DEPARTMENT OF TRANSPORTATION

Office of Environmental Stewardship
Cultural Resources Unit
395 John Ireland Blvd., Mail Stop 620

June 15, 2018

Ms. Sarah Beimers, Environmental Review Manager
Minnesota Historic Preservation Office
Administration Building #203, 50 Sherburne Avenue
Saint Paul, Minnesota 55155

Sarah Beimers

Re: S.P. 107-090-009 - Parking Lot Replacement, Roadway and Trail Improvements, Old Cedar Avenue
Bloomington, Hennepin County
MnSHPO Number: 2016-2460

Dear Ms. Beimers:

Enclosed please find the 2018 report by Florin Cultural Resource Services entitled *Additional Phase II Evaluation at Site 21HE483 for the Replacement of a Parking Lot Adjacent to the Long Meadow Bridge in Hennepin County, MN*. The summarized results of this report were first sent to your office as a letter report on 5/6/2016. The conclusions remain the same.

Sincerely,

Craig Johnson, Archaeologist

Enclosure: Final report

Cc: Julie Long, City of Bloomington
Leonard Wabasha, Shakopee Mdewakanton Sioux Community
James Myster, U.S. Fish and Wildlife Service
Amanda Gronhovd, OSA
Melissa Cerda, MIAC
Charlene Roise, Hess-Roise
Frank Florin, Florin Cultural Resources
Legislative Library

Additional Phase II Evaluation at Site 21HE483 for the Replacement of a Parking Lot adjacent to the Long Meadow Bridge in Hennepin County, MN

State Project Number: 107-090-009

Mn/DOT Contract Number: 1002603 and Amendments 1 to 3

ARPA Permit Number: 2016-MN/3-1

USFWS Special Use Permit Number: 2014-32590-16-15

Authorized and Sponsored by:
Minnesota Department of Transportation
and the Federal Highway Administration

Prepared by:

Frank Florin, Principal Investigator
Kent Bakken, Ph.D, Staff Archaeologist
James Lindbeck, Staff Archaeologist

Florin Cultural Resource Services, LLC
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Reports of Investigation # 126

June 2018

Management Summary

The City of Bloomington plans to replace the parking lot adjacent to the Long Meadow Lake (Old Cedar Avenue) Bridge in Bloomington, Minnesota. Funding for the project is being provided by the Federal Highway Administration (FHWA). The project is located on land owned by the United States Fish and Wildlife Service (USFWS) and the undertaking requires a permit from the USFWS, who has recognized FHWA to serve as the lead federal agency acting on their behalf to fulfill their responsibilities under Section 106. The Minnesota Department of Transportation (MnDOT) Cultural Resources Unit is the delegated review agent acting on behalf of FHWA for the Section 106 review, as per the 2005 Statewide Programmatic Agreement. The MnDOT State Project Number is 107-090-009.

Florin Cultural Resources Services, LLC (FCRS) was retained by MnDOT (Contract No. 1002603) to conduct additional shovel testing as part of the evaluation of site 21HE483, which is located in the USFWS parking lot at the west end of the bridge. As part of this work, a study was conducted on the lithology of the gravel bar on which the site is located. Fieldwork was conducted on April 18 and 19, 2016, under ARPA Permit # 2016-MN/3-1 and USFWS Special Use Permit 2014-32590-16-15. Previous Phase I and Phase II work at 21HE483 was conducted in 2015, but this work was mostly outside of the area of potential effect for the parking lot replacement (Harrison 2016, Harrison and Bakken 2016). The previous work determined that 21HE483 was a toolstone procurement (quarry) site that was primarily limited to cobble testing and early-stage reduction.

Site 21HE483 is on a low terrace of the Minnesota River valley bottom in Archaeological Region 4s - Central Lakes Deciduous South, in T27N, R24W, Section 13 in Hennepin County. The FCRS evaluation consisted of digging 33 shovel tests at intervals of approximately 10 meters in the parking lot and adjacent storm drain outlet. Ten tests contained artifacts from intact soils below fill. These tests were located along the western edge of the parking lot and east of the parking lot at the sewer outlet. The tests contained a relatively high density of lithic artifacts. Artifacts recovered from the current testing are similar to those recovered during previous site investigations and consist primarily of decortication flakes and tested cobbles. A small amount of heat-treated lithics indicate that a fire hearth or heating facility exists at the site. A muskrat bone, which is likely cultural, provides evidence of subsistence activities. The bone yielded a radiocarbon date of 2070 ± 30 RCYBP, providing a date for an Early to Middle Woodland occupation.

Many tests, particularly those in the eastern two-thirds of the parking lot, had impenetrable fill (large limestone rocks) to depths ranging from 55 to 115 cm deep. It is reasonable to suspect that intact soils and artifacts may exist below the fill in this area like in the western portion of the parking lot. However, project impacts for new curbing, electric, and trails in most of this area will not exceed the depth of fill.

Site 21HE483 has integrity and is recommended eligible for listing on the NRHP under Criterion D for the Lithic Scatter context because it is likely to yield important information on toolstone procurement in southeastern Minnesota. Existing information from such sites is very sparse, and 21HE483 plays an important role in the overall exploitation and use-patterns of Prairie du Chien Chert and other materials in the region. Many nearby sites along the Minnesota River valley are noted for having considerable amounts of Prairie du Chien Chert and other lithic materials. However, the sources for these lithic materials have previously been unknown and mostly speculative. Site 21HE483 provides a unique example of a local toolstone procurement site. Construction of the proposed parking lot will directly impact the archaeological deposits at the site, and a Phase III data recovery is recommended to mitigate the project's effects, if the site can't be avoided.

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1.1 Overview

The City of Bloomington plans to replace the parking lot adjacent to the Long Meadow Lake (Old Cedar Avenue) Bridge in Bloomington, Minnesota, and the Federal Highway Administration (FHWA) is providing funding. The project is located on land owned by the United States Fish and Wildlife Service (USFWS) and the undertaking requires a permit from the USFWS, who has recognized FHWA to serve as the lead federal agency acting on their behalf to fulfill their responsibilities under Section 106. The Minnesota Department of Transportation (MnDOT) Cultural Resources Unit is the delegated review agent acting on behalf of FHWA for the Section 106 review, as per the 2005 Statewide Programmatic Agreement. The MnDOT State Project Number is 107-090-009.

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As part of the FCRS work, a study was conducted on the lithology of the gravel bar on which the site is located and on toolstone material availability and selection at the site. A primary goal of the study was to provide data from a lithic procurement site that could be included in a National Register of Historic Places Lithic Scatter multiple properties documentation form developed and sponsored by MnDOT. The results of the study are included in this report in Appendix A: *Analysis of the General Lithology and Toolstone Components of a Quarried Cobble and Gravel Deposit at 21HE483* by Kent Bakken.

Previous Phase I and II work at 21HE483 was conducted in 2015, but this work was mostly outside of the area of potential effect for the parking lot replacement (Harrison 2016, Harrison and Bakken 2016). The previous work determined that 21HE483 was a toolstone procurement (quarry) site that was primarily limited to cobble testing and early-stage reduction.

1.2 Project History

The following summary of the project history is from Harrison and Bakken (2016:1-15):

> In February 2014, the City of Bloomington (Bloomington) retained SRF Consulting Group (SRF) to prepare and implement plans to rehabilitate the Long Meadow Bridge, also known as the Old Cedar Avenue Bridge, which opened in 1920 and was listed in the National Register of Historic Places in 2013.... SRF's team included historical consultant Hess, Roise and Company (Hess Roise) .... Hess Roise included Archaeological Research Services (ARS) as a subconsultant .... The project subsequently expanded to involve enhancements to the area near the bridge. These enhancements included construction of a new shelter/toilet facility and improvements to an existing trail system, the existing parking lot, and Old Cedar Avenue between the bridge and Old Shakopee Road. This trailhead is a gateway for the Long Meadow Lake Unit of the U.S. Fish & Wildlife Service's (USFWS) Minnesota Valley National Wildlife Refuge .... The [ARS] Phase 1 archaeological field review was conducted during the summer of 2015.
>
> When ARS staff conducted a preliminary review of the existing parking lot in late spring of 2015, they found that recent tree clearing and grubbing had created an abundance of subsoil exposure that could be systematically covered by visual

inspection. While results proved mostly negative, the recovery of one piece of lithic chipping debris on the grass and tree covered northeastern part of the lot as well as of several pieces along its less disturbed, partly wooded perimeter, was a clear indication that precontact period evidence would be present in the area proposed for rehabilitation and it was decided that the visual inspection should be supplemented by shovel testing once the needed permits were in place.

> As the northeastern part of the parking lot by that time had been designated to serve as a staging area for the rehabilitation of the bridge, some of the desired Phase I testing was not possible but the visual inspection of a fiber optic cable trench excavated across the area had proven negative as had a thorough investigation of very disturbed soils in some still accessible parts of the grassy areas between the parking lot and the avenue -- results which indicated that this area had little if any archaeological potential. In the northwestern part of the parking area, visual inspection of soil disturbance caused by tree removal had also proven negative.

> Consequently, it was decided that testing should focus on the southern part of the parking lot and its perimeter -- an area which, during the preliminary survey, had produced a number of precontact period items and also, because of its proximity to the Orchard Spring drainage, would have been particularly attractive as a camp site.

> More than 230 items were retrieved, some of them post contact and fairly recent but most of them precontact period Native American: primarily flakes and flaking debris produced during the processing of local Prairie du Chien Chert .... None of the precontact period items are diagnostic enough to indicate their age but the so far complete absence of ceramic evidence suggested that they are from the "pre-ceramic" Archaic period.

Following the completion of Phase I testing, Hess Roise and ARS recommended a Phase II evaluation in and adjacent to the paved parking lot, and that evaluation was conducted during the fall and early winter of 2015. A total of five (one-by-one meter) excavation units and additional shovel tests were dug, resulting in the recovery of 679 precontact period artifacts. The assemblage included lithic debris (n=603), along with 44 tested cobbles and smaller quantities of lithic cores, tools, and fragments. Although none of these materials were diagnostic to age or cultural affiliation, the analysis determined that the main site function was lithic procurement. A map of the Phase I and II ARS testing at 21HE483 in 2015 is presented below in Figure 1.

Harrison and Bakken (2016:61) drew the following conclusion from the 2015 Phase II evaluation:

> Analysis of the lithic artifacts from Old Cedar South (21HE483) indicates that this was a lithic raw material procurement site. Activity was focused on raw material testing, while further core reduction was probably limited. There is practically no evidence for any activity outside of preliminary lithic reduction. The site is located on a river-valley ridge that is rich in cobbles, including cobbles of toolstone. Prairie du Chien Chert was the most abundant of these, but Swan River Chert, Knife Lake Siltstone, Tongue River Silica, Fat Rock Quartz, and other raw materials were also gathered from the cobble deposits.

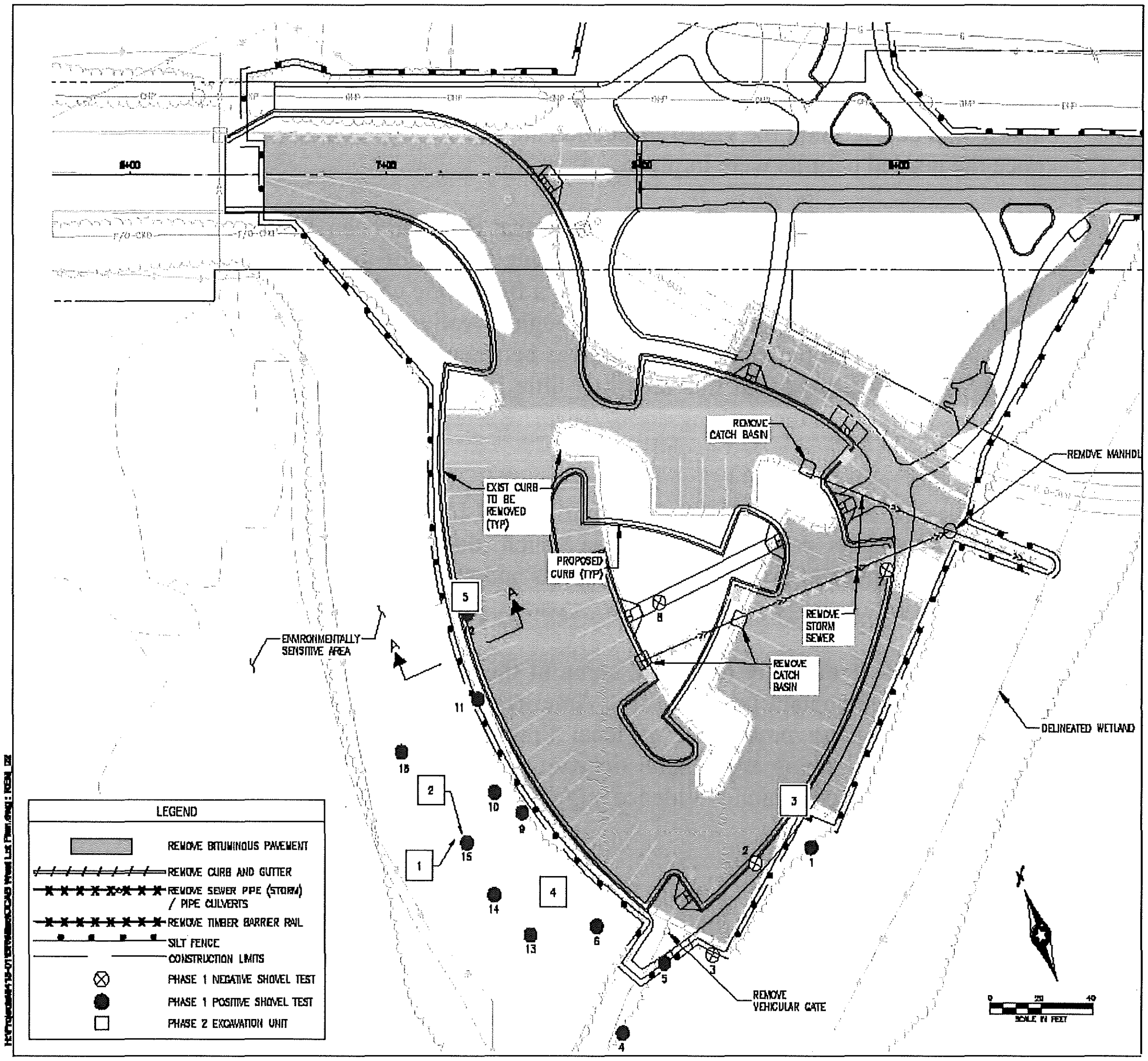

Figure 1. Map of Phase I and II Testing by ARS at 21HE483 in 2015 (from Harrison and Bakken (2016:19).

Lithic raw material procurement sites are not especially common in the region, and procurement sites focused on raw material testing are even less common. In fact, it is not clear whether any examples have been previously reported in the state. Yet sites of this type promise to provide important information on how past societies organized their use of the landscape, on natural resource extraction patterns, on the organization of lithic technology, and more.

This is illustrated by a passage from the concluding section of a recent report on 21CR155, a multicomponent camp farther up the Minnesota River Valley. In this passage, Bakken and Florin (2015:380) hypothesize the existence of sites like Old Cedar South: "Till-derived raw materials are also found at sites within and near the Minnesota River valley, especially in the upper valley, and the importance of these resources should not be overlooked. In addition to the surficial Des Moines lobe tills, older buried tills that were eroded by Glacial River Warren may be locally exposed. The geology of these tills has not been thoroughly explored, and it would be helpful to know more about their lithology and the types of toolstone they might provide. It would also be helpful to know more about the deposition of clasts from these tills along the length of the valley, so we could begin to look at whether the deposits served as raw material sources."

Information from the Old Cedar South site already makes it possible to better understand lithic raw material provisioning and use patterns at 21CR155 and other sites in and near the valley. In addition, knowledge of the existence of a site like Old Cedar South should lead to better informed survey in the Minnesota River Valley, and the chance to discover similar sites and thus better understand this singular aspect of past landscape use, resource use, subsistence systems, and technologies.

Following completion of the ARS Phase II evaluation in 2015, it was determined that additional testing was needed to assess project impacts in the parking lot and at the storm sewer outlet, which would be directly impacted by construction activities. Project features with impacts below the existing fill include the curb and gutter, storm sewer pipe, and electric line. The proposed new parking lot overlays the existing lot and construction activities do not extend beyond the boundaries of the existing lot, except at the sewer outlet on the east side and for the concrete walks. The concrete walk construction will not cause subsurface impacts below the existing fill.

FCRS conducted the additional testing at 21HE483 for all areas that would be impacted by the parking lot replacement, and these areas included: the parking lot, the area between the parking lot and Old Cedar Avenue South, and at the storm sewer outlet area on the east side of the parking lot. This report documents the additional testing at 21HE483.

1.3 Project Location and Setting

Site 21HE483 is located at the south end of Archaeological Region 4s – Central Lakes Deciduous South in T27N, R24W, Section 13 in Hennepin County (Figure 2). The site is on a gravel ridge (low terrace) in the Minnesota River Valley bottom adjacent to Long Meadow Lake and wetlands (Figures 3 and 4). The site is within and adjacent to the USFWS parking lot on south side of Old Cedar Avenue South and on the west side of Long Meadow Lake (Old Cedar Avenue) Bridge.

1.4 Area of Potential Effect

The project consists of replacing the USFWS parking lot adjacent to the Long Meadow Lake (Old Cedar Avenue) Bridge. The area of potential effect (APE) is the construction limits, which encompass the parking lot, the area between the parking lot and Old Cedar Avenue South, a small area on the east side of the parking lot for a sewer outlet, and a small area at the south end of the parking lot for a concrete walk. The APE is 1.1 acre in size.

The vertical APE extends one meter below surface. The archaeological site potential below one meter is low, based on the age of the terrace and lack of Holocene deposits. The UTM coordinates for the center point of the site are E480645 N4964165 (1983 Datum, UTM Zone 15).

1.5 Curation

Copies of project documentation are on file at the FCRS office in Boyceville, Wisconsin. Project documentation and artifacts will be curated at the Minnesota Historical Society (MHS).

1.6 Permit and License

Because the site is located on USFWS lands, an Archaeological Resources Protection Act permit (# 2016-MN/3-1) and a USFWS special use permit (# 2014-32590-16-15) were obtained prior to fieldwork. Copies of these permits are in Appendix B.

1.7 Dating Format

Dates in this report are presented in two formats: 1) by their conventional radiocarbon age (uncalibrated) and 2) as calibrated to actual calendar years. The conventional radiocarbon age (measured radiocarbon age corrected for isotopic fractionation) is presented in the format of "RCYBP" (radiocarbon years before present; with "present" by convention being AD 1950). The use of "RCYBP" dates allows for the consistent comparison of dates from sites in previous reports, as this format has been the standard. Radiocarbon dates from older reports may not have been corrected for isotopic fractionation, but this correction is typically small. Dates calibrated to actual calendar years use the convention "cal BP" (for example 8000 cal BP) to distinguish them from uncalibrated dates (RCYBP).

For various technical reasons, radiocarbon years are not equal to calendar years, and therefore calibration is necessary to assess the actual age of a sample. Radiocarbon years are converted to calendar years by a process called calibration. This process is based on the dating of samples with a precisely known age, such as wood that can be dated to a calendar year by tree-ring counts. These dates reveal systematic variations between radiocarbon years and calendar years, and allow the statistical estimation of actual calendar age for any given radiocarbon date. Generally speaking, conventional age back to about 3000 RCYBP will be close to the actual calendar (calibrated) age, but beyond that the calendar age becomes progressively older than the radiocarbon age. A date of 2500 RCYBP, for example, indicates an age of close to 2,500 calendar years ago, while a date of 10,000 RCYBP indicates a calendar age (calibrated date) of closer to 11,500 years ago. Calibrated dates in this report are 2 sigma calibrations (95% probability).

1.8 Personnel for Lab and Report Tasks

Frank Florin authored all sections of this report, except where noted otherwise. Kent Bakken conducted the artifact analysis, cataloged the artifacts, and prepared lithic data tables. Mr. Bakken also authored the following sections: geology, lithic raw materials, lithic analysis and interpretation, and Appendix A: *Analysis of the General Lithology and Toolstone Components of a Quarried Cobble and Gravel Deposit at 21HE483.* Mr. Bakken's involvement enabled continuity in analytical methods and interpretation, as he did these tasks for the previous site reports. James Lindbeck organized the report sections, compiled information on previous work at the site, authored the Culture History section, and edited the report.

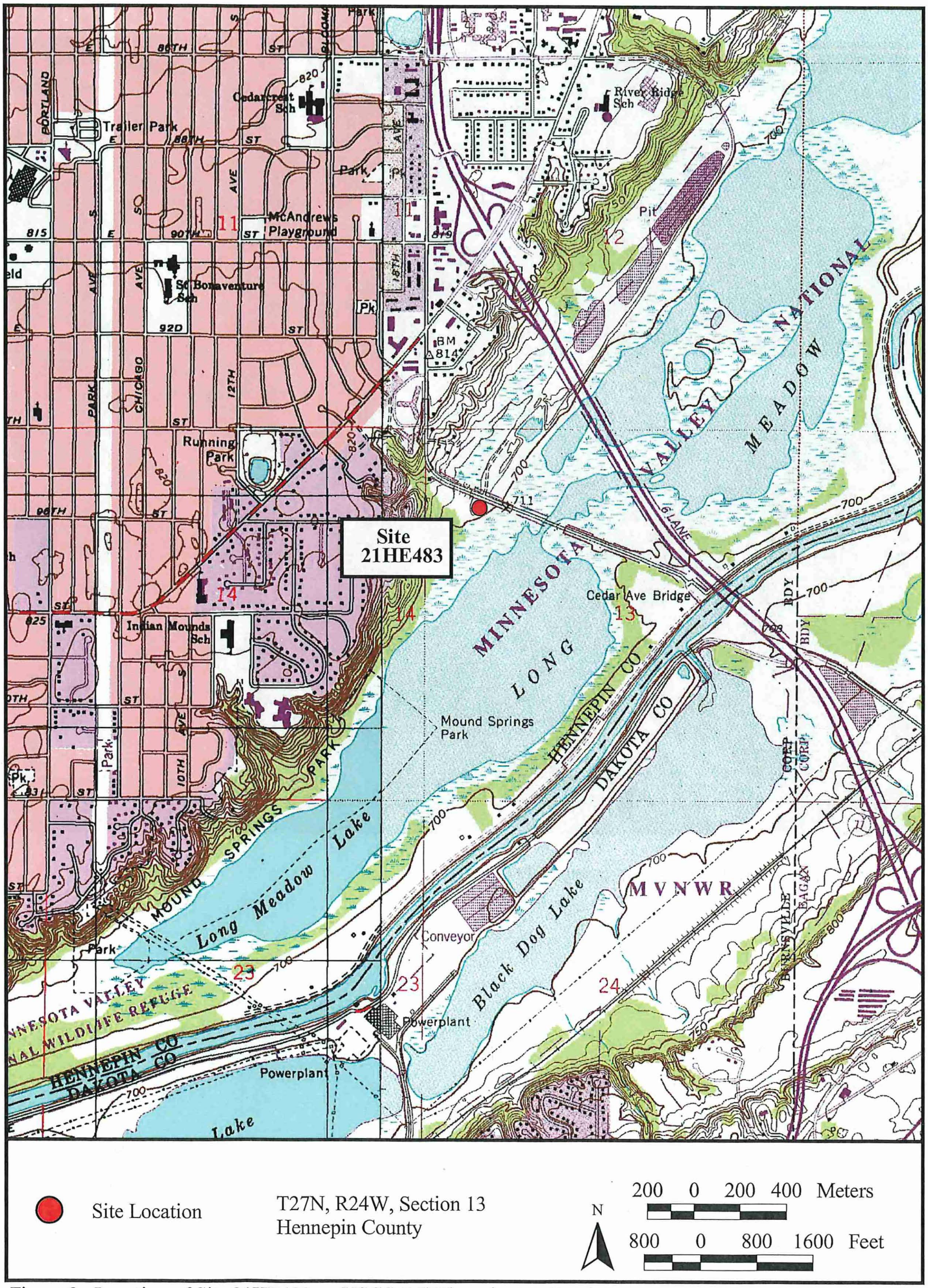

Figure 2. Location of Site 21HE483 on USGS 7.5' Bloomington Quad.

Figure 3. Site 21HE483 on Air Imagery (1991).

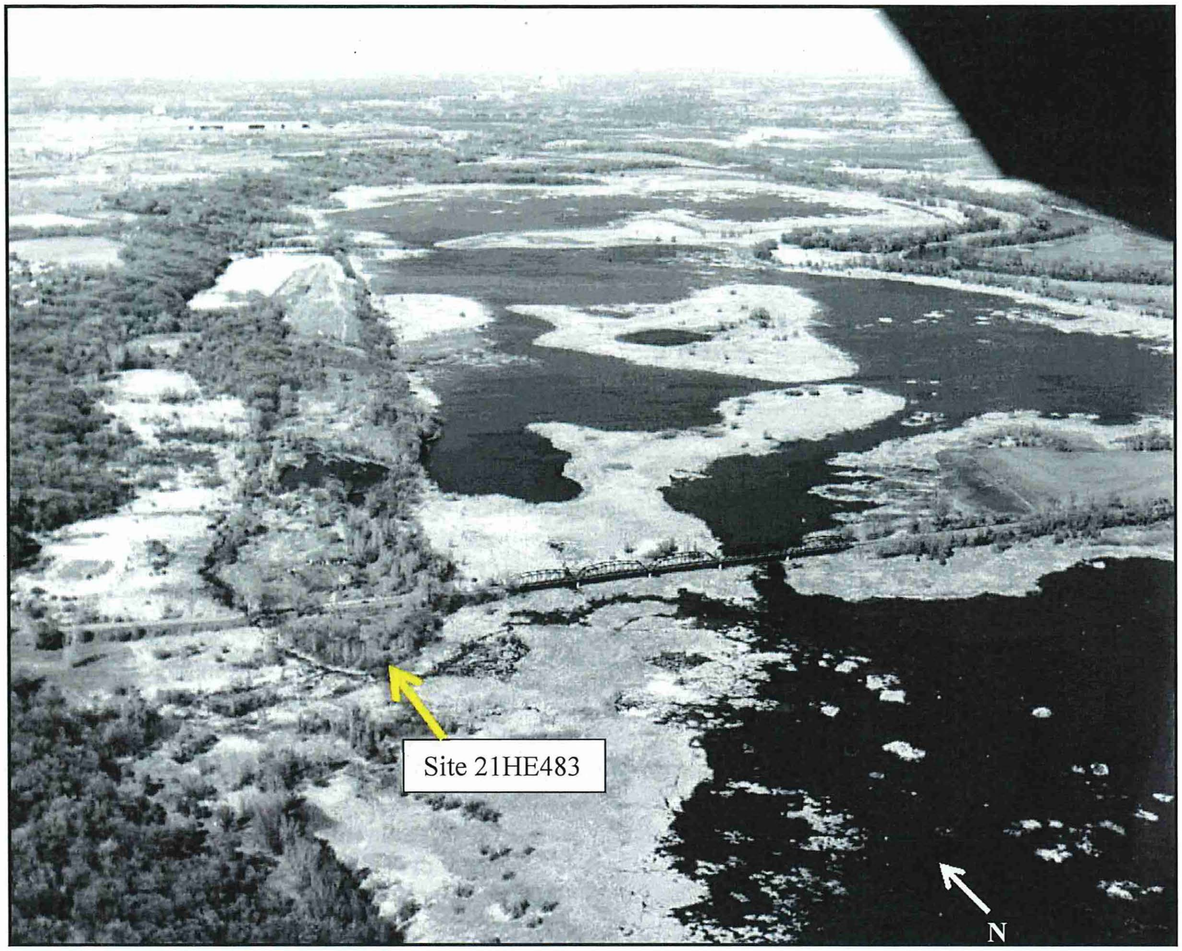

Figure 4. Site 21HE483 on Historic Air Imagery Prior to Construction of Parking Lot – Date Unknown (from Harrison 2016).

2. RESEARCH DESIGN

2.1 Objectives

There are several objectives of the Phase II site evaluation: 1) to aid project sponsors in complying with Section 106 of the National Historic Preservation Act and 36 CFR 800: Protection of Historic Properties; 2) to identify archaeological sites and assess their eligibility for listing on the National Register of Historic Places (NRHP); 3) to aid in project planning; and 4) to produce a report documenting the archaeological investigations.

2.2 Aspects of the Research Design

The research design was developed to meet project objectives, and it adhered to the research and field method guidelines established by the Minnesota State Historic Preservation Office (MnSHPO), Minnesota Office of State Archaeologist (OSA), and MnDOT. These methods, which included a literature search, fieldwork, analysis of data, and production of a technical report, are summarized below and discussed in greater detail in the following sections.

The literature search conducted prior to FCRS fieldwork by Hess Roise and ARS provided information on previous investigations, previously recorded sites, potential cultural resources depicted on historic maps, and the environmental setting. It is available in Harrison (2016) and Harrison and Bakken (2016). Results of the literature search most relevant to the current project are summarized later in this volume.

Archaeological fieldwork comprised shovel testing used to identify artifacts that were present below the ground surface, characterize soils at the survey areas and archaeological sites, and provide information on the horizontal and vertical provenience of artifacts. Specific details of the field methods are presented in Section 3.

The analysis of artifacts was conducted using current methods appropriate to each artifact class. The analysis was oriented towards identifying specific attributes that would provide useful information for interpreting the function and historic context of the site. Specific analytical methods for each artifact class are discussed in detail in Section 4.

The report documents the results of research, fieldwork, and artifact analysis and provides interpretations of the data and recommendations for the sites and project.

2.3 Eligibility Criteria and Historic Contexts

Recommendations for the NRHP eligibility of sites identified for this project are based on the National Register Criteria in 36 CFR Part 60.1 guidelines established by the National Park Service (1991) and Minnesota contexts for the Woodland period and lithic scatters (Anfinson 1994; Arzigian 2008; Dobbs 1988). Archaeological sites that retain integrity may be eligible for the National Register under the following criterion:

A) if they are associated with events that have made a significant contribution to the broad patterns of our history; or

B) if they are associated with the lives of persons significant in our past; or

C) if they embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic value, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D) if they have yielded, or may be likely to yield, information important in prehistory or history.

Integrity is comprised of seven aspects that include: location, design, setting, materials, workmanship, feeling, and association. Several of these aspects must be possessed for a property to retain sufficient integrity for listing on the NRHP. The three aspects of integrity that are specifically relevant to archaeological sites are location, materials, and association. NRHP Criteria A, B, and C do not apply to 21HE483. Site 21HE483 was evaluated for listing on the NRHP under Criterion D for sites that have yielded, or may be likely to yield, information important in prehistory or history.

Specific historic contexts for the precontact period in Minnesota have been developed to summarize the extent of knowledge for each context and provide a framework to aid in determining whether a site has the potential to yield information that is considered important to local and regional prehistory. These contexts propose specific research questions and themes that are specifically relevant to each context. In order for the sites to be eligible for the NRHP under Criterion D, they must retain integrity and contain the potential to provide information on relevant research questions and themes that are applicable to the specific historic contexts present at the sites. These historic contexts are discussed in detail below.

2.3.1 Woodland Period Contexts (2500 to 350 BP)

Bone from site 21HE483 was radiocarbon dated to 2070 +/- 30 RCYBP, placing it near the end of the Early Woodland period and the beginning of the Middle Woodland Period, bearing in mind that the precise delineation of these periods is uncertain. Historic contexts for the Woodland period were initially developed by Dobbs (1988). Updated contexts have been prepared for the National Register of Historic Places Multiple Property Documentation Form (Arzigian 2008). Specific Woodland period research themes for 21HE483 are presented following the summary of Primary Statewide Woodland Tradition Research Themes, below (Arzigian 2008:12-16):

Primary Statewide Woodland Research Themes

- <u>Chronology</u>
  A fundamental need for understanding Minnesota's Woodland complexes is an adequate chronology, including absolute dates for the full span of each complex, but particularly for the beginning and end, as well as charting important changes within the complex.

- <u>Technology and Material Culture</u>

  Besides identifying diagnostic artifacts, the full range of material culture for each complex needs to be described. In addition to artifacts typically considered diagnostic, such as rim sherds and projectile points, can other region- or complex-specific cultural items be identified, such as unique pottery designs, bone tools, or patterns of raw material use?

- Ceramics

  Ceramics provide the most sensitive chronological and regional marker for a complex, but many of the typologies are inadequate or outdated. There is a need for refining and updating existing ceramic typologies, developing a better understanding of spatial distribution and regional and temporal variations for ceramics, and conducting detailed attribute analysis. Changes through time and across regions need to be explored. Comparisons also are needed between ceramic types used in Minnesota and those used in nearby regions (for example, how are Late Woodland corded ceramics in the southern part of the state related to the corded-ware horizon found across the Midwest?). Variability within many types of ceramics seems to be great but is also poorly understood. Single-component sites or separable components within stratified sites are needed to identify the range of contemporary ceramic types and varieties and how they change through time. Attribute analysis could generate a database of ceramic characteristics that could be analyzed statistically and modeled in GIS.

  Ceramic manufacturing processes and vessel function are in general also poorly known. More detailed technological study of ceramics (e.g., paste, temper) could improve understanding, as could thin-section analysis, X-ray florescence, and diffraction, which can help to identify mineralogical and elemental composition and differentiate locally made vs. imported pottery."

- Lithics

  Much more information is needed on the full range of Woodland lithic artifacts, both tools and manufacturing debris, and the raw materials used, both local and exotic. Lithic typologies need to be refined and their associations with cultural complexes verified. Trait comparison to Archaic, Middle Woodland, and Plains types is essential for distinguishing the points from those of other periods and regions, or for confirming that they are all part of a homogeneous complex. Any temporal changes or specific geographic distributions would be useful.

  Lithic tools and debris need to be studied in terms of function, lithic reduction sequences, tool manufacturing, raw material selection, and changes through time in all of these. Can raw material debris profiles be developed to characterize these sites, and possibly to date them even if ceramics are not present? Single-component sites or multicomponent sites with a horizontally or vertically separate component are needed for this research.

  More work is needed on the accurate identification of specific lithic sources, and on documentation of changes in the use of particular raw materials through time and space, and for different tool types. Existing collections might then need to be reexamined, and implications drawn for understanding trade and interaction with other regions. Additional data could help to answer questions related to lithic technology and raw-material acquisition and how those might have changed through time.

Further analysis is needed to identify any differences in lithic assemblages (tools, raw materials, etc.) between sites associated with mound construction and other habitation sites, between complexes in different areas, and between sites with different activities represented. What was the effect of the bow and arrow on the rest of the technological tool kit and on hunting practices, settlement, etc.? Where and when was bipolar core technology used?

- Subsistence

  More detailed information on subsistence is needed for all Woodland complexes in Minnesota. Additional sites with larger samples of subsistence remains are needed from a variety of habitats. Systematic fine-scale recovery from Woodland sites is needed, including flotation to recover plant and animal remains, fine lithic debris, and other small artifacts. Also needed are specialized analyses of these remains, not just superficial analyses such as sorting fauna by class (e.g., fish vs. mammal).

  Interpreting the variety of faunal taxa in terms of habitat selection and seasonal availability will be essential to understanding the whole Woodland seasonal round. Extractive strategies must be examined at the site, local area, and regional scales, including changes through time. Patterns will need to be considered with regard to both variable exploitative strategy and taphonomic changes, such as changes in patterns of transport, processing, and/or disposal of animals, and the final deposition of their remains.

  Floral analyses need to include wood charcoal as a reflection of both the environment and cultural practices, as well as recovery and identification of macroplant remains such as seeds and nuts, and phytolith and pollen studies. Ceramics can be analyzed for evidence of phytoliths and pollen. Infrared spectrometry and gas chromatography can investigate cooking residues and fatty acids from products cooked in vessels, to identify how the vessels were used and what foods were consumed. The role of wild rice in precontact cultures is a crucial question. When was wild rice first used, and when did it become a prominent part of the economy? How did the use of other resources change? Are there special precontact features used to process wild rice? If so, can they be clearly identified, and can they be distinguished from post-contact ricing features? What cultivated plants were used by Woodland tradition populations in Minnesota? How did the northern limits of corn agriculture change through time? When did corn first appear in various regions? How did people exploit different resources as part of the broader annual round?

  In addition to wild rice, where, when, and how were important specialized resources exploited, such as bison or sturgeon? Were sturgeon fisheries occupied for large parts of the year, or only for short periods? What was the nature of bison hunting in various regions, how did it relate to overall way of life, and how did it change through time (including in relation to environmental changes)? Were groups making use of seasonal bison hunts? Which groups, and at what times? Did some groups travel from one region to another as part of a large-scale seasonal round? Was there exchange of bison meat and products, and if so, with whom and in return for what?"

