grids: 01.asg 02.asg 03.asg 04.asg 05.asg 06.asg Mode: Both By: -2 intervals
6	Low pass Gaussian filter: Window: 3 x 3

Table 6. Processing Steps for Magnetometer Data from 26EU1539

Step	Processing Task
1	Base Layer
2	De-stripe Median Traverse: Grids: All
3	Clip from -10 to 10
4	De-stagger: Grids: All Mode: Both By: -4 intervals, 10.00cm
5	De-stagger: Grids: 01.asg 09.asg 30.asg 32.asg Mode: Both By: 2 intervals, 10.00cm
6	De-stagger: Grids: 18.asg 19.asg Mode: Both By: -2 intervals, 10.00cm
7	Low pass Gaussian filter: Window: 3 x 3

Table 7. Processing Steps for Magnetometer Data from 26EU1548

Step	Processing Task
1	Base Layer
2	De-stripe Median Traverse: Grids: All
3	De-stagger: Grids: All Mode: Both By: -3 intervals
4	De-stagger: Grids: 05.asg 09.asg 11.asg 12.asg 13.asg 14.asg 15.asg 16.asg Mode: Both By: -3 intervals
5	Clip from -15 to 15
6	Low pass Gaussian filter: Window: 3 x 3

Table 8. Processing Steps for Magnetometer Data from 26EU2064

Step	Processing Task
1	Base Layer
2	Clip from -15 to 15
3	De-stripe Median Traverse: Grids: All
4	De-stagger: Grids: 01.asg 02.asg 03.asg 04.asg 05.asg 06.asg 07.asg 08.asg 09.asg 10.asg 11.asg 12.asg 13.asg 14.asg 15.asg 16.asg 17.asg 18.asg 19.asg 20.asg 21.asg 22.asg 23.asg 24.asg 25.asg 26.asg 27.asg 28.asg 29.asg 30.asg 31.asg 32.asg 33.asg 34.asg 35.asg 36.asg 37.asg 38.asg 39.asg 40.asg 41.asg 42.asg 43.asg 44.asg 45.asg 46.asg 47.asg 48.asg 49.asg 50.asg 51.asg 52.asg 53.asg 54.asg 55.asg 56.asg 57.asg 58.asg 59.asg 60.asg 61.asg 62.asg 63.asg 64.asg 65.asg 66.asg 67.asg 68.asg 69.asg 70.asg 71.asg 72.asg 73.asg 74.asg 75.asg 76.asg 77.asg 78.asg 79.asg 80.asg 81.asg 82.asg 83.asg 84.asg Mode: Both By: -2 intervals
5	De-stagger: Grids: 50.asg 51.asg 67.asg 70.asg 84.asg Mode: Both By: -4 intervals
6	Low pass Gaussian filter: Window: 3 x 3

Table 9. Processing Steps for Magnetometer Data from 26EU2126

Step	Processing Task
1	Base Layer
2	Clip from -15 to 15
3	De-stripe Mean Traverse: Grids: All Threshold: 2 SDs

CONDUCTIVITY AND MAGNETIC SUSCEPTIBILITY

Conductivity and magnetic susceptibility datasets were processed using both DAT38BW software produced by Geonics and ArcheoSurveyor 2.0. DAT38BW was used to convert the files to an XYZ format positioned with UTM coordinates recorded by the GPS receiver attached to the EM instrument. DAT38BW does this by interpolating the locations of EM readings logged between GPS readings. One GPS reading per second and five EM readings per second were logged; thus, the positions of four of the five EM readings logged every second were interpolated by the DAT38BW program. This interpolation process is conducted after the data are logged, and it therefore utilizes GPS readings taken on both sides of the EM readings.

After a dataset was converted into an XYZ file it was imported into ArcheoSurveyor 2.0. The processing steps taken in ArcheoSurveyor 2.0 for each of the susceptibility and conductivity datasets from the five sites involved in the project are presented in Table 10 through Table 19. The datasets were first gridded using a 3-m search radius to create base layers. Then, if necessary, the data were clipped and/or a low pass filter was applied.

Table 10. Processing Steps for Magnetic Susceptibility Data from 26EU1533

Step	Processing Task
1	Base Layer
2	Low pass Gaussian filter: Window: 8 x 8

Table 11. Processing Steps for Conductivity Data from 26EU1533

Step	Processing Task
1	Base Layer
2	Clip from 3 to 15

Table 12. Processing Steps for Magnetic Susceptibility Data from 26EU1539

Step	Processing Task
1	Base Layer
2	Clip at 2 SD
3	Low pass Gaussian filter: Window: 8 x 8

Table 13. Processing Steps for Conductivity Data from 26EU1539

Step	Processing Task
1	Base Layer
2	Clip at 2 SD

Table 14. Processing Steps for Magnetic Susceptibility Data from 26EU1548

Step	Processing Task
1	Base Layer
2	Clip at 2 SD
3	Low pass Gaussian filter: Window: 8 x 8

Table 15. Processing Steps for Conductivity Data from 26EU1548

Step	Processing Task
1	Base Layer
2	Clip at 2 SD

Table 16. Processing Steps for Magnetic Susceptibility Data from 26EU2064

Step	Processing Task
1	Base Layer
2	Clip from -1 to 1
3	Low pass Gaussian filter: Window: 10 x 10

Table 17. Processing Steps for Conductivity Data from 26EU2064

Step	Processing Task
1	Base Layer
2	Clip at 1 SD
3	Clip from 11 to 28

Table 18. Processing Steps for Magnetic Susceptibility Data from 26EU2126

Step	Processing Task
1	Base Layer
2	Clip at 1 SD

Table 19. Processing Steps for Conductivity Data from 26EU2126

Step	Processing Task
1	Base Layer
2	Clip at 1 SD

4.3. RESULTS

The data produced by each of the three geophysical techniques that were used during the 2007 BGMI project are discussed here. The raw data images that result from the processing steps described above are presented in Appendix C, which is AGA's report on the geophysical work done for this project, and high-resolution electronic copies of these images are being submitted on CD to BLM-Elko with this report. In this section, these images are overlain on site maps that show the relationship of such things as excavation units and modern disturbances to features in the geophysical data. The remote sensing images were visually georeferenced to the site maps by linking grid corners visible in the images to site grid control points, which were mapped by total station.

4.3.1. MAGNETOMETRY

The sediments at the sites involved in this project exhibit considerable variability in their magnetic properties. Much of this variability correlates with modern objects or disturbances such as pieces of metal, roads, and debris piles; these are the causes of the most noticeable features in the magnetometer data. The initial excavations at these sites focused on more subtle features in the magnetometer data that did not obviously reflect such modern objects or disturbances and that were instead thought to possibly reflect archaeological features. However, as noted in Chapter 3, excavation of these magnetic anomalies did not lead to the discovery of archaeological features (few of which were actually present at the sites involved in the project). As is discussed further in Section 4.4, it now appears that the kinds of features in the magnetometer data that were targeted for excavation reflect geological, rather than archaeological, phenomena. Given this, perhaps the most productive contribution that the 2007 BGMI project can make to future geophysical work in the region is to identify methods that might make geophysical survey more efficient and more productive, including methods to control for the effects of geology in archaeo-geophysical surveys. Such issues are considered below. Here, the magnetometer data from each site are discussed, and the anomalies that were targeted for excavation are described.

26EU1533

Of the sites involved in this project, the magnetometer data from 26EU1533 had the widest range of readings (Figure 25). The most obvious features in these data correspond to a two-track road that enters the site from the northwest and a piece of rebar installed as the site datum (the large dipole feature that appears between Operations C and E). These features aside, there are areas of enhanced magnetic activity (i.e., great variability in magnetism) on the crest of the landform in the central and northeast parts of the site, and it was these areas that were targeted in the first excavations conducted at the site in 2007. Specifically, Operation A focused on an area of high magnetism approximately 1 m in diameter, which was located along a ring of slightly lower but still high magnetism that is approximately 4 m in diameter. Operation B, for contrast, focused on an area of low magnetism approximately 2 m in diameter located between two magnetic highs. These magnetometer anomalies were selected for excavation because it was thought that they might reflect small thermal features, and these two anomalies were considered to be representative of the much larger number of similar anomalies present in this part of the site.

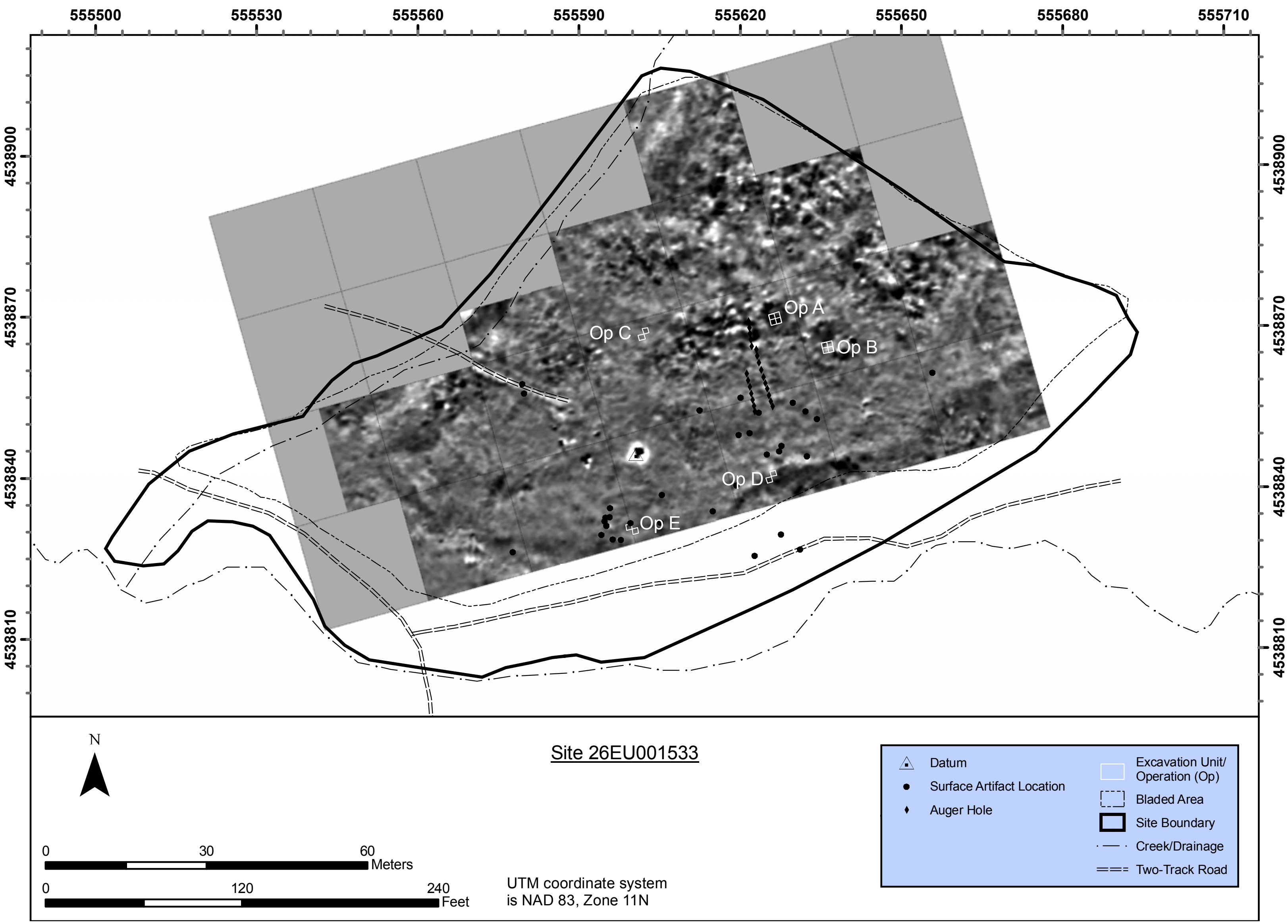

Figure 25. Magnetometer data from 26EU1533.

26EU1539

Prominent features in the magnetometer data from 26EU1539 include the east-west-running road that crosses the site and the historic ditch located to the south of the road, which traverses the site from northwest to southeast (Figure 26, Figure 27). There is also a notable trend in the magnetometer data that corresponds to the edge of the alluvial terrace that runs the length of the site from north to south, with the alluvial channel deposits to the west displaying much less magnetic activity than the terrace deposits to the east. Also visible in the data are a metal sign post on the northern edge of the road (the large magnetic low approximately one-third of the way across the site from west to east) and a shallow channel that runs from northeast to southwest in the northeastern portion of the site. The magnetic anomalies that were specifically targeted in excavations at this site are those explored by Operations A and B. Operation A was a 4 × 1–m trench placed at the edge of a area of relatively high magnetism that is circular in shape, approximately 5 m in diameter, with a projection to the southeast. As noted in Chapter 3, based on its appearance in the magnetic data and on the fact that this feature coincided with a shallow depression on the ground, it was thought prior to excavation that a pit structure might be present here (with an entrance to the southeast reflected by the projection off of the circular magnetic feature), but this proved not to be the case. Operation B targeted a small area of relatively high magnetism (hereafter a "small magnetic high"), approximately 1 m in diameter, that, like the anomalies targeted at 26EU1533, appeared to be consistent with the magnetic signature of a thermal feature. Two additional excavation blocks at this site encompassed magnetometer anomalies similar to ones investigated elsewhere, even though these blocks were placed where they were for reasons other than the presence of a magnetic anomaly. These are Operations C and D, both of which were excavated primarily to investigate conductivity anomalies but which happened to be located over small magnetic lows similar to the one targeted in Operation B at 26EU1533.

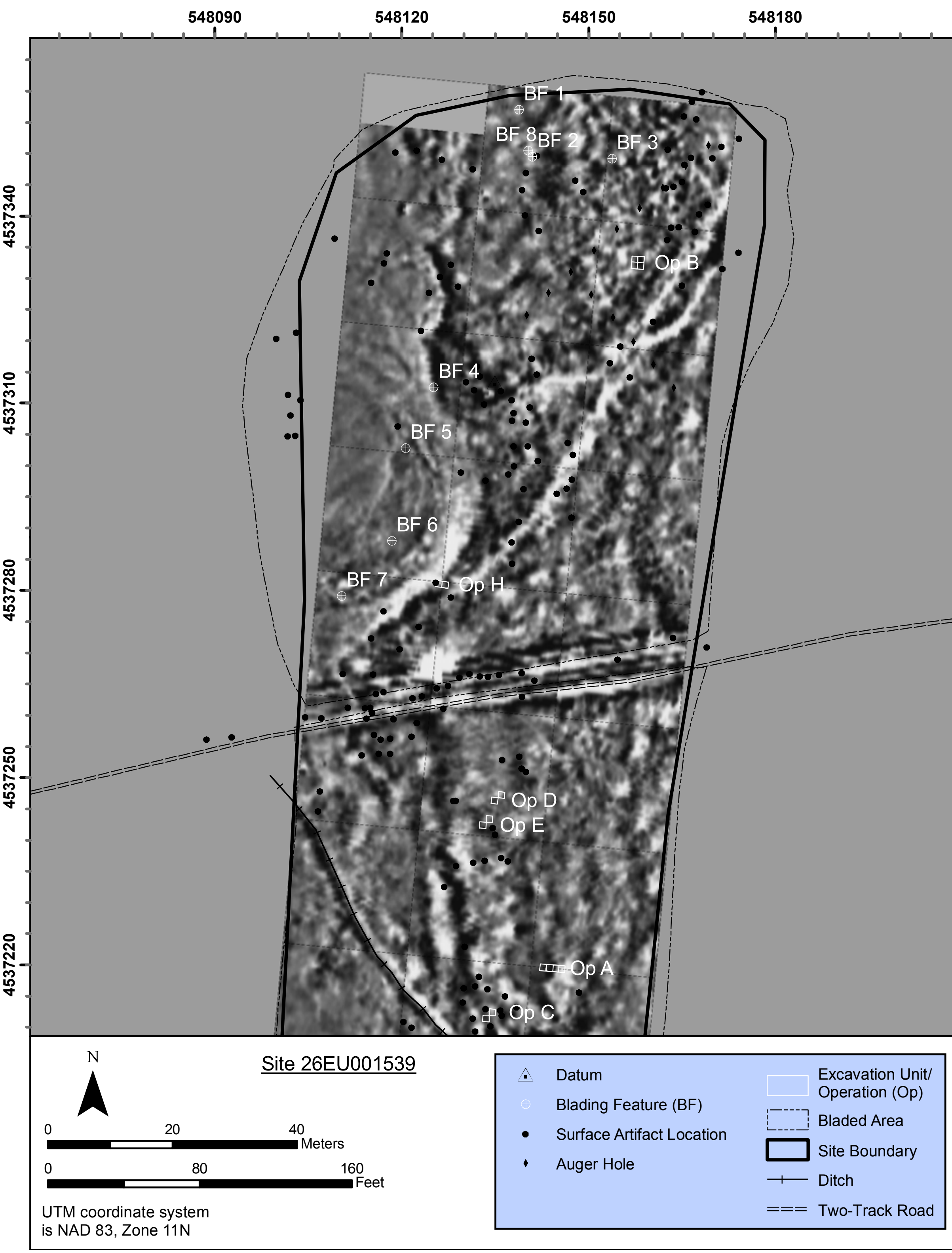

Figure 26. Magnetometer data from the northern portion of 26EU1539.

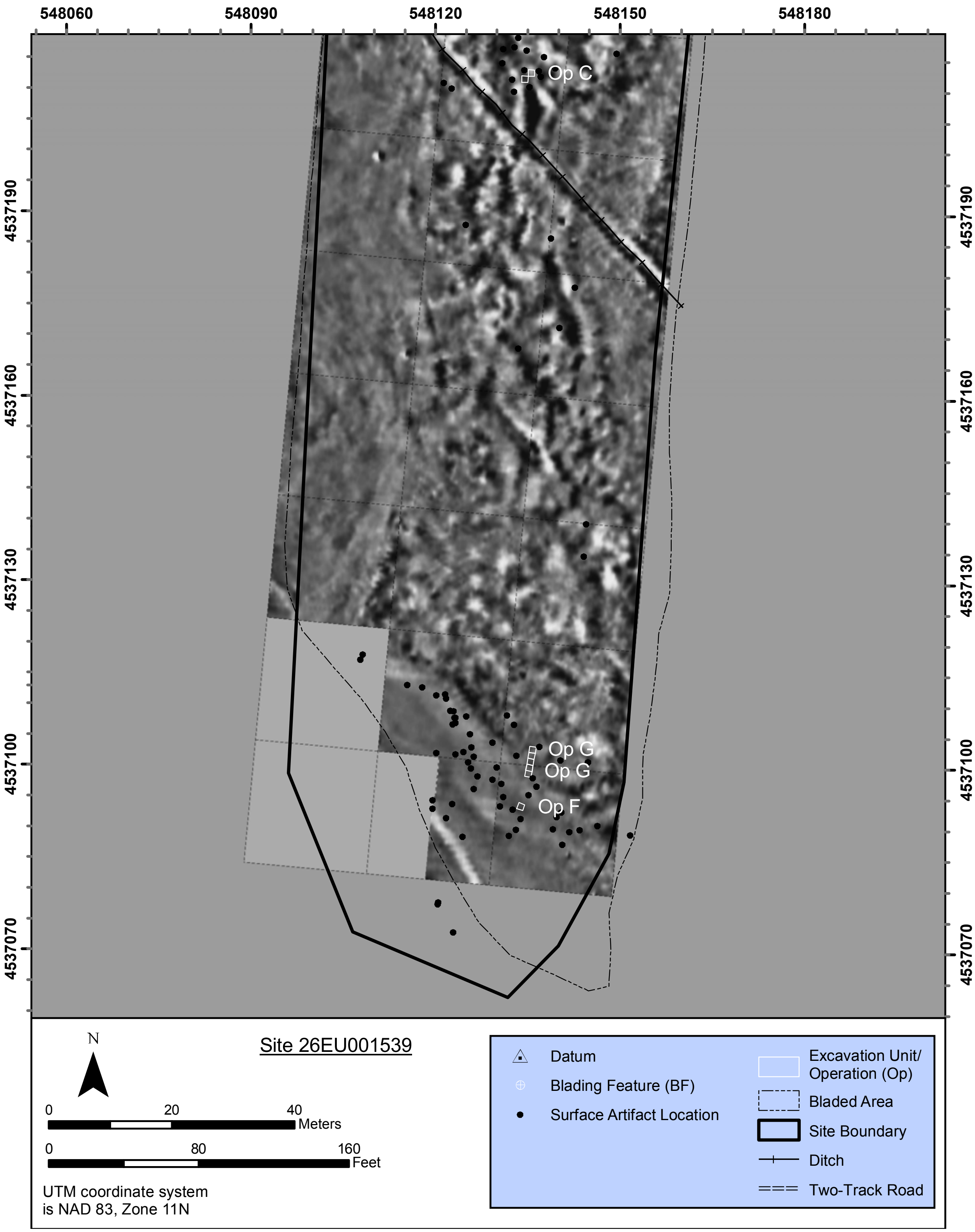

Figure 27. Magnetometer data from the southern portion of 26EU1539.

26EU1548

The southern portion of 26EU1548 is bisected by a road and a ditch along the southern edge of the road, both of which are clear in the magnetometer data from this site, as is the metal rebar installed as a site datum, which lies just to the northwest of Operation C (Figure 28). The shallow channel that runs from northwest to southeast across the middle of the site, in which surface artifacts were abundant, is also visible. In addition, there is a feature that corresponds to an alluvial terrace edge that runs from north to south in the eastern portion of the site; however, in contrast to the situation at 26EU1539, the alluvial channel deposits at 26EU1548 (located in the eastern part of the site) are more magnetically active than are the terrace deposits. These features aside, the entire site area, as well as the area to the west of the site that was also included in the geophysical surveys, is characterized by enhanced magnetic activity similar to that observed on the alluvial terrace at 26EU1539 and in portions of 26EU1533. Operations A, B, and C at this site targeted small magnetic highs similar to those targeted by Operation A at 26EU1533 and Operation B at 26EU1539. As at those sites, it was thought that these magnetometer anomalies might reflect small thermal features, and they were considered to be representative of a large number of similar small magnetic highs at the site. Operation E at this site, though intended to explore a conductivity anomaly, by chance also encompassed a small magnetic low similar to those investigated in Operation B at 26EU1533 and in Operations C and D at 26EU1539.

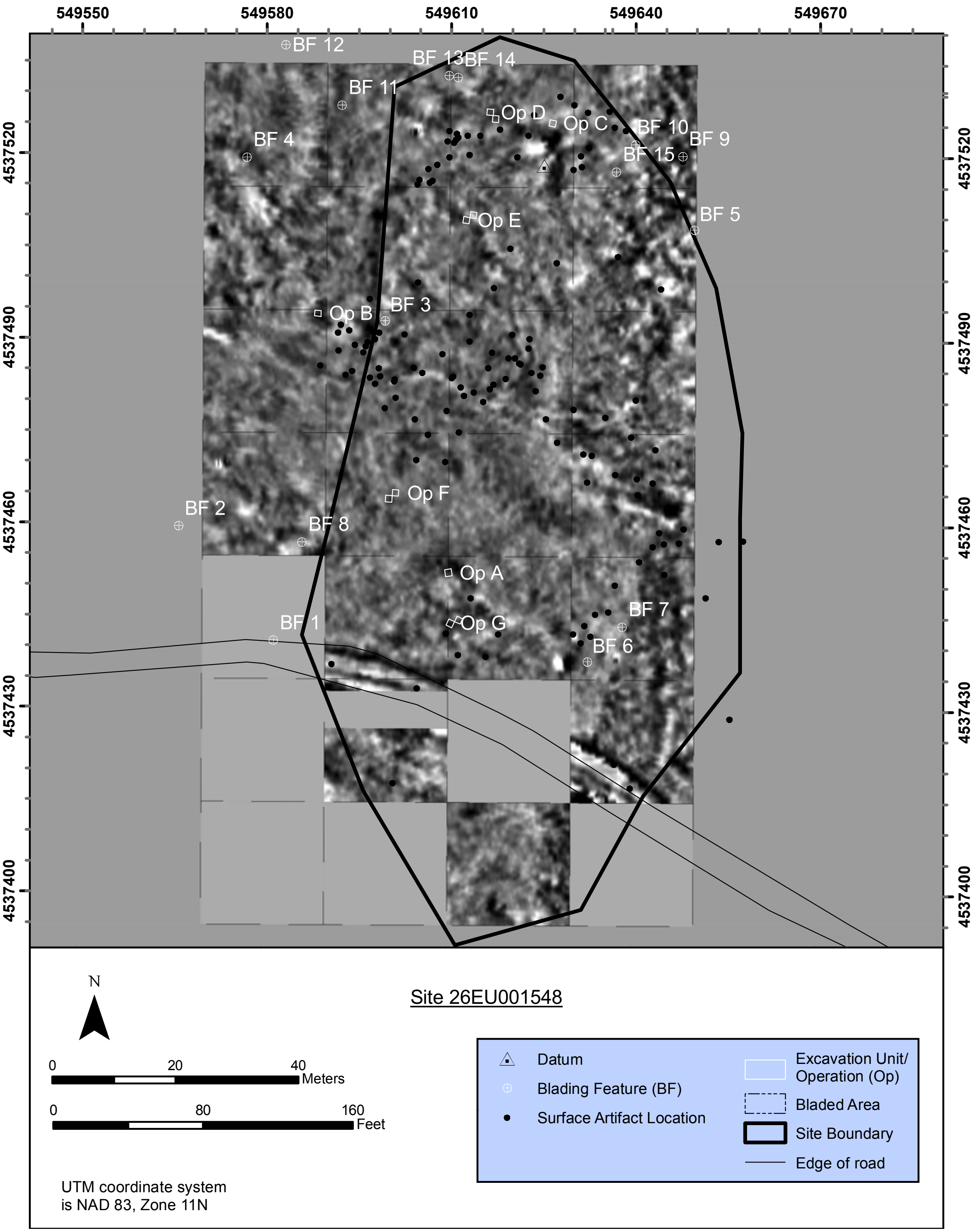

Figure 28. Magnetometer data from 26EU1548.

26EU2064

There are features in the magnetometry data from 26EU2064 that correspond to roads, an aerial photo marker staked down by metal nails (the large feature to the southwest of Operation I), and various other pieces of metal, including rebar survey markers (Figure 29). There are also bands of enhanced magnetic activity that run parallel to the long axis of the site landform, one of which falls within the deep drainage that runs through the northeastern portion of the site. Operations A through G at this site were all tests of small magnetic highs similar to those tested at the sites discussed above. Operation A was placed within a band of enhanced magnetism in the southwestern part of the site, Operations B through F were placed on either side of the large band of enhanced magnetism that runs through the center of the site, and Operation G was placed over an isolated anomaly east of this central band. Operation E was not only placed at the location of a small magnetic high, but it also fell within a larger circular feature in the magnetometer data, approximately 5 m in diameter, that is similar to the feature that was the focus of Operation A at 26EU1539. The presence of this larger feature around the small magnetic high was an additional reason for choosing to excavate here, as it was again thought that the larger magnetic feature was consistent with the signature of a pit structure; however, no evidence of such a structure was found.

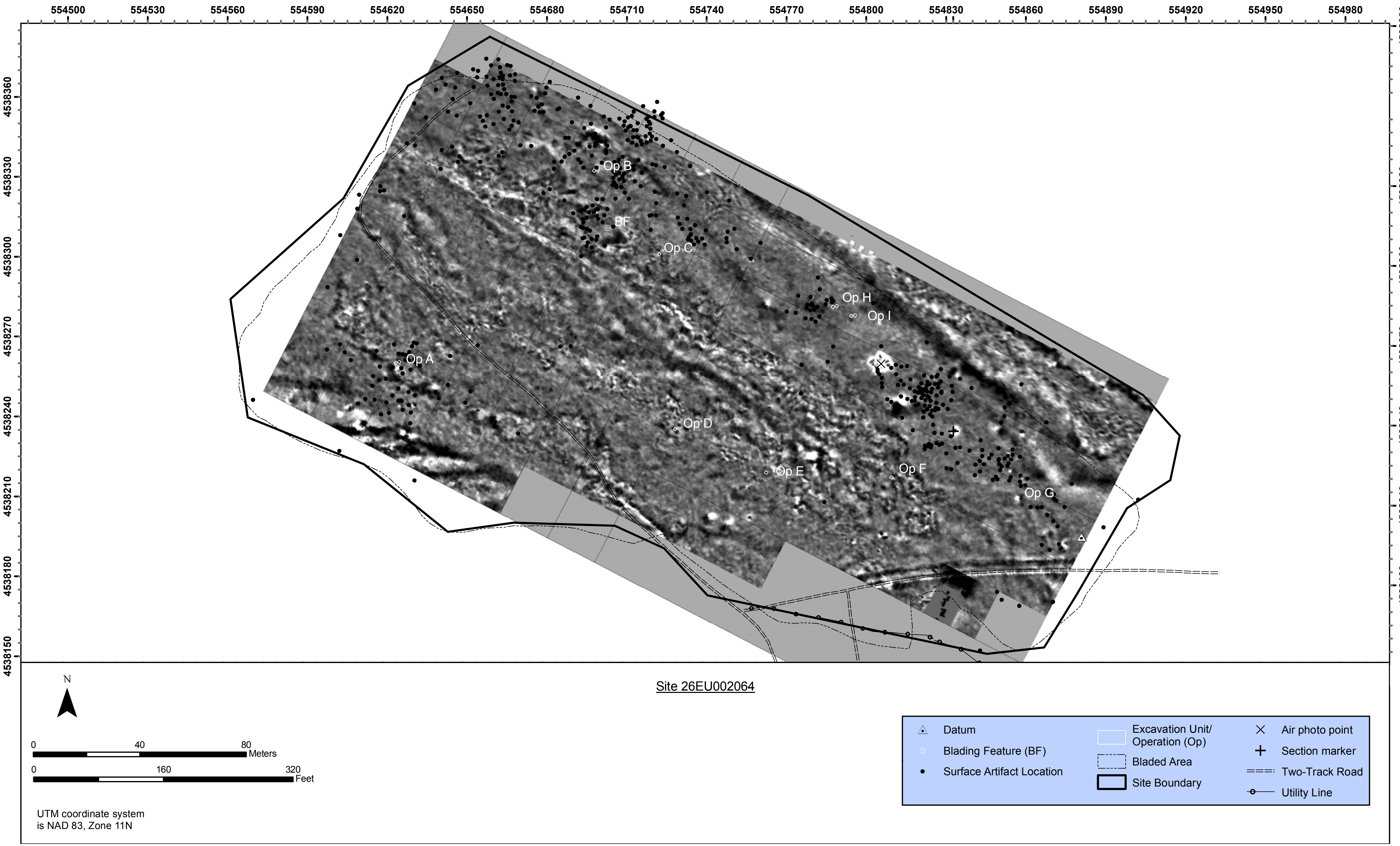

Figure 29. Magnetometer data from 26EU2064.

26EU2126

The metal de-watering pipeline that runs parallel to the northwestern boundary of 26EU2126 overwhelms the magnetometer data from within about 15 m of it (Figure 30). In addition, a modern debris pile in the southwestern part of the site, which apparently consists of highly magnetic material, creates a large circular feature in the magnetometer data approximately 15 m in diameter. Of the remainder of the site area, the central portion is characterized by enhanced magnetic activity. Two small magnetic highs, one outside of the central area of enhanced magnetic activity and one within it, were the targets of excavation for Operations A and B at this site, respectively. In addition, Operation I, though placed as part of the line of systematic units between Operations C and F, fell at the location of a similar small magnetic high that was selected as a possible target for excavation at the initial excavation planning meeting during which excavation locations were chosen based on the magnetometer data. As at the other sites where small magnetic highs were selected for excavation, it was thought that those targeted at 26EU2126 might reflect small thermal features, and they were considered to be a representative sample of a large number of such magnetic anomalies. The southeast corner of Operation F, though not specifically excavated for this reason, encompassed a small magnetic low similar to those investigated in Operation B at 26EU1533, Operations C and D at 26EU1539, and Operation E at 26EU1548.

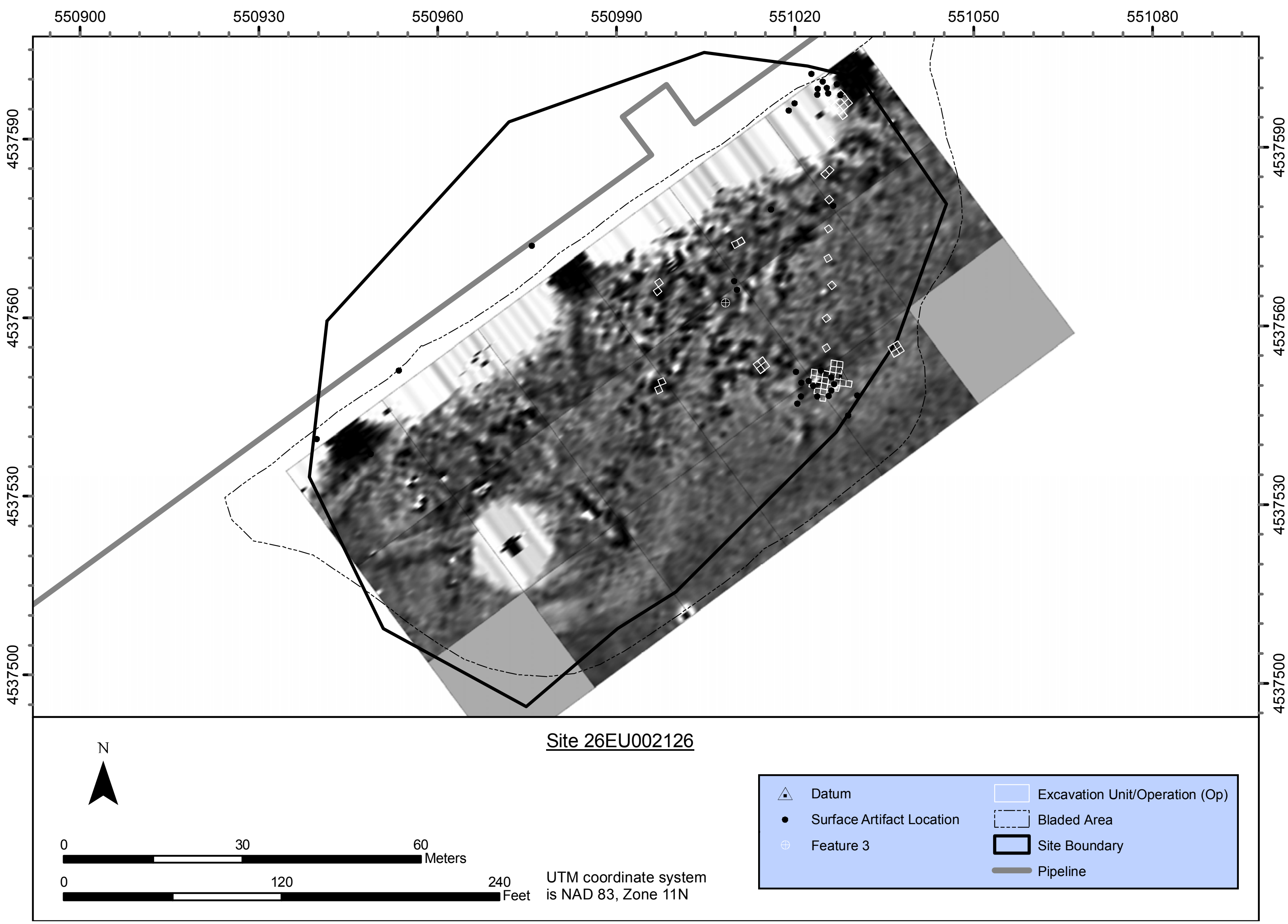

Figure 30. Magnetometer data from 26EU2126.

SUMMARY OF EXCAVATED MAGNETOMETER ANOMALIES

During the 2007 BGMI Data Recovery Project, the location of sixteen excavation areas was determined based solely on magnetometer data. In addition, the location of Operation I at 26EU2126, though placed where it was primarily for a different reason, was adjusted slightly to test a magnetic anomaly identified early in the project as a possible target for excavation. Four other excavation areas at three sites by chance encompassed magnetic anomalies similar to ones that were specifically targeted for excavation. Table 20 lists these 21 excavation areas in which magnetometer anomalies were explored and the type of anomaly investigated in each.

Of the magnetometer anomalies explored in these 21 excavation areas, 15 were small areas of high magnetism, approximately 1 m in diameter. It was initially thought that anomalies of this type might reflect thermal features, and those targeted for excavation were considered to be just samples of the very large number of such anomalies observed at each of the sites involved in the project. However, after excavating 15 of them, across five different sites located in different geomorphic settings, no archaeological features were found associated with any anomalies of this type. Thus, it seems clear that the small magnetic high type of anomaly is not a reliable geophysical signature of thermal features in the LBBA, at least on its own. Although any hearth feature present at a site might appear as a small magnetic high in magnetometer data, such anomalies can clearly be caused by other factors, and perhaps by numerous other factors.

Five excavation areas were placed, intentionally or not, over small areas of low rather than high magnetism. As was the case with small magnetic highs, no archaeological features were associated with the small magnetic lows, and though the excavated sample is much smaller than is the case for the small magnetic highs, it seems safe to conclude that small magnetic lows are likewise not a reliable geophysical signature of archaeological features.

The final type of magnetometer anomaly selected for excavation were large circular features. Such a feature was the focus of Operation A at 26EU1539, and the small magnetic high targeted by Operation E at 26EU2064 fell within a similar feature. It was thought that these features in the magnetometer data might reflect pit structures, at least a few examples of which are known from the greater LBBA region (Reust et al. 1994; Smith and Reust 1995). The magnetic feature at 26EU1539 clearly did correspond to a shallow depression visible on the surface of the site, but, as discussed in Chapter 3, the most likely explanation for this depression is that it is a cattle wallow rather than a pit structure depression. Likewise, no evidence of a structure was found in Operation E at 26EU2064. Thus, whereas magnetometer data from the LBBA should certainly be examined with the possibility of finding pit structures in mind, the fact that other phenomena can produce "pit structure–like" signatures in such data should also be taken into account.

In sum, the magnetometer anomalies that were targeted in excavation did not reflect archaeological features, even though they were consistent with the magnetic signatures that the archaeological features of interest were expected to have. Thus, the main lesson to be learned from the magnetometer surveys conducted during the 2007 BGMI project is that "false positives" are likely to be common, and that the sources of such false positives, which are most likely geological, must be identified before magnetometry can be of greater archaeological use in the area. This issue is addressed further in Section 4.4, after the conductivity and magnetic susceptibility data from the project are discussed.

Table 20. Magnetometer Anomaly Types by Excavation Area

Site	Excavation Area	Magnetometer Anomaly Type
26EU1533	Operation A	small magnetic high
26EU1533	Operation B	small magnetic low
26EU1539	Operation A	5-m diameter circular feature
26EU1539	Operation B	small magnetic high
26EU1539	Operation C	small magnetic low
26EU1539	Operation D	small magnetic low
26EU1548	Operation A	small magnetic high
26EU1548	Operation B	small magnetic high
26EU1548	Operation C	small magnetic high
26EU1548	Operation E	small magnetic low
26EU2064	Operation A	small magnetic high
26EU2064	Operation B	small magnetic high
26EU2064	Operation C	small magnetic high
26EU2064	Operation D	small magnetic high
26EU2064	Operation E	small magnetic high within 5-m diameter circular feature
26EU2064	Operation F	small magnetic high
26EU2064	Operation G	small magnetic high
26EU2126	Operation A	small magnetic high
26EU2126	Operation B	small magnetic high
26EU2126	Operation F (SE corner)	small magnetic low
26EU2126	Operation I	small magnetic high

4.3.2. CONDUCTIVITY

As is the case with the magnetometer data, the sites investigated during the 2007 BGMI Data Recovery Project exhibit considerable variability in sediment conductivity; however, this variability is less obviously associated with modern disturbances than is the case for the magnetometer data. Based on the results of this project, conductivity survey may hold somewhat more promise for archaeological investigations in the LBBA than magnetometry, because an archaeological feature was found in one high-conductivity area that was explored (though this was a different type of feature than what was expected to be associated with areas of high conductivity). Nonetheless, numerous false positives also occurred with the conductivity data, and, as with magnetometry, the causes of such false positives must be identified before conductivity survey can be more useful.

26EU1533

Sediments in the far northern portion of 26EU1533, far from the locations of surface artifact concentrations, are highly conductive (Figure 31). Across the rest of the site, variability in conductivity is more subtle, with the exception of two small areas of very high conductivity. On the premise that occupation surfaces or activity areas should exhibit relatively high conductivity, these areas were targeted in Operations C and D at this site, while Operation E explored a more subtle area of high conductivity located within an area of high surface artifact density. Though not specifically placed where it was for this reason, Operation A also fell within a subtle area of high conductivity.

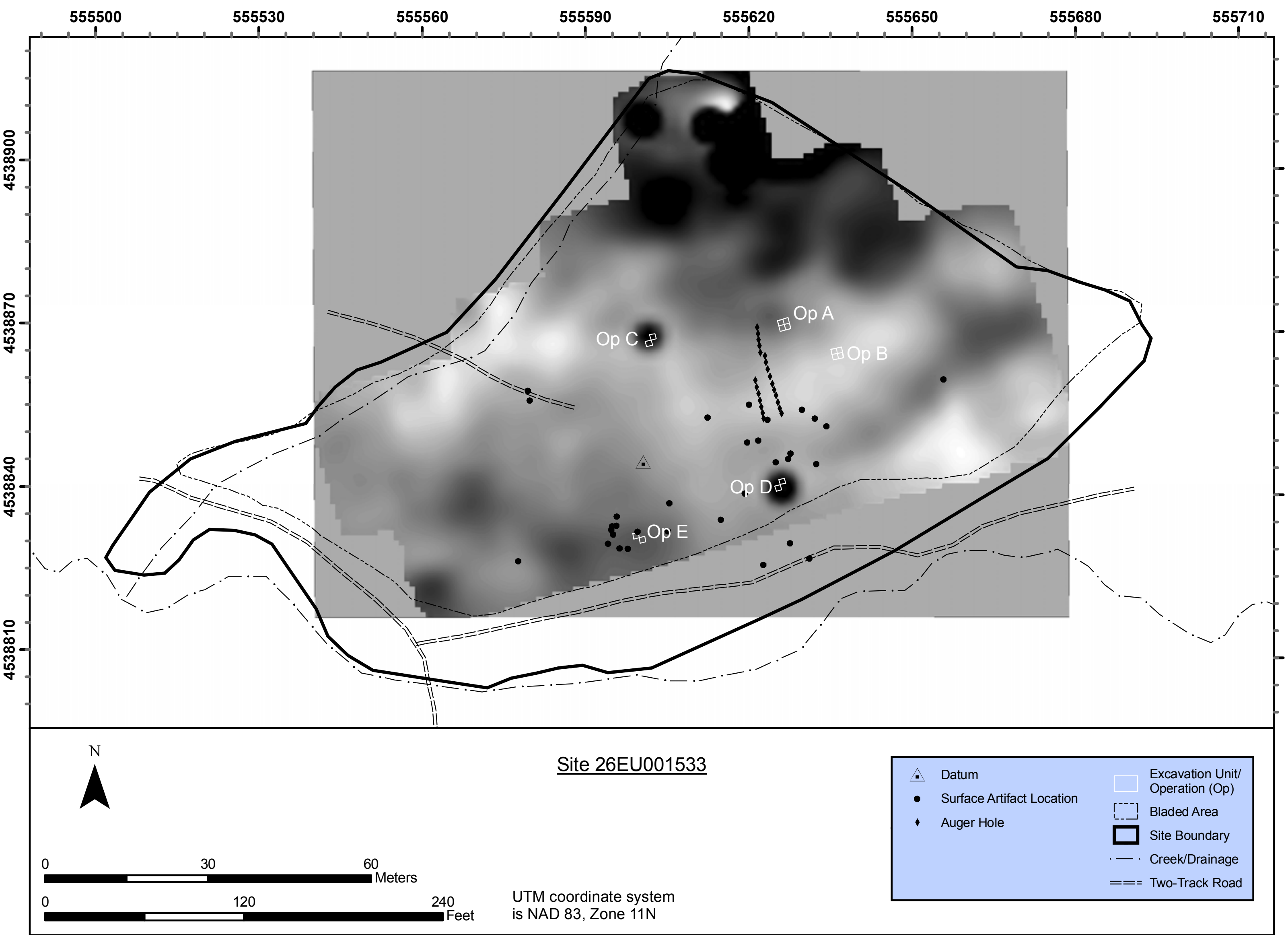

Figure 31. Conductivity data from 26EU1533.

26EU1539

The road and the ditch that cross 26EU1539 are faintly visible in the conductivity data from this site, as is the edge of the alluvial terrace (Figure 32, Figure 33). On top of the terrace, there are many areas of moderate to strong high conductivity. Two of these were specifically targeted for excavation and were the focus of Operations C and D at this site. The areas explored by these operations were chosen out of all other similar high-conductivity anomalies because they were located within areas of high surface artifact density. Operations A, B, and E at this site, though placed where they were primarily due to other reasons, also happened to fall within areas of high conductivity. Operation A was located in a large area of very high conductivity, while the other excavation areas were placed in areas of slightly lower conductivity.

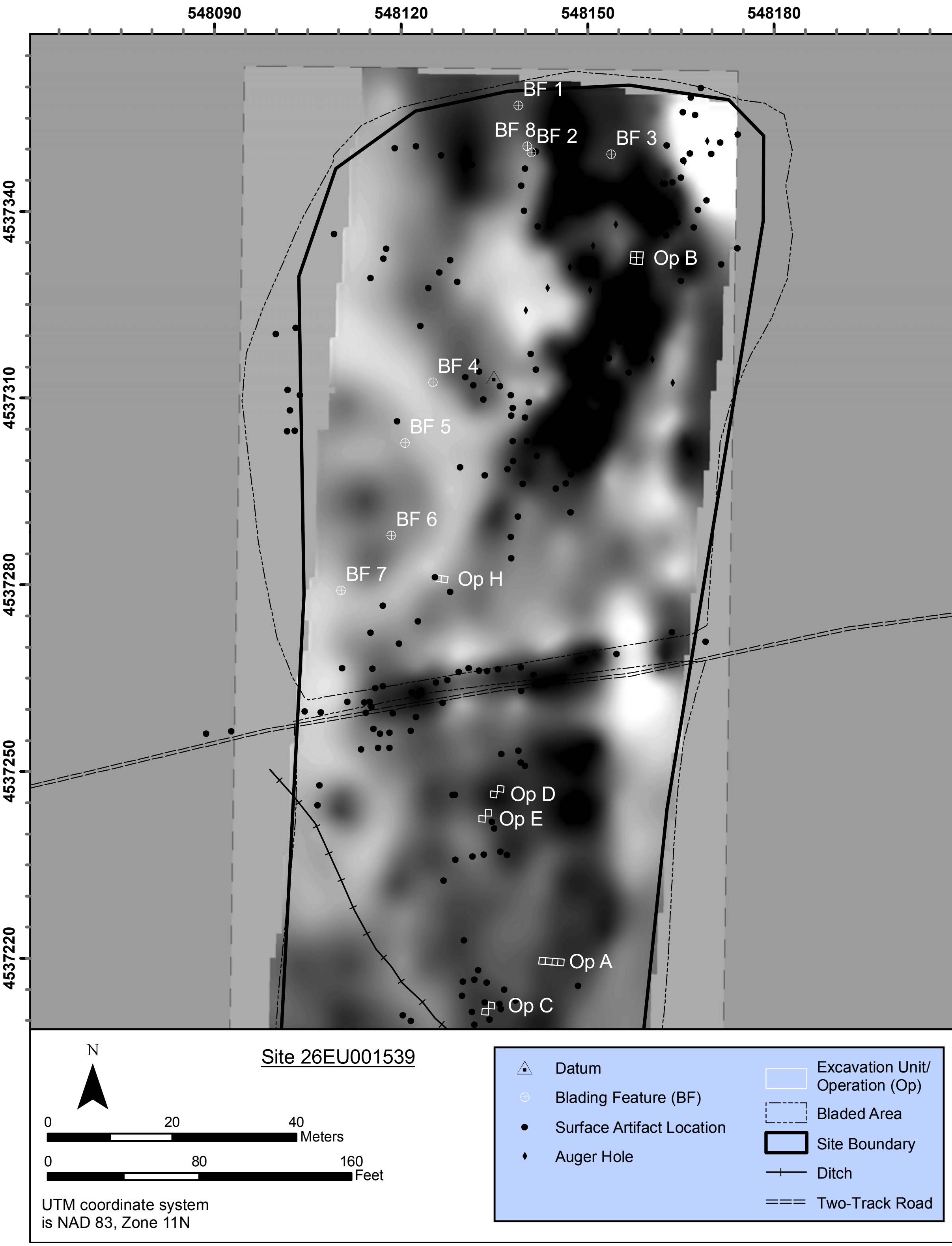

Figure 32. Conductivity data from the northern portion of 26EU1539.

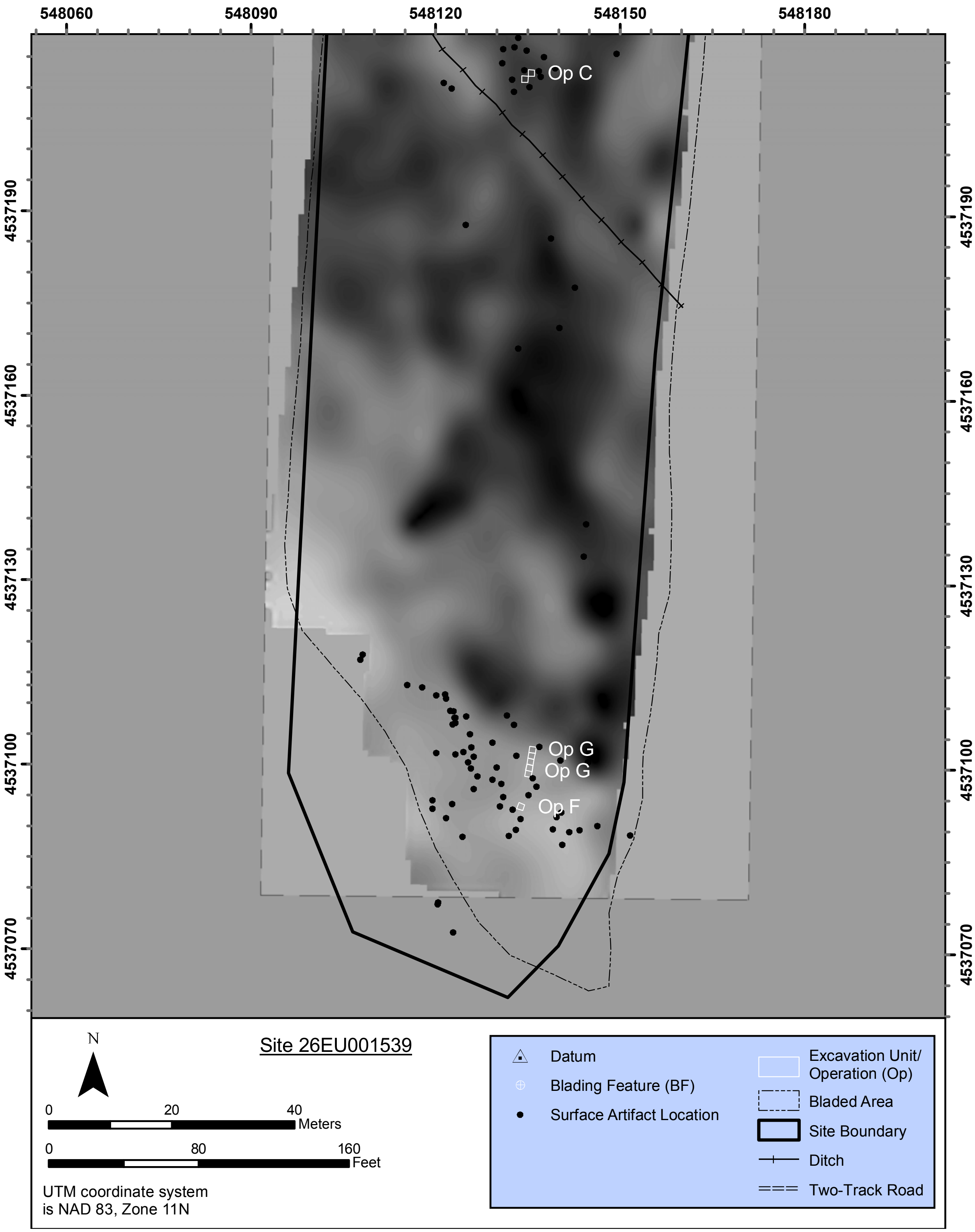

Figure 33. Conductivity data from the northern portion of 26EU1539.

26EU1548

As at 26EU1539, an alluvial terrace edge is apparent in the conductivity data from 26EU1548. Unlike the situation at 26EU1539, however, the terrace deposits at 26EU1548 are less conductive than the alluvial channel deposits at this site (Figure 34). On the terrace, there are both strong and more subtle areas of high conductivity. Operations D, E, and F at this site were placed within a sample of the more subtle anomalies, and Operation D was also located near a surface artifact concentration. Though placed specifically as a test of a magnetometer anomaly, Operation A at this site also fell within another subtle area of high conductivity.

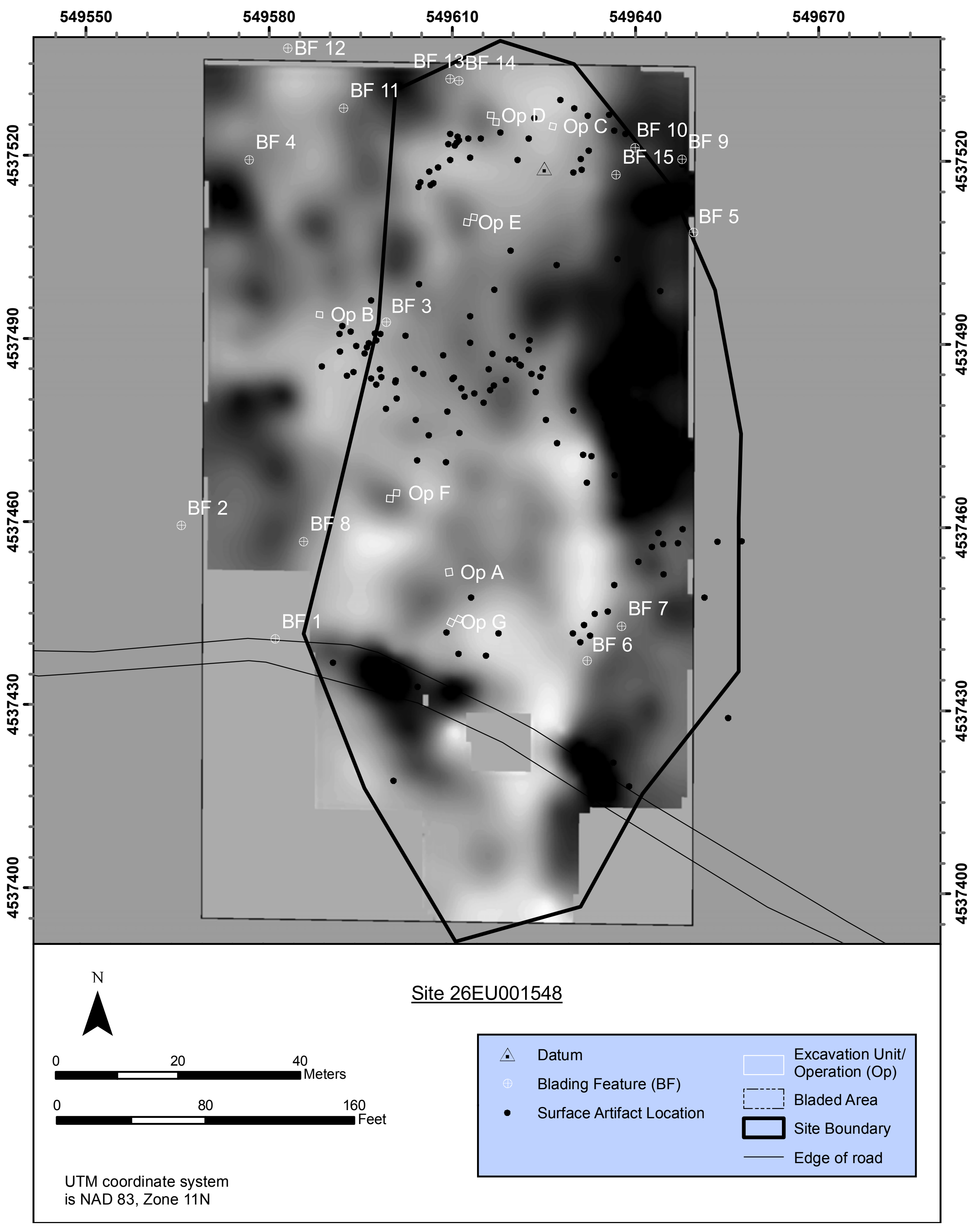

Figure 34. Conductivity data from 26EU1548.

26EU2064

Striking variability in sediment conductivity is present at 26EU2064 (Figure 35). The deep drainage in the northeastern portion of this site is characterized by very low conductivity. In the central and southwestern portions of the site, there are bands of very high conductivity that appear to correlate with areas of magnetic enhancement that are evident in the magnetometer data. The two track roads on the site are faintly visible in the conductivity data, and there is also an odd, grid-like pattern of strong dipolar anomalies (also visible in the magnetic susceptibility data, discussed below) of unknown cause. The surface at the location of each of these anomalies was visually inspected, and nothing obvious was observed, but it is assumed that the source of these anomalies is related to mining exploration activities such as seismic survey. Only one conductivity anomaly was specifically targeted for excavation at 26EU2064: the isolated area of very high conductivity that was investigated by Operation I. Though primarily intended to explore magnetometer anomalies, Operations A and F at this site fell within larger areas of very high conductivity, and the rest of the operations at this site fell within more subtle areas of high conductivity.

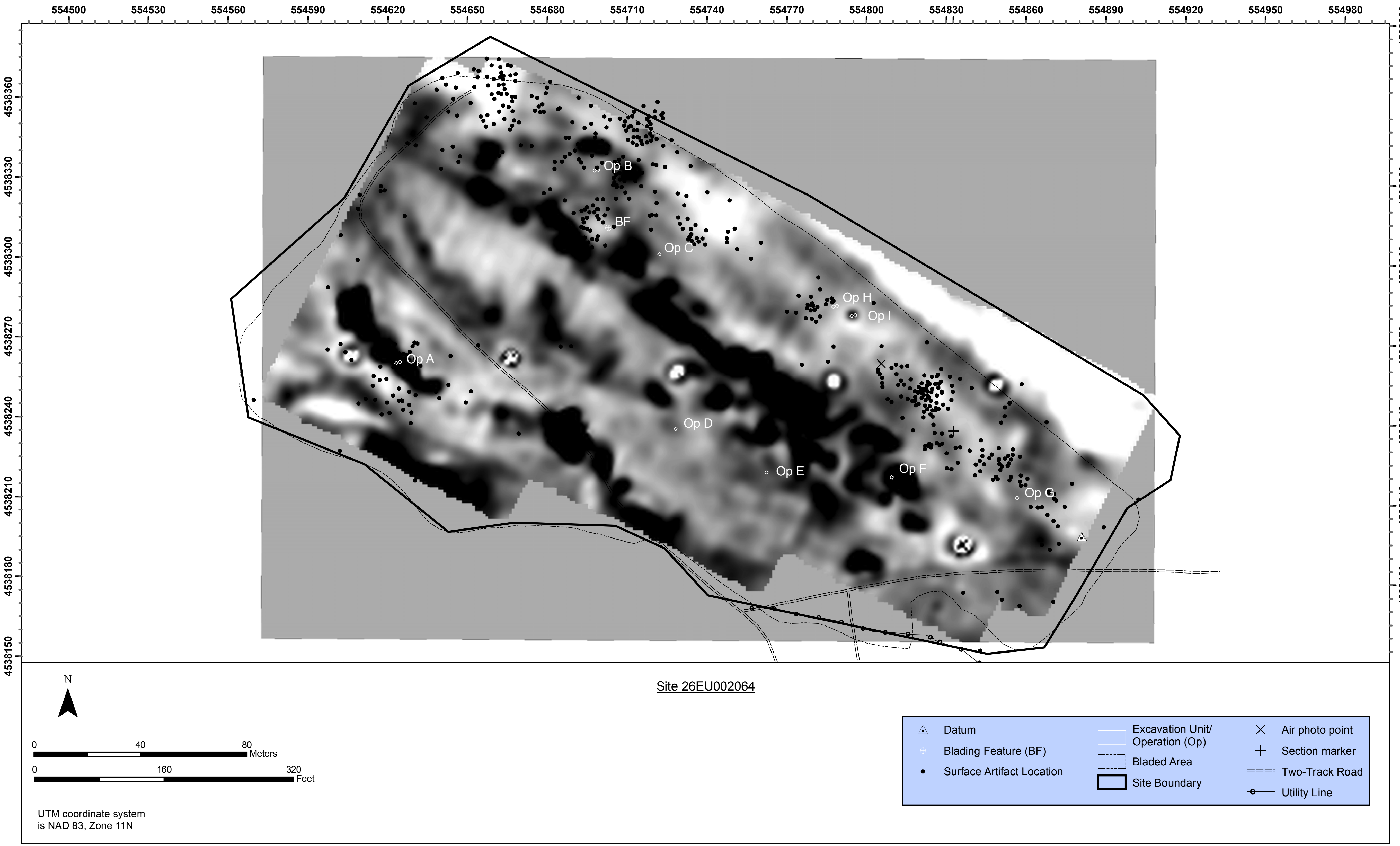

Figure 35. Conductivity data from 26EU2064.

26EU2126

The conductivity data from 26EU2126 do not appear to show systematic effects from either the pipeline or the modern debris piles present at this site (Figure 36). Several small circular areas of very high conductivity are visible in the southwestern half of the site, and one of these was the focus of Operation E. This anomaly is very similar to the strong, localized anomalies investigated by Operations C and D at 26EU1533 and by Operation I at 26EU2064. The northeastern half of 26EU2126 is characterized by more subtle variability in conductivity. Two large areas of moderately high conductivity in this part of the site were explored by Operations C and D; Operation C was also placed where it was in part because one of the surface artifact concentrations at the site was located here. Feature 1 from this site, the FCR concentration found in Operation C, was the only archaeological feature discovered in excavations that specifically focused on conductivity anomalies (or on geophysical anomalies of any sort, for that matter). However, the nature of this feature was somewhat unexpected: large areas of high conductivity were hypothesized to reflect occupational surfaces, which might be recognized by midden deposits and/or high subsurface artifact densities, whereas FCR features were expected to be more likely to appear in magnetometer data than in conductivity data. Nevertheless, since isolated pieces of FCR were scattered throughout the Operation C deposits, it is possible that diffuse FCR scatters do have a conductivity signature. Another large area of relatively high conductivity is present at this site stretching from Operation F to Operation B, and given the abundance of archaeological material found in Operation F, it might be tempting to conclude that this large conductivity anomaly reflects midden deposits associated with the occupation discovered in this operation. As noted in Chapter 3, however, artifact density dropped sharply in the westernmost units of Operation F, those closest to the center of the conductivity anomaly, and ashy, midden-like sediments were most obvious in the eastern half of Operation F rather than the western half. Thus, there is no clear association here between obvious midden deposits and areas with the highest conductivity. Of the remaining excavation areas at this site, Operations A, G, and N, like Operations B and F, were coincidentally placed in areas of moderately high conductivity.

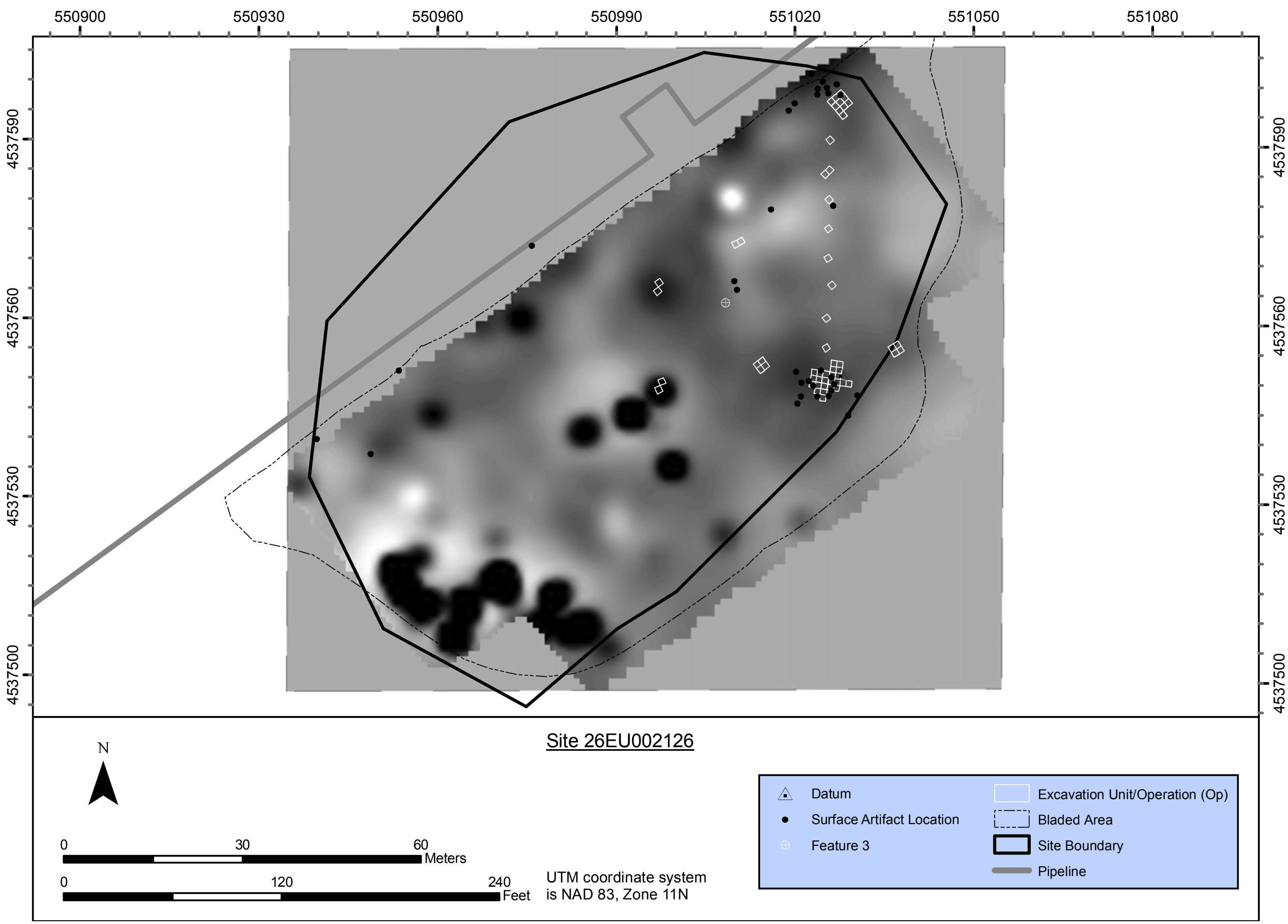

Figure 36. Conductivity data from 26EU2126.

SUMMARY OF EXCAVATED CONDUCTIVITY ANOMALIES

During the 2007 BGMI Data Recovery Project, 12 excavation areas were opened specifically to investigate areas of high sediment conductivity, which were expected to reflect prehistoric occupational surfaces. The locations of an additional 18 excavation areas were chosen for other reasons, but were coincidentally located within areas of high conductivity. Table 21 lists these 30 excavation areas that explored conductivity anomalies, and the type of anomaly investigated in each.

For the project as a whole, 23 excavation areas, ranging in size from 1 to 24 m^2, were placed within areas of moderately high sediment conductivity. At 26EU2126, an archaeological feature, specifically an FCR concentration surrounded by a more diffuse FCR scatter (Feature 1), was found in one of these excavation areas, Operation C. This suggests that FCR scatters may be reflected by a high conductivity signature, but it is also possible that the association between this feature and an area of high conductivity is just coincidental. Feature 3 at 26EU2126, another FCR concentration very similar to Feature 1, was not located in an area of high conductivity (Figure 36), and the fact that so many areas of high conductivity were excavated without finding any features or signs of occupational surfaces suggests that sediment conductivity at sites in the LBBA is primarily a function of non-archaeological phenomena.

An additional four excavation areas were placed within small areas of very high conductivity. This type of conductivity anomaly—isolated, almost perfectly circular, and approximately 10–15 m in diameter—was observed at three of the sites involved in the project. No archaeological features were found associated with anomalies of this type, and no modern disturbances or consistent sedimentological characteristics were observed that might account for them. Given their discrete size and shape, as well as the fact that identical anomalies are present in the same places in the magnetic susceptibility data from 26EU2126 (see below), it is possible that these features in the conductivity data are artifacts of data collection or were caused by atmospheric phenomena.

Finally, three excavation areas were placed within larger areas of very high conductivity; these are Operation B at 26EU1539 and Operations A and F at 26EU2064. Archaeological remains were very rare in the excavation units in these operations, and in hindsight it now seems clear that the large areas of high conductivity that they targeted reflect geological phenomena. The area of high conductivity that was investigated by Operation B at 26EU1539 corresponds to the location of the shallow channel that crosses that part of the site. The large areas of high conductivity at 26EU2064 correspond to the bands of enhanced magnetic activity that cross the site, and it seems likely that the same, as yet unknown, geological phenomenon is responsible for the large-scale patterns in the magnetometry and the conductivity data from this site.

Table 21. Conductivity Anomaly Types by Excavation Area

Site	Excavation Area	Conductivity Anomaly Type
26EU1533	Operation A	moderate high
26EU1533	Operation C	small strong high
26EU1533	Operation D	small strong high
26EU1533	Operation E	moderate high
26EU1539	Operation A	moderate high
26EU1539	Operation B	large strong high
26EU1539	Operation C	moderate high
26EU1539	Operation D	moderate high
26EU1539	Operation E	moderate high
26EU1548	Operation A	moderate high
26EU1548	Operation D	moderate high
26EU1548	Operation E	moderate high
26EU1548	Operation F	moderate high
26EU2064	Operation A	large strong high
26EU2064	Operation B	moderate high
26EU2064	Operation C	moderate high
26EU2064	Operation D	moderate high
26EU2064	Operation E	moderate high
26EU2064	Operation F	large strong high
26EU2064	Operation G	moderate high
26EU2064	Operation H	moderate high
26EU2064	Operation I	small strong high
26EU2126	Operation A	moderate high
26EU2126	Operation B	moderate high
26EU2126	Operation C	moderate high
26EU2126	Operation D	moderate high
26EU2126	Operation E	small strong high
26EU2126	Operation F	moderate high
26EU2126	Operation G	moderate high
26EU2126	Operation N	moderate high

4.3.3. MAGNETIC SUSCEPTIBILITY

As noted previously, magnetic susceptibility data were collected simultaneously with conductivity data using the same instrument, and it was hoped that areas of enhanced magnetic susceptibility would reflect prehistoric occupational surfaces. However, it turned out that the sediments at the sites involved in the project exhibited a very low degree of variability in magnetic susceptibility; often, all variability observed was within the range of the instrument's precision. Consequently, the magnetic susceptibility data proved to be of limited use, and no excavation units specifically targeted susceptibility anomalies. Magnetic susceptibility images for the five sites are shown in Figure 37 through Figure 41.

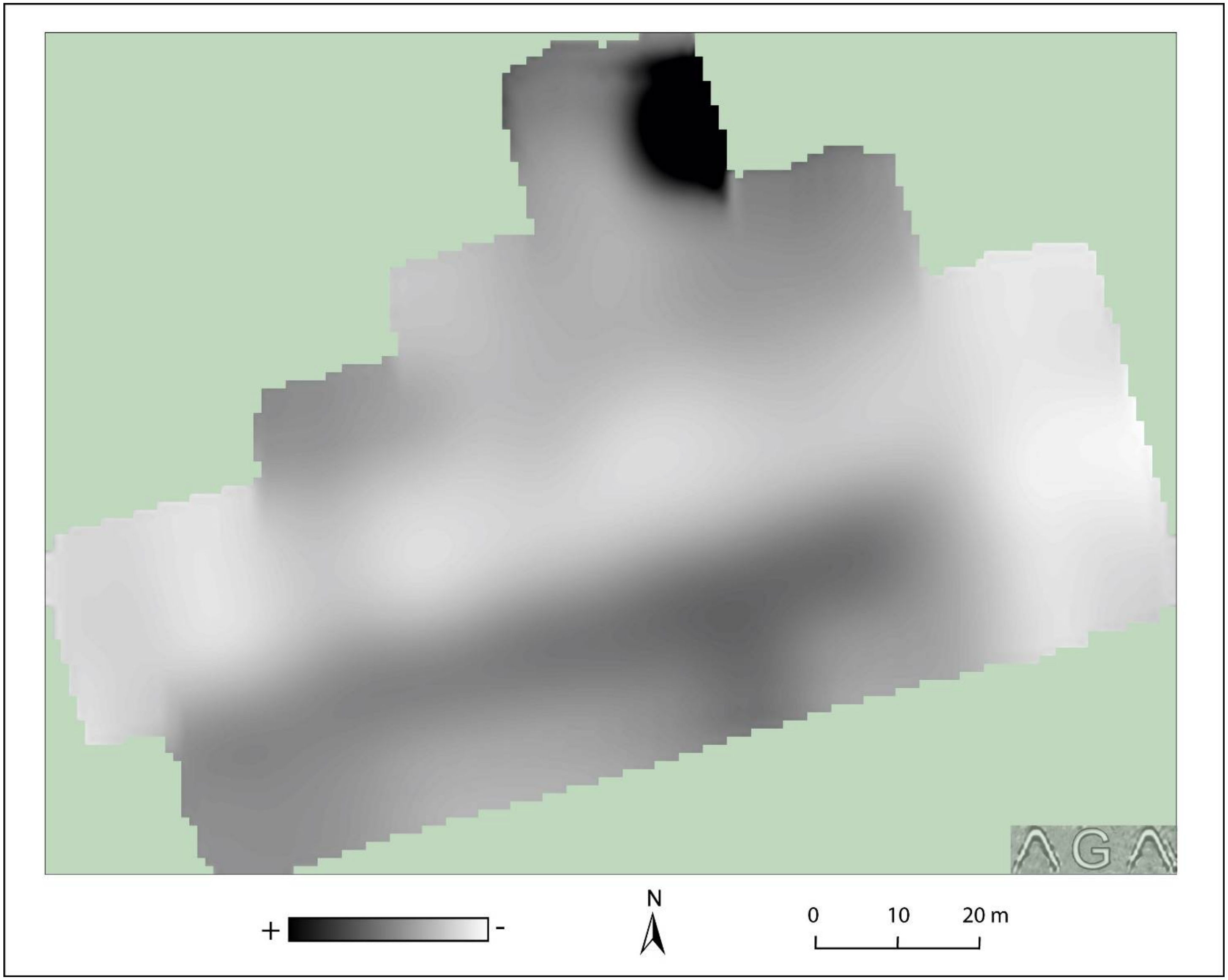

Figure 37. Magnetic susceptibility data from 26EU1533.

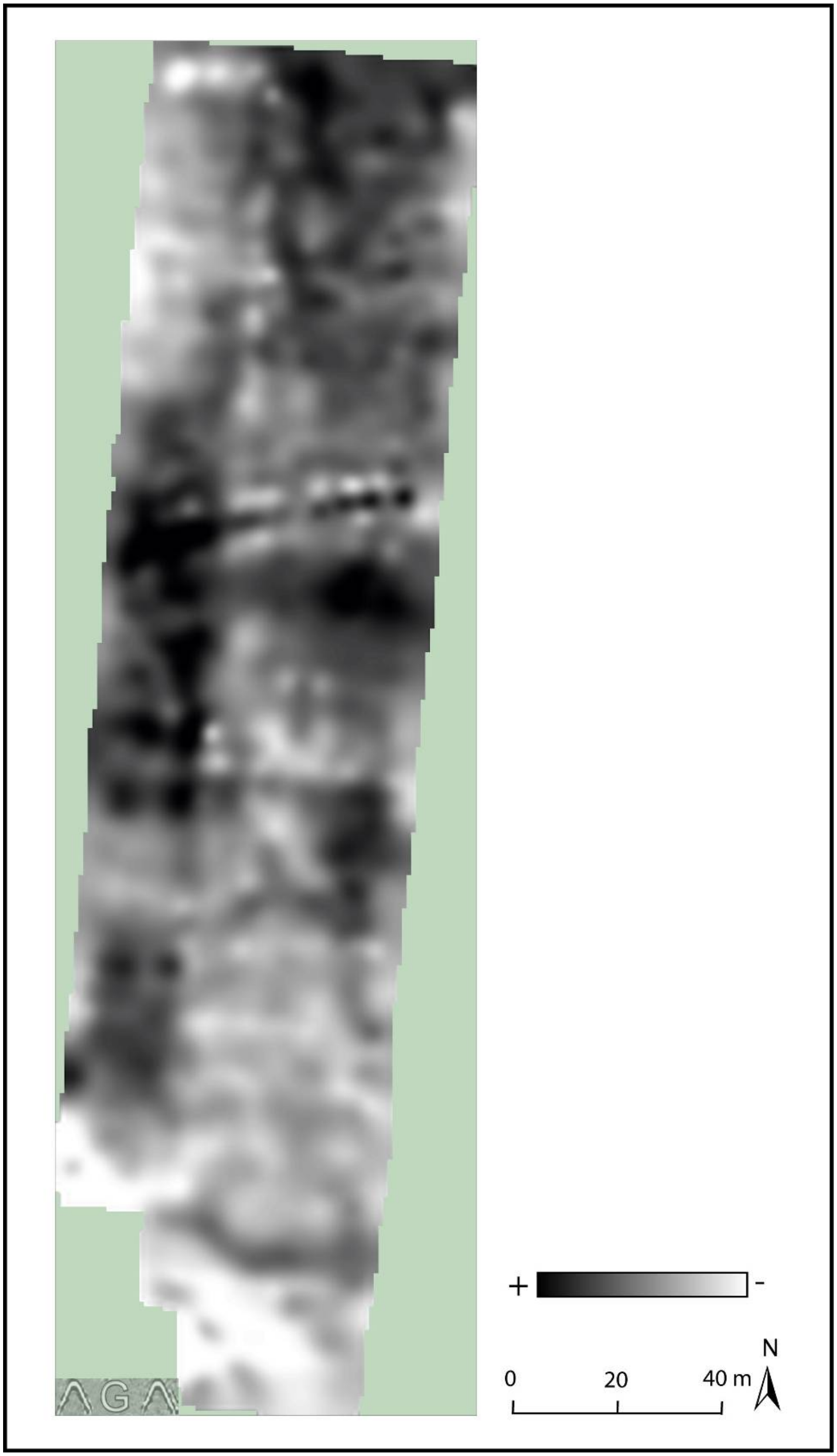

Figure 38. Magnetic susceptibility data from 26EU1539.

Figure 39. Magnetic susceptibility data from 26EU1548.

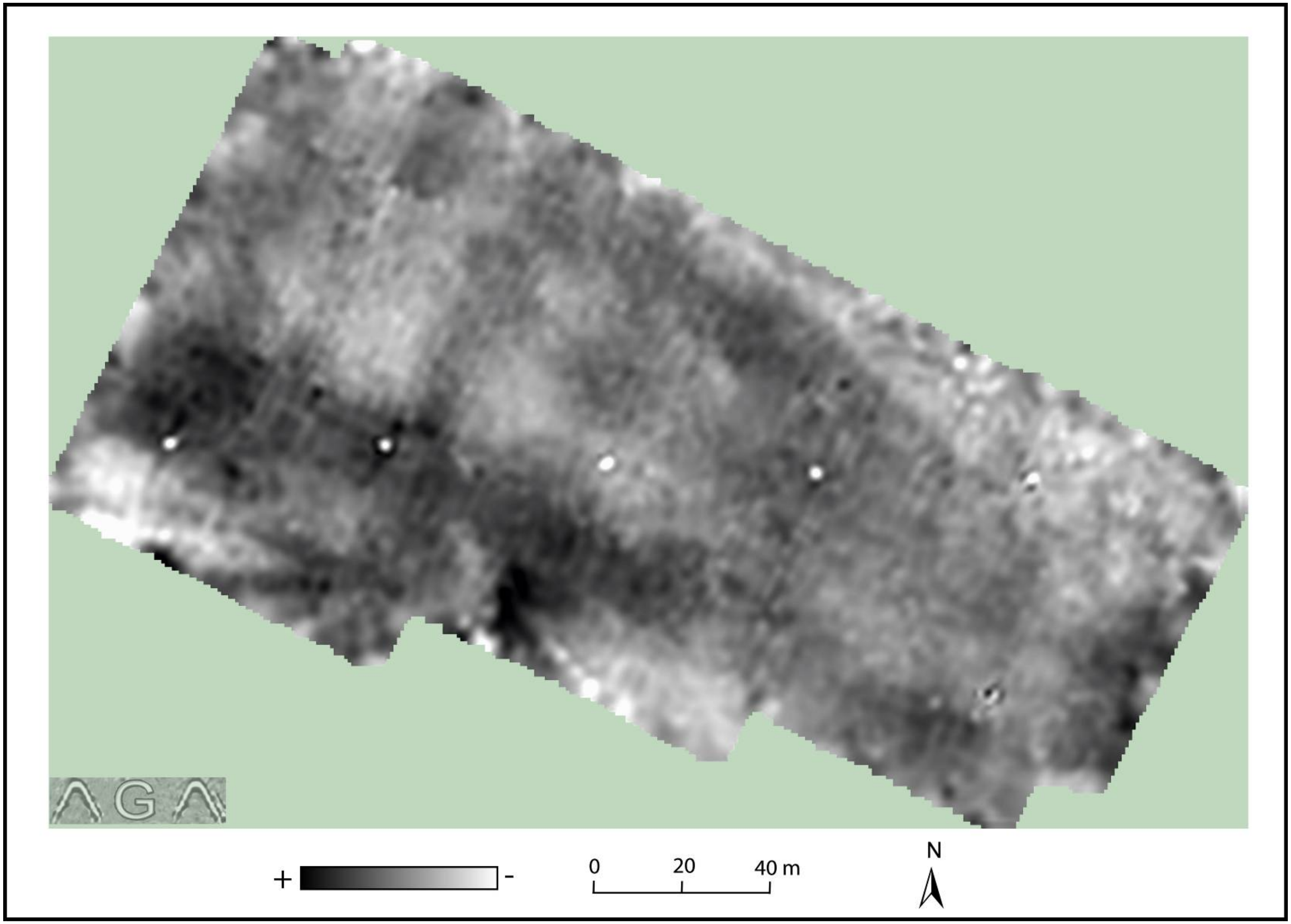

Figure 40. Magnetic susceptibility data from 26EU2064.

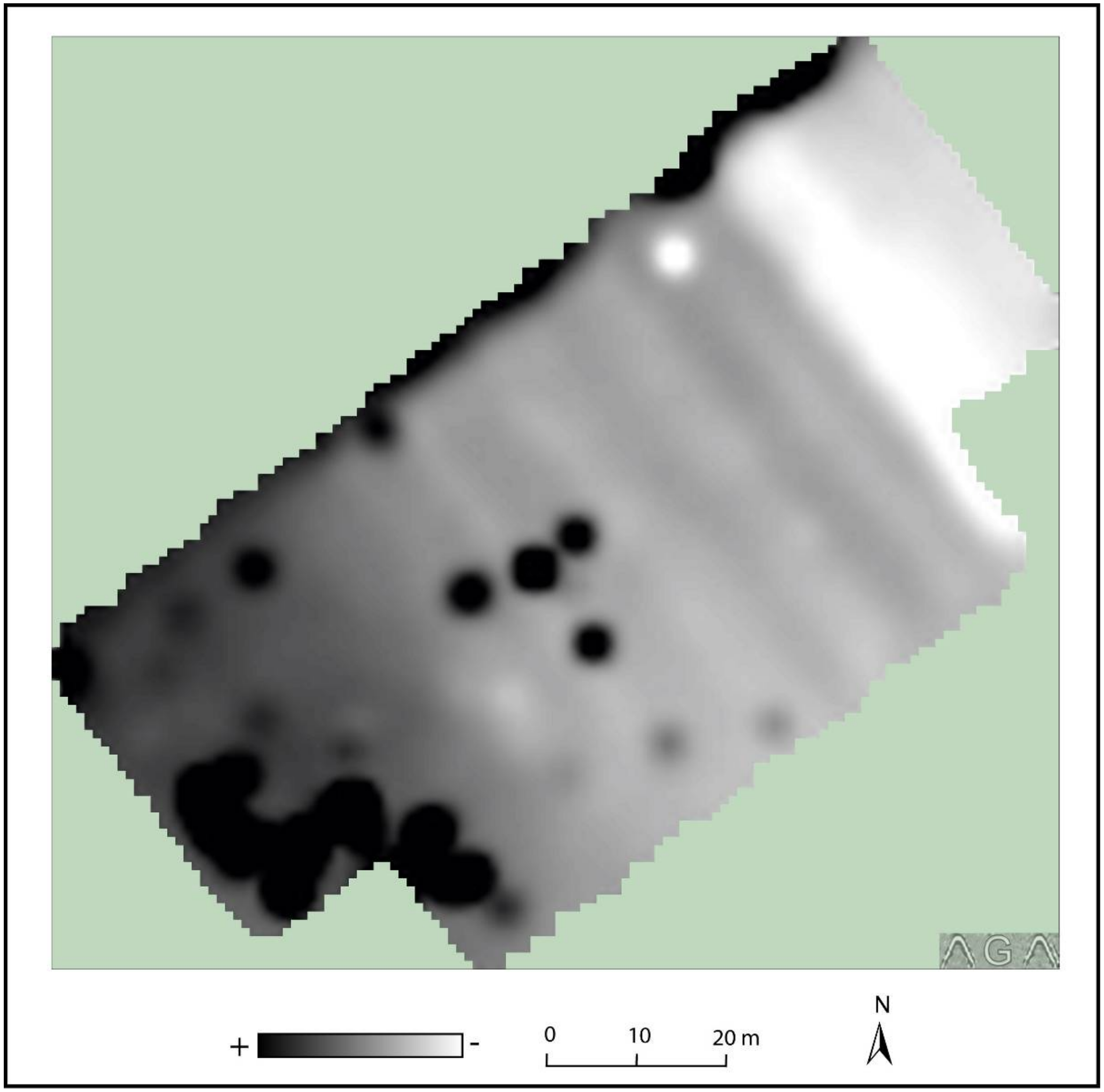

Figure 41. Magnetic susceptibility data from 26EU2126.

4.4. Evaluating Causes of Patterns in the Data

A total of 29 geophysical anomalies that were initially thought to be consistent with the signatures of archaeological features were targeted in excavation, and an additional 22 such anomalies were excavated in units that were not intended specifically to be tests of geophysical anomalies. Of these 51 anomaly locations, an archaeological feature was found in only one (Operation C at 26EU2126), and in that case the association between the archaeological feature and the geophysical anomaly may be coincidental. Moreover, as discussed below, the few archaeological features that were found in excavation and mechanical stripping displayed no consistent signature in the geophysical data. It thus appears that the complex patterning evident in the magnetometer and conductivity data collected from the sites involved in the 2007 BGMI project is primarily a function of geological, rather than archaeological, phenomena. Given this, it seems clear that steps must be taken to understand—and control for—the geological causes of patterning in geophysical data before such data can be of greater use in archaeological research and CRM in the LBBA. While detailed geological analyses of the sort that are required to fully address this issue were beyond the scope of the 2007 BGMI project, some preliminary steps were taken, and the results of those steps are presented in this section. These results follow a discussion of geophysical data at locations of known archaeological features.

4.4.1. Known Archaeological Features

Three clearly archaeological features were identified during the 2007 BGMI project, all from 26EU2126. These include Feature 1, an FCR concentration surrounded by a more diffuse scatter of FCR found in Operation C, Feature 2, an ash lens found in Operation F, and Feature 3, an FCR concentration found in blading that was similar to Feature 1. These known features provide the best available opportunity for determining what archaeological features at sites in the LBBA might look like in geophysical data.

Feature 1 was unfortunately located close to the pipeline that crosses the site, within the area in which the magnetometer data were swamped by the effects of the pipeline, but Feature 3 was located in an area of good magnetometer data. The location of this feature corresponds to a small magnetic high, similar to one of the many that were targeted for excavation during the project on the assumption that they reflected thermal features. The association of this feature with the small magnetic high is somewhat reassuring, as it suggests that thermal features with abundant FCR do have the magnetic signature that they were expected to have going into the project. However, a sample size of one is insufficient for determining whether features with FCR will consistently appear as small magnetic highs in magnetometer data from the LBBA; further test cases are necessary for evaluating this. Moreover, the major problem remains that the large majority of the numerous small magnetic highs that occur in magnetometer data from the LBBA clearly are not associated with archaeological features. Should further test cases demonstrate that archaeological features with FCR do consistently appear as small magnetic highs in magnetometer data, development of methods for dealing with the "false positives" issue will still be required before magnetometry can be of practical use for locating thermal features in the LBBA.

The location of Feature 2 corresponds to neither an area of exceptionally high or exceptionally low magnetism; rather, this feature appears to be virtually invisible in the magnetometry data. Several hypotheses can be proposed to explain why this feature did not exhibit a high enough magnetic contrast with surrounding sediments to be identified in the magnetometer data. Archaeological experiments conducted by Linford and Canti (2001) on the nature of firing and its subsequent effects on magnetometer data offer some insight here. These experiments were conducted to test the magnetic impacts of firing on different sediment types. Temperature levels were measured using an array of thermocouples both above and below the ground. Magnetic measurements were taken in the field before and after firing using traditional archaeo-geophysical instruments (a GeoscanResearch FM36 fluxgate gradiometer and a Bartington MS2 magnetic susceptibility meter), as well as in a laboratory setting (Linford and Canti 2001:212–223). These studies concluded that magnetically enhanced ash exposed to weathering displayed a rapid decrease in the strength of its magnetic signature. These experiments also concluded that the duration of the burning episode had a significant effect on the magnetic signature of the feature. Based on these experiments, there are several possible explanations for the low magnetic contrast of the ash lens Feature 2:

1. The feature did not reach temperatures high enough (greater than 150°C according to Linford and Canti 2001:224) to significantly alter its remanent magnetism.
2. The feature did not sustain high temperatures long enough to significantly alter its remanent magnetism.
3. Post-depositional processes have subsequently reduced the feature's remanent magnetism.
4. The feature's net magnetic properties are below the observed magnetic properties of the surrounding sediments.

Clearly, features such as Feature 2 at 26EU2126 that lack FCR pose greater challenges for magnetometry than do FCR-rich features such as Feature 1 and 3.

Turning to conductivity data, Feature 1 was found in an area that was targeted for excavation because it exhibited enhanced conductivity and because it was in the vicinity of a surface artifact concentration. However, as noted above, the similar Feature 3 was not located in an area of high conductivity (Figure 36), which suggests that the association between Feature 1 and an area of high conductivity is just coincidental. It was expected that conductivity survey would help locate prehistoric occupational surfaces, not simply small thermal features such as Features 1 and 3. Operation F at 26EU2126 provides the best evaluation of the utility of conductivity survey for this purpose, as the richest archaeological deposits were found in this large excavation block and an extensive area of moderately high conductivity was present to the west and northwest of it. However, artifact density in Operation F declined with proximity to the conductivity anomaly, and ashy, midden-like sediments were more obvious in the eastern half of the excavation block than in the western half. Thus, Operation F provides no evidence for an association between areas of high conductivity and midden deposits of the sort that might be expected to occur on and around hunter-gatherer living surfaces.

More broadly, the fact that so many areas of high conductivity were excavated during the project without finding thermal features or occupational surfaces indicates that false positives are an issue to be dealt with when using conductivity survey, just as is the case with magnetometry.

Attempts made during the 2007 BGMI project to address the false positives issue—or to control for the effects of geological noise when the goal is to locate archaeological features—are discussed next.

4.4.2. AUGER PROBING

Limited auger probing was conducted at 26EU1533 and 26EU1539, following methods described in Chapter 3, in order to determine whether variability in sedimentological properties at these sites might help to explain patterns observed in the magnetometer and conductivity data. These two sites were chosen for this auger probing exercise because they are located in very different geomorphic settings—the top of an alluvial and colluvial ridge in the case of 26EU1533 and along an alluvial terrace in the case of 26EU1539—and because sediments might therefore be expected to have different geophysical properties between them.

During the auger probing, sediment characteristics such as texture and color were recorded for each auger bucketful that was brought to the surface, and the depth at which any observable change in sediment characteristics occurred was recorded. The primary change that was observed was one from lighter colored sediments to darker colored sediments at depths ranging between 15 and 50 cm below surface. Excavation results (discussed in greater detail in Section 5.3) suggest that the depth of the color change corresponds to the bottom of a calcic zone (i.e., zone of carbonate illuviation) that is present at all the sites. This color change occurred in almost every auger hole that was excavated to a sufficient depth; the calcic zone was not observed in a small number of auger holes, and a few auger holes were prevented from reaching the bottom of the calcic zone due to gravels that the auger could not penetrate (observed primarily in auger probes placed in shallow channels) or perhaps in some cases due to cementation of the calcic zone itself.

Figure 42 and Figure 43 illustrate the depth to the base of the calcic zone relative to magnetometer data from these two sites, and Figure 44 and Figure 45 do the same for conductivity data. In these figures, the depth to the bottom of the calcic zone is represented by the size of the symbol (a larger circle indicates a greater depth); auger holes for which the depth to the base of the calcic zone is represented as zero are those in which the calcic zone was not observed or in which the auger could not penetrate to the bottom of the calcic zone. As discussed in Chapter 3, 22 probes at 26EU1533 were spaced at intervals of approximately 1 m along three linear transects in the central part of the site, and at 26EU1539, 14 auger probes were spaced at 5-m intervals along two transects in the northeast corner of this site; one of the transects at 26EU1539 was oriented southwest to northeast up the slope of the alluvial terrace, and the second transect began at the first and proceeded to the southeast across a shallow channel.

At 26EU1533, there is a visual correlation between the depth of the calcic zone in an auger hole and the magnetic signal recorded in the vicinity of that auger hole (Figure 42). Areas of higher magnetism (darker areas) tend to be those in which the bottom of the calcic zone is deeper, and areas of lower magnetism tend to be those in which the bottom of the calcic zone is closer to the surface. The series of auger holes located just to the southwest of Operation A was purposefully placed across a series of shallow depressions on the surface: the areas of low magnetism along this series of auger probes (the bright white areas) correspond to the depressions in which the base of the calcic zone is located closer to the surface, and the areas of higher magnetism correspond to higher areas between the depressions. The visual correlation that is present here suggests that the calcic zone has a relatively high magnetic signal, such that magnetometer readings are high in places where it is thick, and/or that the underlying sediments have a relatively low magnetic signal, such that magnetometer readings are low where those sediments are closer to the surface.

If this were the case, then systematic auger probing might routinely be conducted in conjunction with magnetometer survey in order to control for the effects of near-surface geology on magnetometry readings: areas of high magnetism that did not correspond to areas in which the calcic zone was thick would be good candidates for having archaeological features because something other than a thick calcic zone would have to be causing the high magnetism there. However, the results obtained at 26EU1533 were not duplicated at 26EU1539. At this site, there is no clear relationship between the depth of the calcic zone in an auger hole and the magnetic signal recorded in the vicinity of that auger hole (Figure 43). This indicates that the depth to the base of the calcic zone cannot be taken to be a universal cause of patterning in magnetometer data at sites in the LBBA.

A similar conclusion can be reached by comparing the auger probe results to conductivity data. At 26EU1533, there appears to be somewhat of a relationship between sediment conductivity and the depth of the base of the calcic zone (Figure 44), but this is not the case at 26EU1539 (Figure 45).

In sum, the results of the augering exercise unfortunately provide little practical guidance for future archaeological remote sensing work in the LBBA. Results from 26EU1533 suggest that magnetometer and conductivity data might reflect sedimentological properties, specifically the depth to the bottom of the calcic zone that is ubiquitous throughout the area, but the results from 26EU1539 show that such a relationship is not universal. These results may indicate that geophysical data from sites located in different types of geomorphic settings might primarily be reflecting different geological variables. These results also suggest that further work is required to evaluate what specific factors are responsible for the most obvious patterns in geophysical data from sites in the LBBA, patterns that are essentially noise from the perspective of archaeological prospection.

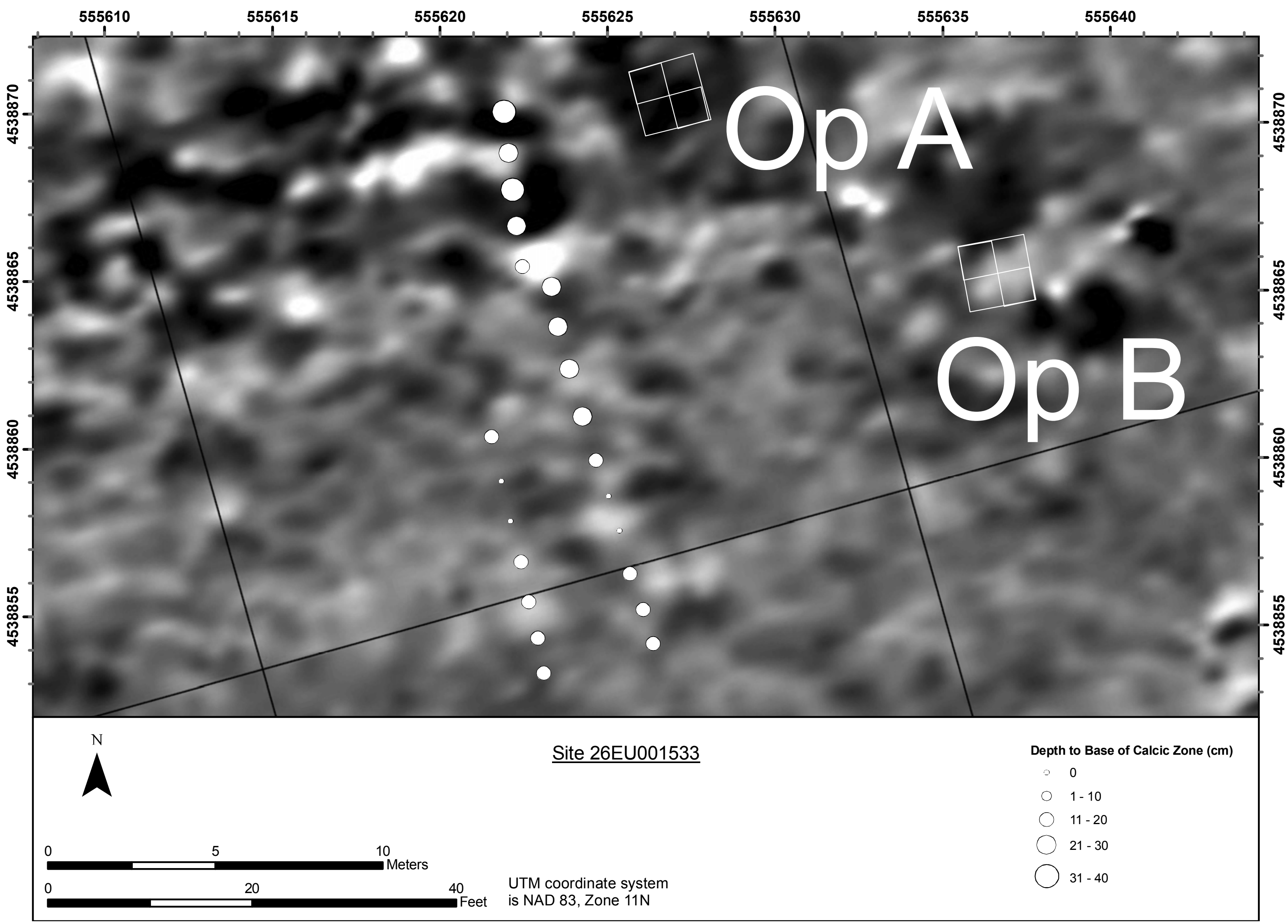

Figure 42. Depth to base of calcic zone overlaid on magnetometer data from 26EU1533.

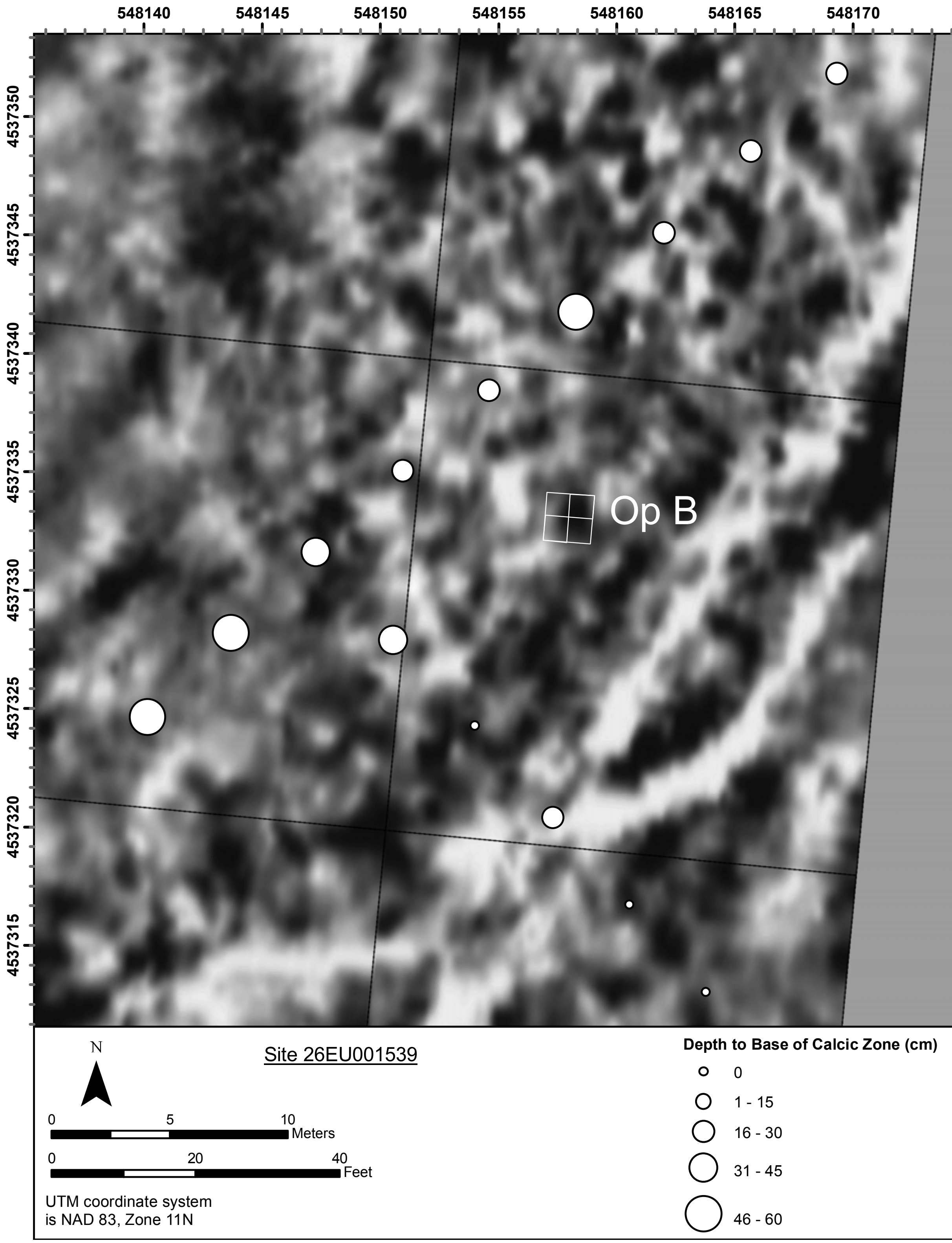

Figure 43. Depth to base of calcic zone overlaid on magnetometer data from 26EU1539.

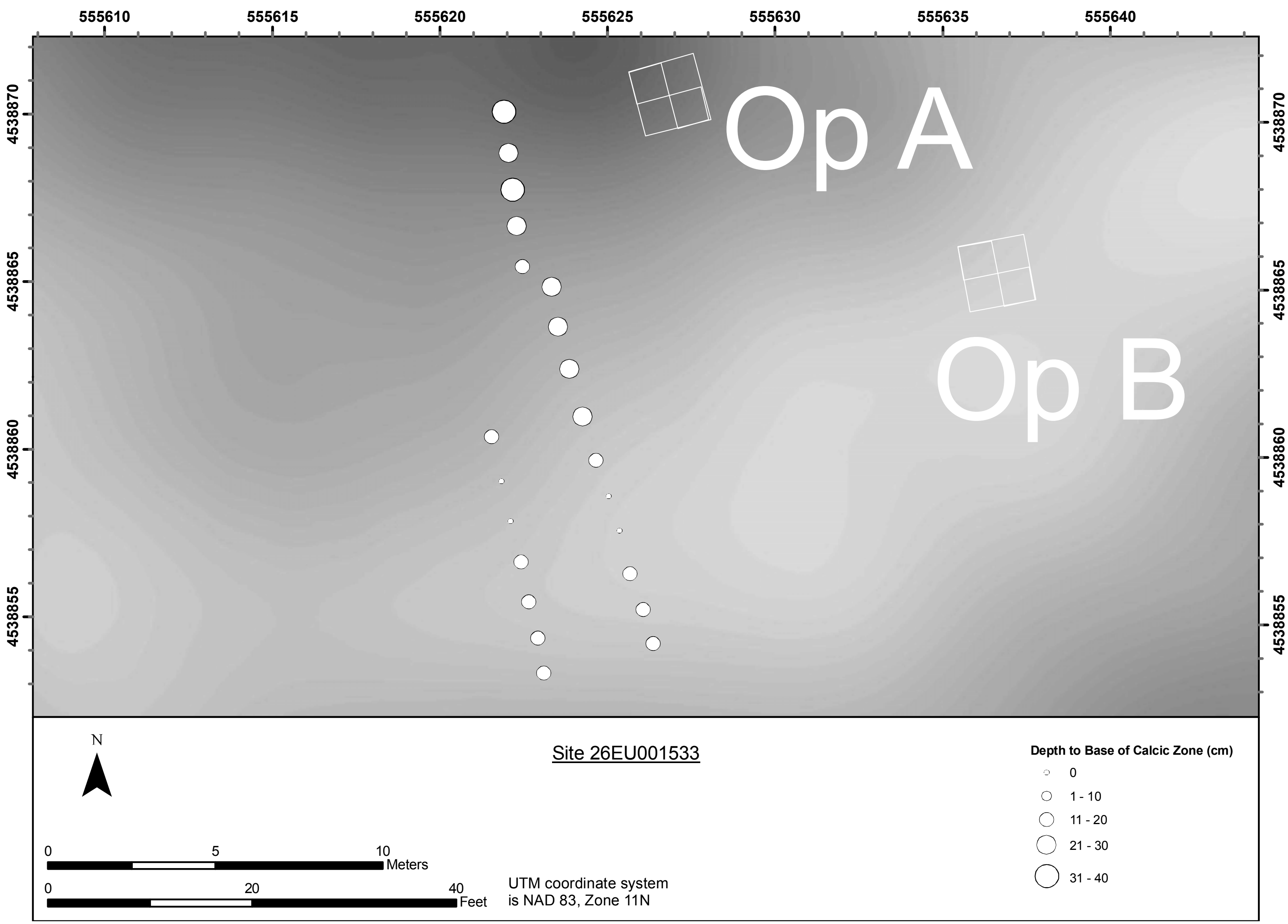

Figure 44. Depth to base of calcic zone overlaid on conductivity data from 26EU1533.

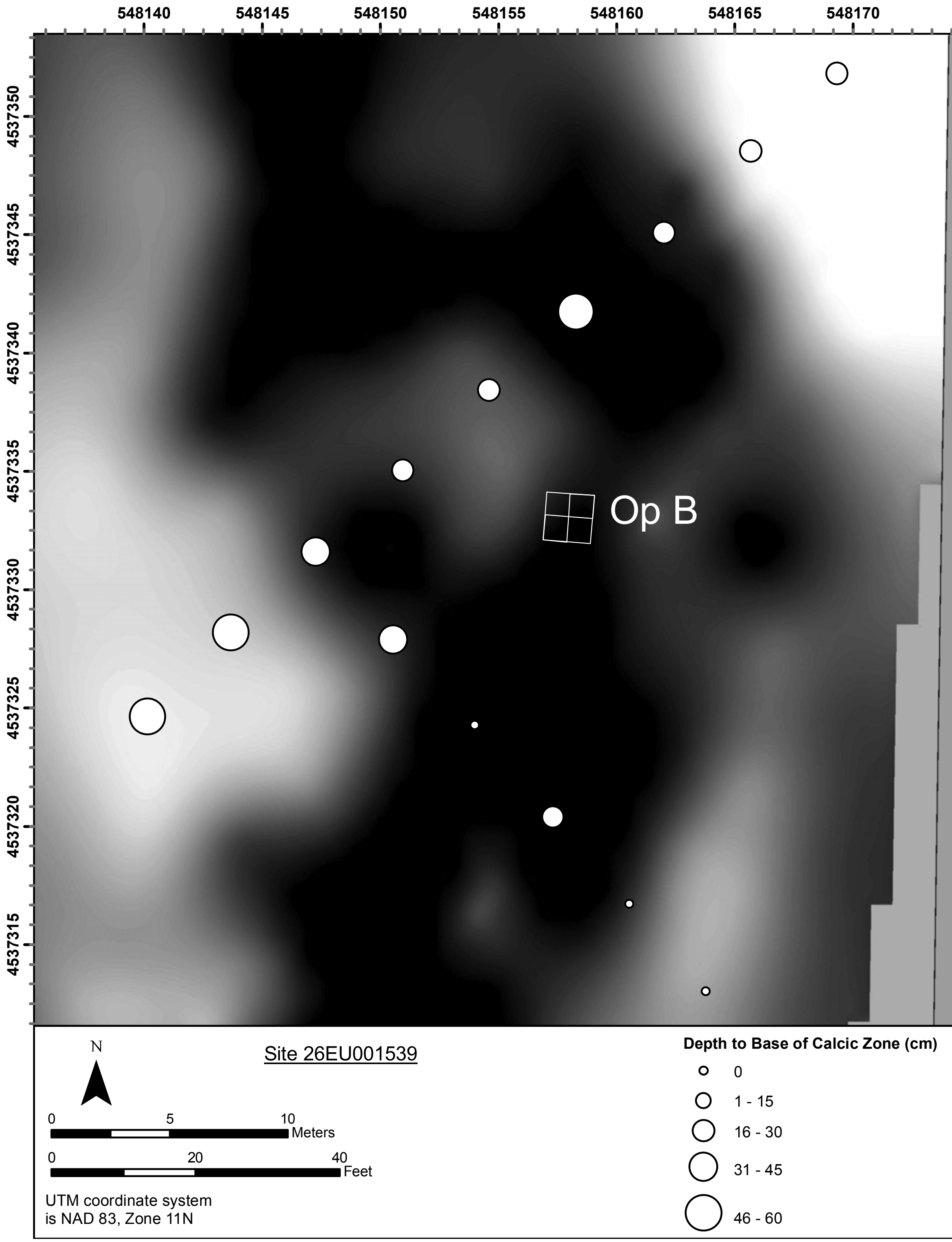

Figure 45. Depth to base of calcic zone overlaid on conductivity data from 26EU1539.

4.4.3. Non-Archaeological Charcoal Lenses

As discussed in Chapter 3, the final step in data recovery fieldwork was to mechanically strip the surface sediments from each site involved in the project in order to locate archaeological features that were not found in manual excavation. This blading revealed many charcoal lenses, the large majority of which appeared to be not archaeological features but simply the remains of vegetation burned by recent wildfires. Bulk sediment samples were collected from a sample of these charcoal lenses and are analyzed in Section 6.2. Some of these charcoal lenses were also mapped so that their distributions could be compared to geophysical data in order to evaluate whether some of the noise in those data might be due to wildfire-burned vegetation; the results of this mapping exercise are presented here.

All of the charcoal lenses revealed by blading at 26EU1548 were mapped by total station (Figure 28, Figure 34; charcoal lenses are labeled as "blading features" in these figures), as were all of those at 26EU1539 located in the part of that site to the north of the road that crosses the site (Figure 26, Figure 32). In addition, a single charcoal lens was mapped at 26EU2064 (by GPS rather than by total station); this is only one of many such features that were found at this site (Figure 29, Figure 35). Similar charcoal lenses were also found at the other two sites involved in the project, but none were mapped.

It can be seen in these images that there is no clear relationship between the locations of these charcoal lenses and patterns in the geophysical data. Some are located in areas of high magnetometer readings, and some are located in areas of low magnetometer readings. Likewise, some are located in areas of high conductivity and some are located in areas of low conductivity. It thus appears that wildfire-burned vegetation is not contributing to the patterns observed in the geophysical data.

4.5. Discussion and Implications for Future Work

Archaeological features were not located by the geophysical remote sensing techniques that were employed during the 2007 BGMI project. This cannot be attributed to any shortcomings of the geophysical methods that were used, per se, but occurred because the types of features that were sought proved to be rare or absent at the sites that were investigated. Further test cases, ideally at sites where it is known that archaeological features are present, are necessary before final conclusions can be drawn about the usefulness of remote sensing in archaeological research and CRM in the LBBA.

Despite the fact that this project did not provide an ideal test case for evaluating geophysical techniques, it does offer some insights that might lead to more successful application of those techniques in the LBBA or other parts of the Great Basin in the future. For one, it seems clear that sites in the area are geologically complex, and that this complexity is reflected in geophysical data. Future use of remote sensing in the region will likely be far more successful if it is closely integrated with detailed geoarchaeological analyses beyond what was within the scope of the present project.

It should also be noted that archaeo-geophysics, especially as it is practiced in the United States, is still a young and burgeoning discipline. Large-scale landscape surveys such as those conducted as part of the 2007 BGMI project are considered by many researchers to be the logical direction in which archaeo-geophysics is headed (Kvamme 2003a). Thus, the current survey is on the leading edge of this type of study, which greatly adds to the importance of the findings presented here. The results of the 2007 BGMI project can be used to guide future regional-scale investigations.

Below are some comments on incorporating the use of geophysics at various scales in future projects in this region. Emphasis is placed on the recovery of quality archaeological information and survey efficiency. A three-stage survey design is suggested, starting with the use of smaller surveys at known sites as an initial assessment of the productivity of various archaeo-geophysical techniques for a given set of geological and archaeological conditions. Secondly, a broad-scale landscape survey is suggested, employing the technique or techniques identified during the initial assessment. The goal of the landscape survey would be to quickly and efficiently cover as much of the site and its surrounding landscape as possible in order to isolate areas of archaeological interest. The third stage would require that areas of archaeological interest identified in the landscape survey be targeted using a suite of archaeo-geophysical techniques at sufficient sample densities to produce high-resolution imagery. These three stages are not necessarily meant to correspond to the various stages of a CRM project on a one-to-one basis; elements of these stages can be incorporated into a single archaeo-geophysical field project or deployed separately within the context of the different phases of the archaeological investigations.

4.5.1. ARCHAEO-GEOPHYSICS IN CRM

Based on the findings from the 2007 BGMI project, a multi-scalar archaeo-geophysical survey methodology appears to the most useful type of approach for use in CRM projects. As previously stated, emphasis is placed on recording quality data as well as overall survey efficacy. If implemented strategically within the existing structure of the CRM workflow, archaeo-geophysics has the potential to increase the information gained at each phase of investigation as well as to decrease the time and money necessary to complete the archaeological work necessary to identify and evaluate archaeological sites in an area of potential effects, and to complete mitigation of archaeological sites to be affected by a development project (see also Lockhart and Green 2006).

While archaeo-geophysics can be considered part of the archaeological tool kit, it is not a replacement for actual subsurface investigations, whether those excavations are of an evaluative or mitigative nature. Although there are several datasets that can provide detailed archaeological interpretations from geophysical data alone (Creel et al. 2005; Kvamme and Ahler 2007; Walker et al. 2007), most datasets are too ephemeral, noisy, and difficult to interpret from a purely archaeo-geophysical perspective (Walker 2007; Walker and Perttula 2007a, 2007b). These require the combination of traditional archaeological data (such as distributions and densities of artifacts and architectural features) with geophysical data in order to isolate culturally significant patterns and trends within a particular site or across a landscape. This would imply that geophysics should not be used alone or solely relied upon as an expedient means to survey an area to identify archaeological sites or complete a site evaluation.

4.5.2. Sample Density, Survey Speed, and Data Quality

Several specific recommendations for future archaeo-geophysical investigations in this region are summarized here. Sample density may be the most important variable controlled by the geophysicist during data collection. Sample density refers to the number of readings recorded in the field. It consists of two variables: 1) sample interval, or the number of readings taken as the surveyor moves back and forth along each traverse, and 2) traverse interval, or the distance between each traverse. Sample density can be expressed as a single number (as in 16 readings per m^2) or more specifically at two numbers that express the relationship between the sample and traverse intervals (as in 0.125 × 0.500 m).

Sample density directly affects the pace of an archaeo-geophysical survey. More specifically, the traverse interval has the greatest impact on survey speed, whereas changing the sample interval has only minor effects, mostly related to data volume. For example, collecting data with a 0.5-m traverse interval takes twice as long as collecting data with a 1.0-m traverse interval, whereas the only difference in survey time between data collected at a sample interval of 1 reading/m or a sample interval of 8 readings/m is the frequency at which data is downloaded from the instrument when it is full (which usually only takes several minutes). Sample density also has a direct impact on the resolution of the geophysical data, as higher densities result in higher-resolution data. Thus, there is a tradeoff between survey speed and data resolution.

Figure 46 shows the same portion of 26EU1533 that was displayed in the original 0.125 × 0.500–m sample density used for all the sites in the current project, but de-sampled at various sample densities to illustrate the implications of the relationship between sample density and image clarity. As discussed above, it is assumed that the survey time is cut in half as the traverse interval is doubled. Figure 46 clearly shows that the 0.500 × 0.125–m sample interval has the sharpest clarity. However, the resolution provided by the 1.0 × 0.250–m sample interval is still sufficient for many purposes, and considering that this sample interval would require half the collection time and that the surveyor would not need to download data in the field (160 grids could be collected before a download), this sample interval is recommended for making archaeo-geophysical assessments or large-scale landscape surveys.

There is no "one size fits all" approach to archaeo-geophysics. It is also not accurate to assume that higher resolution images will be worth the extra time required in the field to collect them. Sample density should be considered as a flexible variable determined by the nature of the archaeological target, the surrounding geological context, and the ground cover present at the time of the survey. This is not a new or even novel concept for archaeologists, and its implementation can be observed at many levels in modern archaeological field practices. For example, surveyors in archaeological survey typically rely on the most time-efficient methods suitable for a given region. Depending on the survey conditions, this can range from aerial photographic analysis to surface collection or shovel testing. The same concept should be considered in the application of archaeo-geophysics in a particular project setting. Empirical knowledge of the correct sample density and survey speed variables to employ in specific archaeo-geophysical investigations will come with test experience in a variety of archaeological and landscape situations. It is virtually a given that finding the correct sample density and survey speed variables to employ in specific archaeo-geophysical investigations will come through empirical testing in different archaeological and landscape situations.

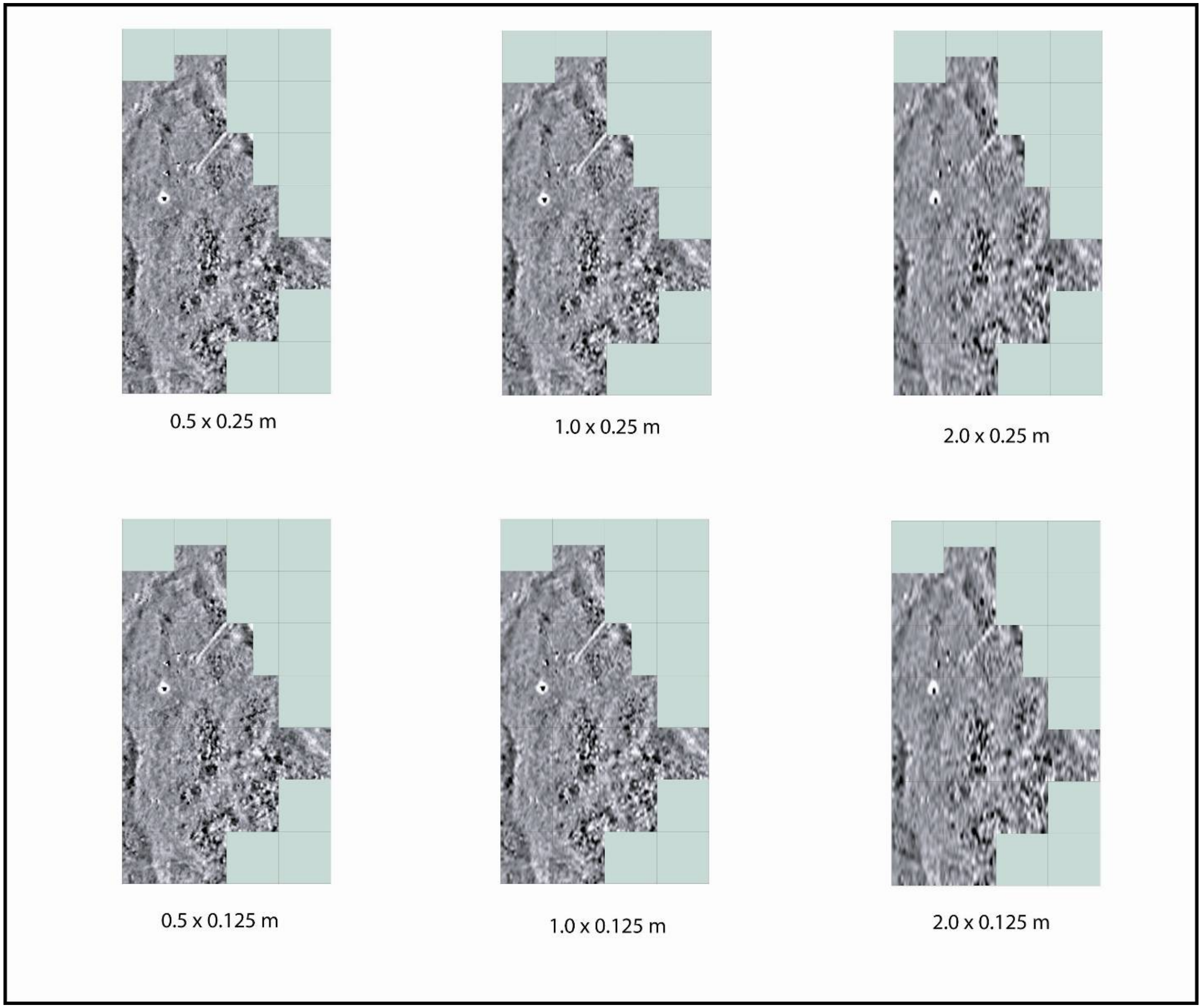

Figure 46. Comparison of magnetometer data from 26EU1533 at different sampling densities.

4.5.3. Archaeo-Geophysical Assessments to Landscape Surveys

A large number of variables affect the results of archaeo-geophysical research. Ballpark predictions of archaeo-geophysical data quality can be made prior to fieldwork based on previous archaeological work in a given region, the nature of the area's geology and geomorphological setting, the current land cover and land use, and the general impacts present in the modern cultural landscape. However, actual fieldwork is required to discern the level of utility that archaeo-geophysical investigations can provide in a given archaeological region. Therefore, archaeologists could greatly benefit from incorporating archaeo-geophysics at different levels of intensity and spatial scale in research designs at different phases of investigation. Several strategies to help incorporate archaeo-geophysics into CRM projects are outlined below.

Archaeo-geophysical assessments are quick field tests of various geophysical methods and techniques on known sites. This type of geophysical survey can be used as a part of site evaluative testing in the beginning stages of a data recovery project, or simply to assess the potential use of archaeo-geophysics for a given region as part of a broad-scale archaeological survey or the development of a landscape study. The primary goal of an archaeo-geophysical assessment, then, is to document the nature and quality of archaeo-geophysical data for a given area, and to determine how best to collect such data. Used together with site evaluative testing, an archaeo-geophysical assessment can be employed to determine the potential for incorporating geophysics at an increased spatial scale for later phases of research, or to help identify specific characteristics of a site (i.e. the use of ground penetrating radar to measure the depth to bedrock, or stratigraphic work to supplement geomorphological test trenches).

The full potential of archaeo-geophysics can be incorporated into CRM projects via landscape surveys. When possible, landscape surveys can be preceded by archaeo-geophysical assessments so that geophysical information on both the target archaeological features as well as their geophysical signatures is known or can be established. Landscape surveys can be implemented on a much larger scale than archaeological testing work alone. The speed and spatial scope at which archaeo-geophysical surveys can be conducted may allow archaeologists to widen their view of the archaeological character of a landscape.

4.5.4. High-Resolution Multisensor Surveys

High-resolution multisensor surveys can be conducted in situations where the specific nature of the archaeological target is known with some precision, but where excavation is not possible for some reason. In such a situation, multiple geophysical techniques can be used in tandem, and data can be collected at close intervals. Collecting data in a single direction will further ensure the highest possible data quality. Multisensor (i.e., multi-instrument or multi-technique) surveys are time-consuming when compared to the aforementioned methods of archaeo-geophysical survey, but can still progress at a much quicker pace—and cover a larger archaeological area—than could manual excavations (including shovel tests).

Multisensor surveys can be useful in combination with landscape surveys. Landscape surveys typically rely on one or more geophysical methods such as magnetometry, conductivity, or magnetic susceptibility that are rapidly conducted, the goal being to simply locate archaeological features on the landscape. Once this is accomplished, a high-resolution multisensor survey can be conducted to obtain more specific information from the cultural features identified. This is done by increasing the sample density as well as the spatial control of the survey. For instance, magnetometer data could be collected at 25-cm traverse intervals using a unidirectional survey pattern; this would greatly increase the data detail but would also increase survey time. Slower geophysical techniques such as ground penetrating radar and resistivity could also be used to increase the clarity of the archaeological targets and the amount of archaeological information yielded from the survey.

The strategic employment of archaeo-geophysics into multiple stages of the CRM process can ultimately decrease the amount of time required to conduct archaeological site assessments, evaluative testing, and data recovery. However, it is vital that archaeo-geophysical and archaeological work be effectively integrated, and there be mutual feedback during the course of a project concerning the results obtained by each set of methods. Archaeo-geophysics has the potential to provide more useful information if it is threaded into the traditional CRM workflow and used at varying levels of intensity throughout the phases of archaeological investigation.

4.5.5. Proposed Archaeo-Geophysical Workflow

Based on the results from the archaeo-geophysical survey conducted as part of the 2007 BGMI project, the following archaeo-geophysical workflow is offered for future consideration and implementation.

For sites with potential for intact subsurface archaeological deposits and features:

Archaeo-geophysical assessment can be performed on areas with known subsurface features or over areas of highest archaeological potential, as identified during the initial site survey or in the early stages of site testing. Several instruments should be tested, and the instrument producing the most legible data should be used over as much of the site as the project allows, at a sample density determined by the initial geophysical assessment (i.e., the lowest resolution where archaeological targets can be identified). Merging these data with archaeological data should identify areas of archaeological interest. High-resolution archaeo-geophysical investigations should be conducted on areas of archaeological interest and used to supplement data recovery excavations and expand on the findings obtained from the data recovery work.

For sites with known subsurface archaeological deposits and features:

Sites with known subsurface features that are undergoing data recovery can gain from following the archaeo-geophysical workflow proposed above, or can proceed directly to a high-resolution archaeo-geophysical survey, depending on the specifics of the project goals and the research design issues and approaches. In this workflow case, sites and areas on sites with known subsurface features can be mapped at sufficiently high sample intervals to produce a supplementary dataset for data recovery excavations.

5. DATING AND SITE FORMATION PROCESSES

Michael D. Cannon, Amy Spurling, and Amber Tews

One of the major research emphases for the 2007 BGMI Data Recovery Project involved identifying deposits that allow documentation of change over time, and the project research design was focused in large part on developing methods for identifying such single-component deposits efficiently. Given this research emphasis, obtaining chronological information was necessarily a major goal for the project. The specific dating methods employed were radiocarbon assay, obsidian hydration band measurement, and recovery of temporally diagnostic projectile points. This chapter discusses the results obtained from these lines of evidence and applies them to the question of whether single-component deposits exist at the sites investigated during this project. Geoarchaeological observations made during the course of the project are also applied to this question. The chapter concludes by discussing the chronology of occupation at the sites involved in the project and by aggregating site or locus assemblages into temporal units to be used in artifact analysis.

5.1. MULTICOMPONENT SITES IN THE LBBA

The 1991 historic context for the LBBA laid out research domains that require the recovery of materials from single-component deposits: i.e., deposits that date to relatively discrete spans of time, usually taken to mean individual culture historical phases. Deposits that date to discrete spans of time are obviously required for consideration of change over time in any aspect of the archaeological record. They are also required for analyses of site structure since such analyses are only defensible if the features or areas within a site whose structure is being considered are temporally associated with each other. As discussed in Chapter 2, the fact that research domains involving issues such as temporal change or site structure have not been fully addressed in the LBBA since 1991 is due in part to the fact that a significant proportion of the deposits previously excavated in the area have been multicomponent rather than single-component. As shown in Table 3 (Chapter 2), nearly 40 percent of the components that have been excavated in the LBBA consist of palimpsest deposits that include material from more than one of the phases that have been defined for the region.

In response to this situation, the guiding principle for the 2007 BGMI project was to develop methods for more effective identification of single-component deposits so that excavation efforts might provide data that would be of greater use for addressing important research topics. In attempting to do so, the project focused on these specific questions:

- Are single-component deposits present at the sites involved in the project?
- If so, what is the age of those deposits, and what can we learn from them about their respective time periods and about diachronic change?

The research design for addressing these questions involved using remote sensing techniques to identify subsurface features, followed by a phased approach to excavation in which chronological information was obtained during initial exploratory efforts. This information, along with dating evidence recovered during surface collection, was then used to evaluate which deposits might be single-component and thus worthy of further investigation through more extensive excavation. As noted in previous chapters, the types of features that were sought through remote sensing proved to be largely absent from the sites involved in this project, but this did not prevent the use of the general strategy of taking a phased approach to excavation. Surface collections and initial exploratory excavations did produce chronological information that was used in determining which areas would be the focus of subsequent, more extensive excavations. This chronological information is described in detail below.

Perhaps of greater significance than the scarcity of archaeological features at the sites involved in the project (and the corresponding fact that such features were not observed in remote sensing data) is that, despite a research design focused primarily on the identification of single-component subsurface deposits with useful archaeological data, only one such deposit (that explored by Operation F at 26EU2126, as discussed below) was identified. Because of this, when data are used later in this report to address issues of change over time, they are not aggregated into individual phases but into broader time periods. Though this approach does not provide resolution as fine as might be desired, it does allow change over time to be explored to some extent using data from the sites investigated during the project. Given that multicomponent deposits are so common in the LBBA, this approach might provide a useful example to be followed in future research in the region. In other words, while the answer to the first question listed above may often be that single-component deposits do not exist, at least in the sense of "single-phase" that is usually meant by "single-component", it may still be possible to do something to address the second question involving learning about change over time.

The time periods defined for the analyses presented later in this report and the attribution of sites or site loci to these time periods are discussed at the end of this chapter. First, the chronological information obtained during the project is detailed, and then geoarchaeological observations on site formation processes that are relevant to resolving chronological relationships are discussed.

5.2. DATING RESULTS

This section presents the results of the dating methods employed for the 2007 BGMI project. The locations of the radiocarbon samples, obsidian artifacts and projectile points discussed in this section are shown in Figure 47 through Figure 51. The results of the various dating methods are synthesized in the concluding section of this chapter.

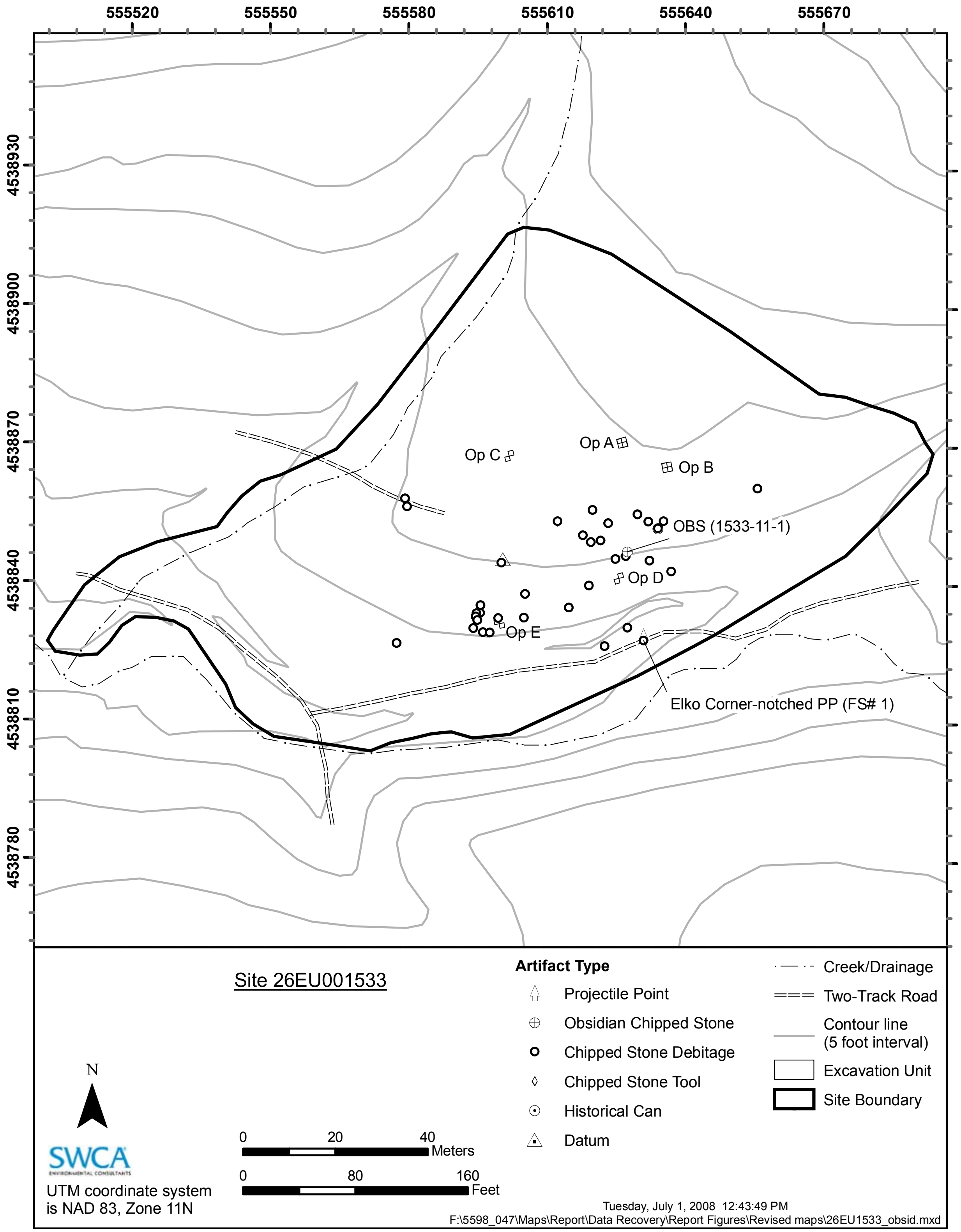

Figure 47. Location of obsidian artifact and projectile point recovered from 26EU1533.

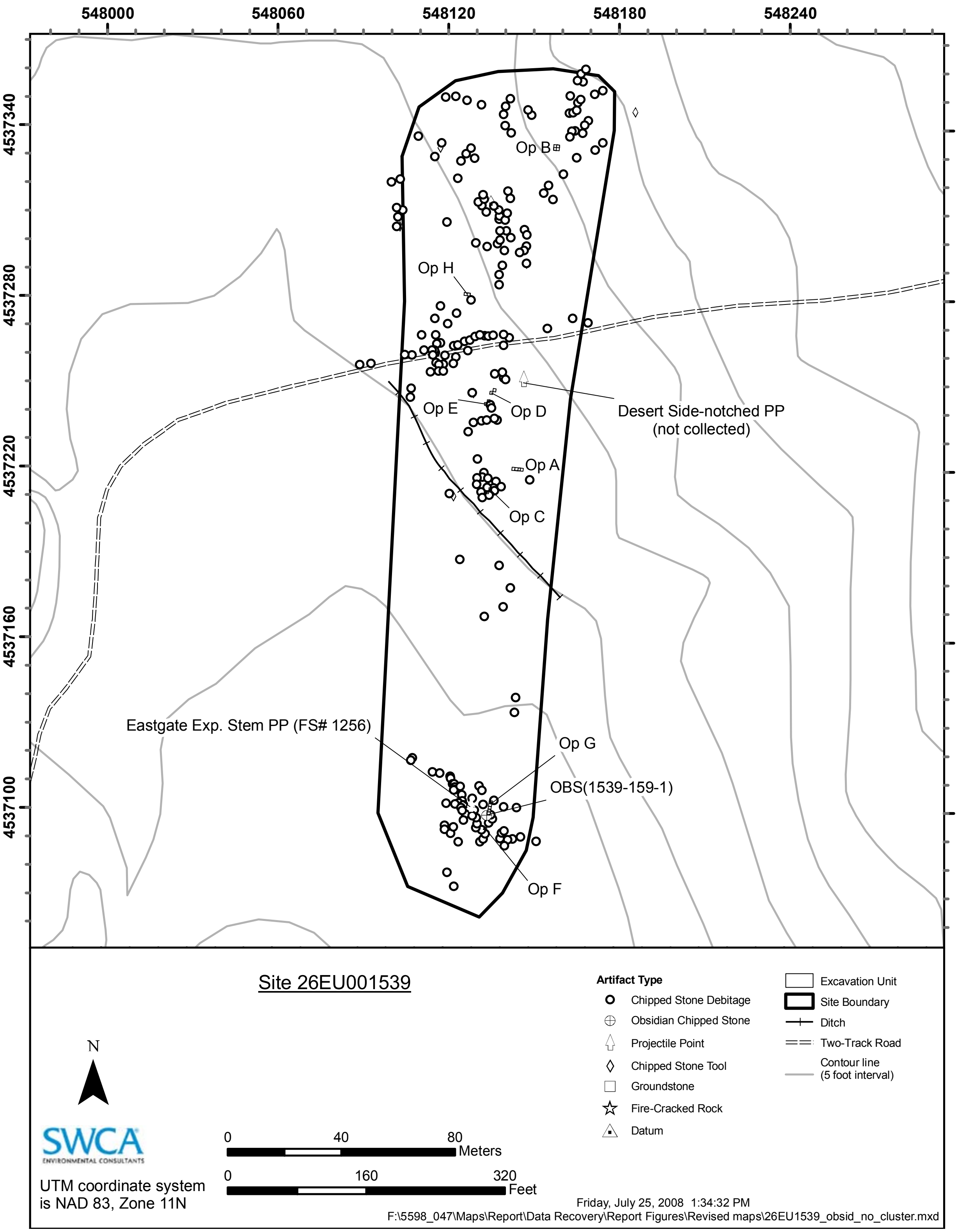

Figure 48. Location of the obsidian artifact and projectile points recovered from 26EU1539.

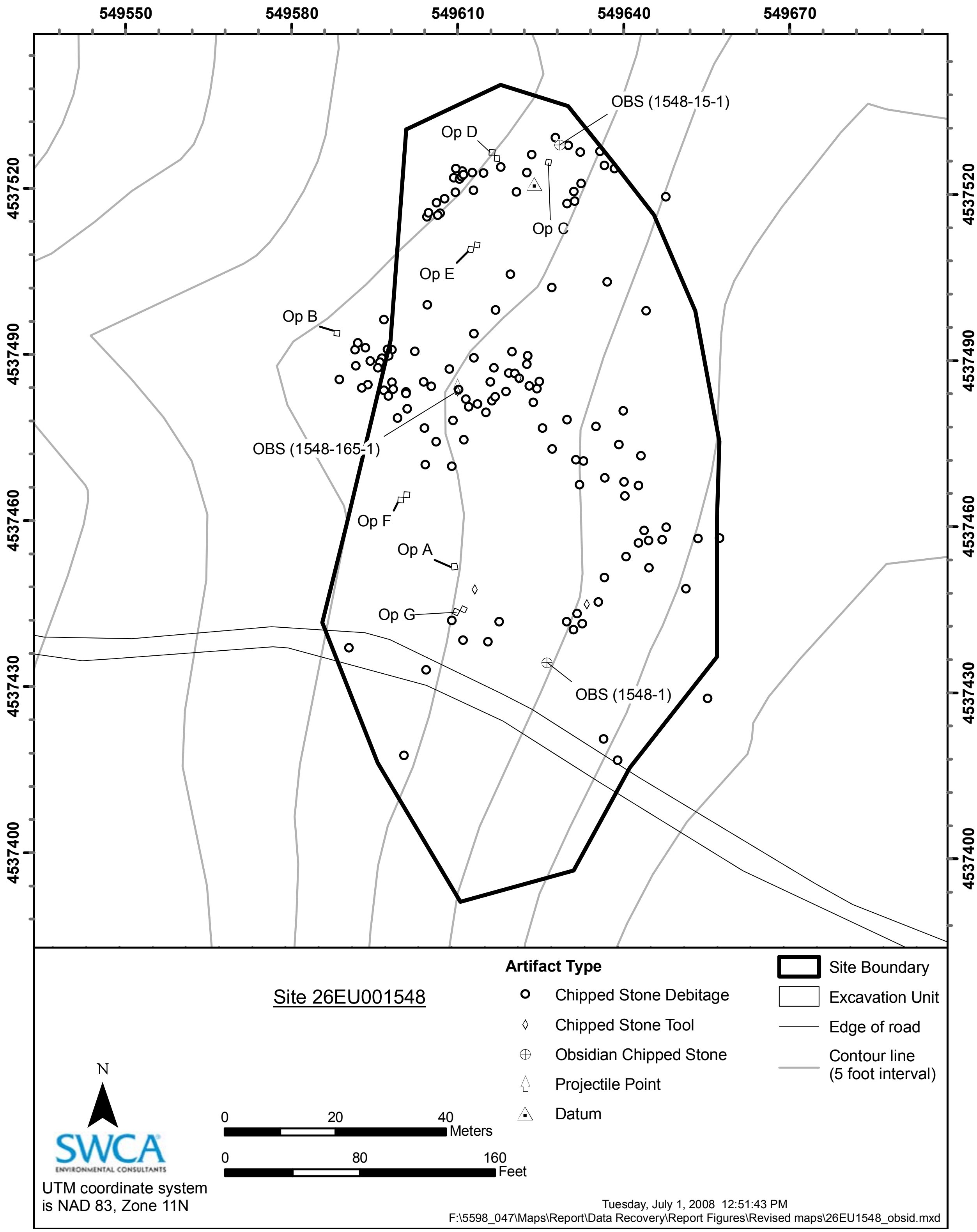

Figure 49. Location of obsidian artifacts recovered from 26EU1548.