- Geographic Distribution

  The boundaries and geographic distribution of individual complexes are poorly known, and the bases on which they were defined are often not explicit.

- Modeling (i.e., Mn/Model)
  Modeling could identify locations along rivers (such as trade routes) that share the characteristics of a complex, to target future field investigations. GIS can be used for site catchment analysis to suggest what resources might have been exploited at individual sites, and how this compares between sites across regions. Site function within the complex's settlement system can be suggested, and multiple alternative explanations for site location and site function proposed and evaluated. How were ecotones exploited? In particular, what were the effects of the prairie/forest ecotone (and possible changes in this ecotone) on subsistence and settlement systems and movement of peoples across the ecotone? Did some areas, such as ecotonal areas, serve as central points, or trading or culture hubs? Were there regions that were transitional between a number of distinct complexes, and that would have made exposure to or intermarriage with other cultural groups more likely? Evidence of distribution of ceramics or raw materials between different groups might document such patterns of interaction.

  What effects did human subsistence and settlement systems have on the environment, including the prairie/forest ecotone? Were people using fires to maintain ecotonal and prairie habitats? Is there evidence of extensive areas of burning (such as in cores obtained from lakes or rivers)? Or evidence of natural resources that are dependent on fire, such as varieties of wood, plants, or animals?"

- Regional Interaction
  Research is needed into the full range of interregional interactions within and between peoples of contemporary cultures or complexes, as well as the relationships that helped to shape changes in cultures through time.

- Defining the Complexes
  Finally, after evaluation of the research themes, the definition of each complex needs to be refined. Additional dating and understanding of the regional distribution and changes through time, as well as the relationships to other complexes and other regional populations, will facilitate development of meaningful archaeological phases.

2.3.2 The Southeast Minnesota Early Woodland Complex

A muskrat bone recovered from site 21HE483 was radiocarbon dated to 2070 +/- 30 BP, which suggests that the site may have an Early Woodland component, although the date is slightly beyond the younger end of the date range established for the Southeast Minnesota Early Woodland Complex (2500 to 2200 BP, 500–200 B.C.) (Arzigian 2008; Gibbon 2012). However, the accuracy of this date range may be questioned, following the recovery of a Waubesa projectile point in a feature that dated to 1690 +/- 30 RCYBP at nearby site 21HE497 (Florin et al. 2017), which suggests that the end date for this period may be later than 2200 BP and closer to the date of 1900 BP for the Early Woodland period proposed for southwestern Wisconsin (Stevenson et al. 1997:150). In addition to the statewide research themes identified above, the following are some important directions for future research on the Southeast Minnesota Early Woodland complex (Arzigian 2008:34):

- Dating
  There are no La Moille Thick dates from Minnesota, but tight association of dates with La Moille ceramics is essential to understanding chronology and how La Moille relates to other possible early ceramics such as Brainerd and to Fox Lake Incised ceramics.

- Material culture
  Virtually every aspect of this complex remains poorly known. Any single-component or separable occupation that could be identified for this complex would facilitate at least a basic understanding of the material culture and other aspects of the complex. Complete analysis of the artifacts and subsistence remains from La Moille Rockshelter would permit some basic separation of the Early Woodland component from the Archaic occupations, and would provide information on subsistence and lithic technology. Since all but three sherds from the rockshelter were from the La Moille vessel (Wilford 1954c:22), the distribution of sherds could be used to separate out this component for more detailed analysis.

- Nature of the "Early Woodland" Transition
  Gibbon (1986:89) argued that how archaeologists define the concept of Early Woodland will affect our understanding of this complex. Is Early Woodland "the incidental addition of ceramics and a few new lithic types to an essentially stable Archaic lifeway"? Is it an Archaic florescence? A new technological stage marked by ceramic manufacture? Or an indicator of the emergence of "a new Woodland lifeway based on marked shifts in settlement-subsistence practices and burial ceremonialism"? Substantial separable components at stratified Archaic and Woodland sites would be important in documenting how cultures changed with the introduction of pottery.

2.3.3 Havana-Related Middle Woodland

The muskrat bone recovered from site 21HE483 was radiocarbon dated to 2070 +/- 30 BP, which suggests that the site may have a Havana-Related Middle Woodland complex in Minnesota (2200 to 1800/1700 BP, 200 B.C. – A.D 200/300). The generally-accepted date range for this complex is derived from radiometric dates at mound sites and residue on ceramics, and from inferred relationships to the Havana culture in Illinois, although Arzigian (2008:37) cautions that:

> The Havana-Related complex encompasses a number of ceramic types, most of them poorly defined; cultural adaptations, defined primarily in terms of their relation to Hopewell and Havana cultures; and mortuary practices, often poorly dated. Specific research has focused on limited excavation at some key sites and tabulation of the presence of ceramic types in surface and limited excavation contexts, but few major excavations have been undertaken, and none at sites with good organic preservation. Thus, our knowledge of these cultures is very limited.

In addition to the statewide research themes identified in Section 2.3.1, Arzigian (2008:52) identifies the following directions for future research on the Havana-Related Middle Woodland complex:

- Subsistence
  Better subsistence information, both floral and faunal, is needed to understand the basic subsistence pattern and how it might have changed, before interpretations about changing demography and social structure can be made. In particular, the roles of both wild rice and large mammals need to be clarified with fine-scale recovery and analysis from single-component sites or separable components.

- Cultural Transitions
  What was the nature of the transition from Middle Woodland and Hopewell-related cultures to the Late Woodland complexes such as Blackduck-Kathio? Comparison of

material culture, settlement systems, and mortuary practices might provide indications. In some scenarios this complex ended with the entry of Mississippian influences. Did Mississippianization play a role in the cultural transformations seen in central Minnesota? What was the nature of any connection to Arvilla mounds? If this complex represented a transition to the bow and arrow, how is this change visible in the archaeological record?

- Regional Connections
  Cultural relationships, both contemporaneous and through time, are poorly known. Specific lithic raw materials, ceramics, or other cultural traits might be found across the region during this period; tracing these would allow identification of regions of interaction. Examining the distribution of similar ceramic traits such as dentate stamping might be one route of investigation. Such a study would also document any differences in ceramic style found in this ubiquitous and widespread complex. Documenting ceramics from other complexes including Plains Village that are found in Central Minnesota Transitional Woodland sites would be useful for tracing patterns of interaction.

2.3.4 Lithic Scatter Thematic Context

Site 21HE483 was evaluated under the Lithic Scatter Thematic Context (Anfinson 1994). Lithic scatters are sites that consist almost exclusively of the products of lithic technology, such as lithic debris, cores, tested materials, and stone tools. They can also contain bone and fire-cracked rock. The need for a Lithic Scatter context is to help assess the significance of lithic sites that lack diagnostic artifacts or absolute dates and thus cannot be firmly linked to a particular cultural/temporal context. The term "lithic scatter" can be used to classify the type of site based on its artifact types and also to assign a site to a thematic context in lieu of a statewide (cultural/temporal) context. All sites described as lithic scatters can be assigned to the Lithic Scatter context if they lack diagnostic materials. In order for a lithic scatter site to be eligible for the NRHP, it must retain integrity and exhibit one or more of the following characteristics (Anfinson 1994):

- The site must have a demonstrated historic context association.
- The site must contain unusual raw materials.
- The site must be in an unusual regional location.
- The site must suggest an exceptional special use.
- The site must be of an exceptional size (greater than 100,000 square meters).
- The site must have an exceptional density of material (one artifact per square meter or more on the surface; 100 artifacts or more per square meter in formal units).

3. ARCHAEOLOGICAL FIELD METHODS

The archaeological field methods adhered to the MnSHPO and OSA guidelines for archaeological fieldwork. Specific field methods were discussed with MnDOT prior to conducting fieldwork. The MnDOT Cultural Resources Unit determined that shovel testing would be sufficient to complete the site evaluation, as previous testing included the excavation of five units (1x1 meter each) and shovel tests. The focus of the current work was to systematically shovel test the parking lot and adjacent areas in the APE that had not been tested during the earlier Phase I and Phase II investigations (Harrison 2016, Volume One; Harrison and Bakken 2016).

3.1 Shovel Tests

Shovel testing was conducted across the parking lot and adjacent areas in the APE in approximately ten meter intervals. The goal of shovel testing was to determine the presence or absence of artifacts and features, recover artifacts, provide data to assess artifact density and their horizontal and vertical distribution, and assess site integrity by an examination of the soils.

The asphalt and subgrade class-five gravel fill were removed by the City of Bloomington at each shovel test location in the parking lot, under the supervision of FCRS staff to ensure that no incidental impacts occurred below the fill. Shovel tests were 35 to 40 cm in diameter and were dug to approximately 90 cmbs when possible. Some tests were dug deeper, if there was thick fill or artifacts were recovered from near the bottom of the tests. A fill layer was present across the site area, and many tests had impenetrable fill, including large cobbles or boulders at various depths, which prevented digging to 90 cmbs. Fill was discarded and not screened. All non-fill soils were screened through 1/4-inch hardware mesh. Soils were typically dug and screened in 20 to 30 cm increments to provide vertical control of artifact provenience. The field crew returned all excavated soil to each test upon completion. All shovel test locations were recorded with a Trimble GeoExplorer XH 6000.

3.2 GPS Data Collection and Site Mapping in ArcView

GPS data was collected with a Trimble GeoExplorer XH 6000. The data has a typical positional accuracy of 10 to 15 cm after post-processing correction. This data was then exported to ArcView to create maps on topographic and aerial imagery.

3.3 Field Documentation

A record of daily activities was recorded in a log that documented fieldwork and relevant information on site conditions. The project design map was used as a base map for recording project information. Photographs of the project area were taken, and a record of the photographs was maintained in a project photo log. A soil profile was drawn for each shovel test. Soil colors, textures, horizons, and disturbances were recorded on the profile. Soil colors were described using the Munsell system, and the soils were moistened prior to determining color.

4. ARCHAEOLOGICAL LAB METHODS

4.1 Artifact Processing

Artifacts were analyzed by Kent Bakken and cataloged at the FCRS laboratory in Boyceville, Wisconsin. The artifact assemblage consisted of lithic debris, cores, tested cobbles, and a faunal fragment.

Artifact catalog numbers are comprised of a provenience bag number and a specimen number, following the MHS system. The provenience bag number is represented in the catalog database by the column titled "Prov.", and the specimen number is represented by the column titled "Specimen #". The artifact catalogs for the sites are contained in Appendix C.

Provenience bag numbers were established by FCRS in the lab and consisted of a unique number assigned to each specific provenience by find spot (FS), shovel test (ST), or excavation unit (XU) by depth ("cmbs" for cm below surface). For example, Prov # 1 would represent Shovel Test 1 (ST 1), 0-20 cmbs, and Prov # 2 would represent ST 1, 20-40 cmbs. The specimen portion of the artifact catalog number is a unique sequential number or number range assigned to artifacts within a specific provenience bag number. Individual artifacts were assigned a single number (e.g., 1.1), while artifacts with similar attributes and size grades were grouped together and assigned a sequential specimen number range based on their count (e.g., 1.2-10). Beginning and ending numbers in the range were recorded in one row of the database with attribute data for related artifacts.

Attribute data recorded in the catalog for each artifact, or group of artifacts, included: site number; provenience bag number; specimen number(s); provenience information; artifact class; artifact descriptions; weight (g); and size grade (in). Additional artifact information was entered in the "Notes" field of the catalog. The descriptive categories that apply to each artifact class are summarized in Table 1. Specific descriptive attributes recorded for each artifact class are discussed in detail in the following artifact sections. All data was entered in a Microsoft® Access 2010 database. Fields left blank in the database indicate that the attribute does not apply or that the attribute is absent.

Gilson standard-testing metal sieves were used for size grading. The following size grades (SG) were used to sort artifacts: $\geq$4.0 inch (SG00); <4.0 to $\geq$2 inch (SG0); <2 to $\geq$1.0 inch (SG1); <1.0 inch to $\geq$0.5 inch (SG2); <0.5 inch to $\geq$0.233 inch (SG3); and <0.233 inch (SG4). The light fraction of flotation samples from the features was recovered in a 0.0165-inch (#40) mesh screen. The heavy fraction was recovered in a 1/16" mesh screen. Weight was measured to the tenth of a gram with an electronic scale. Artifacts weighing less than 0.05g were given a weight of "0".

Table 1. Descriptive Categories for Artifact Classes in the Catalog.

Class	Description 1	Description 2	Description 3	Description 4	Description 5	Description 6	Description 7
Lithic	Debris	Flake type	N/A	N/A	Lithic material	Cortex amount	Heat treatment
Lithic	Tool	Tool category	Tool type	Tool flake type	Lithic material	Cortex amount	Heat treatment
Lithic	Core	Technology	Flake removals	Platform modification	Lithic material	Cortex amount	Heat treatment
Lithic	Fire-cracked rock	FCR type	N/A	N/A	Lithic material	N/A	N/A
Faunal	Class	Element/ Side	Portion	Thermal alteration	Modified	N/A	N/A

4.2 The Lithic Raw Material Resource Base

Bakken (2011) has defined several lithic raw material resource regions in Minnesota (Figure 5). The project area is located at the approximate border of the Hollandale Resource Region (to the southeast), Quartz subregion of the West Superior Resource Region (to the north), and the Shetek subregion of the South Agassiz Resource Region (to the west).

While the regional resource map indicates which raw materials might be available as a local resource based on their occurrence in till, outwash, or bedrock (Table 2), it is possible to refine the picture by looking more closely at the local geology. The landscape of Hennepin County near the project area consists of deposits that originated from northeastern, northern, and western sources. Outwash terraces (undivided as to river association) occur within a one to three-mile-wide corridor of the current Minnesota and Mississippi rivers along the eastern and southeastern edges of the county, including the project area (Meyer and Hobbs 1989). These deposits would include sediments and rocks from the north via the Mississippi River and west via the Minnesota River. Most of the remainder of Hennepin County consists of Des Moines lobe till and outwash (northwestern source material), which overlies older till from the Superior Lobe (northeastern source material) (Meyer and Hobbs 1989; Wright 1972a). The older Superior Lobe till (and the rocks it contained) was incorporated into the overriding Des Moines lobe till creating a till of mixed lithology (Meyer and Hobbs 1989).

Because the project area is north of source areas for Galena, Grand Meadow, and Cedar Valley cherts, which comprise the primary materials from the Hollandale Resource Region, these materials are unlikely to be locally available in the project area. The presence of these materials at sites identified for the project is likely from travel or exchange.

Prairie du Chien Chert, a primary material of the Hollandale Resource Region, is likely to be available locally but probably not on-site. A short distance upriver near Shakopee, Minnesota, the Prairie du Chien Group geologic formation is within three meters of the surface on the lowest outwash terrace that borders the Minnesota River (Lusardi 1997). Also, there are many places where the Prairie du Chien Group is exposed on the surface about 50 feet above the Minnesota River around the city of Shakopee, and outcroppings occur along the bluffs of the valley margin in Scott County (Roberts 1993:81-84). However, there has been no verification of Prairie du Chien Chert being available from bedrock or secondary deposits in the Shakopee area. Abundant sources of Prairie du Chien Chert are known to exist, mostly in residual deposits, near the Mankato area (Jason Reichel, personal communication 2014).

An abundance of Prairie du Chien Chert occurs at sites 21CR155 (near Shakopee) and 21HE483 (Florin et al. 2015; Harrison and Bakken 2016). These sites are located in the Minnesota River valley. At site 21CR155, the debitage includes initial-stage reduction debris, and the Prairie du Chien Chert cortex is smooth and mechanically weathered, lacking any trace of host rock, which indicates it was procured from local secondary sources and was not procured directly from bedrock. Local secondary deposits that may contain concentrations of Prairie du Chien Chert are speculated to include lag or fluvial deposits in or along the Minnesota River valley or tributaries where source stone was transported during powerful late-glacial discharge through the valley, which transported the material some distance from its original primary context. Site 21HE483 is a procurement site on a late-glacial fluvial bar (low terrace) in the Minnesota River bottom near Bloomington, Minnesota where a large number of Prairie du Chien Chert cobbles were quarried. The deposit of Prairie du Chien Chert cobbles at 21HE483 or similar deposits like it were likely sources for the Prairie du Chien Chert observed at site 21CR155 and other sites in the Minnesota River valley and adjacent areas. In the Mankato area, Prairie du Chien Chert concentrations have been observed in lag deposits and residual deposits in river bottoms and washes, which presumably derived from nearby bedrock sources (Jason Reichel, personal communication 2014). It is likely these materials or similar deposits in the area are the source for the redeposited Prairie du Chien Chert cobbles found in fluvial deposits downstream, such as near Shakopee and Bloomington.

In summary, a wide range of lithic materials from the north, west, and south (limited to Prairie du Chien Chert) are likely to be present in the vicinity of the project area. Local sources for raw materials likely would have included areas where stones were exposed on erosional surfaces such as ravines, stream bottoms, lakeshores, and bluff or terrace scarps. Other local sources would include fluvial sediments such as river bars in the Minnesota River valley. Glacial River Warren, the predecessor to the Minnesota River, would have eroded a variety of tills, from the surficial Des Moines lobe to deeply-buried and poorly-known earlier tills, and deposited rock fragments (clasts) from these along the valley floor. These deposits could contain a potentially very diverse set of raw materials, but it is hard to speculate on the range of materials it might include. It seems that most of the raw materials available in the northern two-thirds of Minnesota could potentially be found in local sources and that only the materials with sources south of the project area or outside of the greater region would truly be nonlocal in origin, excluding Prairie du Chien Chert which as noted previously may have been redeposited from the Mankato area in fluvial deposits near the project area.

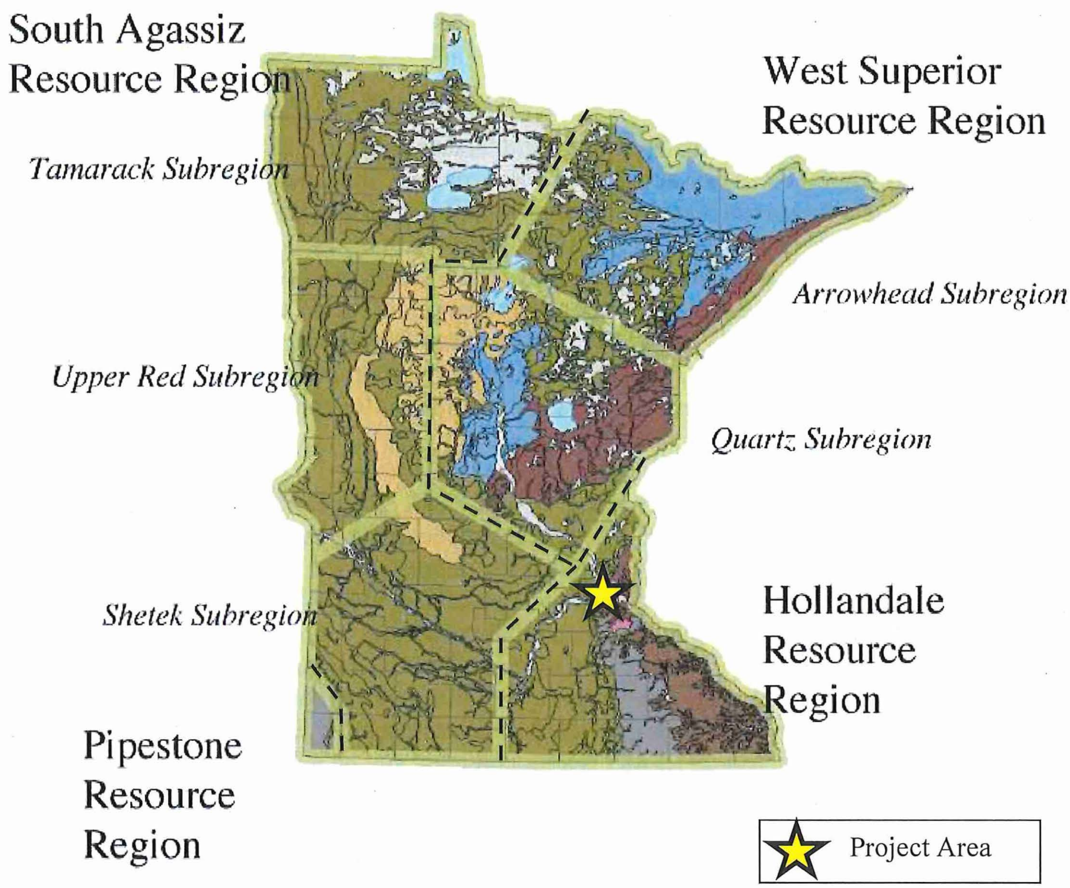

Figure 5. Lithic Resource Regions of Minnesota (adapted from Bakken 2011).

Table 2. Estimated Primary, Secondary, and Minor Lithic Raw Material Status by Region and Subregion (Bakken 2011).

Regions	Primary Raw Materials	Secondary Raw Materials	Minor Raw Materials	Main Exotic Raw Materials
South Agassiz Resource Region				
Tamarack Subregion	Swan River Chert Red River Chert	Border Lakes Greenstone Group	Quartz Tongue River Silica Western River Gravels Group?	Knife River Flint
Upper Red Subregion	Swan River Chert	Red River Chert Tongue River Silica Quartz	Border Lakes Greenstone Group Western River Gravels Group Knife River Flint	Knife River Flint
Shetek Subregion	Swan River Chert	Tongue River Silica Red River Chert Quartz	Border Lakes Greenstone Group Western River Gravels Group Knife River Flint Fat Rock Quartz Other West Superior materials	Knife River Flint Burlington Chert
West Superior Resource Region				
Arrowhead Subregion	Gunflint Silica Knife Lake Siltstone	Quartz Hudson Bay Lowland Chert Jasper Taconite	Border Lakes Greenstone Group	Knife River Flint
Quartz Subregion	Knife Lake Siltstone Tongue River Silica Quartz *(Fat Rock and other)*	Swan River Chert	Lake of the Woods Rhyolite Biwabik Silica Gunflint Silica Jasper Taconite Kakabeka Chert Hudson Bay Lowland Chert Lake Superior Agate	Knife River Flint Hixton Group Burlington Chert
Pipestone Resource Region				
	Tongue River Silica Gulseth Silica?	Sioux Quartzite Swan River Chert? Red River Chert?	Quartz	Knife River Flint
Hollandale Resource Region				
	Cedar Valley Chert Galena Chert Grand Meadow Chert Prairie du Chien Chert	Shell Rock Chert?	Quartz Tongue River Silica Swan River Chert Red River Chert	Hixton Group

4.3 Lithic Artifact Analysis

Kent Bakken conducted the analysis of lithic artifacts from 21HE483 and provided the discussion of the site based on that analysis. His findings are detailed in Section 8.6. The lithic analysis for 21HE483 had two components, a raw material analysis and a technological analysis. Background information and methods for each of these is provided below.

4.3.1 Raw Material Analysis

Raw material identification was based on examination of characteristics such as color, color patterning, degree of translucency, texture of fracture surfaces, inclusions, presence of voids in the rock, etc., aided by low-power magnification. For a more detailed discussion, see Bakken (1997, 2011).

Raw material analysis provides information on such matters as local versus nonlocal toolstone procurement, the selection and use of different raw materials for different purposes, and overall economic patterning of raw material use. Much of this analysis, however, is not relevant for 21HE483 since it represents only a narrow part of the bigger technological and economic system. It seems adequate in this case to simply evaluate the source of the toolstone found at the site, with the context of a model of regional toolstone availability proposed by Bakken (1997, 2011).

In this regional framework, Minnesota can be divided into lithic raw material resource regions, each of which contains a different suite of raw materials (Figure 5, Table 2; Bakken 1997, 2011). The Old Cedar South site is located in the Hollandale resource region, where the most important raw materials are available from primary geologic sources (directly from bedrock) or from near-primary sources (e.g., lag deposits). In addition, parts of the Hollandale resource region are blanketed with Des Moines lobe till, which would provide the raw materials associated with the South Agassiz region. The raw material survey shows that the Des Moines lobe tills in this area also include small complements of materials associated primarily with the West Superior region (e.g., Gronhovd et al. 2013). This likely resulted from mixing of tills as the Des Moines lobe crossed over older tills of different origins. The presence of such till-derived raw materials may be enhanced at the site because Glacial River Warren eroded tills of multiple origins as it formed the valley (Matsch 1972), redistributed clasts from these tills, and concentrated them in locations like the landform at 21HE483.

There is no *de facto* standard protocol for the technological analysis of lithic assemblages. Instead, protocols are commonly tailored to the requirements of individual analyses. This involves balancing research questions, the nature of the assemblage, and the best use of time and resources. Ideally, it also involves striving for a degree of compatibility with other analyses.

Regionally, work by Ahler (e.g., Ahler et al. 1994) and Root (e.g., 2004) has provided the foundation for many analyses (see Florin et al. 2015 for a recent example), and these sources were consulted in formulating this protocol. Analyses of two other toolstone procurement sites in Minnesota were also consulted. These were Myster's (1996) analysis of assemblages from six Galena Chert procurement sites in southeastern Minnesota, and Malik and Bakken's (1999) analysis of an assemblage from Bradbury Brook, a Knife Lake Siltstone procurement site in east-central Minnesota.

It is interesting to note that although these analyses are based in different schools of thought, they use many of the same observations and metrics and also share similar approaches to interpretation. Perhaps this is an indication that lithic technology, and thus lithic analysis, is constrained to a useful degree by such factors as raw material potential and limitations, fracture mechanics, and the functional requirements of stone tools. In any case, the various examples provided a limited set of possible observations. Structuring of the analytical protocol for 21HE483 consisted largely of determining which of the observations would be most time-effective and most informative for this particular site.

4.3.2 Analytical Protocol

Based on the considerations discussed above, a protocol was established that included a few characteristics to be evaluated for the 21HE483 lithic artifacts (Table 3). For most categories of artifacts, a limited set of observations were recorded; an expanded set of observations was applied to flakes. These observations are listed in Table 3. All lithic artifacts were evaluated for morphological category, raw material, and weight. Presence of cortex was evaluated on all flaked stone artifacts. Additional metrics were recorded for tested cobbles and cores, and additional observations were made for flakes. Narrative descriptions were provided for selected artifacts.

Table 3. Overview of Analytical Protocol for Lithic Artifacts from 21HE483.

Observation	Options	Applied to Categories
Category	-Tested cobble -Core -Bipolar core -Flake -Shatter -Tool -Hammerstone -Other fragment	–
Raw material	Prairie du Chien Chert *Etcetera*	All
Weight	To nearest 0.1 g *(or to nearest 5.0 g for pieces over 400 g)*	All
Maximum dimension	To nearest mm *(any axis)*	Tested cobbles, cores
Number of flake removals	Count of flake scars	Tested cobbles, cores
Dorsal cortex (flakes)	-All or nearly all -More than half -About half -Less than half -None or incidental	Flakes
Cortex (other)	-Present -Absent	All besides flakes
Platform	-Cortical -Noncortical -Prepared	Flakes
Bulb of percussion	-Present -Absent	Flakes
Termination	-Feather -Hinge -Step -Other	Flakes
Length	Parallel to ventral face of flake and direction of blow, to nearest 1 mm	Flakes
Thickness	Perpendicular to ventral face, to nearest one mm	Flakes
Description	Written description of important features *(selected pieces only)*	Tested cobbles, cores, bipolar cores, tools

The morphological categories listed in Table 3 reflect the composition of the assemblage. Briefly, the categorical terms are used as follows. Tested cobble refers to an objective piece with few flake removals, when the flake scars tend to encounter and be shaped by flaws in the raw material, and when there is no clear indication of deliberate shaping of the cobble (although the term tested cobble is consistently used for the sake of clarity, some tested pieces are technically pebbles). Core refers to an objective piece which may have more flake removals, when the flake scars are less likely to be distorted by raw material flaws, and when flake removals seem intended to shape the objective piece rather than simply test it. The distinction between tested cobble and core is not exact, and judgement is required on the part of the analyst. Bipolar core refers to an objective piece that has been fractured by bipolar reduction, and thus shows characteristics of compressive fracture. These might include chaotic, nonparallel ripple marks and crushing of paired platforms. Bipolar cores often have a characteristic "lozenge" shape as well (although the previous sample from the site included bipolar cores, the sample from the present work did not. The category is included here for the sake of consistency).

Flakes are subjective pieces with discernable dorsal-ventral and proximal-distal orientation, and with the proximal end intact (or largely intact). Flake fragments with discernable dorsal-ventral and proximal-distal orientation but without the dorsal end intact were grouped with shatter, since it is not possible to produce a complete set of observations for these pieces. Shatter refers to objective pieces without discernable dorsal-ventral or proximal-distal orientation.

Tools refers to pieces that were either deliberately retouched to produce a particular form, or which show wear from use. In this assemblage, tools were limited to a flake showing use wear and a flake that was modified as a piercer.

Hammerstone normally refers to a cobble showing pitting or similar wear from use to knap toolstone. No complete hammerstones were found in this assemblage, and the term is used to refer to fragments that are inferred to have broken off of hammerstones.

Finally, fragments are pieces of stone that appear to have been broken by human activity, are of some raw material not suited to use as toolstone, and are difficult to classify in terms of function or activity.

Weight is an important and reproducible metric that helps quantify the size of artifacts. All pieces under 400 g were weighed to the nearest 0.1 g. Pieces over 400 g were weighed on a different scale with a precision of five g.

For tested cobbles and cores, the number of flake scars were recorded to help assess how much effort was spent on each piece. The maximum dimension in millimeters was also recorded, as a representation (with weight) of the size.

For most categories of artifacts, only presence or absence of cortex was noted. For flakes, however, a semi-quantitative approach was adapted from work by Dibble (1995) and Andrefsky (2005), because it seems to have the potential to produce finer-resolution data for early-stage flaking debris. This adaptation involved five possible states for cortex on the dorsal surface of a flake: none, less than half, about half, more than half, all. The categories are constructed in this way to help produce more consistent results between observers.

The observation of cortex on the flake striking platform was intended to complement the observation for dorsal cortex, and also help assess earlier versus later stage reduction. Note that cortex on the striking platform was only recorded as present or absent.

The presence or absence of a bulb of percussion was noted, with the expectation that initial hard-hammer percussion used in initial raw material testing might produce a predominance of flakes with clear bulbs. Given the issues with raw material quality in this assemblage, it seemed inadvisable to try to characterize how strongly the feature was expressed (e.g., moderate bulb, pronounced bulb). Type of flake termination (feather, hinge, step) was noted, with the expectation that this characteristic might be sensitive to early-stage testing of poor-quality raw material. More specifically, we anticipated that raw material flaws might result in a large number of step terminations. In addition, these two observations may improve comparability with the results of other technological analyses.

Flake length to the nearest millimeter was measured parallel to the direction of the blow as best could be determined, rather than along the longest proximal-distal axis of a flake. In many cases this result would be the same, but in some cases measuring along the axis of the blow produces a shorter measurement. Flake width to the nearest millimeter was measured perpendicular to the axis of the blow. The combination of weight, flake length, and flake thickness were meant to provide a good representation of artifact size, and obviate the need for size grading by providing finer-resolution data in the context of early-stage testing (although in hindsight, flake width would have also been a useful metric. Initially it seemed that length and thickness would provide the necessary information, and save time in making observations).

Issues with raw material quality precluded the use of some commonly used characteristics. Fractures were commonly diverted by joints, vugs, inclusions or other raw material flaws, resulting in the mutation of normal flake morphology. Indeed, observations of flake termination and bulb of percussion were sometimes challenging, and in a few cases even flake orientation was difficult to establish. Some potentially useful observations, such as platform angle, were deemed either prone to observational error or too time consuming to use within the constraints of the analysis.

In addition to this set of standard observations, descriptive narratives were also recorded for certain categories of artifacts. These included all tested cobbles, cores, and tools, plus other selected pieces as appropriate.

4.3.3 Thermal Alteration

Thermal alteration, commonly known as heat treatment, is the intentional alteration of a lithic material to improve its flakability. Heat treatment produces an increase in surface luster, intensifies ripple marks on flake scars, and creates reddish to orangish color in many cherts and other light-colored materials. In some materials, such as Tongue River Silica, Swan River Chert, and Prairie du Chien Chert, the effects of heat treatment are fairly well-documented and can be discerned with a good degree of accuracy. In the current analysis, materials were classified as heat treated if there was significant and noticeable reddish to orangish color and an increase in luster. If these color and texture traits were subdued, then the piece was coded as "probably heat treated". The effects of heat treatment on some materials are not well known.

In contrast to heat treatment, burning is defined by excessive heating that often compromises the stone's flakability. Traits of burning include potlid spalls, crazing, and cracks on the artifact's surface, and a notable darker color. Burning is interpreted to be unintentional, being caused either by accidental over-heating during the heat treatment process or by discard into a cooking facility.

5. Literature Search

5.1 Archival and Background Research for Previous Archaeology Sites

The Minnesota River valley and the surrounding bluffs have been the subject of a number of formal archaeological investigations, beginning with T.H. Lewis and the Northwestern Archaeological Survey (NWAS) in the late 1800s, which focused on recording mound and earthworks. N.H. Winchell later compiled and published the original survey notes and maps from the NWAS (Winchell 1911).

Prior to their 2015 archaeological survey of the project area, Harrison and Bakken (2016:8) conducted archival and background research to determine whether any previously identified archaeological sites are located near the project area, and they described the following results:

> ARS reviewed the files of the Office of the State Archaeologist and the State Historical Society. While a number of archaeological sites have been identified on bluffs overlooking the Minnesota River, many of them Woodland period Native American burial sites, only a few precontact period sites have been identified in the valley -- none of them burial sites but rather habitation sites and other activity areas dating from the Archaic and Woodland traditions. Although none had been found within the current project area, some are located in settings very similar to it.
>
> Of the sites [identified in the valley], all the Hennepin County ones feature mounds while three sites down in the valley are habitation sites located on the floodplain just east/southeast of the Minnesota River:
>
> 21DK65 and 68 which featured Woodland period ceramic body sherds found well below the present surface (in DK68 as deeply as 80-145 centimeters) and therefore though[t] to possibly have been deposited by flooding of the Minnesota River;
>
> 21DK35: Kennealy Creek Village site, which produced early to mid-nineteenth-century Dakota cultural evidence.

5.2 Mn/Model Study of the Big Woods Subsection

The Mn/Model is a statewide GIS-based predictive model for pre-1837 archaeological site locations. The project area is located within Mn/Model's Minnesota Big Woods subsection, which is characterized by a presettlement vegetation of mesic deciduous forest comprised of oak woodland and maple-basswood (Big Woods) and a loamy end moraine associated with the Des Moines Lobe of the Late Wisconsin Glaciation (Hudak et al. 2002). The Minnesota River flows southwest to northeast through the subsection. The Mn/Model depicts areas of high site potential along the Minnesota River, which flows through the center of the region (Hudak et al. 2002, Chapter 8.10; Figure 8.10.3 and 8.10.8). The site potential within the valley is variable and dependent on topography, alluvial history, and geomorphic processes.

5.3 Historic Map, Air Imagery, and Document Review

Harrison (2016) includes as "Attachment A" a detailed historic-era literature review conducted by Hess, Roise and Company for the Long Meadow Bridge Enhancements Project (Peterson and Roise 2015). The literature review spans the period from 1856 to 2002 and was compiled to provide archival materials for the archaeological investigations and as a reference on local historical contexts, particularly gravel mining and farming. The most significant historical activities in and near the project area relate to the Long Meadow Gun Club (ca. 1881) and the construction of the original Cedar Avenue Bridge (ca. 1890), which included extensive gravel mining on the terrace near the project area.

6. CULTURE HISTORY

The following culture history of the precontact period in the project area is derived primarily from *Archaeology of Minnesota: Prehistory of the Upper Mississippi Region* (Gibbon 2012); *Minnesota Archaeology: The First 13,000 Years* (Gibbon and Anfinson 2008); the *Minnesota Statewide Multiple Property Documentation Form for the Woodland Tradition* (Arzigian 2008); and *Outline of Historic Contexts for the Prehistoric Period (ca. 12,000 B.P. - A.D. 1700)* (Dobbs 1988). The discussion follows the organization of cultural periods used by Gibbon (2012) and uses calibrated dates that are 10 to 20 percent older than conventional dates often used in archaeological literature.

The culture history of the project area is complex for three reasons: 1) there is a lack of detailed information about most of the precontact period in the state; 2) the project area is located near the boundary of three different ecological zones (prairie, big woods, and oak savanna vegetation), which shifted during the Holocene in response to climate changes; and 3) the project area is located near the boundary of distinct physiographic settings (Late Wisconsin glacial deposits and loess plains). These complexities are reflected in the multiple MnSHPO Archaeological Regions that border the project area and in the archaeological record of the region.