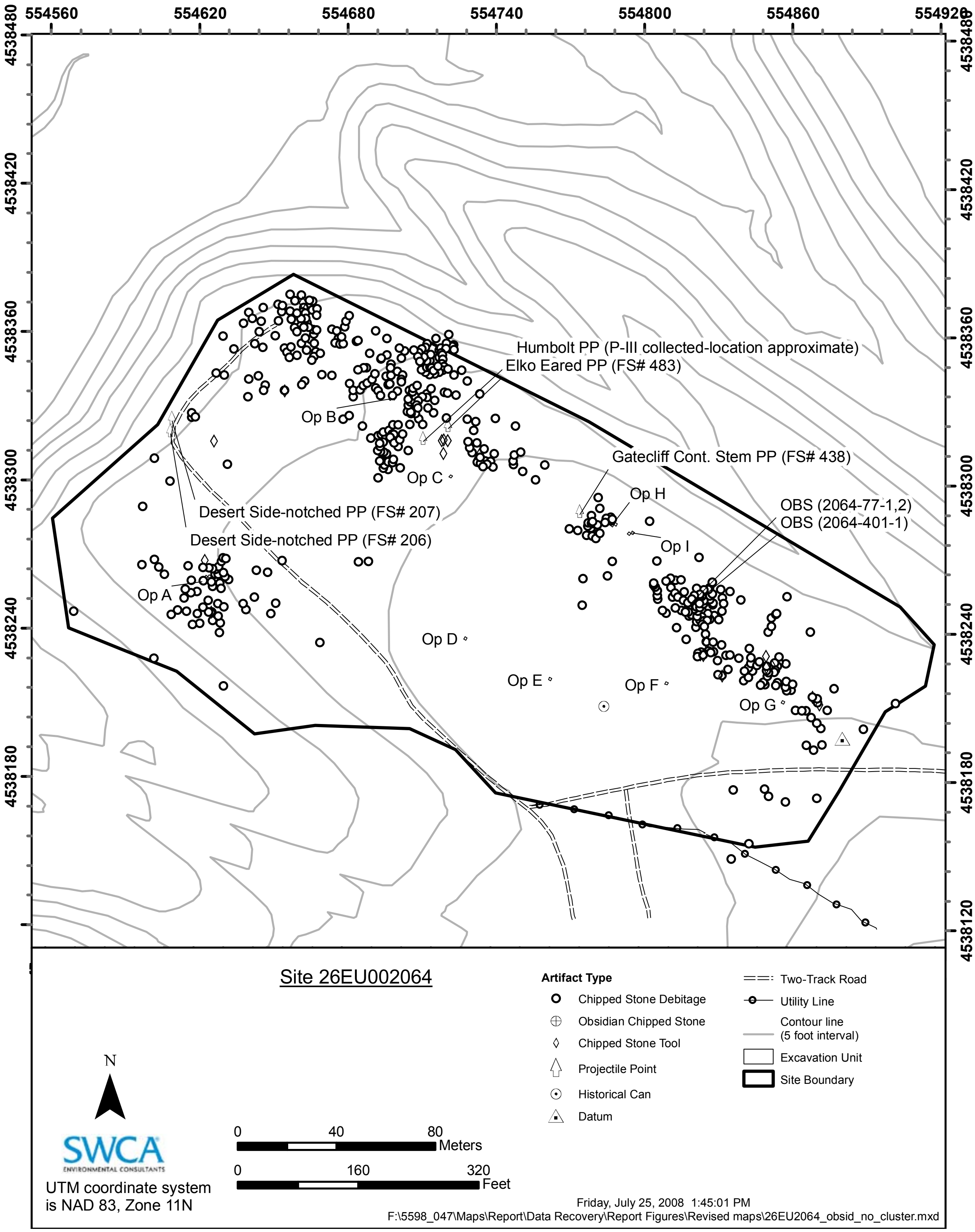

Figure 50. Location of obsidian artifacts and projectile points recovered from 26EU2064.

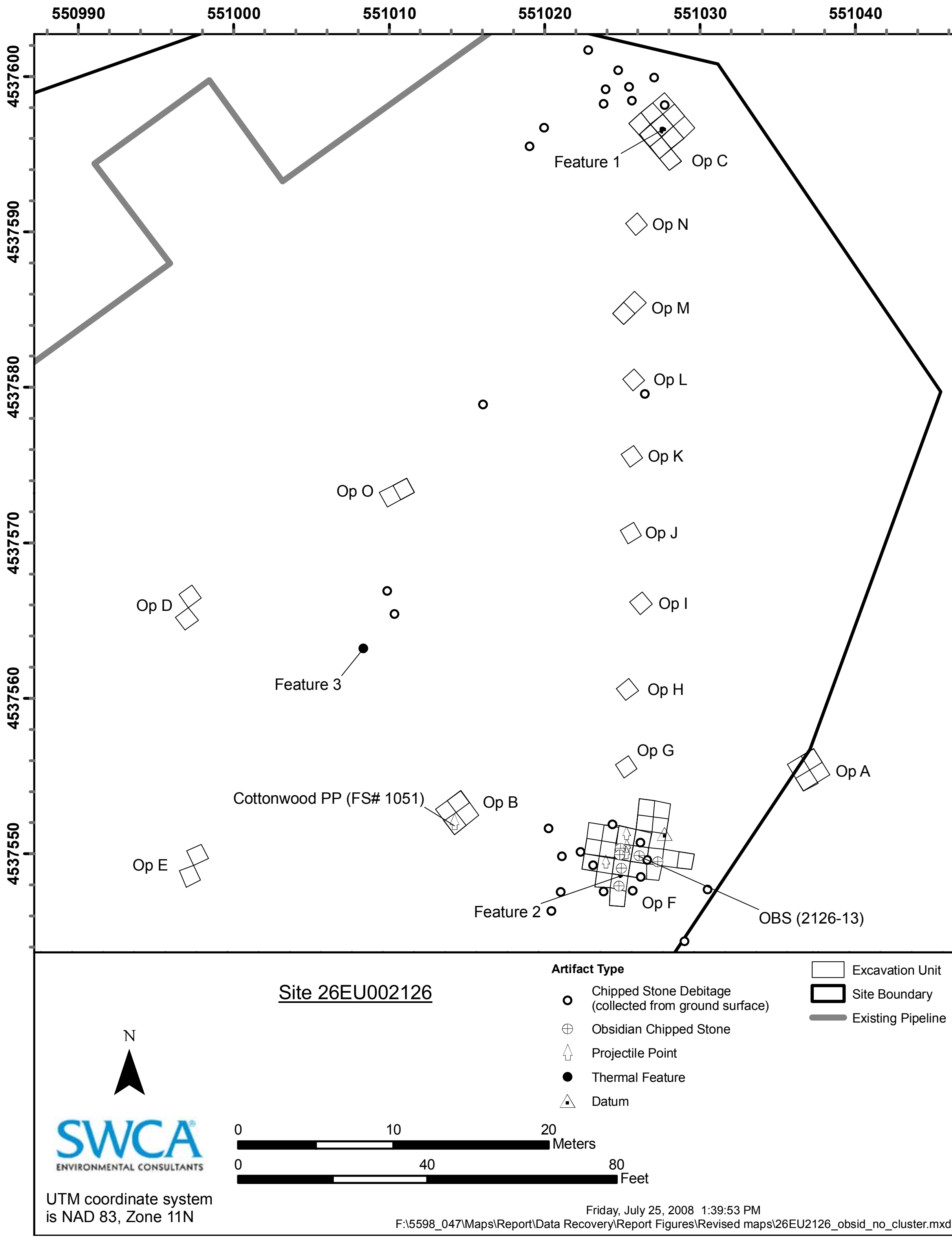

Figure 51. Location of radiocarbon samples, obsidian, and projectile points from 26EU2126.

5.2.1. RADIOCARBON DATES

Five charcoal samples collected from 26EU2126 were submitted to Beta Analytic Inc. of Miami, Florida, for radiocarbon dating using the Accelerator Mass Spectrometry (AMS) technique. These samples come from Features 1, 2 and 3, the locations of which are shown in Figure 51. In addition, two bone samples from this same site were radiocarbon dated; Beta Analtyic performed collagen extraction on these samples and dated the resulting material by AMS. These bone samples were recovered from the vicinity of Feature 2, in the second 10-cm levels of excavation units F2 and F17, respectively (see Figure 19 in Chapter 3). Both specimens are unidentifiable large (deer- or elk-sized) mammal long bone fragments, and the specimen from Unit F2—the unit in which Feature 2 was located—was burned. The bone specimens that were selected for dating were chosen because they were relatively large; as is discussed in Chapter 6, faunal remains from 26EU2126 are extremely fragmented, and most pieces are smaller than the minimum recommended size for AMS radiocarbon dating of bone collagen[5].

Data on the seven radiocarbon assays obtained are presented in Table 22. These data include the measured radiocarbon age, the measured $^{13}C/^{12}C$ ratio, the conventional radiocarbon age corrected for isotopic fractionation based on the measured $^{13}C/^{12}C$ ratio, and calibrated 2-sigma age ranges. Beta Analytic calibrated the radiocarbon ages using the IntCal04 calibration curve (Reimer and al. 2004) and following the approach outlined in Talma and Vogel (1993). Methods of sample preparation and analysis employed by Beta Analytic are detailed in reports provided in Appendix D. The phase designations given in Table 22 were assigned in reference to the culture history sequence that is presented in Table 2 (Chapter 2).

Three of the radiocarbon-dated charcoal samples (SWCA sample numbers 2126-1017, 2126-1018, and 2126-1019) were collected from under Feature 1, an FCR concentration found in Unit C4 of Operation C. All three samples were recovered from beneath cobbles within this FCR concentration, and they were submitted in order to determine the age of the feature and its depositional history. The three samples produced dates that are very consistent with each other: 1620 ± 40 ^{14}C yrs B.P. (A.D. 350–540 cal 2-sigma), 1630 ± 40 ^{14}C yrs B.P. (A.D. 340–540 cal 2–sigma), and 1640 ± 40 ^{14}C yrs B.P. (A.D. 330–540 cal 2–sigma). Using the *T'*-test of Ward and Wilson (1978), these three dates are statistically contemporaneous ($T' = 0.13$, $df = 2$, $p = 0.939$), with a pooled mean radiocarbon age of 1630 ± 23 ^{14}C yrs B.P. (A.D. 380–470, 480–530 cal 2-sigma)[6]. A fourth charcoal sample (SWCA sample number 2126-1200) was collected from the fill of Feature 2, the hearth discovered in Operation F, and it returned a radiocarbon date of 1160 ± 40 ^{14}C yrs B.P. (A.D. 770–980 cal 2-sigma). A fifth radiocarbon date was obtained from a charcoal sample (SWCA sample number 2126-1303) that was recovered beneath Feature 3, a second FCR concentration that was exposed during blading. It returned a radiocarbon date of 1390 ± 40 ^{14}C yrs B.P. (A.D. 600–680 cal 2-sigma). Because this feature was discovered during

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[5] These two dated bone specimens are in addition to one (part of a burned vertebra from an elk-sized artiodactyl) that was recovered from ST3 during probing at 26EU2126 in 2006 and that was submitted for radiocarbon dating prior to the 2007 BGMI project. That specimen did not yield a separable collagen or burned bone organics fraction for dating (Ron E. Hatfield, Beta Analytic, personal communication, 2007).

[6] Calib 5.0.1 software (Stuiver and Reimer 1993) was used to perform *T'*–tests and calculate pooled means. Pooled mean dates were calibrated by SWCA using Calib 5.0.1 software and the IntCal04 calibration curve.

blading, the exact depth of the charcoal sample could not be determined, but it is estimated to have been approximately 15–20 cm below the surface. More information about the depositional context of each charcoal sample is presented in Chapter 3.

Taken at face value, the three contemporaneous radiocarbon dates obtained for Feature 1 (the FCR concentration within Operation C) suggest that this feature was deposited during the latter part of the James Creek Phase (1,500 B.C.–A.D. 600). The radiocarbon date from the fill of Feature 2 (the hearth in Operation F) falls within the early part of the subsequent Maggie Creek Phase (A.D. 600–1300), and the radiocarbon date obtained for Feature 3 (the second FCR concentration found in blading) also returned an early Maggie Creek Phase date. The dates for the two bone specimens, however, suggest that it may not be appropriate to take these charcoal dates at face value.

These two bone specimens returned dates that are much later than all of the dates on charcoal from the site; the radiocarbon ages are 710 ± 40 ^{14}C yrs B.P. (A.D. 1260–1310 [high probability], 1360–1380 [low probability] cal 2-sigma) and 750 ± 40 ^{14}C yrs B.P. (A.D. 1220–1290 cal 2–sigma), respectively. These two dates are statistically contemporaneous ($T' = 0.50$, $df = 1$, $p = 0.480$), with a pooled mean radiocarbon age of 730 ± 28 ^{14}C yrs B.P. (A.D. 1230–1300 cal 2-sigma). In terms of the LBBA culture history sequence, the pooled mean date falls very late in the Maggie Creek Phase or perhaps at the transition between the Maggie Creek and Eagle Rock Phases. The discrepancy in age between these bone dates and the charcoal dates suggests that the charcoal dates are erroneously old due to "old wood" effects (e.g., Smiley 1994, 1998).

This is particularly the case for the charcoal date from Feature 2. The dated bone specimens were recovered from within a dense subsurface concentration of faunal and lithic material located around this feature (see Figure 23 and Figure 24 in Chapter 3; faunal remains are described in detail in Chapter 6). The close spatial proximity of the bone specimens to Feature 2 and the fact that one of them was burned (as are many of those from the surrounding concentration) strongly suggests that the bone truly is associated with the hearth feature; that is, it appears that the bone was deposited as the result of large mammal processing associated with the use of the feature. Given this, the bone radiocarbon dates likely provide a more accurate estimate of the age of the processing event because it is possible that the hearth charcoal that was dated came from plant material that was considerably older. Wood can lie on the surface in arid environments and remain useful to humans for centuries, but this is not the case for animal bone. In addition, any of the charcoal specimens that were dated may have been from heartwood and could thus pre-date the death of the plants from which they came by perhaps several decades. Thus, the most prudent interpretation of the radiocarbon record from Operation F at 26EU2126 is that it indicates occupation sometime during the mid- to late A.D. 1200s.

For the remaining charcoal dates from this site—the three from Feature 1 in Operation C and the one from Feature 3 discovered in blading—there is less direct indication that old wood effects are present since radiocarbon dates on material other than charcoal are not available from the contexts of these dates. However, because there is a direct indication that the charcoal date from Feature 2 is erroneously old, these other charcoal dates from the same site are best viewed with caution: it is quite possible that they substantially pre-date the deposition of the features from which they come.

Table 22. Radiocarbon Dates from 26EU2126

SWCA Sample Number	Beta Analytic Sample Number	Material	Context	Measured Radiocarbon Age (B.P.)	$^{13}C/^{12}C$ Ratio (‰)	Conventional Radiocarbon Age (B.P.)*	Calibrated 2-sigma Age Range (A.D.)	Phase
2126-1017	235062	Charcoal	Unit C4, Level 2; under Feature 1	1590 ± 40	-22.4	1630 ± 40	340–540	Late James Creek
2126-1018	235063	Charcoal	Unit C4, Level 2; under Feature 1	1620 ± 40	-24.0	1640 ± 40	330–540	Late James Creek
2126-1019	235064	Charcoal	Unit C4, Level 2; under Feature 1	1610 ± 40	-24.1	1620 ± 40	350–540	Late James Creek
2126-1072-1	244924	Bone	Unit F2, Level 2	620 ± 40	-19.4	710 ± 40	1260–1310, 1360–1380	Late Maggie Creek**
2126-1166-1	244923	Bone	Unit F17, Level 2	640 ± 40	-18.5	750 ± 40	1220–1290	Late Maggie Creek
2126-1200	235549	Charcoal	Unit F17, Level 2; Feature 2 fill	1130 ± 40	-23.0	1160 ± 40	770–980	Early Maggie Creek
2126-1303	237710	Charcoal	Feature 3 fill (found during blading)	1370 ± 40	-23.5	1390 ± 40	600–680	Early Maggie Creek

* Corrected for isotopic fractionation based on the measured $^{13}C/^{12}C$ ratio.

**The A.D. 1360–1380 range for this date has a very low probability; see calibration results in Appendix D.

5.2.2. OBSIDIAN HYDRATION AND SOURCING

Obsidian hydration analysis was performed to complement the chronological information provided by radiocarbon dates and temporally diagnostic projectile points. Obsidian sourcing analysis was conducted not only for insight into mobility and trade patterns, issues that are discussed in Section 7.2, but also to enable source-specific consideration of the obsidian hydration data that are reported in this section. Obsidian hydration is used here to estimate the phase during which individual obsidian artifacts were flaked. Phase attributions for artifacts from the Paradise Valley obsidian source are based on the regional hydration chronology developed for this source by Schroedl (1995a). For material from other sources, phase attributions are based on a combination of Schroedl's (1995a) Paradise Valley chronology, the chronology for the Wild Horse Canyon source developed by Seddon (2003:452–453), and data from the BLM-Elko obsidian database (Bill Fawcett, personal communication, May 31, 2007).

Obsidian sourcing and hydration analyses were performed for all 16 obsidian artifacts recovered during the probing and data recovery phases of the project. Three of these artifacts were recovered during probing in 2006, and the rest were collected during data recovery in 2007. The obsidian artifacts include one biface, one biface fragment, and 14 pieces of debitage. The context and artifact type of each obsidian specimen are presented in Table 23.

A single obsidian flake was recovered from the surface of 26EU1533 (Figure 47). At 26EU1539, one obsidian biface fragment was collected from the surface in Collection Grid 1, Unit C4 (Figure 48). At 26EU1548 (Figure 49), one obsidian flake was collected from the surface during recordation in 2005 (specimen 1548-15-1), a second was collected during the 2006 probing project (specimen 1548-1; ST-2 was dug at the location of this specimen after it was collected), and a third was recovered during surface collection in 2007 (specimen 1548-165-1, which was recorded but not collected in 2005). All 3 obsidian flakes recovered from 26EU2064 came from surface collection during 2007 (Figure 50). Eight obsidian artifacts were recovered from 26EU2126 (Figure 51): one obsidian biface was recovered from TU1 during probing in 2006, and 7 obsidian flakes were recovered in 2007 from excavations in Operation F, which was an expansion of the 2006 TU1.

Table 23. Obsidian Artifacts Submitted for Sourcing and Hydration Analyses

Site	FS Number	Analysis Sample Number	Context	Artifact Type
26EU1533	11	1533-11-1	Surface	Debitage
26EU1539	159	1539-159-1	Surface (Collection Grid 1, Unit C4)	Biface fragment
26EU1548	200601	1548-1	Surface (2006 Probing, at location of ST-2)	Debitage
26EU1548	200615	1548-15-1	Surface	Debitage
26EU1548	165	1548-165-1	Surface	Debitage
26EU2064	77	2064-77-1	Surface	Debitage
26EU2064	77	2064-77-2	Surface	Debitage
26EU2064	401	2064-401-1	Surface	Debitage
26EU2126	200613	2126-13	Subsurface (2006 Probing, TU-1)	Biface
26EU2126	1070	2126-1070-1	Subsurface (Unit F2, Level 1)	Debitage
26EU2126	1070	2126-1070-2	Subsurface (Unit F2, Level 1)	Debitage
26EU2126	1070	2126-1070-3	Subsurface (Unit F2, Level 1)	Debitage
26EU2126	1078	2126-1078-1	Subsurface (Unit F3, Level 1)	Debitage
26EU2126	1161	2126-1161-1	Subsurface (Unit F17, Level 1)	Debitage
26EU2126	1173	2126-1173-1	Subsurface (Unit F2, Level 2)	Debitage
26EU2126	1174	2126-1174-1	Subsurface (Unit F5, Level 1)	Debitage

OBSIDIAN SOURCING METHODS

The 16 obsidian artifacts recovered from the five sites excavated during the 2007 BGMI project were submitted to Dr. Richard Hughes of Geochemical Research Laboratory in Portola Valley, California, for sourcing analyses using the energy dispersive X-ray fluorescence (edXRF) technique. Trace element concentration data (ppm) for a maximum of six elements along with their respective source assignments as determined by Dr. Hughes were reported. Table 24 gives the trace element concentration values and source assignment for each obsidian artifact analyzed. Details of edXRF equipment and calibration techniques employed by Dr. Hughes are available in Appendix E and are summarized below. Obsidian artifacts collected during the project were matched to four different obsidian sources located in Nevada, Idaho, and Utah (the locations of these sources in relation to the LBBA in are discussed in Section 7.3 and are shown in Figure 95 in that section).

Analyses were performed at Geochemical Research Laboratory on a QuanX-EC™ (Thermo Electron Scientific Instruments Corporation) edXRF spectrometer equipped with a silver (Ag) X-ray tube, a 50 kV X-ray generator, a digital pulse processor with automated energy calibration, and a Peltier-cooled solid state detector with 145 eV resolution (FWHM) at 5.9 keV (Hughes 2007; reprinted in Appendix E). The X-ray tube was operated at different voltage and current settings to optimize excitation of the elements selected for analysis. In this case, analyses were conducted for the elements rubidium (Rb Kα), and certain artifacts were analyzed to determine concentrations of the element barium (Ba Kα) and to generate iron vs. manganese (Fe Kα/Mn Kα) ratios. X-ray spectra were acquired and elemental intensities extracted for each peak region of interest, then matrix correction algorithms are applied to specific regions of the X-ray energy spectrum to compensate for inter-elemental absorption and enhancement effects. Intensities are then converted to concentrations (ppm) using a least-squares calibration line established for each element analyzed, using up to 30 international rock standards. Further information pertaining to calibration can be found in Hughes (1988, 1994). Matches between artifacts and known obsidian chemical groups were made on the basis of correspondences (at the 2-sigma level) in diagnostic trace element concentration values. Diagnostic trace elements are those concentration values allowing Dr. Hughes to draw the clearest geochemical distinctions between sources. Artifact-–to-–obsidian source correspondences were considered reliable if diagnostic mean measurements for artifacts fell within two standard deviations of mean values for source standards.

Table 24. Obsidian Artifact Chemical Concentrations (ppm) and Source Assignments

Sample Number	Rb	Sr	Y	Zr	Nb	Ba	Fe/Mn	Obsidian Source
1533-11-1	196 ± 4	11 ± 3	90 ± 3	514 ± 4	28 ± 3	0 ± 10	64	Double H Mountains, NV
1539-159-1	204 ± 4	61 ± 3	67 ± 3	486 ± 4	46 ± 3	1202 ± 12	nm*	Browns Bench, NV & ID
1548-1	341 ± 4	2 ± 3	72 ± 3	69 ± 4	15 ± 3	nm	67	Paradise Valley, NV
1548-15-1	365 ± 4	1 ± 3	73 ± 3	69 ± 4	15 ± 3	nm	81	Paradise Valley, NV
1548-165-1	333 ± 4	3 ± 3	70 ± 3	68 ± 4	15 ± 3	nm	68	Paradise Valley, NV
2064-77-1	365 ± 4	3 ± 3	73 ± 3	74 ± 4	17 ± 3	nm	71	Paradise Valley, NV
2064-77-2	375 ± 4	2 ± 3	76 ± 3	75 ± 4	15 ± 3	nm	68	Paradise Valley, NV
2064-401-1	390 ± 4	3 ± 3	78 ± 3	74 ± 4	17 ± 3	nm	78	Paradise Valley, NV
2126-13	171 ± 4	37 ± 3	20 ± 3	100 ± 4	20 ± 3	157 ± 10	22	Wild Horse Canyon, UT
2126-1070-1	343 ± 4	3 ± 3	73 ± 3	71 ± 4	15 ± 3	nm	80	Paradise Valley, NV
2126-1070-2	374 ± 4	2 ± 3	73 ± 3	73 ± 4	15± 3	nm	80	Paradise Valley, NV
2126-1070-3	369 ± 4	4 ± 3	74 ± 3	73 ± 4	14 ± 3	nm	78	Paradise Valley, NV
2126-1078-1	345 ± 4	6 ± 3	72 ± 3	71 ± 4	14 ± 3	nm	75	Paradise Valley, NV
2126-1161-1	362 ± 4	2 ± 3	79 ± 3	73 ± 4	15 ± 3	nm	85	Paradise Valley, NV
2126-1173-1	392 ± 4	2 ± 3	82 ± 4	82 ± 4	15 ± 3	nm	73	Paradise Valley, NV
2126-1174-1	349 ± 4	2 ± 3	75 ± 3	72 ± 4	16 ± 3	nm	77	Paradise Valley, NV

*nm = not measured.

OBSIDIAN SOURCING RESULTS

The source attributions for obsidian artifacts collected during the 2007 BGMI project, as determined by edXRF, are shown in Table 24. The majority (81 percent) of these artifacts were attributed to the Paradise Valley source; this is the obsidian source that is closest to the LBBA, located approximately 135 km to the west-northwest. Artifacts from this source include all obsidian specimens from sites 26EU1548 and 26EU2064, as well as 7 of the 8 specimens, all flakes, from 26EU2126. The remaining obsidian specimen from 26EU2126, a biface, is from the Wild Horse Canyon source, located in western Utah. The single obsidian artifact from

26EU1533, a piece of debitage, is from the Double H Mountains source in northwestern Nevada, and the single obsidian artifact from 26EU1539, a biface fragment, is from the Browns Bench source located along the Nevada–Idaho border to the northeast of the LBBA. As is discussed further in Section 7.2, all of the debitage recovered during the project is from the Paradise Valley source except for the Double H Mountains specimen recovered from 26EU1533, while the two obsidian biface specimens come from the more distant Browns Bench and Wild Horse Canyon sources.

OBSIDIAN HYDRATION METHODS

Following the obsidian sourcing analyses, Dr. Hughes forwarded all obsidian artifacts to Tom Origer of Origer's Obsidian Laboratory in Rohnert Park, California, for obsidian hydration analyses. Obsidian hydration analysis is a technique that measures the thickness of a hydration band that forms from the time an edge of obsidian glass is broken (Friedman and Smith 1960). Whenever measurable, Dr. Origer reported the thicknesses (in µm) of one or more hydration bands for each sample according to the methods that are outlined in his reports included in Appendix F. Table 25 gives obsidian hydration measurement information for each obsidian artifact, as well as source attributions. Three of the obsidian artifacts were too weathered for hydration band measurement, and a second hydration band on one sample (specimen 1533-11-1) was also too weathered to be measured.

For each obsidian artifact with a measurable hydration band, hydration band thickness is compared to hydration chronologies that have been developed for the region. Specimens from the Paradise Valley source are evaluated with reference to the chronology that Schroedl (1995a) has developed for this source; this chronology is presented in Table 26. Specimens from the Double H Mountains and Wild Horse Canyon sources are evaluated with reference to Schroedl's (1995a) Paradise Valley chronology as well as the chronology for the Wild Horse Canyon source developed by Seddon (2003:452–453). Results for all Eagle Rock Phase and Maggie Creek Phase artifacts are consistent with the data on projectile point hydration measurements from the BLM-Elko obsidian database (Table 27); these data (provided by BLM-Elko Archaeologist Bill Fawcett, personal communication, May 31, 2007) come from throughout northeastern Nevada and include points from all obsidian sources represented in the region.

Table 25. Obsidian Hydration Results

SWCA Sample Number	Origer Lab Number	Source	Remarks	Mean Hydration Band Thickness (µm)	Standard Deviation	Phase
1533-11-1	1.1	Double H Mountains, NV	Band 1; none	7.8	0.120	South Fork?
1533-11-1	1.2	Double H Mountains, NV	Band 2; weathered	dh*	–	–
1539-159-1	2	Browns Bench, NV/ID	Weathered	nvb**	–	–
1548-1	1	Paradise Valley, NV	None	1.4	0.050	Eagle Rock
1548-15-1	1	Paradise Valley, NV	None	1.1	0.050	Eagle Rock
1548-165-1	3	Paradise Valley, NV	Weathered	nvb	–	–
2064-77-1	4	Paradise Valley, NV	Weathered	1.3	0.040	Eagle Rock
2064-77-2	5	Paradise Valley, NV	Weathered	1.6	0.050	Eagle Rock
2064-401-1	1	Paradise Valley, NV	None	1.1	0.050	Eagle Rock
2126-13	2	Wild Horse Canyon, UT	None	1.6	0.040	Eagle Rock
2126-1070-1	2	Paradise Valley, NV	None	1.2	0.000	Eagle Rock
2126-1070-2	3	Paradise Valley, NV	None	1.8	0.050	Eagle Rock
2126-1070-3	4	Paradise Valley, NV	Weathered	1.8	0.075	Eagle Rock
2126-1078-1	5	Paradise Valley, NV	Weathered	dh	–	–
2126-1161-1	1	Paradise Valley, NV	None	3.2	0.075	Maggie Creek
2126-1173-1	1	Paradise Valley, NV	None	1.3	0.075	Eagle Rock
2126-1174-1	2	Paradise Valley, NV	None	1.3	0.080	Eagle Rock

* dh = diffuse hydration

** nvb = no visible band

Table 26. Hydration Chronology for Obsidian from the Paradise Valley Source after Schroedl (1995a)

Phase	Range (µm)
Eagle Rock	1.0–1.9
Maggie Creek	2.0–3.7
James Creek	3.8–4.9
South Fork	≥ 5.0

Table 27. Hydration Measurements for Projectile Points from the BLM-Elko Obsidian Database*

Point Type	Phase	Count	Mean	Standard Deviation	Range
Cottonwood Triangular	Eagle Rock	21	2.0	1.0	1–5.2
Desert Side-notched	Eagle Rock	60	2.4	1.6	1–8.7
Rose Springs	Maggie Creek	42	3.6	1.4	1.3–6.8
Eastgate	Maggie Creek	4	2.8	1.4	1.2–4.4

*Data provided by Bill Fawcett, BLM-Elko Archaeologist, personal communication, 2007.

OBSIDIAN HYDRATION RESULTS

The single obsidian artifact recovered from 26EU1533 has a hydration band measurement that suggests a South Fork Phase (3,200–1,500 B.C.) age. The Browns Bench obsidian biface fragment from 26EU1539 did not have a measurable hydration band. The two Paradise Valley obsidian artifacts from 26EU1548 with measurable hydration bands are both consistent with an Eagle Rock Phase (A.D. 1300–1850) age, as are the three Paradise Valley obsidian artifacts from 26EU2064.

The eight obsidian artifacts from 26EU2126 all come from Operation F; this includes the biface found during probing in 2006, which is from the test unit (TU1) that became part of Operation F in 2007. Seven of these eight specimens had measurable hydration bands, and all but one of the seven have hydration band thicknesses that suggest occupation during the Eagle Rock Phase; the other—a Paradise Valley obsidian flake—has a wider hydration band that falls within the range for the Maggie Creek Phase (A.D. 600–1300) in Schroedl's (1995a) Paradise Valley hydration chronology. The specimens with hydration bands that fall within the range for the Eagle Rock Phase consist of five Paradise Valley flakes and one Wild Horse Canyon biface. The 1.6 µm hydration band measured on the Wild Horse Canyon biface falls within the range for the Late Prehistoric period (which encompasses the LBBA Eagle Rock Phase) in Seddon's (2003:452–453) hydration chronology for obsidian from this source.

Figure 52 shows the distribution of hydration band measurements across all specimens from the Paradise Valley source recovered during the 2007 BGMI project; the large majority of obsidian artifacts collected during the project are from this source, as noted above, and the most useful hydration chronology applicable to obsidian found in the LBBA is the one that Schroedl (1995a) has developed for material from this source. If this hydration chronology is accurate, the distribution shown in this figure would suggest that the sites investigated during the project, overall, were occupied primarily during the Eagle Rock Phase, and perhaps even relatively late in this phase (compare measurements to the ranges in Table 26), with just a single specimen that is consistent with a Maggie Creek Phase age.

Figure 53 presents the distribution of hydration band measurements across all obsidian specimens recovered from Operation F at 26EU2126, the excavation block that produced over half of the obsidian artifacts with measurable hydration bands recovered during the project. This figure includes the biface from the Wild Horse Canyon source in addition to 6 flakes from the Paradise Valley source (inclusion of the Wild Horse Canyon biface in this distribution is justified since the Late Prehistoric hydration range in Seddon's chronology for this source—2.3 to 1.0 µm—is roughly equivalent to the range for the Eagle Rock Phase in Schroedl's Paradise Valley hydration chronology). This distribution likewise implies a primarily Eagle Rock Phase occupation with just a single artifact that falls within the range for the Maggie Creek Phase.

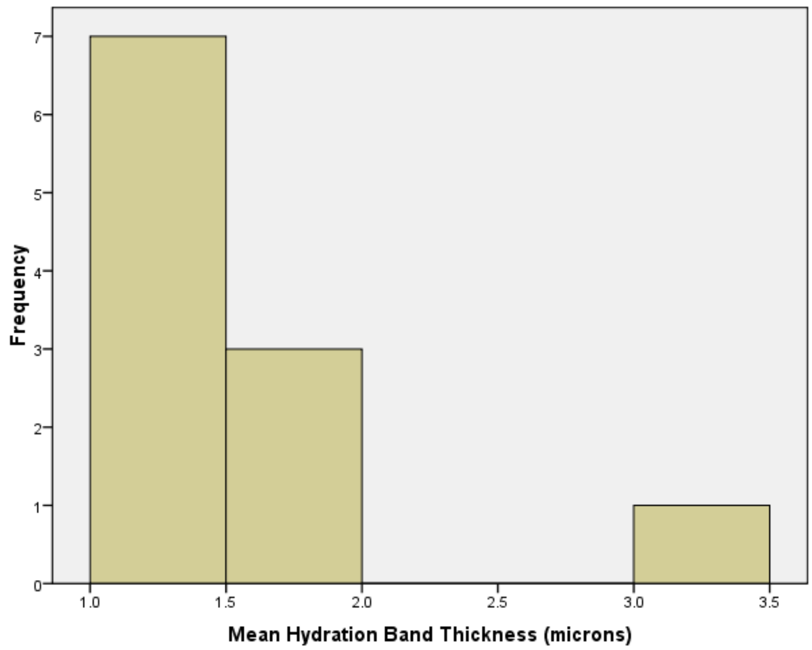

Figure 52. Histogram of hydration band thicknesses for all Paradise Valley obsidian specimens from all sites.

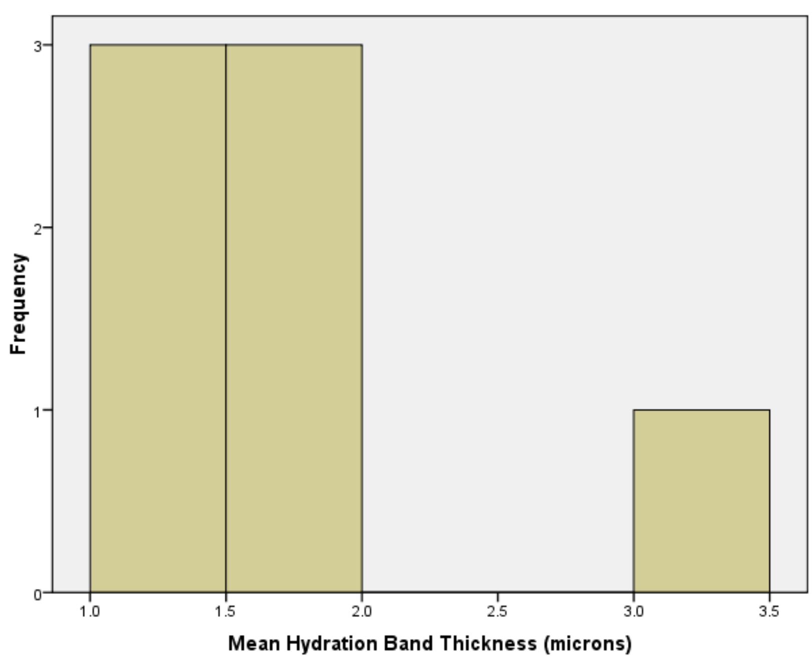

Figure 53. Histogram of hydration band thicknesses for all obsidian specimens from Operation F at 26EU2126.

5.2.3. PROJECTILE POINTS

Eleven projectile points were recovered during the 2007 BGMI project: one from 26EU1533, one from 26EU1539, four from 26EU2064, and five from 26EU2126 (Table 28). These projectile points can be classified into the following types: Gatecliff Contracting Stem, Elko Eared, Elko Corner-notched, Eastgate Expanding Stem, Cottonwood Triangular, and Desert Side-notched. Classification was conducted using Holmer's statistical analysis model, Thomas's angle analysis methodology, and a visual comparison with the typology provided by Justice (Holmer 1978; Justice 2002; Thomas 1981). The projectile points recovered during the project are discussed next by type; following this, implications of the projectile points for the chronology of occupation at each of the sites involved in the project are summarized.

Table 28. Projectile Points Collected from Sites Involved in the 2007 BGMI Project

Site Number	FS Number	Material	Holmer Classification	Thomas Classification	Justice Classification	Classification	Phase
26EU1533	1	White chert	San Rafael Side-notched	Elko Series	Elko Corner-notched	Elko Corner-notched	James Creek
26EU1539	1256	White chert	Elko Eared	Rosegate Series	Eastgate Expanding Stem	Eastgate Expanding Stem	Maggie Creek
26EU2064	206	White chert	San Rafael Side-notched	Rosegate Series	Desert Side-notched	Desert Side-notched	Eagle Rock
26EU2064	207	White chert	San Rafael Side-notched	Elko Series	Desert Side-notched	Desert Side-notched	Eagle Rock
26EU2064	438	White chert	Gypsum	Gatecliff Contracting Stem	Gatecliff Contracting Stem	Gatecliff Contracting Stem	South Fork
26EU2064	483	Dark red mottled chert	Sudden Side-notched	Elko Eared	Elko Eared	Elko Eared	James Creek
26EU2126	1051	White/gray mottled chert	San Rafael Side-notched	Unshouldered	Cottonwood Series	Cottonwood Triangular	Eagle Rock
26EU2126	1069	White and light red chert	San Rafael Side-notched	Unshouldered	Cottonwood Series	Cottonwood Triangular	Eagle Rock
26EU2126	1074	White chert with crystalline inclusions	San Rafael Side-notched	Unshouldered	Cottonwood Series	Cottonwood Triangular	Eagle Rock
26EU2126	1085	Light red chert	San Rafael Side-notched	Unshouldered	Cottonwood Series	Cottonwood Triangular	Eagle Rock
26EU2126	1096	White and light red chert	San Rafael Side-notched	Desert Side-notched	Desert Side-notched	Desert Side-notched	Eagle Rock

GATECLIFF SERIES

One projectile point from 26EU2064 (FS# 438; see Figure 54 and Figure 55) was classified to the Gatecliff series. This is a spear-point type identified by Thomas at the Gatecliff Shelter site; the series includes both a split stem and a contracting stem form, the distinction between which is strictly morphological rather than temporal (Thomas 1981:21). It has been proposed the shape of the hafting element was a function of the hunting equipment, and that the spear shaft and hafting element were designed so the stone tip would detach from the haft, making it easier to retrieve the shaft from a wounded animal (Justice 2002:292).

FS# 438 from 26EU2064 is most likely a Gatecliff Contracting Stem point, also known as a Gypsum point (Thomas 1981:23). The point is a basal fragment manufactured from white chert with evidence of heat treatment. Based upon Holmer's statistical model it was classified as a Gypsum point. Thomas's angle analysis classified this point as a Gatecliff Contracting Stem point, while the visual comparison with Justice's typology confirms Thomas's classification. All three classification systems placed this point within the Gypsum/Gatecliff Contracting Stem morphological type.

Figure 54. Photograph of Gatecliff Contracting Stem point (FS# 438) from 26EU2064.

Figure 55. Illustration of Gatecliff Contracting Stem point (FS# 438) from 26EU2064.

ELKO SERIES

Two projectile points were classified to the Elko series, which includes Elko Eared and Elko Corner-notched points. One projectile point from 26EU2064 (FS# 483; see Figure 56 and Figure 57) was classified as an Elko Eared point, a type considered to have been used for hunting small ungulates and as a light cutting tool (Justice 2002:305). One projectile point from 26EU1533 (FS# 1; see Figure 58 and Figure 59) was classified as an Elko Corner-notched point, a type that is generally considered to have been used as an atlatl dart tip. An Elko Corner-notched point that was recovered in Lincoln County, Nevada, was hafted to a dart foreshaft (Justice 2002:311). Use wear analysis on Gatecliff Shelter's Elko Corner-notched collection indicates these tools were used for multiple tasks, not just as projectile points (Justice 2002:311). Typical use fractures in the Elko series include impact and bending fractures, haft fractures, and the loss of one or both barbs (Justice 2002:299). The distinction between Elko Eared and Elko Corner-notched points is solely morphological, not temporal (Thomas 1981).

The point classified as an Elko Eared type from 26EU2064 (FS# 483) is a midsection and basal fragment manufactured from mottled dark red chert. Based upon Holmer's statistical model, the point was classified as a Sudden Side-notched point. Thomas's angle analysis classified this point as an Elko Eared type, while the visual comparison using Justice's typology confirms Thomas's classification. The results of Holmer's statistical analysis model were discarded because his Sudden Side-notched examples (Holmer 1978:52) are not visually similar in shape or form to this particular projectile point.

The point classified as an Elko Corner-notched type from 26EU1533 (FS# 1) is a basal fragment with a missing barb. It was manufactured from white chert and shows evidence of heat treatment. Based on Holmer's statistical model, this point was classified as a San Rafael Side-notched point. Thomas's angle analysis placed it in the Elko series, and a visual comparison to the typology provided by Justice narrowed it to the Elko Corner-notched type. The results of Holmer's statistical analysis model were discarded for the reasons described for the previous specimen.

Figure 56. Photograph of Elko Eared point (FS# 483) from 26EU2064.

Figure 57. Illustration of Elko Eared point (FS# 483) from 26EU2064.

Figure 58. Photograph of Elko Corner-notched point (FS# 1) from 26EU1533.

Figure 59. Illustration of Elko Corner-notched point (FS# 1) from 26EU1533.

EASTGATE EXPANDING STEM

One projectile point from 26EU1539 (FS# 1256; see Figure 60 and Figure 61) was classified as an Eastgate Expanding Stem point. Points of this type have been recovered from both Fremont- and non-Fremont-associated sites in northeastern Nevada (Hockett and Morgenstein 2003; Justice 2002). The Eastgate Expanding Stem type is thought to have been an arrow point used in the hunting of both large and small game. The placement of the notch on Eastgate points is at the base such that it does not reduce the overall length of the point edge; this characteristic distinguishes Eastgate points from Rose Spring points, which have notches that do reduce the length of the point edge (Justice 2002:331).

FS# 1256 from 26EU1539 is a basal fragment manufactured from white chert with evidence of heat treatment. Based upon Holmer's statistical model, it was classified as an Elko Eared point. Thomas's angle analysis placed this point in the Rosegate series, and a visual comparison with the typology provided by Justice narrowed it to the Eastgate Expanding Stem type. The results of Holmer's statistical model were discarded because his Elko Eared examples (Holmer 1978:33) are not visually similar in shape or form to this particular point. This point likely fell into the Elko Eared statistical range in Holmer's system by default because his system does not include the Rose Spring/Eastgate series.

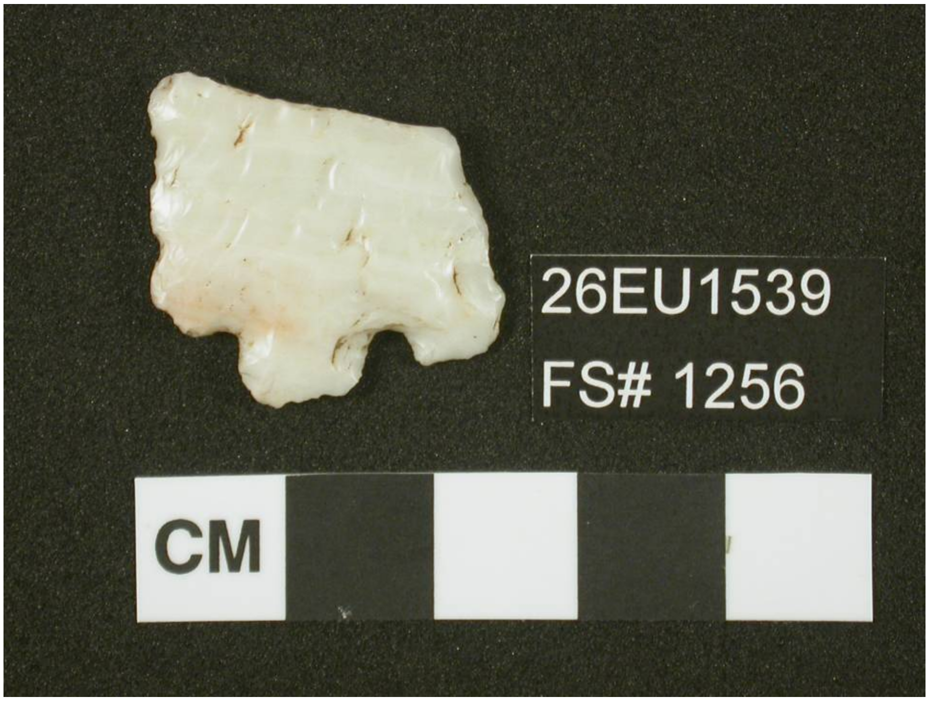

Figure 60. Photograph of Eastgate Expanding Stem point (FS# 1256) from 26EU1539.

Figure 61. Illustration of Eastgate Expanding Stem point (FS# 1256) from 26EU1539.

COTTONWOOD TRIANGULAR

Four projectile points from 26EU2126 (FS# 1051, FS# 1069, FS# 1074, and FS# 1085; see Figure 62 through Figure 69) were classified to the Cottonwood Triangular type. Cottonwood Triangular points are relatively small, lightweight, un-notched, triangular arrow points that were widely used throughout the West (Justice 2002:367). Although the Cottonwood Triangular is considered an arrow point, its shape is similar to that of a knife blade or harpoon point (Justice 2002:368). This point type is widespread across western North America and was likely used by many different cultural groups (Justice 2002).

FS# 1051 is a whole projectile point manufactured from mottled white and gray chert with evidence of heat treatment. FS# 1069 is a basal fragment manufactured from white and light red chert. FS# 1074 is a whole projectile point manufactured from white chert with crystalline inclusions and evidence of excessive heat treatment. Finally, FS# 1085 is a midsection and basal fragment manufactured from light red chert with evidence of heat treatment.

Holmer's statistical model classified all of these points to the San Rafael Side-notched type. Thomas's angle analysis methodology could not be applied to these points because they lack notching. A visual comparison with the typology provided by Justice identified these points as Cottonwood Triangular. Results based on Holmer's statistical model were discarded because his San Rafael Side-notched examples (Holmer 1978:52) are not visually similar in shape or form to these particular projectile points. These four points may have fallen into Holmer's San Rafael Side-notched statistical range simply because he did not conduct statistical analysis for the Cottonwood Triangular point type.

Figure 62. Photograph of Cottonwood Triangular point (FS# 1051) from 26EU2126.

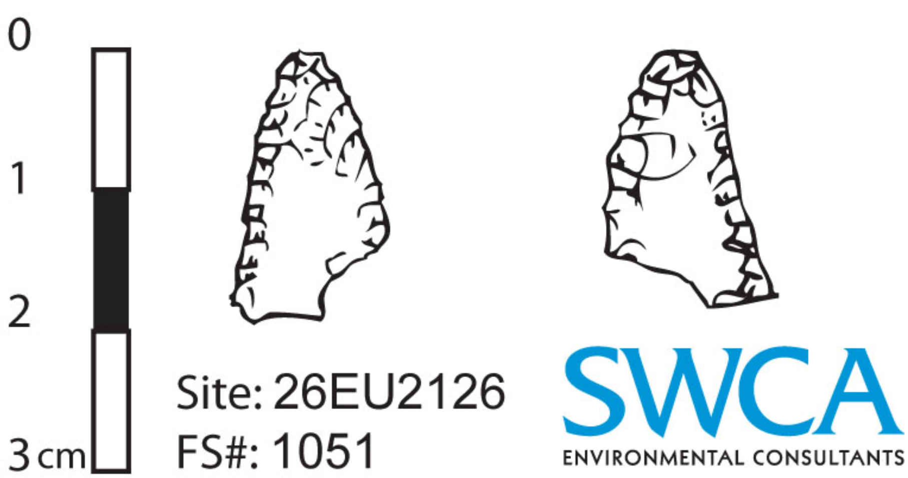

Figure 63. Illustration of Cottonwood Triangular point (FS# 1051) from 26EU2126.

Figure 64. Photograph of Cottonwood Triangular point (FS# 1069) from 26EU2126.

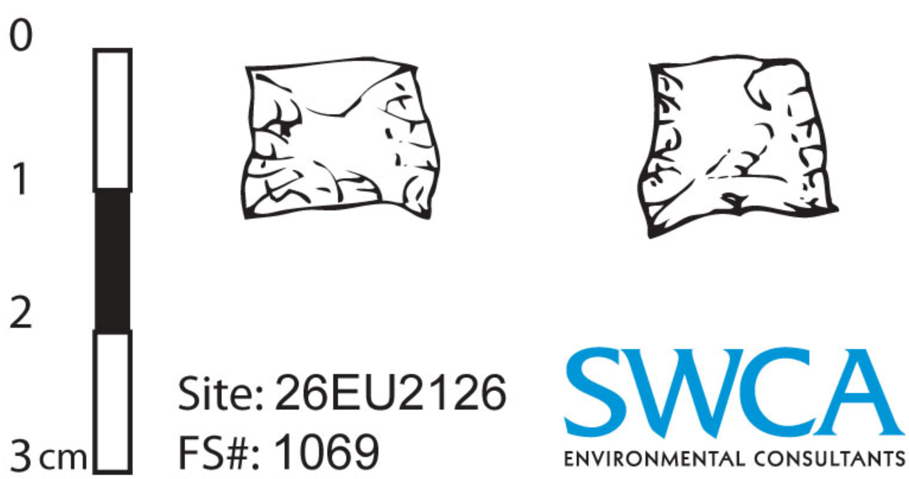

Figure 65. Illustration of Cottonwood Triangular point (FS# 1069) from 26EU2126.

Figure 66. Photograph of Cottonwood Triangular point (FS# 1074) from 26EU2126.

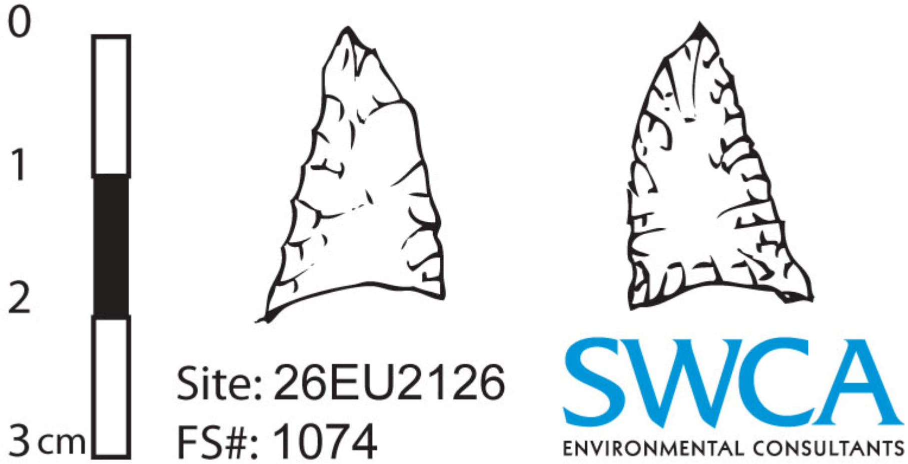

Figure 67. Illustration of Cottonwood Triangular point (FS# 1074) from 26EU2126.

Figure 68. Photograph of Cottonwood Triangular point (FS# 1085) from 26EU2126.

Figure 69. Illustration of Cottonwood Triangular point (FS# 1085) from 26EU2126.

DESERT SIDE-NOTCHED

Two projectile points from 26EU2064 (FS# 206 and FS# 207; see Figure 70 through Figure 73) and one from 26EU2126 (FS# 1096; see Figure 74 and Figure 75) were classified as Desert Side-notched points. These are associated with the bow and arrow and are suitable for the hunting of small and large game. Like the Cottonwood Triangular point type, the Desert Side-notched type was likely used by a variety of Native American groups throughout the West (Justice 2002).

FS# 206 from 26EU2064 is a basal fragment manufactured from white chert. Holmer's statistical model classified this specimen as a San Rafael Side-notched point. Thomas's angle analysis methodology placed it in the Rosegate series, and a visual comparison with the typology provided by Justice classified it as a Desert Side-notched point. The classifications based on the work of Holmer and Thomas are questionable because of the small size of this point fragment. The San Rafael Side-notched type is similar in shape, but not in size, to this projectile point; San Rafael Side-notched points are considerably larger than Desert Side-notched points. The classification based on Holmer's methodology is also questionable because Holmer did not conduct statistical analysis for the Desert Side-notched type.

FS# 207 from 26EU2064 is a whole point manufactured from white chert with evidence of heat treatment. Holmer's statistical model classified this point as a San Rafael Side-notched point. Thomas's angle analysis methodology placed it in the Elko series, and a visual comparison to the typology provided by Justice classified it as a Desert Side-notched. The classifications based on the work of Holmer and Thomas are suspect for the same reasons discussed for the previous specimen. In addition, although use of Thomas's angle analysis method placed this point in the Elko series, it does not visually compare to any Elko series point; rather, visual inspection places this point firmly with the Desert Side-notched category.

FS# 1096 from 26EU2126 is a whole point manufactured from white and light red chert with evidence of heat treatment. Holmer's statistical model classified this point as a San Rafael Side-notched point. Thomas's angle analysis methodology classified it as a Desert Side-notched point, and a visual comparison to the typology provided by Justice confirmed this classification. The classification based on the work of Holmer classification is suspect for the same reasons discussed for the previous specimens.

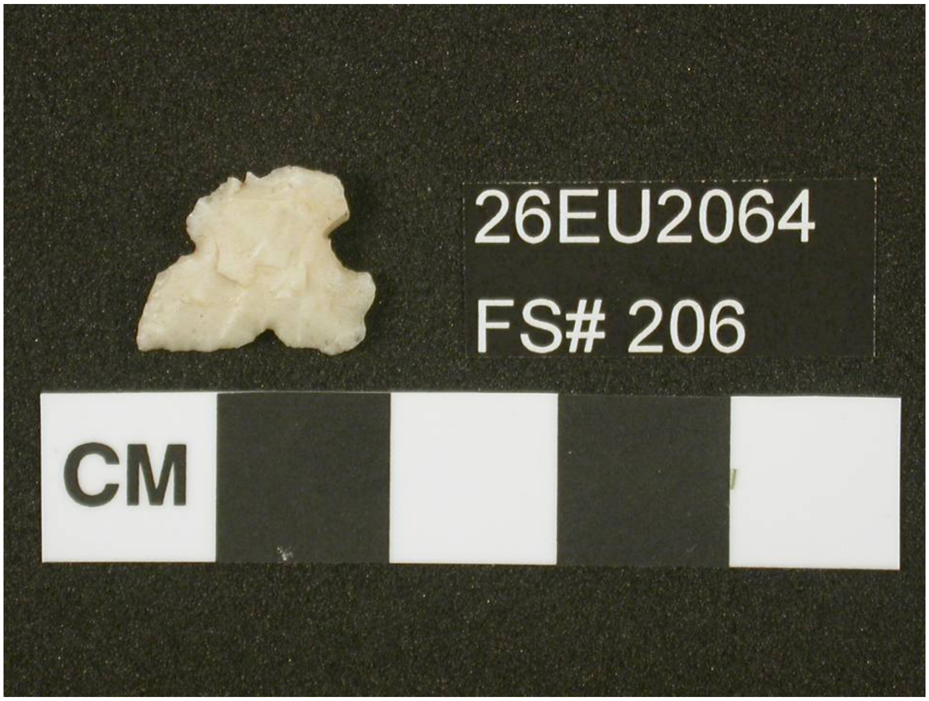

Figure 70. Photograph of Desert Side-notched point (FS# 206) from 26EU2064.

Figure 71. Illustration of Desert Side-notched point (FS# 206) from 26EU2064.

Figure 72. Photograph of Desert Side-notched point (FS# 207) from 26EU2064.

Figure 73. Illustration of Desert Side-notched point (FS# 207) from 26EU2064.

Figure 74. Photograph of Desert Side-notched point (FS# 1096) from 26EU2126.

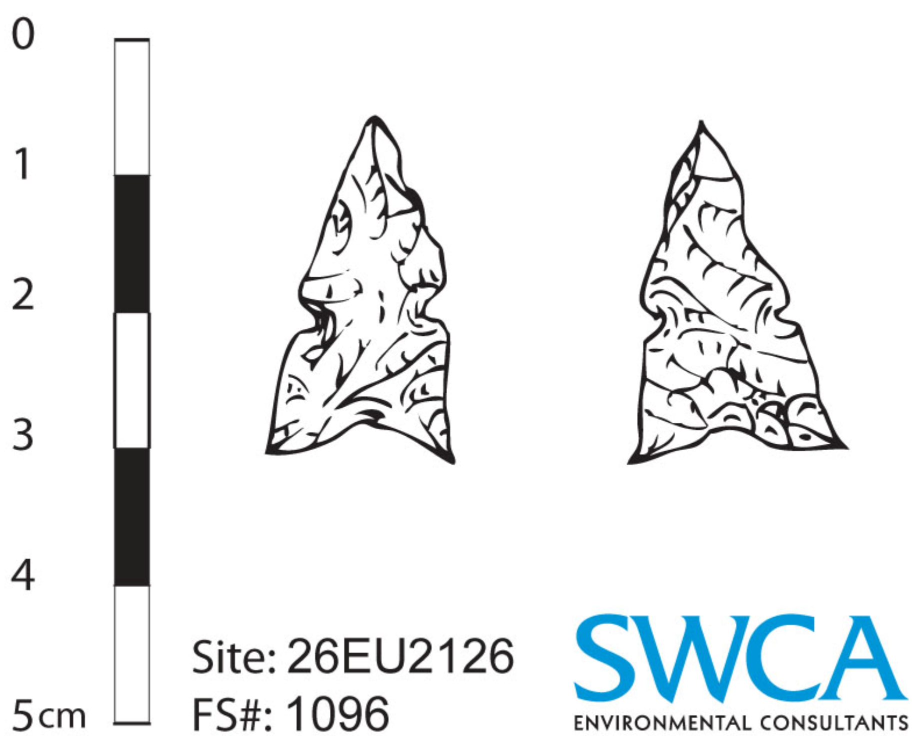

Figure 75. Illustration of Desert Side-notched point (FS# 1096) from 26EU2126.

PROJECTILE POINTS AND SITE CHRONOLOGY

The chronological implications of the points described above are briefly summarized here. Also included in this discussion are points recorded prior to the 2007 BGMI project at the sites involved in the project.

SITE 26EU1533

In 2006, SWCA observed but did not collect an Elko Corner-notched point (FS# 1) on the surface of 26EU1533. During the 2007 BGMI project, this point was relocated and collected (Figure 47), and it is described above. As discussed in Chapter 2, Elko Corner-notched points date primarily to the James Creek Phase in the LBBA but were also used both before and after this time.

SITE 26EU1539

In 2005, SWCA observed, but did not collect, a small side-notched point on the surface in the central portion of 26EU1539 (Figure 48), suggesting that the site was occupied during the Eagle Rock Phase (Cannon and Stettler 2007). This point was not relocated during either 2006 or 2007, and for that reason it is not included in the analyses presented above. However, based on the photo of this point that was taken in 2005 (Figure 76) and a visual comparison to Justice's (2002) typology, it appears to be a Desert Side-notched point, a type that dates to the Eagle Rock Phase. In 2007, SWCA collected the Eastgate Expanding Stem point (FS# 1256) that is described above. This point, found during mechanical stripping in the southern part of the site (Figure 48), suggests use of the site during the Maggie Creek Phase. Together, the two projectile points recorded at site 26EU1539 suggest that the site was occupied during both the Maggie Creek and Eagle Rock Phases.

Figure 76. Photograph of small side-notched point recorded at 26EU1539 in 2005.

SITE 26EU2064

In 1991, P-III recorded and collected a Humboldt projectile point from the surface of 26EU2064, suggesting South Fork Phase use of the site (Popek 1991a; Tipps and Popek 1992a). In 2007, SWCA collected the four diagnostic projectile points described in the previous section. These points, all of which come from the site surface, include two Desert Side-notched points (FS# 206 and FS# 207), which suggest occupation during the Eagle Rock Phase, one Gatecliff Contracting Stem point (FS# 438), which suggests occupation during the South Fork Phase, and one Elko Eared point (FS# 483), which suggests occupation during the James Creek Phase. The locations of the points collected from this site are shown in Figure 50.

SITE 26EU2126

In 1991, P-III recorded and collected a Cottonwood Triangular point fragment from the surface of 26EU2126, suggesting use of the site during the Eagle Rock Phase (Popek 1991b; Tipps and Popek 1992a); the precise location at which this point was found is unknown because it was not shown on the map in P-III's site form. In 2007, SWCA collected the five diagnostic projectile points described above, which include one Desert Side-notched point (FS# 1096) and four Cottonwood Triangular points (FS# 1051, FS# 1069, FS# 1074, and FS# 1085), all of which suggest that the site was occupied during the Eagle Rock Phase. All of these points were recovered during excavation (Figure 51). Four are from Operation F: one Cottonwood Triangular point (FS# 1069) was found in Level 1 of Unit F2, another Cottonwood Triangular point (FS# 1074) was found in Level 2 of Unit F2, a third Cottonwood Triangular point (FS# 1085) was found in Level 1 of Unit F4, and a Desert Side-notched point (FS# 1096) was found in Level 2 of Unit F6. The fifth point (FS# 1051) was a Cottonwood Triangular point found in Level 1 of Unit B3, located in Operation B.

5.3. Geoarchaeological Observations

Excavations and auger probes revealed a consistent depositional and pedogenic profile across most or all of the area of each of the sites involved in the project. Representative depictions of this profile are provided in Figure 77 and Figure 78, which show the northeast wall of Unit C4 at 26EU2126 and the south wall of Operation A at 26EU1539, respectively. Unit C4 at 26EU2126 is used for illustration here because a window trench was dug in this unit to a depth of approximately 40 cm, revealing more of the profile than was exposed in other units, most of which were dug to a depth of 20 cm. Operation A at 26EU1539 is shown here because a relatively long profile was exposed in this 4 × 1–m excavation block.

The major visual distinctions present within these profiles appear to reflect pedogenic processes (processes of soil development) rather than differences in depositional processes. Sediments are uniform in texture throughout the profiles, consisting of a silt loam with some angular and subangular gravels (generally 25 percent or less) that average approximately 2 cm in diameter. At each site, the upper sediments that were exposed in excavation appear to make up a single depositional unit that is likely the result of a combination of aeolian and alluvial processes, with some colluvial input at some sites (particularly 26EU1533, part of which is located on a steep slope). The energy of deposition and the relative contribution of different depositional processes likely varied somewhat over the time of deposition at each site, but this is reflected only in subtle gradations of sediment texture rather than in abrupt textural differences. Bioturbation due to plant roots and to rodent and insect activity has occurred throughout the sediments exposed at all of the sites investigated during the 2007 BGMI project.

A moderately developed calcic soil is present within the upper depositional unit at each site, as indicated by a series of distinct zones that were observed. The first of these zones, labeled Zone I in the profile illustrations shown in this section, extends to a depth of 10–15 cm and consists of pale brown (10YR 6/3 in Unit C4 at 26EU2126[7]), weakly laminated sediments. The laminae in this zone are thin (2–3 mm thick), easily obliterated, and lie parallel to the ground surface. This laminated zone is underlain by a zone of brown (10YR 5/3 in Unit C4 at 26EU2126) sediments that is 15–20 cm thick, here labeled Zone II. The sediments in this zone are massive in structure, enriched in calcium carbonate, and weakly cemented (though in places it is difficult to dig through them). This zone is underlain, in turn, by a zone of unconsolidated dark yellowish brown

[7] Sediment colors vary slightly both within and among sites, but the general trend of lighter colored upper zones underlain by a darker lower zone is consistent. All colors reported here were recorded by comparing dry sediments to the 2000 edition of the Munsell soil color charts.

(10YR 4/6 in Unit C4 at 26EU2126) sediments, here labeled Zone III, the bottom of which was not reached in any excavation unit or auger probe.

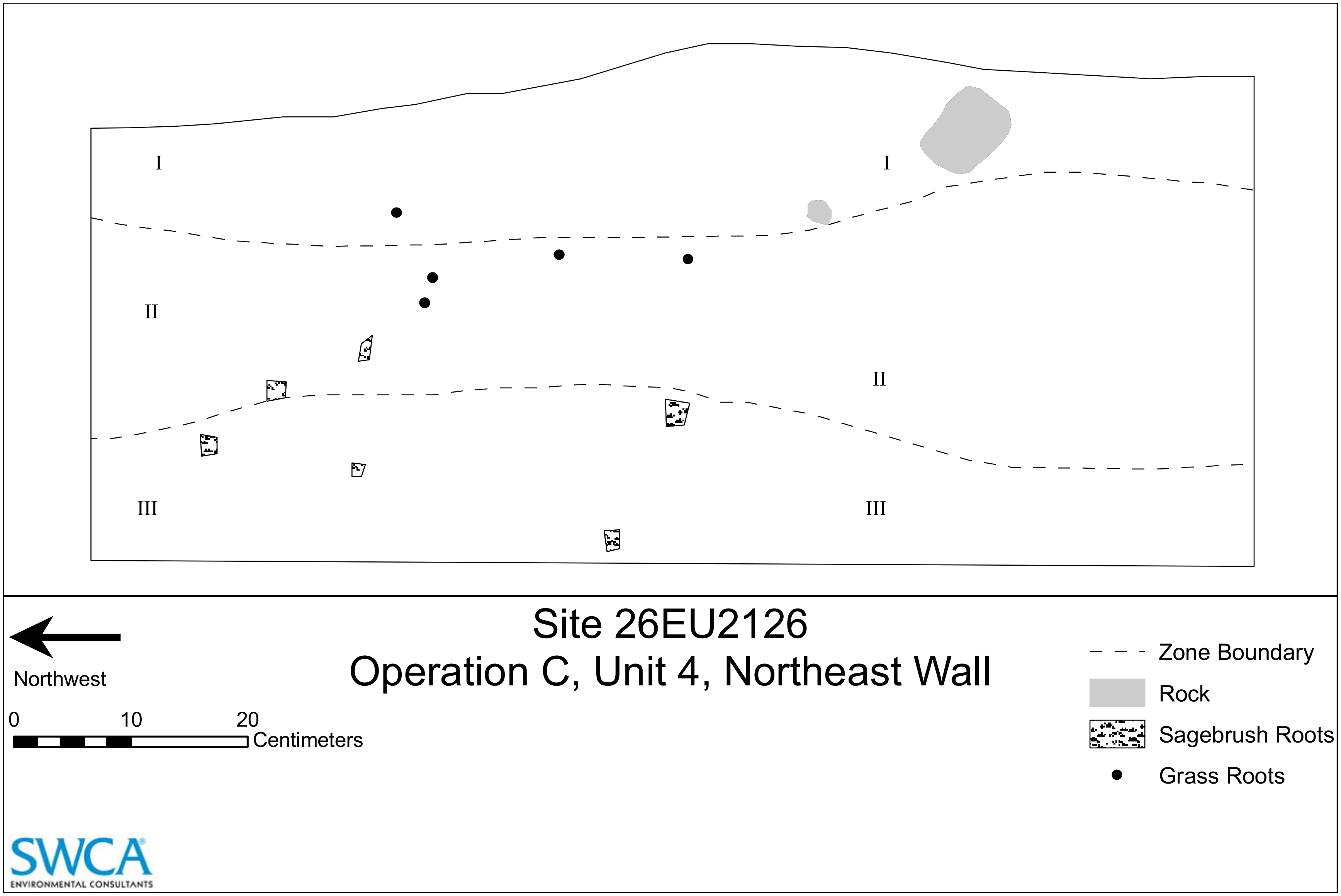

Figure 77. Profile of the northeast wall of Unit C4, 26EU2126.

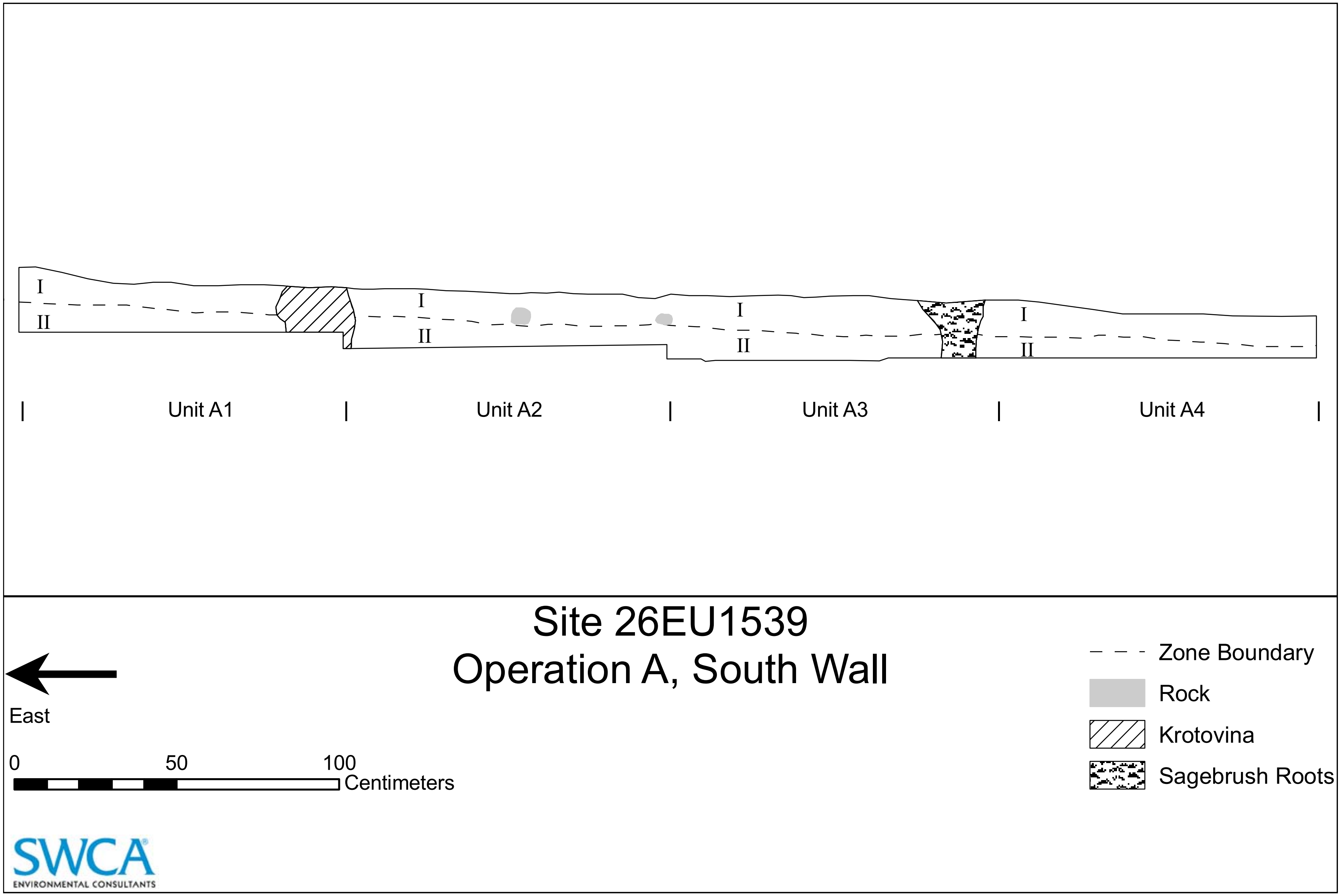

Figure 78. Profile of the south wall of Operation A, 26EU1539.