The project area is located in south-central Minnesota at the south end of MnSHPO Archaeological Region 4s – Central Lakes Deciduous South. Adjacent regions include Archaeological Regions 4e – Central Lakes Deciduous East, 2e – Prairie Lake East, and 3w – Southeast Riverine West.

The Central Lakes Deciduous South region (4s) occurs in central Minnesota and is characterized by 1) glacial moraines, till plains, and outwash plains, 2) hardwood and mixed deciduous-coniferous forests, and 3) numerous lakes, streams, and wetlands. The Prairie Lake region extends across southwestern and south-central Minnesota and is characterized by 1) prairie vegetation with a mixture of oak savannah in the eastern portion, and 2) numerous lakes, wetlands, and rivers resulting from the Late Wisconsin glaciation. The Southeast Riverine region is a loess-covered plain that covers the southeastern corner of Minnesota and borders the Mississippi River valley. The region is characterized by 1) vegetation communities with a mixture of oak savannah, Big Woods, and prairie, and 2) a landscape that consists of a loess plain overlying Kansan till. Lakes and wetlands are largely absent in this region, and the landscape consists of rolling terrain in the west and more extensively-dissected and steeply-incised river valleys in the east.

6.1 Paleoindian Period (13,200 to 9500 BP)

The Paleoindian period was a time of rapid environmental change as the glaciers retreated from Minnesota (Wright 1974). Substantial changes in vegetation, wildlife, waterways, and the landscape occurred as a result of the ameliorating climate, and Paleoindian lifeways reflect adaptations to these rapidly changing landscapes. The first Paleoindian peoples in the southern Minnesota encountered a subarctic environment with no direct parallel in the modern world. It is not known what animals lived in the area at this time, but it can be assumed that mammoths, giant bison, and other now-extinct megafauna were present. Fish would have been present in the newly-formed lakes and rivers soon after the establishment of open water (e.g. Pielou 1991), and plants became established on the ice-free landscape.

It is presumed that Paleoindians were highly mobile and traveled in small bands. However, the lack of Paleoindian sites in Minnesota makes it difficult to identify settlement patterns, subsistence, or site types. Only one burial of this period is known, the Browns Valley site (21TR5) in the west-central part of the state. The known sites appear oriented toward current bodies of water, but these locations are also areas that have had a greater amount of archaeological survey. The locations of known sites therefore do not necessarily represent the actual settlement patterns. It is not clear whether the paucity of sites demonstrates that there was a small Paleoindian population in Minnesota, or whether the population was more numerous but the sites have not been identified because they have been destroyed, are deeply-buried, or lack diagnostic artifacts. It is likely that some of the lithic scatter sites that are scattered throughout the state belong to this period, but without the recovery of diagnostic artifacts or datable material, it is not possible to determine the cultural affiliation of these sites. Research in other parts of the country, where Paleoindian sites are more common, suggests that the margins of lakes and swamps were preferred habitation locations, and these landscapes were prevalent in the late-glacial and early Holocene periods of central Minnesota.

The Paleoindian period is divided into Early (13,200 to 12,500 BP) and Late (12,500 to 9500 BP) periods, as defined by the use of fluted (Early Period) or plano (Late Period) projectile points (spear points) for hunting and also possibly butchering. During the Early Paleoindian period, artifact typologies in Minnesota suggest that the culture was mostly related to the eastern Midwest. During the Late Paleoindian period, the cultural affiliation is clearly more related to the Plains, except in the Mississippi Valley region of southeastern Minnesota.

6.1.1 Early Paleoindian (13,200 to 12,500 BP)

The glaciers were gone from the southern half of the state by approximately 14,000 BP, and the Late Glacial and Early Holocene environments that followed were very dynamic, with rapidly-evolving climate, vegetation, animals, surface hydrology, and landforms. Within the project area, the most dramatic of these evolving landscapes was the cutting of the Minnesota River valley by the Glacial River Warren. Glacial Lake Agassiz, which covered all of northwestern Minnesota, was the source of Glacial River Warren. The current Minnesota River valley was formed by the catastrophic discharge of glacial meltwater that drained from the lake until approximately 12,700 BP, when eastern outlets to Lake Agassiz opened and the lake retreated to the northern Red River valley. The southern outlet of the Glacial River Warren was abandoned for a period at this time, and the landscape of the valley began to stabilize and fill in (Matsch 1983). Vegetation in this post-glacial environment included boreal forest species, with a mix of deciduous tree such as larch and ash, reflecting a wetter and cooler climate than is seen today.

Fluted point types such as Clovis, Folsom, and Gainey of the Early Paleoindian period are rare in Minnesota, and little archaeological evidence of Early Paleoindian people has been documented thus far. Isolated finds, primarily recovered from the surface of agricultural fields, have been recorded at scattered locations across Minnesota (Anfinson 1997:28-30; Buhta et al. 2011; Higginbottom 1996). In Wisconsin most fluted points occur in the southern portion of the state south of the most recent glacial ice margins (Mason 1997:87). These isolated finds are in themselves important contributions to the archaeology of the Early Paleoindians, but it is unfortunate that no other site data are available.

Early Paleoindian people are traditionally thought to have been nomadic big-game hunters, an interpretation derived from the dramatic and defining finds of lanceolate points at megafauna kill sites in the American southwest. These now-famous discoveries at places such as Blackwater Draw and Folsom in New Mexico initially established the antiquity of the Paleoindian tradition and the association of Clovis and Folsom points with mammoths and other extinct megafauna. Mason (1981:97) points out, however, that, "as eastern fluted point sites were found and investigated, and dramatic kill sites eluded discovery… enthusiasm for this idea waned. Because most Paleo-Indian sites east of the Mississippi are unaccompanied by preserved bones, it is now a popular notion that big-game hunting was a western specialization not indulged in by the easterners. But just as it is difficult to argue one way in the absence of evidence, so is it difficult to argue the other way."

While paleontological finds of extinct megafauna have been made in Minnesota, only the Itasca Bison Kill site (Shay 1971), which contained the extinct bison type *Bison occidentalis*, also contained cultural materials. The closest known megafauna kill (or possibly scavenging) sites are in Wisconsin, including several on beach ridges of Glacial Lake Michigan. The Boaz Mammoth site in southwestern Wisconsin is the nearest site. The site, which was discovered in the late nineteenth century, contains the remains of a mammoth in apparent association with a Hixton orthoquartzite fluted point (e.g., Overstreet 1993, 1996; Mason 1981, 1997). Anfinson (1997) suggests that Early Paleoindians in the Prairie Lake Region relied on a much wider variety of resources in their boreal environment, such as smaller animals, fish, and vegetal foods, than did the Paleoindians of the southwestern United States.

6.1.2 Late Paleoindian (12,500 to 9500 BP)

The transition from the Early Paleoindian to the Late Paleoindian period is indicated by the appearance of some groundstone tools, such as the adze, and by a variety of large, finely-crafted stemmed and lanceolate projectile point types that lack the distinctive fluted points of the early period. Some of the Late Paleoindian points in Minnesota and the Midwest are smaller and less-finely crafted than those from the Plains, which is perhaps a result of raw material quality and cultural changes through time (Florin 1996). Many of the points from Minnesota are extensively resharpened and reworked so that their original condition is no longer apparent. Another unique feature on points from the Midwest is the presence of basal ears on some specimens, particularly the stemmed forms. Gibbon (2012:73) suggests the Late Paleoindian may have persisted in northern Minnesota until 8000 to 7000 BP and similar late dates have been suggested for northern Wisconsin (Mason 1997). Two projectile point bases that resemble Agate Basin and an Eden stemmed type were recovered at site 21CR156 in the Minnesota River valley bottom near the current project. A radiocarbon date from calcined bone associated with these points was ca. 7000 RCYBP (cal. 7900 BP), indicating that the Late Paleoindian period overlaps Archaic period, as Gibbon (2012) has suggested. Late Paleoindian points have recovered in association with Archaic points at several sites in Wisconsin and adjacent areas in the Great Lakes region, confirming they are contemporaneous (Mason 1997; Pleger and Stoltman 2009). Hixton quartzite was used as a raw material throughout the eastern Midwest at this time.

Faunal assemblages from five Late Paleoindian sites in Wisconsin contain a variety of terrestrial and aquatic animal resources, including deer, bear, beaver, muskrat, porcupine, birds, turtle, and fish, indicating a generalized foraging subsistence base (Kuehn 2010). This data contrasts with the out-dated concept of Paleoindians being primarily hunters of a few select species of large game animals such as bison, moose, and caribou. The prevalence of wetland and aquatic animals is particularly noteworthy. Faunal material recovered from the Late Paleoindian component at site 21CR156, near the current project area, conforms to this generalized foraging pattern and the reliance on wetland and aquatic resources.

Glacial River Warren began to flow briefly again around 11,000 BP, following a refilling of the southern end of Glacial Lake Agassiz. This was a time of rapid environmental change, and deciduous tree species moved rapidly into the area from the south. Presumably, Late Paleoindians consisted of small, highly mobile groups that foraged widely and occupied territories only briefly.

Late Paleoindian points are found more frequently than Early Paleoindian points, probably reflecting increasing population levels in the post-glacial era. Numerous points have been recorded from private collections and also identified during archaeological investigations across the state (Florin 1996). Twelve points were reported in Hennepin County but none in Dakota County during a statewide survey of Plano points. The point types from Minnesota resemble the stemmed and lanceolate types defined from type sites on the Plains. Point types most commonly found in the Prairie Lake Region include the lanceolate Agate Basin and Browns Valley types and the subsequent stemmed Scottsbluff and Eden types.

One of the best-documented Late Paleoindian sites in the Prairie Lake Region is the Browns Valley Site (21TR5) at the southwestern edge of Lake Traverse in western Minnesota. The site contained human remains, which date to approximately 10,000 BP, and several possibly associated lanceolate bifaces (Browns Valley type) that discovered from a gravel pit. Browns Valley points have also been recovered from site 21CP35 near Montevideo and from the Hildahl #3 site (21YM35) on a terrace of the Minnesota River valley near Granite Falls, which also contained Early Archaic, Middle Woodland, and Late Woodland components. Scottsbluff points were recovered from the Goodrich site (21FA36) in Faribault County; Eden points from 21DL8 and 21DL54 in Douglas County; and a Dalton point from Lac qui Parle County is in the Minnesota Historical Society collection. Late Paleoindian points are also reported from the Pedersen site (21LN2).

Another important Late Paleoindian site is Bradbury Brook (21ML42) located in Mille Lacs County about 100 miles north of the project area. The site is a siltstone lithic procurement and initial reduction site associated with the Alberta Complex (Malik and Bakken 1993, 1999). A Phase III data recover was conducted at the site. One feature was identified, which produced the base of an Alberta point and an associated radiocarbon date of approximately 10,500 BP. The site is the oldest radiometrically dated site in Minnesota, and provides a unique perspective on the Late Paleoindian period in central Minnesota.

The East Terrace site (21BN6) on the Mississippi River near St. Cloud, about 70 miles north of the project area, is described as a Plano site that represents an intermittently-occupied location (BRW, Inc. 1994). Diagnostic points recovered included Hell Gap, Alberta, and Scottsbluff, which were extensively reworked.

The Reservoir Lakes Complex of northeastern Minnesota is one of the best professionally documented sites. The complex consists of a cluster of surface collections along a chain of reservoir lakes near Duluth that contain a variety of stemmed and lanceolate points (Harrison et al. 1995; Steinbring 1974). Some of these points have basal ears, suggesting an eastern influence. A variety of stone tools also occur, including choppers, bifaces, crescentric blades, adzes, long heavy picks, retouched flakes, scrapers, drills, and asymmetrical knives. The sites are located along lake shores that have been eroded by fluctuating water levels. Because of the deflated nature of the sites, it is not possible to confidently characterize the site components, and some of the assemblages are mixed with later Archaic components.

The Cherokee Sewer site (13CK405) in northwestern Iowa provides some of the best information on the Late Paleodindian and Early to Middle Archaic period in the northeastern plains and adjacent prairie region. The site contained three distinct cultural horizons dating from 8400 to 6400 BP. The earliest component contained points resembling the Hell Gap type that were recovered with bison and other animal bone.

6.2 Archaic Period (12,500 to 2500 BP)

The Archaic period is generally characterized by the following: 1) a subsistence base that relied on a variety of game animals and wild plant food resources; 2) the absence of agriculture, ceramics, and burial mounds except at the end of the period; and 3) an increasing variety of notched and stemmed projectile points (e.g., Raddatz, Little Sioux, Durst) and stone tools that included pecked and groundstone implements (adzes, axes, and mauls), native copper artifacts, and some exotic materials such as marine shell. As with Paleoindian sites, most recorded Archaic sites are small, short-term camps and activity areas. Most of the information from this period comes from sites in the southeastern part of the state or in neighboring Wisconsin and Iowa. A few significant Archaic sites have been recorded in the Prairie Lake Region. Geological processes resulting from the climatic changes of the Altithermal may have buried or eroded many Archaic sites, and there has been no comprehensive study of the Archaic on a statewide scale. For these reasons, our knowledge of Archaic period lifeways is still very limited.

The Archaic period spanned the time when the post-glacial environment of Minnesota continued to moderate, and ecosystems similar to those of modern times evolved. During this time, the northern hemisphere experienced an episode of warm and dry weather that is variously referred to as the Altithermal, the Middle Holocene Climatic Optimum, and the Prairie period. The peak of this warming period was reached around 7800 BP, by which time most of southern Minnesota, except the southeast corner, was dominated by a prairie landscape. The hot and dry conditions persisted at their maximum for about 1000 years before gradually giving way to a cooler and wetter climate that led to the evolution of ecological communities similar to those of the modern era by about 5000 BP. The dramatic environmental changes of the Altithermal would have caused major shifts in the lifeways of the people, as post-glacial animal species of the forest such as moose, caribou, and deer were replaced by prairie species such as bison. Plant communities also would have changed with the spread of the prairie, and wild rice may have been gathered during this time. Surface water significantly decreased during the Altithermal, as shallow lakes and wetlands dried up or were greatly reduced in size.

It is likely that Archaic period populations engaged in seasonal rounds of resource gathering as the climate stabilized following the retreat of the glaciers. Small bands would have returned to seasonal campsites, and territories may have been relatively limited. With the onset of prairie conditions, however, resources would have become less predictable, and populations would have been pushed into shrinking areas surrounding the larger lakes and streams. The appearance of groundstone milling tools suggests that there was a greater use of seeds and other plant foods. Domesticated dogs, used for transport, suggest that longer-distance travel was required to keep up with migratory bison herds. Group sizes appear to have remained small throughout the Archaic, and known site locations indicate that a high value was placed on a proximity to game, water, and supplies of wood.

The Archaic has traditionally been divided into Early, Middle, and Late periods, and Gibbon (2012) argues that the Early Archaic period in Minnesota overlapped the Late Paleoindian period for perhaps thousands of years. He emphasizes that this was not necessarily a time of transition from Paleoindian into Archaic, but that the two cultures were contemporaneous and may have interacted in various ways. When this overlapping period is included, the Archaic Period in Minnesota may be understood to extend back as far as 12,500 BP and the Paleoindian Period to as late as 8000 BP. There are a few sites in Wisconsin that have yielded Late Paleoindian points in association with Archaic notched points (Pleger and Stoltman 2009). The transition from Paleoindian to Archaic appears to have been more abrupt and of shorter duration in the eastern and southwestern United States than it was in Minnesota. Gibbon (2012) adds the modifier "Eastern" to his discussion of the Early Archaic in Minnesota for complexes presumed to be derived from the East, which distinguishes it from the "Prairie" Archaic period that is centered on the northeastern plains, including southwestern Minnesota. Anfinson (1997:35) points out that the Prairie Archaic of the northeastern plains region began about 7500 years ago, and Archaic of the eastern Midwest may have begun as early as 10,000 years ago.

6.2.1 Early Eastern Archaic

Most of the information we have about the Early Eastern Archaic period in the upper Midwest (ca. 12,500 to 9500 BP) comes from sites in the mid-south and central Mississippi valley region. The chronology of the various Archaic periods is not firmly established, and dates from adjacent areas are later than those proposed by Gibbon (2012). The Early Archaic period in Iowa extends from 10,000 to 8500 BP (Benn and Thompson 2009) and from 10,500 to 7500 BP (Alex 2000). In Wisconsin the period extends from 11,500 to 7500 BP (Pleger and Stoltman 2009). There has been no comprehensive study of Early Eastern Archaic sites and site distributions in Minnesota, and therefore Gibbon and Anfinson (2008: Chapter 5) state that there is "… little useful to say about that tradition's sites and their distributions in the state." Most Early Eastern Archaic projectile points recovered in Minnesota have come from the southeastern part of the state, although a St. Charles point was found in Martin County in the west.

Classic Early Eastern Archaic point types that have been recognized in Minnesota include Thebes, St. Charles, Kirk Serrated, Graham Cave, and Hardin. Except for the stemmed Hardin type, the Early Eastern Archaic points are generally medium to large size, side- or corner-notched points that lack the parallel flaking characteristic of Late Paleoindian points. The Kirk type is generally smaller than the other types. Gibbon and Anfinson (2008) state that Hardin is considered a likely Late Paleoindian/Early Archaic transitional point form that may have developed in the mid-continent.

Early Eastern Archaic points are often associated with thin scatters of non-diagnostic artifacts such as scrapers, blades, and point blanks. Other materials likely used by Early Eastern Archaic people such as wooden tools, textiles, and bone implements have not survived in the archaeological record.

6.2.2 Middle Archaic

The Middle Archaic in Minnesota spans the period of roughly 9500 to 5000 BP, although dates from adjacent areas are later than those proposed by Gibbon (2012). The Middle Archaic period in Iowa extends from 8500 to 4500 BP (Benn and Thompson 2009) and from 7500 to 5000 BP (Alex 2000). In Wisconsin the period extends from 7000 to 3700 BP (Pleger and Stoltman 2009). This period includes the peak of the Altithermal episode, and the climatological and ecological changes of that time had profound impacts on subsistence and settlement patterns. Warming and drying during the period would have been dramatic, with prairie spreading across northwestern and southern Minnesota, except for the southeastern corner. Eventually, deciduous forests would have been restricted to river valleys and lake edges in most of the southern part of the state. As the post-glacial landscape continued to stabilize, water flows through the Minnesota River valley were reduced and water temperatures warmed. This allowed aquatic species to migrate up the river valley from the south, and waterfowl likely became abundant. Few Middle Archaic sites have been discovered in Minnesota compared to more southerly portions of the Midwest.

Gibbon (2012:73) summarizes a challenge in describing the Middle Archaic period in Minnesota:

> Middle Archaic artifacts and sites are sparse or remain unrecognized at the moment, even though this time period … is well represented by sites and by growing populations farther south. In fact, there is some confusion in Minnesota archaeology about how non-Paleoindian artifact assemblages dating to this period should be classified. The problem in part is the presence of an early Archaic time gradient, with the earlier appearance of Early Eastern Archaic assemblages to the south correlated with the earlier appearance of deciduous forests in that area.

The Prairie landscape and accompanying bison herds begin to enter Minnesota around 10,500 BP at a time when Lake Agassiz still covered the northwestern corner of the state and the glacial River Warren was flowing through the Minnesota River valley. Late Paleoindian people living on the plains likely followed bison herds with the advance of the prairie into Minnesota. By approximately 7800 BP at the peak of the warming and drying, prairie covered most of western and southern Minnesota, and the

Archaic-period bison hunters who used medium-sized, side-notched points spread across the prairie regions of the state.

Middle Archaic projectile points are small to medium-sized and generally smaller and less well-made than the points from the Paleoindian period, and there is an increased use of local cherts. These points were most likely attached to atlatl darts rather than spears and were thrown with an atlatl. Diagnostic Middle Archaic point types common to Minnesota are divided into two broad categories (Eastern Woodlands and Plains), based on their presumed region of origin outside of Minnesota, and by the dates (*Early Phase* and *Late Phase*) of their presence in those regions (Gibbon 2012). *Early Phase* points from the Eastern Woodlands include the Raddatz, Fox Valley, and Osceola types. *Late Phase* Eastern Woodland types include Matanzas, Benton, and Elk River. Point types of the *Early Phase* in the Plains include Simonsen, Little Sioux, and Oxbow. *Late Phase* point types from the plains include McKean and Table Rock. Many of the Middle Archaic point types continued into the Late Archaic. Other artifacts that were developed in the later portion of this period, and more fully in the Late Archaic, include ground stone tools, such as grooved axes and mauls, manos, metates, and apparatus for the atlatl, including bannerstones, gorgets, and boat stones.

The most significant Middle Archaic site recorded in the state is the Itasca Bison Kill site (21CE1) near Lake Itasca in Clearwater County (Shay 1971). At this site a number of now-extinct *Bison occidentalis* were killed in a boggy area, and a campsite associated with the processing of the bison was on a hill overlooking the bog. Projectile points from the site include small to medium-size, side-notched types, which have been referred to as Little Sioux or Simonsen points, and also occur at the Cherokee Sewer (13CK405) and Simonsen (13CK61) sites in northwest Iowa and the Soldow (13HB1), Ocheyeda (13OA401), and Arthur (13DK27) sites north-central Iowa (Alex 2000; Morrow 1984). The date for these points at the Cherokee Sewer site is 8200 to 7900 BP. Similar points have been found at the following sites in southwestern Minnesota: Granite Falls Bison Kill (21YM47), Goodrich (21FA36), Pederson (21LN2), and Hildahl #3 (21YM35) (Anfinson 1997; Christiansen 1990) and the Rustad Quarry site (32RI775) in southeastern North Dakota (Michlovic and Schmitz 1996). The Granite Falls Bison Kill site had four small, side-notched points (3.7 cm long by 2 cm wide, 4.5 cm long by 2 cm wide, and two bases that are similar in sizes to the others) and dates to between 8000 to 7000 BP from two radiocarbon dates (Lewis and Heikes 1990).

The Jackpot Junction site (21RW53) in the Minnesota River valley near Redwood Falls contained bison, turtle, small mammal, and fish bone from depths of 1.5 to three meters along with stone flakes. No projectile points were recovered, but radiocarbon dates of about 5600 BP place the site in the Middle Archaic period. Closer to the project area, site 21NL63 (Fritsche Creek II), located on an alluvial-colluvial fan along the northern margin of the Minnesota River in Nicollet County, contains an intact buried component that dates to the Middle Archaic (ca. 7000 BP), or even earlier, based on dating of bone collagen (Roetzel et al. 1994). The buried component may reflect a short-term occupation associated with a bison kill and processing. Site 21NL58, located near 21NL63 and in a similar landscape setting, also contains a buried component with bison bone and other materials dating to about 7000 BP (Terrell et al. 2005). The dates from 21NL58 and 21NL63 are similar to the dates obtained from sites 21CR155 and 21CR156 which are located in the Minnesota River valley bottom near the current project area.

Archaic site 21CR155, located in the Minnesota River valley near Shakopee, had cultural deposits that included bison and other terrestrial and aquatic remains buried as deep as four meters. The site contained multiple occupations, spanning most of the Holocene from ca. 7100 to 500 RCYBP (8000 to 500 cal BP. The Archaic points include an unnotched "Delong" type and a medium-sized notched type. The site was determined eligible for listing on the NRHP and a Phase III data recovery was conducted prior to highway construction.

The Archaic component at site 21CR156, also located in the Minnesota River valley near Shakopee, contained lithic debris in a buried soil that was dated to ca. 6700 RCYBP (cal. 7600 BP). Multiple buried soils and archaeological components are present across the site area. The site was recommended eligible for listing on the NRHP and the construction plans for the CSAH 61 project that necessitated the archaeological survey were changed to avoid the site area.

A Middle Archaic component, dating from about 8000 to 7500 BP, was identified from a buried component on top of an alluvial fan at site 21CR141, which is in the Minnesota River valley near Shakopee (Schoen 2006). Faunal material (n=203), lithic debitage, and charcoal that were interpreted to represent an intact midden deposit from a buried soil, ranging in depth from 316 to 358 cmbs. The site was recommended as eligible for listing on the NRHP based on the discrete deposit of datable materials from the Archaic period, along with the potential for intact features and diagnostic materials from other parts of the site.

Anfinson (1997) proposed that an "Itasca Phase" be designated to describe the Middle Archaic (Prairie Archaic) adaptation to the widespread prairie landscape in the Prairie Lake region. The social organization during the period is poorly understood, but it is likely that the need to adapt to changing environments and the hunting of bison may have led, at least seasonally, to small family bands merging into larger groups that could more efficiently track and hunt the migratory animals. Burials from the period found in northwestern Iowa reveal that people were interred individually in pits with red ochre and ritual items.

6.2.3 Late Archaic

The Late Archaic in Minnesota begins around 5000 BP, as a cooler and moister climate ushered in the beginnings of today's environmental conditions and biomes; a sequence that was completed by around 2500 BP. Late Archaic dates from adjacent regions are generally similar to those proposed by Gibbon (2012). In Iowa the period extends from 4500 to 2500 BP (Benn and Thompson 2009) and from 5000 to 2800 BP (Alex 2000). In Wisconsin the period extends from 3700 to 2400 BP (Pleger and Stoltman 2009). During this time, smaller lakes that had dried up during the Altithermal once again filled in. Forests in the northern and southeastern part of the state expanded as the prairie retreated west and south. These climatic and environmental changes led to the decrease of bison as the main game animal in reforested areas and the arrival of forest animals into their historical ranges. Bison continued to be a primary species across most of southern Minnesota, except in the southeast.

The Late Archaic is defined by diagnostic side-notched and stemmed projectile point types along with groundstone tools (such as manos, matates, mauls, and axes), the use of communal burial sites without mounds (until the period of transition between Late Archaic and Early Woodland), and the increased presence of exotic raw materials (such as native copper and marine shell). Diagnostic Late Archaic point types are divided into regional clusters (Gibbon 2012:79). The *Upper Mississippi River Valley Region* includes the Large Side-Notched Cluster, the Durst Cluster, and the Late Archaic Stemmed Cluster among others. The *Central Mississippi River Valley Region* includes the Table Rock Cluster, the Etley Cluster, the Nebo Hill Cluster, and the Wadlow Cluster. The *Northern Plains region* includes the McKean and Oxbow Clusters. The *Southeast Region* includes the Eva Cluster, the Benton Cluster, the Ledbetter Cluster, and the Dickson Contracting Stem Cluster. As Gibbon notes, however, some Late Archaic point types overlap with the earlier Middle Archaic and later Initial Woodland occupations, and therefore the dating of Late Archaic occupations based solely on point typology is problematic.

The lifeways of the people during this period in Minnesota were marked by adaptations to the changing environmental conditions and to increasing influences from people and cultures in surrounding regions. It was a time of increasing population numbers and more diverse artifact assemblages, which together with the advent of communal burials and expanded exchange of exotic materials, indicate increased social complexity and changes in subsistence patterns.

In southern and central Minnesota, the people likely adapted to two distinct biomes: the prairies of the west and south and the forests of the north and southeast. To the west, the hunting of migratory bison continued, and sites such as Canning (21NR9) may represent seasonal habitations of people who moved east to the woodlands during the cold months. In the north and east, the people of the period became more adept at exploiting stabilized resources such as fish, forest animals, and wild rice. Woodworking tools and fishhooks begin to appear in the archaeological record during the Late Archaic.

Gibbon and Anfinson (2008) use the term Proto-Horticulturalist to describe the addition of garden produce into the resource base of the Late Archaic period, suggesting that this indicates the beginning of a fundamental social transition, although not a heavy reliance on cultivated foods. Fragments of squash (Cucurbita pepo) recovered from a probable Late Archaic context at the King Coulee site near Winona on the Mississippi River is an example of this type of early horticulture from Minnesota (Perkl 1998).

The people during this period likely inhabited a series of relatively stable "base camps" that shifted during the year to access seasonal resources. A variety of smaller special activity areas, such as quarries, butchering, and extraction sites, radiated from these base camps. Communal burials that appear during the Late Archaic period may indicate increasing territoriality associated with greater settlement permanence. Highly ornamented grave goods have been interpreted as an indication of increasing religious complexity; and the appearance of burial mounds at the transition of the Archaic-Woodland periods is perhaps an indication that it had become more important to make these territorial indicators more visible to outside populations.

As with the preceding Early and Middle Archaic periods, the Late Archaic period has been studied much more thoroughly in the central Mississippi Valley and eastern woodlands than in Minnesota, and a great deal of information about the period in Minnesota is still lacking. Artifact assemblages from the period in Minnesota are not as diverse or abundant as those found in other regions, where plant-processing tools are commonly found and exotic materials such as conch shell were widely-traded. Fiber-tempered pottery was present during the Late Archaic in the southeastern states but no such materials have been found in Minnesota.

Sites in the Prairie Lake region with confirmed or possible Late Archaic components include Pedersen (21LN2), Fox Lake (21MR2), and Mountain Lake (21CO2). Anfinson (1997) has proposed a Mountain Lake phase dating from 5800 to 2200 BP, with 21CO2 as the type-site. Excavations at the site recovered small lanceolate points that more closely resemble forms to the east rather than to the west, and none of the distinctly northern-plains point types such as those of the McKean cluster were found at the site. In the prairies of southwestern Minnesota, the bison-centered lifeway continued until around AD 1000 with the advent of the Plains Village culture. The Pedersen site contained bison bone in all occupation levels, along with remains of other mammals, fish, and bird species. Bison bone is also the main component of the Archaic faunal assemblage at the Mountain Lake site.

There is little information about the Late Archaic period in the southeastern deciduous forest zone of Minnesota, but Gibbon (2012) suggests that it may be associated with the Durst phase in southwestern Wisconsin, suggesting that populations were moving into the state from the south and east during this time.

6.3 Woodland Period (2500 to 350 BP)

While the Woodland period has traditionally been defined by the first appearance of pottery, burial mounds, and agriculture, Gibbon (2012:93) proposes that:

> Information gathered within the last twenty years has clearly demonstrated [that these traits] had already made their first appearance in areas of the Eastern Woodlands in the earlier Late and even Middle Archaic.... The result of these discoveries has been a redefinition of the Woodland tradition, a redefinition that now depends more on new socioeconomic adaptations than on shared diagnostic material traits. Still, the first associations of these three traits in about 700 BC in some areas of the Midwest do seem to mark the inception of these new adaptations. Misleading reconstructions of the culture history of other areas of the Midwest have resulted, however, from the assumption that the presence of pottery, burial mounds, or cultigens, or some combination of the three, necessarily means that similar socioeconomic adaptations were present in those areas, too.
>
> The Woodland period in the Midwest has been divided into Early, Middle, and Late periods based on cultural developments that have been documented primarily in the lower Mississippi Valley region. Gibbon points out that these cultural developments occurred in Minnesota and other parts of the northern Midwest and plains much later or not at all. Furthermore, he argues (2012:93) that "...unique adaptations and artifacts appear in the prairies, Northwoods, and boreal forest of Minnesota that have no specific counterparts in the traditional lower tier zone to the south." To accommodate this distinction, Gibbon divides the Woodland Period into *Initial* and *Terminal* periods rather than Early, Middle, and Late in all but the southeastern corner of the state. He concludes that ... "Although awkward at times, these concepts stress the unique accomplishments of Native Americans in our region rather than their marginality to events and processes that occurred in different environments to the south.

During the late Holocene, from the end of the Archaic period through the Initial Woodland period, the climate and landscape continued to evolve. These changes are well-documented through an extensive series of a series of pollen core studies from across the state and by correlation with other research on vegetation and climate change across the continent. Arzigian (2008:8) summarizes the climate and landscape developments of the Woodland period in Minnesota:

> Of greatest significance to the Woodland tradition is a period of cooler temperatures, the Sub-Boreal, that extended through the Early and Middle Woodland periods and was followed by the warmer Neo-Atlantic and Pacific periods, and then the cooler, moister Little Ice Age from about AD 1550 until 1915. During these broader climatic shifts and more local changes, the most noticeable changes would have been the local expansion or contraction of the prairie-forest ecotone and the prairie bison herds. Changes in local lake levels would have affected settlement patterns adjacent to the lakes, with some lakes drying up completely. Fires would have caused changes in the composition and distribution of forests as well as expansion of shrublands and savannas. Fire frequency would have been affected by local and regional climatic conditions, and possibly also by the human population. Starting about AD 1550, the Big Woods expanded at the expense of prairies as a result of changes in fire frequency in the cooler, moister Little Ice Age climate.

6.3.1 Initial Woodland in Southeastern Minnesota

The Initial Woodland Period in Minnesota dates from approximately 2500 to 1300 BP. This period begins around 2500 BP in the southeastern corner of the state. In the rest of southern Minnesota, the Initial Woodland begins around 2200 BP.

Gibbon (2012) differentiates the Initial Woodland period in the southeastern part of the state (Southeast Riverine region) from the rest of the state by separating the period into the *Southeast Minnesota Early Woodland* (2500 to 2200 BP), the *Havana-Related Middle Woodland* (2200 to 1800 BP), and the *Late Middle Woodland* (1800 to 1500 BP) sub-periods. These sub-periods reflect the Woodland period culture history of regions to the east and south in Wisconsin and Iowa, with which the people in southeast Minnesota appear to have been more closely associated than they were with cultures to the west. Outside of the Mississippi River Valley, the Initial Woodland period in southeastern Minnesota is not well known. Few sites have been excavated, and there has been little systemic research. Therefore, Gibbon cautions that the dates and content of the period remain tentative.

Southeast Minnesota Early Woodland

The Southeast Minnesota Early Woodland period (2500 to 2200 BP) is recognized by diagnostic La Moille Thick pottery, which resembles Marion Thick and other very early pottery types in the southern Midwest. La Moille Thick pottery is cordmarked and has distinct vertical to oblique exterior surface marking and horizontal to oblique cordmarking on the interior. A variety of straight-stemmed projectile points, most commonly the Kramer type, are associated with La Moille occupations. In southwestern Wisconsin, the later part of the Early Woodland, dating to 2100 BP to 1900 BP, is characterized by Black Sand–related Prairie ceramic wares and Waubesa points that have rounded, contracting stems (Arzigian 2008:32; Stevenson et al. 1997:150). Arzigian (2008:30) states that it is unclear whether mounds are associated with the Early Woodland, and that the lack of data on the period in southeastern Minnesota "might reflect the gradual nature of the transition between Archaic and Woodland in this region, and the probable persistence of Archaic lifeways with the addition of ceramics that reflect intermittent contacts with other regional cultures."

Only a few sites have been recorded in Minnesota with La Moille pottery and these include the type-site La Moille Rockshelter (21WI1) in Winona County. The site, located in the bluffs along the Mississippi River, was a deeply-stratified rockshelter excavated by Wilford in 1939. The site was described as a "fishing camp" and in addition to ceramics it contained fish, turtle, and mammal bones along with charcoal and clam shell but few other artifacts. Other Early Woodland sites include Schilling (21WA1), Kunz (21WW8), Enno Schaeffer (21FA104), and NSP II (21GD59). Arzigian (2008) concludes that there is not enough information to speculate on Early Woodland lifeways or settlement patterns in southeastern Minnesota, although it is likely that the people followed as seasonal resource-gathering pattern similar to that of the Archaic period.

Havana-Related Middle Woodland

Gibbon (2012) describes two Havana-Related Middle Woodland period phases in Minnesota, *Howard Lake* and *Sorg*, although Arzigian (2008) adds a *Malmo* phase to the period. *Howard Lake*, with sites concentrated in the Anoka Sand Plain, is considered to be the northernmost regional variant of the Havana Hopewell culture from the Central Illinois River Valley. Significant sites include the type-site 21AN1 (Howard lake), Anderson (21AN8), and Long Lake (21HE100). Sites from the *Sorg Phase* are found mainly in the northern portion of southeast Minnesota, with a concentration along the shores of Spring Lake near St. Paul. Significant sites include the type-site 21DK1 (Sorg), Lee Mill Cave (21DK2), and Hamm (21DK3). Malmo phase sites are the most common of the Havana-Related period and they are found across much of central and eastern Minnesota, with concentrations around the Mille Lacs area and from there to the west into Ottertail County and the plains. Arzigian (2008:37) suggests that there may be a significant underestimation of the distribution of Havana-Related occupations in Minnesota as the statewide database of archaeological sites lists many "Middle Woodland" sites that might be included following a careful examination of ceramic assemblages.

Havana-related ceramics are wide-mouthed jars with thick walls, straight rims, slightly constricted necks, and sub-conoidal bases. They are grit-tempered and are decorated with punctates, bosses, incised lines, slashes, cordwrapped-stick impressions, and dentate stamping. Lithics from the period include small notched and stemmed Manker and Snyders-like points along with small blades, cores, flaked scrapers, perforators and expedient tools. Most lithic raw materials are local but exotic raw materials such as obsidian, Hixton silicified sandstone, and Knife River Flint were also used.

Burial Mounds are present at some *Howard Lake Phase* sites and some of these mounds are quite large and complex, with primary and secondary burials. One of the most significant Havana-Related Middle Woodland sites in Minnesota is 21RA10 (Indian Mounds), which is close to the project area on a bluff overlooking the Mississippi River in St. Paul. Many of these mounds have been excavated, and all were found to contain human remains (Arzigian and Stevenson 2003). Burial treatment and exotic artifacts recorded at several of the mounds reflect Hopewellian influence.

Arzigian (2008:50) points out that there is also a lack of information sufficient to confidently identify a Havana-related settlement pattern in Minnesota, although there is a reasonable expectation of evenly-spaced villages sited along stable resource zones, with relatively large summer villages and smaller winter villages. Summer villages might show evidence of fishing, winter villages of hunting. There should also be burial mounds and smaller special-activity sites. Gibbon and Hohman-Caine (1980) report that Havana-Related Middle Woodland sites generally are found in the hardwood forests, oak savannas, and prairies of southeastern Minnesota in settings that represent cultural adaptations to major riverine environments that include wet prairies, marshes, sloughs, oak openings and barrens, and aspen-oak woods.

Late Middle Woodland

The Late Middle Woodland period in Minnesota is largely unknown and Arzigian (2008) does not cover it as a separate complex. Gibbon (2012) states that the period involved a gradual process of transition from the Havana-Related to the Late Woodland in southeastern Minnesota and the Upper Mississippi valley. He uses the closely-related Millville and Allamakee phases of northeastern Iowa and southwestern Wisconsin as surrogates for the period in Minnesota. The primary distinction of the Late Middle Woodland period is the appearance of thin-walled Linn ware ceramics in a series of seemingly more spatially-restricted occupations, as opposed the relatively widespread presence of Havana wares. Lithic assemblages are defined by the side-notched Steuben point and smaller Ansell points from later in the period. Scrapers, drills, knives, and groundstone tools are also present in assemblages. Some burials of the period continued to be in mounds, although they tend to be smaller and less complex than those of the Havana-Related period. Other burials have been found in pits. Gibbon (2012) suggests that the period represents a process of cultural differentiation or regionalization that occurred in a series of steps. Overall, it appears to have been a less materially-elaborate time than was the earlier Havana-Related period. The Transitional Woodland complex from central Minnesota is a comparatively similar complex for the adjacent area to the north, although there is geographical overlap in the complexes. This complex is discussed below.

6.3.2 The Central Minnesota Transitional Woodland Complex

Some ceramics from 21HE497 are similar to St. Croix stamped ware from the Central Minnesota Transitional Woodland complex, which spans the period of roughly A.D. 300 to A.D. 1000 (1700 to 1000 BP), a period of transition between Middle Woodland (Malmo) and Late Woodland (Blackduck-Kathio) complexes Arzigian (2008). The Transitional Woodland complex is presumably associated with significant shifts in technology, interregional interaction, mortuary practices, subsistence, and settlement, although there is a lack of data to fully document the complex and these probable changes.

Dating of the complex has been based on a relatively small amount of stratigraphic information, radiocarbon dating, and on similarities to other transitional Woodland sherds, such as Onamia-like ceramics from southwestern Wisconsin. Two phases were initially defined for this period in the Mille Lacs area, distinguished by ceramic style; the Isle phase (A.D. 500–800 / 1500 to 1200 BP) with St. Croix pottery and the Vineland phase (A.D. 800–1000 / 1200 to 1000 BP) with Onamia pottery, although there has been some debate among recent researchers over the date ranges for the two ceramic styles and the relationships between them, including the possibility that both styles should be subsumed into subtypes of a single Onamia Series.

Geographically, the complex is defined in Central Minnesota (SHPO archaeological regions 4, 5, 6), though similar ceramics and lifeways are found in adjacent areas (Anfinson 2006; Arzigian 2008). Sites with St. Croix stamped ware extend as far south as the Minnesota River, with a few sites even farther south (Arzigian 2008:206). Two sites are located near the Hennepin and Craver county border near the Minnesota River. Concentrations of sites occur at Mille Lacs and along the Snake River drainage, but sites occur over a much larger area in the region. St. Croix and Onamia pottery are commonly found in the south-central Deciduous Lakes archaeological subregion (Johnson 1994:3.51–3.52) and occur across most of the Minnesota except in the northeast and extreme south. St. Croix Stamped ceramics occur in adjacent areas of northwestern Wisconsin, northeastern South Dakota, and eastern North Dakota.

In general, peoples of the Central Minnesota Transitional Woodland complex followed a hunting-gathering lifeway similar to that of the preceding period and settlement patterns are believed to reflect seasonal use of sites. There are connections between the complex and the later Blackduck-Kathio complex in central Minnesota and to contemporaneous cultures in southwestern Minnesota such as Lake Benton. Arvilla burials have been linked to this complex through the presence of St. Croix and Onamia pottery in burial mounds. Principal sites from the Central Minnesota Transitional Woodland complex in the Mille Lacs area include: 21ML2 (Aquipaguetin Island), 21ML3 (Crace), 21ML6 (Indian School), 21ML7 (Vineland Bay), 21ML9/16 (Cooper), 21ML11 (Petaga Point Site [NRHP]), 21ML12 (Lloyd A. Wilford Site [NRHP]), and 21ML20 (Old Shakopee Bridge). Property types expected for the complex include: habitation sites, resource procurement and processing sites, special-use sites, mound sites, and non-mound mortuary sites.

Leland Cooper first defined St. Croix as a distinct ceramic type based on his excavations at the Altern site in Wisconsin, at Mille Lacs Kathio State Park, and at the Vach, Stumne and Neubauer sites in Pine County (Caine 1966, 1969). This ceramic ware was noted by Elden Johnson as marking the transition from the Middle Prehistoric period to the Late Prehistoric Period in the Mille Lacs region. Elden Johnson included St. Croix as a ceramic series in his initial Mille Lacs typology in 1968 (Dickinson 1968, Bleed 1969), and Christy Caine defined St. Croix Stamped as a ceramic series in *A Handbook of Minnesota Prehistoric Ceramics* (Anfinson 1979). Additional information is presented in George (1979) and (Caine 1983). Matthew Thomas includes St. Croix Stamped as a type within Onamia Ware, based on their many shared similarities (Thomas 2000). In Thomas's typology, Onamia Type I is traditional Onamia ware, Type II is that which Gibbon lists as St. Croix Dentate Stamped Type, and

Type III is the same as Gibbon's St. Croix Comb Stamped Type.

Arzigian (2008) describes St. Croix vessels as subconoidal to rounded, with slight neck constrictions, high vertical rims, and rounded shoulders. They range in size from small bowls with openings of eight centimeters to large vessels with openings of 40 centimeters. They are grit-tempered (often crushed granite) with a surface treatment as tightly-spaced cordwrapped paddle impressions. Rims are usually smoothed before decoration and two varieties of lips have been defined; dentate-stamped and comb-stamped. The dentate-stamped variety features simple geometric decorations formed of square or rectangular impressions that form rows of parallel horizontal, oblique, or vertical lines around the vessel. Occasional rectangular punctates border the lower edge of the decoration. The comb-stamped variety also has simple geometric decorations in rows of parallel horizontal, oblique, or vertical lines in various combinations but with V-shaped rather than rectangular impressions. Caine (1974:63) describes two dentate stamp tools recovered from the Snake River area: "One is made of bone, the other of white chert. When applied to moist clay, both form a dentate impression of the type found on St. Croix Stamped pottery from the region." An additional minor variety is characterized by cord-wrapped stick impressions. Interior treatment consists of horizontal striations. Wall thickness averages four to five millimeters, lip and neck thicknesses average 6.5 millimeters. The vessels are made of medium- to fine-textured paste, though both coarser and sandy-textured pastes were used.

One of the type vessels for St. Croix ware was recovered in the early 20th century from the Fort Poualak site (21CW7/14) on the Whitefish chain of lakes in Crow Wing County (Caine 1983). The context of the find was interpreted as a house depression, and two other fragmented St. Croix vessels were found at the same time. Charcoal residue from the exterior shoulder of the pot provided the first radiocarbon date from St. Croix pottery, ranging from approximately A.D. 600 to 760.

Onamia Series vessels are often very similar to St. Croix in form and decoration and they can be difficult to distinguish. Onamia vessels are also subconoidal to semi-subconoidal, with a constriction of the neck that creates a pronounced shoulder. The rims are straight and vertical, with a wide orifice. The surface of these pottery types is cord-marked, and the walls are notably thinner than Malmo Ware, averaging approximately six millimeters in thickness. Onamia Series ceramics are tempered with grit, composed primarily of crushed granite (Caine 1979, 1983; Ready and Anfinson 1979; Thomas 2000). Decoration of Onamia Series pottery consists of impressions made by a cord-wrapped stick or dentate stamps in oblique and horizontal bands. Cord-wrapped stick impressions are the more common of the decoration types, forming an oblique row around the exterior and sometimes also the interior of the rim. A horizontal band of impressions often appears below the oblique band and sometimes there is a horizontal band of impressions on the rim. When dentate stamps are used, they tend to be described as "heavy" when compared to St. Croix, with larger, more widely-spaced teeth.

Three varieties of the Onamia Series are defined by decorative motif, based on analyses by Caine (1983). Type I is the traditional Onamia Ware, with long oblique decorations, and decoration on the interior of the rim. Types II and III are varieties of the traditional St. Croix Ware. The first (Type II) is typified by oblique or vertical over horizontal decorations, with interior decorations. A subtype has cord-wrapped object impressions. Type III has horizontal decoration but no lip or interior decoration. A subtype has bosses (Thomas 2000). Previous definitions of these wares are provided by Caine (1979, 1983) and Ready and Anfinson (1979). St. Croix mortuary pots from the Arvilla Complex are generally miniature versions of the ware, and are presumed to not be functional artifacts (Johnson 1973).

Caine (1966:89) has suggested that St. Croix pottery was probably made with coils and shaped with a paddle and anvil, though she also acknowledges (1983:94) that there is no good evidence in support of any particular manufacturing technique. She notes (1983:192) that there are distinct size differences between the smaller mortuary vessels from Stumne and DeSpeigler and the much larger vessels from

Cooper Mounds and Poualak/Hay Lake (21CW7/14).

Little is known about lithic use or technology in the Central Minnesota Transitional Woodland complex. The Q-Pattern, reflecting heavy reliance on quartz, continues to be prevalent throughout this period (Bakken 2000), suggesting continuity with the preceding Havanna-Malmo Period. Projectile points found with Onamia ceramics are predominantly side-notched, sometimes described as similar to Prairie Side-Notched. Side-notched Cross Lake points have been associated with St. Croix ceramics in the Snake River Valley (Caine 1969, 1974). Unnotched triangular points have also been recovered. Arzigian (2008) describes the lithics recovered from site 21AN108, a considerable distance south of the Mille Lacs area, and one of the few sites with a well-defined assemblage. Large amounts of fire-cracked basalt and granite were found along with three utilized flakes, two cores, two biface fragments, two retouched blades, two scrapers, and one point. Most of the assemblage was of local raw materials. Burlington chert, Hixton silicified sandstone, Knife River flint, and obsidian were also present.
Very little specific information regarding subsistence for the Central Minnesota Transitional Woodland complex has been recovered from excavations. The Isle Phase is inferred to represent a shift to focal resource use, with a particular emphasis on wild rice utilization (Gibbon and Caine 1980; Johnson 1984). Evidence for this is derived from phytolith analysis of food residues from the Fort Poualak bowl at site 21CW7/14 in nearby Crow Wing County. The charred material from inside the vessel produced a phytolith assemblage consistent with wild rice, but it is cautioned that the diagnostic phytoliths were too infrequent for statistical certainty (Thompson 2000). It seems likely that the Black Brook site plant macrofossil data from the Rum River Phase (*Chenopodium* and raspberry) apply to the Isle Phase as well.

Despite the limited data, Arzigian (2008) outlines a model of subsistence strategy changes proposed by researchers for the Central Minnesota Transitional Woodland complex. An increasing dependence on wild rice and large or abundant animals suggests an increasing availability of wild rice, perhaps as a consequence of ongoing climatic changes, that allowed for the sustenance of growing populations that could not be readily supported by traditional hunting and gathering food resources. She cites Caine (1983) in suggesting that the rapid stylistic changes that culminated in the development of St. Croix ceramics are related to this increased population density, and the shift from diffuse to focal subsistence patterns that this necessitated. The distinctive style of St. Croix ceramics found across a very wide area may also have played a role in maintaining social unity as increasingly large populations began to segment.

Linear earthworks are loosely associated with St. Croix ceramics through Johnson's (1973) definition of the Arvilla Complex. With the working assumption that they can be assigned to the Isle Phase, they are certainly the most visible indicator of sites dating to this time. Linear mounds are found from the Pine City area east of Mille Lacs to the western prairies and in the Red River Valley (Johnson 1973:3-5) with many around the Mille Lacs area. Conical mounds are also known from the Isle Phase, as seen at Cooper Mound 3, excavated by Jan Streiff in the late 1960s. Conical mounds are also listed as a trait of the Isle Phase by Johnson (1984).

Little is known of the temporal, spatial, and cultural relationships between the Central Minnesota Transitional Woodland complex and earlier, later, and contemporary cultures. Arzigian (2008) discusses possible relationships between St. Croix and early Blackduck bossed ceramics and between Onamia and Lake Benton ceramics to the west. In terms of settlement, the Isle Phase does truly seem "transitional" (Caine 1983; Johnson 1984). Some sites, such as Black Brook, show continuity from the preceding Rum River Phase. At others, such as Cooper and Griffin, the Isle Phase appears to be the beginning of an occupation that intensified in later phases. The landscape position of sites is a constant in Mille Lacs archaeology, as all sites are situated on high ground in proximity to water. It is believed that population densities were increasing during this period based on an intensified exploitation of wild rice and a few large animals, although there is not enough subsistence information from excavations to prove this belief. Johnson (1984) suggests a pattern of small winter habitation sites with scattered summer occupations and possibly small-group hunting camps. Most habitation sites with St. Croix Stamped series ceramics have been found along streams near lake outlets. Little information is available on structures or within-site patterning.

6.3.3 Late (Terminal) Woodland in Southeastern Minnesota

The Late Woodland period in southeastern Minnesota dates from ca. 1500 to 800 BP, the time of first European contact. The period is marked in the archaeological record by changes in the design and manufacture of ceramic vessels and projectile points. Throughout the period, population sizes continued to increase and dependence on domesticated plants was becoming more widespread. In southeastern Minnesota and nearby parts of Wisconsin, Iowa, and Illinois, the people of the Late Woodland also developed new forms of social organization, as evidenced by the disappearance of burials in large mounds that contained non-utilitarian items made of exotic materials. In southwestern Minnesota, the Late Woodland period evolved differently than in the southeast, as Gibbon (2012:137) explains:

> Many but not all of these cultural innovations and elaborations [of the southeast] reached southwestern Minnesota by at least A.D. 900. More dramatic changes occurred throughout the southern part of the state between A.D. 900 and 1100, when agricultural societies with large, often defended villages and new material equipment appeared. Later forms of these "Mississippian" cultures still occupied parts of southern Minnesota when European missionaries and adventurers first paddled the Mississippi and Minnesota rivers.

The period of change from Initial to Terminal (Late) Woodland in the southeastern part of the state remains poorly understood, but the main material features found in the archaeological record include the development of the bow and arrow, effigy mounds and elaborate mortuary rituals, increasing long-distance trade networks and the acquisition of exotic materials, an elaborate smoking-pipe complex, and possibly the development of socially-ranked societies (Gibbon 2012). Population sizes were increasing and appear to have begun to develop into more localized cultures with year-round settlements. Domesticated plant foods became an important part of the subsistence base and ceramic vessels developed thinner walls and a finer temper. Given the general lack of data from the period in Minnesota, Gibbon (2012) relies on information from sites in neighboring states and adopts the terminology used for the period in the driftless area, dividing the period into *Initial, Mature,* and *Final* Late Woodland sub-periods.

The Initial Late Woodland spans the period of 1500 to 1300 BP and includes the Mill phase and Lane Farm phases in Wisconsin and Iowa. The ceramic type, Lane Farm, is a cord-impressed ware with a somewhat rounded base and constricted neck. Decoration includes cord impressions on the rim and rocker stamping on the body. The walls are thin and use a fine grit temper. Small corner-notched projectile points (Steuben Stemmed and Manker Corner-Notched types), which may have been the first true "arrowheads" in the region, are associated with the early part of the phase. Other possible points from later in the phase include Scallorn, Klunk Side-Notched, and Koster Corner-Notched. The forms of these points vary greatly and can range for broad to slender, corner-notched to barbed, and straight to convex blade edges. Elongated linear mounds with a limited number of grave goods (including copper beads and clay pipe parts) were developed during the period.

The Mature Late Woodland, from 1300 to 1000 BP, is best known by the Effigy Mound Complex of Southern Wisconsin, with a smaller number of sites in Iowa, Minnesota, and Illinois. A primary ceramic component of the complex, Madison Cord-Impressed, extends throughout southeastern Minnesota to the vicinity of the Blue Earth River. Madison ware vessels are thin-walled and use a fine grit temper. The vessels are globular in shape with constricted necks and out-flaring rims. They have cord-impressed decorations on the exterior and most vessels found are similar in their design treatment, featuring geometrical patterns. Another ceramic type associated with the period is the Angelo Punctated, which is also thin-walled and cord-marked, but is decorated with punctates and fine trailing lines in complex patterns. Gibbon (2012) suggests that the Angelo ware shares traits with Great Oasis ceramics.

Arzigian (2008:105) discusses some considerations regarding the use of Madison Ware in evaluating the Mature Late Woodland period:

> Ceramics with single cords used as decoration over a cord-roughened surface are found across central and southern Minnesota, but the ceramics are not coded as such in the SHPO database and cannot be readily separated except by examination of the ceramics themselves. Detailed ceramic studies are needed for [Mature] Late Woodland sites in Minnesota. The full range of ceramic types in southern Minnesota [Mature] Late Woodland sites should be evaluated, along with a consideration of how they compare to series defined elsewhere in the Midwest. Because of the presence of a geographic reference in the complex name, archaeologists are likely to have identified this complex for the SHPO/OSA database only for sites in southeastern Minnesota, although the ceramics and other aspects of the complex might be found further west and north.

Other ceramic types that Arzigian suggests might be identified within the *Mature Late Woodland* period in Minnesota include Lane Farm, Madison, and Minott Cord-Impressed wares. Projectile points from the period are small, stemmed and side-notched or unnotched in form. Diagnostic types from early in the period include Scallorn, Klunk Side-Notched, and Koster Corner-Notched (the same as in the *Initial Late Woodland* period). The later part of the period (ca. 1200 BP) is marked by the widespread adoption of the simple unnotched triangular Madison Point throughout the eastern United States. Other lithic tools found in association with the Effigy Mound Complex include scrapers and utilized flakes along with a variety of groundstone tools (adzes, axes, celts, grinding stones, pounding stones). Bone awls, needles, punches, and harpoons have also been recovered, along with exotic or ritual goods such as cooper knives and points, clay pipe elbows, obsidian blades, cut mica, effigy pipes, ear spools, and worked shell. Gibbon (2012) points out that Havana-related artifacts are conspicuously absent from *Mature Late Woodland* assemblages.

Two significant *Mature Late Woodland* sites are Sorg (21DK1) at Spring Lake in Dakota County and the Prior Lake Mounds (21SC16) in Scott County, which is the only excavated effigy mound site in Minnesota. Middle and Late Woodland deposits were excavated at Sorg and a variety of Madison ware was recovered, including Cord-Impressed, Punctated, and Plain. The Prior Lake Mounds site is in an upland setting adjacent to the driftless area and is the only know Effigy Mound complex site in Minnesota not adjacent to the Mississippi River. It consisted of five bird effigies and four linear mounds when mapped in 1883. Madison Cord-Impressed and Madison Plain ceramics were recovered from 21NL140 (Falls habitation site), which is on a terrace overlooking the Minnesota River valley west of Mankato, and from 21BE24, just south of the Minnesota River. These are the westernmost sites in Minnesota known to have *Mature Late Woodland* components. Site 21CR156 near the current project appears to have Madison ware ceramics.

The *Final Late Woodland* spans the period of 1000 to 800 BP and is defined by significant changes in the archaeological record of southeastern Minnesota and the Upper Mississippi valley. Effigy mounds are no longer found, and stockaded sites with Mississippian traits become more common as it appears that large portions of the driftless area were abandoned. Corn horticulture and distinctive grit-tempered collared ceramics belonging to the Grant series are found throughout the area of western Wisconsin, southeastern Minnesota, northern Iowa, and northern Illinois. Grant series ceramics are cord-roughened globular vessels with prominent rims that feature collars castellations, and squared orifices. The rims are higher than those of Madison ware vessels and they flare out more. They have a broader shoulder, thicker cord-impressions, and less complex decoration. When present, exterior-surface decoration is generally a single-cord impression in a chevron or zigzag form. It has been suggested (Gibbon 2012:146) that the shape and size of Grant series vessels was designed for simmering large quantities of grain, which requires longer and more gradual heating than does the cooking of seeds and other foods from the time before corn horticulture. Projectile points common to the period include the Madison Triangular type along with Cahokia, Reed, Harrell, and Des Moines types of the Cahokia Side-Notched cluster. Bryan, King Coulee, and Mero I are significant sites from the *Final Late Woodland* in southeastern Minnesota and western Wisconsin.

Following the end of the *Final Late Woodland* period in the Upper Mississippi Valley, Oneota peoples seem to be the only cultural group that remained into the period of Euro-American contact in the seventeenth century. Gibbon and Anfinson (2008) discuss two hypotheses to explain the development of the Oneota culture. Under the first hypothesis (credited to Stoltman and Christiansen 2000), the Effigy Mound Culture of southern Wisconsin, which had established cultivation as a major form of subsistence while continuing a mobile lifestyle that involved regular gatherings at important ritual sites where social bonds were reinforced and territories were demarcated, was gradually influenced by the Middle Mississippian culture centered at Cahokia. As these influences continued to expand, the Effigy Mound peoples were drawn to central locations such as the Red Wing locality to facilitate contact with Cahokia. These newly-emerging Oneota peoples adopted an increasingly sedentary lifestyle focused on maize horticulture and along with it, new social and ceremonial behaviors associated with planting and harvesting.

A second hypothesis from Gibbon and Anfinson (2008) suggests that the cultural developments in the middle Mississippi Valley between 1200 and 1000 BP, which led to the emergence of Cahokia, also reached into the upper Mississippi and Missouri River Valleys and led to the development of maize-growing Oneota and of Plains Village cultures. Under this hypothesis, the widespread Oneota cultural influences found throughout the northern section of the Prairie Peninsula by 800 BP represent a transformation rather than a displacement of Late Woodland peoples through the integration of Middle Mississippian influences and the migration of Oneota peoples from southern Wisconsin, where the culture had already emerged.

6.3.4 Mississippian/Plains Village

The Woodland period in southern Minnesota ended by 800 BP, overlapping with the advent of cultures that began to live in larger settlements, which were often fortified. Distinctive ceramics of the period are identified by shell rather than grit temper, handles rather than collars, smoothed rather than cord-marked surfaces, and decoration on the shoulder rather than rim. These cultural complexes been grouped into a number of cultural subdivisions associated with the central Mississippi River Valley, based on material traits that are more similar to that region than to the earlier local Woodland cultures. The Mississippian cultural manifestation in the central Mississippi River Valley is known as the Middle Mississippian. The northern region has traditionally been known as the *Upper* Mississippian and in the prairie region as the *Plains Village* Mississippian, although Gibbon (2012:159) notes that this usage suggests that the peoples of the period inhabited either "fringe" societies or were migrants from the south. Instead, he argues that the processes of change between Terminal Woodland and Mississippian cultures in Minnesota were more complex and subtle than is suggested by a dependency on cultures to the south and east, and he proposes that the terms *Upper* and *Plains Village* be eliminated – although he acknowledges that it is necessary to continue their use in making comparisons to other areas.

Mississippian complexes in Minnesota include Silvernale, Great Oasis, Cambria, Big Stone, and Blue Earth phases. Archaeological sites from these phases are concentrated along the Minnesota River trench from Mankato to the Red River and at the confluence of the Cannon and Mississippi Rivers near Red Wing.

Silvernale Phase

The Silvernale Phase (950 to 800 BP) is the clearest example of the Middle Mississippian in Minnesota, Illinois, and southern Wisconsin, and it is strongly related to the cultural center at Cahokia, Illinois. The complex is characterized by large fortified villages that were often surrounded by conical burial mounds. Corn horticulture and subterranean storage pits were used. Ceramic vessels are shell-tempered and have rolled rimes and Ramey-scroll designs. Ceremonial objects made of exotic materials such as copper and marine shell from the southeast are found, along with ceramic mask carvings that resemble objects from sites in the southeast. Other artifacts found at Silvernale sites, such as stone tools, and many of the lithic raw material types, appear to be more related to Upper Mississippian cultures. Large Silvernale village sites include Silvernale, Mero, and Adams.

Great Oasis Phase

Great Oasis (1050 to 900) is considered to be the earliest and most widespread Plains Village phase. Ceramics are grit-tempered, globular vessels with a smooth exterior or cordmarked-smoothed and trailed line decorations and motifs. Decoration consists of bands of incised horizontal and oblique parallel lines along the rims, which are outflared and outcurved. The lips are thickened and beveled. Lithic assemblages include small notched and triangular projectile points; a variety of ground stone tools, (celts, abraders, hammerstones, manos, and mutates). A variety of bone and shell items such as awls, chisels, and beads are also found at Great Oasis sites. Corn horticulture was a component of the complex and settlements were focused along shallow lakes in southwestern and western Minnesota, Iowa, Nebraska, and the Dakotas. The Great Oasis site (21MU2) is the primary Great Oasis phase site in Minnesota. No Great Oasis sites have been identified in the southeastern Minnesota region.

Cambria Phase

The Cambria Phase (900 to 800 BP) includes Woodland, Middle Mississippian, and Plains Village characteristics. The ceramics are grit-tempered, globular vessels with a smooth surface. Lithic assemblages contain small side-notched and triangular projectile points; ground stone tools such as celts, abraders, and hammerstones. Bone and shell items such as scapula hoes, punches, and awls have been recovered. Evidence suggests that this phase was linked to the trade network centered at Cahokia. Settlement patterns include village sites on terraces of the upper Minnesota River and smaller habitation areas by lakes or rivers. Subsistence was based on hunting, fishing, gathering wild plant and aquatic foods, and the cultivation of maize and sunflower. The type site is 21BE2 (the Cambria site), which is located along the Minnesota River in Blue Earth County near Mankato.

6.3.5 Oneota Tradition

Oneota sites occur south of the Minnesota River and in the St. Croix River Valley in prairie and forested areas, dating from 800 to 300 BP. Two main phases have been defined: the Blue Earth Phase and the Orr Phase, which is restricted to far southeastern Minnesota and the adjacent area in Iowa.

Blue Earth Phase

The Blue Earth Phase (800 to 500 BP) occurs across southern Minnesota, with notable sites at Red Wing (Bartron), near Stillwater (Sheffield), and also along the Blue Earth and Upper Minnesota rivers. This phase is characterized by smooth surfaced, shell-tempered ceramics and triangular unnotched arrow points. Agriculture is evident from bison scapula hoes and plant remains of maize, sunflower, squash, and beans. Sites consist of large village farming communities with smaller hunting and gathering camps.

7. Environmental Background

7.1 Modern Environment

Site 21HE483 is located in the Long Meadow Lake Unit of the U.S. Fish and Wildlife Service's (USFWS) Minnesota Valley National Wildlife Refuge. This is a natural scenic area in the Minnesota River bottoms. The site is on the south side of Old Cedar Avenue in the parking lot on the west side of the Long Meadow Lake (Old Cedar Avenue) Bridge.

The site is near the bluff base at the south end of a long sand and gravel ridge or bar (low terrace) that trends southwest to northeast, on the north side of the Minnesota River in Bloomington, Minnesota. The ridge is bounded on the north and west by a small southwestward flowing perennial stream and associated marsh. This stream swings around the south end of the ridge, where it enters the main floodplain of the Minnesota River valley. The ridge is bounded on the south and east by Long Meadow Lake and associated marsh. Along the eastern side of the ridge, erosion has exposed a cobble-rich zone two to three meters above the current floodplain. Cobbles are scattered along the side slope of the ridge, which may have alerted prehistoric groups to the potential for toolstone quarrying at this site. The main channel of the Minnesota River is about 1000 meters east of the site.

7.2 Geology of the Minnesota River Valley Region

The stone resource exploited at 21HE483 is geological in nature. To understand the site, it is therefore necessary to understand certain aspects of the regional geological context. First, we need to understand the kinds of rock that would be regionally available. This involves looking at both bedrock and glacial geology. Second, we need to understand the forces responsible for transporting this rock along the valley and for depositing the rock at 21HE483. Specifically, this means the creation of the Minnesota River valley by catastrophic drainage from Glacial Lake Agassiz, and the subsequent geomorphic evolution of the valley.

The bedrock seen in the upper Minnesota River valley (headwaters to about Mankato) is quite distinct from the bedrock of the lower valley (Mankato to the Mississippi River) (Table 4). In the upper valley, the basic sequence is Early Precambrian gneiss with Middle Precambrian granitic intrusions, overlain by Late Precambrian quartzite, overlain by Cretaceous shale, sandstone and some lignite (Morey 1972; Austin 1972a, 1972c). All of these may have contributed to the lithology of the deposit at 21HE483. However, it is likely that only the Late Precambrian Sioux Quartzite made a contribution to the complement of toolstone. The quartzite itself was occasionally used, even though it is tenacious and might be considered at best a marginal quality raw material (Bakken 1997, 2011). Conglomerate found at the base of the quartzite contains cobbles and pebbles of poorly known chert, quartz, and other toolstone (Justin and Radford 1990a, 1990b; Terrell et al. 2005). Clasts that weathered free of the conglomerate were used for flintknapping, but the supply would have been very limited and this must be considered a minor resource.

In the lower valley, the basic sequence is Cambrian sandstone, overlain by an Ordovician sequence that includes carbonate formations containing chert, and over that a patchy distribution of unconsolidated Cretaceous Ostrander Sand (Austin 1972c; Sloan 1964). The Prairie du Chien Group includes the Shakopee and Oneota formations, although the two are not always distinguishable in the study region. Each formation includes several members, most of which contain chert. The chert from the different members can vary considerably (both between and within members), and in Minnesota chert from all members is often identified simply as Prairie du Chien Chert, although recently there has been some progress in distinguishing chert from different members (Wendt 2014a, 2014b).

Table 4. Summary of Relevant Bedrock in the Minnesota River Valley Region.

Chronology	Upper Valley	Lower Valley
Cretaceous	Shale, sandstone, lignite	Ostrander Sand
Ordovician		St. Peter Sandstone
		Prairie du Chien Group carbonates
Cambrian		Various sedimentary deposits, sandstone predominates
Late Precambrian	Sioux Quartzite	
Middle Precambrian	Igneous intrusives	
Early Precambrian	Igneous and metamorphic, principally gneisses	

Based on Austin 1972a, 1972b, 1972c; Grant 1972; Morey 1972; Mossler 1972; shading indicates potential toolstone contributions

7.3 Glacial History and Physiography

The most recent glacial activity in the region occurred during the Late Wisconsin glaciation at the end of the Pleistocene when much of the Upper Midwest was buried beneath glaciers. The Des Moines lobe covered much of western and east-central Minnesota, receding and advancing several times between 15,000 and 11,700 years BP when it finally retreated (Clayton and Moran 1982; Gilbertson 1990). The project area is situated near the eastern extent of the Des Moines lobe. These glacial deposits shaped the surficial features of the landscape that characterize the region today. The final retreat of the Des Moines lobe left behind a vast glacial lake (Lake Agassiz) in northwestern Minnesota that was drained by Glacial River Warren, which carried a tremendous flow of water, forming the wide and deep valley that is now drained by the Minnesota River.

The project area is located in the Owatonna Moraine Area physiographic region, which is characterized by a series of moraines that formed along the eastern margin of the Des Moines lobe (Hobbs and Goebel 1982; Wright 1972b).

7.3.1 Glacial Geology of the Minnesota River Valley and Environs

Pleistocene glaciation deposited multiple till sheets across southern Minnesota. The more extensive and better-exposed tills are well known and can be traced across wide areas. The full sequence, however, is not well known. There is evidence of a number of minor, eroded, or buried tills, but the evidence is not presently strong enough to characterize them adequately, to trace their extent, or to find correlations across a broader region. Table 5 presents a general summary of tills based on good exposures in the Minnesota River valley (Matsch 1972).

Table 5. Summary of Relevant Till Units in and near the Minnesota River Valley.

Till (*Provenance*)*	**Description**	**Lithology**
New Ulm (*Riding Mountain*)	Yellow to olive brown, less commonly grey, sandy loam to clay loam.	Abundant shale, carbonates, and granitic rock.
	Boulder pavement	
Granite Falls (*Winnipeg*)	Yellow to olive brown, less commonly grey, sandy loam to clay loam.	Sparse shale, rich in carbonates, granitic rock abundant.
Unnamed tills of uncertain extent (*Winnipeg*)		
	Outwash, boulder pavement, oxidized zone, or accretion gley	
Hawk Creek (*Superior*)	Reddish brown to pink, sandy clay loam.	Red felsite, pink sandstone, gabbro, rare Lake Superior Agate; shale absent, carbonates minor.
	Leached silt	
Unnamed till	Grey, calcareous clay loam	Shale free

Table based on Matsch 1972

The three best-known tills (oldest to youngest) are Hawk Creek, Granite Falls, and New Ulm. The lithology of Hawk Creek indicates origin in the Superior province to the northeast, while the lithology of the others (including the unnamed tills in the table) indicates origin in the Riding Mountain and Winnipeg Lowland provinces to the northwest. The ages of the older tills are not well constrained. The glacial advance that produced the New Ulm till reached its maximum extent in central Iowa around 14,000 RCYBP, and the study area was probably ice free before 12,000 RCYBP (Johnson et al. 1998:128).

Note that the overall lithology of these tills is quite diverse, indicating contributions from the Riding Mountain and Winnipeg Lowlands provinces to the northwest, as well as the Canadian Shield and Lake Superior provinces to the northeast. It is worth bearing in mind that the lesser-known tills may be contributing further diversity to both the general lithology of valley sediments and to the complement of toolstone.

7.4 Origin and Postglacial Geomorphic Evolution of the Minnesota River Valley

Research on the geomorphic history of the Minnesota River valley is a work in progress. The broad outlines are relatively clear. Many details, however, remain to be worked out, and there is as yet no general synthesis. In general, we know that the final ice advance over this region left a variety of till, outwash and associated lacustrine deposits as the surficial sediments. Meltwater-reworked sediment along the retreating ice front, potentially leaving local deposits that were enriched in terms of pebbles and cobbles. Regional drainage may have been regularly reorganized as ice retreated to progressively lower land towards the center of the broad sag that guided the path of the ice sheet through the region.

A critical event was the retreat of the ice beyond the continental divide that separates the northern drainage to Hudson Bay from the southern drainage to the Gulf of Mexico. Meltwater imponded between the divide to the south and glacial ice to the north, creating Glacial Lake Agassiz. At about 11,700 RCYBP, Agassiz breached the continental divide near Browns Valley and began to drain to the southeast. The initial drainage was apparently catastrophic, rapidly eroding a river valley that was up to five kilometers (three miles) wide and 60 meters (190 feet) deep (Matsch and Wright 1967; Johnson et al. 1998:128). Fenton et al. (1983) estimated that this process may have taken as little as 400 years. The early evolution of valley geomorphology was complex, with simultaneous erosion and infilling in different stretches of the river (Johnson et al. 1998). It was during this time that multiple terraces formed in the valley. By about 10,800 RCYBP, Lake Agassiz began to drain through another outlet, and the basic features of the current valley had been established (Fisher 2003, 2004). Agassiz periodically resumed southward drainage through the Minnesota River valley as late as 9400 RCYBP, but it seems that the later episodes of drainage were not necessarily catastrophic and thus their impact on valley geomorphology was not as great.