Zone II is clearly a zone of carbonate illuviation, that is, a Bk or calcic B soil horizon. The laminae in Zone I, which directly overlie Zone B, may be those of the sort that form in the uppermost portion of calcic horizons due to the plugging of pore spaces with carbonate, which renders the calcic zone impenetrable to water and leads to periodic water flow along the top of it (e.g., Birkeland 1999:129; Machette 1985). However, the calcic zones observed at the sites involved in this project do not themselves appear to be sufficiently developed to have led to the development of laminae; that is, they do not appear to have the other characteristics of Stage IV calcic soil development, such as strong cementation (Birkeland 1999; Machette 1985). Detailed sedimentological and pedological analysis, such as laboratory analyses of particle size and carbonate content, was beyond the scope of the 2007 BGMI project, but future work along these lines could clarify the nature of the soils observed during this project and the cause of the laminae that are present. Underlying Zone II is Zone III, which appears to represent a C horizon because no evidence of illuviation was observed in it. No substantial A horizon was observed in the profile, though in some cases a thin veneer of unlaminated sediments was present on top of the Zone I laminations. The absence of a substantial A horizon may be due to erosion of surface sediments and/or a lack of organic materials sufficient for the formation of a well-developed A horizon.

The soil development observed at these sites suggests that their current surfaces have been stable for some time, perhaps with only limited erosion of whatever A horizon might once have existed; further geoarchaeological analysis of the sort suggested above might enable an estimate of the length of time that these surfaces have been stable. In addition, the fact that the large majority of the archaeological materials recovered occurred either on the surface or within 20 cm of it suggests that only a small amount of deposition (likely primarily aeolian) has occurred since the time the sites began to be occupied.

Previous geoarchaeological work in the LBBA includes Birnie's (1996b) analysis of alluvial stratigraphy exposed in the cutbanks of the major creeks in the LBB, which includes field descriptions of sediments and soils, and, more relevant to the present project, LaFond and Jones's (1995) discussion of the stratigraphy at the Yaha site (26EU1997). At this site, which is located just downstream of 26EU2126 near the confluence of Rodeo and Bell Creeks, LaFond and Jones recorded three strata. The two uppermost of these, as described by LaFond and Jones, appear to be very similar to the uppermost two zones observed at 26EU2126 and other sites involved in the 2007 BGMI project. In particular, LaFond and Jones describe their Stratum 1 as having a platy structure (LaFond and Jones 1995:35), which sounds like laminations described above. However, the stratigraphic interpretation offered here differs from that of LaFond and Jones in some important ways.

First, those authors suggest that a gravel veneer at the Yaha site indicates that the current surface of the site is erosional (i.e., they suggest that the gravel veneer is a lag deposit) (LaFond and Jones 1995:35–36). However, erosion is only one of multiple processes that might form gravel veneers or desert pavements; they can also form on stable surfaces due to the expansion and contraction of clays with wetting a drying cycles (e.g., Springer 1958) or on surfaces that are aggrading due to aeolian deposition (e.g., McFadden et al. 1987), which may well have been the case for surfaces in the LBBA throughout much of the late Holocene. Thus, even though many sites in the LBBA have gravel veneers, these veneers alone do not indicate that the current surfaces of these sites have experienced extensive erosion, as the analysis of LaFond and Jones would seem to suggest. Rather, although some erosion may have occurred during the historic period due to vegetation changes associated with the introduction of domestic livestock (Birnie 1996b), the fact that an apparently recent B horizon remains intact at sites in the area suggests that such erosion has been minimal, perhaps limited to the loss of the few centimeters of A horizon that may once have been present.

A second difference between the stratigraphic interpretation offered here and that of LaFond and Jones is that those authors suggest that their Stratum 1 unconformably overlies their Stratum 2 (i.e., they suggest that there was a hiatus in deposition during which the top of Stratum 2 was a stable exposed surface). This suggestion is based on what LaFond and Jones (1995:36) describe as a "smooth and abrupt" contact between their Strata 1 and 2. During the 2007 BGMI project, no evidence of an unconformity was observed at any of the sites investigated, particularly at 26EU2126, the site located in the geomorphic setting most similar to that of the Yaha site. Instead, what was observed was that the bottom of the laminations in Zone I (likely analogous to the "Stratum 1" of LaFond and Jones) formed a relatively obvious interface with the underlying calcic horizon of Zone II (likely analogous to the "Stratum 2" of LaFond and Jones). Because there is no substantial difference in sediment texture across the transition between the two zones, and because the slight difference in color that was observed is most likely due to the accumulation of carbonate in the calcic horizon, perhaps a better explanation for the variability observed in the uppermost sediments at these sites than the one given by LaFond and Jones is that it is a result of pedogenesis rather than of a hiatus in deposition. In other words, the "smooth and abrupt" contact that LaFond and Jones note (1995:36) may just reflect the depth at which the processes responsible for the formation of the laminations were effective. With just a very few possible exceptions, described below, there is no evidence for discrete depositional events at any of the sites involved in the 2007 BGMI project.

A final difference between the stratigraphic analysis of the Yaha site and the one presented here involves the unit that LaFond and Jones label Stratum 3, which they interpret as a clay- and carbonate-rich B horizon of a truncated Pleistocene paleosol (LaFond and Jones 1995:37). Even though 26EU2126 is located just upstream of the Yaha site along Rodeo Creek, a unit similar to LaFond and Jones's Stratum 3 was not observed in Unit C4 at this site, the only profiled unit that was dug to the depth at which Stratum 3 at the Yaha site began (25–30 cm). In fact, no buried soils were found at any of the sites investigated during the 2007 BGMI project, though few excavation units were dug to a depth at which buried soils might be expected to occur.

The significance of the observations made above for archaeology in the LBBA is that there may be little reason to expect to find deposits (at least dating to the last few thousand years) in which archaeological materials from different time periods are segregated into distinct stratigraphic units. Rather, since rates of deposition in the LBBA appear to have been very low throughout the span of time to which most of the archaeological materials in the area date, since bioturbation is ubiquitous, and since no obvious unconformities (i.e., stable surfaces) that might indicate depositional hiatuses were observed during the present project, it should perhaps be expected that multicomponent deposits are the norm in the LBBA, not the exception. Single-component deposits may occur in instances where assemblages from different time periods are horizontally segregated, but if people used the same point on the landscape during more than one chronological phase, then it is quite likely that materials from those different phases will be completely intermingled on the surface and/or within the same shallow subsurface zone of deposition. This certainly seems to be the case at sites investigated in the 2007 BGMI project, and the geoarchaeological observations made during this project suggest that it is likely the case at sites throughout the LBBA.

The profile described above and illustrated in Figure 77 and Figure 78 is representative of most of the excavation units opened during this project, with just a few exceptions. These exceptions are described next.

At 26EU1533, in the two excavation areas located on the slope of the landform (Operations D and E), sediments became extremely gravelly at a depth of about 10 cm. The gravels were subangular, very poorly sorted, ranging in size from 1 to 10 cm in diameter, and they comprised 50–75 percent of the deposit. These gravels are likely the result of a combination of alluvial deposition associated with nearby Brush Creek and colluvial deposition along the slope. The gravels intergrade upwards into the less gravelly silt loam that is present at the surface of all of the sites involved in the project, and the ubiquitous calcic zone occurs above the transition to the gravels. In Operations D and E at this site, the calcic zone was thinner and closer to the surface than in most other areas excavated during the project, but also more strongly cemented.

As noted in Chapter 3, the very dense surface artifact concentration in the southern part of 26EU1539 occurred on an alluvial gravel deposit. Excavations in Operations F and G at this site revealed that the artifacts extended throughout the upper 20 cm of these gravels. The gravels are rounded and poorly sorted, ranging in size from 1 to 5 cm in diameter. They are present throughout the southern tip of the site to the south and west of a siltier alluvial terrace, and they appear to have been deposited fluvially by Boulder Creek during a period when it flowed with much higher energy than at present, likely the Pleistocene. A modern channel approximately 1 m deep is entrenched into the gravels in the southwestern part of 26EU1539, and it is likely that surface flow today occurs across the gravels adjacent to the channel after periods of heavy precipitation. Thus, the artifacts that were present in and on these gravels may have been redeposited to some extent by alluvial processes.

Figure 79 illustrates the profile of Operation G at 26EU1539, which was a 5 × 1–m trench that began in the gravels within the area of the artifact concentration and extended to the north up the terrace. The profile shows the relationship between the gravel deposit, labeled Zone IV in the figure, and the Zones I and II that are present throughout the site. Both Zones I and II are much more gravelly in this part of the site than they are elsewhere, with gravels making up 25–50 percent of the sediments in them, and the underlying gravel deposit intergrades into the siltier sediments of these zones, rather than forming a sharp contact with them. The gravels of Zone IV occur within a silt loam matrix, and the gravels make up 50–75 percent of the Zone IV deposit. Maximum gravel size decreases from approximately 5 cm in diameter in Zone IV to approximately 3 cm in diameter in Zone I. The calcic horizon, Zone II, pinches out near the toe of the terrace (approximately at the boundary between Units G1 and G1). The presence of the siltier sediments of Zone I above the more gravelly sediments of Zone IV closer to the channel axis (e.g., in Unit G1) is likely due to increased aeolian input since the time when higher fluvial energy deposited the bulk of the gravels.

Finally, in most of the units excavated at 26EU2064, a clay-rich horizon was present beginning at a depth of 10–20 cm. A representative illustration of this horizon, from Operation A at 26EU2064, is shown in Figure 80; the clay layer is labeled Zone IIt in this figure. The clay horizon was strongly cemented (and very difficult to dig through) and formed prismatic peds. It was overlain by a lighter-colored silt loam zone and underlain by a darker silt loam zone, similar to Zones I and III, respectively, as described above. At this point, it is unclear whether the clay horizon is the result of illuviation or whether it formed in situ and was subsequently covered by the siltier sediments of Zone I. The clay horizon was observed in every excavation unit at this site except for those of Operations H and I, and in the cases of Operations E and G, it was encountered only at the very bottom of the units (see Figure 13 for operation locations). As discussed in Chapter 4, the excavation units within which the clay was observed are all located in or near the bands of enhanced magnetic activity and high conductivity that are present in the remote sensing data from this site, and it is possible that the clay is somehow responsible for these geophysical features.

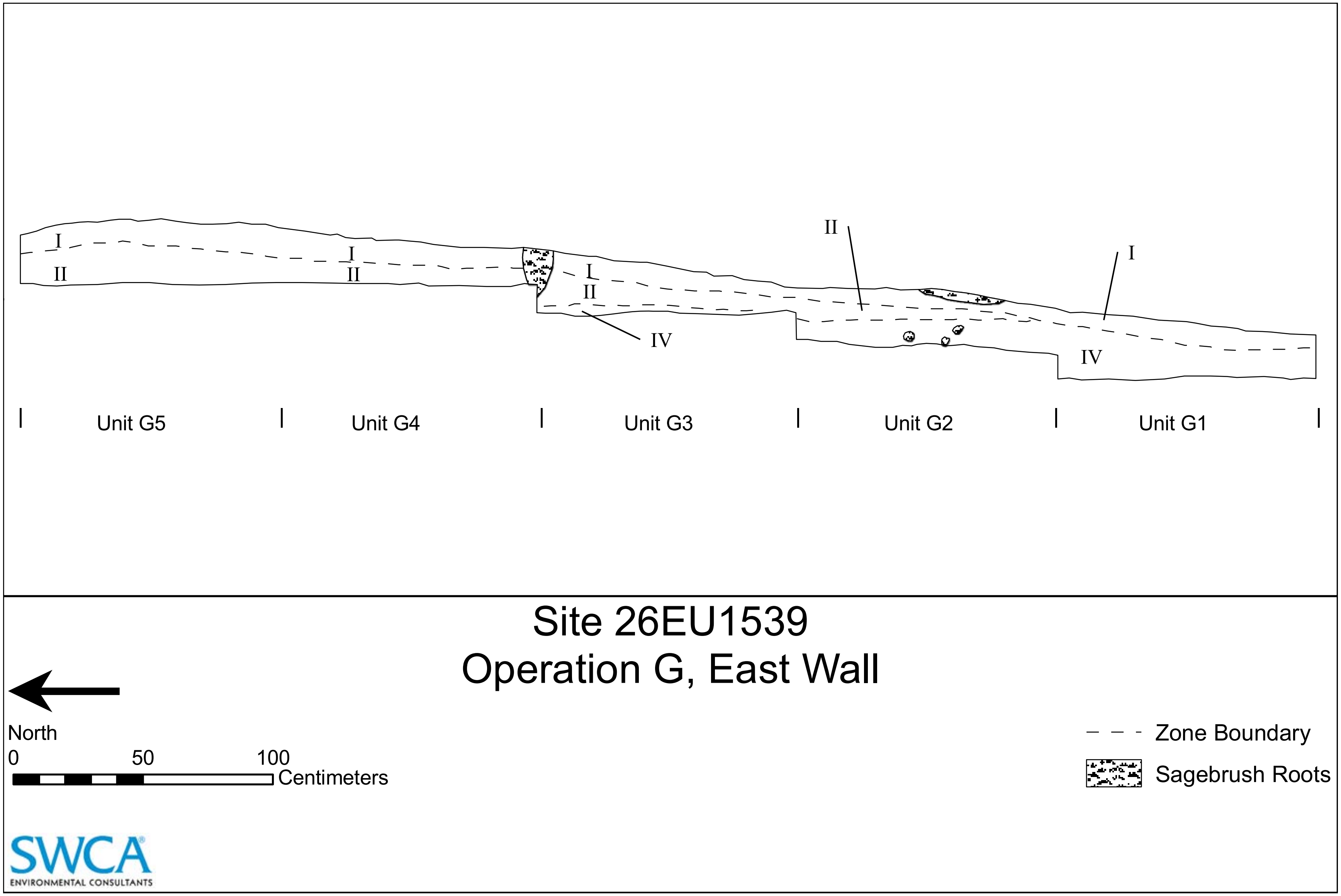

Figure 79. Profile of the east wall of Operation G, 26EU1539.

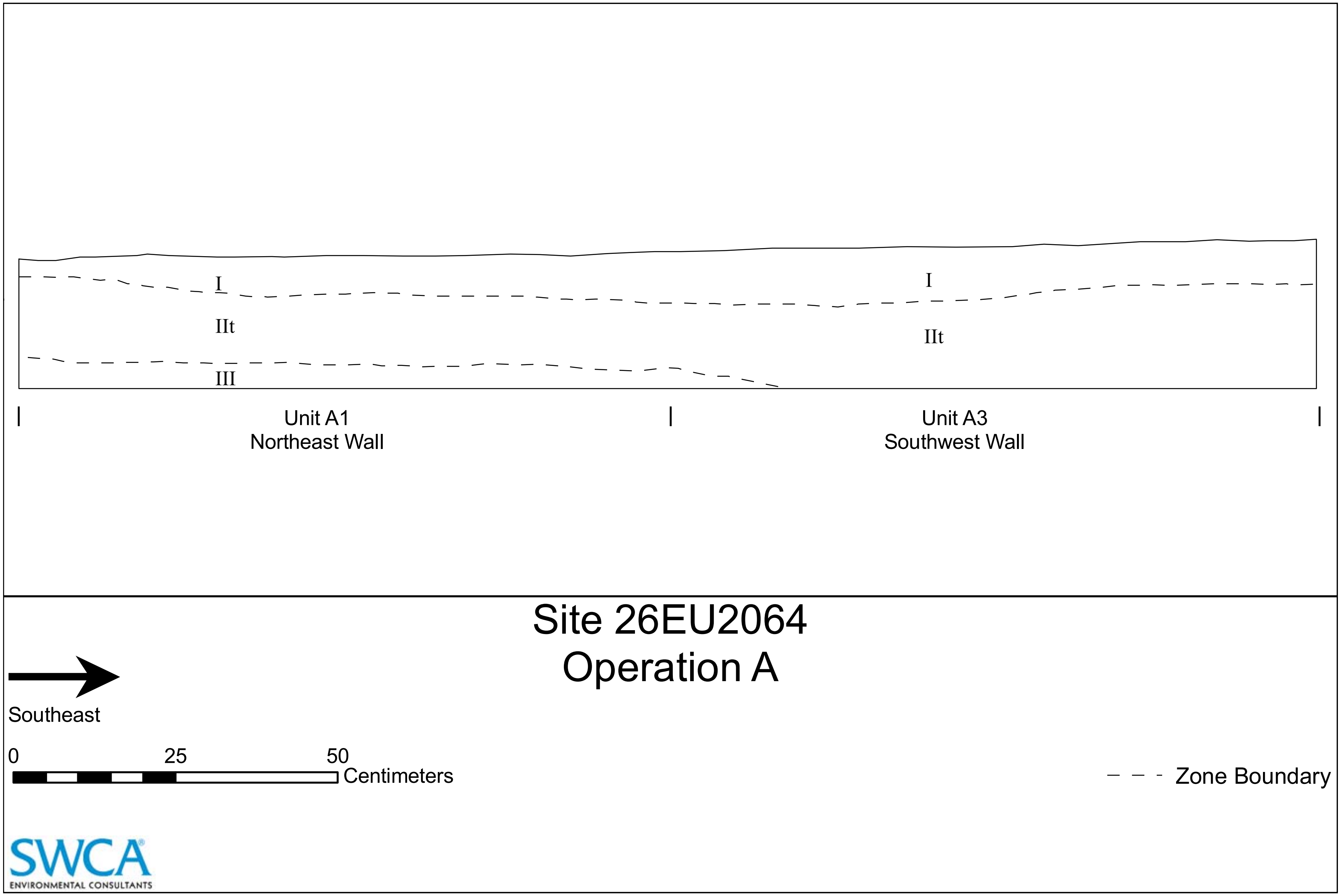

Figure 80. Profile of the northeast wall of Unit A1 and the southwest wall of Unit A3, 26EU2064.

5.4. CHRONOLOGY OF OCCUPATION AT EACH SITE

The dating evidence from sites 26EU1533, 26EU1539, 26EU1548 and 26EU2064 provided by obsidian hydration measurements and temporally diagnostic projectile points is summarized in Table 29. Dating evidence from 26EU2126, which also includes radiocarbon dates, is summarized in Table 30; due to the large number of obsidian artifacts, projectile points, and radiocarbon dates from this site, the dating evidence from it is broken down by location (excavation block or feature). The locations of the obsidian artifacts, projectile points, and radiocarbon samples that were recovered from each site are shown above in Figure 47 through Figure 51.

Information about the age of occupation at 26EU1533 comes from one Elko Corner-notched point and one obsidian artifact from the Double H Mountains source, both of which were recovered from the surface of the site around the periphery of the central surface artifact scatter (Figure 47). Elko series points are most common in the region during the James Creek Phase (1,500 B.C.–A.D. 600), though they also occur in both earlier and later contexts (Schroedl 1995b:56). The presence of this point suggests at the least that the site was occupied relatively early in the regional sequence, most likely during the Middle Archaic period. The hydration measurement on the obsidian artifact from the site falls within the range for the South Fork Phase (3,200–1,500 B.C.) in regional obsidian hydration chronologies. This is consistent in a broad sense with the Middle Archaic age suggested by the Elko Corner-notched point. Thus, while it is not possible to assign this site to a single phase within the LBBA culture history sequence, all available evidence points to occupation during the Middle Archaic.

Dating evidence from 26EU1539 consists of the Desert Side-notched point that SWCA recorded on the surface in 2005 and an Eastgate Expanding Stem point found during mechanical stripping in 2007 (Figure 48). Unfortunately, the one obsidian artifact recovered from this site (sourced to the Browns Bench source) did not have a measurable hydration band. The Eastgate point suggests occupation during the Maggie Creek Phase (A.D. 600–1300), while the Desert Side-notched point suggests occupation during the Eagle Rock Phase (A.D. 1300–1850). The Desert Side-notched point was recorded within the extensive surface artifact scatter that covered the northern and central portions of the site, whereas the Eastgate point was found near the smaller artifact concentration in the far southern part of the site, and it is tempting to conclude that the assemblages from these two parts of the site each date to a different phase. Perhaps supporting such an inference is that, as discussed in Section 7.4.1, there is a statistically significant difference between the technological flake type profiles of the northern and southern artifact clusters at this site, which may suggest that each was produced during a different occupational episode. However, since only one piece of dating information is available from each of these two parts of the site, there is not a strong, objective basis for inferring that either assemblage is single-component; each may include materials that date to a broader span of time than is indicated by a single projectile point. In addition, a difference in debitage technological profiles does not necessarily indicate a chronological difference but may instead reflect functional variability, either within a single occupation or over multiple repeated occupations. For these reasons, subsets of the material from 26EU1539 are not assigned to separate temporal periods for purposes of the analyses presented later in this report. Rather, based on the limited available chronological evidence from the site, it is most judicious to conclude simply that the site as a whole was likely used during both the Maggie Creek and Eagle Rock Phases. The evidence available from the site provides no indication of occupation prior to the Maggie Creek Phase.

No temporally diagnostic artifacts have been observed during archaeological work undertaken at 26EU1548, but three obsidian specimens from the Paradise Valley source have been collected from the surface of the site (Figure 49). Two of these have measurable hydration bands, both of which are consistent with occupation during the Eagle Rock Phase. It thus appears at face value that the site is single-component, though such a conclusion should perhaps be viewed with some caution due to the small number (relative to the size of the site) of datable artifacts from it.

Much more chronological information is available from 26EU2064. SWCA recovered four projectile points and three obsidian artifacts from this site during the 2007 BGMI project, and P-III collected an additional point during its 1991 work at the site. All of these artifacts were found in surface contexts. The projectile points include two Desert Side-notched points, both recovered within a few meters of each other near the site's northwestern boundary, as well as an Elko Eared point, a Gatecliff Contracting Stem point, and a Humboldt point that were recovered from the central portion of the discontinuous artifact scatter that was present on the terrace edge along the northeastern boundary of the site[8]. Given the known age ranges for these projectile point types, these points suggest that the site was used, at least periodically, during virtually all of the late Holocene (Table 29). The three obsidian specimens from 26EU2064 were all recovered very close to one another—two close enough to be recorded with a single GPS measurement—within a dense, relatively discrete surface artifact concentration along the terrace edge to the southeast of the Elko, Gatecliff, and Humboldt points. All three of these artifacts are from the Paradise Valley obsidian source and have hydration bands that are consistent with an Eagle Rock Phase age.

The spatial distribution of the obsidian artifacts and projectile points from 26EU2064 does not lend itself to clear definition of surface artifact concentrations that date to discrete time periods (Figure 50). The points of the earlier types (Elko, Gatecliff, and Humboldt) were all recovered from the central portion of the scatter along the terrace edge, suggesting that this area may have been the focus of Middle Archaic (South Fork and James Creek Phase) occupation. However, later Eagle Rock Phase materials were present both to the west (the two Desert Side-notched points) and to the east (the three obsidian artifacts) of this area, and the possibility that some Eagle Rock Phase material is intermingled with Middle Archaic material along the central part of the terrace edge cannot be ruled out. Technological analysis of debitage from the various concentrations at the site, discussed in detail in Section 7.4.1, does little to clarify the situation. The concentrations in the central part of the terrace that contained the earlier point types (Elko, Gatecliff, and Humboldt) do not differ significantly in flake type profile from the concentration to the southeast that produced the later obsidian hydration measurements. In addition, too few flakes were recovered from the vicinity of the two Desert Side-notched points to allow for meaningful comparison with the debitage from other parts of the site. Thus, technological differences among concentrations with datable artifacts cannot be used to support the hypothesis

[8] The location of the Humboldt point shown in Figure 50 was estimated by manually measuring it relative to the site datum on the map in P–III's site form (Popek 1991a). Thus, there is likely much more error in the location of this artifact shown in this figure than there is for the rest of the artifacts from the site, the locations of which were recorded by GPS.

that there are temporal differences among the overall assemblages from those concentrations (to the extent that technological variability might reflect chronological rather than functional variability). Other concentrations at the site do exhibit interesting and statistically significant differences in flake type profile from the site assemblage as a whole, but those concentrations contained no datable artifacts, and the potential chronological implications of these technological differences are thus unknown. Given these facts, little more can be said about the occupation of 26EU2064 than that the site as a whole was likely used from the Middle Archaic through Late Prehistoric periods.

Site 26EU2126 produced far more dating evidence than any of the other sites involved in the 2007 project (Table 30, Figure 51), and nearly all of this evidence came from subsurface contexts. Five radiocarbon dates, three of which are from a single feature, were obtained on charcoal samples collected from the site, and another two radiocarbon dates were obtained on bone samples. In addition, six temporally diagnostic projectile points were recovered, as were seven obsidian artifacts with measurable hydration bands (an eighth obsidian artifact had no measurable hydration band).

The best dated part of the site is that investigated by Operation F. Two radiocarbon dates were obtained on large mammal bone fragments that were recovered in close proximity to Feature 2, the hearth feature that was encountered in this excavation block. These dates are statistically contemporaneous, and the calibrated 2-sigma age range of their pooled mean is A.D. 1230–1300. These dates would thus place the large mammal processing event that is apparently represented in this area late in the Maggie Creek Phase or perhaps at the transition between the Maggie Creek and Eagle Rock Phases. A date on charcoal recovered from Feature 2 itself has a calibrated 2-sigma age range that falls earlier in the Maggie Creek Phase, at A.D. 770–980. As discussed above, however, there is reason to suspect that this charcoal date is erroneously old due to old wood effects. The bone dates likely provide a more accurate indication of the age of the activities associated with the hearth, falling sometime within the mid- to late A.D. 1200s.

Additional dating evidence from Operation F is provided by projectile points and obsidian hydration measurements. Four projectile points were recovered from subsurface contexts in Operation F within a few meters of Feature 2: three Cottonwood Triangular points and one Desert Side–notched point. An additional Cottonwood Triangular point was recovered during excavation of Operation B, located less than 10 meters away from Operation F. The Desert Side–notched and Cottonwood Triangular point types are considered to be characteristic of the Eagle Rock Phase in the LBBA, to which a beginning date of A.D. 1300 (or about 650 ^{14}C yrs B.P.) is generally applied (see Table 2 in Chapter 2). However, given the arbitrariness of phase boundaries and the somewhat loose association between phases and point types in the region, the presence of points of these types is not entirely inconsistent with the slightly pre-Eagle Rock bone radiocarbon dates from Operation F[9]. Hydration measurements on six of the seven obsidian artifacts recovered from Operation F likewise fall within ranges for the Eagle Rock Phase in regional obsidian chronologies (Schroedl 1995a; Seddon 2003), but again, because obsidian

[9] Alternatively, if Late Prehistoric arrow point types such as Desert Side–notched and Cottonwood Triangular are to be used as diagnostics of the Eagle Rock phase in the LBBA, the bone radiocarbon dates from Operation F at 26EU2126 may suggest that the beginning date for this phase should be moved slightly earlier, to perhaps about 730 ^{14}C yrs B.P. (or about cal A.D. 1275).

hydration is somewhat imprecise as a dating method, these measurements are not entirely inconsistent with the bone radiocarbon dates. The seventh obsidian artifact has a thicker hydration band that suggests an earlier Maggie Creek Phase age. This artifact may be the result of some limited earlier use of the site, it may be from an older piece of obsidian that was curated and deposited by later occupants of the site, or it may simply have an aberrant hydration value.

Overall, though, the bulk of the considerable dating evidence from Operation F, when potential old wood effects are taken into account, suggests occupation during the mid- to late A.D. 1200s. The somewhat large numbers of Eagle Rock Phase diagnostic projectile points and obsidian hydration measurements from Operation F may indicate some post–A.D. 1300 use of this area as well. However, the relatively discrete nature of the Operation F bone and artifact concentration and the lack of evidence for long-term or repeated use (e.g., formal features or substantial ground stone) suggest that the materials encountered are the result of a fairly short duration event. In other words, everything found in Operation F could be accounted for by a single, short-term occupational episode that occurred sometime in the mid- to late A.D. 1200s.

Deposits in Operation C at 26EU2126 are dated by three radiocarbon dates on charcoal specimens recovered from the base of Feature 1, the FCR concentration found in Unit C4. These three dates are statistically contemporaneous, with a pooled mean that has an inclusive calibrated 2-sigma age range of A.D. 380–530. These dates might place the age of the feature near the end of the James Creek Phase, but, as noted above, there is also a strong possibility that they are erroneously old due to old wood effects. For this reason, and because no diagnostic projectile points or obsidian artifacts were recovered from the vicinity of Operation C, it is unclear whether materials from this part of the site truly pre-date those in other parts of the site—particularly the Operation F area—or are coeval with them. As is discussed further in Section 7.4.1, the technological flake type profile of the debitage concentration that was present in the vicinity of Operation C is similar to the profile of the Operation F assemblage, which may suggest contemporaneity, though this comparison is hindered by the very small size of the Operation C sample.

Feature 3 at 26EU2126, an FCR concentration found in blading that is similar to Feature 1, is dated by a radiocarbon determination on charcoal collected from the small amount of ashy fill that was associated with this feature. This date has a calibrated 2-sigma age range of A.D. 600–680, a couple of centuries younger than the dates obtained from Feature 1. This date might place the deposition of Feature 3 in the early Maggie Creek Phase, but, as with Feature 1, it may also be innacurate due to old wood effects. No artifacts were found in blading near Feature 3, though a very few were recovered during surface collection within a few meters of its location.

Finally, P–III collected an additional Cottonwood Triangular point from the surface of site in 1991, but their site form from this recordation (Popek 1991b) does not describe the location where this point was found, nor is the point shown on the site map that accompanies the form. This point, at the least, provides some further evidence for occupation of the site late in the LBBA prehistoric chronological sequence.

To summarize the conclusions that can be drawn about the chronology of occupation at 26EU2126, it seems clear that the part of the site investigated by Operation F was used sometime during the mid- to late A.D. 1200s. It is possible that some later Eagle Rock phase use of this area occurred as well, but this seems unlikely given the lack of clear evidence for long-term or repeated occupation here. Rather, it appears that this part of the site was the location of a relatively short duration occupational episode that included the processing of large mammals. Earlier use of the site, perhaps during the late James Creek Phase and the early Maggie Creek Phase, may be indicated by radiocarbon dates from Features 1 and 3, both of which appear to be the result of FCR dumping episodes. However, there is also a strong likelihood that these dates are erroneously old due to old wood effects. It is not possible to definitively conclude based on the available evidence whether the activities investigated in Operations F and C, the two most productive areas of the site, were contemporaneous.

Table 29. Summary of Dating Evidence from 26EU1533, 26EU1539, 26EU1548, and 26EU2064

Site	Dating Evidence	Context	Project	Phase	Artifact Analysis Period
26EU1533	Elko Corner-notched point (FS# 1)	Surface	SWCA 2007 collection	James Creek	Middle Archaic
	Obsidian debitage (Sample # 1533-11-1; Double H Mountains source, 7.8 μm band)	Surface	SWCA 2007 collection	South Fork	
26EU1539	Desert Side-notched point (not collected)	Surface	SWCA 2005 recordation	Eagle Rock	Late Archaic/Late Prehistoric
	Eastgate Expanding Stem point (FS# 1256)	Sub-surface	SWCA 2007 blading	Maggie Creek	
26EU1548	Obsidian debitage (Sample # 1548-1; Paradise Valley source, 1.4 μm band)	Surface	SWCA 2006 probing	Eagle Rock	Late Archaic/Late Prehistoric
	Obsidian debitage (Sample # 1548-15-1; Paradise Valley source, 1.1 μm band)	Surface	SWCA 2005 recordation	Eagle Rock	
26EU2064	Desert Side-notched point (FS# 206)	Surface	SWCA 2007 collection	Eagle Rock	n/a (palimpsest)
	Desert Side-notched point (FS# 207)	Surface	SWCA 2007 collection	Eagle Rock	
	Elko Eared point (FS# 483)	Surface	SWCA 2007 collection	James Creek	
	Gatecliff Contracting Stem point (FS# 438)	Surface	SWCA 2007 collection	South Fork	
	Humboldt point (collected by P-III)	Surface	P-III 1991 recordation	South Fork	
	Obsidian debitage (Sample # 2064-77-1; Paradise Valley source, 1.3 μm band)	Surface	SWCA 2007 collection	Eagle Rock	
	Obsidian debitage (Sample # 2064-77-2; Paradise Valley source, 1.6 μm band)	Surface	SWCA 2007 collection	Eagle Rock	
	Obsidian debitage (Sample # 2064-401-1; Paradise Valley source, 1.1 μm band)	Surface	SWCA 2007 collection	Eagle Rock	

Table 30. Dating Evidence from 26EU2126, Grouped by Location Within the Site

Location	Dating Evidence	Context	Project	Phase	Artifact Analysis Period
Operation F	Two statistically contemporaneous radiocarbon dates (bone from near Feature 2; cal 2-sigma range for pooled mean date: A.D. 1230–1300)	Sub-surface	SWCA 2007 excavation	Late Maggie Creek	Late Archaic/Late Prehistoric
	Radiocarbon date (charcoal from Feature 2 fill; cal 2-sigma range: A.D. 770–980)	Sub-surface	SWCA 2007 excavation	Early Maggie Creek	
	Cottonwood Triangular point (FS# 1069; Unit F2, Level 1)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Cottonwood Triangular point (FS# 1074; Unit F2, Level 2)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Cottonwood Triangular point (FS# 1085; Unit F4, Level 1)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Desert Side-notched point (FS# 1096; Unit F6, Level 2)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Obsidian biface (Sample # 2126-13; TU1, Level 3; Wild Horse Canyon source, 1.6 µm band)	Sub-surface	SWCA 2006 probing	Eagle Rock	
	Obsidian debitage (Sample # 2126-1070-1; Unit F2, Level 1; Paradise Valley source, 1.2 µm band)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Obsidian debitage (Sample # 2126-1070-2; Unit F2, Level 1; Paradise Valley source, 1.8 µm band)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Obsidian debitage (sample # 2126-1070-3; Unit F2, Level 1; Paradise Valley source, 1.8 µm band)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Obsidian debitage (Sample # 2126-1173-1; Unit F2, Level 2; Paradise Valley source, 1.3 µm band)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Obsidian debitage (Sample # 2126-1174-1; Unit F5, Level 1; Paradise Valley source, 1.3 µm band)	Sub-surface	SWCA 2007 excavation	Eagle Rock	
	Obsidian debitage (Sample # 2126-1161-1; Unit F17, Level 1; Paradise Valley source, 3.2 µm band)	Sub-surface	SWCA 2007 excavation	Maggie Creek	
Operation B	Cottonwood Triangular point (FS# 1051; Unit B3, Level 1)	Sub-surface	SWCA 2007 excavation	Eagle Rock	n/a
Operation C	Three statistically contemporaneous radiocarbon dates (charcoal samples from under Feature 1; inclusive cal 2-sigma range for pooled mean date: A.D. 380–530)	Sub-surface	SWCA 2007 excavation	Late James Creek	n/a
Feature 3	Radiocarbon date (charcoal from Feature 3 fill; cal 2-sigma range: A.D. 600–680)	Sub-surface	SWCA 2007 excavation	Early Maggie Creek	n/a
Unknown	Cottonwood Triangular point (collected by P-III; location not shown on P-III site form)	Surface	P-III 1992 recordation	Eagle Rock	n/a

5.4.1. Periods for Analysis of Temporal Change

Sites or site loci are here assigned to time periods based on the above discussion of the chronology of occupation at each site so that analyses of change over time, particularly in lithic assemblages, can be conducted in subsequent chapters of this report. As noted at the outset of this chapter, and as should be clear from the discussion above, it is not possible to assign most sites or site loci to individual phases within the LBBA culture history sequence; however, it is possible to assign most of them to somewhat broader time periods.

Two such periods are used here: an earlier Middle Archaic period, which incorporates materials that can be assigned to the South Fork and/or James Creek Phases, and a later Late Archaic/Late Prehistoric period, which incorporates materials that can be assigned to the Maggie Creek and/or Eagle Rock Phases. Of course, these periods do not provide as great a degree of chronological resolution as might be hoped for under ideal circumstances. In particular, by combining the Maggie Creek and Eagle Rock Phases, the Late Archaic/Late Prehistoric period potentially mixes materials that date both before and after the hypothesized migration of Numic speakers into the region, precluding consideration of changes associated with what may have been on of the most significant events in Great Basin prehistory (e.g., Madsen and Rhode 1994; see also Hockett and Morgenstein 2003 for a discussion more specific to the LBBA and surrounding region). However, given that it is not possible to definitively conclude that most of the sites investigated in the 2007 BGMI project are single-component, these periods are the only defensible ones that can be used in many cases. In addition, while some sites or site loci do appear more clearly to be single-component—particularly the Operation F area at 26EU2126 and perhaps also site 26EU1548—it is advantageous for reasons of sample size to combine these assemblages into a single sample that spans a broader period of time. Though not ideal, the analysis periods that are used here do allow some exploration of change over time. The period to which materials from each site or site locus are assigned is shown in the far right columns of Table 29 and Table 30.

All materials from 26EU1533 are assigned to the Middle Archaic analysis period. As noted above, the available dating evidence from this site points to occupation during the South Fork and/or James Creek Phases, and there is no indication of later use of this site. The complete assemblages from 26EU1539 and 26EU1548 are assigned to the Late Archaic/Late Prehistoric analysis period. The limited available evidence from 26EU1548 indicates occupation during the Eagle Rock Phase, while that from 26EU1539 suggests occupation during both of the Eagle Rock and Maggie Creek Phases, and there is not a strong basis for attributing subsets of the 26EU1539 assemblage to one or the other of these two phases.

Materials from 26EU2064 are not included in any analysis of change over time. As discussed above, there is evidence that this site was occupied throughout the late Holocene, and it is not possible to define clusters of artifacts at this site that can defensibly be assigned to any shorter period within the late Holocene.

Materials from the site locus investigated by Operation F at 26EU2126, both from subsurface contexts and from the surface artifact scatter that was present in the vicinity of this excavation block, are assigned to the Late Archaic/Late Prehistoric period. As discussed above, it appears that this part of the site was the location of a relatively short duration occupational event sometime in the mid- to late A.D. 1200s. This age range, which comes from radiocarbon dates on bone, falls very late in the period of time generally associated with the Maggie Creek Phase, while the projectile points and most of the obsidian hydration measurements from Operation F are more typical of the Eagle Rock Phase. The remainder of the materials from 26EU2126 are not included in analyses of change over time. Operation C is dated only by the potentially problematic radiocarbon dates from Feature 1. No artifacts were recovered in the immediate vicinity of Feature 3 (which was found in blading), and, aside from the Cottonwood Triangular point found in Operation B, only two flakes were found in this excavation block; there is thus little reason to assign these contexts to time periods for purposes of artifact analysis. For the few remaining artifacts from surface contexts or other excavation areas at this site, no direct dating information exists.

6. SUBSISTENCE EVIDENCE

Nicci Barger, George Cox, Emily Root-Garey, and Michael D. Cannon

Although addressing research questions about subsistence was not a primary focus of the 2007 BGMI Data Recovery Project, some data relevant to issues of subsistence were recovered. These data are presented in this chapter and, to the extent possible, are applied to research questions that derive from the 1991 historic context for the LBBA or from work conducted since that time. Recovered materials applicable to these research questions, and discussed in this chapter, include faunal remains, macrobotanical specimens collected from flotation samples, and ground stone artifacts.

6.1. FAUNAL REMAINS

During the 2007 BGMI project, a total of 307 faunal specimens were recovered, all from 26EU2126. Faunal remains were found in Operations C, F (including ST3 and TU1 excavated in 2006), and O. One bird specimen was recovered, and the remaining specimens are from mammals. The faunal assemblage is composed primarily of fragmentary specimens, with only three complete elements. In all, 77 percent of the specimens are burned and three specimens exhibit cut marks. The analysis of this assemblage is focused on identifying the taxa that were used prehistorically at 26EU2126 and on providing such additional information about subsistence strategies as is possible.

6.1.1. METHODS

All faunal remains were collected during excavation using 1/4" mesh screens. These remains were identified to taxon in the lab using a comparative skeletal collection. Prior to beginning the analysis, a list of mammal species that currently occur in the vicinity of the LBBA was compiled (Table 31). While it was kept in mind that species not currently present in the area might have occurred here in the past, this list provided guidance regarding the taxa most likely to be encountered during the analysis. Specimens were identified to the lowest taxonomic level possible, and the number of identified specimens (NISP) was tabulated for each taxon in each provenience. Skeletal element, portion, side, age-related data (degree of epiphyseal fusion), and taphonomic surface modifications (cut marks, burning, weathering, root etching, and carnivore or rodent modification) were also recorded. Burning was recorded as not burned, burned (recognized by blackening of the bone), or calcined (recognized as whitening of the bone, which occurs as a result of a longer burn period and/or a higher burn temperature).

In addition to taxonomic identification, all faunal specimens, including unidentified specimens, were assigned to a size class adapted from Thomas's mammal size classification (Thomas 1969). Size classes are defined as Size Class 6, Very Large Mammal (elk, bison); Size Class 5, Large Mammal (deer, sheep); Size Class 4, Medium Mammal (coyote, badger); Size Class 3, Small Mammal (leporid, marmot); Size Class 2, Very Small Mammal (squirrel, gopher); Size Class 1, Micromammal (mouse, vole); and Size Class 0, Indeterminate size class. If a specimen might have fallen into either of two adjacent size classes, an intermediary size class of .5 was assigned; for example, a specimen was given a size class designation of 5.5 if it might have come either from a Very Large (Size Class 6) or a Large (Size Class 5) Mammal. Specimens whose size class could not be determined to this level were classified as Size Class 0/Indeterminate.

Table 31. List of Mammal Species Present in the LBBA in Historic Times

Common Name	Scientific Name
Order Insectivora	
Family Soricidae	
Merriam's shrew	*Sorex merriami*
Vagrant shrew	*Sorex vagrans*
Water shrew	*Sorex palustris*
Order Carnivora	
Family Procyonidae	
Raccoon	*Procyon lotor*
Family Mustelidae	
Subfamily Lutrinae	
Northern river otter	*Lontra canadensis*
Subfamily Mustelinae	
American mink	*Mustela vison*
Badger	*Taxidea taxus*
Long-tailed weasel	*Mustela frenata*
Short-tailed weasel (ermine)	*Mustela erminea*
Family Mephitidae	
Spotted skunk	*Spilogale gracilis*
Striped skunk	*Mephitis mephitis*
Family Canidae	
Coyote	*Canis latrans*
Gray wolf (extirpated)	*Canis lupus*
Kit fox (includes Swift fox [*V. macrotis*])	*Vulpes velox*
Red fox	*Vulpes vulpes*
Family Felidae	
Bobcat	*Lynx rufus*
Mountain lion/puma/cougar	*Felis concolor*
Order Rodentia	
Family Sciuridae	
Subfamily Xerinae	
Belding's ground squirrel	*Spermophilus beldingi*
Golden-mantled ground squirrel	*Spermophilus lateralis*
Least chipmunk	*Tamias minimus*
Merriam's ground squirrel	*Spermophilus canus*
Piute ground squirrel	*Spermophilus mollis*
Uinta (Say) chipmunk	*Tamias umbrinus*
White-tailed antelope ground squirrel	*Ammospermophilus leucurus*
Wyoming ground squirrel	*Spermophilus elegans*
Yellow-bellied marmot	*Marmota flaviventris*

Table 31, continued

Family Geomyidae	
Northern pocket gopher	*Thomomys talpoides*
Southern (Botta's) pocket gopher	*Thomomys bottae*
Townsend pocket gopher	*Thomomys townsendii*
Family Heteromyidae	
Subfamily Perognathinae	
Great Basin pocket mouse	*Perognathus parvus*
Little pocket mouse	*Perognathus longimembris*
Subfamily Dipodomyinae	
Chisel-toothed kangaroo rat	*Dipodomys microps*
Dark Kangaroo mouse	*Microdipodops megacephalus*
Ord's Kangaroo rat	*Dipodomys ordii*
Family Castoridae	
Beaver	*Castor canadensis*
Family Dipodidae	
Subfamily Zapodinae	
Western jumping mouse	*Zapus princeps*
Family Cricetidae	
Subfamily Neotominae	
Bushy-tailed woodrat (packrat)	*Neotoma cinerea*
Canyon mouse	*Peromyscus crinitus*
Deer mouse	*Peromyscus maniculatus*
Desert woodrat (packrat)	*Neotoma lepida*
Northern grasshopper mouse	*Onychomys leucogaster*
Pinyon mouse	*Peromyscus truei*
Western harvest mouse	*Reithrodontomys megalotis*
Subfamily Arvicolinae	
Long-tailed vole	*Microtus longicaudus*
Montane vole	*Microtus montanus*
Muskrat	*Ondatra zibethicus*
Sagebrush vole	*Lemmiscus curtatus*
Family Erethizontidae	
Porcupine	*Erethizon dorsatum*
Order Lagomorpha	
Family Ochontonidae	
American Pika	*Ochotona princeps*

Table 31, continued

Family Leporidae	
Black-tailed jackrabbit	*Lepus californicus*
Mountain cottontail	*Sylvilagus nuttalli*
Pygmy cottontail	*Brachylagus idahoensis*
White-tailed jackrabbit	*Lepus townsendii*
Order Artiodacyla	
Family Cervidae	
Elk	*Cervus elaphus*
Mule deer	*Odocoileus hemionus*
Family Antilocapridae	
Pronghorn antelope	*Antilocapra americana*
Family Bovidae	
American bison	*Bison bison*
Bighorn sheep	*Ovis canadensis*

Note: List includes species reported within a 50 mile radius of the BGMI project area with the exception of bats and introduced species. Compiled from Burt and Grossenheider (1980), Hall (1946), Kays (2002), and Zeveloff (1988).

6.1.2. Taxonomic Composition

A small portion of the faunal assemblage was identified to three genera: *Lepus*, *Cervus,* and *Spermophilus*. The remaining specimens could only be identified to higher-level taxa including Aves, Artiodactyla, Cervidae, Leporidae, Rodentia, and Arvicolinae. The assemblage consists of 37 specimens identified at least to the level of order and 270 specimens that could not be identified to this level.

One size category, Very Large/Large Mammal, dominates the overall assemblage, while one genus, *Lepus* (jackrabbit), dominates the specimens that could be identified to the generic level. The Very Large/Large Mammals were recovered primarily from Operation F, and *Lepus* remains were found only in Operation O. The remaining taxa are uncommon and were found within Operations O and F. These are the class Aves, the orders Artiodactyla and Rodentia, and the family Leporidae. No remains of reptiles, amphibians, or fishes were recovered.

It was first necessary to distinguish faunal remains deposited by humans from those introduced in other ways, and three identified specimens were determined to most likely not be archaeological. These are a *Spermophilus* sp. (ground squirrel) mandible from Unit F14, Level 2, an Arvicoline (vole) skull from Unit O2, Level 2, and an unidentified rodent sacrum from Operation F, TU1, Level 3. Small mammals (i.e., rodents) were typically roasted and consumed whole in the Great Basin (Steward 1943:304). The three rodent specimens mentioned above are the only complete rodent elements in the entire assemblage, and none of them show any signs of burning, polishing, weathering, or root etching. Thus, although rodent taxa are known to have been used ethnographically in this area, there is no evidence for human involvement in the deposition of the rodent specimens recovered during this project. The discussion of the faunal remains from this point on therefore considers only the remaining 304 total specimens (34 identified, 270 unidentified), and data for these specimens are shown in Table 32.

Table 32. NISP per Taxon by Excavation Operation at Site 26EU2126

Taxon	Operation C	Operation F	Operation O	Total
Aves			1	1
Artiodactyla		3		3
Cervidae		5		5
Cervus elaphus		1		1
Leporidae			6	6
Lepus sp.			18	18
Very Large Mammal		1		1
Very Large/Large Mammal		39		40
Large Mammal	1	17		18
Large/Medium Mammal		2		2
Medium Mammal		1	25	26
Indeterminate Mammal	1	176	7	184
Total	2	245	57	304

DESCRIPTIVE SUMMARY

CLASS AVES

A single specimen recovered from Unit O1, Level 1 was identified to the class Aves and categorized as Size Class 3 (medium-sized bird). The specimen is a distal femur with a visible epiphyseal line, indicating juvenile age at death. It shows no evidence of weathering, burning, or other surface modifications.

CLASS MAMMALIA
ORDER LAGOMORPHA
FAMILY LEPORIDAE

Six specimens were identified to the family Leporidae. These specimens are from Unit O1, Level 1. The fragmentary size of these specimens did not allow for differentiation between *Lepus* sp. and *Sylvilagus* sp. The recovered fragments are an auditory bulla, a mandibular diastema, an alveolus portion of the mandible, a distal radius, and two distal tibiae. All are burned, with three being calcined. No other forms of surface modifications are present.

Lepus sp. (Jackrabbits)

A total of 18 *Lepus* sp. specimens were recovered Units 1 and 2 in Operation O. No complete elements were found; all specimens are fragmented. Unit O1, Level 1 yielded 12 specimens: a premolar (P1), an inferior border of a mandible, an alveolus portion of the lower first incisor, a scapular head, a sternal end of a rib shaft, a rib shaft, a proximal femur, a femur middle shaft, two proximal tibiae, and two distal tibiae. Level 2 yielded a radius middle shaft fragment. The three fragments found in Unit O2, Level 1 are a fully fused proximal end of a tibia with tibial tuberosity, a proximal shaft of a tibia, and a distal shaft of a tibia. Level 2 had a palatine fragment and a distal shaft of a tibia. All specimens are burned, with seven being calcined. No surface modifications that indicate human involvement (i.e., cut marks, etc.) were visible on any of these remains. It is possible that a single jackrabbit individual could account for all of the *Lepus* sp. specimens as well as the six specimens identified to Leporidae and the unidentified Size Class 3 fragments that were also recovered from Operation O.

ORDER ARTIODACTYLA

Three specimens were identified to the order Artiodactyla; all were too fragmentary to identify below the ordinal level. A proximal humerus fragment was recovered from Unit F2, Level 2; this specimen is categorized to Size Class 5. A burned vertebra fragment from Operation F, ST3 was classified as Size Class 6. Finally, one cheek tooth enamel fragment from Operation F, TU1 was categorized to Size Class 5.5. The two specimens other than the cheek tooth show evidence of burning, and the humerus fragment exhibits cut marks.

FAMILY CERVIDAE

Five specimens were identified as cervids but were too fragmented to be identified to the level of genus. Two cheek teeth enamel fragments were recovered from Unit F2, Level 2. A third cheek tooth enamel fragment as well as an anterior metatarsal fragment and a posterior metacarpal fragment were recovered from Unit F5, Level 1. The three cheek tooth fragments exhibited crenulated enamel, leading to their identification as cervids.

Cervus elaphus (Elk)

One specimen was identified as *Cervus elaphus*. This is a tooth enamel fragment recovered from Unit F5, Level 1. The fragment is from the buccal surface of a left upper molar. It exhibits crenulation, which is characteristic of cervids, and it is clearly identifiable as *Cervus* rather than *Odocoileus* sp. on the basis of its large size. The specimen was compared with several reference specimens of *Cervus*, *Bison*, and smaller artiodactyls, and its morphology is consistent only with identification as *Cervus*.

UNIDENTIFIED SPECIMENS

There are 270 faunal specimens in the assemblage that can be identified only as mammal. Of these, 86 have been assigned to size classes, and 184 are of indeterminate size class. In addition, 207 of the 270 unidentified specimens are burned or calcined and 2 exhibit cut marks.

6.1.3. Excavation Operations

Operation C

Only one of the 10 excavation units in Operation C produced faunal remains. These were two unidentified fragments recovered from Unit C6, Level 2. One specimen was assigned to Size Class 5 and the other was of indeterminate size class. A concentration of FCR was discovered in Operation C, but neither of the faunal specimens from this operation is burned.

Operation F

Of the 22 units excavated in Operation F in 2007, 10 produced faunal remains. In addition, one shovel test (ST3) and one test unit (TU1) excavated during 2006 in the area that would become Operation F also yielded faunal specimens, and these specimens are included in the data from Operation F presented here. In all, 245 specimens were recovered from Operation F. Of these, 176 fragments are of indeterminate size class; size categories for the remaining specimens range from Size Class 3 to Size Class 6. In addition, 179 of the specimens from Operation F are burned or calcined. A hearth feature, Feature 2, was found in Operation F, and most of the faunal specimens from this excavation block were recovered within a few meters of it (see Figure 24 in Chapter 3). The association of the faunal specimens from Operation F with Feature 2, the fact that many of them are burned, and the fact that 3 of them exhibit cutmarks (discussed further below) together strongly indicate that these specimens (or at least the majority of them) were deposited by humans. Table 33 provides counts of faunal specimens from Operation F by size class and degree of burning (specimens identified taxonomically to Artiodactyla, Cervidae and *Cervus elaphus* are included with their respective size classes in this table).

From ST3, 17 faunal specimens were recovered. One burned vertebra fragment was identified to the order Artiodactyla and classified as Size Class 6. The 16 remaining specimens were unidentifiable below the level of class, but 13 were classified to Size Class 5.5 and 3 were classified to Size Class 5. All but four of the specimens from ST3 are burned.

From TU1, 17 faunal specimens were recovered. One cheek tooth fragment was identified to the order Artiodactyla and classified as Size Class 5.5. The 16 remaining specimens were taxonomically unidentifiable below the level of class, but 14 were classified to Size Class 5 and 2 were classified to Size Class 4.5. Of these specimens from TU1, one is burned and four are calcined.

During the 2007 excavations in Operation F, 211 faunal specimens were recovered. Of these, 176 are of indeterminate size class and 160 are burned or calcined. Identified specimens include a cheek tooth fragment identified as *Cervus elaphus*; three cheek tooth fragments, an anterior metatarsal fragment, and a posterior metacarpal fragment identified to the family Cervidae; and a proximal humerus fragment identified to the order Artiodactyla. Both of the metapodial fragments and the humerus fragment are burned. In addition, three specimens from Operation F exhibit cutmarks; these include the artiodactyl humerus fragment (from Unit F2, Level 2) and two unidentified specimens (a Size Class 5.5 specimen from Unit F2, Level 2 and a specimen of indeterminate size class from Unit 5, Level 1).

In addition to 47 Very Large/Large Mammal specimens (Size Class 5.5; these include 8 specimens identified as artiodactyl or cervid), 2 specimens from Operation F are from Very Large mammals (Size Class 6). These are the elk tooth fragment and a vertebra fragment from an elk-sized artiodactyl; though this vertebra specimen cannot positively be identified as elk based on osteological criteria, the presence of an elk tooth in the Operation F assemblage suggests that the vertebra is from an elk. An additional 17 specimens from Operation F cannot be identified to order on osteological grounds but can be positively identified as Large Mammal (Size Class 5); the presence of these specimens indicates that a smaller-bodied artiodactyl taxon such as deer or pronghorn is represented in the assemblage in addition to elk.

Table 33. Operation F: NISP by Size Class and Degree of Burning

Size Class	Burned	Calcined	Not Burned or Calcined	Total
Very Large Mammal	1		1	2
Very Large/Large Mammal	24	10	13	47
Large Mammal	3	4	10	17
Large/Medium Mammal			2	2
Medium Mammal		1		1
Indeterminate Mammal	85	51	40	176
Total	113	66	66	245

OPERATION O

The two excavation units in Operation O produced 57 faunal specimens (Table 34). Of these, 18 were identified as *Lepus* sp., 6 were identified to the family Leporidae, and 1 was identified to the class Aves (all of these specimens are included in the "Medium Mammal" category in Table 34). There are also 25 unidentified Size Class 3 fragments and seven fragments of indeterminate size class from Operation O. As noted above, it is possible that a single jackrabbit individual accounts for all of the mammal specimens recovered from Operation O.

All specimens from Operation O are burned or calcined except for one unidentified Size Class 3 fragment. However, none of these specimens are clearly associated with any archaeological feature, so it is unknown whether they are burned as a result of natural or cultural processes. In addition, no surface modifications that indicate human involvement (i.e., cut marks, etc.) were observed on any of these remains. Thus, there is no clear indication that these remains are archaeological.

Table 34. Operation O: NISP by Size Class and Degree of Burning

Size Class	Burned	Calcined	Not Burned or Calcined	Total
Medium Mammal*	23	26	1	50
Indeterminate Mammal		7		7
Total	23	33	1	57

* Includes the specimen identified as Aves.

6.1.4. Burning and Cut Marks

Of the 304 faunal specimens in the assemblage from 26EU2126, 235, all from Operations F and O, are burned or calcined (see Table 35). There are 136 burned specimens and 99 calcined specimens. Of the 34 identified specimens in the assemblage, 28 are burned or calcined. Table 36 lists the distribution of burned and calcined specimens across size classes for bone from all operations combined.

Three specimens from Operation F exhibit cut marks, recognized as linear incisions that are "V"-shaped in cross-section. One specimen is an Artiodactyla (Size Class 5) proximal humerus fragment, specifically a portion of the bicepital notch, which displays cut marks within the notch. The second specimen is a long bone fragment classified as a Very Large/Large Mammal (Size Class 5.5). It has two linear cut marks, one above the other, that are made at a 45-degree angle relative to the proximal-distal axis of the bone. Both of these first two specimens were recovered from Unit F2, Level 2, in close proximity to Feature 2. The artiodactyl humerus fragment is burned, but the long bone fragment is not. The third specimen is an unidentified fragment of indeterminate size class that exhibits two linear incisions. This specimen is burned and was recovered from Unit F5, Level 1, which contained the northern portion of Feature 2.

Table 35. NISP by Operation and Degree of Burning

Operation	Burned	Calcined	Not Burned or Calcined	Total
Operation C			2	2
Operation F	113	66	66	245
Operation O	23	33	1	57
Total	136	99	69	304

Table 36. NISP by Size Class and Degree of Burning, all Operations

Size Class	Burned	Calcined	Not Burned or Calcined	Total
Very Large Mammal	1	0		1
Very Large/Large Mammal	24	10	14	48
Large Mammal	5	4	11	18
Large/Medium Mammal			2	2
Medium Mammal*	23	27	1	51
Indeterminate Mammal	85	58	41	184
Total	136	99	69	304

* Includes the specimen from Operation O identified as Aves.

6.1.5. Other Surface Modifications

Very small numbers of specimens in the assemblage exhibit taphonomically-relevant surface modifications other than burning and cut marks. No signs of carnivore modification, such as gnawing or digestive etching, were observed on any specimens. Three specimens exhibit rodent gnawing, recognized as sets of parallel linear incisions that are flat-bottomed in cross-section. All three of these specimens were recovered from Unit F2, two from Level 1 and one from Level 2, and all three specimens are also burned.

6.1.6. Features 1 and 2

In Operation F, a small hearth (Feature 2) was located within Units F17 and F5. A total of 39 faunal specimens were recovered from these two units. Of these specimens, 2 have cut marks and 24 are burned. Level 1 of Unit F17 produced four unidentified specimens of indeterminate size class, one of which is burned. Level 2 of Unit F17 produced one unidentified fragment classified as Size Class 5.5. Level 1 of Unit F5 produced 22 specimens, including a cheek tooth fragment identified as *Cervus elaphus*, a cheek tooth fragment identified to the family Cervidae, an anterior metatarsal fragment and a posterior metacarpal fragment identified to the order Artiodactyla, one unidentified Size Class 5.5 specimen, and 17 specimens of indeterminate size class. Sixteen of these specimens are burned, with five of these being calcined. Level 2 of Unit F5 produced twelve specimens of indeterminate size class. Seven of these are burned with four being calcined. Of the identifiable specimens, all are from very large- to large-sized cervids, and one can be definitively identified as elk. There were no small mammal remains identified, and of the unidentified specimens that could be assigned to a size class, none were smaller than Size Class 4.

As discussed in greater detail in Chapter 5, radiocarbon dates were obtained on two bone specimens recovered from the vicinity of Feature 2. One of these was an unidentified Size Class

5.5 specimen from Level 2 of Unit F17, and the other was an unidentified, burned, Size Class 5.5 specimen from Level 2 of Unit F2, located just to the north of Unit F5. These two dates are statistically contemporaneous, and the calibrated 2-sigma age range for the pooled mean of these two dates is A.D. 1230–1300. In addition, a charcoal sample from Feature 2 returned a radiocarbon date with a calibrated 2-sigma age range of A.D. 770–A.D 980, but this date appears to be erroneously old due to old wood effects.

Two unidentified bone fragments were recovered from Unit C6, Level 2, near the FCR concentration that was found in Operation C (Feature 1). One is classified as Size Class 5 and the other is of indeterminate size class. Although these specimens were found near the FCR concentration, they show no evidence of burning or other surface modifications that indicate human involvement.

6.1.7. DISCUSSION

The faunal inventory from site 26EU2126 likely includes specimens that are a result of both cultural and natural deposition, but only remains for which there is evidence of human use are discussed here. Such remains consist exclusively of specimens from Operation F, from which 245 faunal specimens were recovered. The majority of these (179, or 73 percent) are burned, and three exhibit cut marks. Given the presence of cutmarks, the abundance of burned bone, the degree of fragmentation, and the association with a hearth (Feature 2), it is likely that most, if not all, of the specimens from Operation F were deposited by humans. It cannot be determined whether the 57 specimens from Operation O, which include 1 bird, 18 jackrabbit and 6 additional leporid specimens, are the result of cultural activity or are natural because, although these remains are burned and highly fragmented, they are not in direct association with any archaeological feature, and no evidence of butchery by humans, such as cutmarks, is present. There is no evidence at all for human use of the two unidentified specimens from Operation C.

Of the specimens from Operation F, 69 are identifiable at least to size class. Of these, 66 (or 96 percent) are specimens from either Large or Very Large mammals, 42 of which are burned and one of which can be positively identified as elk. The remaining 3 of the 69 are specimens identified as Medium or Large/Medium mammal, one of which is burned. The presence of elk in the Operation F assemblage—represented at least by one tooth fragment if not also by additional elk-sized specimens that could not be identified osteologically to the generic or specific level—is notable because this taxon is very rare in prehistoric archaeofaunas from northeastern Nevada (Bill Fawcett, personal communication, May 15, 2008). Elk are not reported from any site included in the most recent synthesis of faunal data from the LBBA (Corbeil 1996:Table 184). The closest archaeological records of this taxon from outside of the LBBA come from two sites located to the southeast: Bronco Charlie Cave in Ruby Valley (Casjens 1975) and South Fork Shelter along the South Fork of the Humboldt River (Heizer et al. 1968).

As discussed in Chapter 5, the archaeological materials recovered from Operation F appear to be the result of a short duration occupational episode that occurred sometime in the mid– to late A.D. 1200s. This falls right on the verge of what appears to have been a major transition in subsistence and settlement in the LBBA, as summarized by Ugan and Bright (2001). Synthesizing results from numerous previous excavations in the LBBA, these authors note that "the prehistory of the LBBA is best divided into pre– and post–A.D. 1300 categories" (Ugan and Bright 2001:1311). Among the changes that Ugan and Bright (2001) note occur between the pre- and post–A.D. 1300 periods are a decline in the abundance of high-caloric return large-bodied mammal relative to lower-return small-bodied mammals. This, together with an increase in the diversity of seed types in macrobotanical assemblages (Coulam 1996), indicates that a decline in foraging efficiency and a corresponding increase in diet breadth occurred around A.D. 1300 (and see Bright et al. 2002 for a discussion of associated changes in subsistence-related technology). The high relative abundance of large mammal remains in the Operation F assemblage is consistent with the pattern noted by Ugan and Bright (2001) for the pre–A.D. 1300 period in the LBBA. More generally, it is consistent with high artiodactyl relative abundances that have been noted in late Holocene archaeofaunal assemblages from throughout the Great Basin (e.g., Broughton et al. 2008; Byers and Broughton 2004; McGuire and Hildebrandt 2005).

The very low abundance of identified postcranial elements, both axial and appendicular, in the large mammal assemblage from Operation F, together with a high number of small, unidentifiable fragments, indicates intensive processing (e.g., marrow extraction). In addition, the presence of tooth enamel fragments suggests that complete carcasses were processed at the site. It is possible that body parts of high economic value were transported away from the site after processing (e.g., Binford 1978), but it cannot be determined whether this is the reason why so few post-cranial elements were identified in the assemblage or whether the reason is simply that most specimens were fragmented beyond identifiability.

Nevertheless, the degree of fragmentation and burning, the presence of cutmarks, and the association with a thermal feature seems to make it clear that the deposit excavated in Operation F is the result of large mammal carcass processing activities. Moreover, given the relatively discrete nature of the artifact and bone concentration, the association with only a single thermal feature, and the absence of other features or artifacts that suggest residential activities, it appears that the deposit is the result of a relatively short-term event, perhaps a single episode. These conclusions are consistent with the pattern of logistical organization that has been described for the late Holocene in the Great Basin (e.g., McGuire and Hildebrandt 2005; Zeanah 2004). That is, the deposit may be the result of large mammal processing activities conducted by a hunting party operating from a residential base located elsewhere.

Finally, Bright (1998) has analyzed previously excavated hearths in the LBBA, noting that there is "a bias toward small mammal remains" in small hearths, whereas remains of larger-bodied mammals tend to be associated with larger, rock-lined hearths (Bright 1998). Feature 2 at 26EU2126 is a small hearth that is not rock-lined, but, as noted above, the deposits surrounding this feature contain the remains of Large to Very Large mammals (i.e., Size Classes 5.0 to 6.0) to the virtual exclusion of smaller taxa. Thus, results from this project do not follow the trend for thermal features found in previous work in the LBBA, and they suggest that there may have been greater variability in prehistoric resource processing activities in the area than previously recognized.

In sum, the faunal remains from the 2007 BGMI project that are informative about prehistoric human subsistence are those from Operation F at 26EU2126. These remains are radiocarbon dated to the period between A.D. 1230 and 1300. Nearly all of the faunal specimens from

Operation F are from deer/pronghorn- or elk-sized artiodactyls, including one specimen positively identified as elk, which provides the first prehistoric record of this taxon in the LBBA. The artiodactyl specimens from Operation F are highly fragmented, suggesting that they were intensively processed. The high relative abundance of artiodactyl specimens in this area of the site is consistent with an LBBA-wide pattern of high artiodactyl relative abundance in pre–A.D. 1300 archaeofaunal assemblages. In addition, the isolated large mammal processing episode that appears to be represented in the Operation F deposit is consistent with the pattern of logistical settlement organization that has previously been described for the late Holocene in the Great Basin. On the other hand, the association between large mammal remains and a small hearth that lacks FCR is not consistent with patterns previously noted in the LBBA, suggesting that there was some variability in the kinds of resources processed in association with specific types of thermal features.

6.2. MACROBOTANICAL REMAINS

This section presents the results of analyses of macrobotanical and other types of remains collected from sediment samples that underwent flotation. Two of these sediment samples come from archaeological features found at 26EU2126: Features 2 and 3, which are, respectively, an ash lens that is likely a hearth feature and a FCR concentration with a small amount of ashy fill (Figure 15 and subsequent figures)[10]. Samples of the fill from these features were analyzed to determine whether they contained subsistence remains. A third sample comes from a small ash lens that was encountered in Operation G at 26EU1539 (Figure 7); this sample was analyzed to determine whether the feature from which it comes is archaeological. Finally, as discussed in Section 4.4.3, sediment samples were collected from several charcoal lenses that were exposed during mechanical stripping of the sites involved in the project (labeled as "blading features" in Figure 26, Figure 28, Figure 29, Figure 32, Figure 34, and Figure 35). Most of these charcoal lenses appeared in the field to be the result of relatively recent burning of shrubs, primarily sagebrush (*Artemesia*), due to wildfire, but a few contained artifacts or soot–covered rock, and it was unclear whether these few were archaeological or natural. Materials from the sediment samples that were collected from these charcoal lenses were analyzed to shed light on their origin and to provide criteria that could be used in the future to more clearly distinguish archaeological charcoal lenses from non-archaeological ones.

Summary information about the sediment samples that underwent flotation analysis is provided in Table 37. A description of the vegetation of the LBBA is provided in Section 2.1.3.

[10] Feature 1 at 26EU2126, an FCR concentration similar to Feature 3, is not included in the flotation analysis because no obvious feature fill was associated with it.

Table 37. Context of Sediment Samples that Underwent Flotation Analysis

Site	FS Number*	Feature Designation **	Field Evaluation	Comments
26EU1539	1539-1064	ash lens	possibly archaeological	small subsurface ash lens near dense surface artifact concentration
26EU1539	1539-1252	BF2	not archaeological	appeared to be wildfire-burned vegetation
26EU1548	1548-2000	BF1	not archaeological	appeared to be wildfire-burned vegetation
26EU1548	1548-2001	BF2	not archaeological	appeared to be wildfire-burned vegetation
26EU1548	1548-2002	BF3	possibly archaeological	appeared to be wildfire-burned vegetation, though with soot-covered rock
26EU1548	1548-2003	BF4	not archaeological	appeared to be wildfire-burned vegetation
26EU1548	1548-2004	BF12	not archaeological	appeared to be wildfire-burned vegetation
26EU1548	1548-2005	BF5	possibly archaeological	appeared to be wildfire-burned vegetation, though with many small flakes nearby
26EU1548	1548-2006	BF6	possibly archaeological	appeared to be wildfire-burned vegetation, though with soot-covered rock
26EU1548	1548-2007	BF7	not archaeological	appeared to be wildfire-burned vegetation
26EU2064	2064-2000	BF	not archaeological	appeared to be wildfire-burned vegetation
26EU2126	2126-1201	Feature 2	archaeological	hearth feature (ash lens, no FCR)
26EU2126	2126-1302	Feature 3	archaeological	FCR concentration with small amount of ashy fill

*Designation used in analyses in this section.

**Designation shown on maps in Sections 3.2 and 4.3.

6.2.1. METHODS

The bulk sediment samples collected from the field were measured into one-liter sub-samples for flotation analysis, except for five samples that were smaller than one liter to begin with; analyzed sample volumes are provided in Table 38. In addition to the sub-samples removed for flotation analysis, 100 g of each bulk sample was removed will be curated for possible future palynological analysis.

Flotation analysis was conducted using a device constructed in a plastic five-gallon bucket. Water is introduced into the bottom of the bucket through a sprinkler head attached to short length of PVC pipe, which extends outside of the bucket and is, in turn, connected to a garden hose. A sediment sample is poured into the bucket, the water is turned on, and the flow from the sprinkler head agitates the sample, facilitating separation of the heavy and light fractions. When the water level reaches the top of the bucket, the light fraction is guided out through a spout attached to the bucket rim and collected in a sieve lined with cheesecloth. The sample is processed in this manner, with additional agitation of the bucket as needed, until the entire light fraction is collected. The cheesecloth containing the light fraction is then closed and hung to dry, and the heavy fraction is collected separately from the bottom of the bucket and also allowed to dry. The device is washed thoroughly between samples to prevent cross-contamination.