The terraces of the Minnesota River valley have been mapped and categorized in general terms (e.g., Johnson et al. 1998), as have terraces in some Minnesota River tributaries (e.g., Gran et al. 2013). It does not appear, however, that the terraces have been comprehensively studied, described, and analyzed. Interpretations vary and are not always in agreement. Matsch (1972:558-559), for example, posits three sets of terraces and relates each to the general history of valley formation and evolution:

> Terrace segments preserved at various heights above the floodplain of the Minnesota River fall within three major categories that relate to the history of the valley.... The highest surface, only slightly inset into the till plain, is underlain by flat-bedded coarse sand and cobbly, well- to poorly-sorted gravel 10 to 40 feet thick. These sediments are remnants of an extensive braided stream system that drained the margins of the retreating Des Moines lobe. The master stream followed the axis of the regional topographic sag that had been such an important control on iced movement during glaciation.
>
> Another set of terrace surfaces at intermediate heights is distinguished by a veneer of lag boulders that lie atop older Quaternary sediments or bedrock. These boulder-armed surfaces are remnants of successively lower channel bottoms of Glacial River Warren, a highly competent stream that discharged water from Lake Agassiz in late-glacial and early postglacial times.
>
> A third type of sediment is found both slightly higher than the modern floodplain and locally buried beneath the floodplain sands and silts. These alluvial deposits are boulder-gravel beds composed of well-rounded boulders and cobbles in a matrix of coarse gravel and sand. Commonly, the dominant size reaches as much as 12 inches in diameter. These deposits were once part of the bedload of River Warren and lagged during the waning stages of its discharge through the present Minnesota River Valley.

Maps of surficial geology for the region either reference three sets of unnamed terraces (e.g., Lusardi 2000) or four sets of named terraces (e.g., Meyer and Lusardi 2000; Meyer 1999; Hobbs and Setterholm 1998; Hobbs 1999a, 1999b). The latter are summarized in Table 6, which is the preferred schema in this discussion.

Table 6. Summary of Terraces Mapped in the Lower Minnesota River Valley and Adjacent Parts of the Mississippi and St. Croix river Valleys.

Terrace*	Height Above Floodplain	Elevation in Minnesota River Valley
Richfield	160 feet (49 m)	880 feet (268 m) W 850 feet (259 m) E
Langdon	125 feet (38 m)	840 feet (256 m) W 820 feet (250 m) E
Grey Cloud	50 feet (15 m)	770 feet (235 m) W 740 feet (226 m) E
St. Mary's	10-20 feet (3-6 m)	725 feet (221 m) W 700 feet (213 m) E

Table based on Meyer and Lusardi 2000

Further, Johnson et al. (1998:128) note that:

> ...some of the fill terraces in the valley may be outwash terraces that formed as the Des Moines Lobe melted back. Comparison of radiocarbon ages for the advance of the Des Moines Lobe (14,000 yrs B.P., Clayton and Moran, 1982) with those for the initiation of Glacial Lake Agassiz (11,500 yrs B.P., Teller and Clayton, 1983) indicate that parts of the Minnesota River valley would have been ice-free for at least 1000 years prior to the formation of Glacial Lake Agassiz. The valley would certainly have been the path of outwash streams. Upham (1883) considered all of the fill terraces to be composed of outwash, and it is clear that the terraces of the Minnesota River valley in the Twin Cities region grade to the same level as outwash terraces of the Mississippi River.

7.5 Geomorphology of 21HE483

The geomorphology of the ridge that the site is located on was not initially clear. A long, sloping ridge does not immediately suggest that the landform is a fluvial terrace. Meyer and Lusardi (2000), however, map this landform as St. Mary's terrace, which Meyer (1999) describes as follows:

> St. Mary's Terrace (named after the community of St. Mary's Point in southern Washington County)—Clasts are mostly Superior provenance. Surface about 10 to 30 feet (3 to 9 m) above floodplain level, at an elevation of about 700 feet (213 m). It does not extend above the dam at Taylors Falls. Most contacts with other map units (except peat) are scarps.

It should be noted that the reference to Superior provenance clasts is for the St. Mary's terrace along the St. Croix River, and is not mentioned in the description of the terrace along the Minnesota River.

Stretches of the St. Mary's terrace are mapped along the lower Minnesota River valley as far upstream as Belle Plaine, beyond which "the terrace merges with, and is buried by, the modern floodplain" (Meyer and Lusardi 2000). It is the lowest and youngest of a series of terraces that are also found along parts of the Mississippi and St. Croix rivers (e.g., Hobbs 1999a, 1999b; Hobbs and Setterholm 1998).

The ridge-like shape of the terrace on which 21HE483 is located is likely the result of its formation as a channel bar that formed during the large floods in Glacial River Warren during the late glacial period, and subsequently the river channel incised below the valley fill, leaving the bar as a terrace (personal communication with Mike Kolb, Geomorphologist, on April 25, 2018).

According to Johnson et al. (1998:128-129), the terraces all predate the Moorhead phase of Lake Agassiz which began around 10,800 RCYBP as the lake stopped draining through the Minnesota River valley. The St. Mary's terrace is the youngest of these, so may be relatively close to 10,800 RCYBP in age.

Cobble-rich deposits of the kind quarried at 21HE483 are seen at other location in the valley. Johnson et al. (1998:126) describe an example near Kasota, which "consists of poorly sorted, clast-supported sand and gravel interpreted as deposits of channel bars in a braided stream. It is much coarser than any of the other facies found in the study area; this is the result of the winnowing action of the braided stream, which removed much of the sand but not the coarser gravel." The deposit at 21HE483 should have a similar genesis. It might be noted, however, that the facies described for Kasota is either at the surface or shallowly buried by overbank silts or loess, while the facies at 21HE483 is buried by about five meters of sand and gravel. This would suggest a period with a braided stream environment followed by substantial valley infilling, perhaps pointing to the episodic nature of drainage pulses through the valley. Per the lowest terraces described above, Johnson et al. (1998:559) note that the deposits in general "were once part of the bedload of River Warren and lagged during the waning stages of its discharge through the present Minnesota River Valley," which would also indicate such an origin.

7.6 Soils at 21HE483

Soils at the site are mapped as Malardi-Hawick complex (Web Soil Survey 2017). Detailed soil profiles from the site are included in the previous report from Harrison and Bakken (2016), in Section 8.4 of this report, and in Appendix D of this report.

The Malardi series formed on nearly level or convex slopes on outwash plains and stream terraces in loamy outwash sediments and the underlying sandy and gravelly outwash sediments. A typical soil profile consists of the following:

Ap--0 to 25 centimeters; black (10YR 2/1) sandy loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; very friable; many fine roots; about 4 percent gravel; slightly acid; abrupt smooth boundary.

Bt1--25 to 38 centimeters; brown (10YR 4/3) sandy loam; weak fine subangular blocky structure; friable; few discontinuous dark brown (10YR 3/3) clay films on faces of peds; common fine roots; about 6 percent gravel; slightly acid; gradual wavy boundary.

2Bt2--38 to 74 centimeters; brown (10YR 4/3) loamy coarse sand; weak fine subangular blocky structure; very friable; clay bridging between sand grains; few fine roots; about 8 percent gravel; neutral; gradual wavy boundary.

2C--74 to 203 centimeters; brown (10YR 5/3) gravelly sand; single grain; loose; about 16 percent gravel; strongly effervescent; moderately alkaline.

The Hawick series formed in formed on outwash plains and stream terraces in sandy outwash sediments with or without a thin loamy mantle. A typical soil profile consists of the following:

Ap--0 to 18 centimeters; very dark brown (10YR 2/2) sandy loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; very friable; about 12 percent gravel; neutral; abrupt smooth boundary.

Bw--18 to 28 centimeters; dark brown (10YR 3/3) gravelly loamy coarse sand, brown (10YR 4/3) dry; weak fine subangular blocky structure; very friable; about 20 percent gravel; slightly effervescent; slightly alkaline; abrupt smooth boundary.

C--28 to 203 centimeters; light yellowish brown (2.5Y 6/4) gravelly coarse sand; single grain; loose; about 30 percent gravel; few, soft, very pale brown (10YR 8/2) accumulations of calcium carbonate on underside of gravel and very coarse sand fragments; strongly effervescent, slightly alkaline.

7.7 Hydrology

The project is located within the Minnesota River valley, which is the primary drainage for a large portion of southern Minnesota, extending from its headwater near the North and South Dakota border to its outlet at the Mississippi River in St. Paul. The Minnesota River's broad drainage system provided a route for the transmission of people, goods, and ideas across distant areas, connecting the prairie and Plains region of western Minnesota and the Dakotas with the woodlands in the eastern part of the state. Further connections in all directions across the middle of the continent could be maintained via the Mississippi River, the Red River, and their tributaries.

The Minnesota River flows within a large, steep-walled valley. On the valley bottom adjacent to site 21HE483 is an extensive floodplain with a floodplain lake (Long Meadow Lake) and wetlands.

7.8 Ecology

The project lies within the Big Woods subsection of the Minnesota and Northeastern Iowa Morainal Section of the Eastern Broadleaf Forest Province (Minnesota DNR 1998). The primary characteristics are a loamy end moraine associated with the Des Moines Lobe of Late Wisconsin Glaciation and presettlement vegetation of mesic deciduous forest comprised of oak woodland and maple-basswood forest. In general, the landscape consists of rolling terrain with scattered lakes and streams.

Vegetation in the Minnesota River valley bottom near the project area at the time of European settlement consisted of river bottom forest (silver maple, elm, ash, cottonwood, and willow) (Marschner 1974). The upland and terraces above the valley bottom consisted primarily of hardwood forest (oak, maple, basswood, and hickory), oak barrens, and smaller areas of prairie.

7.8 Post-Glacial Ecology

Regional vegetation changes during the Holocene are inferred from pollen samples preserved in lake-bottom sediments from several lakes in eastern Minnesota. The following discussion is derived from Gibbon (2012) and Gibbon and Anfinson (2008), citing the research of Wright (1992, 1976a, 1976b); Wright and Watts (1969); Amundson and Wright (1979); Webb et al. (1983); and Webb (1981).

These analyses show that following the retreat of the glaciers in southern Minnesota about 12,000 RCYBP (14,000 cal BP) all of the area was covered with an open boreal forest of grasses and stands of conifer trees mixed with deciduous species such as black ash; a composition that is not seen in modern landscapes. This "spruce parkland" landscape was more open on high ground and was likely swampy or contained open water in the low areas. The parkland evolved into a more uniform spruce forest by 11,000 RCYBP (13,000 cal BP). By approximately 10,500 RCYBP (12,500 cal BP), deciduous forest had developed across southern Minnesota. In the project area and to the south and west, the forest composition was oak and elm, while just east of the project area it comprised birch, alder, and pine. The oak-elm forest continued to advance and covered the entire south central and southeastern parts of the state by 9,000 RCYBP (10,000 cal BP).

Continued warming and drying of the climate provided the conditions for prairie and oak savannah to flourish in the western and southern parts of the state by 8000 RCYBP (8800 cal BP), and the broad vegetation zones of historic times had begun to develop, with prairie in the west, deciduous forest in the southeast, and coniferous forest in the north and northeast. Further warming and drying led to continued eastward expansion of the prairie, which reached its maximum extent and covered all but the northeastern quarter of the state by 7000 RCYBP (7800 cal BP). The climate cooled and grew wetter after 6000 RCYBP (6900 cal BP), causing the prairie to retreat westward and oak woodland to expand. Gibbon (2012) points out that this advancing oak woodland would not have been the same as the historic oak forest but rather would have been a mosaic of prairie and woodland, with the forest gradually becoming denser. The basic vegetation zones present at the time of settlement (1850's) were in place by 3000 RCYBP (3200 cal BP), with oak woodland near the project area. By approximately 400 years ago, the Big Woods (elm, basswood, ironwood, hickory, maple, ash, and butternut) became established in south-central Minnesota in the vicinity of the project area.

A more fine-scale review of the landscape evolution near the project area is provided in a recent research project for Le Sueur County (Schirmer et al. 2014), which is adjacent to and environmentally similar to the project area. Using historic records (e.g., Marschner 1974) and studies of pollen and charcoal specimens from regional lake-bottom sediment cores (e.g. Sugita 1994 and Umbanhowar 2004), the authors looked at major climatic regimes, vegetation changes, and the associated occurrences of large-scale fires. Schirmer et al. (2014) note that the pollen studies used to provide much of the vegetation reconstructions by other researchers are somewhat generalized, in that they rely on information from localized features such as lake and pond basins, which are then extrapolated onto the broader ecosystem. Complex landscapes that occur near the project area, such as the Minnesota River valley, uplands, wetlands, smaller streams, and many lakes and ponds, require a more nuanced review of the paleoenvironmental data. The Minnesota River valley includes many niche environments ranging from the bluffs tops and side slopes to the valley bottom, where numerous springs, lakes, and wetlands occur.

Schirmer et al. (2014:27) define five major climatic regimes that have dominated the landscape of south-central Minnesota and the project area since the retreat of the glaciers: a cool and humid period from 10,200 to 7700 RCYBP (12,000 to 8500 cal BP), a warm and arid period from 7700 to 4000 RCYBP (8500 to 4500 cal BP), a warm and humid period from 4000 to 2900 RCYBP (4500 to 3000 cal BP), a cool and humid period from 2900 to 1000 RCYBP (3000 to 1000 cal BP), and finally a cool and arid period from 1000 to 200 BP. Two comparatively wet episodes of approximately 500 years each, spanning 6500 to 6000 cal BP and 5000 to 4500 cal BP, have been identified during the warm and arid period. These climatic regimes are divided by vegetation trends and the occurrence of fires, as postulated by the abundance of charcoal in sediment samples recovered from lakes and ponds in the south-central Minnesota area (Table 7).

Table 7. Holocene Climatic Regimes and Ecological Trends near the Project Area.

<table>
<tr><th>ca. Date Range (cal BP)</th><th>ca. Date Range (RCYBP)</th><th>Climatic Regime</th><th>Vegetation Trends</th><th>Dominant Species</th><th>Fire Regime</th></tr>
<tr><td>12,000–11,500</td><td>10,200–10,050</td><td rowspan="7">Cool and Humid</td><td>Boreal Forest</td><td>Spruce, Pine</td><td rowspan="6">Low</td></tr>
<tr><td>11,500–11,000</td><td>10,050–9550</td><td rowspan="3">Deciduous Forest</td><td rowspan="5">Oak, Elm, Forbs</td></tr>
<tr><td>11,000–10,500</td><td>9550–9300</td></tr>
<tr><td>10,500–10,000</td><td>9300–8900</td></tr>
<tr><td>10,000–9500</td><td>8900–8500</td><td rowspan="2">Woodland</td></tr>
<tr><td>9500–9000</td><td>8500–8050</td></tr>
<tr><td>9000–8500</td><td>8050–7700</td><td rowspan="5">Prairie</td><td rowspan="3">Grasses, Forbs</td><td rowspan="9">Moderate</td></tr>
<tr><td>8500–8000</td><td>7700–7200</td><td rowspan="4">Warm and Arid</td></tr>
<tr><td>8000–7500</td><td>7200–6600</td></tr>
<tr><td>7500–7000</td><td>6600–6150</td><td rowspan="2">Oak, Grasses</td></tr>
<tr><td>7000–6500</td><td>6150–5750</td></tr>
<tr><td>6500–6000</td><td>5750–5300</td><td>Wet Episode</td><td>Savanna</td><td>Oak, Elm, Grasses, Forbs</td></tr>
<tr><td>6000–5500</td><td>5300–4800</td><td>Warm and Arid</td><td>Prairie</td><td>Grasses, Forbs</td></tr>
<tr><td>5500–5000</td><td>4800–4450</td><td>Wet Episode</td><td>Savanna</td><td>Oak, Elm, Grasses, Forbs</td></tr>
<tr><td>5000–4500</td><td>4450–4000</td><td>Warm and Arid</td><td>Prairie</td><td>Oak, Grasses, Forbs</td></tr>
<tr><td>4500–4000</td><td>4000–3700</td><td rowspan="3">Warm and Humid</td><td rowspan="7">Woodland</td><td>Oak, Ironwood, Hickory, Basswood, Forbs</td><td rowspan="3">High</td></tr>
<tr><td>4000–3500</td><td>3700–3300</td><td rowspan="2">Oak, Grasses</td></tr>
<tr><td>3500–3000</td><td>3300–2900</td></tr>
<tr><td>3000–2500</td><td>2900–2500</td><td rowspan="4">Cool and Humid</td><td rowspan="4">Oak, Elm, Ironwood, Pine, Forbs</td><td rowspan="5">Moderate</td></tr>
<tr><td>2500–2000</td><td>2500–2050</td></tr>
<tr><td>2000–1500</td><td>2050–1550</td></tr>
<tr><td>1500–1000</td><td>1550–1100</td></tr>
<tr><td>1000–500</td><td>1100–400</td><td rowspan="2">Cool and Arid</td><td rowspan="2">Forest</td><td>Oak, Ironwood, Elm, Basswood</td></tr>
<tr><td>500–200</td><td>400–150</td><td>Maple, Basswood, Ironwood, Elm (Big Woods)</td><td>Low</td></tr>
</table>

(from Schirmer et al. 2014: 26-27)

A boreal forest of spruce and pine advanced into southern Minnesota between 10,200 to 10,050 RCYBP (12,000 to 11,500 cal BP). This was followed by oak-elm forest and woodland from 10,050 to 8050 RCYBP (11,500 to 9000 cal BP). Prairie dominated the landscape during the warm and dry climatic regime of the mid-Holocene, which persisted from 8050 to 4000 RCYBP (9000 to 4500 cal BP). Prairie is defined as a fire-maintained ecosystem with a mix of grasses and forbs and less than 10% tree cover, primarily oak. During the later portion of this period from 5750 to 4000 RCYBP (6500 to 4500 cal BP), two wetter episodes allowed the spread of savanna vegetation. *Savanna* is a grassland ecosystem containing oak, elm, and forbs, in which the trees are sufficiently widely-spaced so that the canopy remains open. Woodland vegetation (primarily oak, elm, hickory, basswood, grasses, and forbs with 10-70% total tree cover) with areas of grasslands and sparse brush was the dominant vegetation type from 4000 to 1100 RCYBP (4500 to 1000 cal BP). Forest (primarily maple, oak, elm, basswood, and ironwood with 70% or greater tree cover, closed or nearly closed canopy, and comparatively little shrub growth but significant forb and grass ground cover) occurred in the area from 1100 RCYBP (1000 cal BP) to the present day. Big Woods developed around 400 RCYBP (500 cal BP).

Schirmer et al. (2014) found the same type of relationship between landscape changes and fire prevalence as is discussed in Yansa (2007), noting that there is a counter-intuitive interaction between arid and warm periods and charcoal evidence of large-scale fires. The reason for this is that during the arid times there was less fuel to support large fires, and therefore fires were more common during wetter periods when primary fuels such as grasses and forbs would have been more plentiful.

Yansa (2007) focused on pollen and diatom samples from the Altithermal period of warming and drying from 7200 to 4000 RCYBP (8000 to 4500 cal BP), which corresponds to the Early and Middle Archaic periods. While these data are from the northern Great Plains, east and north of the project area, they can be extrapolated to provide insights into the landscapes of the project area as well, given that the shifting prairie/forest border meant that there were periods of time in which the general environment of the project area would have shared many similarities with the Great Plains study area as described. The shifts in climate, and subsequently in habitat and vegetation, were more variable in time and space than has been previously understood. The onset of widespread grasslands on the northern Plains does not represent a large-scale biome shift, but rather a series of localized changes in species composition along the edges of lakes and ponds (Yansa 2007:129). She proposes that fine-scale fluctuations during the periods of drought and moisture resulted in the creation of "oasis" landscapes, in which large areas became very dry but other areas closer to water sources (such as the river valley of the project area) would have stayed relatively wet, thereby supporting resources for animals and humans.

Yansa suggests that the proposed oasis landscape model of the Early Archaic means that populations would not have had to abandon the prairie region to the degree that has been assumed, but rather would have been able to thrive in localized upland areas and river valleys, such as the Minnesota River, that did retain moisture.

Another recent study (Williams et al. 2009) supports Yansa and Schirmer in suggesting that the shifting mid-Holocene boundaries of the prairie-forest ecotone in southeastern Minnesota were more asymmetrical than previously believed, with a relatively rapid early Holocene deforestation and more gradual reforestation later in the Holocene. Using fossil pollen records and modern surface analogs, the researchers mapped changes in "woody cover". They argue that the period of rapid deforestation was likely caused by fairly sudden climate changes and the subsequent onset of large fires, which caused a positive feedback loop in which a shift to grasslands increased the frequency of fires, which then accelerated the burning of more forest. The loss of forest cover was also likely exacerbated by climate change-caused outbreaks of pests and pathogens that weakened trees and made forests even more susceptible to fire.

The researchers conclude that the prairie-forest ecotone boundaries in the eastern Dakotas and southern Minnesota generally match earlier mapping efforts (e.g. Webb et al. 1983), with some differences in detail (Williams et al. 2009:201). The general patterns are similar; there is a dramatic regional advance of prairie between 8900 to 7200 RCYBP (10,000 to 8000 cal BP), a maximum advance to the east from 6100 to 5300 RCYBP (7000 to 6000 cal BP), followed by a retreat of the prairie to the west after 5300 RCYBP (6000 cal BP). While the maximum extent of the ecotone boundary in southeastern Minnesota is somewhat ambiguous (Williams et al. 2009:195), they find that the range of movement is smaller than in Webb et al. (1983), and that the boundary of the prairie-forest ecotone did not advance much farther to the east than the current project area. Their reconstructions indicate that the Holocene prairie-forest ecotone in southern Minnesota and Wisconsin was gentler than in northern Minnesota. They conclude that the changes in both the northern and eastern prairie-forest ecotone boundaries were caused by the changing climate, while the causes for differences in the rates of change between the north and east are less certain.

7.9 Plant and Animal Resources

The paleoenvironmental data cited by Schirmer et al. (2014) indicate that, although the landscape and environment around the project area changed through time, from forest and woodland to prairie and savanna and then back to woodland and forest, all of these major vegetation types would have been present in south-central Minnesota during each of the climatic episodes at differing locales and in varying amounts. It appears that there was never a time of complete ecological uniformity in the prairie-forest ecotone. The variety of landscape settings, along with the presence of wetlands, lakes, and streams associated with the broad Minnesota River valley would have created niche environments around the project area in which a wide and changing variety of vegetation and associated plant and animal resources would have been available.

Aquatic habitats such as lakes, streams, and wetlands around the project area would have provided fish, clams, small mammals, turtles, waterfowl, edible tubers, and wild rice. Spector (1993:112) reports that the remains of bottom-dwelling fish, such as drumfish, along with turtles were the most abundant in the archaeological record at the Little Falls site, which is located upstream of the project area near the town of Jordan. Other aquatic resources recovered during excavation and potentially used by the Dakota people in the Minnesota River valley included catfish, walleye, gar, pike, muskellunge, sucker, teal, mallard, shoveler, wood duck, coot, merganser, grebe, grouse, goose, loon, muskrat, otter, beaver, fisher, mink, ermine, and shellfish (Spector 1993:144). While these types of aquatic resources would have been more limited during warm and dry periods (when water levels declined), they would have remained viable even during those periods in the Minnesota River valley and the lake basins associated with it, which would have continued to support more diversity of flora and fauna than was found in the upland areas farther from water sources.

The wide variety of plant resources available in the woodland and savanna habitats of the project area are also summarized in Spector (1993:145): legumes, crabapple, cress family, elderberry, grape, seed grasses, hazelnuts, acorns, joe-pye weed, mint, knotweed, pig weed, pin cherry, black cherry, plantain, purslane, raspberry, gooseberry, sorrel, sumac, strawberry, and vervain among others. Faunal remains recovered from the Little Falls site (Spector 1993:144) include deer, coyote, squirrel, rabbit, grouse, elk, raccoon, and pigeon.

Based on early historical accounts, a wide variety of mammalian game species were present in southern Minnesota, including bison, elk, deer, muskrat, rabbit, beaver, bear, and occasionally antelope (Anfinson 1997; Ernst and French 1977; Herrick 1892). Anfinson (1997) explains that plant foods were much less abundant in the prairie landscape, consisting primarily of the prairie turnip and a type of bean called ground plum. Most of the prairie vegetation comprised grasses and forbs that provided excellent forage for prey species, primarily bison, with smaller numbers of elk and both white tail and mule deer. Large prey species such as elk and deer were not as abundant in closed-canopy forests due to limited browse and therefore this type of environment provided a more limited animal resource base.

8. SITE 21HE483 DISCUSSION
by Kent Bakken and Frank Florin

8.1 Overview

Site 21HE483 is a toolstone procurement (quarry) site situated on a low terrace in the Minnesota River Valley bottom. The terrace, forming a bar in the river bottom, was comprised of sand, gravel, and cobbles. The age and cultural affiliation of the occupation(s) is not known with certainty, although a radiocarbon date from a muskrat bone of 2070 ± 30 RCYBP provided an Early to Middle Woodland period date.

The site is in T27N, R24W, S½ NW¼ NW¼ Section 13 (Figures 2 and 6) and is approximately 80 by 80 meters in size, encompassing 1.6 acres. The site likely extends beyond the area tested for the project. The UTM coordinates for the center of the site are E480645 N4964165 (1983 NAD Zone 15). A map of the site on aerial imagery is presented in Figure x. Photo of the site are presented in Figures 7 and 8.

8.2 Physical Setting

The site located on south side of Old Cedar Avenue and is within and adjacent to the USFWS parking lot. The site is located on the upstream end of an elongated ridge or bar in the Minnesota River valley bottom and is bordered by Long Meadow Lake (a perennial floodplain lake) on the south and east and a small creek and associated wetlands on the north and west. The main channel of the Minnesota River is about 1000 meters east of the site. The ridge on which the site is located is mapped as a low terrace that was deposited during the late-glacial period, between about 11,700 and 10,800 RCYBP (Johnson et al. 1998:128-129; Meyer and Lusardi 2000). The terrace ridge is about ten feet above the surrounding floodplain and is rich in gravel and cobbles, which served as a raw material source at the site. Prairie du Chien Chert (PdC) was the main lithic material procured at the site, but a variety of other materials were also procured. The latter material were likely redeposited from glacial till that was eroded by Glacial River Warren at the end of the Pleistocene, and it is likely that all of the lithic materials in the landform at the site were transported down the valley by high-volume, high-velocity flows of River Warren.

8.3 Radiocarbon Dating

A muskrat bone was submitted to Beta Analytic, Inc (Beta) for AMS dating to aid in establishing the age of the site. The sample results are summarized below in Table 8. The report from Beta is included in Appendix E.

Table 8. Radiocarbon Date from 21HE483

Provenience	Material	Beta Lab No.	Conventional Age	2 Sigma Calibrated Results (95% Probability)	Historic Context
ST F29 100-120 cmbs	Bone collagen	437528	2070 +/- 30 BP	Cal BC 170 to 20 (Cal BP 2120 to 1970) and Cal BC 10 to AD 0 (Cal BP 1960 to 1950)	Early-Middle Woodland

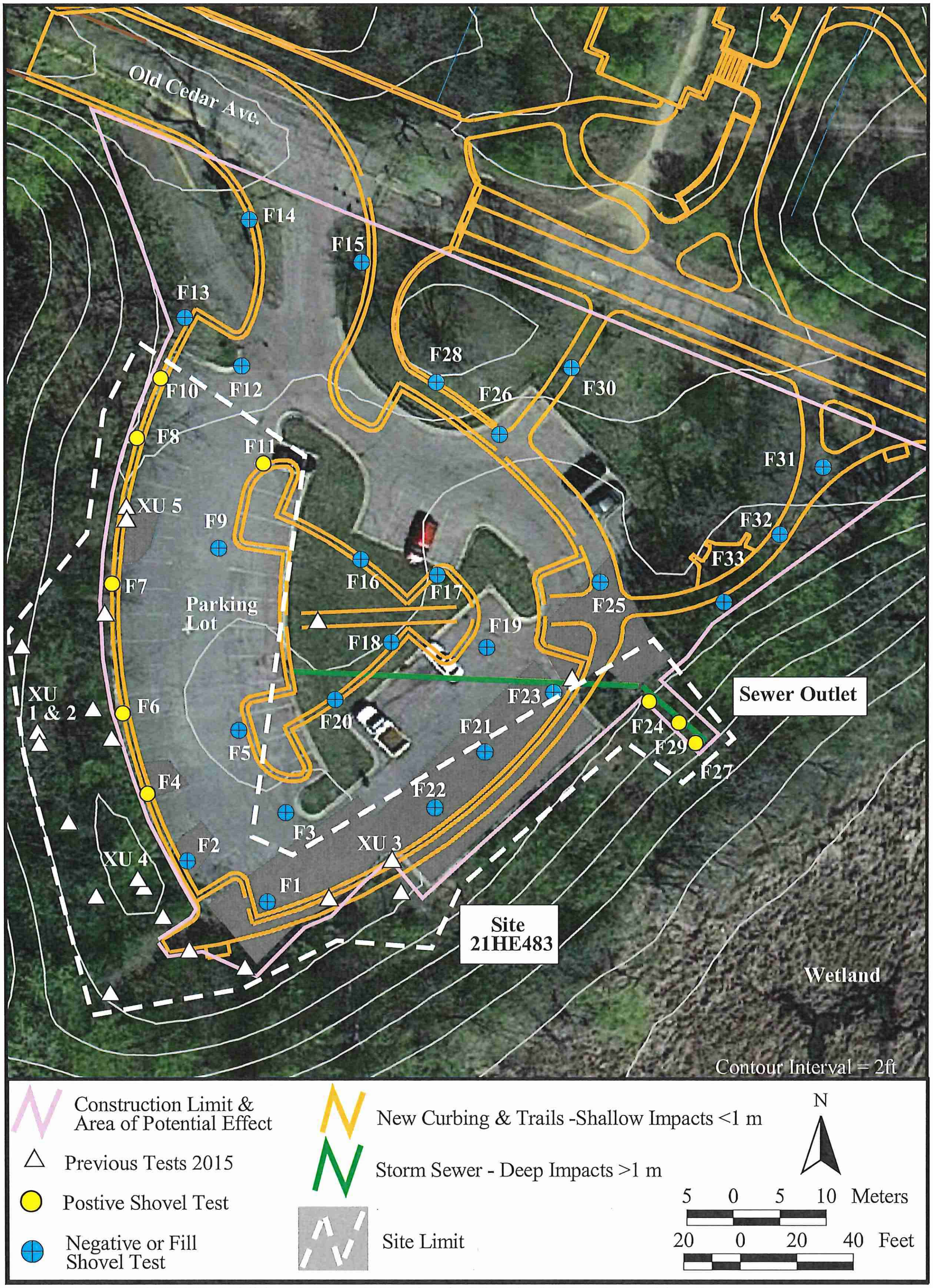

Figure 6. Site 21HE483 Additional Phase II Testing in 2016 by FCRS for Parking Lot Replacement.

Figure 7. Photo of West Edge of Parking Lot at 21HE483, Facing South.

Figure 8. Photo of Storm Sewer Outlet East of Parking Lot at 21HE483, Facing North.

8.4 Soils

Soil profiles from all of the FCRS 2016 shovel tests are contained in Appendix D, and the profiles are summarized in Table 9. The profiles across the site were generally similar but had fill and blading to varying depths. The shovel test profiles at the storm sewer outlet east of the parking lot on the terrace bar side slope differed from the tests in the parking lot in that they had a 75 to 90-cm-thick black (10YR 2/1) and very dark gray (10YR 3/1) soil below fill (Table 10), whereas tests in the parking lot lacked or had a much thinner dark (10YR2/1-3/1) soil below fill, and instead typically had a brown-colored (7.5YR 4/4 or 5/4) soil below the fill (Table 11). The general lack of dark topsoil in the parking lot was because the soils were truncated, presumably from blading-off the topsoil prior to construction of the parking lot. Shovel Tests F8, F10, and F15 were the only tests in the parking lot that contained intact, dark-colored topsoil (10YR 2/1, 3/1, or 3/2 color; A or AB horizons) below the fill.

Intact soils were typically loamy sand with the deepest and lightest-colored soil consisting of sand. Moderate to dense amounts of cobbles and gravels were present throughout all intact soils. Several tests had impenetrable fill (large limestone rocks or highly compacted rocks) to depths ranging from 55 to 115 cm deep. The absence of artifacts in some tests was likely because testing could not reach intact soils below the impenetrable fill. It is reasonable to suspect that intact soils and artifacts exist below the fill. It is likely that prior to parking lot construction the landscape was leveled off by blading higher areas and filling low areas.

Table 9. Soil Profile Summary from 2016 Shovel Tests at 21HE483.

Shovel Test	Max Depth of Fill (cmbs)	Max Depth of Test (cmbs)	Intact Soil below Fill or Disturbance?
F1	115	115	No
F2	37	90	Yes
F3	85	85	No
F4	30	86	Yes
F5	63	63	No
F6	36	96	Yes
F7	29	90	Yes
F8	19	90	Yes
F9	55	55	No
F10	60	100	Yes
F11	51	85	Yes
F12	63	63	No
F13	90	90	No
F14	60	60	No
F15	53	80	Yes
F16	90	90	No
F17	60	60	No
F18	55	55	No
F19	60	60	No
F20	60	60	No
F21	60	60	No
F22	90	90	No

Table 9. Continued.

Shovel Test	Max Depth of Fill (cmbs)	Max Depth of Test (cmbs)	Intact Soil below Fill or Disturbance?
F23	70	70	No
F24	45	75	Yes
F25	75	75	No
F26	50	50	No
F27	35	110	Yes
F28	55	55	No
F29	30	120	Yes
F30	100	100	No
F31	80	80	No
F32	95	95	No
F33	90	106	Yes

Table 10. Site 21HE483 Shovel Test F29 Soil Profile at Storm Sewer Outlet East of Parking Lot.

Below Surface cm	Description
0-30	Very dark gray (10YR 3/1) sandy loam; probably redeposited soil or fill
30-120	Black (10YR 2/1) loamy sand transitioning to very dark gray (10YR3/1) loamy sand with depth; gravels and cobbles; intact soil

Depth of fill shaded

Table 11. Site 21HE483 Shovel Test F4 Soil Profile in Parking Lot.

Below Surface cm	Description
0-7	Asphalt
7-19	Class 5 gravel; fill
19-30	Very dark gray (10YR 3/1) loamy sand; fill with clay pockets; abrupt boundary
30-64	Brown (7.5YR 4/4) loamy sand; intact soil; cobbly
64-86	Yellowish brown (10YR 5/4) cobbly sand; intact soil

Depth of fill shaded

Phase II testing in 2015 included one-by-one meter excavation units (XUs) placed adjacent to the parking lot, and the soils from XUs 1 and 2 provide an example of relatively undisturbed soil profiles at the site. These soils are summarized in Table 12 (Harrison and Bakken 2016:25). The other 2015 XUs had deeper soil disturbances and fill.

Table 12. Example of Relatively Undisturbed Soils at 21HE483, based on 2015 XUs 1 and 2 (from Harrison and Bakken 2016:25).

Level (cmbs)	**XU 1 count**	**XU 2 count**	**Soil**	**Gravel**	**Cobble**	**Interpretation**
0-10	0	2	Clay loam 10YR 2/2		+	Fill
10-20	17	22	Loam 10YR 3/1	+	+	Top of artifact deposit, some disturbance.
20-30	31	37				
30-40	36	15	Sandy loam 10YR 3/2	++	+	Bottom of artifact deposit, intact.
40-50	27	36	Sandy loam 10YR 4/3 (Coarse and fine layers)	++	++	
50-60	18	*not dug*				
60-70	8					Artifact displaced downward in soil profile below primary artifact deposit.
70-80	2					
80-90	3					
90-100	5		Loamy sand 10YR 4/3 *(at 95 cm)*			

+ means present; ++ means abundant

8.5 Field Methods and Results

A total of 33 shovel tests (ST) were dug in approximately 10-meter intervals in the parking lot and adjacent area in the APE. A total of 236 artifacts were recovered from nine shovel tests, including 108 flakes, 75 pieces of shatter, 28 fragments, 15 tested cobbles, five hammerstones, two stone tools, one core, one spall, and one faunal fragment (Table 13). The depth of fill and the maximum depth of each test is included in Table 9, and soil profiles are in Appendix D. Artifacts were recovered from fill in three shovel tests (F12, F16, and F30), and these artifacts are listed below Table 13.

Nine shovel tests (F4, F6-8, F10, F11, F24, F27, and F29) contained artifacts from intact soils below fill. Artifacts were recovered from 0 to 120 cmbs, and artifacts from most tests were recovered from a broad vertical span (often 50 cm or more). The broad vertical span is likely the result of prehistoric digging to extract cobbles, which would have left shallow pits that eventually partially refilled, and also displacement from natural processes such as rodent burrowing, freeze-thaw cycles, and tree throws and roots. The broad vertical patterning of artifacts is consistent with results from previous testing at the site (Table 12) (Harrison and Bakken 2016).

Many tests, particularly those in the eastern two-thirds of the parking lot, had impenetrable fill (large limestone rocks) to depths ranging from 55 to 115 cm deep. It is reasonable to suspect that intact soils and artifacts may exist below the fill. However, project impacts for new curbing, electric, and trails in most of this area will not exceed fill depth.

Artifacts recovered from the current Phase II testing are similar to those recovered during previous site investigations and consist primarily of decortication flakes and tested cobbles. One muskrat bone fragment was recovered from Shovel Test F 29 from 100 to 120 cmbs. The bone is likely cultural, as it was recovered from a shovel test that had a high density of lithics, and the depth it was recovered from also had a lot of lithics. Two lithics were confidently determined to be heat- treated, indicating that a fire hearth or heating facility existed at the site. The two heat-treated lithics were Prairie du Chien Chert from Shovel Test F27 at 60 to 80 cmbs (Acc. # 27.16 and 27.22).

Table 13. Summary of Phase II Shovel Tests at 21HE483.

Shovel Test	Max Depth of Fill (cmbs)	Max Depth of Test (cmbs)	Artifact Depth (cmbs)	Count	Artifact
F4	30	86	23-43	10	Flake, basaltic (4), Prairie du Chien Chert (4), and Siltstone (2)
				2	Fragment, basaltic (1) and limestone (1)
				1	Hammerstone, granitic
				4	Shatter, Prairie du Chien Chert (1), quartz (1), basaltic (1), and granitic (1)
				1	Tested cobble, Prairie du Chien Chert
			43-63	5	Flake, basaltic (1), granitic (2), and Prairie du Chien Chert (2)
				1	Fragment, granitic
				3	Shatter, basaltic
				1	Tested cobble, Prairie du Chien Chert
			63-83	2	Shatter, basaltic
F6	36	96	36-56	1	Flake, Swan River Chert
				1	Shatter, chert
				1	Shatter, Prairie du Chien Chert
			56-76	2	Flake, basaltic (1) and Prairie du Chien Chert (1)
				1	Hammerstone, granitic
				1	Shatter, quartzite
F7	29	90	30-50	2	Shatter, basaltic (1) andPrairie du Chien Chert (1)
				1	Tested cobble, quartzite
			50-70	2	Shatter, granitic
			70-90	1	Flake, quartzite
				3	Shatter, quartzite
F8	19	90	40-55	2	Flake, Prairie du Chien Chert (1) and Swan River Chert (1)
				1	Fragment, granitic
				1	Shatter, basaltic
			55-75	5	Flake, basaltic (1), chert (1), Prairie du Chien Chert (2), and Tongue River Silica (1)
				3	Shatter, quartz
				1	Tested cobble, quartz
				1	Tool, chert
			75-90	1	Flake, basaltic
F10	60	100	20-40	1	Flake, basaltic
				2	Fragment, Unidentified material
				2	Shatter, basaltic (1) and Prairie du Chien Chert (1)
			40-60	1	Flake, Siltstone
				2	Shatter, Prairie du Chien Chert (1) and quartzite (1)
			60-80	2	Flake, Prairie du Chien Chert
				2	Shatter, chert (1) and Prairie du Chien Chert (1)
				1	Tested cobble, quartzite
			80-100	3	Flake, Prairie du Chien Chert
				3	Fragment, Iron concretion (1) and Siltstone (2)
				1	Hammerstone, granitic

Table 13. Continued.

Shovel Test	Max Depth of Fill (cmbs)	Max Depth of Test (cmbs)	Artifact Depth (cmbs)	Count	Artifact
F11	51	85	60-80	7	Flake, basaltic (2), chert (2), and Prairie du Chien Chert (3)
				2	Fragment, basaltic (1) and Schist (1)
				9	Shatter, Prairie du Chien Chert (8) and unidentified material (1)
				1	Tested cobble, Prairie du Chien Chert
			80-84	2	Flake, limestone (1) and Prairie du Chien Chert (1)
				2	Shatter, Prairie du Chien Chert (1) and Red River Chert (1)
F24	45	75	0-10	1	Flake, basaltic
			30-40	1	Shatter, chert
			50-60	2	Flake, Prairie du Chien Chert
			60-70	1	Fragment, granitic
F27	35	110	0-20	1	Flake, Swan River Chert
			20-40	2	Flake, Prairie du Chien Chert
				2	Fragment, granitic
				1	Shatter, Prairie du Chien Chert
			40-60	6	Flake, basaltic (1), chert (1), Prairie du Chien Chert (3), and Swan River Chert (1)
				1	Fragment, granitic
				2	Shatter, Prairie du Chien Chert
			60-80	12	Flake, Knife Lake Siltstone (1), Prairie du Chien Chert (8), Red River Chert (2), and Silicified wood (1)
				3	Fragment, basaltic
				2	Hammerstone, granitic
				8	Shatter, basaltic (1), Prairie du Chien Chert (5), and Red River Chert (2)
				1	Tested cobble, unidentified material
			80-100	10	Flake, basaltic (1), Prairie du Chien Chert (7), and Red River Chert (2)
				4	Shatter, Prairie du Chien Chert
				1	Spall, Prairie du Chien Chert
				3	Tested Cobble, Prairie du Chien Chert (2) and Red River Chert (1)
			100-110	2	Flake, basaltic
				1	Shatter, basaltic

Table 13. Continued.

Shovel Test	Max Depth of Fill (cmbs)	Max Depth of Test (cmbs)	Artifact Depth (cmbs)	Count	Artifact
F29	30	120	0-20	3	Flake, basaltic (1), Prairie du Chien Chert (1), and Red River Chert (1)
				1	Shatter, basaltic
			20-40	2	Flake, Prairie du Chien Chert
				2	Shatter, basaltic (1) and granitic (1)
				2	Tested cobble, basaltic (1) and Prairie du Chien Chert (1)
				1	Tool, Prairie du Chien Chert
			40-60	1	Core, Sioux Quartzite
				1	Flake, chert
				2	Shatter, chert (1) and Red River Chert (1)
				1	Tested cobble, Prairie du Chien Chert
			60-80	5	Flake, Prairie du Chien Chert (3), quartz (1), and quartzite (1)
				1	Fragment, basaltic
				6	Shatter, Prairie du Chien Chert (3) and quartz (3)
				1	Tested cobble, Prairie du Chien Chert
			80-100	7	Flake, Knife Lake Siltstone (1), Prairie du Chien Chert (5), and quartzite (1)
				2	Fragment, basaltic
				5	Shatter, Prairie du Chien Chert (2), quartz (1), and Red River Chert (2)
			100-120	11	Flake, basaltic (2), Prairie du Chien Chert (7), Red River Chert (1), and Swan River Chert (1)
				7	Fragment, basaltic (4) and granitic (3)
				2	Shatter, Prairie du Chien Chert
				1	Tested cobble, Prairie du Chien Chert
				1	Faunal, muskrat, right ilium fragment, sent to Beta & destroyed during radiocarbon dating
Total				**236**	

Artifacts were recovered from fill in the following shovel tests: F12 had one flake of quartzite from 40-60 cmbs; F16 had one shatter of Prairie du Chien Chert from 50-60 cmbs; and F30 had one core of Animikie Silicate from 80-100 cmbs.

8.6 Lithic Analysis Methods and Results

by Kent Bakken

The following discussion was authored by Kent Bakken and includes lithic data from the current FCRS Phase II testing, along with comparative data from the previous investigations at 21HE483 and from similar regional sites. A study was also conducted on the lithology of the gravel bar on which the site is located and on toolstone material availability and selection at the site. The results of this study are presented separately in Appendix A: *Analysis of the General Lithology and Toolstone Components of a Quarried Cobble and Gravel Deposit at 21HE483* by Kent Bakken.

The lithic analysis methods are described in Section 4.3. The results of the raw material analysis and lithic technological analysis are presented below. The technological analysis focuses on determining the reduction stages represented at the site. Since this is a raw material procurement site, the analysis is especially focused on examining the earliest steps in reduction, and on determining whether reduction at the site was limited to raw material testing or also included patterned core reduction. The analysis concludes with a comparison of Old Cedar South with selected other raw material procurement sites. A lithologic analysis of the underlying geologic resource will be completed at a later date.

At this point, it is helpful to briefly consider the nature of the 21HE483 lithic assemblage, and the questions that we wish to ask about the assemblage. A preliminary examination makes it clear that the early stages of lithic reduction predominate in this assemblage. This leads to a primary question: How early in the reduction trajectory does this material fall? A somewhat closer look at a subsample of the assemblage produces another observation that is helpful in shaping an analytical protocol. The significance of this observation requires a brief digression.

From one perspective, technological analysis is often an attempt to understand the evolving form of a core. The form of a core results from a series of human intentions, choices and actions. Thus, to read the form of the core is to gain some insight into such intentions, choices and actions, not to mention such factors as cultural constraints and individual skill. In the case of 21HE483, however, the flaking debris seems not so much to reflect the form of the *core* as the form of the *cobble*. The reduction is just that early in the sequence. Thus, observations that mostly serve to understand how cores were shaped and reduced may not be optimal for analyzing this assemblage.

Technically, it might still be correct to say this assemblage represents the process of turning cobbles into cores. Practically, however, that statement might be a bit optimistic. Instead we might be seeing just the process of removing "dead weight," so to speak, whether by eliminating poor-quality parts of cobbles or by eliminating entire poor-quality cobbles. The result of the process might technically be defined as a core, but that artifact has perhaps not been deliberately shaped to any meaningful degree. The choices and actions of the flintknapper are governed largely by the form of the cobble, while the intention is simply to eliminate poor-quality stone. This leads to a reformulation of the primary question: Does reduction proceed beyond elimination of substandard stone to deliberate shaping of a core?

One other factor influences formulation of an analytical protocol for this site. Raw material flaws have affected artifact morphology to a greater than usual degree. In case after case, a propagating fracture has been captured and diverted by internal flaws. Perhaps this should not be surprising, if the primary purpose here was to remove flawed and substandard raw material. The practical results, in any case, is a departure from standard fracture morphology, and compromised potential for making some of the observations common to a technological analysis.

8.6.1 Lithic Analysis Results

The lithic assemblage recovered during Phase II testing of the Old Cedar South site included 238 artifacts (Table 14). Close to half of these were flakes, and together flakes and shatter made up about three-quarters of the assemblage. Miscellaneous broken rock fragments constitute the third most abundant category, followed by tested cobbles. Cores, tools and hammerstones occur in small numbers.

Table 14. Summary of Metric Data for Spring 2016 Phase II Lithic Artifacts by Category.

Category	N =	%	Grams (g) =	%	Max g	Avg g	Min g	SD*
Tested cobble	15	6.3	4,904.7	45.1	1815.0	327.0	12.5	571.4
Core	2	0.8	136.6	1.3	88.6	68.3	47.9	28.8
Flake	109	45.8	1,882.9	17.3	343.7	17.3	< 0.1	41.1
Shatter	76	31.9	580.8	5.3	143.1	7.6	< 0.1	18.5
Tool	2	0.8	12.1	0.1	8.8	6.0	3.2	3.9
Hammerstone	5	2.1	2,466.0	22.7	1650	493.2	160.91	647.5
Other fragment	29	12.2	899.9	8.3	137.8	31.0	< 0.1	37.3
TOTAL	**238**	-	**10,882.9**	-	-	-	-	-

* SD=standard deviation

8.6.2 Raw Material Analysis

The 2016 Phase II lithic assemblage from 21HE483 included 18 different raw materials. Of these, eight are specific identifications (e.g., Swan River Chert, Knife Lake Siltstone) and 10 are generic identifications (e.g., basaltic rock, chert, quartzite). Prairie du Chien Chert (44.1%) was the most common material, comprising a little under half of the assemblage (Table 15). Basaltic rock (%=18.9) and granitic rock (%=8.4) were the next most common, and they are included in "Chopping Tool Materials" in Table 15. Red River Chert comprised 5.5 percent of the assemblage. All other materials were present in small amounts.

Table 15. Lithic Raw Material Inventories by Count and Percentage from 2016 Testing in Comparison to 2015 Testing.

Raw Material Category	2016 FCRS Phase II n =	2016 FCRS Phase II % =	2015 ARS* Phase I % =	2015 ARS* Phase II % =
South Agassiz Region Materials	**19**	**8.0**	**1.3**	**3.7**
Swan River Chert	5	2.1	0.9	1.0
Red River Chert	13	5.5	-	2.7
Silicified Wood	1	0.4	0.4	-
West Superior Region Materials	**1**	**0.4**	**0.4**	**1.2**
Animikie Silicate Group	1	0.4	-	-
Biwabik Silica	-	-	-	0.1
Jasper Taconite	-	-	0.4	0.3
Gunflint Silica	-	-	-	-
Hudson Bay Lowland Chert	-	-	-	-
Kakabeka Chert	-	-	-	-
Lake Superior Agate	-	-	-	-
Fat Rock Quartz	-	-	-	0.7
Pipestone Region Materials	-	-	-	-
Gulseth Silica	-	-	-	-
Hollandale Region Materials	**105**	**44.1**	**83.7**	**78.1**
Cedar Valley Chert	-	-	-	-
Galena Chert	-	-	-	-
Grand Meadow Chert	-	-	-	-
Prairie du Chien Chert	105	44.1	83.7	78.1
Shell Rock Chert	-	-	-	-
Tongue River Silica	**1**	**0.4**	-	**0.3**
Border Lakes Greenstone Group	**2**	**0.8**	**2.1**	**0.4**
Knife Lake Siltstone	2	0.8	2.1	0.3
Lake of the Woods Rhyolite	-	-	-	0.1
Indeterminate BLG Group	-	-	-	-

Table 15. Continued.

Raw Material Category	2016 FCRS Phase II n =	2016 FCRS Phase II % =	2015 ARS* Phase I % =	2015 ARS* Phase II % =
Sioux Quartzite Group	**1**	**0.4**	-	-
Western River Gravels Group	-	-	-	**0.1**
Quartz	**10**	**4.2**	**9.0**	**2.2**
Generic Identifications	**33**	**13.9**	**3.4**	**6.6**
Agate	-	-	-	-
Burned chert	-	-	-	-
Chalcedony	-	-	1.3	-
Chert	10	4.2	0.4	3.5
Iron ore concretion	1	0.4	-	-
Jasper	-	-	0.4	-
Limestone	2	0.8	-	-
Quartzite	11	4.6	0.4	3.2
Graywacke	5	2.1	-	-
Unidentified	4	1.7	-	1.2
Exotic Raw Materials	-	-	-	**0.1**
Burlington Chert	-	-	-	0.1
Hixton Quartzite	-	-	-	-
Knife River Flint	-	-	-	-
Obsidian	-	-	-	-
Other Nonlocal Materials	-	-	-	-
Ontario associations	-	-	-	-
Wisconsin associations	-	-	-	-
Iowa associations	-	-	-	-
South Dakota associations	-	-	-	-
North Dakota associations	-	-	-	-
Chopping Tool Materials**	**66**	**27.7**	**0.9**	**5.9**
TOTAL	**238**	*****99.9**		

* ARS - *Archaeological Research Services from Harrison and Bakken (2016);** basaltic rock, granitic rock, and miscellaneous metamorphic materials;* *** Does not total 100.0 percent because of rounding error.

The specifically identified raw materials are associated with the South Agassiz, West Superior, and Hollandale source regions (see Table 15). Their presence in the assemblage can be explained by the geologic history of the Minnesota River valley. The valley was excavated by River Warren at the end of the Pleistocene. River Warren carried high-volume, high-velocity outflow from Glacial Lake Agassiz (Matsch 1983; Fisher 2003; Jennings 2007). Near the spillway at the head of the valley, the flux of water had sufficient volume and velocity to transport large boulders (Matsch 1983; Fisher 2004), at least during periodic catastrophic discharges from Lake Agassiz. It is likely that downstream the flow would have at least periodically been strong enough to transport pebbles and cobbles.

The valley was cut through a series of surficial and buried tills of varying origins (Matsch 1972). These deposits would have furnished clasts of toolstone of northwestern, northeastern, far western, and possibly other origins, as well as clasts of more local origin. In addition, erosion of local bedrock could have enriched the sediment load with toolstone clasts, particularly of Prairie du Chien Chert (cf. Wendt 2014a, 2014b). Sioux Quartzite is present in the deposits, and it is possible that the basal conglomerate of the Sioux Quartzite contributed clasts of chert, jasper, quartzite, quartz, or iron formation (see Bakken 2011 re. Sioux Conglomerate Group; Austin 1972a). Since the basal conglomerate is not widely exposed, however, its contribution to the assemblage is probably minimal and may be limited to some of the generically identified chert, quartz and quartzite.

The generically identified raw materials are either of unknown origin or are widely distributed and are not associated with a particular resource region or source area. In the present context it seems reasonable to conclude that they were procured on site, given the range of other raw materials found in the local gravel and cobble deposits.

There is a general association between the percentage of cortex-bearing pieces for a given raw material and the distance to the source area from a site. The more distant the source area is, the lower the percentage of cortical pieces tends to be. Figure 9 shows the prevalence of cortex for raw material groups and some individual raw materials at 21HE483. Note that in most cases, at least three-quarters of the pieces exhibit cortex. For the assemblage as a whole, about 80 percent of the pieces exhibit at least some cortex. These very high numbers support the conclusion that all materials were likely procured on site.

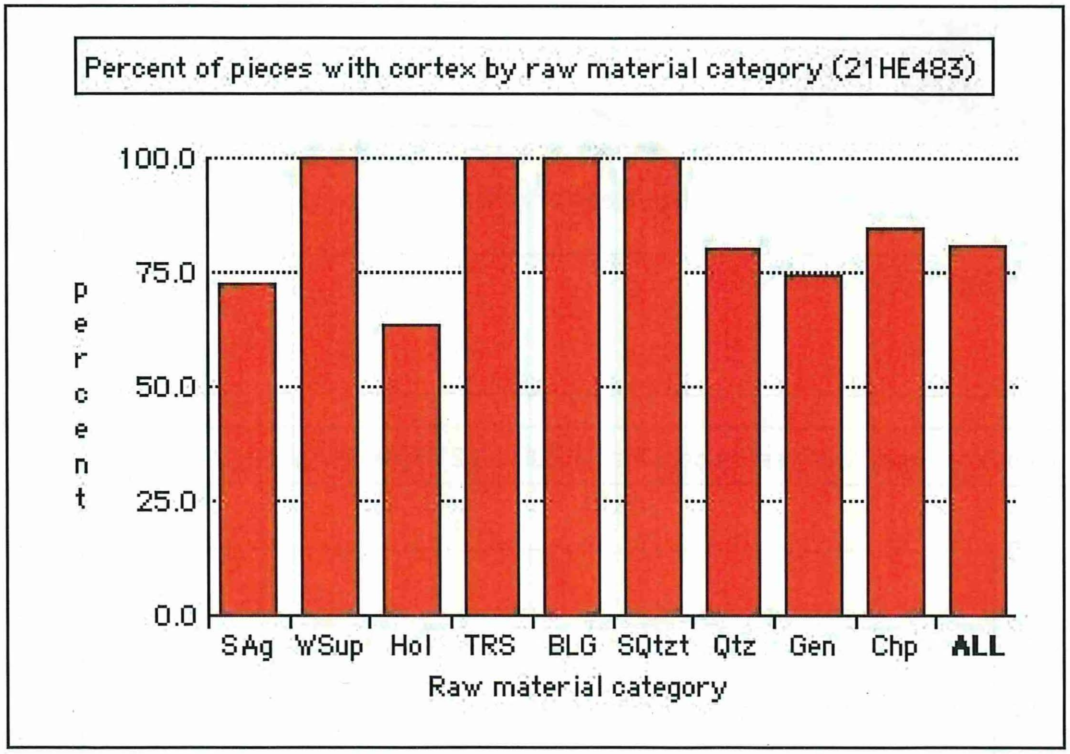

Figure 9. Percent of Pieces with Cortex by Raw Material Category.

8.6.3 Artifacts by Morphological Category

Tested Cobbles. A total of 15 tested cobbles were identified in the assemblage (Table 16, Figures 10 and 11). Nine of the tested cobbles are Prairie du Chien Chert (Figure 12), two are quartzite, and there are one cobble each of Red River Chert, quartz, basaltic rock, and unidentified rock. The testing of materials like basaltic rock cobbles is somewhat surprising. This, and the presence of deliberately struck flakes of materials that are not suitable toolstone, suggests that the flintknappers were not entirely focused on finding familiar types of toolstone, but were testing any cobble that appeared potentially useable at a glance.

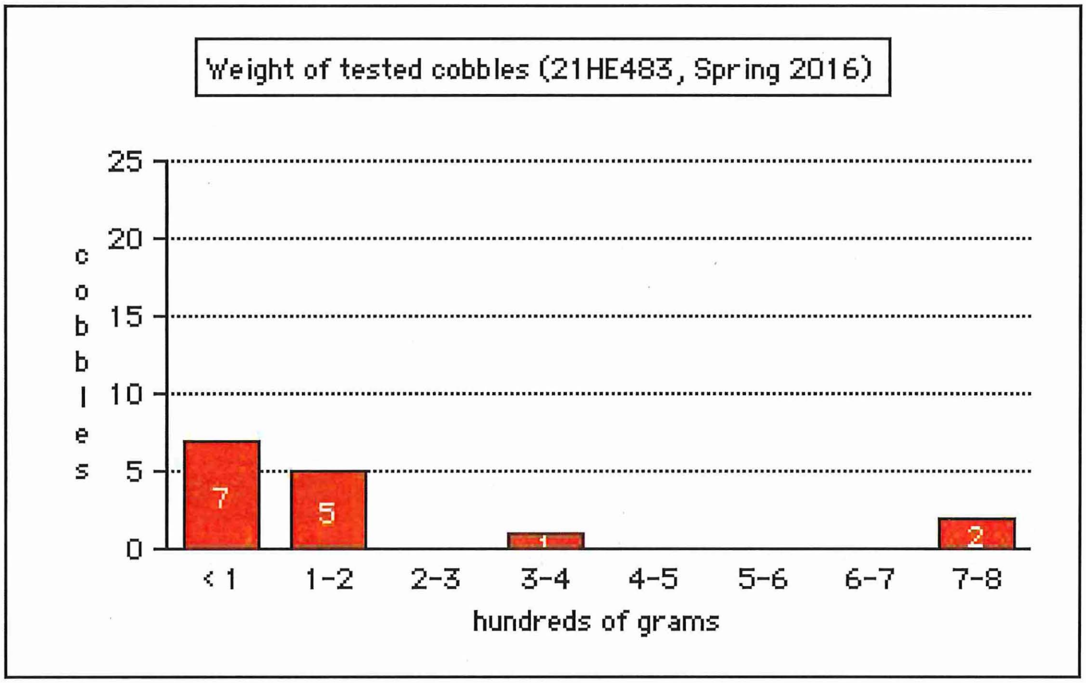

Figure 10. Weight of Tested Cobbles.

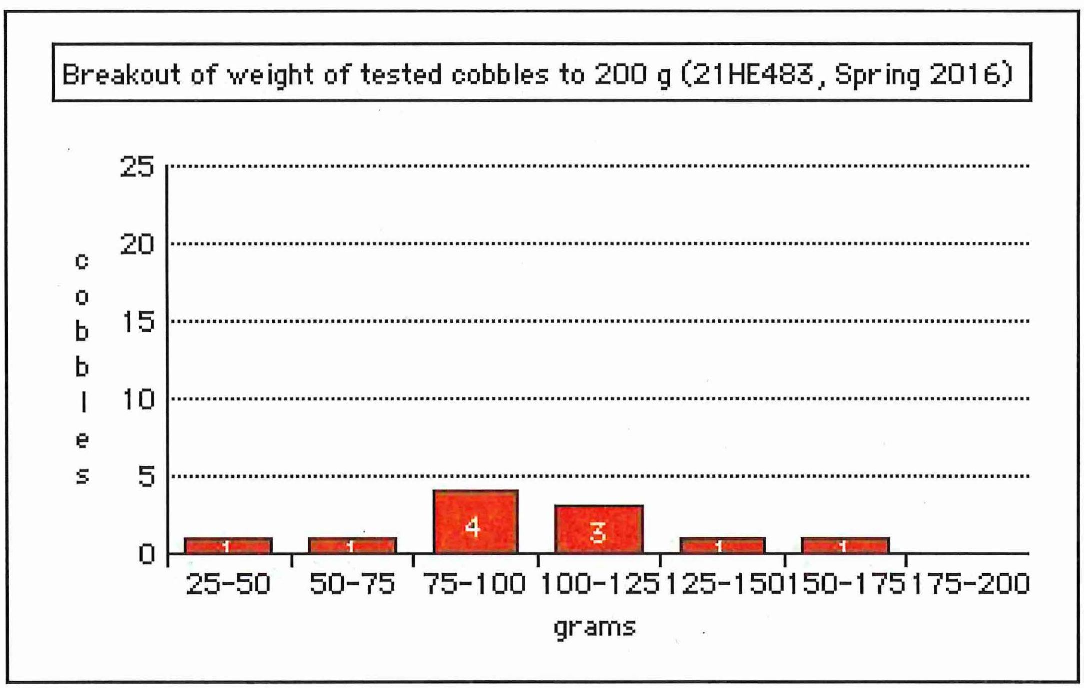

Figure 11. Breakout of Weight of Tested Cobbles to 200 g.

Table 16. Summary of Information for Tested Cobbles from Spring 2016 Phase II Excavation.

Catalog #	Provenience	Raw Material	Flake Rem's	Max (mm)	g =
1.1	ST F 4, 23-43 cm	Prairie du Chien Chert	1	108	1,625.0
2.1	ST F 4, 43-63 cm	Prairie du Chien Chert	*3	69	166.1
6.1	ST F 7, 30-50 cm	Quartzite	1	84	337.2
10.1	ST F 8, 55-75 cm	Quartz	*4	80	138.4
14.1	ST F 10, 60-80 cm	Quartzite	1	54	76.0
16.1	ST F 11, 60-80 cm	Prairie du Chien Chert	3	80	124.4
27.1	ST F 27, 60-80 cm	Unidentified rock	1	68	118.9
28.1	ST F 27, 80-100 cm	Prairie du Chien Chert	2-4	64	96.4
28.3	ST F 27, 80-100 cm	Prairie du Chien Chert	1	48	38.7
28.6	ST F 27, 80-100 cm	Red River Chert	1	33	12.5
31.1	ST F 29, 20-40 cm	Basaltic rock	*2	61	85.0
31.2	ST F 29, 20-40 cm	Prairie du Chien Chert	min 5	56	71.8
32.1	ST F 29, 40-60 cm	Prairie du Chien Chert	min 5	69	111.6
33.1	ST F 29, 60-80 cm	Prairie du Chien Chert	min 1	144	1,815.0
35.1	ST F 29, 100-120 cm	Prairie du Chien Chert	3	68	87.8
	Minimum		**1**	**33**	**12.5**
	Average		**2.3**	**63**	**327.0**
	Maximum		**min 5**	**144**	**1,815.0**

* Flake removal count not clear. Weight to nearest 0.1 g, except to nearest 5 g for specimens over 400 g.

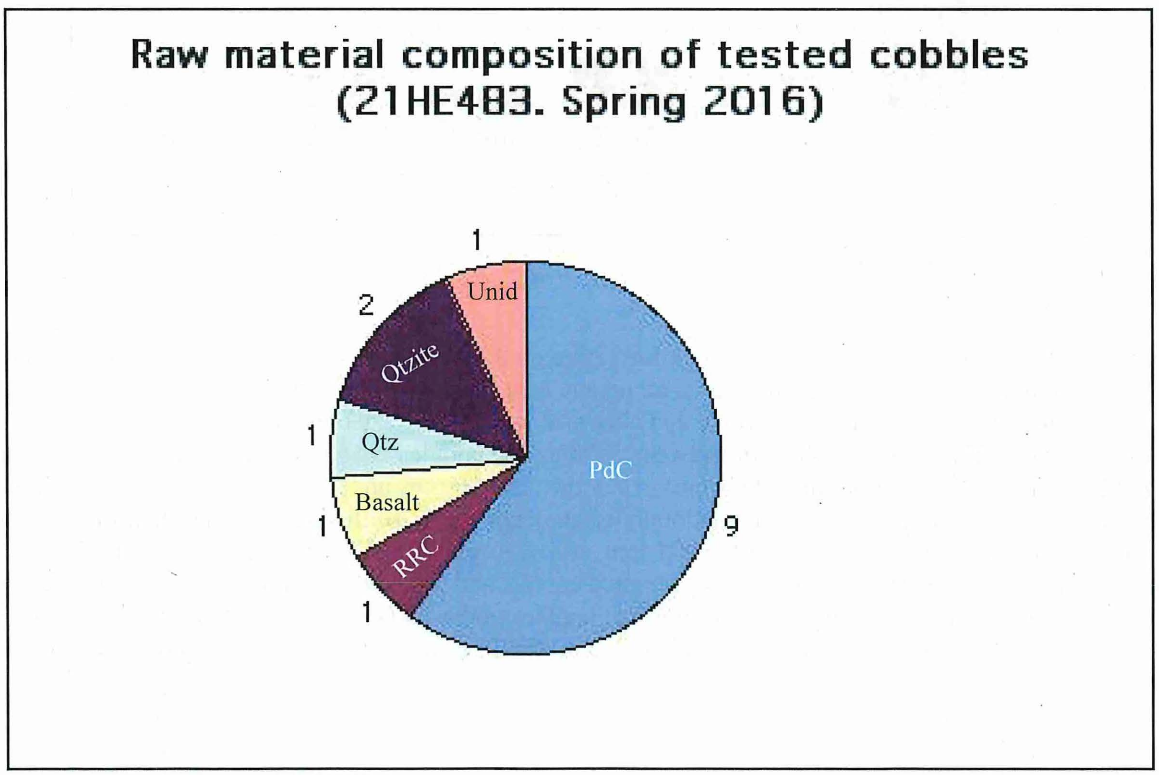

Figure 12. Raw Material Composition of Tested Cobbles.

Figure 13 shows the number of flake removals per cobble for specimens where flake removals could be counted. (Some were of such coarse material or so full of flaws that individual flake scars could not easily be distinguished.) In cases where flake removals could generally be distinguished but the total number was not clear, the minimum number of flake removals is plotted. The number of flake removals ranges from one to five, and averages a bit more than two (note that some pieces had more flake scars, but these were classified as cores based on other evidence). Presumably these numbers reflect how many blows it took for the flintknapper to evaluate the quality of the cobble (and for these specimens decide that the cobble was not useable). These numbers also raise interesting questions about defining tested cobbles based in part on the number of flake removals. Florin et al. (2015:32, 33), for example, limit tested cobbles to no more than three flake removals. The results from 21HE483, however, suggest that it may be necessary to rethink such definitions.

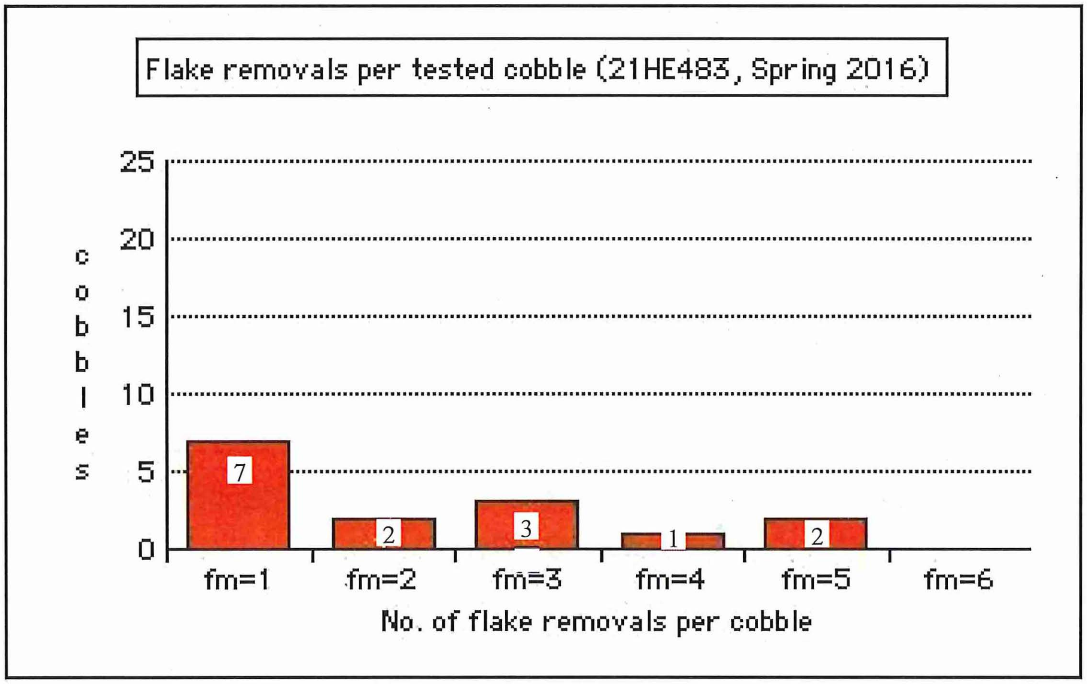

Figure 13. Flake Removals per Tested Cobble.

Figures 10, 11, and 14 summarize metric information on the size of the tested cobbles. Figure 14 shows the maximum cobble dimension measured along any axis. Note that the X axis of the graph is demarcated to correlate with the particle and clast size scale used by geologists (Udden 1914; Wentworth 1922), where the division between pebbles and cobbles is 64 mm, and the division between cobbles and boulders is 256 mm. This means that the tested pieces under 64 mm are technically "tested pebbles." However, making this distinction in terminology seems confusing instead of helpful. Maximum dimension ranges from 42 to 171 mm, and averages just under 78 mm (Table 16). Figure 10 shows the overall distribution of weight per tested cobble, and indicates that most weighed under 200 g. Figure 11 therefore breaks out the distribution of cobbles under 200 g, and shows that the distribution is fairly even across this range. Tested cobble range in weight from about 30 to 755 g, and average just over 200 g.

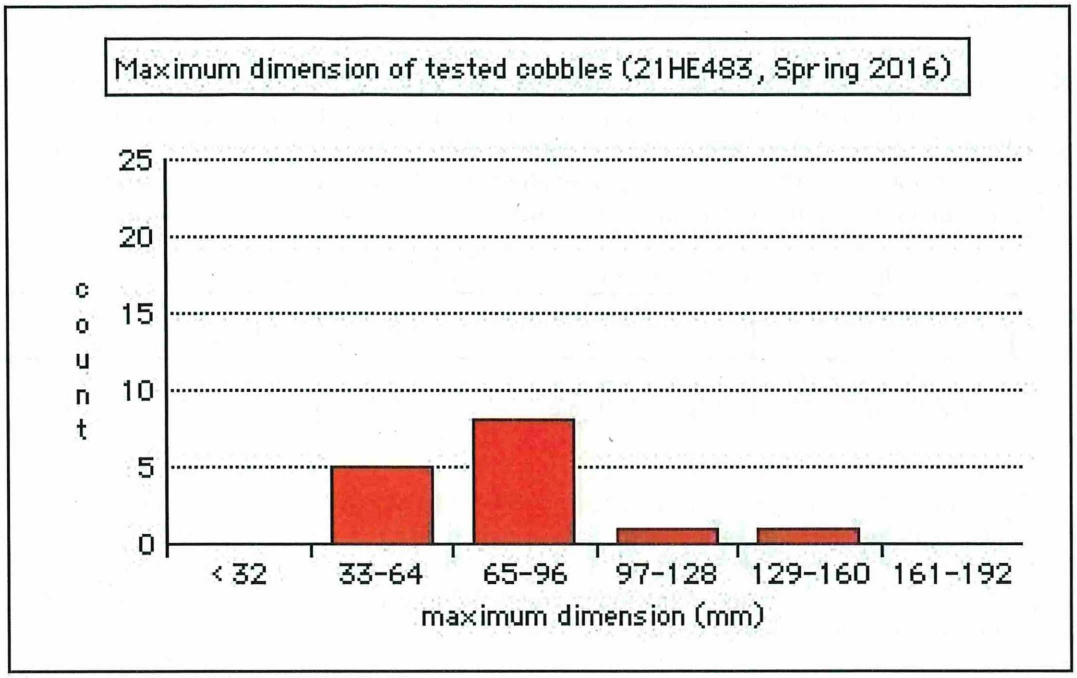

Figure 14. Maximum Dimensions of Tested Cobbles.

The tested cobbles were generally notable for their poor raw material quality. They tended to have numerous internal cracks, voids, areas of coarse texture, and other problems. Areas of better quality raw material were limited in extent. Such poor quality should not be surprising, however, since these were rejected pieces.

Tools. Two tools were identified in the assemblage (Table 17). One is a piercer, and the other is a utilized flake. The piercer is an elongated piece with a triangular cross section. One end has a sharp, stout tip. Back from this, two edges exhibit rough bifacial retouch along half the length of the tool. The retouch served only to form the sharp tip, and no apparent effort to create a usable bifacial edge. The piercer was likely used for puncturing soft materials like animal hides, although the tip could also have been used as a graver for incising bone or wood. The utilized flake exhibits small flake scars along part of thin edge. Utilized flakes are typically light-duty cutting, slicing, scraping, and sawing tools that were used on soft materials (meat, hides, and plant material) or moderately resistant materials (wood and bone).