For this project, the light fraction of all analyzed samples was sorted after drying, and all organic materials, which include plant and insect parts as well as vertebrate fecal pellets, were identified by comparison to modern reference specimens. Charcoal specimens were examined in cross section by transverse section, and then identified using manuals (Core et al. 1976; Panshin and de Zeeuw 1980) in addition to modern reference specimens. As these specimens could potentially be used for radiocarbon analysis, clean conditions were employed to avoid sample contamination with modern ^{14}C. To facilitate sorting, light fraction samples were first screened through nested 2.0-mm and 1.0-mm mesh geological sieves. Organic specimens from the light fraction were quantified by taxon and material type (e.g., plant part, invertebrate body portion, etc.). For samples in which more than 1,000 specimens of a material type of a taxon were present, counting ceased at 1,000 and the quantity was recorded as 999.

The heavy fraction from the analyzed samples was sorted after drying in order to recover any lithic artifacts or small bone specimens that might have been present; no other materials from the heavy fraction were analyzed. One flotation sample (1539-1252) produced seven small chipped stone flakes; no other sample produced artifacts, and no animal bones were recovered from any sample.

To determine whether the features from which the samples came were the result of either a cultural or a natural fire, all samples were examined first for specimens that showed signs of human use, such as partial, carbonized seeds or worked wood specimens. No such specimens were identified. The ratio of uncarbonized to carbonized specimens was then used as a second pass, and a ratio of uncarbonized to carbonized specimens of greater than 0.10 was used as a cut-off to eliminate a sample from consideration as cultural. To further evaluate a sample, a Poaceae to non-Poaceae ratio was used as a third pass, and if more Poaceae specimens than *Artemisia* sp. specimens were present, a sample was eliminated from consideration as cultural. This ratio was chosen because the vast majority of macrobotanical specimens recovered were from the family Poaceae or the genus *Artemisia*. The Poaceae recovered came from the Poeae and the Triticeae tribes, both of which contain numerous exotic species, and are hence a sure sign of a non-cultural sample. *Artemesia* sp. was selected because it was the only sample type recovered that was present in all samples and could be easily identified.

Table 38. Summary of Macrobotanical Samples Recovered During the 2007 BGMI Project

FS Number	Pollen Sample (g)	Volume Floted (mL)	<1.0mm (g)	g/L (<1.0mm)	1mm– 2mm (g)	g/L (1.0mm– 2.0mm)	>2.0mm (g)	g/L (>2.0mm)	Total g/L
1539-1064	100	200	2.4	0.01	6.9	0.03	13.1	0.07	0.11
1539-1252	100	550	8.9	0.02	4.6	0.01	35.9	0.07	0.09
1548-2000	100	350	7.9	0.02	8.7	0.02	22.8	0.07	0.11
1548-2001	100	1,000	7.0	0.01	43.7	0.04	65.1	0.07	0.12
1548-2003	100	1,000	32.6	0.03	46.8	0.05	71.9	0.07	0.15
1548-2004	100	1,000	12.7	0.01	25.8	0.03	65.1	0.07	0.10
1548-2005	100	1,000	40.5	0.04	18.1	0.02	65.1	0.07	0.12
1548-2006	100	1,000	16.6	0.02	28.6	0.03	65.1	0.07	0.11
1548-2007	100	900	8.9	0.01	25.8	0.03	58.6	0.07	0.10
2064-2000	100	1,000	27.1	0.03	18.9	0.02	35.1	0.04	0.08
2126-1201	100	1,000	5.3	0.01	38.3	0.04	65.1	0.07	0.11
2126-1302	100	850	4.8	0.01	2.0	0.00	55.3	0.07	0.07
2126-2002	100	1,000	3.0	0.00	33.6	0.03	88.1	0.09	0.12

6.2.2. RESULTS

Floatation of samples from the 2007 BGMI project yielded an average recovered light-fraction sample for identification of 91.22 g (mean g/L = 0.11g/L); weights of material recovered in each screen-size fraction from each sample are presented in Table 38. The results of macrobotanical analyses are discussed next by site.

26EU1539

Site 26EU1539 yielded approximately 2,480 analyzed specimens in the two samples (FS 1539-1064 and FS 1539-1252) taken for macrobotanical analysis. Taxonomic abundances for the site as a whole are presented in Table 39 and Table 40. Taxonomic abundances from FS 1539-1064 are presented in Table 41 and Table 42, and taxonomic abundances from FS 1539-1252 are presented in Table 43 and Table 44. Overall, 4.4 percent of the specimens in the samples collected at 26EU1539 were carbonized.

Table 39. Abundance of Carbonized Specimens at 26EU1539

Class	Taxon	Material Type	Count	Percentage
Plantae	*Artemisia*	Wood	13	11.82%
	Unidentified	Wood	83	75.45%
	Triticeae	Seed	4	3.64%
	Poeae	Seed	10	9.09%
	Total		110	

Table 40. Abundance of Uncarbonized Specimens at 26EU1539

Class	Taxon	Material Type	Count	Percentage
Plantae	*Artemisia*	Leaf	3	0.13%
	Artemisia	Wood	30	1.27%
	Unidentified	Root	330	13.94%
	Unidentified*	Fiber	1,998	84.41%
Insecta	Coleoptera	Elytra	1	0.04%
	Coleoptera	Cocoon	2	0.08%
Mammalia	Unidentified	Fecal Pellet	3	0.13%
	Total		2,367	

*Sample size exceeded 1,000 in two of two samples; count ceased at 999 for each.

Table 41. Abundance of Carbonized Specimens in FS 1539-1064

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	4	4.26%
	Unidentified	Wood	83	88.30%
	Triticeae	Seed	3	3.19%
	Poeae	Seed	4	4.26%
	Total		94	

Table 42. Abundance of Uncarbonized Specimens in FS 1539-1064

Class	Taxon	Material	Count	Percentage
Plantae	Unidentified*	Fiber	999	75.57%
	Unidentified	Root	323	24.43%
	Total		1,322	

*Sample size exceeded 1000; count ceased at 999.

Table 43. Abundance of Carbonized Specimens in FS 1539-1252

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	5	31.25%
	Artemisia	Bark	4	25.00%
	Triticeae	Seed	1	6.25%
	Poeae	Seed	6	37.50%
	Total		16	

Table 44. Abundance of Uncarbonized Specimens in FS 1539-1252

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	30	2.86%
	Artemisia	Bark	3	0.29%
	Artemisia	Leaf	3	0.29%
	Unidentified	Root	7	0.67%
	Unidentified*	Fiber	999	95.32%
Insecta	Coleoptera	Cocoon	2	0.19%
	Coleoptera	Elytra	1	0.10%
Mammalia	Unidentified	Fecal Pellet	3	0.29%
	Total		1,048	

*Sample size exceeded 1000; count ceased at 999.

26EU1548

Site 26EU1548 yielded 19,126 specimens in the samples taken for macrobotanical analysis. Taxonomic abundances for the site as a whole are presented in Table 45 and Table 46, and data for individual samples are presented in Table 47 through Table 62. Overall, 32.09 percent of the specimens in the samples collected at 26EU1548 were carbonized.

Table 45. Abundance of Carbonized Specimens at 26EU1548

Class	Taxon	Material Type	Count	Percentage
Plantae	*Amelanchier*	Seed	2	0.03%
	Arctostaphylos	Bract	1	0.01%
	Artemisia	Wood	2,101	30.30%
	Atriplex	Seed	2	0.03%
	Chenopdium	Seed	9	0.13%
	Poeae*	Seed	1,875	27.04%
	Polygonum	Seed	14	0.20%
	Rumex	Seed	17	0.25%
	Triticeae*	Seed	1,716	24.75%
	Unidentified*	Wood	1,179	17.01%
	Verbascum	Seed	2	0.03%
Animalia	Unidentified	Fecal Pellet	14	0.20%
Unknown	Unidentified	Unidentified	1	0.01%
	Total		6,933	

*Sample size exceeded 1,000 in one of eight samples; count ceased at 999.

Table 46. Abundance of Uncarbonized Specimens at 26EU1548

Class	Taxon	Material Type	Count	Percentage
Plantae	*Artemisia*	Wood	10	0.08%
	Artemisia	Leaf	2	0.02%
	Bromus	Lemma	2	0.02%
	Poaceae	Leaf	5	0.04%
	Rosaceae	Leaf	1	0.01%
	Unidentified	Wood	196	1.61%
	Unidentified*	Root	7,992	65.55%
	Unidentified†	Fiber	3,846	31.54%
Insecta	Coleoptera	Abdomen, Thorax	2	0.02%
	Coleoptera	Cocoon	6	0.05%
	Coleoptera	Elytra	4	0.03%
	Coleoptera	Pupa	3	0.02%
Mammalia	Unidentified	Fecal Pellet	124	1.02%
	Total		12,193	

*Sample size exceeded 1,000 in three of eight samples; count ceased at 999 for each.

†Sample size exceeded 1,000 in eight of eight samples; count ceased at 999 for each.

Table 47. Abundance of Carbonized Specimens in FS 1548-2000

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	53	50.48%
	Triticeae	Seed	21	20.00%
	Poeae	Seed	31	29.52%
	Total		105	

Table 48. Abundance of Uncarbonized Specimens in FS 1548-2000

Class	Taxon	Material	Count	Percentage
Plantae	Unidentified	Wood	24	2.17%
	Unidentified	Root	83	7.50%
	Unidentified*	Fiber	999	90.33%
	Total		1,106	

*Sample size exceeded 1,000; count ceased at 999.

Table 49. Abundance of Carbonized Specimens in FS 1548-2001

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	129	76.79%
	Poeae	Seed	27	16.07%
	Triticeae	Seed	7	4.17%
	Rumex	Seed	5	2.98%
	Total		168	

Table 50. Abundance of Uncarbonized Specimens in FS 1548-2001

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	9	0.55%
	Unidentified	Root	493	30.32%
	Unidentified*	Fiber	999	61.44%
Insecta	Coleoptera	Elytra	1	0.06%
	Coleoptera	Pupa	1	0.06%
	Coleoptera	Abdomen	1	0.06%
Mammalia	Unidentified	Fecal Pellet	122	7.50%
	Total		1,626	

*Sample size exceeded 1,000; count ceased at 999.

Table 51. Abundance of Carbonized Specimens at FS 1548-2002

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Bark	312	47.56%
	Artemisia	Wood	288	43.90%
	Poeae	Seed	31	4.73%
	Triticeae	Seed	19	2.90%
	Rumex	Seed	1	0.15%
	Verbascum	Seed	2	0.30%
	Unidentified	Wood	2	0.30%
Mammalia	Unidentified	Fecal Pellet	1	0.15%
	Total		656	

Table 52. Abundance of Uncarbonized Specimens in FS 1548-2002

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	1	0.08%
	Artemisia	Leaf	1	0.08%
	Bromus	Lemma	2	0.15%
	Poaceae	Leaf	2	0.15%
	Unidentified	Bark	9	0.70%
	Unidentified	Root	273	21.15%
	Unidentified*	Fiber	999	77.38%
Insecta	Coleoptera	Pupa	2	0.15%
Mammalia	Unidentified	Fecal Pellet	2	0.15%
	Total		1,291	

*Sample size exceeded 1,000; count ceased at 999.

Table 53. Abundance of Carbonized Specimens at FS 1548-2003

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	94	7.53%
	Poeae	Seed	619	49.60%
	Rumex	Seed	7	0.56%
	Triticeae	Seed	521	41.75%
Mammalia	Unidentified	Fecal Pellet	7	0.56%
	Total		1,248	

Table 54. Abundance of Uncarbonized Specimens in FS 1548-2003

Class	Taxon	Material	Count	Percentage
Plantae	Unidentified	Wood	91	8.33%
	Unidentified*	Fiber	999	91.40%
Insecta	Coleoptera	Elytra	1	0.09%
	Coleoptera	Cocoon	2	0.18%
	Total		1,093	

*Sample size exceeded 1,000; count ceased at 999.

Table 55. Abundance of Carbonized Specimens in FS 1548-2004

Class	Taxon	Material	Count	Percentage
Plantae	*Amelanchier*	Seed	2	0.61%
	Arctostaphylos	Bract	1	0.30%
	Artemisia	Wood	89	26.97%
	Chenopdium	Seed	1	0.30%
	Polygonum	Seed	14	4.24%
	Poeae	Seed	97	29.39%
	Triticeae	Seed	121	36.67%
	Unidentified	Bark	2	0.61%
Mammalia	Unidentified	Fecal Pellet	2	0.61%
Unknown	Unidentified	Unidentified	1	0.30%
	Total		330	

Table 56. Abundance of Uncarbonized Specimens in FS 1548-2004

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Leaf	1	0.05%
	Unidentified*	Root	999	49.95%
	Unidentified*	Fiber	999	49.95%
Insecta	Coleoptera	Abdomen, Thorax	1	0.05%
	Total		2,000	

*Sample size exceeded 1,000; count ceased at 999.

Table 57. Abundance of Carbonized Specimens in FS 1548-2005

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	96	4.55%
	Atriplex	Seed	2	0.09%
	Chenopodium	Seed	5	0.24%
	Poeae*	Seed	999	47.37%
	Rumex	Seed	4	0.19%
	Triticeae*	Seed	999	47.37%
Mammalia	Unidentified	Fecal Pellet	4	0.19%
	Total		2,109	

*Sample size exceeded 1,000; count ceased at 999.

Table 58. Abundance of Uncarbonized Specimens in FS 1548-2005

Class	Taxon	Material	Count	Percentage
Plantae	Unidentified	Wood	72	6.70%
	Unidentified*	Fiber	999	92.93%
Insecta	Coleoptera	Elytra	1	0.09%
	Coleoptera	Cocoon	3	0.28%
	Total		1,075	

*Sample size exceeded 1,000; count ceased at 999.

Table 59. Abundance of Carbonized Specimens in FS 1548-2006

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	259	14.53%
	Artemisia	Bark	444	24.90%
	Artemisia	Root	43	2.41%
	Poeae	Seed	31	1.74%
	Triticeae	Seed	7	0.39%
	Unidentified*	Wood	999	56.03%
	Total		1,783	

*Sample size exceeded 1,000; count ceased at 999.

Table 60. Abundance of Uncarbonized Specimens at FS 1548-2006

Class	Taxon	Material	Count	Percentage
Plantae	*Rosa*	Leaf	1	0.05%
	Unidentified*	Root	999	49.95%
	Unidentified*	Fiber	999	49.95%
Insecta	Coleoptera	Elytra	1	0.05%
	Total		2,000	

*Sample size exceeded 1,000; count ceased at 999.

Table 61. Abundance of Carbonized Specimens in FS 1548-2007

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	117	22.03%
	Artemisia	Bark	177	33.33%
	Poeae	Seed	40	7.53%
	Triticeae	Seed	21	3.95%
	Unidentified	Wood	176	33.15%
	Total		531	

Table 62. Abundance of Uncarbonized Specimens in FS 1548-2007

Class	Taxon	Material	Count	Percentage
Plantae	Poaceae	Leaf	3	0.15%
	Unidentified*	Root	999	49.90%
	Unidentified*	Fiber	999	49.90%
Insecta	Coleoptera	Cocoon	1	0.05%
	Total		2,002	

*Sample size exceeded 1,000; count ceased at 999.

26EU2064

Site 26EU2064 yielded 1,722 specimens in the single sample taken for macrobotanical analysis; 29.38 percent of these specimens are carbonized. Taxonomic abundances for this site are presented in Table 63 and Table 64.

Table 63. Abundance of Carbonized Specimens at 26EU2064 (FS 2064-2000)

Class	Taxon	Material Type	Count	Percentage
Plantae	*Artemisia*	Wood	97	19.17%
	Chenopodium	Seed	21	4.15%
	Poeae	Seed	229	45.26%
	Triticeae	Seed	141	27.87%
Mammalia	Unidentified	Fecal Pellet	5	0.99%
Unknown	Unidentified	Mass	13	2.57%
	Total		506	

Table 64. Abundance of Uncarbonized Specimens at 26EU2064 (FS 2064-2000)

Class	Taxon	Material Type	Count	Percentage
Plantae	*Artemisia*	Wood	37	3.04%
	Poeae	Seed	29	2.38%
	Unidentified	Bark	13	1.07%
	Unidentified	Root	118	9.70%
	Unidentified*	Fiber	999	82.15%
Insecta	Coleoptera	Pupa	1	0.08%
Mammalia	Unidentified	Fecal Pellet	19	1.56%
	Total		1,216	

*Sample size exceeded 1,000; count ceased at 999.

26EU2126

Site 26EU2126 yielded 3,074 specimens in the two samples taken for macrobotanical analysis; 9.95 percent of the specimens in these samples were carbonized. Taxonomic abundances for the site as a whole are presented in Table 65 and Table 66. Taxonomic abundances from FS 2126-1201 are presented in Table 67 and Table 68, and taxonomic abundances from FS 2126-1252 are presented in Table 69 and Table 70.

Table 65. Abundance of Carbonized Specimens at 26EU2126

Class	Taxon	Material Type	Count	Percentage
Plantae	*Artemisia*	Wood	263	85.95%
	Poeae	Seed	21	6.86%
	Triticeae	Seed	17	5.56%
	Unidentified	Seed	4	1.31%
Mammalia	Unidentified	Fecal Pellet	1	0.33%
	Total		306	

Table 66. Abundance of Uncarbonized Specimens at 26EU2126

Class	Taxon	Material Type	Count	Percentage
Plantae	*Artemisia*	Bark	43	1.55%
	Artemisia	Leaf	1	0.04%
	Poaceae	Collar	2	0.07%
	Poaceae	Lemma	2	0.07%
	Poaceae	Stem	2	0.07%
	Rumex	Seed	1	0.04%
	Unidentified	Root	440	15.90%
	Unidentified	Root	273	9.86%
	Unidentified*	Fiber	1,998	72.18%
Insecta	Coleoptera	Cocoon	2	0.07%
	Coleoptera	Elytra	1	0.04%
	Coleoptera	Abdomen	1	0.04%
Mammalia	Unidentified	Fecal Pellet	2	0.07%
	Total		2,768	

*Sample size exceeded 1,000 in two of two samples; count ceased at 999 for each.

Table 67. Abundance of Carbonized Specimens in FS 2126-1201

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Bark	64	52.46%
	Artemisia	Wood	19	15.57%
	Poeae	Seed	21	17.21%
	Triticeae	Seed	17	13.93%
Insecta	Unidentified	Fecal Pellet	1	0.82%
	Total		122	

Table 68. Abundance of Uncarbonized Specimens in FS 2126-1201

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Bark	22	1.47%
	Artemisia	Wood	21	1.40%
	Artemisia	Leaf	1	0.07%
	Poaceae	Collar	2	0.13%
	Poaceae	Lemma	2	0.13%
	Poaceae	Stem	2	0.13%
	Rumex	Seed	1	0.07%
	Unidentified*	Fiber	999	66.78%
	Unidentified	Root	440	29.41%
Insecta	Coleoptera	Cocoon	2	0.13%
	Coleoptera	Elytra	1	0.07%
	Coleoptera	Abdomen	1	0.07%
Mammalia	Unidentified	Fecal Pellet	2	0.13%
	Total		1,496	

*Sample size exceeded 1,000; count ceased at 999.

Table 69. Abundance of Carbonized Specimens in FS 2126-1302

Class	Taxon	Material	Count	Percentage
Plantae	*Artemisia*	Wood	97	96.04%
	Unidentified	Seed	4	3.96%
	Total		101	

Table 70. Abundance of Uncarbonized Specimens in FS 2126-1302

Class	Taxon	Material	Count	Percentage
Plantae	Unidentified	Root	273	21.46%
	Unidentified*	Fiber	999	78.54%
	Total		1,272	

*Sample size exceeded 1,000; count ceased at 999.

6.2.3. Discussion

The twelve plant taxa identified from the samples collected during the 2007 BGMI Data Recovery Project are listed in Table 71.

Table 71. Plant Taxa Identified in Flotation Samples from the 2007 BGMI Project

Taxon	Material
Amelanchier	Seed
Arctostaphylos	Bract
Artemisia	Leaf, Bark, Wood
Atriplex	Seed
Bromus	Lemma
Chenopodium	Seed
Poeae	Seed
Polygonum	Seed
Rosa	Leaf
Rumex	Seed
Triticeae	Seed
Verbascum	Seed

None of the analyzed samples contained any plant specimens that could be clearly identified as having been deposited by humans. While a number of the taxa recovered have cultural uses, the state of preservation of carbonized specimens does not appear to indicate human deposition; for example, there were no partial seeds or worked wood samples, either of which would be a definite indicator of human-plant interaction. Rather, all samples appeared to contain naturally charred specimens of *Artemisia* spp. and whole, naturally burned seeds.

Based on ratios of carbonized to uncarbonized specimens, the following samples can be considered to likely be the result of natural fires: FS 1548-2001, FS 1548-2002, FS 1548-2003, FS 1548-2004, FS 1548-2005, FS 1548-2006, FS 1548-2007, and FS 2064-2000. These samples have carbonized-to-uncarbonized ratios of greater than 0.10, which implies a greater presence of modern floral remains than in cases with a ratio lower than 0.10. Samples FS 1539-1064, FS 1539-1252, FS 1548-2000, FS 2126-1201, and FS 2126-1302 are not excluded from a possible cultural origin on this basis.

A second ratio, Poaceae to non-Poaceae, can be used to evaluate the origin of these remaining five samples. This ratio was chosen because the vast majority of macrobotanicals recovered during the 2007 BGMI project were from the family Poaceae and the genus *Artemisia*. The Poaceae taxa recovered at these sites were from the Poeae and Triticeae tribes, both of which contain numerous exotic species: *Bromus tectorum* was introduced to North America in the 1800s (Klemmedson and Smith 1964; Young 2000) and *Agropyron cristatum* was introduced to North America between 1907 and 1935 (Dillman 1946). *Artemesia* spp. was selected because it was the only taxon that was present in all samples and could be easily identified. On the basis of this ratio (with more Poaceae present than Artemesia being the indicator of modernity) samples FS 1539-1252 and FS 1548-2000 are likely not cultural in origin, while samples FS 1539-1064 and FS 2126-1201 can be considered to be potentially cultural in origin. Sample FS 2126-1302 is excluded from further consideration altogether due to a low sample size. These conclusions derived from flotation analysis regarding whether individual features were created by humans are presented in Table 72.

Table 72. Comparison of Field and Flotation Evaluations of Sampled Features

Site	FS Number	Feature Designation	Field Evaluation	Flotation Evaluation
26EU1539	1539-1064	ash lens	possibly archaeological	possibly archaeological (no subsistence remains, but low proportion of exotic taxa)
26EU1539	1539-1252	BF2	not archaeological	not archaeological (high proportion of exotic taxa)
26EU1548	1548-2000	BF1	not archaeological	not archaeological (high proportion of exotic taxa)
26EU1548	1548-2001	BF2	not archaeological	not archaeological (high proportion of modern remains)
26EU1548	1548-2002	BF3	possibly archaeological	not archaeological (high proportion of modern remains)
26EU1548	1548-2003	BF4	not archaeological	not archaeological (high proportion of modern remains)
26EU1548	1548-2004	BF12	not archaeological	not archaeological (high proportion of modern remains)
26EU1548	1548-2005	BF5	possibly archaeological	not archaeological (high proportion of modern remains)
26EU1548	1548-2006	BF6	possibly archaeological	not archaeological (high proportion of modern remains)
26EU1548	1548-2007	BF7	not archaeological	not archaeological (high proportion of modern remains)
26EU2064	2064-2000	BF	not archaeological	not archaeological (high proportion of modern remains)
26EU2126	2126-1201	Feature 2	archaeological	possibly archaeological (no subsistence remains, but low proportion of exotic taxa)
26EU2126	2126-1302	Feature 3	archaeological	indeterminate (high proportion of carbonized remains; sample size is otherwise too small)

Based on its morphology and context in a deposit rich in artifacts and faunal remains, Feature 2 at 26EU2126 (represented in this analysis by FS 2126-1201) is clearly an archaeological feature. It is interesting, however, that very few plant specimens that might have had a subsistence use were recovered from this feature. Given the abundance of burned faunal remains that were recovered in the vicinity of Feature 2, it appears that this feature was associated with animal processing activities rather than plant processing activities. The absence of plant specimens that might have had a subsistence use in Feature 3 from 26EU2126 (represented in this analysis by FS 2126-1302) is not so surprising given the morphology of this feature. Like Feature 1 at this site (which had no obvious feature fill that could undergo flotation analysis), Feature 3 was a concentration of FCR that may have been the result of hearth cleaning, rather than an actual hearth itself.

Flotation analysis of material from the ash lens found in Operation G at 26EU1539 (represented in this analysis by FS 1539-1064) does not shed light on the origin of this feature as was hoped. This feature was very small, and though it was found in a subsurface context near the dense surface artifact concentration that was located in the southern part of the site, artifact density was not particularly high in the immediate vicinity of the feature, nor were any faunal remains recovered in the Operation G trench. Given the absence of plant specimens that might have had a subsistence use in addition to these points, there is no clear reason to conclude that the feature is archaeological.

The remaining samples subjected to flotation analysis are those from "blading features", or charcoal lenses found in mechanical stripping. Based on the flotation analysis, all of these appear to be natural in origin. The high abundances of modern plant specimens and/or remains of exotic taxa in the few blading features that appeared possibly to be archaeological in the field suggests that the associations with artifacts or rock observed for these few features are fortuitous. Moreover, the ratios used to conclude that these features are not archaeological provide a method that might be employed to make similar evaluations in the future.

6.3. GROUND STONE

The ground stone assemblage discussed here was collected from three of the five sites investigated during the 2007 BGMI project: 26EU1533, 26EU1539, and 26EU2126. No ground stone was observed at sites 26EU1548 and 26EU2064, and the assemblage collected from sites 26EU1533, 26EU1539, and 26EU2126 was small: three mano fragments, two metate fragments, one hammerstone, and one indeterminate grinding tool. Four of the seven artifacts were collected from the modern ground surface, two were recovered during mechanical stripping of surface sediments, and one was recovered in an excavation unit.

6.3.1. METHODS

The total assemblage consists of seven pieces of ground stone. Analysis of these artifacts consisted of classifying them by type (grinding tools, percussion tools) and by subtype (hammerstone, mano, metate); length, width, thickness, and weight measurements were also taken. Material was described in terms of type, color, and texture, using the following definitions (Adams 2002):

Coarse texture: grain size greater than 2 mm

Intermediate texture: grain size smaller than 2 mm and larger than 1 mm

Smooth texture: grain size smaller than 1 mm

Wear level was determined using the following definitions (Adams 2002):

Light wear: damage barely visible to the unaided eye

Moderate wear: obvious damage present but not extensive enough to alter the basic shape of the tool

Heavy wear: enough damage present to alter the shape of the tool

Method of tool design was determined using Adams's definitions of expedient and strategic design: a design is expedient if the natural shape of the rock has been altered only through use; it is strategic if modifications have been made to the stone in order to make it easier to hold or to achieve a specific shape. Artifact use was classified by both primary and secondary use, primary being the original use for which the tool was designed, and secondary being a later addition to the tool's use (Adams 2002). The number of grinding surfaces and battered surfaces on each artifact was recorded, and length and width measurements were taken of each grinding surface (no surfaces were ground down enough for a depth measurement to be taken). Signs of burning and completeness were also recorded.

The data recorded for each ground stone specimen are presented in Table 73. Illustrations of these specimens are provided in Appendix G.

Table 73. Ground Stone Artifacts Collected from Sites Involved in the 2007 BGMI Project

Site #	FS #	Artifact Type	Artifact Subtype	Length × Width × Thickness (mm)	Weight (g)	Material	Texture	Wear Level	Design	Primary Use	Second-ary Use	# of Battered Surfaces	Complete-ness
26EU1533	2000	Indeterminate	Indeterminate	119.03 × 90.32 × 49.02	738.7	Light brown and red arkosic sandstone	Intermediate	Light	Expedient	Abrading or grinding	Battering	1	Complete
26EU1539	51	Percussion tool	Hammerstone	149.04 × 134.77 × 61.29	1477.9	Red, purple, and light brown mineralized arkosic sandstone	Intermediate	Moderate	Expedient	Battering	None	1	Complete
26EU1539	107	Grinding tool	Rectangular, one–hand mano	101.68 × 70.84 × 62.97	719.2	Mottled red, pink, and white pegmatite vein (quartz and mica)	Coarse	Moderate	Expedient	Grinding	Unknown	1	Incomplete
26EU1539	294	Grinding tool	Unknown	88.38 × 83.49 × 56.63	381.7	Dark red and brown, lightweight intermediate lava; possibly dacite	Smooth	Moderate	Expedient	Grinding	None	0	Incomplete
26EU1539	1250	Grinding tool / chopper	Flat metate	129.32 × 87.96 × 42.55	619.0	Light brown, brown–gray, orange, and red intermediate lava; possibly dacite	Smooth with small number of quartz inclusions	Moderate	Strategic	Grinding	Chopping	1	Incomplete
26EU1539	1251	Grinding tool	Flat metate	98.37 × 74.17 × 33.86	344.2	Orange and dark red intermediate lava; possibly dacite	Smooth	Moderate	Expedient	Grinding	None	0	Incomplete
26EU2126	1001	Grinding tool	Rectangular mano	48.82 × 54.81 × 39.78	138.5	Gray sandstone	Smooth	Moderate	Expedient	Grinding	Unknown	0	Incomplete

6.3.2. Ground Stone By Site

26EU1533

A single piece of ground stone (FS# 2000) was recovered at 26EU1533 during mechanical stripping. This artifact was recovered from the eastern portion of the site, just south of Operation B and near the eastern edge of the central surface artifact concentration observed during surface collection (see Figure 4 in Chapter 3). This specimen is a rounded cobble with a single lightly ground surface and some possible pecking marks on one end. The material appears to be arkosic sandstone with an intermediate grain and naturally occurring pock marks; therefore, the possible pecking marks are equally likely to be natural. What this stone was used for is undetermined; it appears to be a grinding or abrading tool, possibly a hand stone. Because no modification other than use wear has been made to this artifact, it is classified as expedient. It was slightly damaged during surface blading: the ground surface has a long scrape made by the grader blade (clearly shown on the illustrations of this artifact in Appendix G).

26EU1539

Most of the ground stone artifacts collected during the 2007 BGMI project came from 26EU1539. Five were recovered from this site, three during surface collection and two during mechanical stripping (Figure 81). The ground stone artifacts from this site include two metate fragments, two manos, and one hammerstone.

A large, teardrop-shaped hammerstone (FS# 51) was recovered during surface collection approximately 20 m north of the road that crosses the site. The hammerstone displays percussion marks on one edge and is lightly ground on one side. It is a large rock; only a person with large hands could have effectively used it as a tool. There is a depression that could fit the thumb of a right-handed user; however, this appears to be natural. The material appears to be heavy, mineralized arkosic sandstone. Because no modification other than use wear has been made to this artifact, its design is classified as expedient.

A rectangular one-hand mano (FS# 107) was recovered during surface collection in the far northeastern corner of the site. The mano is almost complete, has been heavily ground on two sides, and displays pecking marks at one end. The material appears to be composed primarily of quartz crystals and mica, and is probably from a pegmatite vein. Because no modification other than use wear has been made to this artifact, its design is classified as expedient.

A one-hand mano fragment (FS# 294) was recovered during surface collection from the artifact concentration in the southern part of the site. It has been heavily ground on one side and along an edge, implying that it was modified by the user with a rocking stroke, rather than a flat stroke. It displays no obvious pecking marks and has a roughly wedge shape. The material appears to be lightweight intermediate lava of some sort, perhaps dacite. Because no modification other than use wear has been made to this artifact, its design is classified as expedient.

A metate fragment (FS# 1250) was recovered during blading in the far northeastern corner of the site, approximately 15 m west of the location where FS# 107 was found on the surface. The metate has been ground on two sides and on a third smaller surface adjacent at an oblique angle to one of the larger ground surfaces. No signs of pecking are present. One of the two large ground surfaces on this specimen is heavily polished and the other displays relatively deep striations. Although the fragment is too small for the original shape or size of the full metate to be determined, its thickness (more than 4.2 cm) indicates that it was a non-portable, flat metate. Non-portable metates are defined by Schmitt and Madsen (2005) as greater than 3.5 cm in thickness. The material appears to be intermediate lava. After breaking, this artifact was modified for a secondary use. A series of blows along the edge of one side, along with the small, angled ground surface, form a rough edge, indicating that the specimen was likely used as a chopper. This is the only tool in the 2007 BGMI project ground stone assemblage to display qualities of strategic design.

Finally, a metate fragment (FS# 1251) was recovered during blading in the far northeastern corner of the site, approximately 10 m south of the location where FS# 107 was found on the surface. The metate has been ground on one surface. No signs of pecking are present. The fragment is too small for the original size or shape of the metate to be determined. This specimen is 3.4 cm thick, just below Schmitt and Madsen's (2005) threshold for non-portable metates, but as such, and given its small size, it cannot be definitively considered to have come from a portable metate. The surface of the fragment suggests that it comes from a flat metate. The material appears to be intermediate lava. Because no modification other than use wear has been made to this artifact, its design is classified as expedient.

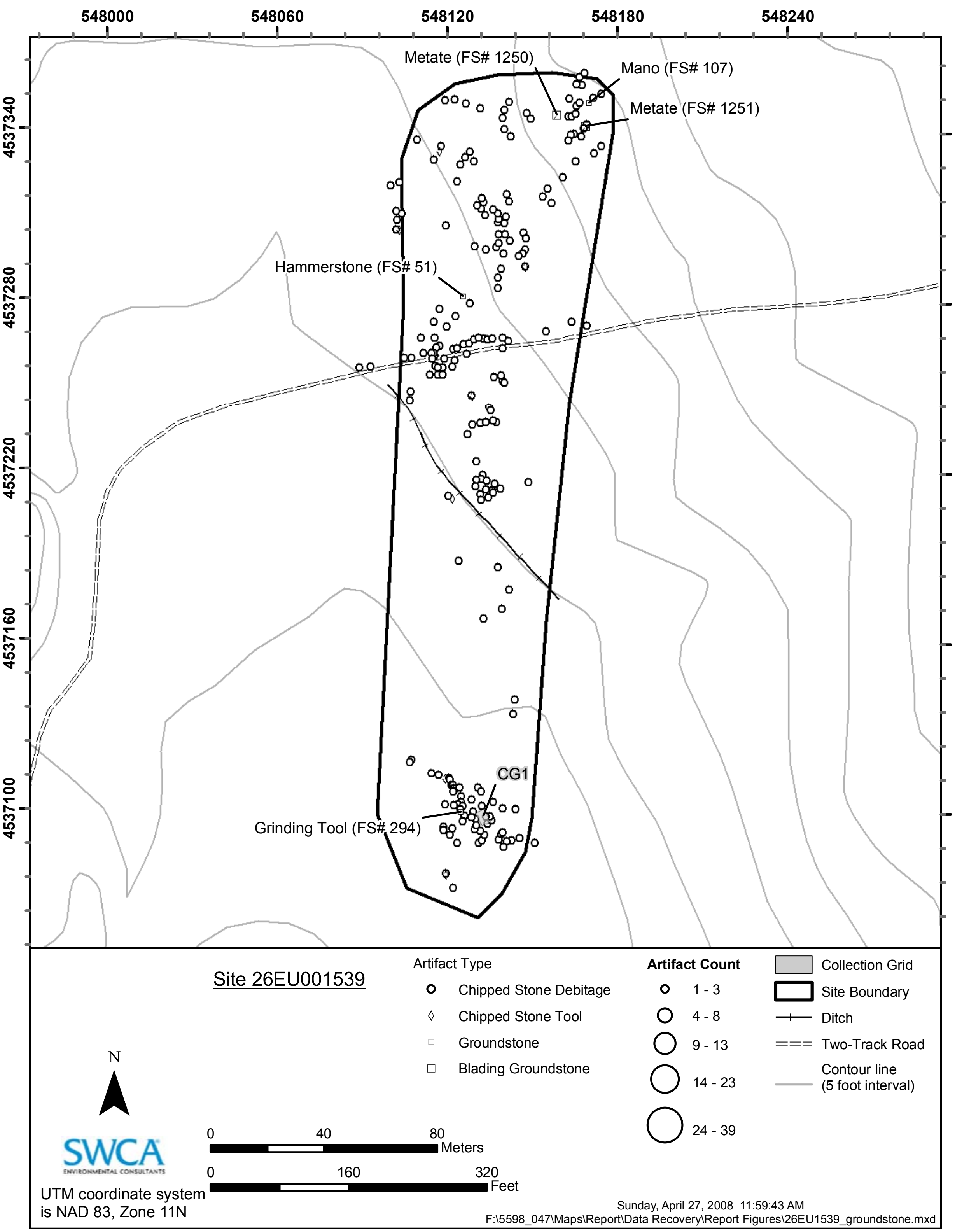

Figure 81. Locations of ground stone artifacts recovered at 26EU1539.

26EU2126

Although 26EU2126 produced the highest quantity of prehistoric artifacts of any site involved in the 2007 BGMI project—including lithic flakes, chipped stone tools, burned faunal bone, and FCR—only a single piece of ground stone was recovered from it during the project[11]. This artifact (FS# 1001) was found in Operation C, in Level 1 of Unit C1, approximately 2 m south of the location of the FCR concentration designated Feature 1 (see Figure 16 in Chapter 3). This specimen is a small mano fragment that appears to be from a rectangular-shaped mano, and it has been ground smooth on two sides. It displays no pecking marks. Because of its small size, it is difficult to estimate the original size of this specimen. The material is gray sandstone with a smooth texture. Because no modification other than use wear has been made to this artifact, its design is classified as expedient, but this determination is not definitive due to the small size of the specimen.

6.3.3. Discussion

The ground stone assemblage recovered from 26EU1533, 26EU1539, and 26EU2126 is modest in size and in information. However, when considered with reference to ground stone samples recovered from previously investigated sites in the LBBA, it has the potential to provide some insight into two research domains outlined in the 1991 historic context for the LBBA (Schroedl 1991a): site structure and function, and settlement and subsistence patterns. Several avenues of research previously conducted in the region, including both ethnohistoric research among the Western Shoshone and archaeological work, provide a context in which to fit the 2007 BGMI project assemblage.

The Western Shoshone employed a diverse range of strategies for food procurement, falling at various times into either of Binford's (1980) categories of foragers and collectors. Ethnographic accounts indicate that the Western Shoshone living north of the Humboldt River (Harris 1940), an area that includes the LBBA and where staple resources were sparsely but fairly evenly distributed, employed a forager strategy. Since occupation of the sites investigated during the 2007 BGMI project appears to date primarily to the Eagle Rock Phase (A.D. 1300–1850), when the area was likely occupied by Western Shoshone, on a generalized level it can be assumed that the people who occupied these sites spent the majority of each year living in nucleated family groups, foraging in a small area around their residential camps and relocating when resources in the area became sufficiently depleted. For a short time during the winter months, however, multiple family groups likely came together in aggregated camps and employed more of a collector strategy, venturing out on trips longer than a day in search of resources before returning to camp. The ground stone recovered during the 2007 BGMI project can be used to begin to assess this reconstruction for the project area.

A detailed synthesis by Birnie (1996a) of ground stone data from the LBBA discusses 233 artifacts collected from 13 sites. This synthesis provides a foundation with which to compare the

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[11] P–III collected an additional ground stone artifact, described as a basin milling stone fragment, from the surface of site in 1991, but their site form from this recordation (Popek 1991b) does not describe the location where this artifact was found, nor is it shown on the site map that accompanies the form.

considerably smaller sample collected during the 2007 BGMI project. Birnie divided ground stone artifacts into two categories: milling implements (used to process food and other materials) and grinding implements (for smoothing or shaping tools). Of the 233 pieces of ground stone recovered by Birnie, almost 90 percent were categorized as milling tools, primarily manos and metate fragments. The majority of the grinding implements are edge-ground cobbles. The artifacts in Birnie's sample are made of several different material types, but the most common are a variety of sandstones, tougher materials such as granite, and volcanic tuff. The ground stone artifacts recovered by SWCA in 2007 are similar in tool and material type. Of the seven artifacts recovered, six can be classified under Birnie's definitions as milling implements, consisting primarily of manos and metate fragments. A seventh artifact, recovered at 26EU1533, is classified as indeterminate. Six of the ground stone artifacts are composed of a variety of sandstones and lava material, while one mano is made from what appears to be a pegmatite vein composed of quartz and mica.

Birnie noted that the majority of ground stone artifacts from the LBBA consist of partial or complete manos and fragments of metates (Birnie 1996a). This was also observed in the assemblage discussed here: the two metate fragments are small, less than 13 cm long, while the manos are all almost fully complete. This can be partially explained by the fact that metates are typically much thinner than manos, and thus more susceptible to breakage. It also suggests that they were discarded more readily, perhaps because the raw material used for manos was easier to come by than that used for metates. (It is also important to mention that artifacts could have been broken during post-occupation disturbances.)

The design of a ground stone artifact, whether expedient or strategic, can be used to help interpret a group's level of mobility and dependency on plant foods. Birnie (1996a) identified the following four milling strategies associated with mobile hunter-gatherer groups in the LBBA:

1. The predominant use of expedient milling implements.
2. The predominant use of expedient implements supplemented with the use of curated [analogous to Adams's (2002) term strategic] implements.
3. A mix of expedient and curated/strategic implements.
4. The predominant use of curated/strategic implements, supplemented with the use of expedient implements.

Six of the seven ground stone artifacts recovered in 2007 were of expedient design, and one showed signs of strategic design. Two of the sites, 26EU1533 and 26EU2126, yielded only a single ground stone artifact each; both artifacts were expediently designed, but little information can be inferred from such a small sample. Of the five tools recovered at 26EU1539, four display an expedient design and one displays a strategic design. This indicates that the occupants of this site followed a milling strategy similar to one of the first two listed above, from which a high level of mobility can be inferred. This follows the generalized assumption that groups in the area were highly mobile and not as heavily reliant on plant foods as other groups, as discussed above.

It should be mentioned that highly mobile groups that are dependent on plant foods could circumvent the burden of carrying around the heavy stone implements by caching them. No evidence of caching was observed at any of the five sites excavated in 2007; however, because caches could have been located away from the sites, such a strategy cannot be ruled out. Likewise, none of the ground stone specimens recovered during the project show any signs of fire blackening, and none were recovered from thermal features or clear midden contexts which would suggest that they were used in cooking features or secondarily discarded. Thus, assuming that post-depositional disturbances have been minimal, it would appear that the contexts in which these specimens were found reflect their general locations of use.

The small size of the ground stone assemblage collected during the 2007 BGMI project limits a more detailed discussion than is presented here. Of the five sites involved in the project, only 26EU1539 produced more than one ground stone implement. However, when put into a comparative context with previously recovered ground stone assemblages, several things can be inferred. Indigenous groups in the LBBA were historically documented as highly mobile hunter-gatherers who lived in small, nucleated family groups for most of the year, and congregated in larger groups only during the coldest winter months. The ground stone assemblage from the 2007 BGMI project, dominated by expedient tool types, suggests that such was also the case prehistorically, at least with the occupants of 26EU1539.

6.4. Synthesis of Subsistence Data

While addressing subsistence-related research questions was not a primary research focus of the 2007 BGMI Data Recovery Project, some subsistence data were recovered during the course of the project. This information derived from faunal and macrobotanical remains, as well as from the analysis of ground stone artifacts. It was described in detail in the three preceding sections of this chapter and is summarized here.

The types of subsistence-related data collected from the sites excavated during the 2007 BGMI project are listed in Table 74, which also gives the analysis period for each site as defined in Section 5.4.1.

Table 74. Subsistence Data Types Recovered by Site

Site	Analysis Period	Data Type Collected
26EU1533	Middle Archaic	c
26EU1539	Late Archaic/Late Prehistoric	b, c
26EU1548	Late Archaic/Late Prehistoric	b
26EU2064	n/a*	b
26EU2126	Late Archaic/Late Prehistoric	a, b, c

a = faunal; b = macrobotanical; c = ground stone.

* Site has material from each of the Middle Archaic, Late Archaic and Late Prehistoric periods.

Faunal remains were recovered from 26EU2126, and those for which there is evidence of cultural use come from Operation F at this site; a small hearth feature (Feature 2) was also found in this excavation block. These remains are radiocarbon-dated to the period between A.D. 1230 and 1300. The large majority of the faunal specimens from Operation F are from artiodactyls, which is consistent with a region-wide pattern of high artiodactyl relative abundance in late

Holocene archaeofaunal assemblages. In addition, these specimens are highly fragmented, suggesting that they were intensively processed. The association that occurs in Operation F between large mammal remains and a small hearth that lacks FCR is not consistent with the pattern previously noted in the LBBA, in which large mammal remains are typically associated with larger, rock-lined or rock-filled thermal features. The materials from Operation F are consistent with a logistical settlement pattern in that they suggest an isolated resource processing event.

Flotation samples were recovered from four sites: 26EU1539, 26EU1548, 26EU2064, and 26EU2126. Only two of the thirteen samples analyzed come from features that are likely archaeological. Most of the remainder come from charcoal lenses that appear to be the remains of wildfire-burned vegetation, and the methods used here to confirm that these features are likely not archaeological may provide an example to be followed in future work in the area. The two archaeological features from which flotation samples were obtained are Features 2 and 3 at 26EU2126. Based on its morphology and context in a deposit rich in artifacts and faunal remains, Feature 2 appears to be a small hearth. No subsistence plant remains were recovered from the fill of this feature, and given the abundance of burned faunal remains that were recovered in its vicinity, it is likely that this feature was associated with animal processing activities rather than plant processing activities. Subsistence plant remains were also absent in the small amount of ashy fill recovered from Feature 3, but this is not surprising given that this feature was a concentration of FCR that may have been the result of hearth cleaning, rather than an actual hearth itself.

A total of seven ground stone artifacts were recovered at sites 26EU1533, 26EU1539, and 26EU2126. In light of ethnohistorically documented practices of the Western Shoshone and previous archaeological research conducted by Birnie (1996a), the fact that six out of the seven recovered ground stone tools can be classified as expedient suggests that the sites that were investigated were occupied only periodically by highly mobile individuals and that those individuals did not rely on plant foods as much as on animal foods. This is consistent with the high relative abundance of large mammal remains observed in the faunal assemblage from Operation F at 26EU2126, which suggests that, during much of the late Holocene, foraging efficiency was high and it was not necessary for foragers to adopt broad diets that frequently included low return plant resources requiring intensive processing (Byers and Broughton 2004).

It has been observed that foraging efficiency apparently declined, and that diet breadth accordingly increased, toward the end of the LBBA prehistoric sequence during the Eagle Rock phase (e.g., Bright et al. 2002; Ugan and Bright 2001). Given the date obtained for the faunal remains from Operation F at 26EU2126, which immediately precedes the Eagle Rock Phase, faunal data from the 2007 BGMI project are not inconsistent with the Eagle Rock phase decline in foraging efficiency and expansion of diet breadth that has previously been observed for the LBBA. Thus, taken together, subsistence data from the project appear to be consistent with a pattern documented previously for the region, in which foraging efficiency was high, and diet breadth narrow, during much of the late Holocene, with a decline in foraging efficiency and corresponding expansion of diet breadth evident during the Late Prehistoric Eagle Rock Phase.

7. CHIPPED STONE ARTIFACTS

Victor Villagran, Sara Meess, Amy Spurling, Sarah Grant, Emily Root-Garey, George Cox, Allison Twist, and Michael D. Cannon

The 2007 BGMI Data Recovery Project recovered 14,009 pieces of debitage, 6 cores, and 78 chipped stone tools (including projectile points)[12]. The number of chipped stone artifacts collected from each of the five sites involved in the project is shown in Table 75.

Table 75. Counts of Chipped Stone Artifacts by Site

	Debitage	Tools	Cores	Total
26EU1533	189	2	0	191
26EU1539	4,531	23	2	4,556
26EU1548	829	4	0	833
26EU2064	1,763	21	0	1,784
26EU2126	6,697	28	4	6,729
Total	14,009	78	6	14,093

The analysis of chipped stone artifacts for the project was directed toward addressing research domains from the historic context prepared for the LBBA by Schroedl (1991a) (see Section 2.3). These research domains fall primarily into the category of "Lithic Technology and Technological Organization" and include:

- Variability in the Use of Lithic Raw Materials
- Lithics and Activity Locus Function
- Lithic Procurement Strategies
- Lithic Technology and Mobility

Much of the analysis conducted within these research domains focused on the procurement, transport, reduction, and use of chert from the Tosawihi Quarries, which overwhelmingly dominates the chipped stone assemblages recovered during the project. In addition to these domains, an analysis was conducted to assess the potential effect of artifact collecting on the recovered chipped stone assemblage, a topic that falls within the "Site Formation Processes and Paleoenvironment" category of research domains. The analyses conducted to address these

[12]These totals also include artifacts recovered during the 2006 probing project from the five sites involved in the 2007 data recovery project. As noted in Chapter 1, materials from these five site that were collected during probing in 2006 are incorporated into the analyses presented in this report.

research domains are reported in the various sections of this chapter, following a description of the sampling, classification, and analysis methods that were employed in doing so.

7.1. Analysis and Sampling Methods

7.1.1. Debitage Analysis

Analysis of debitage was carried out for each site by systematically examining the contents of each field specimen (FS) bag containing debitage. Within each FS bag, each piece of debitage was assigned a sequential number starting at one. Field specimen bags that contained more than 200 pieces of debitage were not analyzed completely, but were sampled such that approximately 200 flakes were analyzed from each of these FS bags; the procedures that were followed in sampling are discussed below. Any flakes exhibiting retouch were classified as tools (modified flakes) and were included in the tool analysis rather than the debitage analysis.

The following variables were recorded for each analyzed piece of debitage: material type, material description, presence or absence of cortex, size class, weight, and debitage type. If present, use wear, evidence of heat treatment such as crazing or potlid fractures, and crystalline inclusions were also recorded.

The only material types present in the assemblage are obsidian and cryptocrystalline silicate (CCS), and all CCS material exhibits characteristics consistent with identification as Tosawihi chert (Elston and Budy 1990; Lyons et al. 2003). The material description is a simple color description and was used primarily to create subgroups for Tosawihi chert based on color. The presence or absence of cortex was recorded to provide a general indication of early- versus later-stage reduction. Size was recorded using an incremental size-class template, and artifacts were grouped into these size categories based on their approximate diameter: greater than 2 inches, 1 to 2 inches, 1/2 to 1 inch, 1/4 to 1/2 of an inch, 1/8 to 1/4 of an inch, and less than 1/8 of an inch. Weights for each artifact were recorded in hundredths of a gram.

Three categories of debitage type were recorded after Andrefsky (2005): proximal flake, flake shatter, and angular debris. A proximal flake is a flake, whether complete or not, on which a striking platform or point of impact is present. Any piece of debitage that lacked the striking platform or point of impact but had a discernable ventral and dorsal surface was classified as flake shatter. Any piece of debitage that that did not have a single discernable ventral or dorsal surface present, or that had more than one ventral or dorsal surface, was classified as angular debris.

Three additional variables—termination type, platform type and flake type—were recorded only for debitage specimens that were classified as proximal flakes. The termination categories used, again after Andrefsky (2005), were feathered, stepped, hinged, or overshot. "Feathered" indicates that the distal end is sharp or that it tapers to a point when viewed in a cross-section. "Stepped" indicates that the distal edge forms approximately a 90° angle with the ventral surface. This category surely includes flakes that were broken long after initial reduction and exhibit a stepped termination for that reason. "Hinged" indicates that the ventral edge of the distal end was rounded. "Overshot" indicates that the ventral surface curved sharply inwards at the distal end, such that the distal end is thicker than the medial portion of the flake.

Platform type is based on the striking platform on the proximal end of the flake and was categorized after Andrefsky (2005) as cortical, flat, complex, or abraded. "Cortical" indicates that the striking platform has some cortex present. "Flat" indicates that the striking platform was smooth and flat, having no flake scars. "Complex" indicates that the striking platform was rounded and/or had flake scars on it, but no abrasion. "Abraded" indicates that the striking platform was complex and had abrasion on it.

Finally, the flake type variable involved classifying proximal flakes into these categories: core reduction, biface reduction, biface thinning, pressure, bipolar, and indeterminate. Core reduction flakes were recognized as flakes that are flat, have a platform angle approaching 90°, are relatively thick in cross-section, have few dorsal flake scars, and have flake scars that are roughly parallel to flake margins. Biface reduction flakes were recognized as flakes that are moderately thick and very curved in cross-section, with dorsal surfaces containing numerous flake scars oriented in various directions, complex or abraded platform types and acute platform angles, often with a lip on the proximal ventral surface. Biface thinning flakes were recognized as flakes that are thinner and flatter in cross-section, with dorsal surfaces that have numerous flake scars oriented in various directions, complex or abraded platforms, and platform angles that are relatively acute, often with a lip on the proximal ventral surface. Pressure flakes were recognized as flakes that are small, very thin and relatively flat in cross-section, have a very small platform, and lack a discernable bulb of percussion. Bipolar flakes are flakes with evidence of the application of force in two different places but that are otherwise similar to core reduction flakes; no bipolar flakes were actually identified in the assemblage. The indeterminate flakes category was used for flakes that could not be confidently assigned to any of the other categories.

Much of the debitage analysis that is presented below involves exploring variability in flake type profiles—or distributions of flakes across the flake type categories listed above—among sites, site loci or time periods. To show that these flake type categories capture variability in more objective variables related to lithic reduction strategies and stages (see, e.g., Sullivan and Rozen 1985), descriptive information for the flakes in the 2007 BGMI debitage assemblage that were classified into each of these categories is presented in Table 76 through Table 78 and illustrated in Figure 82 through Figure 84. Cortex is present on over a third of the debitage specimens classified as core reduction flakes, but it occurs in very small percentages on biface reduction and biface thinning flakes, and it was not observed on any pressure flakes (Table 76, Figure 82). These differences in the percentage of cortical flakes among flake types are statistically significant at the 0.05 alpha level (chi-square = 205.0, $df = 3$, $p < 0.001$, mean expected frequency = 110.1[13]). Regarding flake size, the pressure flake category is dominated by flakes in the 1/8"–1/4" size class, while 1/2"–1" flakes are most common in the biface thinning flake category, 1/2"–1" and 1"–2" flakes co-dominate the biface reduction flake category, and 1"–2"

[13] A common rule of thumb is that chi-square should be used only if each expected frequency is at least 5.0. As summarized by Zar (1999:504-505), a more well-grounded and less restrictive guideline is to require that the average expected frequency be at least 6.0 when using an alpha level of 0.05. Mean expected frequencies are therefore reported here along with chi-square results. There is one case in this report in which mean expected frequency is less than 6.0; in this case, which involves a 2 × 2 contingency table, Fisher's exact test is used.

flakes are most common in the core reduction category, which is also the only category that contains an appreciable percentage of flakes in the > 2" size class (Table 77, Figure 83). This trend of increasing numbers of flakes in the larger size classes from pressure flakes to core reduction flakes is statistically significant (chi–square = 410.8, $df = 12$, $p < 0.001$, mean expected frequency = 44.1). Consistent with this trend in flake size is a trend in flake weight (Table 78, Figure 84; note that logarithmic scales are used on both axes of Figure 84 because distributions are very skewed), which likewise increases significantly from pressure to core reduction flakes ($F = 211.5$, $df = 3$, $p < 0.001$[14]). All of these differences in objective variables among flake types are as would be expected if the flake type categories were a useful measure of reduction stage or technique.

[14] To meet the assumptions of analysis of variance (e.g., Zar 1999:273–275), the weight variable was transformed for purposes of statistical analysis using a power transformation with an exponent of -0.016, the value of which was determined based on the slope of a spread vs. level plot (Mosteller and Tukey 1977). Using the transformed variable, there is no significant difference in variance among the flake types ($p = 0.212$), and Tukey post-hoc tests indicate that the mean for each of the flake types is significantly different at the 0.05 alpha level from that of each of the three others.

Table 76. Presence or Absence of Cortex by Flake Type in the 2007 BGMI Project Analyzed Debitage Assemblage

	Cortex Present		Cortex Absent		
Flake Type	**Count**	**Percent of Flake Type**	**Count**	**Percent of Flake Type**	**Total**
Core Reduction	28	37.3%	47	62.7%	75
Biface Reduction	9	2.5%	352	97.5%	361
Biface Thinning	3	0.8%	397	99.2%	400
Pressure	0	0.0%	45	100.0%	45
Total	*40*	*4.5%*	*841*	*95.5%*	*881*

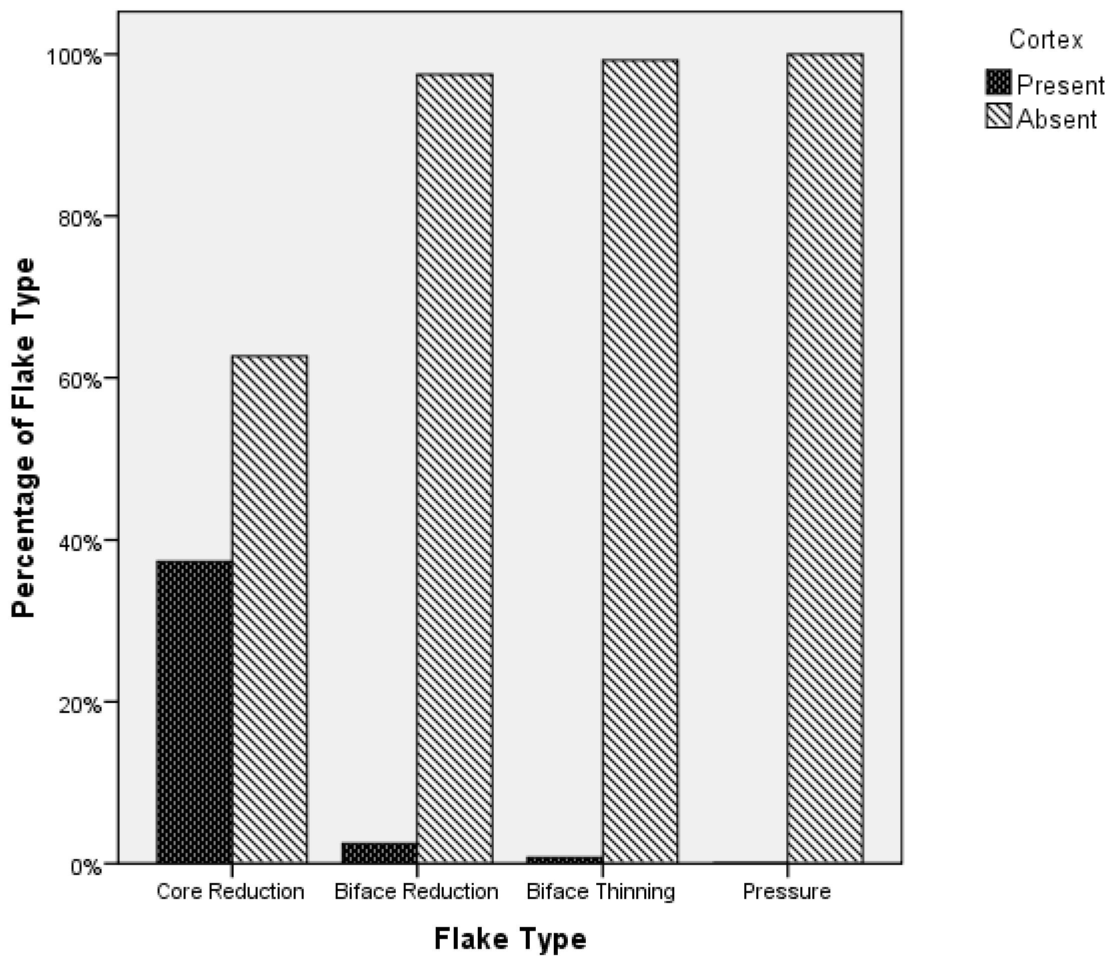

Figure 82. Distribution of cortical and non-cortical flakes by flake type in the 2007 BGMI project analyzed debitage assemblage.

Table 77. Flake Types by Size Class in the 2007 BGMI Project Analyzed Debitage Assemblage

	1/8"–1/4"		1/4"–1/2"		1/2"–1"		1"–2"		> 2"		
Flake Type	**Count**	**Percent of Flake Type**	**Count**	**Percent of Flake Type**	**Count**	**Percent of Flake Type**	**Count**	**Percent of Flake Type**	**Count**	**Percent of Flake Type**	**Total**
Core Reduction	1	1.3%	4	5.3%	31	41.3%	35	46.7%	4	5.3%	75
Biface Reduction	3	0.8%	49	13.6%	153	42.4%	155	42.9%	1	0.3%	361
Biface Thinning	22	5.5%	139	34.8%	208	52.0%	31	7.8%	0	0.0%	400
Pressure	24	53.3%	14	31.1%	6	13.3%	1	2.2%	0	0.0%	45
Total	*50*	*5.7%*	*206*	*23.4%*	*398*	*45.2%*	*222*	*25.2%*	*5*	*0.65%*	*881*

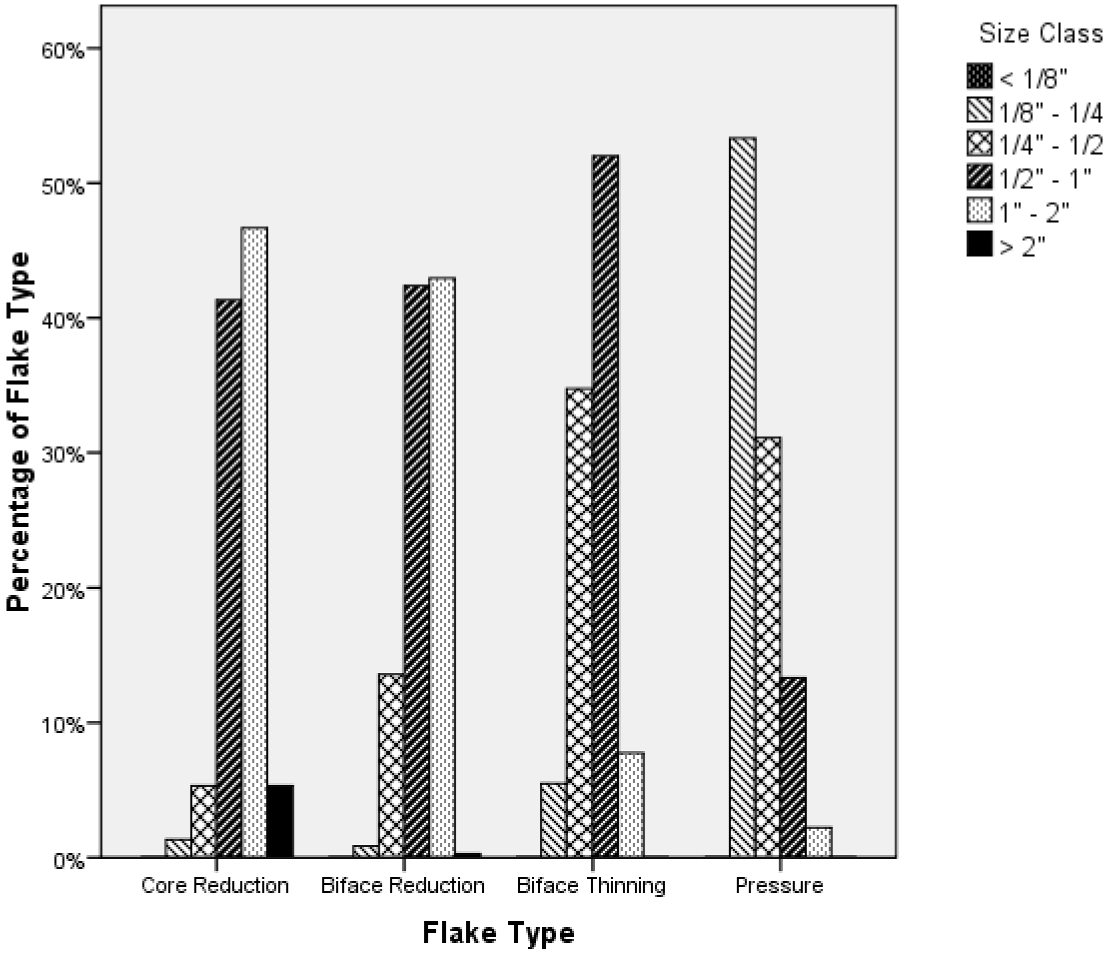

Figure 83. Size class distributions for flake types in the 2007 BGMI project analyzed debitage assemblage.

Table 78. Mean Weight per Flake Type in the 2007 BGMI Project Analyzed Debitage Assemblage

Flake Type	Mean Weight (g)	Standard Deviation	Count
Core Reduction	4.87	7.04	75
Biface Reduction	2.10	2.12	361
Biface Thinning	0.55	0.56	400
Pressure	0.14	0.25	45

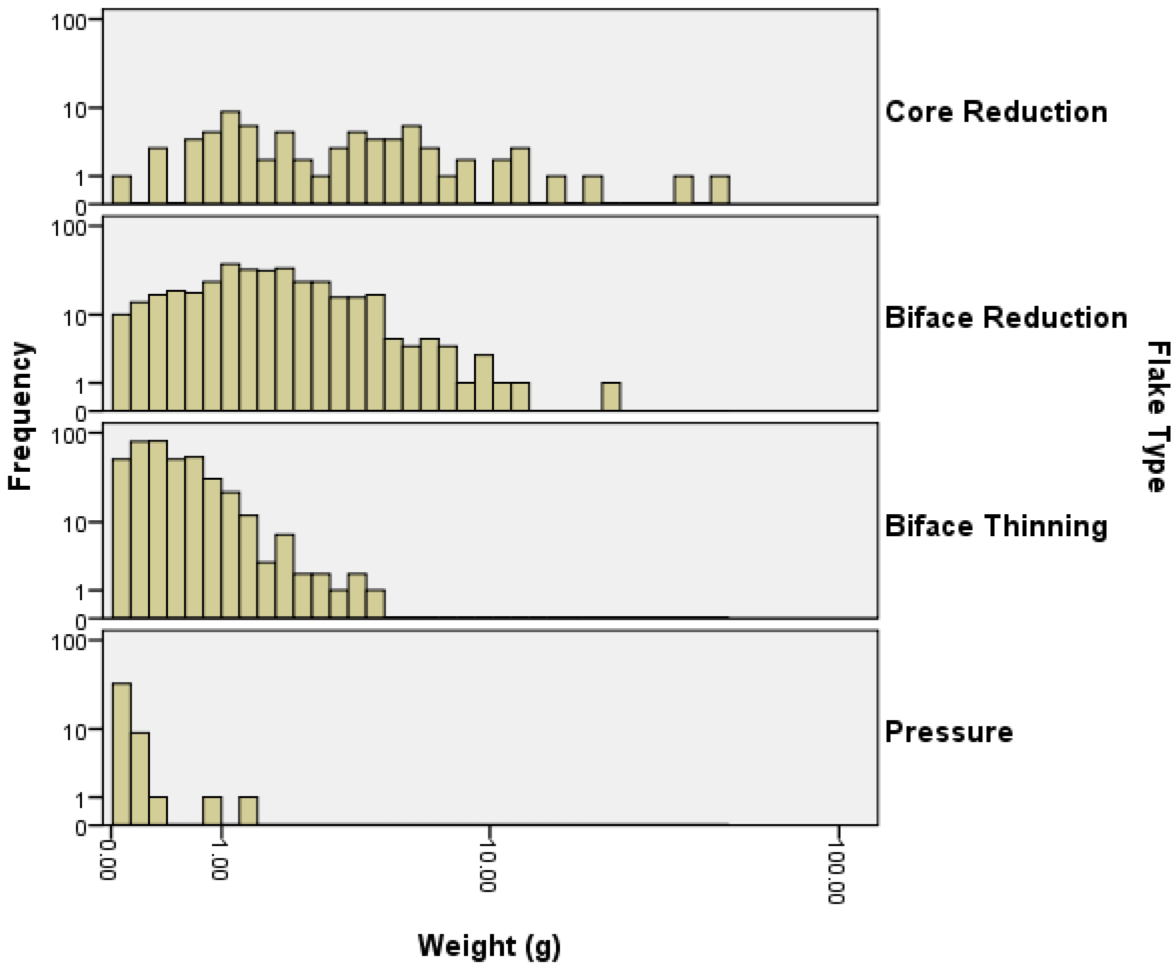

Figure 84. Histogram of flake weights per flake type in the 2007 BGMI project analyzed debitage assemblage.

DEBITAGE SAMPLING

As noted above, FS bags with more than 200 pieces of debitage were not completely analyzed but were sampled. There were 12 such FS bags. These bags were sampled such that approximately 200 pieces of debitage from each were selected for analysis; this sample size was estimated to be adequate for statistical analysis. To ensure that the samples selected would not be biased with respect to artifact size, the contents of FS bags were stratified by size for sampling. This was done by screening the debitage in each FS bag through nested geological sieves; sieve sizes used were 1-inch, 1/2-inch, 1/4-inch, and <1/4-inch. A sampling percentage was calculated for each individual FS bag by dividing 200 by the number of pieces of debitage in that bag, and this proportion of the artifacts retained in each sieve size was collected for analysis (the remaining, unanalyzed artifacts were bagged separately and kept within their respective FS bags). The result was a random sample, stratified by size, totaling approximately 200 artifacts for each FS bag (with some slight deviations from 200 due to rounding error). The sampling resulted in an analyzed sample of 10,637 pieces of debitage, out of the total of 14,009 pieces recovered. Details for each of the 12 sampled FS bags, including original counts, sampling percentages, and sieve size fractions are provided in Table 79.

Table 79. Counts and Sampling Percentages for Sampled Debitage FS Bags

Site	FS	Count	Sampling Percentage	1" Count	1/2" Count	1/4" Count	<1/4" Count	1" Sample	1/2" Sample	1/4" Sample	<1/4" Sample	Total Sample
26EU1539	141	241	83.0	0	12	94	141	0	10	78	117	205
26EU1539	143	512	39.1	1	51	264	197	0	20	103	77	200
26EU1539	144	416	48.1	0	33	237	154	0	16	114	74	204
26EU1539	146	373	53.6	2	59	227	85	1	32	121	46	200
26EU1539	161	262	76.3	0	10	106	151	0	8	81	115	204
26EU1539	1004	257	77.8	0	20	183	54	0	16	142	42	200
26EU2126	1067	1,267	15.8	6	110	827	324	1	17	131	51	200
26EU2126	1075	559	35.8	3	85	368	103	1	30	132	37	200
26EU2126	1087	289	69.2	1	12	165	111	1	8	114	77	200
26EU2126	1092	648	30.9	0	48	503	97	0	15	155	30	200
26EU2126	1099	580	34.5	0	37	377	166	0	13	130	57	200
26EU2126	1105	381	52.5	0	22	263	96	0	12	138	50	200

7.1.2. Chipped Stone Tools and Cores

Chipped stone tools and cores were classified into categories used by LaFond (1996), with a few modifications. LaFond's tool categories include general biface, indeterminate biface, quarry biface, drill, knifelike biface, scraper, modified flake tool, expedient drill, expedient scraper, chopper, denticulate, expedient composite tool, and graver. For this analysis, bifaces were classified according to Callahan's five stages of biface reduction (Andrefsky 2005:187), rather than into LaFond's categories of general, indeterminate or quarry bifaces. Another modification to LaFond's classification system was the addition of a compound tool category. This category was created because one tool in the 2007 BGMI assemblage had the characteristics of both a scraper and graver (FS# 238 from 26EU1539, discussed further below; see Figure 85). In addition, projectile points, which are discussed in greater detail Section 5.2.3, are included as tools in the analyses presented in this chapter.