Table 17. Summary of Information for Lithic Tools from Spring 2016 Phase II Excavation.

Catalog #	Provenience	Category	Raw Material	mm=	g=
10.4	ST F8, 55-75 cm	Piercer	Chert	L = 49 W = 18 T = 18	8.8
31.4	ST F29, 20-40 cm	Utilized flake	Prairie du Chien Chert	L = 36 W = 18 T = 7	3.3

Cores. Two cores were found (Table 18). A core of Sioux Quartzite displays at least seven flake removals from one acute edge and two faces of core. It looks like the core may have broken through the middle along a weak plain in the rock. The reduction is organized and patterned in a way that goes beyond merely testing the cobble. A core of Animikie Silicate displays 10 major flake removals, plus a few small flake scars. Several flake removals are positional along a thin edge covering ca. one half of the circumference of the core. There was an apparent attempt to thin and edge the piece. The piece may have been abandoned because it was too small. There were also issues with raw material quality.

Table 18. Summary of Information for Cores from Spring 2016 Phase II Excavation.

Catalog #	Provenience	Raw Material	Flake Rem's	Max (mm)	g =
32.2	ST F 29, 40-60 cm	Sioux Quartzite	min. 7	57	47.9
36.1	ST F 30, 80-100 cm	Animikie Silicate	10	71	88.6

Flakes. Flakes comprised the largest artifact category in this assemblage (Table 14). There were 109 flakes, weighing a total of 1,882.9 g. The largest flake weighed 343.7 g, while the smallest piece weighed less than 0.1 g. The average weight was 17.3 g, more than twice the average weight for pieces of shatter. Each flake was analyzed according to the protocol outlined in the methods section above. The results of the analysis are presented below.

Shatter. Pieces of shatter comprised the second largest category of artifacts in this assemblage (Table 14). There were 76 pieces, weighing a total of 580.8 g. The largest piece weighed 143.1 g, and the smallest less than 0.1 g. The average weight was 7.6 g. Raw materials composition was included in site totals but not separately tabulated for this artifact category. Other metrics were not compiled for this category, and the artifacts were not subjected to more detailed examination.

Other Artifacts. Other artifacts included hammerstones, pieces that may have been broken from hammerstones, and other fragments that may have been broken by human activity but were not easily classified (Table 14). Since these pieces seemed minimally informative, they were not analyzed in any detail. There was no clearly-identifiable fire-cracked rock.

8.6.4 Technological Analysis

Several characteristics were evaluated for each of the 109 flakes identified in the assemblage. These characteristics are outlined in Table 3. The results are discussed below, by characteristic.

Cortex on Dorsal Surface. The amount of dorsal cortex on each flake was evaluated in five categories ranging from all to none. The number of flakes for each category is shown in Figure 15. The data produced a skewed negative bell curve, with "all" and "none" equal in importance. In reading this graph, it is important to keep in mind that there is only an approximate correspondence between the left side of the graph with early reduction stages and the right side of the graph with late reduction stages. It is true that flakes with cortex on the entire dorsal surface (the "all" bar) are strongly associated with the first step of lithic reduction. Flakes with no cortex on the dorsal surface (the "none" bar), however, can be produced at any stage of reduction, even though they are less common in early-stage reduction and become more common as reduction proceeds. Thus, the graph does not indicate equal support for early and late stage reduction.

An adequately informed interpretation of these data would require experimental reduction of the sorts of cobbles found at this site. Lacking that, the interpretation must be more cautious. The large number of flakes in the "all," "half+", and "half" columns clearly indicates that cobble testing or decortication were important at the site. It seems reasonable to suggest that many of the flakes represented in the "half-" column also resulted from testing or early reduction. Similarly, an unknown proportion of the flakes represented in the "none" column could have resulted from testing or early stage reduction, although the proportion is no doubt smaller than for the "half-" flakes. Thus, a cautious reading of the data suggests a strong representation of very early stage reduction, with some continued reduction.

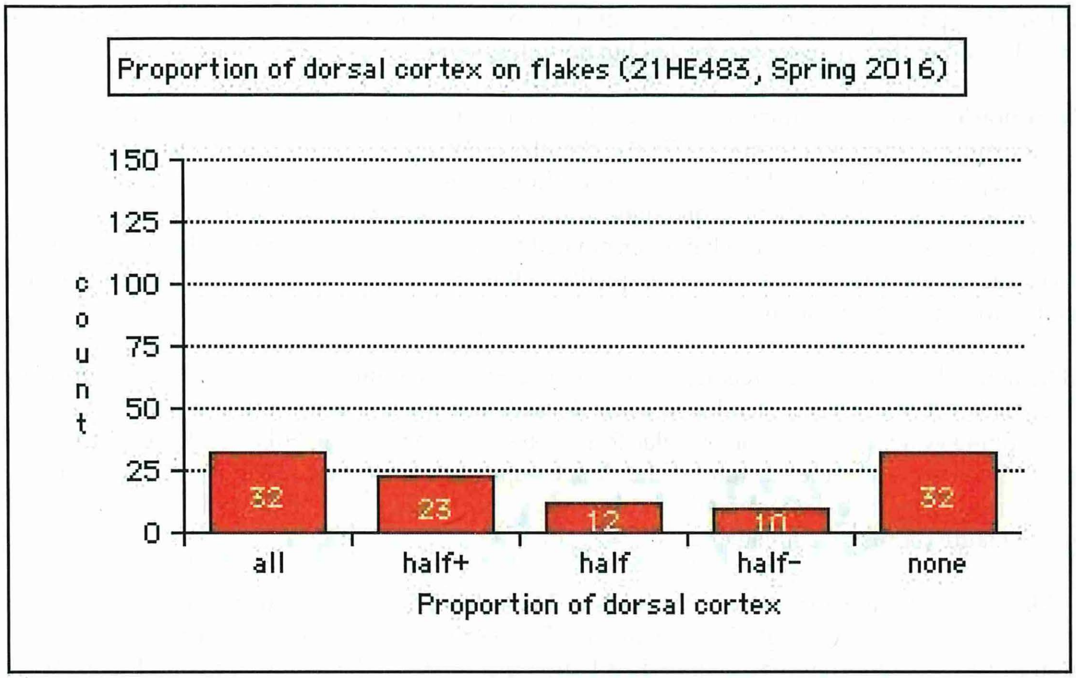

Figure 15. Proportion of Dorsal Cortex on Flakes.

The tested cobbles and core described above can provide some further help in understanding the data shown in Figure 15. Given the number of flake removals per tested cobble (minimum one, maximum five, average 2.3), we can see that many (perhaps all) of the resulting flakes would display cortex. The first flake must necessarily be cortical on the entire dorsal surface. If the second flake was struck next to the first one, then the second flake could tend to have cortex on around half the dorsal surface. The same would be true for the third flake. If the core was rotated between flake removals, the next flake would most likely again be entirely cortical on the dorsal surface.

The importance of early-stage reduction in this assemblage is emphasized by looking at the total number of flakes with any cortex on the dorsal surface (thus making the data compatible with studies where cortex is only recorded as present or absent.) Of the total 109 flakes, 77 (70.6 percent) exhibit some cortex on the dorsal surface.

Cortex on Striking Platform. A total of 47 flakes (43.1 percent) were classified as having a cortical striking platform, and 60 (55.0) as having a noncortical striking platform. As with dorsal cortex, this is a high percentage and suggests a predominance of early-stage reduction (note that presence or absence of cortex could not be determined on two flakes with damaged or missing platforms). It should also be noted that there was some ambiguity in this observation. The generally poor quality of the raw material affected expression of flake morphology, and the position of the striking platform could not always be determined clearly. In some cases, this was compounded by difficulty in distinguishing striking platform from dorsal surface. These problems, however, may also be to some degree indicative of cobble testing and early stage reduction. As reduction continued and the form of the core became more regular and platform angles more acute, there would be less problem with identifying striking platforms or clearly distinguishing striking platform from dorsal surface.

Bulb of Percussion. A total of 26 of 109 flakes (%=23.9) were thought to exhibit a bulb of percussion. This number is probably not significant, however. Poor raw material quality hindered the expression of standard flake morphology, and the presence or absence of a bulb of percussion was often hard to determine. Therefore, this number is reported but not interpreted.

Flake Termination. Flake terminations were evaluated as feather, hinge, or step. The majority of flakes had a feather termination (n=85, %=78.0). Smaller numbers had a hinge termination (n=4, %=3.7) or a step termination (n=11, %=10.1). In addition, termination types were mixed (e.g., part feather, part step) on six flakes (%=5.5) and undetermined on three flakes. Many of the step terminations resulted from the fracture being terminated by a crack in the rock or another raw material flaw. Given the issues with poor raw material quality in this assemblage, it is perhaps surprising that step fractures were not more common.

It should be noted that many of the feather terminations were in fact quite steep, rather than tapering to a thin edge. This is because flakes tended to be thick, with a dorsal geometry reflecting the variable form of the cobble rather than the more regular form of a core. These were still considered feather terminations, however, since the fracture neither hinged upward nor stopped abruptly at a break. It may be that another category of flake termination was needed, and would have been helpful in better revealing the nature of this assemblage.

Weight. Flake weight ranged from less than 0.1 g to 343.7 g; with an average weight of 17.2 g and a median of 4.8 g. The average weight is large, and the heaviest pieces are unusually large. The distribution of flake weights has a bell curve distribution that peaks in the 8 to 16 g range (Figure 16).

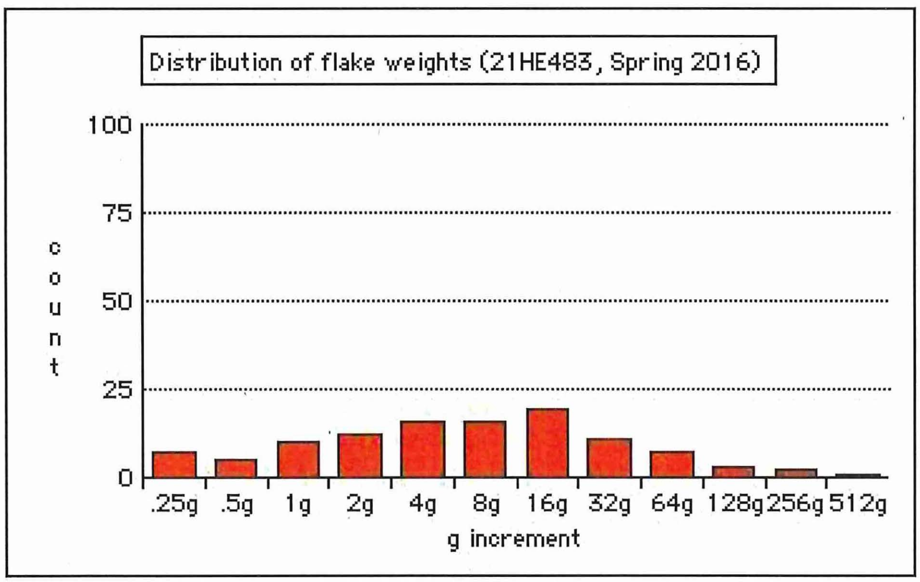

Figure 16. Distribution of Flake Weights.

Length and Thickness. Flake length ranged from 6 to 177 millimeters, with an average of 31.1 millimeters and a median of 27.0 millimeters. Flake thickness ranged from one to 47 millimeters, with an average of 10.7 millimeters and a median of 9.0 millimeters. These figures again indicate relatively large flake size. The distributions of length and thickness are shown in Figures 17 and 18 (note that the distribution curve is strongly skewed to the left and therefore the data are categorized with a logarithmic scale to facilitate display). Flake length peaks in the 20.3 to 30.4 millimeter category. Flake thickness does not show a single clear peak in distribution.

It is also interesting to compare the ratio of flake length to thickness as a way of assessing how blocky the flakes are. Early stage testing could be expected to produce blocky flakes, since the thickness and dorsal configuration of the flake are controlled by the form of the cobble rather than by the form of a regularly shaped core. Thus, the early-stage flakes would tend to be thicker and more blocky, with a lower ratio of length to thickness. As reduction proceeded and the form of the core became better controlled, the resulting flakes should tend to be thinner and have a higher ratio of length to thickness.

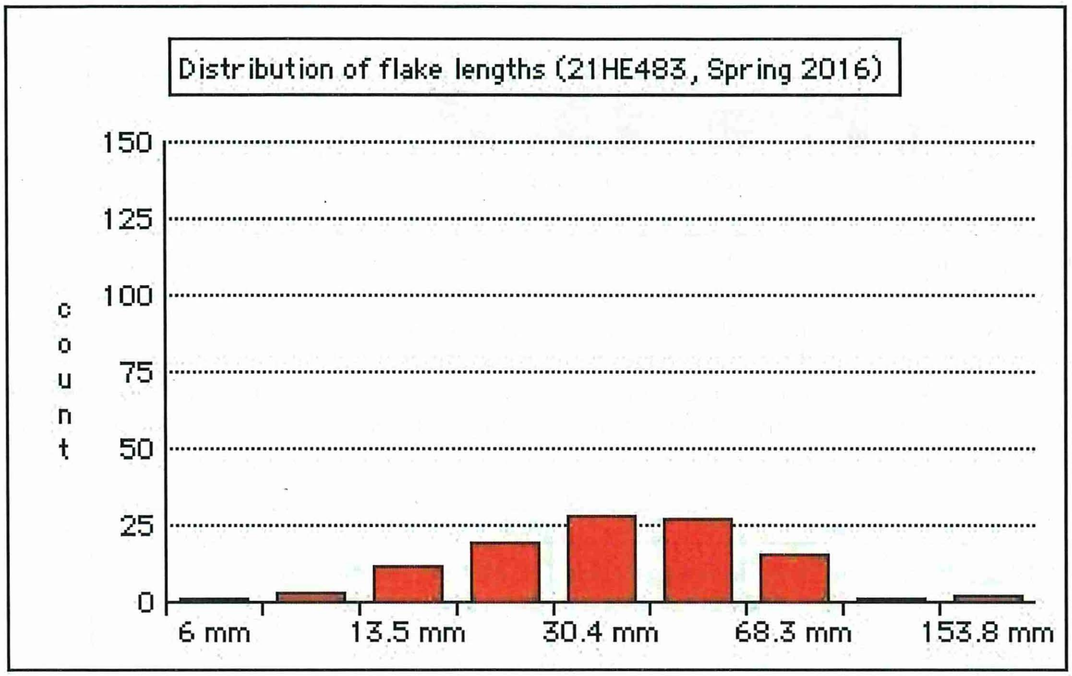

Figure 17. Distribution of Flake Length.

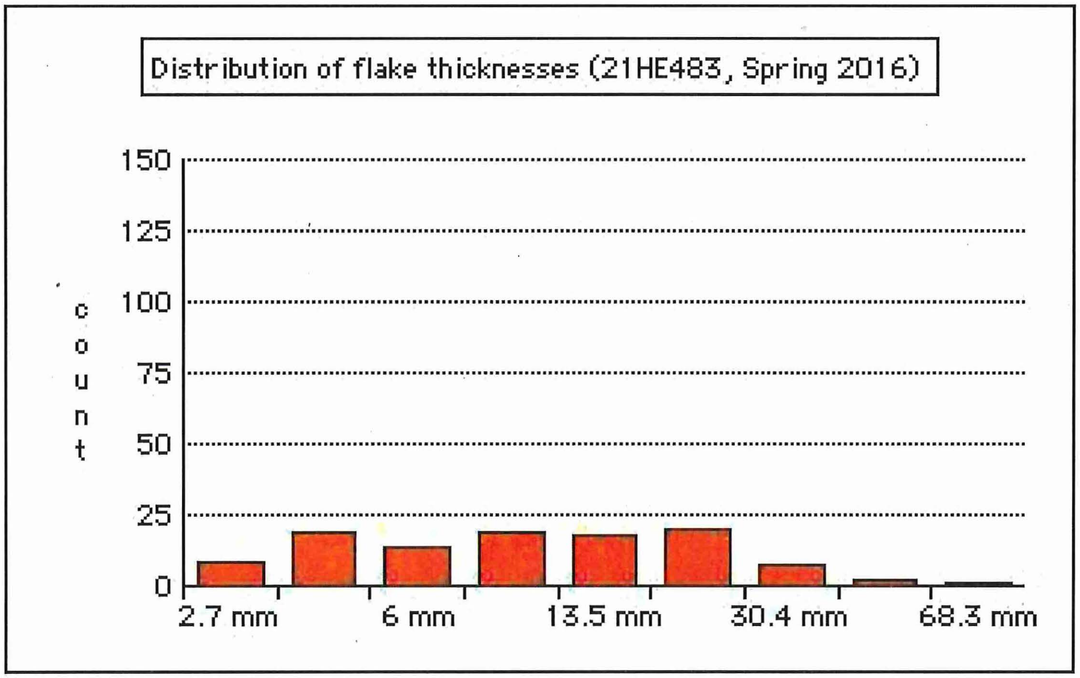

Figure 18. Distribution of Flake Thicknesses.

Figure 19 shows the distribution of flake length-to-thickness ratios for 21HE483. The largest category includes flakes that are two to three times longer than they are thick, a metric which indicates a relatively blocky flake. Further, two-thirds of the flakes are no more than four times as long as they are thick. Long, thin flakes are present, but they are in a minority, suggesting that continued core reduction has a limited representation in this assemblage.

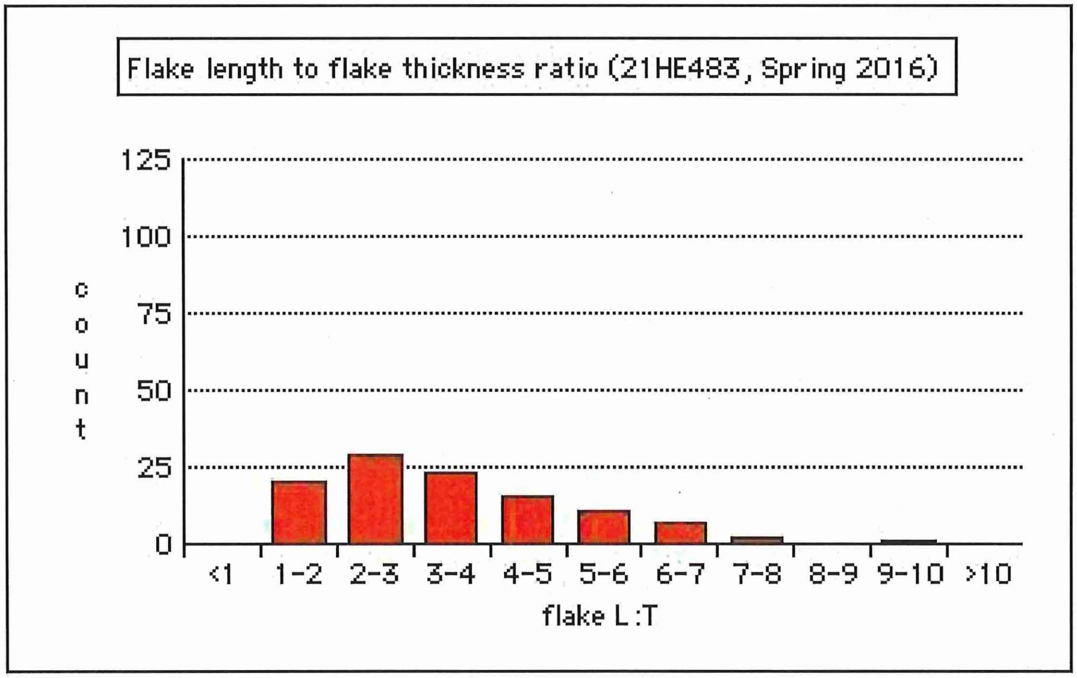

Figure 19. Flake Length to Flake Thickness Ratio.

8.6.5 Lithic Discussion

The types of artifacts recovered from 21HE483 indicate that lithic reduction was the focus of activity at the site. Evidence of other activity is scant. Two flake tools indicate some minor ancillary activity, but this might have been as prosaic as slicing a bite of food or mending a tool. A number of rock fragments may have been pieces broken off a hammerstones, and no clearly identifiable fire-cracked rock was found.

The raw material analysis suggests that essentially all of the raw material worked at the site could have been, and probably was, also procured at the site. The raw materials comprising the assemblage are associated with different resource regions, but their presence at the site can be explained by the glacial history of the region and the geologic history of the Minnesota River valley. Local procurement is supported by the high proportion of cortical pieces, which ranges from 60-plus to 100 percent for all flakeable materials (noting that this excludes a few pieces of broken stone that may be cultural but were apparently not produced by flintknapping).

The recovery of 15 tested cobbles suggests that raw material testing, the first step in the reduction process, was an important activity at the site. The high ratio of tested cobbles to cores (15 to two) seems to support this, although it should be borne in mind that successful cores would have been removed from the site. The tested cobbles show that the flintknappers removed anywhere from one to five flakes before concluding that a cobble was not workable, with an average of about a little more than two flake removals per cobble. The tested cobbles average over six centimeters in maximum dimension, and just over 300 g in weight. In addition to familiar types of toolstone, the flintknappers also occasionally tested a cobble of poor quality rock.

A detailed analysis of flakes also suggests that early-stage reduction was the main activity at the site, and that raw material testing may have been especially important. About 70 percent of the flakes exhibit some cortex on the dorsal surface, with almost 30 percent having cortex on all of the dorsal surface, and over 50 percent having cortex on half or more of the dorsal surface. Cortex was also identified on 43 percent of striking platforms, although this observation proved somewhat problematic.

Measurements of weight, length and thickness showed that average flake size was rather large, as would be expected for cobble testing and early-stage reduction. Some individual pieces were exceptionally large, with maximum length in excess of 15 centimeters, width near five centimeters, and weight 300 g. The ratio of flake length to thickness shows a preponderance of thick, blocky flakes, which could be expected if flake morphology was controlled by the irregular form of a cobble rather than the controlled form of a core.

Over three-quarters of the flakes had a feather termination, and only about 10 percent had a step termination. A higher proportion of step terminations might be expected for an assemblage produced by raw material testing and early-stage reduction. However, flakes that did not terminate in a hinge or step fracture were counted as having feather terminations even when the termination was quite blunt. Had the protocol distinguished between blunt and tapered terminations, the results might have been more revealing. Thus, this observation probably has limited utility for assessing reduction stage for this assemblage.

8.6.6 Comparison with Other Raw Material Procurement Sites

The report of the initial Phase II work at 21HE483 (Harrison and Bakken 2016) included an extended discussion of selected lithic raw material procurement site in Minnesota, and a detailed comparison of data from those sites with data from 21HE483. The discussion and comparison are only summarized here, and the reader is directed to the previous report for further information. The selected sites included six Galena Chert procurement sites in southeastern Minnesota (Myster 1996); Bradbury Brook, a Late Paleoindian age Knife Lake Siltstone procurement site in east-central Minnesota (Malik and Bakken 1999); and 21BE271, a Prairie du Chien Chert procurement site farther up the Minnesota River valley near Mankato (Withrow 2003).

Myster (1996) reported on 24 artifact concentrations at six Galena Chert procurement sites in Fillmore County of southeastern Minnesota. The age of these subareas ranged from Paleoindian to Middle Woodland and Mississippian, although the early components were more common. Myster (1996:17) noted that most of the artifacts from these sites related to lithic reduction, and that the sites "exhibited a paucity of subsistence remains, fire-cracked rock, and substantial tool-type diversity." Myster concluded that the assemblages all represented bifacial core technologies rather than core-flake technologies. Based on flake characteristics, he concludes that most of the subareas represented mixed stages of lithic reduction, with a few leaning towards earlier reduction stages and a few towards later reduction stages.

Malik and Bakken (1999) reported on Bradbury Brook, a Knife Lake Siltstone procurement and reduction site located in Mille Lacs County of east-central Minnesota. A radiocarbon date of 9,220 $\pm$ 75 RCYBP and the recovery of a stemmed projectile point base recently reclassified as Scottsbluff (M. Muñiz, personal communication 2014) make the site Late Paleoindian in age. The main artifact concentration was a dense workshop deposit that included flaking debris, a wide variety of tools, hammerstones, and even fragmented anvil stones. Based on a flake attribute analysis, Malik and Bakken (1999:157-158) concluded that "A small percentage of the flake data reflects initial reduction or decortication of cores," that "Cross-comparison of various features indicates that 70 percent of the lithic reduction activity at the site relates to initial reduction and the primary bifacial trimming of selected pieces," and that "Another 15 percent to 20 percent of the flake data represent secondary trimming of the preform bifaces."

Withrow (2003) reported on 21BE271, a Prairie du Chien procurement site near Mankato, in Blue Earth County of south-central Minnesota. Most of the site consists of a light-density lithic artifact scatter, but a high-density lithic workshop was also identified and sampled. The basal portion of a Table Rock point indicated a Late Archaic age for the workshop. The workshop focused on the initial reduction of Prairie du Chien Chert, likely gathered from secondary concentrations associated with the nearby Minneopa Creek. Small percentages of till-sourced raw materials were also reduced on site, and still smaller proportions of nonlocal stone were present. Based on a detail technological analysis, Withrow (2003:40) concluded that "on-site processing of the local stone emphasized early stage biface reduction. This strongly suggests that blanks and early-stage biface preforms were being prepared for transport rather than on-site use."

The Fillmore County sites, Bradbury Brook, 21B271 and Old Cedar South all represent some aspect of raw material procurement and initial reduction, and therefore the assemblages from these sites have similar characteristics. There were also, however, differences between the assemblages, and these point to some differences in the reduction stage represented.

Differences in the percentage of cortical flakes seemed especially informative. Fillmore County sites were generally in the range of 20 to 40 percent, leading to the conclusion that raw material testing and selection was undertaken at another location and the resulting early-stage cores were brought to the site and further reduced. The figure of more than 70 percent for Old Cedar South would seem to point to the opposite conclusion – raw material testing and selection were undertaken at Old Cedar, and the resulting "cores" were carried to another location for further reduction.

Data for flake length, thickness and weight from Bradbury Brook and Old Cedar South reflected a significant difference between the assemblages. The Bradbury Brook assemblage included large flakes, similar in size to the larger pieces at Old Cedar South. However, Bradbury Brook also included an abundance of small flakes that represented further core and biface reduction. These smaller flakes constituted a smaller proportion of the Old Cedar South assemblage, again suggesting that Old Cedar South primarily represents the earliest reduction stages.

Low artifact diversity and a scarcity of evidence for subsistence activities suggested that the Fillmore County sites, 21BE271 and Old Cedar South were tightly focused on lithic reduction. These appear to be single-purpose sites that provide a clear picture of a limited range of activity. In effect these sites present a "snapshot" of one part of a broader technological and subsistence system that was spread variously across the landscape. Bradbury Brook, in contrast, seems to be a multipurpose camp that included a lithic workshop. Different parts of the Bradbury Brook site were functionally distinct, artifact diversity was high, and the presence of use wear on a variety of tools suggested that a variety of tasks were carried out at the site.

8.6.7 Lithic Conclusion

There are differences between the data derived from the initial Phase II and the supplemental Phase II reported here. These differences are, however, generally small (see Tables 15 and 19 for examples), and do not affect the conclusions reached in the previous report. Both sets of flake analysis data in particular are strikingly similar in most metrics, and both data sets support the same conclusions regarding the activity carried out this site. Therefore, the previous conclusion bear repeating.

Table 19. Comparison of Selected Flake Characteristics for Bradbury Brook (21ML42) and Old Cedar South (21HE483).

	Weight (g)		**Length (mm)**		**Width (mm)**		**Thickness (mm)**		**Termination**	
21ML42	Max	515.0	Max	154	Max	151	Max	46	Feath	54.4
	Aver	6.6	Aver	22.2	Aver	21.0	Aver	5.3	Hinge	4.1
	Min	0.1	Min	3	Min	3	Min	1	Step	38.1
21HE483	Max	415.0	Max	142	Max	-	Max	53	Feath	68.9
Fall	Aver	11.3	Aver	27.1	Aver	-	Aver	9.6	Hinge	8.9
2015	Min	< 0.1	Min	25	Min	-	Min	8	Step	15.6
21HE483	Max	343.7	Max	177	Max	-	Max	47	Feath	78.0
Spring	Aver	17.3	Aver	30.8	Aver	-	Aver	10.6	Hinge	3.7
2016	Min	< 0.1	Min	6	Min	-	Min	1	Step	10.1

Analysis of the lithic artifacts from Old Cedar South (21HE483) indicates that this was a lithic raw material procurement site. Activity was focused on raw material testing, while further core reduction was probably limited. There is scant evidence for any activity outside of preliminary lithic reduction, and any other activity might have been as prosaic as eating a meal or quickly preparing a tool. The site is located on a river-valley ridge that is rich in cobbles, including cobbles of toolstone. Prairie du Chien Chert was the most abundant of these, but Swan River Chert, Knife Lake Siltstone, Tongue River Silica, Fat Rock Quartz, and other raw materials were also gathered from the cobble deposits.

Lithic raw material procurement sites are not especially common in the region, and procurement sites focused on raw material testing are even less common. In fact, it is not clear whether any examples have previously been reported in the state. Yet sites of this type promise to provide important information on how past societies organized their use of the landscape, on natural resource extraction patterns, on the organization of lithic technology, and more.

This is illustrated by a passage from the concluding section of a recent report on 21CR155, a multicomponent camp farther up the Minnesota River Valley. In this passage, Bakken and Florin (Florin et al. 2015:380) hypothesize the existence of sites like Old Cedar South:

> Till-derived raw materials are also found at sites within and near the Minnesota River valley, especially in the upper valley, and the importance of these resources should not be overlooked. In addition to the surficial Des Moines lobe tills, older buried tills that were eroded by Glacial River Warren may be locally exposed. The geology of these tills has not been thoroughly explored, and it would be helpful to know more about their lithology and the types of toolstone they might provide. It would also be helpful to know more about the deposition of clasts from these tills along the length of the valley, so we could begin to look at whether the deposits served as raw material sources.

Information from the Old Cedar South site already makes it possible to better understand lithic raw material provisioning and use patterns at 21CR155 and other sites in and near the valley. In addition, knowledge of the existence of a site like Old Cedar South should lead to better informed survey in the Minnesota River Valley, and the chance to discover similar sites and thus better understand this singular aspect of past landscape use, resource use, subsistence systems, and technologies.

Note: *Since the investigations reported here are an extension of previous Phase II work at 21HE483, and since the lithic analysis for both the previous and current stages of work was done by the same analyst, parts of this analysis are essentially an edited version of the analysis from the report on the initial Phase II work (Harrison and Bakken 2016). Thanks to Christina Harrison, Archaeological Research Services (ARS), for permission to re-use text first published in the ARS Phase II report.*

9. SITE 21HE483 SUMMARY AND RECOMMENDATIONS

The additional Phase II testing at 21HE483 has been completed. The artifacts are similar to those recovered during previous site investigations and consist primarily of decortication flakes and tested cobbles, supporting the interpretation that the primary site activity was toolstone procurement. A muskrat bone, which is likely cultural, yielded a radiocarbon date of 2070 ± 30 RCYBP, providing a date for an Early to Middle Woodland occupation. The bone provides evidence of subsistence activities. A small amount of heat-treated lithics indicate that a fire hearth or heating facility existed at the site. Two stone tools were recovered, including a utilized flake and piercer. These tools indicate that site activities also likely included such tasks as animal/plant processing, hide working, and bone/wood working. The soils and archaeological deposits appear to be intact below fill.

Site 21HE483 has integrity and is recommended eligible for listing on the NRHP under Criterion D for the Lithic Scatter context because it is likely to yield important information on toolstone procurement in southeastern Minnesota. The site meets Lithic Scatter context criteria for eligibility, including: 1) the site has a historic context association; 2) the site contains unusual materials in the sense that it contains an abundance of redeposited Prairie du Chien Chert cobbles along with smaller amounts of a wide variety of other materials derived from local tills; 3) the site is in an unusual location in the Minnesota River valley bottom; 4) the site is known to have an exception use (toolstone procurement); and 5) the site has an exceptional density of material that consists of 100 artifacts or more per square meter in formal units (see Harrison and Bakken 2016). Also, a high density of artifacts was recovered from Shovel Tests F27 (62 lithics) and F29 (65 lithics), and several other shovel tests contained artifact counts that are projected to easily exceed 100 artifacts in a square meter unit.

Existing information from toolstone procurement sites is very sparse, and 21HE483 plays an important role in the overall exploitation and use-patterns of Prairie du Chien Chert and other materials in the region. Many nearby sites along the Minnesota River valley are noted for having considerable amounts of Prairie du Chien Chert and other lithic materials. However, the source for these lithic materials has previously been unknown and mostly speculation. Site 21HE483 provides a unique example of a local toolstone procurement site.

Construction of the proposed parking lot will directly impact the archaeological deposits at the site, and a Phase III data recovery is recommended to mitigate the project's effects, if the site can't be avoided. A mitigation plan should be developed that takes into consideration the following:

1) Project impacts for new curbing and trails are shallow (less than one meter) and do not extend below existing fill in most areas. Therefore, no additional archaeology work is recommended in areas where fill depth exceeds project impact depth. However, in areas with shallow fill, such as along the western portion of the parking lot, new curbing may impact the archaeological deposits, and data recovery by excavation is recommended in this area.

2) The storm sewer outlet on the east side of the parking lot has high artifact density and will be directly impacted by the project. Data recovery by excavation is recommended in this area.

3) Because of impenetrable fill, testing was not possible for the portion of the site where impacts more than one meter deep will occur for the storm sewer. No data currently exists for this portion of the site. It is recommended that a backhoe remove the fill in this area so that shovel testing can determine if intact soils and artifacts are present at the storm sewer locations. Data recovery by excavation may be needed in this area, depending on the results of shovel testing after the fill is removed.

4) Because of the unique landscape setting and rarity of the site type, a geomorphological investigation should be conducted to assess the site formation processes, soils, geomorphology, and the cause of the extensive vertical distribution of artifacts (c. one meter thick in ST F29), which extend deep into the cobbles and gravels.

5) Data recovery should address several research themes, including: refining the age and cultural affiliation by radiocarbon dating of bone or charcoal samples; activities at the site other than toolstone procurement; and refining and expanding the analysis and interpretation of toolstone procurement activities.

6) Previous formal excavation units were mostly limited to the area adjacent to the southern portion of the parking lot outside of the area of direct impact. Excavation units should be placed in site areas that will be directly impacted, and if possible, units should be placed in other portions of the site so that a more representative sample of data is recovered from across the site to aid in interpretation and intra-site analysis. It is clear that site activities include other activities besides toolstone procurement, as indicated by other artifact types including a bone fragment, heat-treated lithics, and stone tools that are indicative of habitation and subsistence activities. While no conclusive fire-cracked rocks were identified, the heat-treated lithics indicate that fire hearths or heating facilities probably exist at the site.

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APPENDIX A:

ANALYSIS OF THE GENERAL LITHOLOGY AND TOOLSTONE COMPONENTS OF A QUARRIED COBBLE AND GRAVEL DEPOSIT AT 21HE483

By Kent Bakken

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Analysis of the General Lithology and Toolstone Components of a Quarried Cobble and Gravel Deposit at 21HE483

By Kent Bakken

21HE483 is a toolstone procurement site associated with a section of St. Mary's terrace in the Minnesota River valley in Bloomington, Minnesota. Erosion of the terrace exposed a cobble-rich channel deposit that contained toolstone. This deposit was quarried. Potential toolstone clasts were tested, then either discarded or removed from the site. A muskrat bone from the quarry deposits suggests an age of 2070 ± 30 rcy BP for the activity. The lithology of a sample from the cobble-rich deposit was analyzed in order to investigate its provenance and help clarify what types of toolstone might be associated with this and other fluvial toolstone sources in the lower Minnesota River valley. The sample was found to include clasts from local bedrock and multiple tills of Riding Mountain, Winnipeg, and Superior provenance. The proportion of the contribution from the various sources could only be roughly estimated, although Superior provenance till may predominate. Toolstone clasts were also identified by specific raw material types. This analysis indicated that Prairie du Chien Chert was the primary toolstone in the deposit, complemented by small percentages of raw materials associated with the West Superior and South Agassiz resource regions and by a number of unidentified materials.