The majority of the 78 tools recovered were bifaces (n = 38) and modified or retouched flakes (n = 24). Also recovered were 11 projectile points, three scrapers, one knifelike biface, and the compound tool mentioned above. Summary information about each of these tools is provided in Table 80, and they are illustrated in Appendix H.

Notable tools recovered include the compound tool, the knifelike biface, and the three scrapers (Table 81). The compound tool (FS# 238 from 26EU1539) is made from Tosawihi chert, and, as mentioned above, can be classified as both a scraper and a graver (Figure 85). It exhibits retouch on both surfaces of the scraper portion and on one surface of the graver end of the tool. No use wear is apparent on this specimen. The knifelike biface (FS# 1086 from 26EU2126) is made from Tosawihi chert, is subtriangular in shape, has retouch on one edge, and exhibits no use wear (Figure 87). Only the distal portion of this tool was recovered. The three scrapers are all expedient tools made from Tosawihi chert with unifacial retouch on a single edge (Figure 89 through Figure 93). Two (FS# 8 and FS# 139 from 26EU1539) exhibit use wear in the form of perpendicular striations, while the third (FS# 233 from 26EU1548) has no clear use wear.

The core categories used for this analysis include random/expedient cores, random/expedient microcores, bipolar cores, unidirectional cores, and unidirectional microcores. Random/expedient cores and microcores are cores that have no distinctive pattern in flake removal. Unidirectional cores and microcores have one platform surface from which all flakes are struck. Flake removal from unidirectional cores leaves parallel scars that are continuous, causing the core form to become symmetrical. Bipolar cores show evidence of application of force to both proximal and distal end of the core, usually causing the core to shatter. All 6 of the cores recovered during the project were classified as random/expedient cores. Information about these cores is provided in Table 82, and illustrations of them are included in Appendix H.

Material type was recorded for all tools and cores as described above for debitage. In addition, maximum length, maximum width, maximum thickness, and weight were recorded for all tools and cores, and all were inspected microscopically for the presence of usewear.

Table 80. Chipped Stone Tools Recovered During the 2007 BGMI Project and 2006 Probing

Site	FS#	Specimen#	Tool Type	Material	Completeness
26EU1533	1	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU1533	53	1	Modified Flake	CCS	Complete
26EU1539	6	1	Biface (Stage 3)	CCS	Incomplete
26EU1539	8	1	Scraper	CCS	Complete
26EU1539	44	1	Biface (Stage 4)	CCS	Incomplete
26EU1539	71	1	Biface (Stage 4)	CCS	Incomplete
26EU1539	122	1	Biface (Stage 4)	CCS	Incomplete
26EU1539	136	1	Modified Flake	CCS	Complete
26EU1539	136	2	Modified Flake	CCS	Complete
26EU1539	137	1	Modified Flake	CCS	Complete
26EU1539	137	2	Modified Flake	CCS	Complete
26EU1539	137	3	Modified Flake	CCS	Complete
26EU1539	139	1	Modified Flake	CCS	Complete
26EU1539	139	2	Scraper	CCS	Complete
26EU1539	148	1	Modified Flake	CCS	Complete
26EU1539	148	2	Modified Flake	CCS	Complete
26EU1539	154	1	Modified Flake	CCS	Complete
26EU1539	159	1	Biface (Stage 5)	Obsidian	Incomplete
26EU1539	166	1	Biface (Stage 1)	CCS	Incomplete
26EU1539	201	1	Biface (Stage 2)	CCS	Incomplete
26EU1539	238	1	Compound Tool	CCS	Complete
26EU1539	292	1	Biface (Stage 3)	CCS	Incomplete
26EU1539	1005	1	Biface (Stage 3)	CCS	Incomplete
26EU1539	1254	1	Biface (Stage 2)	CCS	Incomplete
26EU1539	1256	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU1548	100	1	Biface (Stage 4)	CCS	Incomplete
26EU1548	179	1	Biface (Stage 4)	CCS	Incomplete
26EU1548	233	1	Scraper	CCS	Complete
26EU1548	1000	1	Biface (Stage 2)	CCS	Incomplete
26EU2064	1	1	Biface (Stage 5)	CCS	Incomplete
26EU2064	114	1	Biface (Stage 3)	CCS	Incomplete
26EU2064	128	1	Modified Flake	CCS	Incomplete
26EU2064	140	1	Biface (Stage 4)	CCS	Incomplete
26EU2064	141	1	Modified Flake	CCS	Incomplete
26EU2064	206	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU2064	207	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU2064	210	1	Modified Flake	CCS	Complete
26EU2064	230	1	Biface (Stage 4)	CCS	Incomplete
26EU2064	300	1	Biface (Stage 3)	CCS	Incomplete

Table 80, continued

26EU2064	302	1	Modified Flake	CCS	Complete
26EU2064	303	1	Biface (Stage 4)	CCS	Incomplete
26EU2064	438	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU2064	483	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU2064	518	1	Modified Flake	CCS	Complete
26EU2064	530	1	Biface (Stage 4)	CCS	Incomplete
26EU2064	620	1	Biface (Stage 4)	CCS	Incomplete
26EU2064	2001	1	Modified Flake	CCS	Incomplete
26EU2064	200605	1	Biface (Stage 3)	CCS	Incomplete
26EU2064	200646	1	Biface (Stage 4)	CCS	Incomplete
26EU2064	200680	1	Modified Flake	CCS	Incomplete
26EU2126	1	1	Biface (Stage 3)	CCS	Incomplete
26EU2126	33	1	Modified Flake	CCS	Incomplete
26EU2126	33	2	Biface (Stage 4)	CCS	Incomplete
26EU2126	34	1	Modified Flake	CCS	Incomplete
26EU2126	34	2	Biface (Stage 5)	CCS	Incomplete
26EU2126	35	1	Biface (Stage 5)	CCS	Incomplete
26EU2126	36	1	Modified Flake	CCS	Complete
26EU2126	37	1	Modified Flake	CCS	Complete
26EU2126	301	1	Modified Flake	CCS	Incomplete
26EU2126	1011	1	Modified Flake	CCS	Complete
26EU2126	1051	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU2126	1069	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU2126	1071	1	Biface (Stage 2)	CCS	Incomplete
26EU2126	1071	2	Biface (Stage 2)	CCS	Incomplete
26EU2126	1073	1	Biface (Stage 2)	CCS	Incomplete
26EU2126	1074	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU2126	1085	1	Projectile Point (Stage 5)	CCS	Incomplete
26EU2126	1086	1	Knifelike Biface (Stage 2)	CCS	Incomplete
26EU2126	1091	1	Biface (Stage 3)	CCS	Incomplete
26EU2126	1094	1	Biface (Stage 4)	CCS	Incomplete
26EU2126	1096	1	Projectile Point (Stage 5)	CCS	Complete
26EU2126	1122	1	Biface (Stage 5)	CCS	Incomplete
26EU2126	1129	1	Biface (Stage 5)	CCS	Incomplete
26EU2126	1148	1	Biface (Stage 1)	CCS	Incomplete
26EU2126	1148	2	Modified Flake	CCS	Incomplete
26EU2126	1150	1	Biface (Stage 1)	CCS	Incomplete
26EU2126	1155	1	Biface (Stage 2)	CCS	Incomplete
26EU2126	200613	1	Biface (Stage 2)	Obsidian	Complete

Table 81. Compound Tool, Knifelike Biface, and Scraper Measurements

Site	FS #	Specimen #	Raw Material	Material Description	Tool Type	Usewear	Max. Length (mm)	Max. Width (mm)	Max. Thickness (mm)	Weight (g)
26EU1539	8	1	CCS	White	Scraper	Perpendicular Striations	38.28	30.76	10.63	14.38
26EU1539	139	2	CCS	White	Scraper	Perpendicular Striations	27.75	13.33	5.88	2.85
26EU1539	238	1	CCS	White	Compound Tool	Absent	51.68	42.15	8.67	16.68
26EU1548	233	1	CCS	White	Scraper	Indeterminate	34.46	20.17	7.42	5.16
26EU2126	1086	1	CCS	White	Knifelike Biface	Absent	49.95	35.16	10.56	21.37

Table 82. Cores Recovered During the 2007 BGMI Project and 2006 Probing

Site	FS #	Specimen #	Raw Material	Material Description	Core Type	Usewear	Max. Length (mm)	Max. Width (mm)	Max. Thickness (mm)	Weight (g)
26EU1539	246	1	CCS	White	Random/ Expedient	Absent	49.66	28.63	15.76	17.16
26EU1539	1253	1	CCS	White	Random/ Expedient	Indeterminate	55.92	54.15	20.4	69.99
26EU2126	9	1	CCS	White	Random/ Expedient	Absent	58.54	32.14	20.76	34.47
26EU2126	1063	1	CCS	White	Random/ Expedient	Absent	49.79	35.48	20.48	34.71
26EU2126	1300	1	CCS	White	Random/ Expedient	Absent	55.74	42.85	19.35	62.18
26EU2126	200602	1	CCS	White	Random/ Expedient	Indeterminate	51.81	38.41	22.87	48.13

Figure 85. Photograph of compound tool (FS# 238) from 26EU1539.

Figure 86. Illustration of compound tool (FS# 238) from 26EU1539.

Figure 87. Photograph of knifelike biface (FS# 1086) from 26EU2126.

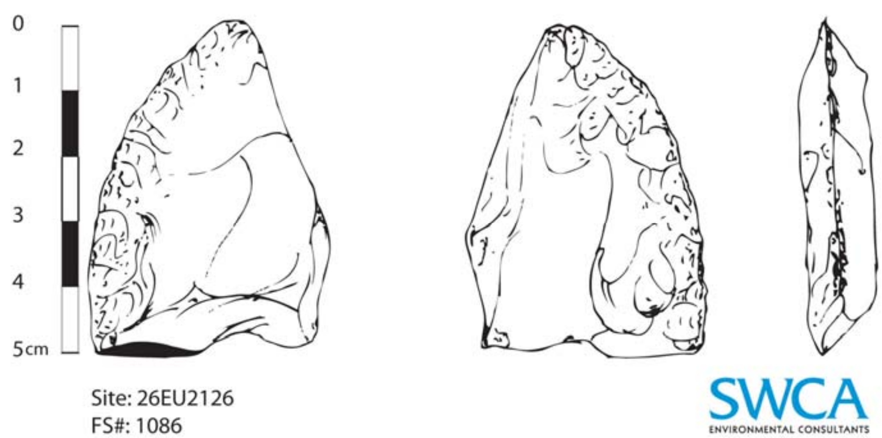

Figure 88. Illustration of knifelike biface (FS# 1086) from 26EU2126.

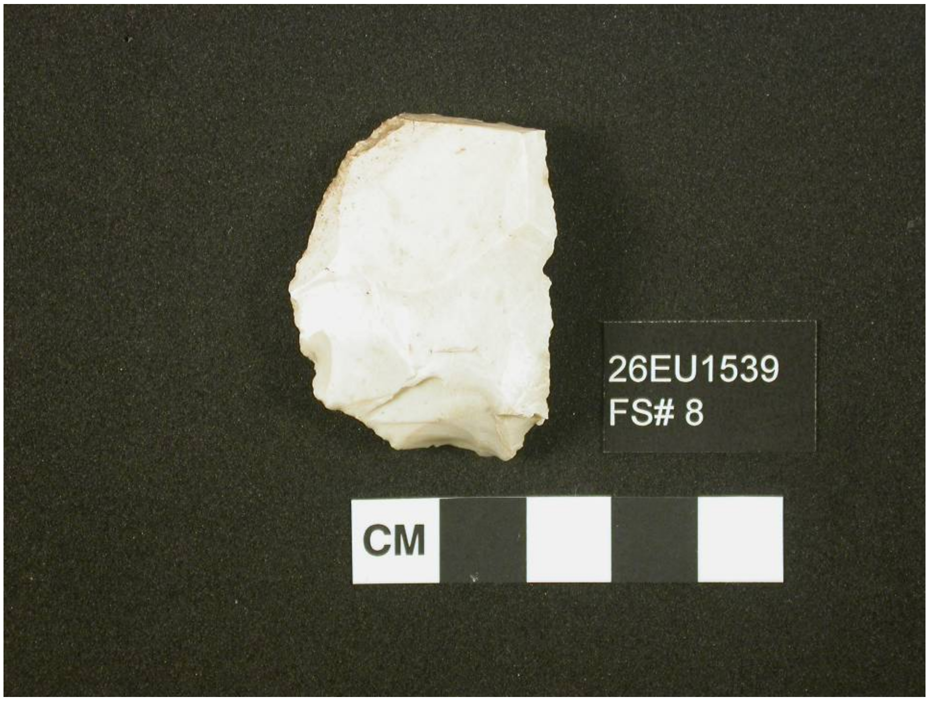

Figure 89. Photograph of scraper (FS# 8) from 26EU1539.

Figure 90. Illustration of scraper (FS# 8) from 26EU1539.

Figure 91. Photograph of scraper (FS# 139) from 26EU1539.

Figure 92. Illustration of scraper (FS# 139) from 26EU1539.

Figure 93. Photograph of scraper (FS# 233) from 26EU1548.

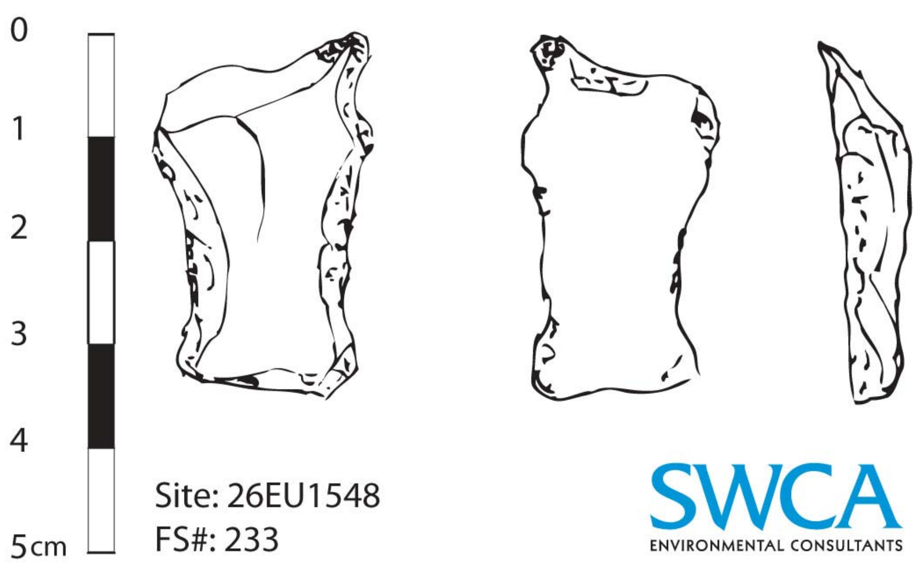

Figure 94. Illustration of scraper (FS# 233) from 26EU1548.

7.2. RAW MATERIAL VARIABILITY

As discussed in Section 2.3.1, Tosawihi chert overwhelmingly dominates lithic assemblages from the LBBA. According to Schroedl (1991a:38), "upwards of 90% of toolstone material identified on the sites in the Little Boulder Basin Area is from the Tosawihi Quarries approximately 20 kilometers to the northwest".

Now administered by BLM-Elko, the Tosawihi Quarries Archaeological District (26EK6624) is 4,000 acres in size, contains 152 loci, and is still being explored (Hockett 2006:8). Material from this source has been found at sites ranging in age from the late Pleistocene to the historic period (Hockett 2006:11). Tosawihi material can appear opaque or translucent and characteristically has a banded or mottled appearance; it is primarily white, cream colored, or grayish white but can appear in a variety of colors such as red, pink, lavender, purple, blue, yellow, or brown (Elston and Budy 1990; Lyons et al. 2003). Another indicator of Tosawihi chert is the occasional presence of crystalline inclusions.

The dominance of Tosawihi chert at sites in the LBBA noted by Schroedl (1991a:38) is convincingly replicated at the sites investigated in the 2007 BGMI project (Table 83 through Table 88[15]): only 0.10 percent of the recovered debitage and 2.56 percent of the recovered tools are obsidian, and the remainder of the recovered chipped stone artifacts are Tosawihi chert. As noted above, no CCS material other than Tosawihi chert was identified in the 2007 BGMI project assemblage. The very low percentage of obsidian in this assemblage—slightly more than 0.1 percent of all recovered chipped stone artifacts—is virtually identical to the percentage that occurs in a much larger sample of LBBA lithic assemblages analyzed by LaFond (1996:Table 169).

Chi–square tests were performed to determine whether material type frequencies vary significantly among the sites investigated in this project (Table 83 through Table 85) or among the analytical time periods defined in Section 5.4.1 (Table 86 through Table 88). These tests indicate that material type frequencies do not vary significantly among sites for tools (chi-square = 1.12, $df = 4$, $p = 0.892$, mean expected frequency = 7.8), but they do for debitage (chi-square = 14.60, $df = 4$, $p = 0.006$, mean expected frequency = 1400.9). Inspection of chi-square adjusted standardized residuals (Everitt 1992) from the test for debitage indicates that the significant result is due primarily to the assemblages from 26EU1539 and 26EU1548 (see Table 83): the absence of obsidian at site 26EU1539 is unexpected given the large debitage sample from this site (the adjusted standardized residual for obsidian from 26EU1539 is -2.6), and obsidian occurs in a higher than expected frequency at 26EU1548 (the adjusted standardized residual for obsidian from 26EU1548 is 2.5[16]). Thus, even though the differences among sites in the percentage of obsidian relative to Tosawihi chert are very small, some of these differences can be

[15] Debitage counts in Table 83 and Table 86 for 26EU1539 and 26EU2126 include all recovered debitage specimens, rather than only those in the analyzed samples from sampled FS bags (Table 79), because material type was recorded for all debitage. Material type was the only variable recorded for unanalyzed specimens in the sampled FS bags.

[16] The even higher percentage of obsidian from 26EU1533 (0.53% vs. 0.36%) does not produce a large adjusted standardized residual (i.e., one that falls beyond two standard deviations) due to the smaller sample from this site. In other words, the high percentage of obsidian at 26EU1533 cannot be considered to be "significant" due to the small sample size.

considered to be significant. The difference in the percentage of obsidian between the two time periods is not significant for tools (chi–square = 0.08, *df* = 1, *p* = 0.773, mean expected frequency = 13.0), but it is for debitage (chi–square = 3.97, *df* = 1, *p* = 0.046, mean expected frequency = 2978.8); this suggests that there was a reduction, however slight, in the proportional use of obsidian between the Middle Archaic and the Late Archaic/Late Prehistoric periods. All of the cores recovered during the project are Tosawihi chert, and all come from contexts that suggest a Late Archaic/Late Prehistoric age.

Table 83. Debitage Material Type by Site

	Obsidian		Tosawihi		
Site	**Count**	**Percent**	**Count**	**Percent**	**Total**
26EU1533	1	0.53%	188	99.47%	189
26EU1539	0	0.00%	4,531	100.00%	4,531
26EU1548	3	0.36%	826	99.64%	829
26EU2064	3	0.17%	1,760	99.83%	1,763
26EU2126	7	0.10%	6,690	99.90%	6,697
Total	14	0.10%	13,995	99.90%	14,009

Table 84. Tool Material Type by Site

	Obsidian		Tosawihi		
Site	**Count**	**Percent**	**Count**	**Percent**	**Total**
26EU1533	0	0.00%	2	100.00%	2
26EU1539	1	4.35%	22	95.65%	23
26EU1548	0	0.00%	4	100.00%	4
26EU2064	0	0.00%	21	100.00%	21
26EU2126	1	3.57%	27	96.43%	28
Total	2	2.56%	76	97.44%	78

Table 85. Core Material Type by Site

	Tosawihi		
Site	**Count**	**Percent**	**Total**
26EU1539	2	100.00%	2
26EU2126	4	100.00%	4
Total	6	100.00%	6

Table 86. Debitage Material Type by Period

	Obsidian		Tosawihi		
Period	Count	Percent	Count	Percent	Total
Middle Archaic	1	0.53%	188	99.47%	189
Late Archaic/Late Prehistoric	10	0.09%	11,716	99.91%	11,726
Total	11	0.09%	11,904	99.91%	11,915

Table 87. Tool Material Type by Period

	Obsidian		Tosawihi		
Period	Count	Percent	Count	Percent	Total
Middle Archaic	0	0.00%	2	100.00%	2
Late Archaic/Late Prehistoric	2	4.00%	48	96.00%	50
Total	2	3.85%	50	96.15%	52

Table 88. Core Material Type by Period

	Tosawihi		
Period	Count	Percent	Total
Middle Archaic	0	0.00%	0
Late Archaic/Late Prehistoric	6	100.00%	6
Total	6	100.00%	6

It is also interesting to note that the slight difference in the percentage of obsidian between tools and debitage (2.56 percent vs. 0.10 percent; see Table 83 and Table 84) is highly significant (chi–square = 41.52, $df = 1$, $p < 0.001$, mean expected frequency = 3521.8). Given that obsidian sources are located much further from the LBBA than the Tosawihi Quarries, this difference in the percentage of obsidian between tools and debitage mirrors a pattern described below in Section 7.3 wherein the obsidian tools recovered come from more distant sources than does most of the obsidian debitage. In both cases, it appears that tools made of material from more distant sources was more likely to be brought into the LBBA in the form of curated tools, and that material from closer sources was more likely to be used in knapping carried out at LBBA sites.

The significance of Tosawihi chert documented here opens the door for further inquiry into the adaptive behaviors of the hunter-gatherers who quarried at Tosawihi. Issues of this sort are discussed further below in Section 7.4.

7.3. OBSIDIAN SOURCING AND MOBILITY

As reported in Section 5.2 (also see Appendix E), obsidian sourcing analyses were performed by Dr. Richard Hughes of the Geochemical Research Laboratory using the energy dispersive X-ray fluorescence (edXRF) technique. These analyses were done both to enable source-specific consideration of obsidian hydration data, which was done in Chapter 5, and for purposes of studying prehistoric patterns of obsidian source use in the region, an issue that is addressed here.

7.3.1. OBSIDIAN USE IN THE LBBA

Although Tosawihi chert overwhelmingly dominates chipped stone assemblages in the LBBA, obsidian occurs regularly but in very limited quantities on sites in the region throughout the prehistoric and ethnographic periods (Elston 1992; Elston and Budy 1990). Overall, sites in the region exhibit low frequencies of obsidian, and only a small number of assemblages containing obsidian have been reliably dated. However, regional patterns in the acquisition of material from different obsidian sources have been observed (Elston and Budy 1990; LaFond 1996; Rusco and Raven 1992). Lithic material sourcing has been the most common approach used to illuminate patterns of mobility from archaeological assemblages (Jones et al. 2003:5), and this line of analysis is continued here.

The historic inhabitants of the LBBA and surrounding region were called the Tosawihi, or "White Knife", Shoshone for their use of the local white chert. The pattern of use of this raw material in the region has been hypothesized to represent an interaction-sphere boundary that separated ethnic groups in historic times, which also extended into prehistory (Elston 2006). Stephenson and Wlikinson (1969) first described a "black/white line" that stretched from Iron Point on the Humboldt River to the north. West of this line is the "black zone", in which archaeological lithic assemblages are dominated by Paradise Valley obsidian, while east of the line is the "white zone" (in which the LBBA is located), where lithic assemblages are dominated by chert from the Tosawihi Quarries. In addition, Elston (2006) notes that this black/white line corresponds to the ethnographically-described boundary between the Northern Paiute on the west and the Western Shoshone on the east.

According to Elston and Budy (1990:14), any obsidian found in the LBBA should be considered to be an "exotic" raw material since all obsidian sources are located further than 120 km away, beyond what they assume to be the limit of the logistic foraging range (also see LaFond 1996). LaFond (1996:679) notes that the only lithic material types that can be considered to be exotic in the LBBA by this definition are obsidians, and he suggests that the presence of obsidian thus indicates the existence of trade and exchange networks in the region. Historically, the White Knife Shoshone traded Tosawihi chert to groups to the north and northeast for fishing rights and for specific trade items, likely including obsidian from sources in that area (LaFond 1996:680; Rusco and Raven 1992). Thomas (1983), however, reports that a Western Shoshone informant claimed that resources within a 240 km range were monitored. If this is true, direct procurement ranges may have encompassed some obsidian sources, and the presence of obsidian in the LBBA would not necessarily indicate the existence of an exchange network. Steward (1937:627) also indicates that the region in the vicinity of the present-day Nevada–Idaho border was not permanently settled ethnographically but instead was only visited in the summer by Humboldt and northern Shoshone groups. This would also suggest that direct procurement of obsidian by inhabitants of the LBBA was possible. Thus, because there is evidence to indicate both that obsidian was traded into the area and that it was directly procured, obsidian sourcing results from the 2007 BGMI project might provide insight into patterns in both mobility and socioeconomic interaction.

7.3.2. Obsidian Sourcing Results

All 16 of the obsidian artifacts recovered from the five sites involved in the 2007 BGMI project were submitted for sourcing analysis. All of these returned source-specific results, and 13 also returned obsidian hydration measurements. The sourcing results for artifacts from each culture historical phase are summarized in Table 89; the phase attributions for the artifacts in this table are based on obsidian hydration analysis (see Section 5.2.2 for greater detail on the sourcing and hydration analyses).

Obsidian was sourced to a total of 4 distinct sources located in the eastern Great Basin. The distance from these sources to the LBBA are presented in Table 90 and illustrated in Figure 95. Material from the Paradise Valley source, located approximately 110 km to the west–northwest of the LBBA, is by far the most dominant in the 2007 BGMI project assemblage, comprising over 80 percent of the recovered obsidian. This is consistent with results from previous studies in the region. LaFond (1996:680) found that Paradise Valley obsidian represented more than 50 percent of sourced obsidian artifacts in samples that he examined. Likewise, in the Tosawihi Quarries area, Elston and Drews (1992) and Ataman et. al. (1995) found that material from the Paradise Valley source was the most common type of obsidian throughout prehistory, making up 48.6 percent of assemblages. Other obsidian sources represented at the sites investigated during the 2007 BGMI project, each by only one specimen, are Double H Mountains, Browns Bench, and Wild Horse Canyon. Material from the Browns Bench source, located 140 km to the north–northeast along the Idaho–Nevada border, has previously been shown to be the next most common in the LBBA after Paradise Valley obsidian (LaFond 1996:680).

Table 89. Obsidian Sources Represented in the 2007 BGMI Assemblage by Phase

Phase	Paradise Valley	Double H Mountains	Browns Bench	Wild Horse Canyon	Total
Eagle Rock	10			1	11 (68.75%)
Maggie Creek	1				1 (6.25%)
South Fork		1			1 (6.25%)
Unknown*	2		1		3 (18.75%)
Total	13 (81.25%)	1 (6.25%)	1 (6.25%)	1 (6.25%)	16 (100%)

*No measurable hydration band.

Table 90. Distance from the LBBA to Obsidian Sources Represented

Source	Distance (km)
Paradise Valley	110
Double H Mountains	140
Browns Bench	140
Wild Horse Canyon	400

As alluded to above, diachronic changes in the diversity of obsidian sources represented at sites in the LBBA and surrounding region have been explained in terms of both mobility and trade. The Late Archaic period has been shown to have the highest source diversity, with the percentage of Browns Bench obsidian covarying with overall diversity (Elston and Drews 1992:617). Prior to the Late Archaic, obsidian assemblages in the LBBA are heavily dominated by material from the Paradise Valley source. Following the Late Archaic, during the Eagle Rock Phase, obsidian from sources located in Idaho become increasingly common in the LBBA. At James Creek Rockshelter, located to the east of the LBBA, Browns Bench obsidian is second in abundance to Paradise Valley obsidian throughout the archaeological record (Elston and Budy 1990).

The presence of Paradise Valley, Double H Mountains, Browns Bench, and Wild Horse Canyon obsidian shows that prehistoric inhabitants of the LBBA had access to obsidian, either through trade or direct procurement, from sources located both to the north and the south of the Humboldt River. Beyond this, it is difficult to draw conclusions about diachronic patterns in obsidian source use from the 2007 BGMI project obsidian assemblage due to the small size of this assemblage. As shown in Table 89, 68.75 percent of the obsidian from the project dates to the Eagle Rock Phase, and the obsidian from this phase is dominated by Paradise Valley material, with only a 1 out of 11 artifacts coming from any another source (a biface from the Wild Horse Canyon source). Of the two other dated obsidian artifacts, one is attributed to each of the South Fork and Maggie Creek Phases. The South Fork Phase specimen comes from the Double H Mountains source, while the Maggie Creek Phase specimen is from Paradise Valley.

In the Great Basin and adjoining regions of western North America, patterns in obsidian source use have been found to vary between debitage and formal tool specimens. In western Utah, Simms and Isgreen (1984) report that debitage is dominated by obsidian from the closest sources, whereas projectile points come from a wider variety of sources including more distant ones. Similar patterns are reported by Jones et. al. (2003) for Paleoarchaic obsidian source use in the central and eastern Great Basin. These patterns are consistent with a model developed by Eerkens et. al. (2007:588), which predicts that material diversity should be low among large flakes and dominated by material from the closest raw sources, whereas smaller flakes (i.e., retouching debris) and formal tools should be made from a more diverse range of materials from both local sources and more distant sources, reflecting the transport of curated tools during foraging rounds.

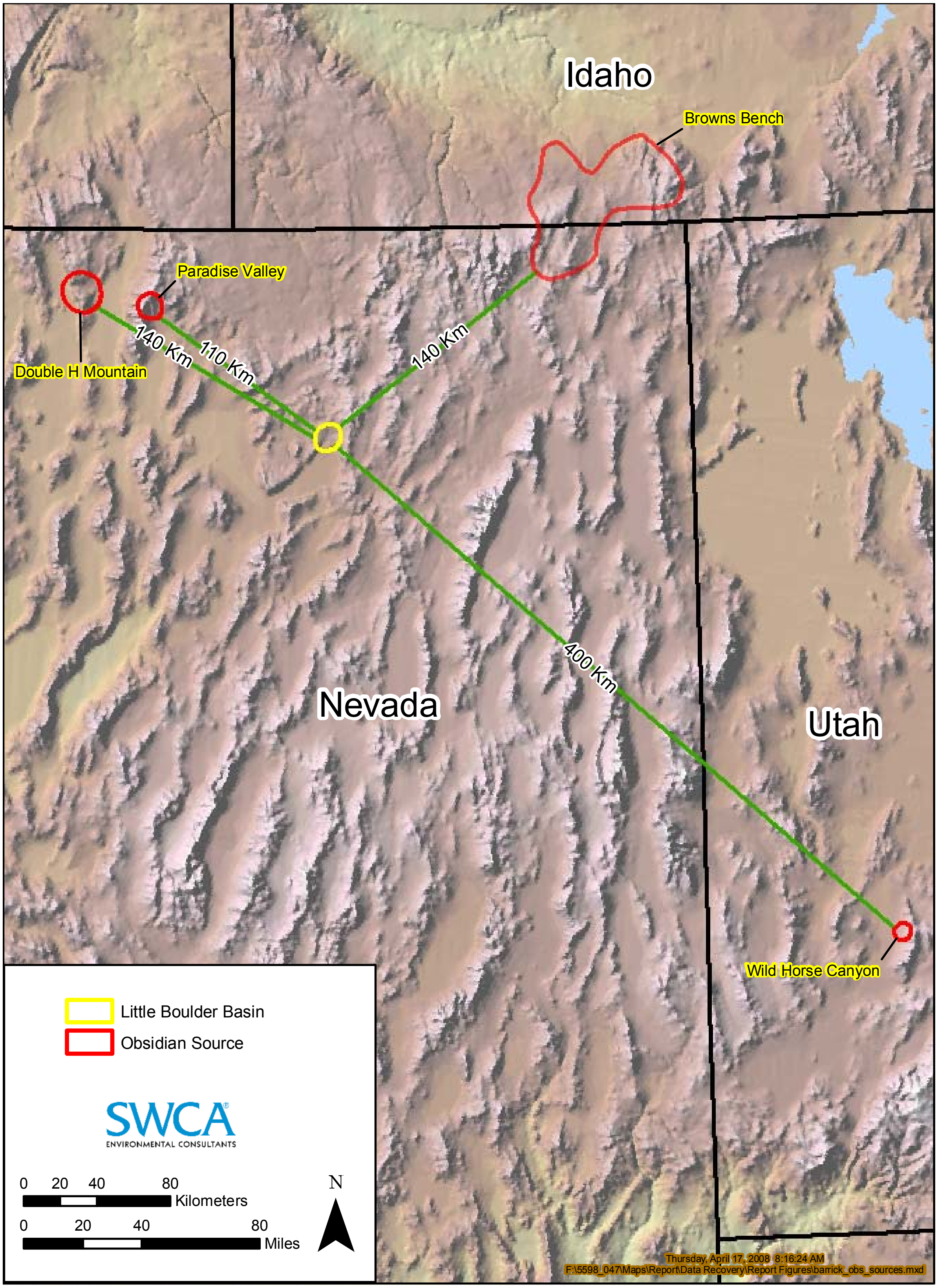

Figure 95. Map of obsidian sources in relation to the LBBA.

There is evidence for this type of pattern in the obsidian assemblage from the 2007 BGMI project. This is shown in Table 91, in which artifacts made of obsidian from Paradise Valley, the source closest to the LBBA, are compared to those from the other three more distant sources. Of the 14 obsidian debitage specimens recovered during the project, all but one are from Paradise Valley, whereas both of the obsidian tools in the assemblage (a biface and a biface fragment) are from the more distant sources. This association between debitage and the Paradise Valley source, on the one hand, and tools and the more distant sources, on the other hand, is significant (Fisher's exact test: $p = 0.025$).

These results are consistent with the pattern described above (Eerkens et al. 2007; Simms and Isgreen 1984). Specifically, it appears that the more distant obsidian sources are represented primarily by curated formal tools, either transported or traded into the area, while material from the closer Paradise Valley source was the primary type of obsidian used in earlier stage reduction that actually occurred in the LBBA. As noted above in Section 7.2, a consistent pattern also appears when the percentage of obsidian relative to Tosawihi chert among tools and debitage is considered: far less than one percent of artifacts from the very close Tosawihi source are tools, whereas a slightly but significantly higher percentage of the obsidian artifacts, which must come from more distant sources, are tools.

Table 91. Obsidian Sourcing Results by Artifact Type

Source	Debitage Count	Number of Tools
Paradise Valley	13	0
Double H Mountains	1	0
Browns Bench	0	1
Wild Horse Canyon	0	1
Total "Distant"	*1*	*2*
Grand Total	*14*	*2*

7.3.3. Obsidian Sourcing and Mobility Summary

The small sample size of obsidian artifacts recovered during the 2007 BGMI project makes it difficult to examine diachronic patterns in obsidian source use. However, when specimens from all phases and all sites are combined, obsidian sourcing results are consistent both with theoretical expectations and with patterns documented empirically in other Great Basin contexts. Differences in source representation between debitage and tools suggest the curation of tools made from obsidian from more distant sources and more expedient use or earlier-stage reduction of material from closer sources. Obsidian from the Paradise Valley source, the closest to the LBBA, is by far the most common type of obsidian in the assemblage. However, other sources located to the northwest and northeast of the project area are represented in limited quantities, suggesting movement from and/or trade with these areas, and one obsidian specimen from a more distant source to the southeast provides evidence for even wider ranging mobility or trade.

7.4. TECHNOLOGICAL ORGANIZATION

In this section, the chipped stone data from the 2007 BGMI project are used to explore several different aspects of prehistoric technological organization. The study of the organization of technology can in turn be used to infer how sites were used and how they relate to broader settlement and subsistence patterns. Section 7.4.1, Activity Locus Function, addresses the various activities conducted at each site and potential intra-site variability in those activities; flake type profiles, tool type diversity, and the types of tools recovered are explored in order to do so. Section 7.4.2, Tosawihi Quarrying Behavior, moves to a discussion of the use of the Tosawihi Quarries by prehistoric groups in the LBBA, which has important implications for mobility patterns. The final section, Section 7.4.3, Technology and Mobility, looks at the different types of lithic reduction strategies employed at each site and in each time period in order to assess the mobility strategies used by prehistoric groups. Together, these various lines of analysis contribute to a broader understanding of prehistoric settlement in the LBBA.

7.4.1. ACTIVITY LOCUS FUNCTION

Examining the types and diversity of activities that occurred at the five sites involved in the 2007 BGMI project will provide a better understanding of site function. This type of analysis, in turn, contributes to our understanding of regional settlement patterns. Three lines of evidence relevant to site function are explored here: intra-site variability in debitage assemblages, the diversity of chipped stone tools recovered from each site, and the functional types of tools recovered from each site.

INTRA–SITE VARIABILITY IN FLAKE TYPE PROFILES

As alluded to in Section 5.4, three of the sites involved in the 2007 BGMI project—26EU1539, 26EU2064, and 26EU2126—exhibited spatial patterns in artifact distributions that may reflect chronologically and/or functionally discrete activity areas. Here, intra-site spatial variability in the debitage assemblages from these three sites—and specifically in flake type profiles, or distributions of debitage specimens across flake types—is explored in order to derive such conclusions about site or locus function as are possible. The chronological implications of this analysis are discussed above in Section 5.4.

For purposes of this analysis, artifact "clusters" were defined based on visual inspection of surface artifact distributions at the three sites involved (see Figure 5, Figure 12, and Figure 14 in Chapter 3). Cluster boundaries were placed in pronounced areas of low surface artifact density, and artifacts from low density areas between clusters were not included in any cluster. The clusters defined for this analysis are illustrated in Figure 96 through Figure 98.

At 26EU1539, there was a smaller, very dense artifact concentration in the southern part of the site and a larger, more diffuse artifact scatter across the central and northern portions of the site (Figure 96). A Desert Side-notched point, suggesting an Eagle Rock Phase age, was recorded within the more northerly cluster, and an Eastgate Expanding Stem point, suggesting a Maggie Creek Phase age, was found within the southern concentration. The large, northern artifact scatter is here called Cluster 1 (1539-1), and the southern concentration is here called Cluster 2 (1539-2).

Six clusters are defined for 26EU2064 (Figure 97). Clusters 1 through 4 are areas of locally high artifact density along the terrace edge that the northeastern boundary of the site follows. No datable artifacts were recovered from Cluster 1 (2064-1), but Cluster 2 (2064-2) contained an Elko point and a Humboldt point, both of which suggest a Middle Archaic age, Cluster 3 (2064-3) contained a Gatecliff point, again suggesting a Middle Archaic age, and Cluster 4 (2064-4) contained three obsidian artifacts with hydration bands that fall in the range established for the Eagle Rock Phase in the regional hydration chronology. Cluster 5 (2064-5) was defined in the vicinity of the two Desert Side-notched points that were recovered along the northwestern edge of the site; though artifact density in this part of the site was very low and Cluster 5 consequently contains very few artifacts, a cluster was defined in this area due to the chronological significance of the Desert Side-notched points, which suggest an Eagle Rock Phase occupation. Finally, Cluster 6 (2064-6), which contained no datable artifacts, corresponds to an isolated artifact concentration in the southwestern part of the site.

Two clusters are defined for 26EU2126 (Figure 98). The larger Cluster 1 (2126-1) consists of artifacts excavated from Operation F and surrounding surface artifacts, while the smaller Cluster 2 (2126-2) consists of artifacts from in and around Operation C.

The debitage assemblages from the clusters defined for these sites—including debitage both from surface contexts and from subsurface contexts in cases where excavation units, test units or shovel tests occurred within cluster boundaries—are analyzed in order to determine whether there are technological differences among them. This is done by comparing flake type profiles. Only the core reduction, biface reduction, and biface thinning flake types are used in this comparison. Pressure flakes are not included because the proportion of very small flakes differs between samples from surface and subsurface contexts, likely due to differences in collection methods (see Section 7.5.2 and Figure 110 below), and because the proportion of flakes from surface and subsurface contexts varies among clusters; thus, differences in pressure flake percentages among clusters might reflect differences in collection methods rather than true technological differences. Flakes that were identified to the "indeterminate" flake type and debitage specimens classified as flake shatter or angular debris are not included in this analysis due to the limited technological information that they provide.

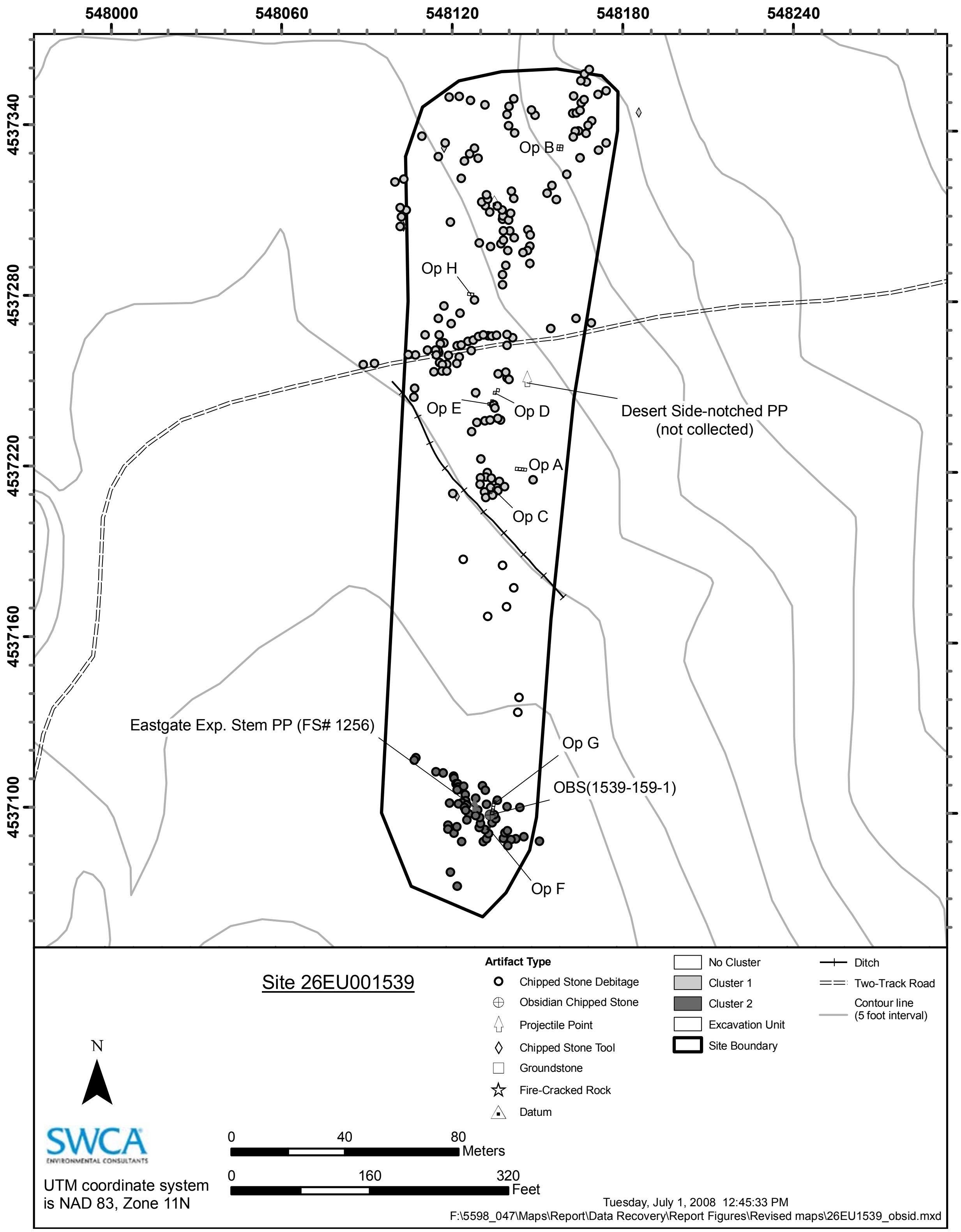

Figure 96. Artifact clusters defined for 26EU1539.

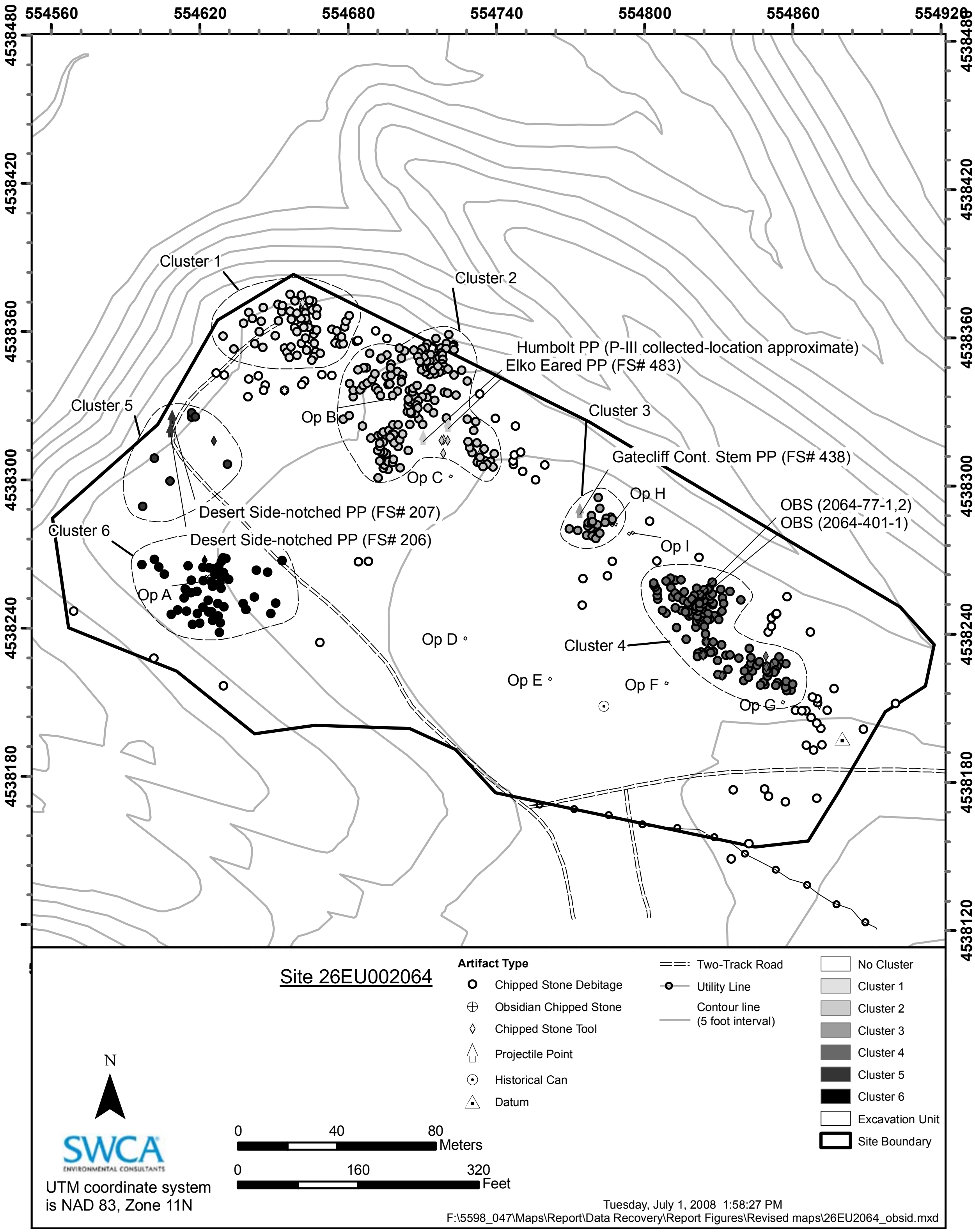

Figure 97. Artifact clusters defined for 26EU2064.

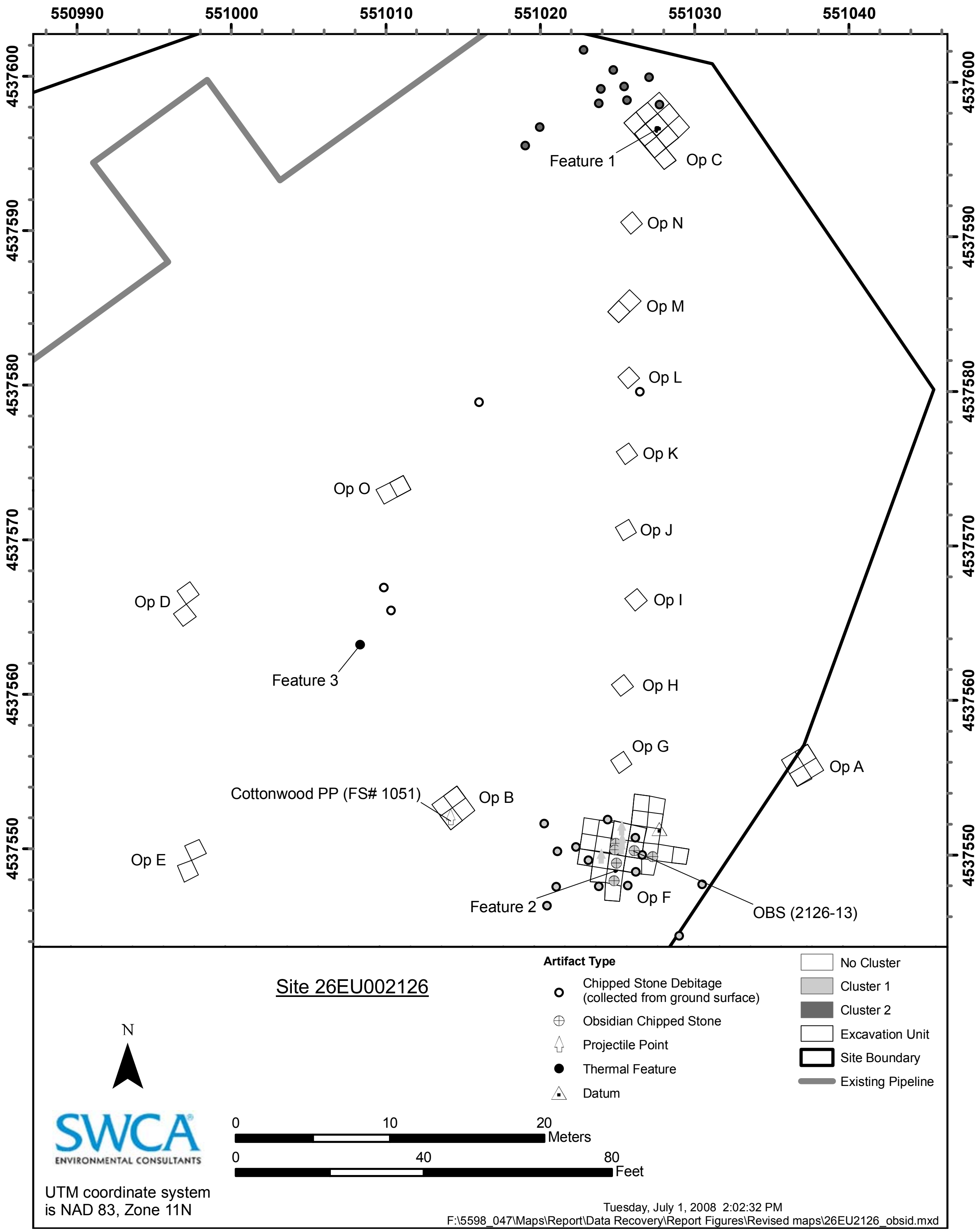

Figure 98. Artifact clusters defined for 26EU2126.

There is a marked difference in flake type profiles between the two artifact clusters at 26EU1539 (Table 92, Figure 99). The debitage assemblage from Cluster 1, the larger, northern cluster, is dominated by biface thinning flakes, whereas earlier-stage biface reduction and core reduction flakes make up greater proportions of the assemblage from the southern Cluster 2. This difference is statistically significant (chi-square = 19.2, df = 2, $p < 0.001$, mean expected frequency = 44.3), and it suggests that different types of activities were pursued in the two parts of the site. Specifically, though some degree of core reduction and all stages of biface reduction evidently occurred in both areas, it appears that lithic reduction activities in the northern part of the site focused on the later stages of tool manufacture and refurbishing to a greater degree than was the case in the area where the Cluster 2 assemblage was produced. It should also be noted that the two cores recovered from 26EU1539 (Table 82) came from Cluster 2[17]. Given the more limited and much denser spatial distribution of the Cluster 2 artifacts, it may be that this assemblage represents a relatively discrete episode of core reduction and initial tool manufacture (though, as discussed in Sections 3.2.2 and 5.3, it is also possible that the spatial distribution of these artifacts is the result, at least in part, of alluvial processes). Cluster 1, on the other hand, appears to represent more spatially dispersed activities of bifacial tool completion and rejuvenation, which might suggest, in turn, that resource acquisition and processing activities and/or residential activities occurred throughout this area of the site.

Flake type profiles for the clusters defined for 26EU2064 are shown in Table 93 and Figure 100. As with the 25EU1539 clusters, significant differences in flake type frequencies occur among the clusters at this site (chi-square = 42.9, df = 10, $p < 0.001$, mean expected frequency = 14.0). Inspection of chi-square adjusted residuals indicates that this result is due primarily to three clusters: Cluster 1, in which core reduction flakes are notably under-represented (adjusted standardized residual = -2.3), Cluster 2, in which biface reduction flakes are notably over–represented (adjusted standardized residual = 2.0), and Cluster 6, in which core reduction flakes are substantially over-represented (adjusted standardized residual = 5.9; all other adjusted standardized residuals from the chi-square test fall within two standard deviations). For the other three clusters, either sample sizes are too small to produce meaningful results (Clusters 3 and 5), or flake type proportions do not differ appreciably from those observed for the site as a whole (Cluster 4). It thus appears that there are some important technological differences among loci at this very large site. Perhaps most notable, particularly in the context of issues discussed below in Section 7.4.2, is the abundance of core reduction flakes in Cluster 6, the only cluster at any site at which core reduction flakes constitute the most abundant flake type. Though no cores were recovered from this cluster (or from anywhere else at 26EU2064), its debitage assemblage indicates a high degree of core reduction relative to biface reduction compared to other areas of the site. Unfortunately, because no datable artifacts were recovered from Cluster 6, it is not possible to determine the age of the core reduction episode or episodes represented in this assemblage.

Table 94 presents data that can be used to further explore technological variability among clusters at 26EU2064 from which datable artifacts were recovered. These data include combined

[17] FS 246 was recovered from the surface at approximately 548124 m E., 4537108 m N., and FS 1253 was recovered during blading from approximately 548120 m E., 4537097 m N. (see Figure 96; UTM coordinates are for Zone 11N, NAD 83).

flake type frequencies for Clusters 2 and 3, both of which contained Middle Archaic projectile points, along with the flake type frequencies for Cluster 4, from which Eagle Rock Phase obsidian hydration measurements were obtained. Use of these data allows comparison of samples that appear at face value to date to the Middle Archaic Period and the Eagle Rock Phase, respectively. Cluster 5, the only other cluster at the site that produced datable artifacts, is not included here due to the very small size of the debitage sample from this cluster. Though the shape of the Cluster 2 and 3 flake type profile differs somewhat from that of the Cluster 4 flake type profile (Figure 101), and despite the reasonably large size of both of the samples, the difference in flake type frequencies is not statistically significant (chi–square = 3.16, $df = 2$, $p = 0.206$, mean expected frequency = 43.5). Thus, regardless of whether the few projectile points or obsidian hydration measurements from these clusters provide an accurate indication of the age of the rest of the material in them, it cannot be concluded that there is any real technological difference between them.

Regarding the types of activities pursued at 26EU2064 overall, the heavy co-dominance of biface reduction and biface thinning flakes in all clusters except Cluster 6 suggests that dispersed resource acquisition and processing activities and/or residential activities occurred throughout most of the site. The Cluster 6 assemblage may represent a relatively discrete episode of core reduction and earlier-stage tool manufacture.

At 26EU2126, the reasonably large Cluster 1 assemblage is dominated by biface thinning flakes, followed by biface reduction flakes with a very low proportion of core reduction flakes (Table 95, Figure 102). This assemblage is from a spatially discrete artifact and feature concentration that, as discussed in Chapters 5 and 6, appears to be the result of a temporally discrete large mammal processing episode. The flake type profile for Cluster 1 is consistent with such activities in that it suggests late stage tool manufacture and rejuvenation. In addition, despite the low number of core reduction flakes in Cluster 1, four expedient cores were recovered within it (Table 82)[18]. The flake type profile for the small Cluster 2 assemblage is roughly similar in shape to that for Cluster 1 and is not significantly different from it (chi-square = 2.94, $df = 2$, $p = 0.230$, mean expected frequency = 34.0). This may indicate that activities similar to those conducted in the Cluster 1 area occurred in the Cluster 2 area, though the lack of statistical significance is likely a function of the small size of the Cluster 2 sample as much as anything, and it is probably best not to draw detailed conclusions based on such a small sample.

To summarize, there is evidence from two sites—26EU1539 and 26EU2064—for spatial variability in lithic reduction activities, particularly in the relative degrees of core reduction, biface reduction, and biface thinning. Unfortunately, due to limited chronological information from individual artifact clusters, it is not possible to determine whether this spatial variability is associated with temporally distinct occupations or whether it reflects functional variability within individual occupations. Variability in flake type profiles is explored further at the coarser scales of the site and the analysis time period in Sections 7.4.2 and 7.4.3 below.

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[18] FS 9 was recovered from the surface at approximately 551021 m E., 4537546 m N., and FS 1300 was recovered during blading at approximately 551024 m E., 4357544 m N. (see Figure 98; UTM coordinates are for Zone 11N, NAD 83). FS 1063 was recovered during excavation from the first 10 cm level of Unit F1 (Figure 19), and FS 200602 was recovered during probing in 2006 from ST–2 (Figure 15).

Table 92. Flake Type Profiles for 26EU1539 Artifact Clusters

	Core Reduction		Biface Reduction		Biface Thinnning		
Cluster	**Count**	**Percent**	**Count**	**Percent**	**Count**	**Percent**	**Total**
1539-1	12	11.2%	31	29.0%	64	59.8%	107
1539-2	27	17.0%	80	50.3%	52	32.7%	159
Total	*39*	*14.7%*	*111*	*41.7%*	*116*	*43.6%*	*266*

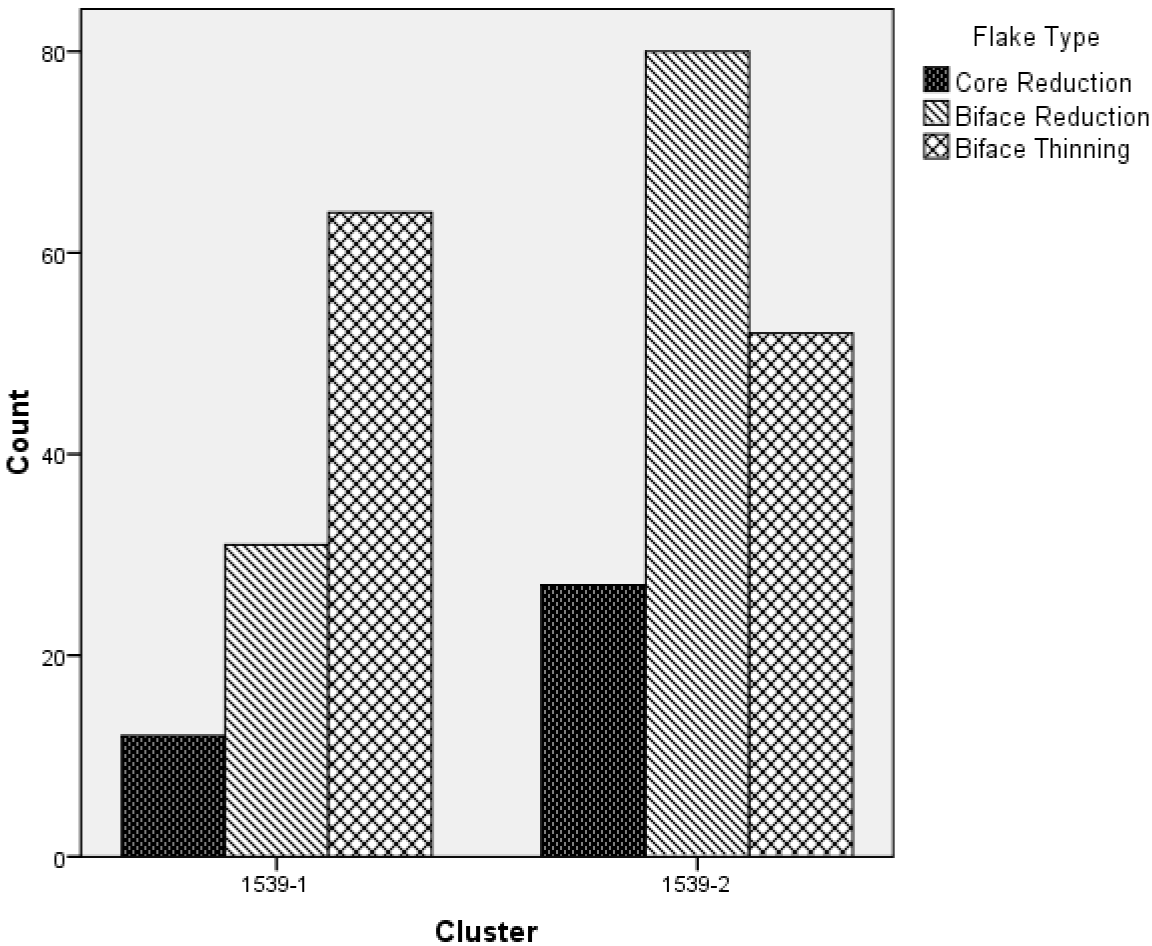

Figure 99. Flake type profiles for 25EU1539 artifact clusters.

Table 93. Flake Type Profiles for 26EU2064 Artifact Clusters

	Core Reduction		Biface Reduction		Biface Thinnning		
Cluster	Count	Percent	Count	Percent	Count	Percent	Total
2064-1	0	0.0%	23	41.8%	32	58.2%	55
2064-2	3	3.9%	42	54.5%	32	41.6%	77
2064-3	0	0.0%	4	44.4%	5	55.6%	9
2064-4	7	8.0%	37	42.0%	44	50.0%	88
2064-5	0	0.0%	2	66.7%	1	33.3%	3
2064-6	8	40.0%	6	30.0%	6	30.0%	20
Total	*18*	*7.1%*	*114*	*45.2%*	*120*	*47.6%*	*252*

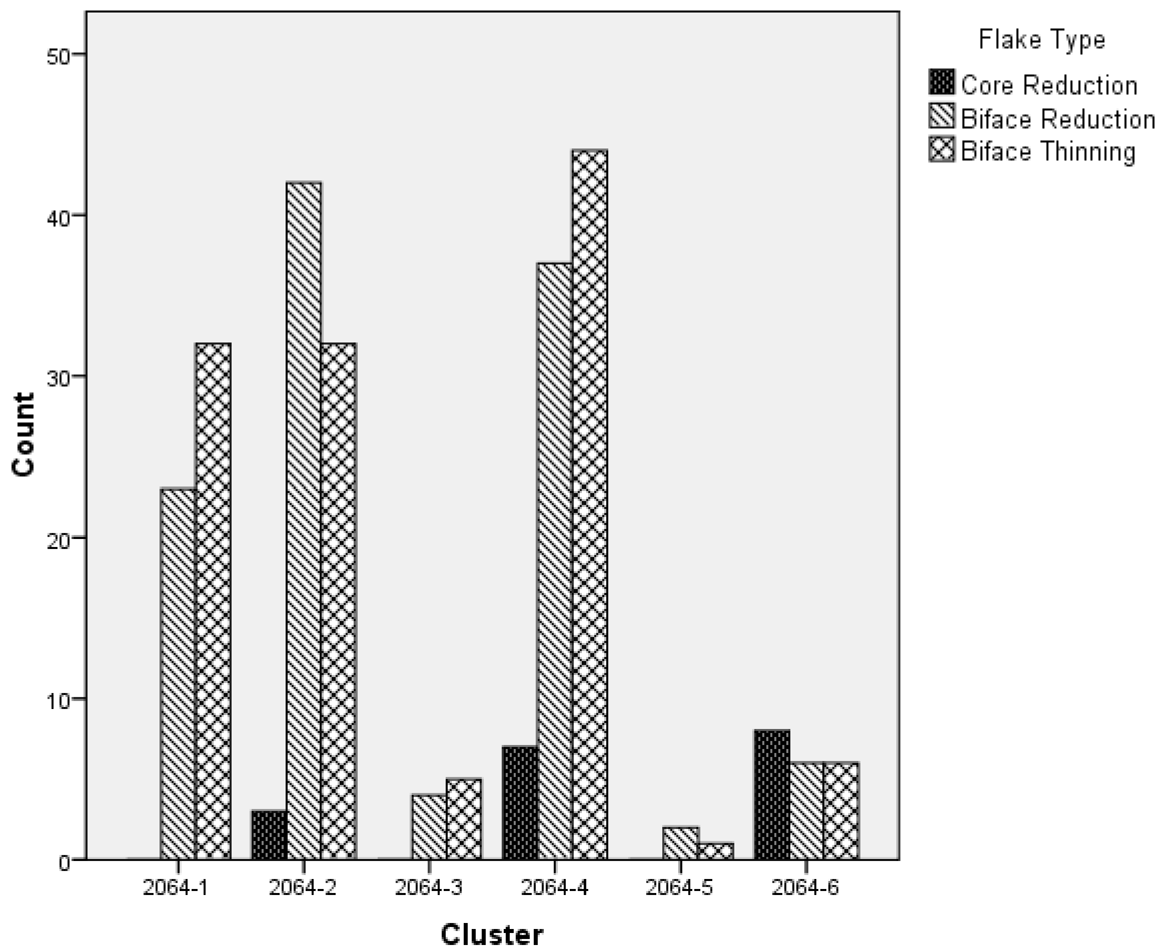

Figure 100. Flake type profiles for 25EU2064 artifact clusters.

Table 94. Flake Type Profiles for 26EU2064 Combined Cluster 2 and 3 Sample and Cluster 4

	Core Reduction		Biface Reduction		Biface Thinnning		
Cluster	Count	Percent	Count	Percent	Count	Percent	Total
2064-2 and 2064-3	3	3.5%	46	53.5%	37	43.0%	86
2064-4	7	8.0%	37	42.0%	44	50.0%	88
Total	*10*	*5.7%*	*83*	*47.7%*	*81*	*46.6%*	*174*

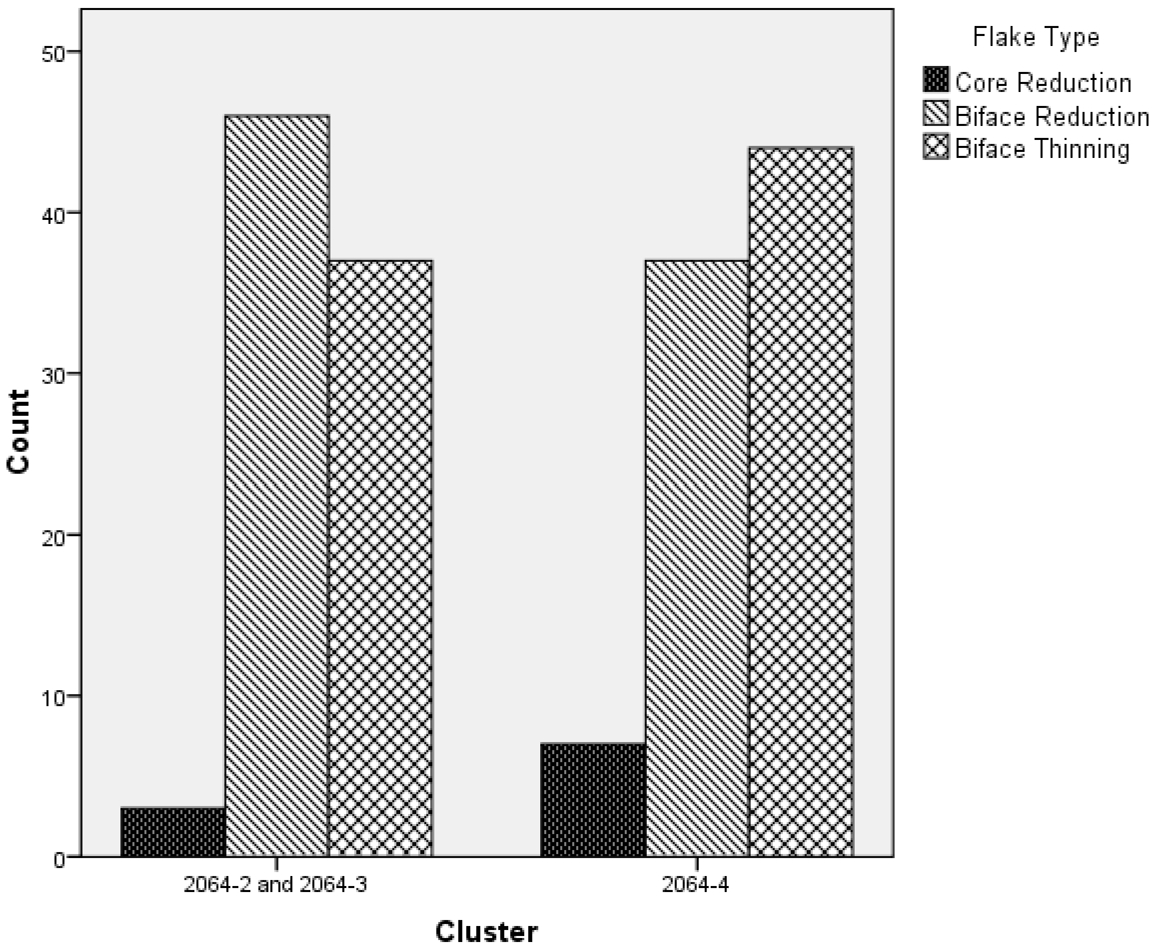

Figure 101. Flake type profiles for 26EU2064 combined Cluster 2 and 3 sample and Cluster 4.

Table 95. Flake Type Profiles for 26EU2126 Artifact Clusters

	Core Reduction		Biface Reduction		Biface Thinnning		
Cluster	Count	Percent	Count	Percent	Count	Percent	Total
2126-1	7	3.7%	65	34.6%	116	61.7%	188
2126-2	2	12.5%	6	37.5%	8	50.0%	16
Total	*9*	*4.4%*	*71*	*34.8%*	*124*	*60.8%*	*204*

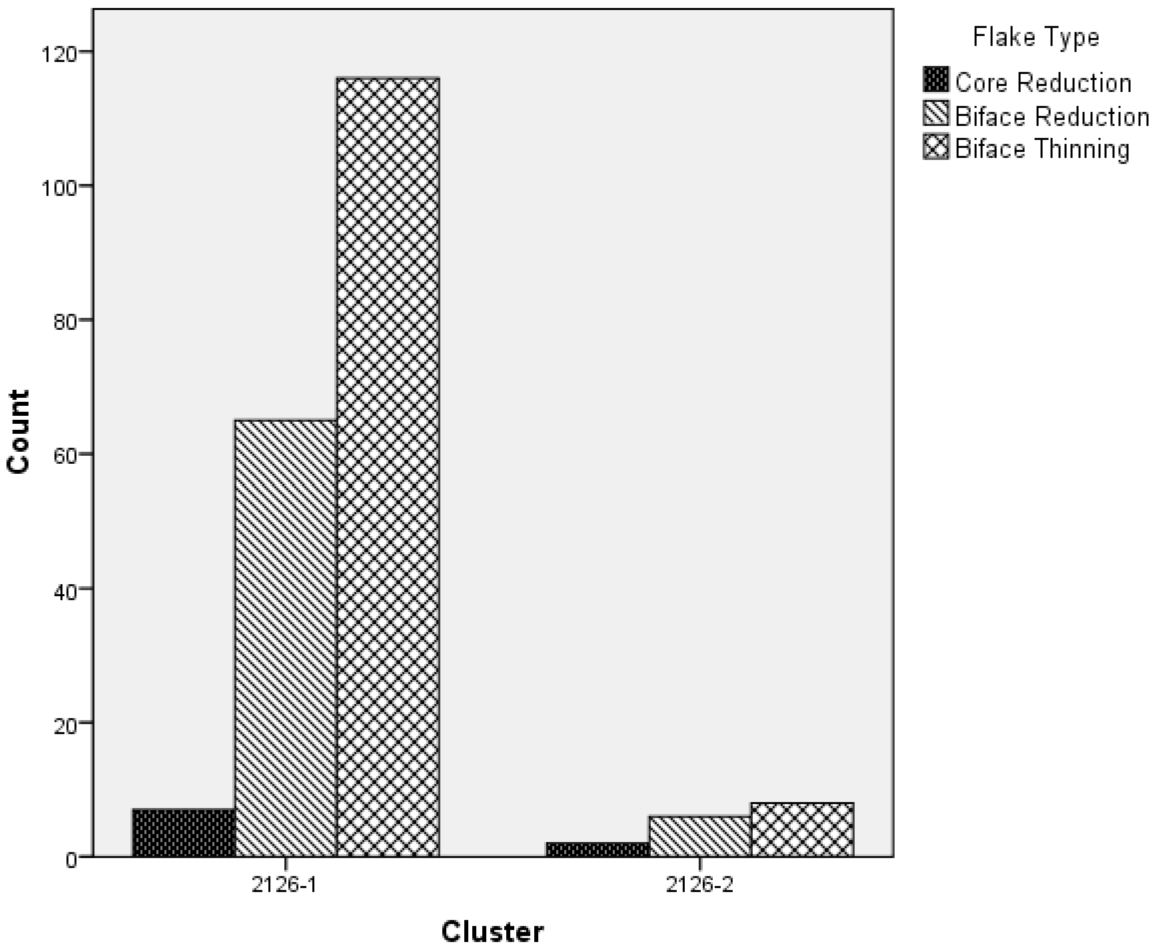

Figure 102. Flake type profiles for 25EU2126 artifact clusters.

TOOL DIVERSITY

Hunter-gatherer settlement patterns have long fascinated anthropologists, especially with regard to how the archaeological record reflects these patterns (Steward 1938). It has been suggested that prehistoric lithic assemblages are systematically patterned in ways that can reveal hunter-gatherer settlement strategies (Binford 1979). Thomas (1989) proposes that site function can be inferred by analyzing the relationship between lithic assemblage size and lithic assemblage diversity. These models will be discussed in more detail below, and then applied to data from the LBBA.

This research will employ the theoretical framework developed by Binford's (1980) study of the forager-collector continuum. His model assumes that settlement patterns are closely related to environmental factors, especially the hunter-gatherer seasonal round and the distribution of important food resources. In the model, Binford (1979; 1980) posits that ecological variation is the key factor determining hunter-gatherer settlement patterns. The model assumes that people arrange themselves on the landscape in ways to acquire resources through either a "forager" strategy or a "collector" strategy, based on resource predictability. Hunter-gatherer groups that subsist in environments where resources are temporally and spatially incongruent should opt for the collector strategy. In this scenario, people use specialized field camps to collect resources to bring back to a residential base. Artifact assemblages at the field camps often consist of special purpose tools that result from the exploitation of a particular suite of resources. There should be many different types of sites among groups using a collector strategy, but each type of site should have low artifact diversity, as tools are produced for a specific use. Alternatively, hunter-gatherers that subsist in environments characterized by resource abundance and predictability should favor the forager strategy. Binford suggests the sites of such groups should differ according to variables such as group size and length of stay, but remain consistent in having higher artifact diversity than specialized collector camps, with assemblages containing tools designed for a variety of purposes. This analysis demonstrates the relationship between environmental variability and hunter-gatherer mobility strategies (Binford 1980), and supports other theoretical analyses that examine environmental "patchiness" (Kelly 1995).

This framework leads to certain expectations regarding site variability as a consequence of settlement patterns (Binford 1980; see also O'Connell 1987; Zeanah et al. 1993). On the forager end of the continuum, there are two expected types of sites: "residential bases," where most activities take place, and "locations," where resources are procured. Forager residential bases should be visible archaeologically and analogous to one another because of the similar nature of activities taking place in these sites. On the contrary, a logistically mobile pattern at the collector end of the continuum should have a greater variety of site types including "field camps," "stations," and "caches." There should be more differences between these types of sites, but each individual type would have lower artifact diversity than residential bases.

As briefly discussed above, Thomas (1989) created a simple model involving the relationship between assemblage diversity and assemblage size. This model has been used in previous investigations to assess site function in the LBBA (e.g. Schroedl 1991a; Zeanah et al. 1993). Schroedl uses Thomas's model to suggest that artifact diversity should measure site function within three expected categories: residential bases, which have the greatest artifact diversity;

short-term camps, with moderate diversity; and extractive locations, with very little diversity. These site types can be determined by examining the slopes of regression lines for the relationship between assemblage diversity, measured as the number of tool types present, and sample size. Specifically, steep slopes, indicating a greater number of tool types for any given sample size, are more likely representations of residential base camps while flatter slopes would likely suggest extractive locations. Short-term field camps fall in between the other two categories. Schroedl's adaptation of Thomas's model is shown below in Figure 103.

A variation on this approach is used here due to the small number of assemblages involved. Because only five sites were investigated in the project, it is not possible to examine separate relationships among sets of sites that may have served different functions: sample sizes for any site type would be far too small for regression analysis. Instead, a single regression line is plotted for all five sites, and deviations of individual sites from this single relationship are explored. A greater number of tool types than is predicted based on sample size (i.e., a positive regression residual) would suggest that a relatively wider variety of activities were carried out at a site, and a smaller number of tool types than is predicted (i.e., a negative regression residual) would suggest that fewer activities were carried out.

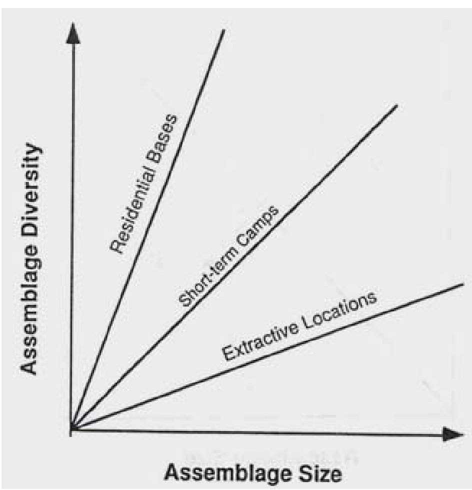

Figure 103. Expected assemblage diversity relationships for site types (from Schroedl 1991a; after Thomas 1989).

Table 96 shows the number of tools of various types recovered from each of the sites involved in the project. The tool types included here are those described above with the exception of bifaces. Bifaces are not included because it is unlikely that those collected during the project were actually used as tools; for example, none of the 38 bifaces recovered exhibit any usewear. Rather, as is discussed further below, it is likely that bifaces served primarily as "packages" for the transport of Tosawihi chert, which was subsequently manufactured into both flake tools and bifacial tools such as projectile points. Because the bifaces themselves do not appear to have been used as tools, they are excluded from this anaylsis of diversity in tool functional types.

Table 96. Counts of Chipped Stone Tool Types by Site

Site	Projectile Point	Knifelike Biface	Scraper	Compound Tool	Modified Flake	Number of Tools	Number of Tool Types
26EU1533	1				1	2	2
26EU1539	1		2	1	9	13	4
26EU1548			1			1	1
26EU2064	4				7	11	2
26EU2126	5	1			7	13	3
Total	11	1	3	1	24	40	5

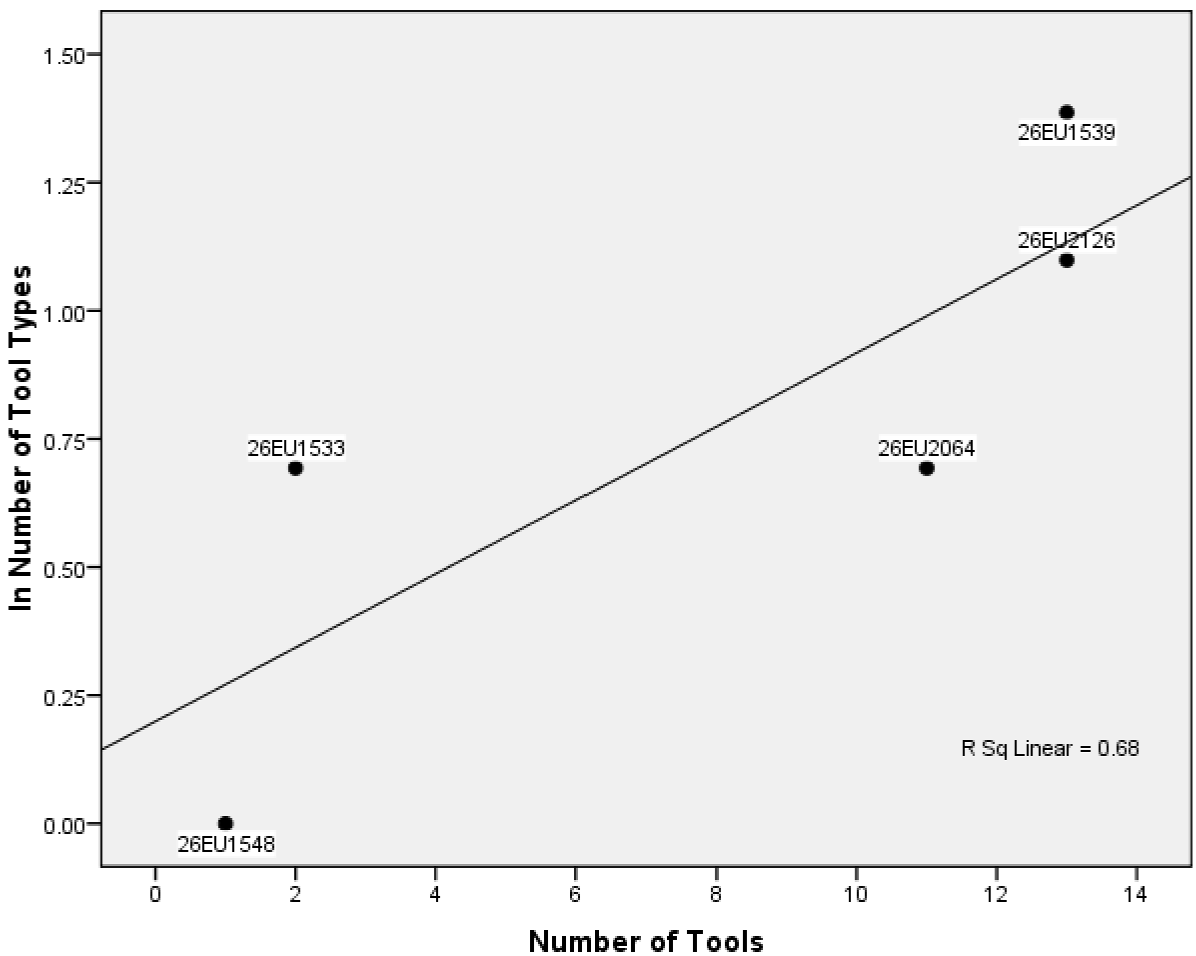

Figure 104. Relationship between tool assemblage diversity and tool assemblage size.

Tool assemblage diversity is plotted against tool assemblage size in Figure 104 (the natural log of the number of tool types is used here to reduce heteroscedasticity in the relationship). The relationship is fairly strong, with an r^2 value of 0.68 (p = 0.086). Overall, the slope for the relationship is relatively low (standardized beta coefficient = 0.825), suggesting that all of the sites investigated were more likely extractive locations or short-term camps than residential bases (compare with Figure 103). Indeed, no more than four tool types are present at any single site, consistent with a limited degree of activity diversity. However, two of the sites, 26EU1533 and 26EU1539, have greater numbers of tool types than is to be expected based on sample size, and two others, 26EU1548 and 26EU2064, have fewer tool types than is predicted, while one site, 26EU2126, has a negligible deviation from the relationship. This suggests that a somewhat greater range of activities may have been carried out at 26EU1533 and 26EU1539 than at 26EU1548 and 26EU2064, with 26EU2126 lying somewhere in between. It should be pointed out, however, that none of the sites has a standardized residual with an absolute value greater than 2 (the largest standardized residual, at 1.03, is that for 26EU1533), so none is truly an outlier from the relationship. Rather, it appears that all of the sites investigated were likely loci for a relatively limited range of activities, with only a small degree of variability in activity diversity among them. In turn, these results would suggest that the sites were used by groups with a relatively high degree of mobility, particularly if the sites were indeed short-term base camps. On the other hand, it is also possible that the sites were components of a logistical settlement system and were associated with larger residential sites that may have been located elsewhere in the area. Such issues are discussed further below in Section 7.4.3.

Tool Functional Types

The function of different activity loci can be further addressed by examining the specific functional types of chipped stone tools present at each site excavated during the 2007 BGMI project (Table 96) and by considering these functional types in relation to features and other artifact classes.

At 26EU1533, only two chipped stone tools were recovered: a modified flake and an Elko Corner-notched point. Although the sample size is too small to provide much insight into site function, modified flakes are considered expedient tools and can perform a variety of cutting tasks associated with the processing of floral and faunal remains, as well as the manufacture of wood or bone tools (LaFond 1996:E-5). Elko series points are generally thought to have been used as hafted dart points, although use wear analysis has shown that they were also used for a variety of other tasks (see Section 5.2.3). The combination of these two tool types may indicate that 26EU1533 was used for hunting and processing game.

A greater variety of tools was found at 26EU1539: in addition to ten bifaces, nine modified flakes, two scrapers, a projectile point, and a compound tool were recovered. Both formal tools and expedient tools are present in the assemblage from this site, in fairly even proportions. The bifaces may represent the remains of bifacial cores, but they are also potential precursors to formal bifacial tools. The projectile point is an Eastgate Expanding Stem type, thought to be an arrow point used for hunting both large and small game. Expedient scrapers such as those recovered from the site are typically considered hide-working tools, but can be employed in a variety of ways (LaFond 1996:E-5). The compound tool is also an expedient tool, able to perform varied functions. Like 26EU1533, 26EU1539 appears to have been used for hunting and processing game, but the abundance of bifaces (not to mention the very large amount of debitage from the site; see Table 75) also suggests that lithic production activities occurred here.

From 26EU1548, three bifaces and a scraper were collected. The absence of any projectile points or modified flakes may indicate that hunting was less a focus of activity than at the two sites discussed previously. However, the presence of the scraper suggests that some game processing may have occurred here, and the presence of bifaces and lithic debitage is an indication of lithic tool production.

26EU2064 contains a higher proportion of formal tools relative to expedient tools than the three sites described above. The assemblage from the site includes four projectile points and seven modified flakes, in addition to ten bifaces. Projectile points and bifaces are dominant, and can be associated with both hunting and lithic tool production. The modified flakes may have been used for processing game. Projectile points excavated at the site consist of a Gatecliff Contracting Stem point, an Elko Eared point, and two Desert Side-notched points. The Gatecliff point is likely a dart point. As noted above, Elko Eared points are also dart points, but may have been used to hunt smaller game than was the Elko Corner-notched from 26EU1533. Desert Side-notched points are associated with the use of the bow and arrow, and could have been used to hunt small and large game. Although 26EU2064 is a multicomponent site, it generally seems to have been primarily a hunting locale throughout its period of use.

Like 26EU2064, the chipped stone tool assemblage from 26EU2126 also contains a high proportion of formal tools relative to expedient tools, with five projectile points, a knifelike biface and eight modified flakes, in addition to 15 bifaces. Knifelike bifaces are large cutting tools and were often hafted. The projectile points consist of four Cottonwood Triangular points and a Desert Side-notched point, all of which are arrow points. The modified flakes may have been used in game processing, and as such are consistent with other evidence for such activities from Operation F at this site (discussed above in Section 6.1 and further below). Thus, the tool assemblage from 26EU2126 appears to represent hunting and game processing, although as noted above, the bifaces are likely also associated with lithic tool production activities.

Beyond chipped stone tools, the presence of ground stone at three of the sites involved in the project is also relevant to understanding the types of activities that occurred at those sites (Table 97). As noted in Section 6.3, one ground stone artifact was collected from 26EU1533, five were recovered from 26EU1539, and one was excavated from Operation C at 26EU2126. The ground stone artifact from 26EU2126 and four of the five from 26EU1539 can be identified as grinding tools, which suggest that processing of plant resources occurred at these two sites (though, as noted in Section 6.2, macrobotanical evidence to support this conclusion is lacking from these sites). Furthermore, six of the seven ground stone tools are considered expedient, which may indicate that the prehistoric groups using these sites were highly mobile and less reliant on plant resources (see Section 6.3). Nonetheless, the presence of ground stone does suggest that an area was used for some aspect of food production. The mano fragment recovered from 26EU2126 was found approximately two meters south of Fetaure 1, an FCR concentration. The proximity of ground stone to an area where fires were apparently built would suggest that preparing and cooking food occurred there. However, Feature 1 appears more likely to be simply the result of an FCR dumping episode (see Chapter 3), and the mano found near it is fragmented. This area may thus have been used for waste disposal rather than for food preparation.

Table 97. Counts of Ground Stone Types by Site

Site	Flat Metate	Rectangular Mano	Rectangular, One-Hand Mano	Unknown Grinding Tool	Hammer-stone	Indeterminate	Total
26EU1533	0	0	0	0	0	1	1
26EU1539	2	0	1	1	1	0	5
26EU2126	0	1	0	0	0	0	1
Total	2	1	1	1	1	1	7

Finally, archaeological features and their distribution can be examined to determine activity locus function. The only features encountered during the 2007 BGMI data recovery project that are clearly archaeological are Features 1, 2 and 3 from 26EU2126 (Table 98). Feature 1 was discussed above in relation to the ground stone fragment found nearby. Two bone fragments were recovered from near this feature, though it is unclear whether the presence of bones is due to human activity. Feature 2 is the only feature from the site that can be definitively identified as a hearth. Its location in Operation F places it within an area of very dense debitage, suggesting that lithic reduction activities occurred in the area. In addition, as discussed in Section 6.1, a large number of large mammal remains were recovered from Operation F, many of which are burned, and some of which display cut marks. It thus appears that game processing occurred in this area, in addition to lithic reduction activities. Feature 3 appears to have been the result of an FCR dumping episode similar to that which produced Feature 1. A few pieces of debitage were observed during surface collection in the vicinity of this feature, but the feature itself did not contain any debitage, faunal remains, or subsistence-related macrobotanical evidence.

Table 98. Summary of Features at 26EU2126

26EU2126	Type of Feature	Interpretation of Feature	^{14}C Date (cal 2-sigma)	Provenience	Subsistence Evidence
Feature 1	FCR Concentration	FCR dumping episode	A.D. 330–540	Operation C	Faunal remains (may not be cultural)
Feature 2	Thick ash lens	Hearth	A.D. 770–980	Operation F	Faunal remains
Feature 3	FCR Concentration with ashy fill	FCR dumping episode	A.D. 600–680	Blading	None

To summarize, an overall low degree of chipped stone tool type diversity suggests that a limited range of activities occurred at each of the sites investigated during the 2007 BGMI project. However, there is also some evidence for variability among the sites in activity diversity, as tool type diversity (controlling for sample size) is somewhat higher at 26EU1533 and 26EU1539, intermediate at 26EU2126, and very low at 26EU1548 and 26EU2064. The specific types of tools recovered suggest that very similar activities, including lithic tool production and game hunting and/or processing, occurred at all of the sites. At 26EU2126, the presence of Feature 2 and the faunal remains associated with it provide compelling additional evidence for large mammal processing. The recovery of ground stone from three sites—26EU1533, 26EU1539, and 26EU2126—provides an indication that plant processing activities occurred at these sites. Based on chipped stone tool diversity and the abundance of ground stone, it would appear that, of the five sites involved in the project, the greatest diversity of activities occurred at 26EU1539. However, the absence of archaeological features at this site suggests that it was an extractive location or perhaps a very short-term camp, rather than a residential base.

Thus, there are two possible conclusions that might be derived from these sites with respect to where the prehistoric occupants of the LBBA fell along Binford's forager-collector continuum. Considering the sites in isolation, it would appear that they were used by groups with a relatively high degree of mobility who fell towards the forager end of the continuum: none of the sites provide evidence for more than very short-term occupation. On the other hand, it is also possible that the sites were components of a logistical settlement system and were associated with larger residential sites that were not investigated during this project. If so, this would indicate a settlement system towards the collector end of the continuum. Evaluating potential associations with other sites in the LBBA in order to address this issue further is a subject that is ripe for future synthetic research in the area.

7.4.2. Tosawihi Quarrying Behavior

The Tosawihi Quarries in north-central Nevada produce high-quality chert that was widely used as toolstone both prehistorically and historically. Elston (1992) notes that Tosawihi chert has been found in archaeological contexts as far as 150 km from the quarries, although it becomes less dominant at greater distances and becomes increasingly replaced by more local materials beginning at a distance of approximately 60 km from the quarries. The LBBA, where the 2007 BGMI project took place, is located about 20 km southeast of the Tosawihi Quarries. LaFond (1996:677) suggests that the quarries would have been just outside of a 15-km diurnal foraging range from the LBBA, but still well within the logistical range for acquiring non-local resources. An examination of data from the five sites excavated during the 2007 project can provide insights about the importance of Tosawihi chert in the LBBA, how it was quarried, and its relationship to prehistoric settlement and subsistence patterns in the area.

Elston (1992) argues that quarrying behavior can be modeled in terms of its relative costs and benefits (see also Beck et al. 2002). The time and energy that prehistoric groups spent extracting, processing, and transporting toolstone from the Tosawihi Quarries are considered direct costs, whereas other opportunities that were lost while acquiring toolstone are indirect costs. The benefit derived from quarrying stone is measured by the utility of the tools it produces. Indirect costs prove difficult to model, but Elston uses proxy measures to assess direct costs and tool utility. He finds that distance traveled to and from the quarry is the primary factor determining whether it is more efficient to process toolstone at the quarry or after returning to a residential base. When traveling longer distances, the cost of transporting weight that becomes waste after processing is very high. In this case, it is more efficient to process at the quarry, thus reducing weight and transporting toolstone in smaller packages. Using experimental data, Elston suggests that at some threshold between about 5 and 10 km, the costs of deferred processing become prohibitive, and there should accordingly be evidence of increased processing at the quarry. He writes, "At [sites located] about 10 km from the quarry, we expect a sharp decrease in proportions of cores, blanks, early stage bifaces, and debitage" (Elston 1992:798). However, he also notes that in cases of "immediate contingencies," deferred processing may be more practical. Contingencies include situations limiting the amount of time spent at the quarry such as bad weather, lack of water or food, and hostility between groups. Elston concludes that most quarrying at the Tosawihi Quarries involved either logistical forays or residentially mobile groups making seasonal trips to the quarries.

Elston's model operates on the assumption that bifacial cores are the most efficient means of transporting toolstone. This assumption is most notably based on an argument made by Robert Kelly (1988), who proposes that bifacial cores maximize the amount of usable edge that a core can produce while minimizing the weight that must be transported. As discussed in the following section (7.4.3), several significant experiments and articles have challenged Kelly's argument. Nonetheless, biface production appears to have been the primary activity at the Tosawihi Quarries. Elston writes, "Tosawihi archaeological biface assemblages contain between 70 and 76 percent Stage 3 bifaces and one to eight percent Stage 4 bifaces" (Elston 1992:788). The sites surrounding the Tosawihi Quarries also show evidence of flake blanks being transported away from the quarries, but in much smaller numbers.

As noted above in Section 7.2, Tosawihi chert constitutes 99.90 percent of the debitage and 97.44 percent of the tools recovered from the five sites investigated during the 2007 project, with obsidian supplying the rest of the raw material. The Tosawihi Quarries were very clearly the primary lithic resource exploited in the LBBA. LaFond suggests that the LBBA provided "a resource patch for mobile residential groups…[or] logistic groups while en route to and returning from the Tosawihi Quarries" (LaFond 1996:703). As such, sites in the LBBA should provide an opportunity to examine the extent to which processing occurred at the quarries and the extent to which processing involved the production of bifacial cores for transport.

Bifaces are the dominant tool type observed at the five sites excavated in 2007, comprising 47.37 percent of the combined Tosawihi Chert tool assemblage from all five sites (Table 99). Moreover, 26 of the 36 Tosawihi Chert bifaces recovered (72.22 percent) are late–stage bifaces classified as either Stage 3, 4, or 5. These data appear to support Elston's claim that toolstone was processed into bifacial cores at the Tosawihi Quarries and then transported elsewhere. However, projectile points are also present, constituting 14.47 percent of the Tosawihi Chert tool assemblage, and several of the later stage Tosawihi bifaces, which are fragmentary, may represent projectile point midsections or performs. It remains unknown whether projectile points were manufactured at the Tosawihi Quarries or the LBBA sites. The Tosawihi Chert formal tool assemblage from the project also includes one knifelike biface.

In addition to these formal tools, the sites investigated during the 2007 BGMI project yielded a number of expedient tools made from Tosawihi Chert, including modified flakes, scrapers (all of which are expedient in design), and one compound tool (Table 99). Modified flakes make up 31.58 percent of the total Tosawihi Chert tool assemblage. Modified flakes are less common than bifaces, but they are at least as common as projectile points at each site (Table 100). Additionally, a very small number of flakes recovered during excavation displayed use wear.

Table 99. Counts and Percentages of Tosawihi Chert Tool Types

Tool Type	Count	Percentage
Stage 1 Biface	3	3.95%
Stage 2 Biface	7	9.21%
Stage 3 Biface	8	10.53%
Stage 4 Biface	13	17.11%
Stage 5 Biface	5	6.58%
Projectile Point	11	14.47%
Knifelike Biface	1	1.32%
Compound Tool	1	1.32%
Scraper	3	3.95%
Modified Flake	24	31.58%
Total	76	100.00%

Table 100. Counts and Percentages of Tosawihi Chert Tool Types by Site

Site Number	Biface		Projectile Point		Knifelike Biface		Compound Tool		Scraper		Modified Flake		Total Number of Tools
	n	%	n	%	n	%	n	%	n	%	n	%	
26EU1533	0	0.00%	1	50.00%	0	0.00%	0	0.00%	0	0.00%	1	50.00%	2
26EU1539	9	40.91%	1	4.55%	0	0.00%	1	4.55%	2	9.09%	9	40.91%	22
26EU1548	3	75.00%	0	0.00%	0	0.00%	0	0.00%	1	25.00%	0	0.00%	4
26EU2064	10	47.62%	4	19.05%	0	0.00%	0	0.00%	0	0.00%	7	33.33%	21
26EU2126	14	51.85%	5	18.52%	1	3.70%	0	0.00%	0	0.00%	7	25.93%	27
Total	36	47.37%	11	14.47%	1	1.32%	1	1.32%	3	3.95%	24	31.58%	76

The presence of expedient tools made from core reduction flakes in the LBBA suggests that not all toolstone was transported from the Tosawihi Quarries as bifacial cores. Of the 24 Tosawihi Chert modified flakes, only 2 (8.33 percent) were bifacial reduction flakes, whereas fifteen (62.50 percent) were core reduction flakes. This suggests that simple core reduction did occur to some extent in the LBBA. Moreover, two Tosawihi Chert random/expedient cores were observed at 26EU1539 and four were observed at 26EU2126. It thus appears that some cores and perhaps also some flake blanks were also transported from the Tosawihi Quarries to sites in the LBBA. It is possible that processing was sometimes deferred until toolstone was transported to a residential base, but it seems more likely that cores and flake blanks were included in mobile toolkits because of functional concerns. LaFond notes that "generic, nonspecialized tool forms represent a range of potential functional applications" (LaFond 1996:694), while Kuhn (1994) suggests that cores and larger tools may have been included in mobile toolkits because their size confers a mechanical advantage for tasks such as chopping or cleaving. However, it should be noted that the LBBA is relatively close to the Tosawihi Quarries, and maximizing efficiency of transport may not always have been a crucial concern for prehistoric groups in the area. If this were the case, evidence of core reduction may not indicate that cores were used for their functional properties, but simply that they provided convenient means of transporting toolstone in at least some situations.

The debitage recovered during the 2007 BGMI project supports the evidence from the tool and core assemblages in suggesting that bifacial transport was the primary, but not sole, strategy employed for material obtained from the Tosawihi Quarries. Table 101 presents debitage counts from each site by debitage type and material type, and counts limited to Tosawihi chert proximal flakes that can be identified as core reduction, biface reduction and biface thinning flakes (i.e., excluding pressure flakes and indeterminate proximal flakes) are given in Table 102 and illustrated in Figure 105[19]. Biface reduction and biface thinning flakes dominate the classifiable proximal flake assemblage from each site, and in the overall assemblage for all sites, core reduction flakes account for only 8.97 percent of the flakes assigned to one of the three flake types included in Table 102 (though, as noted above in Section 7.4.1, core reduction flakes make up substantially higher proportions of certain artifact concentrations at 26EU1539 and 26EU2064). As LaFond (1996) notes in an earlier analysis of chipped stone debitage from the LBBA, core reduction may have been conducted closer to the quarries to reduce the weight that had to be transported. Furthermore, it is often difficult to distinguish core reduction flakes from those produced in the early stages of bifacial reduction. These two factors may result in an underrepresentation of the importance of core reduction strategies in the LBBA.

Another aspect of Tosawihi chert quarrying behavior was the heat-treatment of toolstone to render it more workable. Elston (2006:40) states, "Heat-treatment is used to improve sharpness and compliance (although at some expense of durability and increased risk of failure in manufacture)". Elston (1992:790) notes that many of the tools found at the Tosawihi Quarries show evidence of having been heat-treated, with a more lustrous appearance and brown discoloration. Pot lid fractures and crazing also indicate that material has been heated. Andrefsky (Andrefsky 2005:260) characterizes pot lid fractures as "a concave scar in the surface of rock usually caused by differential expansion and contraction of the rock, such as heating by fire".

[19] For sites 26EU1539 and 26EU2126, the data in the remainder of the tables in Section 7.4 include only the debitage in the analyzed samples; unanalyzed debitage from the FS bags that were sampled (Table 79) are not included.

Similarly, crazing, or surface cracks, is likewise cause by heating and cooling (Andrefsky 2005:260). Although pot lid fractures and crazing may result from inadvertent heating, they can also indicate deliberate heat-treatment of lithic raw material, especially given other studies demonstrating that Tosawihi chert was often heated.

Table 101. Debitage and Flake Types by Site

Site	Material	Proximal Flake Type						Flake Shatter	Angular Debris	*Total*
		Core Reduction	Biface Reduction	Biface Thinning	Pressure	Indeterm-inate	*Total*			
26EU1533	Obsidian	0	0	0	0	0	*0*	1	0	*1*
	Tosawihi	1	6	3	0	35	*45*	136	7	*188*
	Total	*1*	*6*	*3*	*0*	*35*	*45*	*137*	*7*	*189*
26EU1539	Obsidian	0	0	0	0	0	*0*	0	0	*0*
	Tosawihi	39	112	120	17	543	*831*	2,164	688	*3,683*
	Total	*39*	*112*	*120*	*17*	*543*	*831*	*2,164*	*688*	*3,683*
26EU1548	Obsidian	0	2	0	0	0	*2*	1	0	*3*
	Tosawihi	1	40	27	1	159	*228*	518	80	*826*
	Total	*1*	*42*	*27*	*1*	*159*	*230*	*519*	*80*	*829*
26EU2064	Obsidian	0	1	2	0	0	*3*	0	0	*3*
	Tosawihi	25	128	125	7	195	*480*	1,137	143	*1,760*
	Total	*25*	*129*	*127*	*7*	*195*	*483*	*1,137*	*143*	*1,763*
26EU2064	Obsidian	0	1	0	0	3	*4*	3	0	*7*
	Tosawihi	9	75	125	20	755	*984*	2,531	651	*4,166*
	Total	*9*	*76*	*125*	*20*	*758*	*988*	*2,534*	*651*	*4,173*
Grand Total		*75*	*365*	*402*	*45*	*1,690*	*2,577*	*6,491*	*1,569*	*10,637*

Table 102. Tosawihi Chert Flake Type Profiles for 2007 BGMI Project Sites

	Core Reduction		Biface Reduction		Biface Thinnning		
Site	**Count**	**Percent**	**Count**	**Percent**	**Count**	**Percent**	**Total**
26EU1533	1	10.00%	6	60.00%	3	30.00%	10
26EU1539	39	14.39%	112	41.33%	120	44.28%	271
26EU1548	1	1.47%	40	58.82%	27	39.71%	68
26EU2064	25	8.99%	128	46.04%	125	44.96%	278
26EU2126	9	4.31%	75	35.89%	125	59.81%	209
Total	*75*	*8.97%*	*361*	*43.18%*	*400*	*47.85%*	*836*

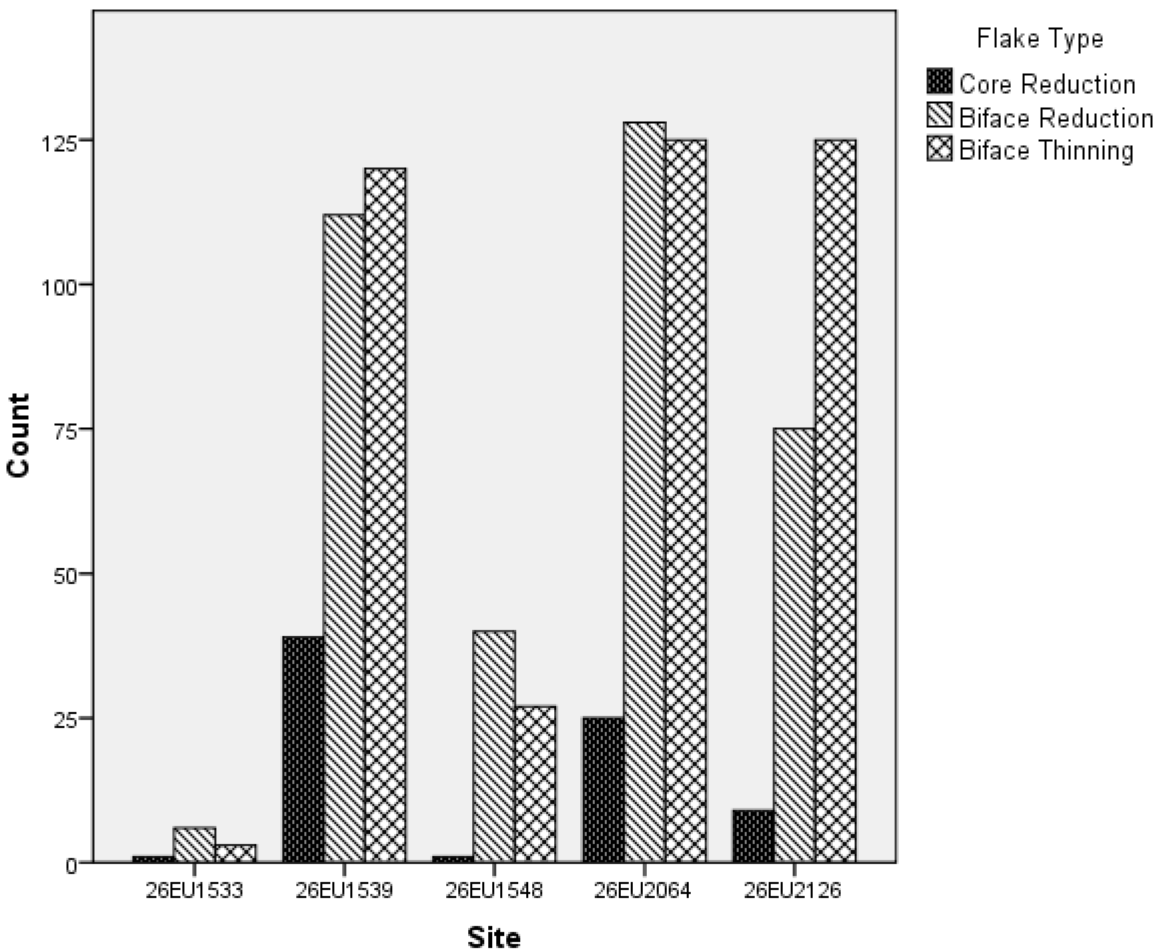

Figure 105. Tosawihi chert flake type profiles for 2007 BGMI Project sites.

Table 103. Counts and Percentages of Heat–treated Material by Site

Site	Total Number of Flakes	Number of Flakes with Pot Lid Fractures or Crazing	Percentage of Flakes with Pot Lid Fractures or Crazing
26EU1533	189	1	0.53%
26EU1539	3,683	115	3.12%
26EU1548	829	2	0.24%
26EU2064	1,763	24	1.36%
26EU2126	4,173	194	4.65%
Total	10,637	336	3.16%

Only a small amount (3.16 percent) of the debitage recovered during the 2007 project exhibits pot lid fractures or crazing (Table 103). Heat-treatment thus seems to have played a relatively small role in the processing of Tosawihi chert in the LBBA. Of the five sites involved in the 2007 BGMI project, evidence of heat treatment occurs in the highest frequency at 26EU2126; the percentage of debitage specimens from this site that exhibit pot lids or crazing is 4.65 percent. Moreover, the percentage of debitage from excavations in Operation F at this site, where the Feature 2 hearth was found, is identical to the overall percentage for the site: 175, or 4.65 percent, of the analyzed 3767 debitage specimens from Operation F excavations exhibit pot lids or crazing. The abundance of debitage in Operation F with pot lids and crazing may be the result of the heat treatment of toolstone in the Feature 2 hearth. This would be consistent with experimental data that Elston uses to suggest that "heat-treatment occurred in ordinary campfire hearths, a few artifacts at a time" (Elston 1992:790). Evidence of heat-treatment of Tosawihi chert in the LBBA may suggest that processing was deferred at least until the material was transported to this area. It should be noted, however, that the abundance of debitage with pot lid fractures in the vicinity of a hearth feature may be incidental; it does not necessarily denote an intentional effort to heat material for processing.

In conclusion, evidence from the artifact assemblage recovered from the 2007 BGMI project indicates that prehistoric groups in the LBBA procured abundant lithic raw material from the Tosawihi chert quarries. Bifacial reduction was the main strategy used to manufacture tools made from Tosawihi chert, and it appears that while some processing was conducted at the Tosawihi Quarries, some was also performed at sites in the LBBA. Additionally, there is evidence of core reduction in the LBBA, although this strategy appears to have been much less common than bifacial reduction. Finally, some Tosawihi chert recovered from LBBA sites was heat-treated, perhaps after transport to the LBBA.

7.4.3. Technology and Mobility

Kelly (1988) discusses how the archaeological record reflects prehistoric systems of technological organization and mobility. The organization of technology includes tool manufacture, use, and discard, as well as the spatial and temporal relations between these elements. Mobility is defined as "the way in which hunter-gatherers move across a landscape during their seasonal round" (Kelly 1988:717) in order to acquire various resources, including food and lithic material. Access to lithic material may have become limited as groups pursued food resources in certain areas, and consequently, hunter-gatherers may have had to transport either tools or the material needed to produce them. Mobility thus can create conditions that influenced how tools and raw material were transported, in addition to determining the functions for which tools were used (Kelly 1988:718).

In order to propose some initial hypotheses about the relationships between stone tools, lithic technology, and mobility strategies, Kelly examined three different types of bifacial tools: bifaces used as cores, bifaces that were long use-life tools, and bifaces that resulted from the shaping process. In groups with a high degree of residential mobility, Kelly suggests that bifacial tools were rare and expedient tools were predominant, provided that raw material was abundant. With an increasing scarcity of raw material, groups put more effort into producing tools that were easier to transport long distances. Logistical groups traveling away from a residential base faced the possibility of a similar scarcity, and thus also carried portable tools. Kelly argues that bifacial cores were the most efficient type of portable tool because they maximized the amount of cutting edge that could be produced while minimizing the weight that must be transported. Under conditions of raw material scarcity or low residential mobility, bifaces also occurred as long use-life tools. A long use-life permits a tool to be multifunctional; this is especially important on logistical forays, as tools needed to be adapted to varied and sometimes unanticipated conditions. Finally, bifaces may have resulted from the shaping process if they were intended for use as hafted tools. Kelly suggests that tools with multiple functions occurred in logistically mobile groups and were generally used to procure specific seasonally available resources.

Using the assumptions described above, Kelly identifies archaeological consequences that can be expected for groups with varying degrees of mobility. Although these consequences are largely hypothetical, they provide a useful starting point from which to approach data from the 2007 BGMI Data Recovery Project. Before Kelly's model is applied, however, it is important to note several more recent articles that identify exceptions to his argument.

Kuhn (1994) modifies Kelly's argument by suggesting that in some cases, it may have been more efficient to transport small flake blanks or functionally-specific tools than bifacial cores. He models the utility of tools of different sizes and compares utility to mass. Because more waste is created when cores are processed, they are determined to be less efficient than smaller flakes and tools. However, Kuhn suggests that cores may often be included in toolkits due to their functional properties, as they can meet a variety of needs that smaller flake tools cannot. He cites "hammers, anvils, pestles, or pounders, or chopping tools" (Kuhn 1994:437) as examples of functions that can be performed by larger cores. While small flakes and tools may optimize utility relative to cost of transportation, functional concerns may result in the inclusion of cores and larger flakes in toolkits, even at some distance from the raw material source or in a system with high logistical mobility. This may explain the frequent inclusion of bifacial cores in mobile toolkits, as noted by Kelly.

Prasciunas (2007) also disputes whether bifacial cores were more efficient than other means of transporting lithic materials. She calculated the total amount of usable flake edge produced by a core relative to its initial weight, and then compared these ratios for bifacial and amorphous cores. She found no significant differences in the ratios, indicating that bifacial cores may not have maximized the utility of transported material. Reasons other than maximizing efficiency may thus determine varying degrees of reliance on bifacial technology, including the following: anticipated tool function; tool multifunctionality, maintainability, and durability; and increased utility, because a biface still remains once the bifacial core has been exhausted. Caryn Berg (personal communication, 2007) notes that Parry and Kelly (1987) show that even if bifacial cores are not the most efficient means of transporting toolstone, a higher ratio of core reduction to biface production still tends to occur among less mobile populations. Nonetheless, Prasciunas' research suggests that assemblages at both residential and logistical sites may be more varied than predicted by Kelly's 1988 model.

Kelly's model predicts that if bifaces were being used as cores at residential sites, then there should be a correlation between the frequency of bifacial reduction flakes or biface fragments and the total amount of lithic debris. At all five sites investigated during the 2007 BGMI project, bifacial reduction and bifacial thinning flakes are the dominant types of identifiable proximal flakes among the lithic debitage, as shown in Table 101, Table 102, and Figure 105 above. In Table 104 below, these data are presented in a format for further addressing Kelly's hypothesis; the data in this table combine artifacts made of both Tosawihi chert and obsidian, and they include the total amount of bifacial debitage—which includes biface reduction, biface thinning and pressure flakes—as well as the number of bifaces and biface fragments recovered from each site. There is a strong and significant correlation between the total amount of debitage from each site and the number of bifaces recovered (r = 0.92, p = 0.013; see Figure 106), and a weaker and nearly significant correlation between total debitage and the amount of bifacial debitage (r = 0.79, p = 0.056; see Figure 107). Thus, Kelly's model would suggest that bifaces were used as cores at the sites investigated in the 2007 BGMI project.

Table 104. Counts of Debitage and Flake Types per Site, with Total Bifacial Debitage Counts and Number of Bifaces

	Proximal Flake Type										
Site	Core Reduction	Biface Reduction	Biface Thinning	Pressure	Indeterm-inate	*Total*	Flake Shatter	Angular Debris	*Debitage Total*	Bifacial Debitage Total	Bifaces
26EU1533	1	6	3	0	35	*45*	*137*	*7*	*189*	9	0
26EU1539	39	112	120	17	543	*831*	*2,164*	*688*	*3,683*	249	10
26EU1548	1	42	27	1	159	*230*	*519*	*80*	*829*	70	3
26EU2064	25	129	127	7	195	*483*	*1,137*	*143*	*1,763*	263	10
26EU2126	9	76	125	20	758	*988*	*2,534*	*651*	*4,173*	221	15

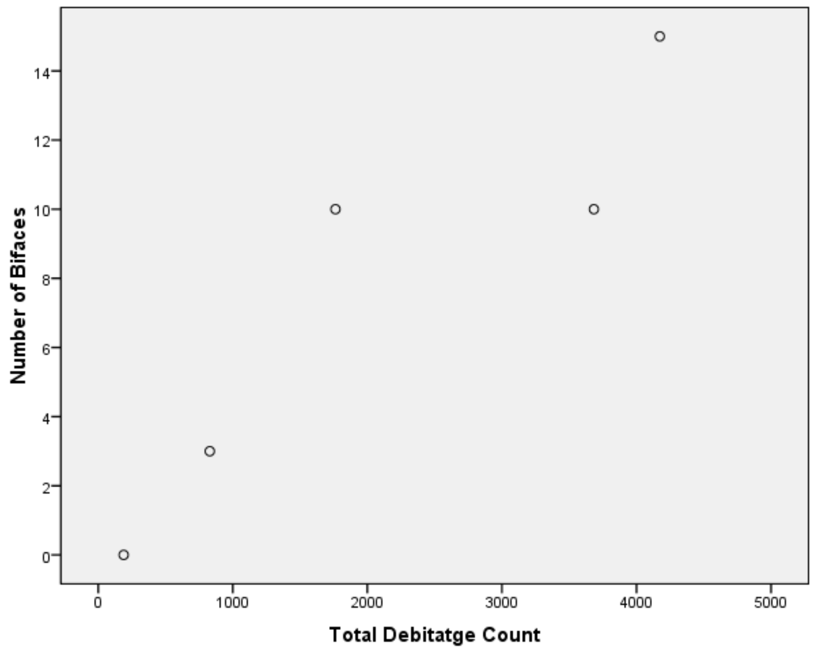

Figure 106. Relationship between number of bifaces and total amount of debitage at the 2007 BGMI project sites.

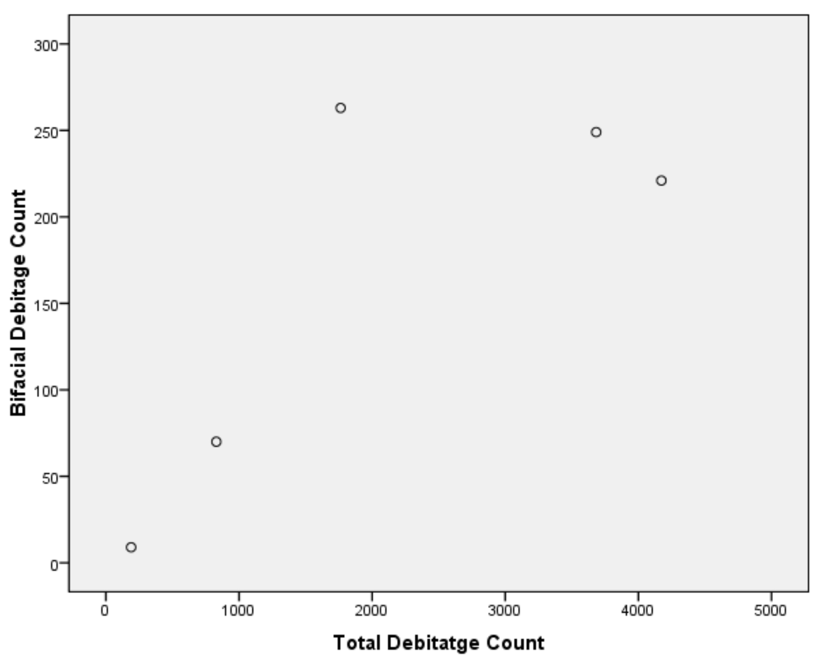

Figure 107. Relationship between amount of bifacial debitage and total amount of debitage at the 2007 BGMI project sites.

Kelly also suggests that the use of bifacial cores at residential sites should result in a low number of simple percussion cores, a low number of flakes with cortex, and the use of high-quality raw material. Of the over 14,000 chipped stone artifacts recovered during the 2007 BGMI project, only 6 were cores (2 from 26EU1539 and 4 from 26EU2126; see Table 75), and all chipped stone artifacts recovered are made of either Tosawihi chert or obsidian, both high-quality material types. In addition, only 2.17 percent of the debitage recovered during the project has cortex (all of it Tosawihi chert), and at no single site is the percentage of debitage with cortex greater than 3.18 percent (Table 105). These observations provide further support for the proposition that bifaces were used as cores at the sites investigated.

Table 105. Counts and Percentages of Flakes with Cortex by Site

Site	Material	Cortex Present	Cortex Absent	*Total*	% with Cortex
26EU1533	Obsidian	0	1	*1*	0.00%
	Tosawihi	6	182	*188*	3.19%
	Total	*6*	*183*	*189*	*3.17%*
26EU1539	Obsidian	0	0	*0*	n/a
	Tosawihi	117	3,566	*3,683*	3.18%
	Total	*117*	*3,566*	*3,683*	*3.18%*
26EU1548	Obsidian	0	3	*3*	0.00%
	Tosawihi	11	815	*826*	1.33%
	Total	*11*	*818*	*829*	*1.33%*
26EU2064	Obsidian	0	3	*3*	0.00%
	Tosawihi	47	1,713	*1,760*	2.67%
	Total	*47*	*1,716*	*1,763*	*2.67%*
26EU2126	Obsidian	0	7	*7*	0.00%
	Tosawihi	50	4,116	*4,166*	1.20%
	Total	*50*	*4,123*	*4,173*	*1.20%*
Grand Total		*231*	*10,406*	*10,637*	*2.17%*

Other archaeologists who study the Great Basin also use evidence of lithic technologies to draw inferences about mobility strategies, but without adopting all aspects of Kelly's model. McGuire et al. (2004) examine temporal changes in technology and mobility at the Pie Creek Rockshelter, located to the east of the LBBA. They note that in the Middle Archaic period, tool technology relied heavily on large bifaces that were produced at quarries and transported throughout a large range surrounding the quarries. As distance from the quarries increases, archaeological assemblages are found to contain less debitage from early reduction stages, as well as a greater number of curated tools. McGuire et al. (2004) argue that this pattern of technological organization "suggests that Middle Archaic subsistence-settlement adaptations were extremely wide-ranging and logistically well organized, with highly mobile groups traversing hundreds of kilometers up and down valley corridors". During the Late Archaic period, on the other hand, these authors suggest that prehistoric groups had more constricted annual ranges, as indicated by an increased emphasis on core reduction and expedient tools, though bifaces still remained an important part of the organization of lithic technology. They also note that prehistoric groups in eastern Nevada generally experienced population growth and a concomitant intensification of resource use during the Late Holocene. This shift may have resulted in decreased lithic material diversity and transport distances, fewer specialized camps and more uniform artifact assemblages, and an increased reliance on plant resources (McGuire et al. 2004:27).

As noted above (Table 88), all of the cores recovered during the 2007 BGMI project are from contexts that appear to be Late Archaic or Late Prehistoric in age and none are from the single Middle Archaic site that was investigated; this is consistent with the hypothesis about change over time in settlement and technological organization proposed by McGuire et al. (2004). Debitage data from the project that are applicable to this hypothesis are presented in Table 106 and Table 107 and illustrated in Figure 108. The Middle Archaic debitage sample, which consists exclusively of the small assemblage from 26EU1533, contains very few flakes for which flake type could be determined. The percentage of Tosawihi chert core reduction flakes in this sample is slightly higher than that in the Late Archaic/Late Prehistoric sample, in contrast to the pattern that McGuire et al. (2004) observed at Pie Creek Rockshelter. However, due to the small size of the Middle Archaic sample, this difference is not statistically significant (for data in Table 107: chi–square = 1.64, $df = 2$, $p = 0.441$, mean expected frequency = 89.5). Clearly, larger samples of Middle Archaic debitage are required before it can be determined more fully whether the pattern observed at Pie Creek Rockshelter also holds for the LBBA.

Table 106. Debitage and Flake Types by Period

Period	Material	Proximal Flake Type						Flake Shatter	Angular Debris	*Total*
		Core Reduction	Biface Reduction	Biface Thinning	Pressure	Indeterm-inate	*Total*			
Middle Archaic	Obsidian	0	0	0	0	0	*0*	1	0	*1*
	Tosawihi	1	6	3	0	35	*45*	136	7	*188*
	Total	*1*	*6*	*3*	*0*	*35*	*45*	*137*	*7*	*189*
Late Archaic/ Late Prehistoric	Obsidian	0	3	0	0	3	*6*	4	0	*10*
	Tosawihi	47	217	263	38	1,389	*1,954*	5,030	1,360	*8,344*
	Total	*47*	*220*	*263*	*38*	*1,392*	*1,960*	*5,034*	*1,360*	*8,354*
Grand Total		*48*	*226*	*266*	*38*	*1,427*	*2,005*	*5,171*	*1,367*	*8,543*

Table 107. Tosawihi Chert Flake Type Profiles for Analysis Time Periods

	Core Reduction		Biface Reduction		Biface Thinnning		
Period	**Count**	**Percent**	**Count**	**Percent**	**Count**	**Percent**	**Total**
Middle Archaic	1	10.00%	6	60.00%	3	30.00%	10
Late Archaic/Late Prehistoric	47	8.92%	217	41.18%	263	49.91%	527
Total	*48*	*8.94%*	*223*	*41.53%*	*266*	*49.53%*	*537*

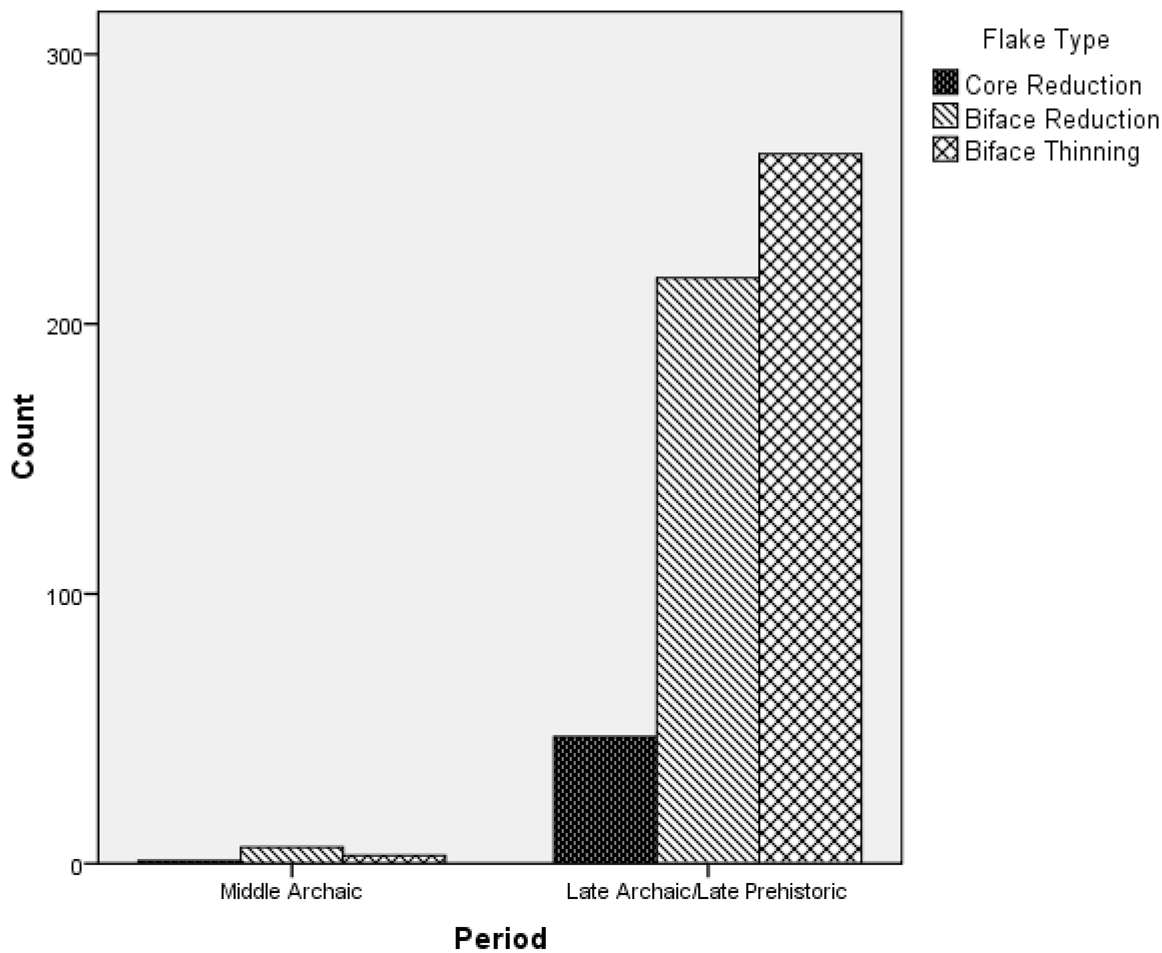

Figure 108. Tosawihi chert flake type profiles for analysis time periods.

LaFond (1996) examines the frequencies of debitage from different reduction stages in order to determine systems of technological organization in the LBBA. LaFond classifies bifacial reduction flakes as early, middle, or late stage. LaFond suggests that when all stages are evenly represented in the debitage assemblage, a site was most likely used for the initial manufacture of tools from local raw material. If early stage flakes are more heavily represented, material was probably being transported as flake blanks, cores, and early stage preforms. Conversely, an emphasis on late stage flakes may indicate the final production of staged bifaces, as well as rejuvenation of bifacial tools. LaFond finds that late-stage bifacial reduction flakes are dominant among diagnostic Tosawihi chert debitage in the LBBA and that early-stage flakes are common, while middle-stage bifacial reduction flakes are the least abundant (LaFond 1996:702).

Debitage from the 2007 BGMI project was classified into the flake type categories defined above, rather than into the categories that LaFond (1996) used. Despite the difference in classification systems, though, it is still possible to examine relative abundances of early and late stage reduction debris to draw conclusions following LaFond's logic (see also the analysis of intra-site variability in flake type profiles presented in Section 7.4.1 above). As shown above in Table 102 and Figure 105, biface reduction and biface thinning flakes dominate the debitage assemblages from all five sites investigated during the project. However, there are statistically significant differences in flake type profile among the sites (chi-square = 35.1, $df = 8$, $p < 0.001$, mean expected frequency = 55.7). Based on chi-square adjusted standardized residuals (specifically flake types with adjusted standardized residuals that fall beyond two standard deviations for a given site), core reduction flakes can be considered to be significantly over-represented at 26EU1539 and significantly under-represented at 26EU1548 and 26EU2126, biface reduction flakes can be considered to be significantly over-represented at 26EU1548 and significantly under-represented at 26EU2126, and biface thinning flakes can be considered to be significantly over-represented at 26EU2126.

Thus, relative to all sites investigated during the project, lithic reduction at 26EU2126 appears to have been biased towards completion and/or retouching of bifacial tools, while at 26EU1548 it appears to have been biased towards earlier stages of bifacial reduction, and sites 26EU1539 and 26EU2064 can be considered to be intermediate along this dimension. In addition, the debitage assemblage from 26EU1539 is notable for its high frequency of core reduction flakes, which, as discussed in Section 7.4.1, come primarily from the dense artifact concentration that was located in the southern part of this site. It is perhaps best not to draw conclusions about 26EU1533 due to the small size of the debitage assemblage from this site. Beyond these site-specific conclusions, the fact that bifacial reduction and bifacial thinning flakes (i.e., earlier- and later-stage bifacial reduction debris) occur in roughly equal proportions in the the combined assemblage from the project suggests that the full reduction sequence was carried out within the LBBA.

An analysis based on platform type can be used as a check on these conclusions derived from analysis of flake types (Table 108, Figure 109). Andrefsky describes experiments conducted by Gilreath and notes that her findings showed that, "As the stage of production increased from the original nodule to a finished biface, the amount of striking platform preparation increased. Similarly, striking platform types changed from stage to stage" (Andrefsky 2005:90). Andrefsky proceeds to describe four types of platforms: cortical, flat, complex, and abraded. These are the categories used for analysis of debitage from the 2007 BGMI project (see Section 7.1 above).

Relative to the analysis of flake types, sample size increases considerably when platform type is examined because platform type could be recorded for many proximal flakes for which flake type could only be recorded as "indeterminate".

There are significant differences in platform type distributions among the sites excavated during this project (chi–square = 92.4, $df = 12$, $p < 0.001$, mean expected frequency = 128.4). Of these sites, the distribution of platform types is most even for 26EU1533 (Figure 109). Though sample size is small for this site even when platform type rather than flake type is considered, this even distribution of platform types would suggest that, of all of the sites involved in the project, the Middle Archaic 26EU1533 was the single site most likely to have had the full lithic reduction sequence completed at it. The most common platform type at 26EU1539, 26EU1548, and 26EU2064 is complex, followed by flat and abraded. Such a distribution is consistent with the conclusion drawn above that lithic reduction at these sites was biased towards the early or intermediate stages of bifacial reduction. Finally, abraded platforms are most common at 26EU2126, which is consistent with the above conclusion that lithic reduction at this site was biased towards completion and/or retouching of bifacial tools.

Table 108. Flake Platform Types by Site

	Cortical		Flat		Complex		Abraded		
Site	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Total
26EU1533	5	11.11%	7	15.56%	15	33.33%	18	40.00%	45
26EU1539	19	2.29%	246	29.60%	309	37.18%	257	30.93%	831
26EU1548	4	1.75%	40	17.54%	107	46.93%	77	33.77%	228
26EU2064	7	1.46%	139	28.96%	223	46.46%	111	23.13%	480
26EU2126	6	0.61%	261	26.52%	332	33.74%	385	39.13%	984
Total	*41*	*1.60%*	*693*	*26.99%*	*986*	*38.40%*	*848*	*33.02%*	*2,568*

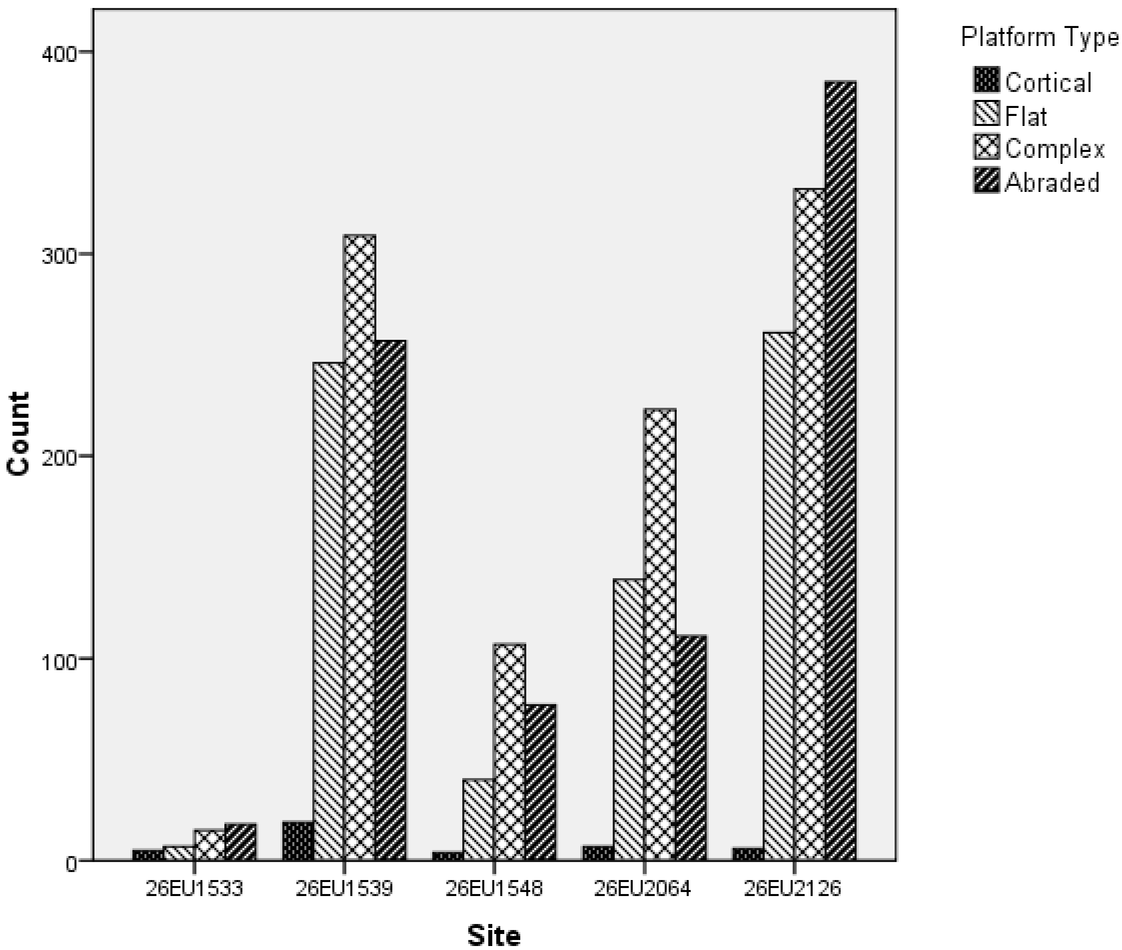

Figure 109. Flake platform types by site.

In conclusion, the different types of analyses applied to data from the 2007 BGMI project all point towards a heavy reliance on bifacial technology to produce generalized and formal tools. As Elston notes in a discussion of the Tosawihi Quarries, "That biface technology, particularly well adapted for use by highly mobile hunter-gatherers, has been the focus of lithic production in the Great Basin throughout prehistory perhaps is indicative of the overall importance of mobility in the region" (Elston 2006:43). Nonetheless, core reduction and the use of expedient tools have also been shown to play an important part in systems of technological organization in the LBBA. The presence of alternative strategies may indicate that the efficiency of bifacial cores for transporting lithic material has been overstated or that there were other reasons compelling prehistoric groups to include flake blanks and cores in their mobile toolkits. These reasons may include the functional properties of cores, the need for a variety of flake blanks and tool forms on a contingency basis, or simply that the LBBA is close enough to Tosawihi that processing was sometimes deferred. Additionally, the six cores recovered during excavation are all relatively small (none weigh more than 70 g), and may not have had a high cost of transport; however, these cores could also represent the exhausted remains of larger cores.

It appears that lithic material was transported—primarily as bifaces, though occasionally as expedient cores—from the quarries to sites in the LBBA, where further processing occured. The combination of available resources and relative proximity to the Tosawihi Quarries would have made the LBBA an ideal location for short-term field camps where hunting–gathering and more intensive lithic processing could be conducted in preparation for travel to more remote areas. Therefore, it seems likely that the LBBA was used by mobile groups making their seasonal rounds from a lithic procurement locus to areas rich in other necessary resources.

7.5. EVIDENCE FOR A COLLECTION EFFECT?

Unsurprisingly, illicit artifact collecting at archaeological sites is often noted only when evidence is easily observed; looters' holes and damage or destruction of features are examples of this. The effects of surface collection, albeit less overt, are just as potentially harmful to archaeological contexts. Because of the lack of obvious physical evidence, this kind of vandalism often goes unnoticed; its impacts on interpretation of an archaeological site, however, can be significant.

The majority of data gathered during archaeological field investigations comes from detailed observations of what is present on the ground surface. Assigning a cultural and temporal affiliation to any given site is often possible only when diagnostic artifacts are present. Most commonly these artifacts include projectile points and pot sherds (at American Indian sites), which are unfortunately the items most often collected illegally.

For this reason, determining whether or not surface collection has occurred (and if so, the extent of the damage) could be an invaluable step to take in the recording and study of archaeological sites. Unfortunately, since most sites are assessed by examining the ground surface assemblage only, this determination can be challenging to make. However, since the current project entailed not only surface survey and recordation, but also testing and excavation, it is possible in this case to determine the extent of surface collection by comparing artifact assemblages observed on the ground surface with those recovered in excavation. Since no pottery has been recovered at the sites involved in this project, we focus on lithic debitage and chipped stone tools, particularly projectile points, to attempt to make this determination.

7.5.1. Methods

This analysis is based on the study done by Fawcett (1993) on a collection effect in Anasazi village sites. That study compared ratios of decorated to plain pot sherds between surface and subsurface contexts. Fawcett cites two studies (Lightfoot 1978; Lightfoot and Francis 1978) suggesting that collectors prefer decorated pot sherds over plain ones. For the purposes of this study, it is assumed that there is a similar preference for projectile points over chipped stone flakes. Point and debitage counts for surface and subsurface contexts at the five sites involved in the 2007 BGMI project are presented in Table 109. The data in this table include only artifacts recovered in surface collection or manual excavation and exclude the few artifacts recovered during mechanical stripping; in addition, these data include all recovered debitage specimens, rather than only analyzed specimens from FS bags that were sampled. Also shown in Table 109 is an index of the number of points recovered per 1000 debitage specimens. This index is used to compare the ratio of points to debitage between the surface and subsurface assemblages from a given site.

Table 109. Projectile Point and Debitage Counts by Context

	Surface		Subsurface		Points per 1000 Debitage Specimens	
Site	Points	Debitage	Points	Debitage	Surface	Subsurface
26EU1533	1	135	0	54	7.41	0.00
26EU1539	1	3,485	0	1,038	0.29	0.00
26EU1548	0	617	0	212	0.00	0.00
26EU2064	4	1,325	0	438	3.02	0.00
26EU2126	0	123	5	6,574	0.00	0.76
Total	*6*	*5,685*	*5*	*8,316*	*1.06*	*0.60*

7.5.2. Results

No projectile points were recovered from either surface or subsurface contexts at 26EU1548. At three of the four remaining sites—26EU1533, 26EU1539, and 26EU2064—the ratio of points to debitage is higher for surface contexts than for subsurface contexts, and this is also the case for the project assemblage as a whole. This is the opposite of what would be expected if large numbers of points had been removed from the surfaces of these sites due to artifact collecting. Only for 26EU2126 is the ratio of points to debitage higher for the subsurface assemblage than the surface assemblage. This may indicate that some collecting of projectile points from the surface of this site has occurred; however, given the small size of the surface assemblage from this site—the smallest of any site involved in the project—it is also possible that the lack of points in the surface assemblage is simply a sampling fluke. Overall, there is no evidence for systematic collection of projectile points across the sites involved in the project.

Of course, it is possible that assemblages from surface and subsurface contexts might differ for reasons other than illicit artifact collecting. In particular, archaeological recovery methods could affect the composition of those assemblages. It seems intuitive that surface collection should result in a bias toward larger, more visible flakes and that this bias would not affect excavated assemblages recovered through screening. Such a bias against smaller flakes, which would result in smaller overall debitage samples, might be the cause of the higher ratios of points to debitage observed here for surface assemblages. However, such a bias does not, in fact, seem to be affecting the assemblages from the 2007 BGMI project, as illustrated in Figure 110 (data from all five sites involved in the project are aggregated in this figure; note that the percentages on the vertical axis are shown on a logarithmic scale). Debitage in the smallest two size classes (less than 1/8" and between 1/8" and 1/4") actually comprises a higher percentage of the surface–collected assemblages than the excavated assemblages, so it is unlikely that recovery methods are responsible for the difference in the proportion of points relative to debitage that occurs between surface and subsurface assemblages.

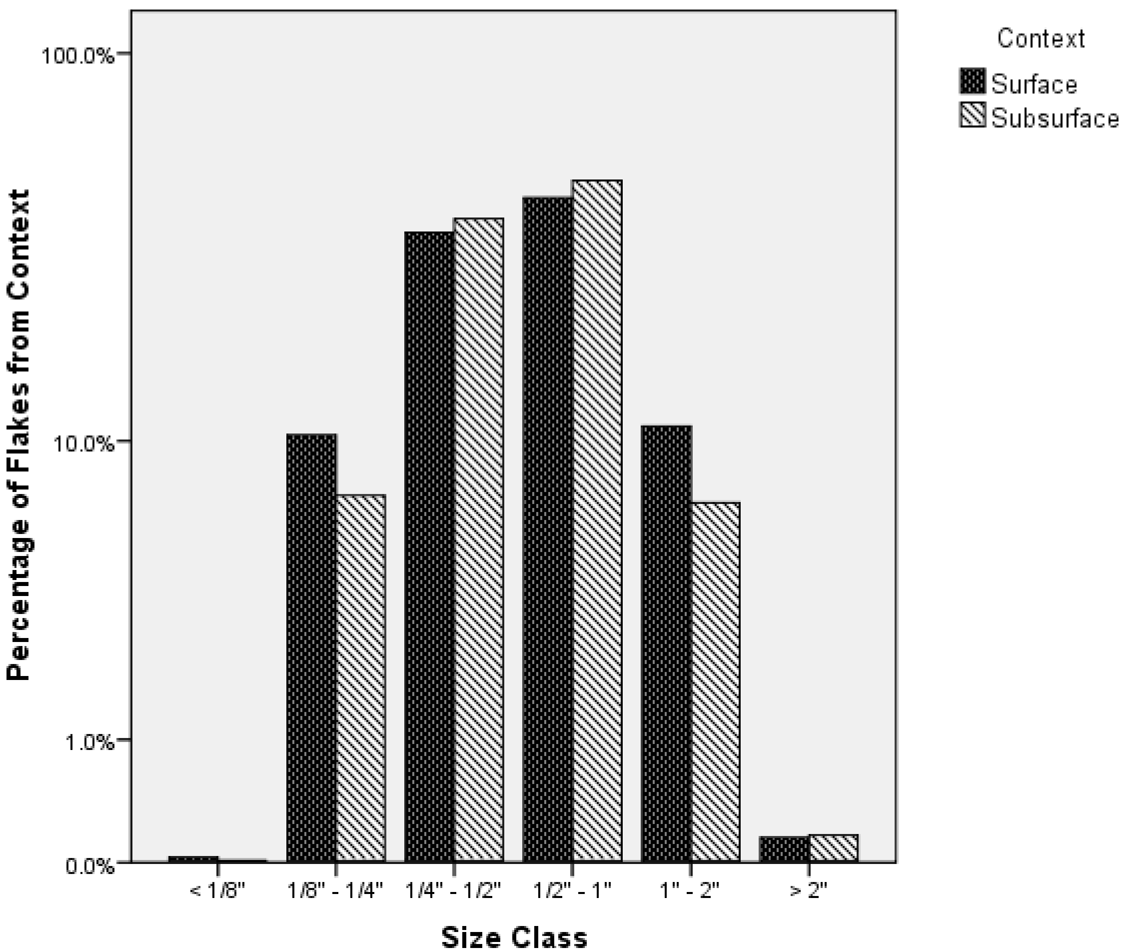

Figure 110. Distribution of debitage from surface and subsurface contexts across size classes.

7.5.3. CONCLUSIONS

The harmful impacts from surface collecting at archaeological sites often go unnoticed when such activities leave little to no visual evidence. However, collecting can have a serious effect on the evaluation of a site, given that the most important artifacts for assigning cultural and temporal affiliation are the most commonly removed by illicit collectors. By comparing ratios of projectile points to chipped stone flakes between surface and subsurface assemblages, it was possible to determine whether illicit collection has had a substantial impact at the sites involved in the 2007 BGMI project. This analysis indicates that little, if any, collecting activity has been carried out at these sites. Given that the lands on which these sites are located are controlled by Barrick Goldstrike, this is not completely surprising. Controlled access has resulted in the presence of far fewer people than on public lands and has apparently left the surface assemblages at these sites relatively untouched.

7.6. Synthesis of Lithic Data

The analyses presented in this chapter revealed some general trends in the lithic assemblages from the five sites excavated during the 2007 BGMI Data Recovery Project and provide some important new insights into prehistoric adaptations in the LBBA.

It has long been known that Tosawihi chert dominates lithic assemblages in the LBBA, and this material type accordingly comprises the vast majority of the toolstone recovered during the project. The Tosawihi Quarries are located relatively close to the LBBA, and it appears likely that the prehistoric groups who occupied the area did so as part of a settlement system that involved procurement of material from the quarries during seasonal rounds, or possibly logistical (sensu Binford 1980) resource acquisition trips to the quarries.

A very small amount of obsidian accounts for the remainder of the lithic material recovered during the project, and analysis of this material leads to insights beyond what has long been known. The proportion of obsidian relative to Tosawihi chert varies slightly but significantly among the debitage assemblages from the five sites, with obsidian significantly underrepresented at 26EU1539 and significantly overrepresented at 26EU1548. There is some evidence for a slight reduction in the use of obsidian relative to Tosawihi chert between the Middle Archaic and the Late Archaic/Late Prehistoric periods. More significantly, obsidian sourcing indicates that four sources were used, at distances from the LBBA ranging from 110 to 400 km. The range of sources represented indicates a high degree of mobility and/or the presence of extensive trade networks. In addition, though the size of the obsidian sample is too small to allow analysis of diachronic change in obsidian source use, an interesting pattern is apparent among samples from all phases combined.

Obsidian from Paradise Valley, the nearest source, is the most common in the assemblage and consists solely of debitage. On the other hand, material from two of the three more distant sources, Browns Bench and Wild Horse Canyon, occurs only in the form of bifaces (one specimen from each source). This pattern of differential source representation between tools and debitage is consistent both with theoretical expectations and with patterns documented empirically in other Great Basin contexts. It suggest that tools made from obsidian from more distant sources were curated and brought into the LBBA, while material from closer sources was more likely to be used in earlier-stage tool reduction that actually occurred in the LBBA. An analogous pattern of differential source representation between tools and debitage occurs in the proportion of obsidian from all sources relative to material from the nearby Tosawihi Quarries: obsidian comprises a slightly but significantly higher proportion of the tool assemblage than the debitage assemblage, again suggesting that material from more distant sources was more likely to be brought into the LBBA in the form of curated tools, while material from closer sources was more likely to be used in knapping carried out at LBBA sites.

Material from the Tosawihi Quarries was further examined in an effort to ascertain how it was processed and transported. Bifacial reduction appears to have been the dominant strategy used to process Tosawihi chert, but evidence of expedient tools and core reduction was also observed. Lithic assemblages recovered from the 2007 BGMI project support Elston's (1992) claim that material was processed at the quarries, as well as Kelly's (1988) arguments regarding the transport of lithic material in the form of bifacial cores. However, assemblages were more varied than either model would predict. The LBBA sites indicate that processing was sometimes deferred, and that cores and flake blanks were also used to transport material. Evidence of core reduction and expedient tools may suggest that conditions at Tosawihi constrained the amount of time that could be spent there. It appears that sites in the LBBA were used to further process material obtained at the Tosawihi Quarries, either on a contingency basis or to prepare for travel to more remote locations.

The reliance on bifacial technology in the LBBA suggests that its occupants were highly mobile groups who required an efficient means of transporting toolstone. Although core reduction and expedient tools were also present, they do not necessarily controvert the hypothesis that mobile groups were using the area. It is possible that they were not as much of a barrier to transport as assumed by the models mentioned above, that they had functional properties making them suitable for inclusion in mobile toolkits, or were small enough that they did not have a high cost of transport (e.g., Kuhn 1994).

The chipped stone data were also considered, along with other lines of evidence, to address the issue of site function. Analysis of debitage conducted at the level of the site indicates that, relative to other sites investigated during the project, lithic reduction at 26EU2126 was most biased towards completion and/or rejuvenation of bifacial tools, while at 26EU1548 it was most biased towards earlier stages of bifacial reduction, and at 26EU1539 and 26EU2064 it was more evenly balanced between earlier and later stages of bifacial reduction. Though the assemblage from 26EU1533 is small, this site may have been the one at which the most complete lithic reduction sequence was carried out. Overall, the lithic reduction activities evident at these sites are consistent with resource extraction and processing or residential uses.

At the intra–site level, two sites—26EU1539 and 26EU2064—exhibit complexity in the spatial distribution of debitage that suggests that the relative degree of core reduction, biface reduction, and biface thinning varied among different site loci. At 26EU1539, it appears that a perhaps discrete episode of core reduction occurred in the southern part of the site, while spatially dispersed bifacial tool completion and/or rejuvenation activities occurred throughout the northern part of the site. At 26EU2064, there is evidence for one isolated core reduction activity area and several dispersed areas of bifacial tool completion and/or rejuvenation. Unfortunately, due to limited chronological information from individual site loci, it is not possible to determine whether this intra-site spatial variability in debitage assemblages is associated with temporally distinct occupations or whether it reflects functional variability within individual occupations.

Chipped stone tools recovered from the sites investigated suggest that these sites were used for hunting and/or processing game. In addition, the presence of ground stone at three of the sites suggests that plant resources were processed at these sites. These lines of evidence suggest that the sites involved in the project were extractive locations or very short-term field camps where both foraging and lithic production activities took place. A generally low degree of chipped stone tool diversity is also consistent with the proposition that the investigated sites represent the remains of short-term field camps or extractive locations, and, controlling for assemblage size, variability in tool diversity suggests that a greater range of activities may have occurred at 26EU1533 and 26EU1539 than at the other sites. In sum, it appears that the individual sites investigated during the project were either short-term camps used by highly mobile foragers or extractive locations that played a role in a larger logistically organized settlement system.

Finally, an analysis was conducted, following Fawcett (1993), to evaluate whether contemporary artifact collecting has produced biases in the surface artifact assemblages recovered from the sites involved in the project. A comparison of surface and subsurface assemblages indicates that surface assemblages tend to have higher proportions of projectile points relative to debitage than do subsurface assemblages. This is the opposite of what would be expected if large numbers of points had been removed from the surfaces of these sites due to artifact collecting. Not only does this suggest that artifact collecting has not been an extensive problem at the Goldstrike mine, it also suggests that analyses presented in this chapter, such as the analysis of tool diversity, are not subject to effects that might result from artifact collecting.

8. SYNTHESIS

Michael D. Cannon

The 2007 BGMI Data Recovery Project applied innovative methods in an attempt to avoid the problems that multicomponent deposits pose for understanding change over time in the archaeological record. The project employed a phased approach to excavation, in which single-component deposits with abundant and informative archaeological materials were sought prior to beginning more extensive block excavation. This excavation approach, in turn, relied both on data from geophysical remote sensing surveys and on chronological information obtained from surface collection and initial exploratory excavations.

Remote sensing techniques were used in an effort to locate subsurface archaeological features such as hearths and activity areas or occupational surfaces, and the project was intended to serve as a test case for evaluating whether the techniques used were effective at identifying these types of features at sites in the LBBA. It turned out that the project was unable to provide a useful test case because the features that were targeted proved to be rare or absent at the sites investigated. Thus, a full evaluation of the utility of remote sensing methods for archaeological research and cultural resource management in the LBBA will require another test case at a site or sites where the archaeological features of interest are actually present. However, the 2007 BGMI project does provide some insight into steps that might be taken to ensure more efficient and effective use of remote sensing in the future. These issues were discussed in Chapter 4 of this report and are summarized in Section 8.1 below.

Despite the fact that the sites investigated did not provide the type of geophysical test case that was hoped for, the general strategy of taking a phased approach to excavation did prove successful and resulted in a data recovery process that was very efficient overall. Based on the results of surface collection and initial exploratory excavations (considered in conjunction with the results of the 2006 probing project), it was determined relatively quickly that single-component subsurface deposits containing materials useful for addressing important research questions were unlikely to be present at four of the five sites involved in the project[20]. Accordingly, the bulk of excavation effort was expended at the fifth site, 26EU2126, which proved to have the only archaeological features discovered during the project and which produced a large samples of lithic debitage and faunal remains from subsurface context.

Based on the chronological information that was recovered during the project, it was not possible to assign most sites or site loci to a single one of the temporal phases that have been defined for the LBBA. However, it is possible to explore change over time at a coarser scale by assigning materials recovered during the project to time periods broader than individual phases. Given the obvious abundance of multicomponent deposits in the LBBA, which has been demonstrated both in this project and in much previous work in the area, and given that a consideration of site

[20] This, of course, does not imply that the overall assemblages from these sites, which consist primarily of material from surface contexts, are not useful for all research purposes.

formation processes suggests that multicomponent deposits should be expected to be the rule in the LBBA rather than the exception, it may be useful to adopt this sort of approach more often in the future. Rather than making demands of the archaeological record that frequently cannot be met in the LBBA, future research should perhaps be designed with the degree of chronological resolution that can be achieved in mind. In addition, to the extent that single-component deposits are present in the area, predictive modeling based on characteristics of known sites may help to more successful identification of such deposits in the future.

A second research emphasis for the project, after addressing the multicomponent site issue, involved documenting and understanding site structure. The research design called for this to be done based on distributions of contemporaneous archaeological features and associated artifacts across individual sites. However, since archaeological features turned out to be absent or rare at the sites involved in the project, and since the surface artifact concentrations at these sites lack chronological information necessary for identification as single-component, it proved not to be possible to implement this part of the research design.

On the other hand, while it was not possible to conduct the thorough analysis of site structure that was hoped for, it was possible to use data from this project to address some of the research domains from the 1991 historic context that are somewhat related to site structure. In particular, it was possible to implement methods for identifying activity locus function specified in the 1991 historic context (Section 7.4.1). In addition, data collected during the project turned out to be unexpectedly applicable to research topics that were not selected as major research emphases going into the project. Some subsistence data were recovered, as was considerable information pertaining to mobility, the organization of lithic technology, and use of the Tosawihi Quarries. In fact, the lithic data recovered likely comprise the most significant information to result from the project, and Chapter 7 of this report presents a synthetic, multi-site analysis of a sort not previously attempted for the LBBA, directed at addressing several of the research domains outlined in the 1991 LBBA historic context. The results of analyses of subsistence and technological data from the project are synthesized below in Section 8.2.

8.1. Remote Sensing in Research and Compliance in the LBBA

The geophysical remote sensing techniques of magnetometry and electromagnetic (EM) survey were used during the 2007 BGMI project in an attempt to locate subsurface archaeological features. The target of magnetometry was small thermal features, while the target of EM survey, which involved measurement of both sediment conductivity and magnetic susceptibility, was larger occupational surfaces. It was hoped that remote sensing would enable such features to be located efficiently so that less time could be spent finding features and more time could be spent evaluating whether deposits containing features were single-component. It turned out, however, that the types of archaeological features that were targeted were rare or absent at the sites involved in the project, and that virtually all of the remote sensing anomalies that were investigated were "false positives" that did not reflect archaeological features.

Most of the effort spent during the exploratory stage of excavation was devoted to investigating the locations of remote sensing anomalies. A total of 29 anomalies that were thought to be consistent with the signatures of archaeological features were specifically targeted in excavation, and virtually all of these were investigated during the exploratory stage. An additional 22 anomalies were excavated over the course of the project in units that were not intended specifically to be tests of geophysical anomalies. Of these 51 anomaly locations, an archaeological feature was found in only one (Operation C at 26EU2126), and, as discussed in Chapter 4, the association between the archaeological feature and the geophysical anomaly in this case may be coincidental. Moreover, it is not possible to derive generalizations about associations between archaeological features and geophysical anomaly types based on the three archaeological features that were discovered in excavation and mechanical stripping, all of which were found at 26EU2126. One FCR concentration (Feature 1, in Operation C) comes from an area in which magnetometer data were not useful due to the presence of a metal pipeline nearby. A second FCR concentration (Feature 3, found in blading) is associated with a small area of high magnetism, but a sample size of one is insufficient for determining whether features with FCR are regularly associated with small magnetic highs in magnetometer data from the LBBA. The third feature (Feature 2, in Operation F) lacks an obvious magnetic signal; as noted in Section 4.4.1, this may be due to insufficient initial heating of this feature, post-depositional alteration, and/or insufficient magnetic contrast with surrounding sediments. In addition, these three features exhibit no consistent signature in the conductivity data. On the whole, then, it appears that the patterning evident in the remote sensing data collected during the project is primarily a function of geological, rather than archaeological, phenomena.

Given the extent to which false positives were a problem for the project, it seems clear that steps must be taken to understand—and control for—the geological causes of patterning in geophysical data from the LBBA before such data can be of greater use in archaeological research and cultural resource management in the area. Detailed geological analyses of the sort that are required to fully address this issue were beyond the scope of the 2007 BGMI project; however, some preliminary steps along these lines were taken.

Limited auger probing was conducted at 26EU1533 and 26EU1539 in order to determine whether variability in sedimentological properties at these sites might help to explain the patterns observed in the remote sensing data. The results of this exercise were mixed and unfortunately provide little practical guidance for future archaeological remote sensing work in the LBBA. Observations made at 26EU1533 suggest that variability in both magnetometer and conductivity data might be reflecting the depth to the bottom of the calcic zone that is ubiquitous throughout the area, but these observations were not reproduced at 26EU1539. These results may indicate that geophysical data from sites located in different types of geomorphic settings are primarily reflecting different geological variables.

In addition, charcoal lenses exposed in mechanical stripping, which are likely the remains of vegetation burned by wildfire, were mapped at 26EU1548 and across a portion of 26EU1539 so that their distributions could be plotted on remote sensing data images (a single charcoal lens was also mapped at 26EU2064). It does not appear that these non-archaeological features are reflected in either magnetometry or conductivity data. This result is good news in that it suggests that these geophysical techniques can be used at sites that have been affected by wildfire without experiencing false positives due to the wildfire itself. However, this result also means that causes of the patterns observed in the remote sensing data must be sought elsewhere.

In sum, the limited work along these lines that could be conducted during the 2007 BGMI project did not lead to a clear understanding of the causes of variability in geophysical data from the LBBA. However, given the substantial benefits that might result (e.g., Kvamme 2003a), further efforts to develop a successful geophysical protocol for the LBBA and other parts of the Great Basin would likely be very worthwhile. Such efforts should involve at least two components.

First, a robust test case involving a site or sites where archaeological features are known to be present (or at least where there is a strong likelihood that features are present) should be conducted to evaluate what geophysical signature, if any, archaeological features of various types have in the LBBA. Experimental replication of archaeological features and burial in sediments of the sort found in the LBBA might also suffice for this purpose. Research along these lines should also involve further experimentation with survey parameters such as instrument height and orientation. Archaeological features are likely to occur at very shallow depths in the LBBA, and much of the geophysical noise detected during this project may be the result of deeper geological phenomena. Because the depth of detection is related to the height of the instrument above the ground, both for magnetometry (e.g., Witten 2006:106–107) and for EM survey (McNeill 1980a:6–7), holding instruments higher above the ground should increase the contribution of shallow features to the overall geophysical signal that is detected (though it might also increase the contribution of above-ground phenomena to the signal). In addition, conducting EM surveys with the instrument dipoles oriented horizontally, rather than vertically as was the case in this project, would also increase the contribution of shallow features to the overall signal (McNeill 1980a:6–7)[21]. Experimentation with various instrument heights and orientations in a context where real or simulated archaeological features are known to be present might lead to the development of guidelines for optimal geophysical data acquisition.

Second, further geoarchaeological research should be conducted in conjunction with geophysical surveys to determine what geological factors are responsible for the most obvious patterns observed in the remote sensing data; that is, the causes of the false positives that were pursued during the 2007 BGMI project must be identified so that they might be controlled in future work. More extensive and more detailed auger probing surveys of the sort conducted during this project are one possible way in which this might be done.

Finally, it should be noted that the amount of work that would be necessary to carry out additional geophysical test cases and conduct further geoarchaeological research is probably beyond what can reasonably be accomplished in a cultural resource compliance project; rather, development of a successful remote sensing protocol for the LBBA will likely require some "pure research" effort.

Assuming that the geophysical signatures of archaeological features in the LBBA can be determined and that the causes of non-archaeological noise can be understood and controlled, the use of remote sensing methods should greatly improve the efficiency and productivity of data recovery projects in the area, as was hoped would be the case for the 2007 BGMI project. In the

[21] It should also be pointed out that resolution of shallow features requires relatively close horizontal spacing of sample and traverse intervals, on the order of those employed in the 2007 BGMI project (see Witten 2006:106–107, 181–185).

spirit of improving efficiency, an analysis of data from this project does provide some specific suggestions about how future geophysical surveys can be structured to be even more cost-effective. As the de-sampling exercise presented in Section 4.5 shows, doubling the traverse interval relative to the interval that was used in this project would reduce survey time by approximately half, but data resolution would still be sufficient for identifying areas of archaeological interest. Such areas of interest could then be surveyed at a higher resolution to provide the degree of detail necessary for planning excavations. This type of multi-scalar approach to remote sensing, starting with a lower-resolution landscape survey and following up with higher-resolution surveys of smaller areas, would likely reduce the overall amount of time required for geophysical survey, while producing data that are archaeologically just as useful.

Perhaps the most important conclusion that can be drawn from this project about the use of remote sensing methods is that these methods are still in their infancy in the LBBA. It was premature to reject archaeo-geophysics as not useful following its initial application in the LBBA (Schroedl 1996:521), and it is probably still premature to do so. Archaeological sites in the LBBA are clearly very geophysically complex, and the factors that contribute to this complexity will need to be sorted out before remote sensing can reach its full potential in the area. This makes applications of remote sensing somewhat more difficult than is the case in regions where the geophysical background is considerably less noisy (e.g., Jones and Munson 2005). However, there is at present no reason to think that the contributing factors cannot be sorted out with sufficient research effort. Such effort, which will likely require the involvement of geophysical and geoarchaeological research specialists working both within the CRM and academic realms, may yet led to the development of an approach to archaeo-geophysics that produces substantial returns in the LBBA and other parts of the Great Basin. The application of remote sensing and the initial evaluative steps taken during the 2007 BGMI project provide just one contribution of many that will be required to reach this goal.

8.2. Insights into Prehistoric Adaptations in the LBBA

Substantive insights about prehistoric human adaptations in the LBBA are discussed in Chapter 6 of this report, which analyzes archaeological materials directly relevant to issues of subsistence, and Chapter 7, which analyzes the large chipped stone artifact assemblage recovered during the 2007 BGMI project. The conclusions of these analyses are summarized and synthesized here. While most of the topics discussed here were not selected as major research emphases for the project (as noted above, the sites investigated proved not to be amenable to the main substantive research emphasis for the project, documenting and understanding site structure), data collected during the project do allow them to be addressed, and in doing so provide important new information about aspects of the prehistoric occupation of the LBBA.

Faunal remains were recovered from 26EU2126, and those for which there is evidence of human use come from Operation F at this site. A small hearth feature (Feature 2) was found in this excavation block, and the majority of the faunal specimens from it are burned and highly fragmented; three specimens also exhibit cut marks. These remains are radiocarbon-dated to the period between A.D. 1230 and 1300, and a similarly late age is indicated by the temporally diagnostic projectile points and obsidian hydration measurements obtained from Operation F. The large majority of the faunal specimens from Operation F are from artiodactyls, which is consistent with a pattern of high artiodactyl relative abundance that occurs in late Holocene archaeofaunal assemblages from throughout the eastern Great Basin (e.g., Byers and Broughton 2004). At least one specimen is from an elk, representing the first archaeofaunal record of this taxon in the LBBA. The association that occurs in Operation F between large mammal remains and a small hearth that lacks FCR is not consistent with the pattern previously noted in the LBBA, in which large mammal remains are typically associated with larger, rock-lined or rock-filled thermal features (Bright 1998). On the other hand, given that the materials from Operation F appear to be the remains of an isolated large mammal processing event, they are consistent with a pattern on logistical resource acquisition that has been described for the late Holocene in the Great Basin (e.g., McGuire and Hildebrandt 2005; Zeanah 2004).

Flotation samples were recovered from four sites: 26EU1539, 26EU1548, 26EU2064, and 26EU2126. Only two of the thirteen samples analyzed come from features that are likely archaeological, while most of the remainder come from charcoal lenses that appear to be the remains of wildfire-burned vegetation; the methods used here to confirm that these features are likely not archaeological may provide an example to be followed in future work in the area. The two archaeological features from which flotation samples were obtained are Features 2 and 3 at 26EU2126. Based on its morphology and context in a deposit rich in artifacts and faunal remains, described above, Feature 2 appears to be a small hearth; however, no plant remains that are clearly the result of subsistence activities were recovered from the fill of this feature. Given the abundance of burned faunal remains that were recovered in its vicinity, it is likely that this feature was associated with animal processing activities rather than plant processing activities. Unambiguously subsistence-related plant remains were also absent in the small amount of ashy fill recovered from Feature 3, but this is not surprising given that this feature was a concentration of FCR that may have been the result of hearth cleaning, rather than an actual hearth itself.

Seven ground stone artifacts were recovered from sites 26EU1533, 26EU1539, and 26EU2126. Applying a hypothesis put forth by Birnie (1996a) to the ground stone data recovered during the 2007 BGMI project, and given that six of the seven recovered ground stone tools can be classified as expedient, it appears that the sites that were investigated were occupied only periodically by highly mobile individuals and that those individuals did not rely on plant foods as much as on animal foods. This is consistent with the high relative abundance of large mammal remains observed in the faunal assemblage from Operation F at 26EU2126, which suggests that, during much of the late Holocene, foraging efficiency was high and it was not necessary for foragers to adopt broad diets that frequently included low return plant resources that required intensive processing (Byers and Broughton 2004).

It has been observed that foraging efficiency apparently declined in the LBBA, and that diet breadth accordingly increased, after about A.D. 1300 (e.g., Bright et al. 2002; Ugan and Bright 2001). Because the faunal remains from Operation F at 26EU2126 date to just before this time, the faunal data from the 2007 BGMI project are not inconsistent with this post-A.D. 1300 decline in foraging efficiency and expansion of diet breadth that has previously been observed for the LBBA. Thus, taken together, subsistence data from the project appear to conform with a pattern documented previously for the region, in which foraging efficiency was high, and diet breadth narrow, during much of the late Holocene, with a decline in foraging efficiency and corresponding expansion of diet breadth evident during the Late Prehistoric Eagle Rock Phase.

The chipped stone tool and debitage assemblages collected during the project provide insight into a wide range of research topics, including raw material selection, mobility, site function, technological organization, and strategies for using material from the Tosawihi Quarries. Before addressing these issues, however, it should be noted that an analysis conducted to evaluate the effects of contemporary artifact collecting (after Fawcett 1993) suggests that the composition of surface assemblages at the sites involved in the project has not been biased by such collecting. A comparison of surface and subsurface assemblages indicates that surface assemblages tend to have higher proportions of tools relative to debitage than do subsurface assemblages, the opposite of what would be expected if large numbers of tools had been removed from the surfaces of these sites due to artifact collecting. Not only does this suggest that artifact collecting has not been an extensive problem at the Goldstrike mine, it also suggests that lithic analyses presented in this report are not subject to effects that might result from artifact collecting.

It has long been known that Tosawihi chert dominates lithic assemblages in the LBBA, and this material type accordingly comprises the vast majority of the toolstone recovered during the 2007 BGMI project. The Tosawihi Quarries are located relatively close to the LBBA, and it appears likely that the prehistoric groups who occupied the area did so as part of a settlement system that involved procurement of material from the quarries during seasonal rounds and/or logistical (sensu Binford 1980) resource acquisition trips to the quarries.

A very small amount of obsidian accounts for the remainder of the lithic material recovered during the project, and analysis of this material leads to insights beyond what has long been known. The proportion of obsidian relative to Tosawihi chert varies slightly but significantly among the debitage assemblages from the five sites, with obsidian significantly underrepresented at 26EU1539 and significantly overrepresented at 26EU1548. There is some evidence for a slight reduction in the use of obsidian relative to Tosawihi chert between the Middle Archaic and the Late Archaic/Late Prehistoric periods. More significantly, obsidian sourcing indicates that four sources were used, at distances from the LBBA ranging from 110 to 400 km. The range of sources represented indicates a high degree of mobility and/or the presence of extensive trade networks. In addition, though the size of the obsidian sample is too small to allow analysis of diachronic change in obsidian source use, an interesting pattern is apparent among samples from all phases combined.

Obsidian from Paradise Valley, the nearest source, is the most common in the assemblage and consists solely of debitage, and a single piece of debitage from the Double H Mountains source was also recovered. On the other hand, material from two more distant sources, Browns Bench and Wild Horse Canyon, occurs only in the form of bifaces (one specimen from each source). This pattern of differential source representation between tools and debitage is consistent both with theoretical expectations and with patterns documented empirically in other Great Basin contexts. It suggest that tools made from obsidian from more distant sources were curated and brought into the LBBA, while material from closer sources was more likely to be used in earlier-stage tool reduction that actually occurred in the LBBA. An analogous pattern of differential source representation between tools and debitage occurs in the proportion of obsidian from all sources relative to chert from the nearby Tosawihi Quarries: obsidian comprises a slightly but significantly higher proportion of the tool assemblage than the debitage assemblage, again suggesting that material from more distant sources was more likely to be brought into the LBBA in the form of curated tools, while material from closer sources was more likely to be used in knapping carried out at LBBA sites.

Material from the Tosawihi Quarries was further examined in an effort to ascertain how it was processed and transported. Bifacial reduction appears to have been the dominant strategy used to produce tools from Tosawihi chert, but evidence of expedient tools and core reduction was also observed. Lithic assemblages recovered from the 2007 BGMI project support Elston's (1992) claim that material was processed at the quarries, as well as Kelly's (1988) arguments regarding the transport of lithic material in the form of bifacial cores. However, assemblages were more varied than either model would predict. While bifacial reduction debris dominates the overall debitage assemblages from the investigated sites, core reduction debris is fairly abundant in assemblages from certain artifact concentrations at 26EU1539 and 26EU2064 (concentrations that, unfortunately, cannot be tightly dated). Lithic data from the project suggest that processing of Tosawihi chert was sometimes deferred, and that cores and flake blanks were also used to transport material, perhaps because conditions at Tosawihi constrained the amount of time that could be spent there. It appears that sites in the LBBA were used to further process material obtained at the Tosawihi Quarries, either on a contingency basis or to prepare for travel to more remote locations.

The reliance on bifacial technology in the LBBA suggests that its occupants were highly mobile and required an efficient means of transporting toolstone. Although core reduction and expedient tools were also present, they do not necessarily controvert the hypothesis that mobile groups were using the area. It is possible that cores had functional properties making them suitable for inclusion in mobile toolkits, or that they were small enough that they did not have a high cost of transport (e.g., Kuhn 1994).

Finally, the chipped stone data were also considered, along with other lines of evidence, to address the issue of site function. Lithic data from the sites investigated suggests that these sites were used for hunting game, as well as for lithic tool production. In addition, the presence of ground stone at three of the sites, as well as faunal remains, a hearth and two FCR features at 26EU2126, suggests that food resources were processed at these sites. These lines of evidence indicate that the sites involved in the project were extractive locations or very short-term field camps where both foraging and lithic production activities took place. Patterns of chipped stone tool diversity are consistent with the proposition that the investigated sites represent the remains of short-term field camps, and they also suggests that a greater range of activities may have occurred at 26EU1533 and 26EU1539 than at the other sites. In sum, it appears that the LBBA was used by mobile groups, perhaps acquiring resources logistically from residential bases not investigated during this project.

Taken together, the faunal, ground stone, and chipped stone data from the project suggest that the prehistoric occupants of the sites investigated were highly mobile, and that the sites themselves were used as extractive locations or very short-term hunting and resource processing camps. The subsistence-related data are consistent with high foraging efficiency and narrow diet breadth. This, in turn, is consistent with patterns documented previously for the LBBA prior to A.D. 1300, when a reduction in foraging efficiency and an expansion of diet breadth apparently occurred. Lithic data from the project, in addition to suggesting a high degree of mobility, provide evidence for greater variability in the strategies used to acquire and transport material from the Tosawihi Quarries than has traditionally been thought to have existed. While the factors that might have structured this variability in the use of Tosawihi chert are not understood at this point, the analyses presented here point towards important research questions to be addressed in the future.

REFERENCES CITED

Adams, Jenny L.

2002 *Ground Stone Analysis: A Technical Approach*. University of Utah Press, Salt Lake City, Utah.

Aikens, C. Melvin and Y. T. Witherspoon

1986 Great Basin Numic Prehistory: Linguistics, Archaeology, and Environment. In *Anthropology of the Desert West: Essays in Honor of Jesse D. Jennings*, edited by C. J. Condie and D. D. Fowler, pp. 7–20. University of Utah Anthropological Papers No. 110, Salt Lake City.

Andrefsky, William

2005 *Lithics: Macroscopic Approaches to Analysis.* 2nd ed. Cambridge University Press, Cambridge.

Antevs, Ernst

1955 Geologic–Climatic Dating in the West. *American Antiquity* 20:317–335.

Armentrout, L. and R. C. Hanes

1986 Archaeological Survey of the Susie Creek Area, Elko County, Nevada. *Nevada Archaeologist* 6:9–22.

Ataman, Kathryn and Michael P. Drews

1992 Projectile Points and Preforms. In Archaeological Investigations at Tosawihi, A Great Basin Quarry, Part 1: The Periphery, edited by Robert G. Elston and Christopher Raven, pp. 179–216. Reprinted in *Tosawihi Quarries: Archaeological Investigations and Ethnographic Studies in Nevada* (2006), compiled by Robert G. Elston. Bureau of Land Management Nevada Cultural Resources Series No. 16. Reno, NV.

Ataman, Kathryn, Margaret Bullock, Daniel P. Dugas and Robert G. Elston

1995 Archaeological Investigations at Tosawihi, A Great Basin Quarry, Part 7: 26Ek5040. Reprinted in *Tosawihi Quarries: Archaeological Investigations and Ethnographic Studies in Nevada* (2006), compiled by Robert G. Elston. Bureau of Land Management Nevada Cultural Resources Series No. 16. Reno, NV.

Bailey, R. C.

1978 *Descriptions of the Ecoregions of the United States*. U.S. Department of Agriculture Forest Service, Ogden, Utah.

Bartington, G. and C. E. Chapman

2004 High-stability Fluxgate Magnetic Gradiometer for Shallow Geophysical Survey Applications. *Archaeological Prospection* 11:19–34.

Beck, Charlotte and George T. Jones

1997 The Terminal Pleistocene/Early Holocene Archaeology of the Great Basin. *Journal of World Prehistory* 11:161–236.

2007 Early Paleoarchaic Point Morphology and Chronology. In *Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene/Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 23–41. The University of Utah Press, Salt Lake City.

Beck, Charlotte, Amanda K. Taylor, George T. Jones, Cynthia M. Fadem, Caitlyn R. Cook and Sara A. Millward

2002 Rocks are Heavy: Transport Costs and Paleoarchaic Quarry Behavior in the Great Basin. *Journal of Anthropological Archaeology* 4:481–507.

Benson, Larry, Michaele Kashgarian, Robert Rye, Steve Lund, Fred Paillet, Joseph Smoot, Cynthia Kester, Scott Mensing, Dave Meko and Susan Lindström

2002 Holocene Multidecadal and Multicentenial Droughts Affecting Northern California and Nevada. *Quaternary Science Reviews* 21:659–682.

Bettinger, Robert L. and M. A. Baumhoff

1982 The Numic Spread: Great Basin Cultures in Competition. *American Antiquity* 46:485–503.

Bevan, B. M.

1983 Electromagnetics for Mapping Buried Earth Features. *Journal of Field Archaeology* 10:47–54.

Binford, Lewis R.

1978 *Nunamiut Ethnoarchaeology*. Academic Press, New York.

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35:255–273.

1980 Willow Smoke and Dogs Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45:4–20.

Birkeland, Peter W.

1999 *Soils and Geomorphology*. Oxford University Press, New York.

Birnie, Robert I.

1996a Groundstone Technology in the Little Boulder Basin. In Open Site Archeology in the Little Boulder Basin: 1993–1994 Data Recovery Excavations in the North Block Tailings Impoundment Area, North-central Nevada, edited by Alan R. Schroedl, pp. 707–728. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1614.

1996b Paleoenvironment and Alluvial Stratigraphy in the Little Boulder Basin. In Open Site Archeology in the Little Boulder Basin: 1993–1994 Data Recovery Excavations in the North Block Tailings Impoundment Area, North-central Nevada., edited by Alan R. Schroedl, pp. A1–A26. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1614.

Brewster, Melvin G.

2003 Numu Views of Numu Cultures and History: Cultural Stewardship Issues and a Punown View of Goshiute and Shoshone Archaeology in the Northeast Great Basin. Unpublished Ph.D. dissertation, Department of Anthropology, University of Oregon, Eugene.

Bright, Jason

1998 Little Boulder Basin Area Thermal Feature Analysis. In Open-Site Archaeology: 1996 Bootstrap Data Recovery Excavations, North-central Nevada, edited by Alan R. Schroedl, pp. 341–362. Prepared by P-III Associates, Inc., Salt Lake City, UT. Little Boulder Basin Series No. 12. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1897.

Bright, Jason, Andrew Ugan and Lori Hunsaker

2002 The Effect of Handling Time on Subsistence Technology. *World Archaeology* 34:164–181.

Broughton, Jack M., David A. Byers, Reid Bryson, William P. Eckerle and David B. Madsen

2008 Did Climatic Seasonality Control Late Quaternary Artiodactyl Densities in Western North America? *Quaternary Science Reviews*, in press.

Bureau of Land Management

1992a *Mammal List*. Bureau of Land Management, Elko District, Elko, Nevada.

1992b *Bird List*. Bureau of Land Management, Elko District, Elko, Nevada.

2007 Draft Supplemental Environmental Impact Statement, South Operations Area Project Amendment Newmont Mining Corporation. Bureau of Land Management, Elko District, Elko, Nevada.

2008 Draft Supplemental Environmental Impact Statement Betze Pit Expansion Project. Bureau of Land Management, Elko District, Elko, Nevada.

Burt, W. H. and R. P. Grossenheider

1980 *A Field Guide to the Mammals: North America North of Mexico.* 3rd ed. The Peterson Field Guide Series. Houghton Mifflin Company, New York.

Byers, David A. and Jack M. Broughton

2004 Holocene Environmental Change, Artiodactyl Abundances, and Human Hunting Strategies in the Great Basin. *American Antiquity* 69:235–257.

Cannon, Michael D. and Heather K. Stettler

2007 Data Recovery Plan for Five Prehistoric Archaeological Sites in the Little Boulder Basin, Eureka County, Nevada. Prepared by SWCA Environmental Consultants, Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-2595.

Casjens, Laurel Ann

1975 The Prehistoric Human Ecology of Southern Ruby Valley, Nevada. Dissertation, Department of Anthropology, Harvard University.

Clay, B. R.

2006 Conductivity Survey: A Survival Manual. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by J. K. Johnson, pp. 79–108. University of Alabama Press, Tuscaloosa.

Coats, Robert R.

1987 *Geology of Elko County, Nevada*. Nevada Bureau of Mines and Geology Bulletin 101. University of Nevada, Reno.

Conyers, L. B.

2004 *Ground-Penetrating Radar for Archaeology,* Volume 1. Altamira Press, Walnut Creek.

Corbeil, Marcel R.

1996 Faunal Utilization in the Little Boulder Basin. In Open Site Archeology in the Little Boulder Basin: 1993–1994 Data Recovery Excavations in the North Block Tailings Impoundment Area, North-central Nevada, edited by Alan R. Schroedl, pp. 755–786. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1614.

Core, H. A., W. A. Cote and A. C. Day

1976 *Wood: Structure and Identification*. Syracuse University Press, Syracuse, New York.

Coulam, Nancy J.

1996 Plant Utilization in the Little Boulder Basin. In Open Site Archeology in the Little Boulder Basin: 1993–1994 Data Recovery Excavations in the North Block Tailings Impoundment Area, North-central Nevada, edited by Alan R. Schroedl, pp. 729–754. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1614.

Creel, D. G., D. Hudler, S. M. Wilson, T. C. Schultz and C. P. Walker

2005 A Magnetometer Survey of Caddoan Mounds State Historic Site. Technical Report 51. Texas Archaeological Research Laboratory, The University of Texas, Austin.

Currey, Donald R. and Steven R. James

1982 Paleoenvironments of the Northeastern Great Basin and Northeastern Basin Rim Region: A Review of Geological and Biological Evidence. In *Man and Environment in the Great Basin*, edited by David B. Madsen and James F. O'Connell, pp. 27–52. Society for American Archaeology Papers No. 2, Washington, DC.

Dalan, R. A.

2006 Magnetic Susceptibility. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by J. K. Johnson, pp. 161–204. University of Alabama Press, Tuscaloosa.

David, A.

1995 *Geophysical Survey in Archaeological Field Evaluation*. Ancient Monuments Laboratory, English Heritage Society, London.

Dillman, A. C.

1946 The Beginnings of Crested Wheatgrass in North America. *Journal of the American Society of Agronomy* 38:237–250.

Duke, Daron G. and D. Craig Young

2007 Episodic Permanence in Paleoarchaic Basin Selection and Settlement. In *Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene/Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 123–138. The University of Utah Press, Salt Lake City.

Eerkens, Jelmer W., Jeffrey R. Ferguson, Michael D. Glascock, Craig E. Skinner and Sharon A. Waechter

2007 Reduction Strategies and Geochemical Characterization of Lithic Assemblages: A Comparison of Three Case Studies from Western North American. *American Antiquity* 72:585–597.

Elston, Robert G.

1990 A Cost-Benefit Model of Lithic Assemblage Variability. In *The Archaeology of James Creek Shelter*, edited by R. G. Elston and E. E. Budy, pp. 153–164. University of Utah Anthropological Papers No. 115. University of Utah, Salt Lake City.

1992 Economics and Strategies of Lithic Production at Tosawihi. In Archaeological Investigations at Tosawihi, A Great Basin Quarry, Part 1: The Periphery, edited by Robert G. Elston and Christopher Raven, pp. 775-802. Reprinted in *Tosawihi Quarries: Archaeological Investigations and Ethnographic Studies in Nevada* (2006), compiled by Robert G. Elston. Bureau of Land Management Nevada Cultural Resources Series No. 16. Reno, NV.

2006 Preface: A Guide to the Tosawihi Quarries Reports. In *Tosawihi Quarries: Archaeological Investigations and Ethnographic Studies in Nevada*, compiled by Robert G. Elston. Bureau of Land Management Nevada Cultural Resources Series No. 16. Reno, NV.

Elston, Robert G. and Elizabeth E. Budy (editors)

1990 *The Archaeology of James Creek Shelter*. University of Utah Anthropological Papers No. 115. University of Utah Press, Salt Lake City.

Elston, Robert G. and Michael P. Drews

1992 Cultural Chronology. In Archaeological Investigations at Tosawihi, A Great Basin Quarry, Part 1: The Periphery, edited by Robert G. Elston and Christopher Raven, pp. 775–802. Reprinted in *Tosawihi Quarries: Archaeological Investigations and Ethnographic Studies in Nevada* (2006), compiled by Robert G. Elston. Bureau of Land Management Nevada Cultural Resources Series No. 16. Reno, NV.

Elston, Robert G. and Christopher Raven (editors)

1992 Archaeological Investigations at Tosawihi, A Great Basin Quarry, Part 1: The Periphery. Reprinted in *Tosawihi Quarries: Archaeological Investigations and Ethnographic Studies in Nevada* (2006), compiled by Robert G. Elston. Bureau of Land Management Nevada Cultural Resources Series No. 16. Reno, NV.

Everitt, Brian S.

1992 *The Analysis of Contingency Tables*. Chapman and Hall, New York.

Fawcett, William B.

1993 Why Should it Matter if I Take Another Potsherd? The Impacts of Contemporary Artifact Collecting at Anasazi Villages. *Utah Archaeology* 6:37–47.

Friedman, I. and R. L. Smith

1960 A New Dating Method Using Obsidian: Part I. The Development of the Technique. *American Antiquity* 25:476–522.

Gaffney, C. and J. Gater

2003 *Revealing the Buried Past: Geophysics for Archaeologists*. Tempus Publishing Ltd., Stroud, Gloucestershire, England.

Gaffney, C., J. Gater, P. Linford, V. Gaffney and R. White

2000 Large-Scale Systematic Fluxgate Gradiometry at the Roman City of Wroxeter. *Archaeological Prospection* 7:81–99.

Gilbert, M. Thomas P., Dennis L. Jenkins, Anders Götherstrom, Nuria Naveran, Juan J. Sanchez, Michael Hofreiter, Philip Francis Thomsen, Jonas Binladen, Thomas F. G. Higham, Robert M. Yohe II, Robert Parr, Linda Scott Cummings and Eske Willerslev

2008 DNA from Pre-Clovis Human Coprolites in Oregon, North America. *Science* 320:786–789.

Graf, Kelly E. and Dave N. Schmitt (editors)

2007 *Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene/Holocene Transition*. The University of Utah Press, Salt Lake City.

Grayson, Donald K.

1993 *The Desert's Past: A Natural Prehistory of the Great Basin*. Smithsonian Institution Press, Washington, D.C.

2000 Mammalian Responses to Middle Holocene Climatic Change in the Great Basin of the Western United States. *Journal of Biogeography* 27:181–192.

2006 Holocene Bison in the Great Basin, Western USA. *The Holocene* 16:913–925.

Hall, E. Raymond

1946 *Mammals of Nevada*. University of California Press, Berkeley.

Harris, Jack S.

1940 The White Knife Shoshoni of Nevada. In *Acculturation in Seven American Indian Tribes*, edited by Ralph Linton, pp. 39–118. Appleton-Century, New York.

Heizer, R. F., M. A. Baumhoff and C. W. Clewlow, Jr.

1968 Archaeology of South Fork shelter (NV-El-11), Elko County, Nevada. *University of California Archaeological Survey Reports* 71:1–58.

Hicks, Pat

1988a IMACS Site Form: 26EU1548/CrNV 12-7446. Prepared by Desert Research Institute, University of Nevada, Reno. Copies available from Bureau of Land Management, Elko Field Office, Elko, NV. BLM 1-1244.

1988b IMACS Site Form: 26EU1539/CrNV 12-7426. Prepared by Desert Research Institute, University of Nevada, Reno. Copies available from Bureau of Land Managment, Elko Field Office, Elko, NV. BLM 1-1244.

1988c IMACS Site Form: 26EU1533/CrNV 12-7420. Prepared by Desert Research Institute, University of Nevada, Reno. Copies available from Bureau of Land Management, Elko Field Office, Elko, NV. BLM 1-1244.

1989 A Class III Cultural Resource Inventory of 3698 Acres in Elko and Eureka Counties, Nevada. Prepared by Desert Research Institute, University of Nevada, Reno. Cultural Resource Short Report 88-6. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1244.

Hockett, Bryan

1995 Chronology of Elko Series and Split Stemmed Points from Northeastern Nevada. *Journal of California and Great Basin Anthropology* 17(1):41–53.

2005 Middle and Late Holocene Hunting in the Great Basin: A Critical Review of the Debate and Future Prospects. *American Antiquity* 70:713–731.

2006 The Current Status of the Tosawihi Quarries: Significance beyond Lithic Procurement. In *Tosawihi Quarries: Archaeological Investigations and Ethnographic Studies in Nevada*, compiled by Robert G. Elston. Bureau of Land Management Nevada Cultural Resources Series No. 16. Reno, NV.

2007 Nutritional Ecology of Late Pleistocene to Middle Holocene Subsistence in the Great Basin: Zooarchaeological Evidence from Bonneville Estates Rockshelter. In *Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene/Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 204–230. The University of Utah Press, Salt Lake City.

Hockett, Bryan and Maury Morgenstein

2003 Ceramic Production, Fremont Foragers, and the Late Archaic Prehistory of the North-central Great Basin. *Utah Archaeology* 16:1–36.

Holmer, Richard N.

1978 A Mathematical Typology for Archaic Projectile Points of the Eastern Great Basin. Unpublished Ph.D. dissertation, Department of Anthropology, University of Utah, Salt Lake City, UT.

Hughes, Richard E.

1988 The Coso Volcanic Field Reexamined: Implications for Obsidian Sourcing and Hydration Dating Research. *Geoarchaeology* 3:253–265.

1994 Intrasource Chemical Variability of Artifact-Quality Obsidians from the Casa Diablo Area, California. *Journal of Archaeological Science* 21:263–271.

2007 Energy Dispersive X-ray Fluorescence Analysis of Obsidian Artifacts from Two Archaeological Sites (26EU1548 and 26EU2126) Near Rodeo Creek in Northern Eureka County, Nevada. Geochemical Research Laboratory Letter Report 2007-36. Submitted to SWCA, Inc.

Jones, Geoffrey and Gene Munson

2005 Geophysical Survey as an Approach to the Ephemeral Campsite Problem: Case Studies from the Northern Plains. *Plains Anthropologist* 50:31–43.

Jones, George T., Charlotte Beck, Eric E. Jones and Richard E. Hughes

2003 Lithic Source Use and Paleoarchaic Foraging Territories in the Great Basin. *American Antiquity* 68:5–38.

Justice, Noel D.

2002 *Stone Age Spear and Arrow Points from California and the Great Basin*. Indiana University Press, Bloomington, Indiana.

Kays, Roland W. and Don E. Wilson

2002 *Mammals of North America*. Princeton University Press, Princeton, NJ.

Kelly, Robert L.

1988 The Three Sides of a Biface. *American Antiquity* 53:717–734.

1995 *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways*. Smithsonian Institution Press, Washington, DC.

Klemmedson, James O. and Justin G. Smith

1964 Cheatgrass (*Bromus tectorum*). *Botanical Review* 30:226–262.

Kuhn, Steven L.

1994 A Formal Approach to the Design and Assembly of Mobile Toolkits. *American Antiquity* 59:426–442.

Kvamme, Kenneth L.

2003a Geophysical Surveys as Landscape Archaeology. *American Antiquity* 68:435–457.

2003b Multidimensional Prospecting in North American Great Plains Village Sites. *Archaeological Prospection* 10:131–142.

2006a Data Processing and Presentation. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by J. K. Johnson, pp. 235–250. University of Alabama Press, Tuscaloosa.

2006b Integrating Multidimensional Geophysical Data. *Archaeological Prospection* 13:57–72.

2006c Magnetometry: Nature's Gift to Archaeology. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by J. K. Johnson, pp. 205–233. University of Alabama Press, Tuscaloosa.

Kvamme, Kenneth L. and Stanley A. Ahler

2007 Integrated Remote Sensing and Excavation at Double Ditch State Historic Site, North Dakota. *American Antiquity* 72:539–562.

Kvamme, Kenneth L., J. K. Johnson and B. S. Haley

2006 Multiple Methods Surveys: Case Studies. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by J. K. Johnson, pp. 251–267. University of Alabama Press, Tuscaloosa.

LaFond, Andre D.

1996 Chipped Stone Technology in Little Boulder Basin. In Open Site Archaeology in Little Boulder Basin: 1993–1994 Data Recovery Excavations in the North Block Tailings Impoundment Area, North-central Nevada, edited by Alan R. Schroedl, pp. 673–706. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1614.

LaFond, Andre D. and Joe B. Jones

1995 Data Recovery Excavations at the Yaha Site: An Open Prehistoric Camp Site Along Rodeo Creek, Northern Eureka County, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1638.

LaFond, Andre D., Betsy L. Tipps and M. Kate Stratford

1995 Data Recovery Excavations at Site 26EU1494. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-2020.

Lightfoot, K. G.

1978 The Impact of Casual Collecting on Archaeological Interpretation through Regional Surface Surveys. In *An Analytical Approach to Cultural Resource Management: The Little Colorado Planning Unit*, edited by F. Plog, pp. 83–90. Anthropological Research Paper No. 23. Arizona State University, Tempe, AZ.

Lightfoot, K. G. and J. E. Francis

1978 The Effects of Casual Surface Collection on Behavioral Interpretations of Archaeological Data. In *An Analytical Approach to Cultural Resource Management: The Little Colorado Planning Unit*, edited by F. Plog, pp. 83–90. Anthropological Research Paper No. 23. Arizona State University, Tempe, AZ.

Linford, N. T. and M. G. Canti

2001 Geophysical Evidence for Fires in Antiquity: Preliminary Results from an Experimental Study Paper Given at the EGS XXIV General Assembly in the Hague, April 1999. *Archaeological Prospection* 8:211–225.

Lockhart, J. J. and T. J. Green

2006 The Current and Potential Role of Archaeogeophysics in Cultural Resource Management in the United States. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by J. K. Johnson, pp. 18–32. University of Alabama Press, Tuscaloosa.

Lyneis, Margaret M.

1982 Prehistory in the Southern Great Basin. In *Man and Environment in the Great Basin*, edited by David B. Madsen and James F. O'Connell, pp. 172–185. SAA Papers No. 2. Society for American Archaeology, Washington, D.C.

Lyons, W. H., M. D. Glascock and P. J. Mehringer, Jr.

2003 Silica from Sources to Site: Ultraviolet Fluorescence and Trace Elements Identify Cherts from Lost Dune, Southeastern Oregon, USA. *Journal of Archaeological Science* 30:1139–1160.

Machette, Michael N.

1985 Calcic Soils of the Southwestern United States. In *Soils and Quaternary Geology of the Southwestern United States*, edited by David L. Weide, pp. 1–41. Special Paper 203. Geological Society of America, Boulder, Colorado.

Madsen, David B.

1975 Dating Paiute-Shoshoni Expansion in the Great Basin. *American Antiquity* 40:82–86.

1990 The Analysis of Cultural Pollen Samples, James Creek Shelter: A Guide to Human Behavior. In *The Archaeology of James Creek Shelter*, edited by Robert G. Elston and Elizabeth E. Budy, pp. 105–116. University of Utah Anthropological Papers No. 115. University of Utah Press, Salt Lake City.

2000 *Late Quaternary Paleoecology in the Bonneville Basin*. Utah Geological Survey, Salt Lake City.

Madsen, David B., Charles G. Oviatt and Dave N. Schmitt

2005 A Geomorphic, Environmental, and Cultural History of the Camels Back Cave Region. In *Camels Back Cave*, edited by Dave N. Schmitt and David B. Madsen, pp. 20-45. University of Utah Anthropological Papers No. 125. University of Utah Press, Salt Lake City.

Madsen, David B. and David Rhode (editors)

1994 *Across the West: Human Population Movement and the Expansion of the Numa*. University of Utah Press, Salt Lake City.

Madsen, David B., David Rhode, Donald. K. Grayson, Jack. M. Broughton, S. D. Livingston, J. Hunt, J. Quade, David N. Schmitt and Monson W. Shaver III

2001 Late Quaternary Environmental Change in the Bonneville Basin, Western USA. *Palaeogeography, Palaeoclimatology, Palaeoecology* 167:243–271.

Maurer, Douglas K., R. W. Plume, J. M. Thomas and A. K. Johnson

1996 *Water Resources and Effects of Changes in Ground-water Use Along the Carlin Trend, North-central Nevada*. U.S. Geological Survey Water-Resources Investigations Report 96-4134, Carson City, Nevada.

McFadden, Leslie D., Stephen G. Wells and Michael J. Jercinovich

1987 Influences of Eolian and Pedogenic Processes on the Origin and Evolution of Desert Pavements. *Geology* 15:504–508.

McGuire, Kelly R. and William R. Hildebrandt

2005 Re-thinking Great Basin Foragers: Prestige Hunting and Costly Signaling during the Middle Archaic Period. *American Antiquity* 70:695–712.

McGuire, Kelly R., Michael G. Delacorte and Kimberly Carpenter

2004 Archaeological Excavations at Pie Creek and Tule Valley Shelters, Elko County, Nevada. Nevada State Museum Anthropological Papers No. 25, Carson City, NV. BLM 1-2268.

McNeill, J. D.

1980a Electromagnetic Terrain Conductivity Measurement at Low Induction Numbers. Technical Note TN–6. Geonics Limited, Mississauga, Ontario.

1980b Electrical Conductivity of Soils and Rocks. Technical Note TN–5. Geonics Limited, Mississauga, Ontario.

Milsom, J.

2005 *Field Geophysics: The Geological Field Guide Series.* 3rd ed. Wiley, West Sussex.

Mosteller, F. and J. W. Tukey

1977 *Data Analysis and Regression*. Addison-Wesley, Reading, Massachusetts.

Newsome, Daniel K.

1992 IMACS Site Form: 26EU1533/CrNV 12-7420. In National Register Evaluations of 30 Historic Properties Recorded by Desert Research Institute in Unnamed Parcels A and B within the South Block of Barrick Goldstrike Mines, Inc.'s Betze Project, Little Boulder Basin, Eureka County, Nevada, edited by Betsy L. Tipps and Gary M. Popek. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1244.

Newsome, Daniel K., Gary M. Popek and Betsy L. Tipps

1993 Cultural Resource Inventory of Private and Public Lands Along and Near Bell, Boulder, and Rodeo Creeks in Northern Boulder Valley, Eureka County, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1800.

Newsome, Daniel K. and Betsy L. Tipps

1997 Cultural Resource Inventory of the GQX Parcels and Summary of the South Operations Area Project, Elko and Eureka Counties, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, Utah. Cultural Resources Report 5096-01-9714. Submitted to Bureau of Land Management, Elko District Office, Elko, Nevada on behalf of Newmont Gold Company, Carlin, Nevada.

O'Connell, James F.

1987 Alyawara Site Structure and Its Archaeological Implications. *American Antiquity* 52:74–108.

Panshin, A. J. and Carl de Zeeuw

1980 *Textbook of Wood Technology*. 4th ed. McGraw-Hill, New York.

Parry, William J. and Robert L. Kelly

1987 Expedient Core Technology and Sedentism. In *The Organization of Core Technology*, edited by Jay K. Johnson and Carol A. Morrow, pp. 285–304. Westview Press, Boulder, Colorado.

Pinson, Ariane

2007 Artiodactyl Use and Adaptive Discontinuity Across the Paleoarchaic/Archaic Transition in the Northern Great Basin. In *Paleoindian or Paleoarchaic? Great Basin Human Ecology at the Pleistocene/Holocene Transition*, edited by Kelly E. Graf and Dave N. Schmitt, pp. 187–203. The University of Utah Press, Salt Lake City.

Popek, Gary M.

1991a IMACS Site Form: 26EU2064/CrNV 12-10507. In An Assessment of National Register Eligibility of 29 Cultural Properties Recorded by Desert Research Institute and P-III Associates, Inc. in the Eastern Portion of the North Block of Barrick Goldstrike Betze Mine, edited by Daniel K. Newsome, Kathleen M. Heath, Alan R. Schroedl, Betsy L. Tipps and David W. Zeanah. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1527.

1991b IMACS Site Form: 26EU2126/CrNV 12-11124. In Class III Cultural Resource Inventory of Portions of Sections 13 and 24, T. 36 N., R. 49 E., Eureka County, Nevada, edited by Betsy L. Tipps and Gary M. Popek. Prepared by P-III Associates, Inc., Salt

Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1643.

Popek, Gary M. and Daniel K. Newsome

1993 IMACS Site Form: 26EU1539/CRNV 12-7426. In Evaluation of Seven Cultural Resource Properties Recorded by Desert Research Institute In or Near Barrick Goldstrike's Clydesdale Parcel, Boulder Valley, Eureka County, Nevada, edited by Alan R. Schroedl. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1922.

Prasciunas, Mary M.

2007 Bifacial Cores and Flake Production Efficiency: An Experimental Test of Technological Assumptions. *American Antiquity* 72:334–348.

Reimer, Paula J., Mike G. L. Ballie, Edouard Bard, Alex Bayliss, J. Warren Beck, Chanda, J. H. Bertrand, Paul G. Blackwell, Caitlin E. Buck, George S. Burr, Kirsten B. Cutler, Paul E. Damon, R. Lawrence Edwards, Richerd G. Fairbanks, Michael Friedrich, Thomas P. Guilderson, Alan G. Hogg, Konrad A. Hughen, Bernd Kromer, Gerry McCormac, Sturt Manning, Christopher Bronk Ramsey, Ron W. Reimer, Sabine Remmele, John R. Southon, Minze Stuiver, Sahra Talamo, F. W. Taylor, Johannes van der Plicht, and Constanze E. Weyhenmeyer

2004 IntCal04 Atmospheric Radiocarbon Age Calibration, 26–0 ka BP. *Radiocarbon* 46:1026–1058.

Reust, T. P., C. S. Smith and H. R. Wright

1994 The Archaeology of the Dry Susie Creek Site, Elko County, Nevada. Prepared by Mariah Associates, Inc., Reno, NV. Technical Report No. 878. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1846.

Rhode, David

1994 Direct Dating of Brown Ware Ceramics Using Thermoluminescence and Its Relation to the Numic Spread. In *Across the West: Human Population Movement and the Expansion of the Numa*, edited by David B. Madsen and David Rhode, pp. 124–130. University of Utah Press, Salt Lake City.

Rhode, David, David B. Madsen and Kevin T. Jones

2006 Antiquity of Early Holocene Small-Seed Consumption and Processing at Danger Cave. *Antiquity* 80:328–339.

Roberts, R. J., K. M. Montgomery and R. E. Lehner

1967 *Geology and Mineral Resources of Eureka County, Nevada*. Nevada Bureau of Mines and Geology Bulletin 64. University of Nevada, Reno.

Rusco, Mary and Shelly Raven

1992 Background Study for Consultation with Native Americans on Proposed Mining Development Within the Traditional Tosawihi ('White Knife') Quarry North of Battle Mountain, Nevada, in the Traditional Land of the Tosawihi People, Western Shoshone Nation. Reprinted in *Tosawihi Quarries: Archaeological Investigations and Ethnographic Studies in Nevada* (2006), compiled by Robert G. Elston. Bureau of Land Management Nevada Cultural Resources Series No. 16. Reno, NV.

Schmitt, Dave N. and David B. Madsen

2005 *Camels Back Cave*. University of Utah Anthropological Papers Number 125. University of Utah Press, Salt Lake City.

Schroedl, Alan R.

1991a A Treatment Plan for Prehistoric and Protohistoric Cultural Resources in the Little Boulder Basin Area. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1582.

1991b Paleo-Indian Occupation in the Eastern Great Basin and Northern Colorado Plateau. *Utah Archaeology* 4:1–15.

1993 Evaluation of Seven Cultural Resource Properties Recorded by Desert Research Institute In or Near Barrick Goldstrike's Clydesdale Parcel, Boulder Valley, Eureka County, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1922.

1995a Cultural Chronology of the North-central Great Basin. In Open Site Archeology in Little Boulder Basin: 1992 Data Recovery Excavations in the North Block Heap Leach Facility Area, North-central Nevada, edited by Alan R. Schroedl, pp. 33–57. Prepared by

P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-2021.

1995b Open Site Archeology in Little Boulder Basin: 1992 Data Recovery Excavations in the North Block Heap Leach Facility Area, North-central Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-2021.

1996 Open Site Archeology in the Little Boulder Basin: 1993–1994 Data Recovery Excavations in the North Block Tailings Impoundment Area, North-central Nevada, Vol. 1–2. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1614.

1997 Data Recovery Excavations at Site 26EK6232, Eureka County, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-2447.

Seddon, Matthew T.

2003 A Revised Relative Obsidian Hydration Chronology for Wild Horse Canyon, Black Rock Area, and Panaca Summit/Modena Obsidian. In The Kern River 2003 Expansion Project, edited by Alan D. Reed, Matthew T. Seddon and Heather K. Stettler, pp. 447–498. Prepared by Alpine Archaeological Consultants Inc. and SWCA Environmental Consultants, Salt Lake City, UT. Copies available from Utah State Historical Society, Salt Lake City, UT.

Seddon, Matthew T., Rachael Gruis, Amber Tews, Derek Heersink, Scott Edmisten and Heather K. Stettler

2007 The Little Boulder Basin Area Revisited: A Revised Context, Site Reevaluations, Probing Results, and a Testing Plan for Cultural Resources in the Barrick Goldstrike Property Area, Elko and Eureka Counties, Nevada. SWCA Environmental Consultants, Salt Lake City, Utah.

Simms, Steven R. and Marilyn C. Isgreen

1984 Archaeological Excavations in the Sevier and Escalante Deserts, Western Utah: The Intermountain Power Project Transmission Line, Utah Section, IPP Generating Plant to Dead Horse Junction. Prepared by University of Utah Archaeological Center, Salt Lake City, UT. University of Utah Archaeological Center Reports of Investigations 83-12. Copies available from Utah State Historical Society, Salt Lake City, UT.

Smiley, Francis E.

1994 The Agricultural Transition in the Northern Southwest: Patterns in the Current Chronometric Data. *Kiva* 60:165–202.

1998 Old Wood: Assessing Age Overestimation. In *Archaeological Chronometry: Radiocarbon and Tree-Ring Models and Applications from Black Mesa, Arizona*, edited by Francis E. Smiley and Richard V. N. Ahlstrom, pp. 49–64, Chapter 4. Southern Illinois University at Carbondale, Center for Archaeological Investigations, Occasional Paper No. 16.

Smith, Craig S. and Thomas P. Reust

1995 The Dry Susie Creek Site: Site Structure of Middle Archaic Habitation Features from the Upper Humboldt River Area, Nevada. *Journal of California and Great Basin Anthropology* 17:244–266.

Springer, M. E.

1958 Desert Pavement and Vesicular Layer of Some Desert Soils in the Desert of the Lahontan Basin, Nevada. *Proceedings of the Soil Science Society of America* 22:63–66.

Stephens, David W. and John R. Krebs

1986 *Foraging Theory*. Princeton University Press, Pinceton, NJ.

Stephenson, R. L. and K. Wilkinson

1969 Archaeological Reconnaissance of the Winnemucca-Battle Mountain Area of Nevada. Nevada Archeological Survey Research Paper. Copies available from University of Nevada, Reno.

Steward, Julian H.

1937 *Ancient Caves of the Great Salt Lake Region*. Bureau of American Ethnology Bulletin No. 116. Smithsonian Institution, Government Printing Office, Washington, D.C.

1938 *Basin-Plateau Aboriginal Sociopolitical Groups*. Bureau of American Ethnology Bulletin 120. Smithsonian Institution. Reprinted (1997) by University of Utah Press, Salt Lake City, UT.

1943 Culture Element Distributions: XVIII Northern and Gosiute Shoshone. *Anthropological Records* 8(3).

Stuiver, M. and P. J. Reimer

1993 Extended 14C Database and Revised CALIB 3.0 14C Age Calibration Program. *Radiocarbon* 35:215.

Sullivan, Alan R. and Kenneth C. Rozen

1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50:755–779.

Talma, A. S. and J. C. Vogel

1993 A Simplified Approach to Calibrating C14 Dates. *Radiocarbon* 35:317–322.

Thomas, David Hurst

1969 Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. *American Antiquity* 34:392–401.

1981 How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3:7–43.

1983 *The Archaeology of Monitor Valley 2: Gatecliff Shelter*. Anthropological Papers Volume 59. American Museum of Natural History, New York.

1989 Diversity in Hunter-Gatherer Cultural Geography. In *Quantifying Diversity in Arcaheology*, edited by R. D. Leonard and G. T. Jones, pp. 85–92. New Directions in Archaeology. Press Syndicate of the University of Cambridge, Cambridge.

Tipps, Betsy L.

1996 Open Site Archeology Near Upper Boulder Creek: Data Recovery Excavations at Sites 26EK5270, 26EK5271, and 26EK5274 in the East Basin Development Area, Elko County, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1753.

1997 Data Recovery Excavations at Site 26EU2184: A Multicomponent Spring Site in the Lower Maggie Creek Area, North-central Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1756.

Tipps, Betsy L. and Gary M. Popek

1992a Class III Cultural Resource Inventory of Portions of Sections 13 and 24, T. 36 N., R. 49 E., Eureka County, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1643.

1992b National Register Evaluations of 30 Historic Properties Recorded by Desert Research Institute in Unnamed Parcels A and B within the South Block of Barrick Goldstrike Mines, Inc.'s Betze Project, Little Boulder Basin, Eureka County, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1244.

Tipps, Betsy L. and Gregory H. Miller

1998 Spring-Site Archeology in the Lower Maggie Creek Area: Data Recovery Excavations at Three Prehistoric Sites along Simon Creek, North-central Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1773.

Ugan, Andrew and Jason Bright

2001 Measuring Foraging Efficiency with Archaeological Faunas: The Relationship Between Relative Abundance Indices and Foraging Returns. *Journal of Archaeological Science* 28:1309–1321.

Walker, C. P.

2007 Magnetometer Survey at the Leaning Rock Site (41SM325). AGA Report Number 2007-3. Archaeo-Geophysical Associates, LLC, Austin, TX.

Walker, C. P. and T. K. Perttula

2007a Geophysical Surveying at the Tallow Grove (41NA231), Foggy Fork (41NA235), and Beech Ridge (41NA242) Sites. In Lake Naconiche Archeology, Nadogdoches County, Texas: Results of the Data Recovery Excavations at Five Prehistoric Archeological Sites, edited by T. K. Perttula, pp. 228–243. Review Draft. Report of Investigations No. 60. Austin, TX.

2007b Remote Sensing at the Horace Cave Site (41BW14). *Caddo Archaeology Journal* 16:37–44.

Walker, C. P., A. King, R. Sharp and F. K. Reilly

2007 Geophysical Survey at the Etowah Site (9BR1), Barstow County, Georgia. Collaborative Report: AGA Report Number 2007-7, CASAA Report Number 2-A, and SRARP Research Series No. 27. Submitted to the Georgia Department of Natural Resources, East Atlanta, GA.

Ward, G. K. and S. R. Wilson

1978 Procedures for Comparing and Combining Radiocarbon Age-Determinations–Critique. *Archaeometry* 20:19–31.

Witten, Alan J.

2006 *Handbook of Geophysics and Archaeology*. Equinox Handbooks in Anthropological Archaeology. Equinox Publishers, London and Oakville, CT.

Young, Jim

2000 *Bromus Tectorum* L. In *Invasive Plants of California's Wildlands*, edited by Carla C. Bossard, John M. Randall and Marc C. Hoshovsky, pp. 76–80. University of California Press, Berkeley, California.

Zar, Jerrold, H.

1999 *Biostatistical Analysis.* 4th ed. Prentice Hall, Upper Saddle River, New Jersey.

Zeanah, David W.

2004 Sexual Division of Labor and Central Place Foraging: A Model for the Carson Desert of Western Nevada. *Journal of Anthropological Archaeology* 23:1–32.

Zeanah, David W., Eric E. Ingbar, Robert G. Elston and Charles D. Zeier

2004 *Archaeological Predictive Model, Management Plan, and Treatment Plans for Northern Railroad Valley, Nevada*. USDI BLM–Nevada Cultural Resources Series No. 15, Reno, NV.

Zeanah, David W., Betsy L. Tipps, Alan R. Schroedl and Andre D. LaFond

1993 Treatment Plan for Data Recovery at Four Historic Properties in the East Basin, Upper Boulder Creek, Nevada. Prepared by P-III Associates, Inc., Salt Lake City, UT. Copies available from Bureau of Land Management, Elko, NV. BLM 1-1848.

Zeveloff, Samuel I. and F. Collett

1988 *Mammals of the Intermountain West*. University of Utah Press, Salt Lake City.