1. Introduction

A primary goal of the lithology study was to provide data from a lithic procurement site that could be included in a National Register of Historic Places Lithic Scatter multiple properties documentation form developed and sponsored by MnDOT. Site 21HE483 is a toolstone procurement site associated with a river terrace in the Minnesota River valley in Bloomington, Minnesota (Figure 1). The site was discovered in the spring of 2015 (Harrison and Bakken 2016). Phase II work was conducted in December of 2015 (Harrison and Bakken 2016), and April of 2016 (Florin 2016).[1] Additional work conducted at the site in 2017 will be documented in a forthcoming report. The site was identified around the perimeter of a parking lot belonging to a wildlife area, and was later found to continue under parts of the parking lot. The combined testing in 2015 and 2016 produced just over 900 lithic artifacts, including mainly flakes, shatter, and tested cobbles, with smaller numbers of hammerstones, cores, bipolar cores, flake tools, a single crude biface, and other broken rock. It is interesting to note that 59 tested cobbles were recovered, a very large sample from a regional perspective, and a large enough sample to support a focused analysis of this preliminary step in toolstone procurement. A technological analysis of flakes indicated that lithic reduction was heavily biased toward preliminary cobble testing, and that little further reduction was done. Prairie du Chien Chert was the most common raw material, constituting almost 80 percent of the combined assemblages. A variety of other materials occurred at frequencies of less than five percent. A muskrat bone found in the lower part of the archaeological deposit provided a radiocarbon date of 2070 ± 30 rcy BP.[2]

The site is near the bluff base on the low end of a long sand and gravel ridge (low terrace) that trends southwest to northeast, sloping up to the northeast. The ridge is bounded on the north and west by a small southwestward flowing perennial stream and associated marsh. This stream swings around the

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[1] Additional Phase III fieldwork was undertaken in the fall of 2017; the report is still in preparation.

[2] The Phase III testing referenced in the previous footnote recovered three ceramic sherds from various depths in the quarry deposits. These may support the radiocarbon date, pending more detailed analysis.

south end of the ridge, where it enters the main floodplain of the Minnesota River valley. The ridge is bounded on the south and east by Long Meadow Lake and associated marsh. Along the eastern side of the ridge, erosion has exposed a cobble-rich zone two to three meters above the current floodplain. Cobbles are scattered along the side slope of the ridge, which may have alerted prehistoric groups to the potential for toolstone quarrying at this site.

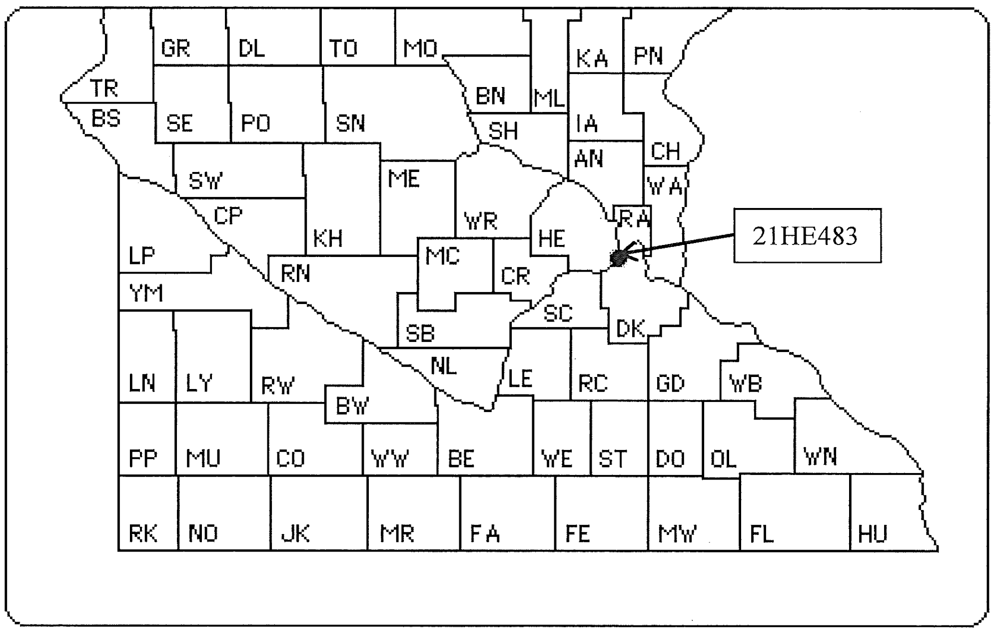

Figure 1. Location of Site 21HE483 in Hennepin County.

The quarrying took place above the side slope and at the low end of the ridge. Here the cobble-rich zone was shallow, so a limited amount of digging was required. It is hard to determine how far the cobble-rich zone would have begun below the original surface because of historic alterations to the landscape. However, it is possible that some cobbles were present immediately beneath the surface and that the densest cobble concentration began on the order of 30 cm below the surface. A representative profile for the site is shown in Table 1, and the right hand column shows an interpretation of the stratigraphy. Note that the zone of highest artifact concentration and the zone of highest cobble density are both on the order of 50 to 60 cm thick, but they only partly overlap. The zone with the highest artifact concentration goes 20 to 30 cm into the densest cobble concentration but not to the bottom of the latter.

Table 1. Representative Stratigraphy for 21HE483, based on Excavation Units 1 and 2 (from Harrison and Bakken 2016:25).

Level (cmbs)	XU 1 Artifact Count	XU 2 Artifact Count	Historics Present	Soil	Gravel	Cobble	Interpretation
0-10		2	Y	Clay loam 10YR 2/2		+	Fill
10-20	17	22	Y	Loam 10YR 3/1	+	+	Top of artifact deposit, some disturbance.
20-30	31	37	Y				
30-40	36	15	N	Sandy loam 10YR 3/2	++	+	Bottom of artifact deposit, intact.
40-50	27	36	N	Sandy loam 10YR 4/3 (Coarse and fine layers)	++	++	
50-60	18	*not dug*	N				
60-70	8		N				Artifact displaced downward in soil profile below primary artifact deposit.
70-80	2		N				
80-90	3		N				
90-100	5		N	Loamy sand 10YR 4/3 (*at 95 cm*)			
Total	**147**	**112**					

+ means present; ++ means abundant

The site is particularly interesting because it is the first clear example of a toolstone procurement site in the lower reaches of the Minnesota River valley. The existence of such sites was posited by Florin et al. (2015:20), who suggested that

> Fluvial sediments in the river valley may have served as another raw material source. Glacial River Warren would have eroded a variety of tills, from the surficial Des Moines lobe to deeply buried and poorly known early tills, and deposited clasts from these along the valley. This could be a potentially very diverse set of raw materials, but it is hard to speculate on the range of materials it might include.

21HE483 offers a chance to learn about such toolstone sources, the associated quarrying practices, and the types of toolstone the sources provided.

One way to study the latter question is to understand the sources of the pebbles and cobbles in the quarried deposit. Florin et al. (2015) expected a diverse and mixed lithology, which seems reasonable in light of the geology of the region and of the valley. This expectation can be tested at 21HE483. The analysis reported here used a two-part approach. First, a pebble lithology analysis applied methods developed by regional glacial geologist to the medium and coarse pebble fraction of a sediment sample taken from the site. This produced information that is interpreted in the context of regional geological studies. Second, a toolstone identification analysis by the author examined the very coarse pebble and cobble fraction. All pieces of potential toolstone were identified as specifically as possible. This produced information that is interpreted in the context of regional archaeological raw material studies. The two data sets are complementary.

The geology of the Minnesota River valley and nearby region are reviewed below in Section 2 in order to provide relevant context, and the geomorphology of 21HE483 is also reviewed from that perspective. The identification of grain lithology is reviewed in the Lithology Methods in Section 3, along with a discussion of the sampling methods used at 21HE483 and an archaeological perspective on regional toolstone availability. Data from the two-part lithology analysis are presented in the Results in Section 4. The significance of the results are examined from both geological and archaeological contexts in the Discussion in Section 5, which is followed by the Summary in Section 6.

2. Geology of the Minnesota River Valley Region

The resource exploited at 21HE483 is geological in nature. To understand the site it is therefore necessary to understand certain aspects of the regional geological context. First, we need to understand the kinds of rock that would be regionally available. This involves looking at both bedrock and glacial geology. Second, we need to understand the forces responsible for transporting this rock along the valley and for depositing the rock at 21HE483. Specifically, this means the creation of the Minnesota River valley by catastrophic drainage from Glacial Lake Agassiz, and the subsequent geomorphic evolution of the valley.

2.1 Bedrock Geology of the Minnesota River Valley and Surrounding Area

The bedrock seen in the upper Minnesota River valley (headwaters to about Mankato) is quite distinct from the bedrock of the lower valley (Mankato to the Mississippi River) (Table 2). In the upper valley, the basic sequence is Early Precambrian gneiss with Middle Precambrian granitic intrusions, overlain by Late Precambrian quartzite, overlain by Cretaceous shale, sandstone and some lignite (Morey 1972; Austin 1972a, 1972c). All of these may have contributed to the lithology of the deposit at 21HE483. However, it is likely that only the Late Precambrian Sioux Quartzite made a contribution to the complement of toolstone. The quartzite itself was occasionally used, even though it is tenacious and might be considered at best a marginal quality raw material (Bakken 1997, 2011). Conglomerate found at the base of the quartzite contains cobbles and pebbles of poorly known chert, quartz, and other toolstone (Justin and Radford 1990a, 19900b; Terrell et al. 2005). Clasts that weathered free of the conglomerate were used for flintknapping, but the supply would have been very limited and this must be considered a minor resource.

In the lower valley, the basic sequence is Cambrian sandstone, overlain by an Ordovician sequence that includes carbonate formations containing chert, and over that a patchy distribution of unconsolidated Cretaceous Ostrander Sand (Austin 1972c; Sloan 1964). The Prairie du Chien Group includes the Shakopee and Oneota formations, although the two are not always distinguishable in the study region. Each formation includes several members, most of which contain chert. The chert from the different members can vary considerably (both between and within members), and in Minnesota chert from all members is often identified simply as Prairie du Chien Chert.[3]

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3. Recently, however, there has been some progress in distinguishing chert from different members (Wendt 2014a, 2014b).

Table 2. Summary of Relevant Bedrock in the Minnesota River Valley Region.

Chronology	Upper Valley	Lower Valley
Cretaceous	Shale, sandstone, lignite	Ostrander Sand
Ordovician		St. Peter Sandstone
		Prairie du Chien Group carbonates
Cambrian		Various sedimentary deposits, sandstone predominates
Late Precambrian	Sioux Quartzite	
Middle Precambrian	Igneous intrusives	
Early Precambrian	Igneous and metamorphic, principally gneisses	

Table based on Austin 1972a, 1972b, 1972c; Grant 1972; Morey 1972; Mossler 1972; shading indicates potential toolstone contributions

2.2 Glacial Geology of the Minnesota River Valley and Surrounding Area

Pleistocene glaciation deposited multiple till sheets across southern Minnesota. The more extensive and better-exposed tills are well known and can be traced across wide areas. The full sequence, however, is not well known. There is evidence of a number of minor, eroded, or buried tills, but the evidence is not presently strong enough to characterize them adequately, to trace their extent, or to find correlations across a broader region. Table 3 presents a general summary of tills based on good exposures in the Minnesota River valley (Matsch 1972).

Table 3. Summary of Relevant Till Units in and near the Minnesota River Valley.

Till (*Provenance*)*	**Description**	**Lithology**
New Ulm (*Riding Mountain*)	Yellow to olive brown, less commonly grey, sandy loam to clay loam.	Abundant shale, carbonates, and granitic rock.
Boulder pavement		
Granite Falls (*Winnipeg*)	Yellow to olive brown, less commonly grey, sandy loam to clay loam.	Sparse shale, rich in carbonates, granitic rock abundant.
Unnamed tills of uncertain extent (*Winnipeg*)		
Outwash, boulder pavement, oxidized zone, or accretion gley		
Hawk Creek (*Superior*)	Reddish brown to pink, sandy clay loam.	Red felsite, pink sandstone, gabbro, rare Lake Superior Agate; shale absent, carbonates minor.
Leached silt		
Unnamed till	Grey, calcareous clay loam	Shale free

Table based on Matsch 1972

The three best-known tills are (oldest to youngest) Hawk Creek, Granite Falls, and New Ulm. The lithology of Hawk Creek indicates origin in the Superior province to the northeast, while the lithology of the others (including the unnamed tills in the table) indicates origin in the Riding Mountain and Winnipeg Lowland provinces to the northwest. The ages of the older tills are not well constrained. The glacial advance that produced the New Ulm till reached its maximum extent in central Iowa around 14,000 rcy BP, and the study area was probably ice free before 12,000 rcy BP (Johnson et al. 1998:128).

Note that the overall lithology of these tills is quite diverse, indicating contributions from the Riding Mountain and Winnipeg Lowlands provinces to the northwest, as well as the Canadian Shield and Lake Superior provinces to the northeast. It is worth bearing in mind that the lesser-known tills may be contributing further diversity to both the general lithology of valley sediments and to the complement of toolstone.

2.3 Origin and Geomorphic Evolution of the Minnesota River Valley

Research on the geomorphic history of the Minnesota River valley is a work in progress. The broad outlines are relatively clear. Many details, however, remain to be worked out, and there is as yet no general synthesis. In general, we know that the final ice advance over this region left a variety of till, outwash and associated lacustrine deposits as the surficial sediments. Meltwater reworked sediments along the retreating ice front, potentially leaving local deposits that were enriched in terms of pebbles and cobbles. Regional drainage may have been regularly reorganized as ice retreated to progressively lower land towards the center of the broad sag that guided the path of the ice sheet through the region.

A critical event was the retreat of the ice beyond the continental divide that separates northern drainage to Hudson Bay from southern drainage to the Gulf of Mexico. Meltwater imponded between the divide to the south and glacial ice to the north, creating Glacial Lake Agassiz. At about 11,700 rcy BP, Agassiz breached the continental divide near Browns Valley and began to drain to the southeast. The initial drainage was apparently catastrophic, rapidly eroding a river valley that was up to 5 km (3 miles) wide and 60 m (190 feet) deep (Matsch and Wright 1967; Johnson et al. 1998:128). Fenton et al. (1983) estimated that this process may have taken as little as 400 years. The early evolution of valley geomorphology was complex, with simultaneous erosion and infilling in different stretches of the river (Johnson et al. 1998). By about 10,800 rcy BP, Lake Agassiz began to drain through another outlet, and the basic features of the current valley had been established (Fisher 2003, 2004). Agassiz periodically resumed southward drainage through the Minnesota River valley as late as 9400 rcy BP, but it seems that the later episodes of drainage episodes were not necessarily catastrophic and thus their impact on valley geomorphology was not as great.

The terraces of the Minnesota River valley have been mapped and categorized in general terms (e.g., Johnson et al. 1998), as have terraces in some Minnesota River tributaries (e.g., Gran et al. 2013). It does not appear, however, that the terraces have been comprehensively studied, described, and analyzed. Interpretations vary and are not always in agreement. Matsch (1972:558-559), for example, posits three sets of terraces and relates each to the general history of valley formation and evolution:

> Terrace segments preserved at various heights above the floodplain of the Minnesota River fall within three major categories that relate to the history of the valley.... The highest surface, only slightly inset into the till plain, is underlain by flat-bedded coarse sand and cobbly, well- to poorly-sorted gravel 10 to 40 feet thick. These sediments are remnants of an extensive braided stream system that drained the margins of the retreating Des Moines lobe. The master stream followed the axis of the regional

topographic sag that had been such an important control on iced movement during glaciation.

Another set of terrace surfaces at intermediate heights is distinguished by a veneer of lag boulders that lie atop older Quaternary sediments or bedrock. These boulder-armed surfaces are remnants of successively lower channel bottoms of Glacial River Warren, a highly competent stream that discharged water from Lake Agassiz in late-glacial and early postglacial times.

A third type of sediment is found both slightly higher than the modern floodplain and locally buried beneath the floodplain sands and silts. These alluvial deposits are boulder-gravel beds composed of well-rounded boulders and cobbles in a matrix of coarse gravel and sand. Commonly, the dominant size reaches as much as 12 inches in diameter. These deposits were once part of the bedload of River Warren and lagged during the waning stages of its discharge through the present Minnesota River Valley.

Maps of surficial geology for the region either reference three sets of unnamed terraces (e.g., Lusardi 2000) or four sets of named terraces (e.g., Meyer and Lusardi 2000; Meyer 1999; Hobbs and Setterholm 1998; Hobbs 1999a, 1999b). The latter are summarized in Table 4, which is the preferred schema preferred in this discussion.

Table 4. Summary of Terraces Mapped in the Lower Minnesota River Valley and Adjacent Parts of the Mississippi and St. Croix river Valleys.

Terrace*	**Height Above Floodplain**	**Elevation in Minnesota River Valley**
Richfield	160 feet (49 m)	880 feet (268 m) W 850 feet (259 m) E
Langdon	125 feet (38 m)	840 feet (256 m) W 820 feet (250 m) E
Grey Cloud	50 feet (15 m)	770 feet (235 m) W 740 feet (226 m) E
St. Mary's	10-20 feet (3-6 m)	725 feet (221 m) W 700 feet (213 m) E

Table based on Meyer and Lusardi 2000

Further, Johnson et al. (1998:128) note that

> some of the fill terraces in the valley may be outwash terraces that formed as the Des Moines Lobe melted back. Comparison of radiocarbon ages for the advance of the Des Moines Lobe (14,000 yrs B.P., Clayton and Moran, 1982) with those for the initiation of Glacial Lake Agassiz (11,500 yrs B.P., Teller and Clayton, 1983) indicate that parts of the Minnesota River valley would have been ice-free for at least 1000 years prior to the formation of Glacial Lake Agassiz. The valley would certainly have been the path of outwash streams. Upham (1883) considered all of the fill terraces to be composed of outwash, and it is clear that the terraces of the Minnesota River valley in the Twin Cities region grade to the same level as outwash terraces of the Mississippi River.

2.4 Geomorphology of 21HE483

The geomorphology of the ridge that the site is located on was not initially clear. A long, sloping ridge does not immediately suggest that the landform is a fluvial terrace. Meyer and Lusardi (2000), however, map this landform as St. Mary's terrace, which Meyer (1999) describes as follows:

> St. Mary's Terrace (named after the community of St. Mary's Point in southern Washington County)—Clasts are mostly Superior provenance. Surface about 10 to 30 feet (3 to 9 m) above floodplain level, at an elevation of about 700 feet (213 m). It does not extend above the dam at Taylors Falls. Most contacts with other map units (except peat) are scarps.[4]

Stretches of the St. Mary's terrace are mapped along the lower Minnesota River valley as far upstream as Belle Plaine, beyond which "the terrace merges with, and is buried by, the modern floodplain" (Meyer and Lusardi 2000). It is the lowest and youngest of a series of terraces that are also found along parts of the Mississippi and St. Croix rivers (e.g., Hobbs 1999a, 1999b; Hobbs and Setterholm 1998).

It appears that the terrace must have been eroded near the bluff line by the small stream that flows there. What remained of the terrace thus acquired its form as a ridge. Since we would expect that the terrace surface would have initially been level, it appears that there was also progressive erosion from northeast to southwest which created the slope and exhumed the cobble-rich zone where the erosion cut deepest. The stream would also be a likely agent for this progressive erosion, although they dynamics of the process are somewhat hard to imagine.

According to Johnson et al. (1998:128-129), the terraces all predate the Moorhead phase of Lake Agassiz which began around 10,800 rcy BP as the lake stopped draining through the Minnesota River valley. The St. Mary's terrace is the youngest of these, so may be relatively close to 10,800 rcy BP in age. The cobble-rich deposits underlying the terrace, however, would be older.

Cobble-rich deposits of the kind quarried at 21HE483 are seen at other location in the valley. Johnson et al. (1998:126) describe an example near Kasota, which "consists of poorly sorted, clast-supported sand and gravel interpreted as deposits of channel bars in a braided stream. It is much coarser than any of the other facies found in the study area; this is the result of the winnowing action of the braided stream, which removed much of the sand but not the coarser gravel." The deposit at 21HE483 should have a similar genesis. It might be noted, however, that the facies described for Kasota is either at the surface or shallowly buried by overbank silts or loess, while the facies at 21HE483 is buried by about five meters of sand and gravel. This would suggest a period with a braided stream environment followed by substantial valley infilling, perhaps pointing to the episodic nature of drainage pulses through the valley. Per the lowest terraces described above, Johnson et al. (1998:559) note generally that the deposits "were once part of the bedload of River Warren and lagged during the waning stages of its discharge through the present Minnesota River Valley," which would also indicate such an origin.

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4. It should be noted that the reference to Superior provenance clasts is for the St. Mary's terrace along the St. Croix River, and is not mentioned in the description of the terrace along the Minnesota River.

3. LITHOLOGY METHODS

The analysis reported here used a two-part approach. First, a lithology analysis applied methods developed by regional glacial geologists to the medium and coarse pebble fraction (cf. Table 5) of a sediment sample from the site. The resulting information is interpreted in the context of regional geological studies. Second, a toolstone identification analysis examined the very coarse pebble and cobble fraction. All pieces of potential toolstone were identified as specifically as possible. The resulting information is interpreted in the context of regional archaeological raw material studies. The two data sets are complementary. Each set of methods is reviewed below, followed by information on sample collection and preparation.

Table 5. Geologic Particle Size Scale for Size Ranges Applicable in This Study.

Size range (mm)	Terminology	Pebble Lithology	Toolstone ID
> 256	Boulder		
64 - 256	Cobble		
32 - 64	Very coarse pebble		
16 - 32	Coarse pebble		
8 - 16	Medium pebble		

Table based on Udden 1914; Wentworth 1922

In addition to counts, weights were also noted – for each category in the pebble lithology analysis, and for each specimen in the toolstone identification analysis. Weight was recorded to the nearest 0.1 g for samples weighing up to 400 g. Larger samples were weighed with a different scale, and weight was recorded to the nearest 5.0 g.

3.1 Pebble Lithology Analysis

Analysis of the lithology of grains in glacial sediment is a technique used by geologists in the Upper Midwest to better understand the distribution of various glacial deposits, their provenance, the degree to which different till bodies were mixed, and to assist with correlation of till units. The analysis involves sorting the clasts from a till sample into general categories. Table 6 shows the categories used by Hobbs (1998), along with a brief description of the rock types included in each category. Note that these are broad categories, meant to associate specimens with broad geologic provinces (Figure 2) rather than to provide specific rock-type identifications.

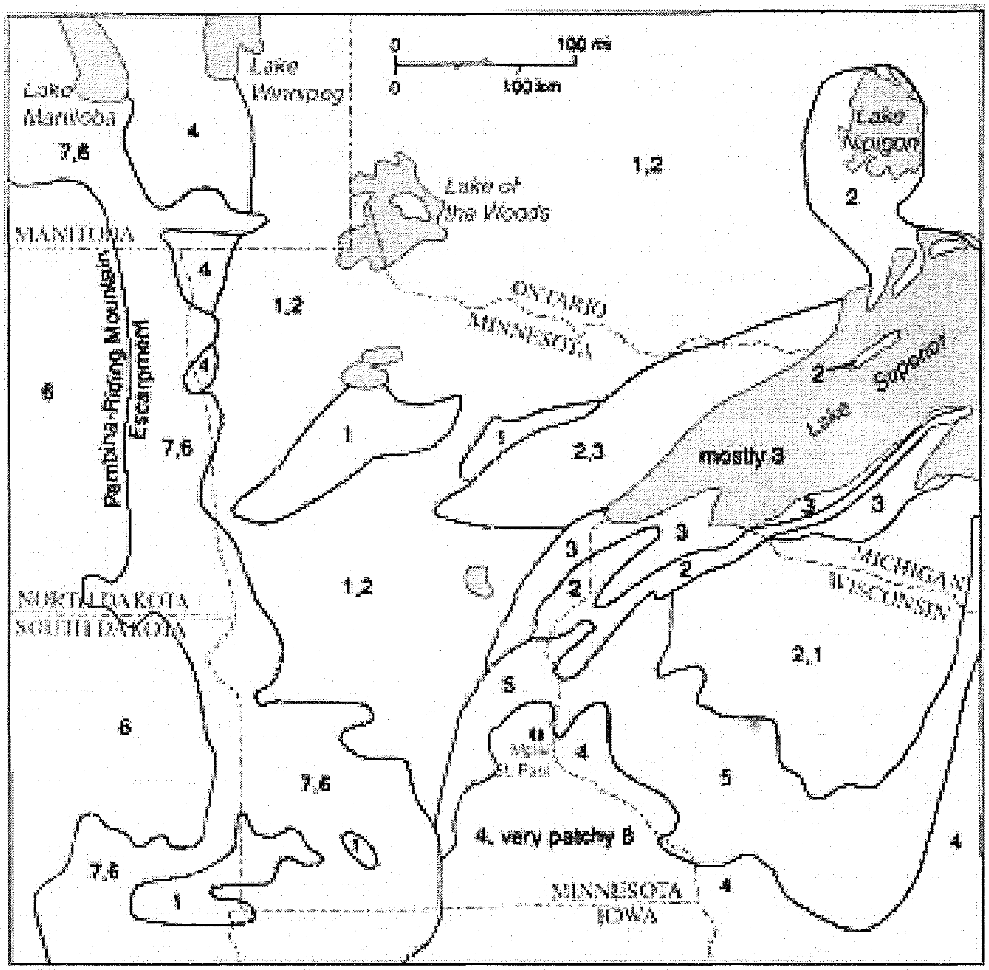
Table 6. Rock Classification System of Hobbs (1998).

Group	Class	Grain Type	Explanation
Precambrian	Light	Granite and gneiss	"all coarse-grained felsic igneous and metamorphic rock" which can include monomineralic quartz.
		Quartzite	"clean metamorphic quartzite and solidly quartz-cemented sandstone... included because of its importance in recording Sioux Quartzite grains..."
	Dark *	Mafic igneous	"basalt, gabbro, and low-grade... metavolcanics ('greenstone')" and "intermediate rocks that lack quartz, such as diorite. These grains are gray, green, or black, and are not foliated."
		Other metamorphic	"metagraywacke, slate, argillite, phyllite, and fine-grained schist."
	Red	Iron Formation	"various Precambrian iron formations... as well as jasper."
		Rhyolite and agate	"red nonclastic grains inferred to be from the Lake Superior basin" including "felsite, red granophyre and red-stained basalt."
		Sandstone	Includes red arkose, quartzose sandstones, brown to buff sandstones. Also minor red siltstone, red shale from the Superior basin, red sediments interbedded with North Shore volcanics.
	Other		"grains that do not fit into one of the preceding types but are still thought to be Precambrian."
Paleozoic	Carbonate and chert		"limestone, dolomite, and chert grains, which are mostly gray to ivory in color."
	Sandstone		"generally soft and easy to disaggregate... because cement does not fill their pores, but instead forms 'spot welds' on the grain boundaries" and "sandstone grains that contain green glauconite...."
	Shale		"soft to very soft, blue-gray to greenish-gray noncalcareous grains" that are "easily abraded and extremely rare...."
	Other		"especially useful for the insoluble residuum left by weathering of carbonate rocks, quartz rinds (former vug linings), geothite pseudo-morphs after marcasite, and irregularly shaped grains of 'siliceous trash.'"

Table 6. Continued.

Cretaceous Other	Western	Shale (gray)	"fragments are distinctive" but "so soft that its fragments rarely survive transport as clasts."
	Inter-mediate	Shale (speckled)	"calcareous shale grains... that are speckled white and dark."
		Limestone	"clear to translucent calcite grains that are gray in color and are not completely fused together.... These grains are easily distinguished from grains in the Paleozoic Carbonate class."
		Pyrite	"fine grained..." with a "hackly surface."
		Lignite	"grains that are soft and black and range from shiny to cull in luster. These grains are light in weight and break easily."
	Eastern	Ostrander sand	"grains of quartz, chert, and black iron formation or aggregates of such grains cemented by iron oxides. The grains are typically polished and somewhat rounded although not spherical."
	Other		"Angular iron oxide fragments are the most common grain of this type... Shark teeth also fit into this category..."
Other	Unknown		"fine-drained and lack diagnostic features. Many are either weathered or are partly coated with secondary minerals..."
	Secondary		"secondary carbonate, gypsum, and iron and manganese oxides that formed post-glacially in the till."
	Other		"grains that can be identified... but are not Secondary, and cannot be assigned to one of the major groups."
* Hobbs (1998:198) notes that mafic igneous and other metamorphic "are difficult to separate from each other" and that "for most purposes they are grouped together."			

From Hobbs 1998, all quotations from that source



Map Key: (1) Precambrian granite, gneiss, and quartzite; (2) Precambrian mafic igneous and other metamorphic rocks; (3) Precambrian iron formation, rhyolite, agate, and sandstone; (4) Paleozoic carbonate, chert, and shale; (5) Paleozoic sandstone; (6) Cretaceous gray shale; (7) Cretaceous speckled shale and limestone;* (8) Cretaceous Windrow Formation. Where more than one rock type is present in an area, the dominant bedrock type is listed as the first number.* Includes Jurassic sedimentary rocks in northwest Minnesota and southern Manitoba, which are mostly carbonates, shales and evaporites; these grain categories have not been recognized in grain counts.

Figure 2. Bedrock Geology of the Region Keyed to Relate to Lithologic Categories (from Hobbs 1998).

Because lithologic studies deal with general rock categories and broad geographic regions, high sample density is not required. Thorleifson et al. (2007), for example, collected samples intended to characterize glacial sediments throughout Minnesota. The samples were taken at intervals of about 30 kilometers, and totaled 250 in number (with some sample locations actually falling just past the state border in neighboring states and provinces). In addition, because the till samples are essentially randomized by glacial processes, only one sample is required per depositional unit (i.e., each till unit exposed at a location). Multiple samples from a single unit are redundant and do not provide additional information.

Hobbs (1998:193-194) recommends using the very coarse (one to two millimeter) sand fraction for a lithologic analysis, arguing that

> The boulder and cobble fraction does not provide a quantitative measure of the range in clast types, because of the difficulties inherent in obtaining a representative sample. Clast counts conducted on the pebble fraction are potentially more useful.... However, statistically valid clast counts on pebble-grade material may require more than 1 kg of sample, depending on how pebbly the till is, and the size range of the pebbles. The fine-sand fraction [is]... increasingly dominated by quartz, offering less potential for contrast between units.

He further notes that one gram of the very course sand fraction should provide an adequate sample of about 300 grains.

Our analysis, however, used a larger fraction (> 32 mm). This was done mostly to make the resulting data more archaeologically useful, and also to simplify visual identification. The larger clast size aids with identification of specific raw material types (in the archaeological sense) for toolstone clasts, thus increasing comparability with the lithic artifact data from the site. In addition, sample collection could be piggy-backed onto standard archaeological data collection procedures. Any bias introduced by these procedures should apply equally to both the lithology sample and the artifact assemblage, controlling for one potential source of variation. Although use of the two to three-millimeter fraction would make the resulting data more directly comparable to many geological studies, such comparability was not deemed essential for the present analysis.

3.2 Toolstone Identification Analysis

Specific identification of the toolstone clasts in the sample was also undertaken. This information helps with interpreting the results of the lithologic analysis, and also helps with addressing more typical archaeological analyses and questions. The raw material identifications followed methods and toolstone categories laid out by Bakken (1997, 2011), supplemented with other recent literature on regional raw materials (e.g., Wendt 2014a, 2014b). Identification was aided by low power magnification.

The results are interpreted in terms of a regional raw material availability model proposed by Bakken (1997, 2011). In this model, Minnesota is divided into four raw material resource regions and further subregions (Figure 3). Each region contains a particular suite of raw materials. The individual materials are ranked as primary, secondary or minor in importance in terms of their occurrence in the archaeological record (Table 7).

The regions are based in part on the state's surficial geology, and thus are also easily related to the overall results of this two-part analysis. The South Agassiz resource region is associated with the Des Moines and related lobes, and thus raw materials from the Riding Mountain and Winnipeg Lowlands provinces. The West Superior resource region is associated with the Superior and Rainy lobes, and thus raw materials from the Precambrian provinces to the northeast. The Hollandale resource region includes a variety of tills, but these are often secondary in importance to bedrock toolstone sources. The Pipestone resource region is associated with older till exposed outside the footprint of the Des Moines lobe. The till is not well understood geologically, but based on toolstone content it originates from the northwest.

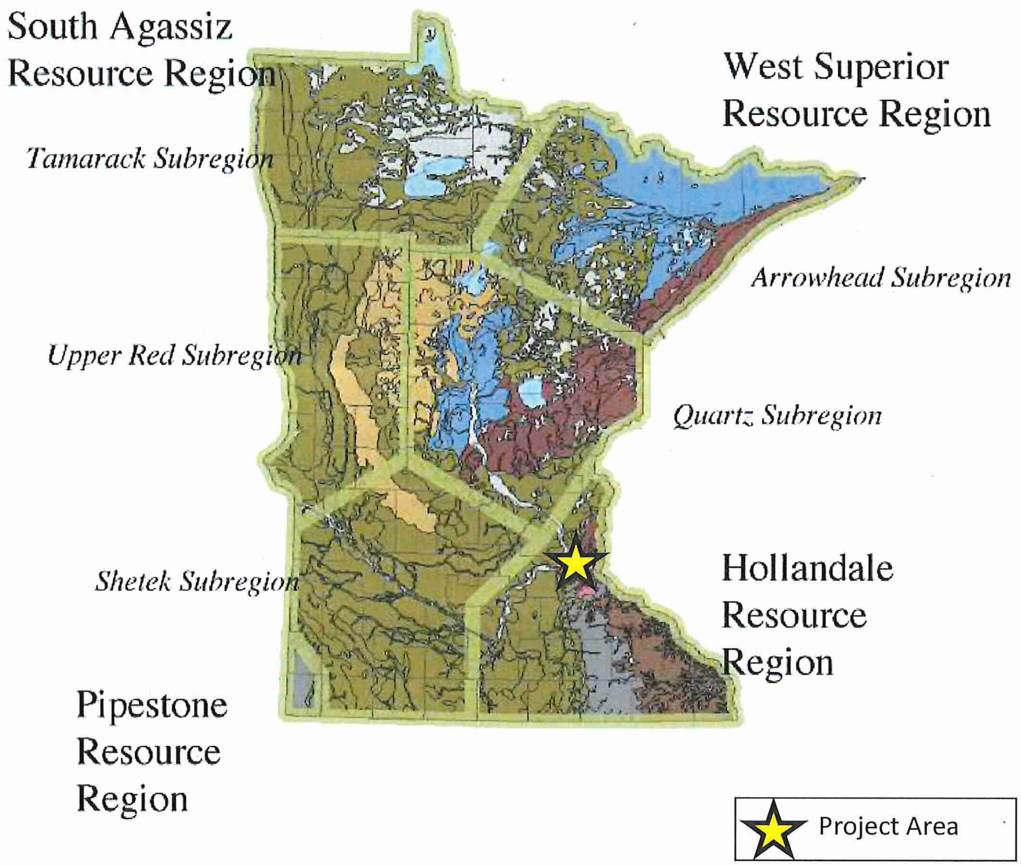


Figure 3. Lithic Resource Regions of Minnesota (adapted from Bakken 2011).

Table 7. Estimated Primary, Secondary, and Minor Lithic Raw Material Status by Region and Subregion (Bakken 2011).

Regions	Primary Raw Materials	Secondary Raw Materials	Minor Raw Materials	Main Exotic Raw Materials
South Agassiz Resource Region				
Tamarack Subregion	Swan River Chert Red River Chert	Border Lakes Greenstone Group	Quartz Tongue River Silica Western River Gravels Group?	Knife River Flint
Upper Red Subregion	Swan River Chert	Red River Chert Tongue River Silica Quartz	Border Lakes Greenstone Group Western River Gravels Group Knife River Flint	Knife River Flint
Shetek Subregion	Swan River Chert	Tongue River Silica Red River Chert Quartz	Border Lakes Greenstone Group Western River Gravels Group Knife River Flint Fat Rock Quartz Other West Superior materials	Knife River Flint Burlington Chert
West Superior Resource Region				
Arrowhead Subregion	Gunflint Silica Knife Lake Siltstone	Quartz Hudson Bay Lowland Chert Jasper Taconite	Border Lakes Greenstone Group	Knife River Flint
Quartz Subregion	Knife Lake Siltstone Tongue River Silica Quartz *(Fat Rock and other)*	Swan River Chert	Lake of the Woods Rhyolite Biwabik Silica Gunflint Silica Jasper Taconite Kakabeka Chert Hudson Bay Lowland Chert Lake Superior Agate	Knife River Flint Hixton Group Burlington Chert
Pipestone Resource Region				
	Tongue River Silica Gulseth Silica?	Sioux Quartzite Swan River Chert? Red River Chert?	Quartz	Knife River Flint
Hollandale Resource Region				
	Cedar Valley Chert Galena Chert Grand Meadow Chert Prairie du Chien Chert	Shell Rock Chert?	Quartz Tongue River Silica Swan River Chert Red River Chert	Hixton Group

3.3 Sample Collection and Preparation

Two samples were collected during field work at 21HE483 in December of 2015. Sample 1 came from Excavation Unit (XU) 1, 30-40 cm below surface (cmbs), SE quadrant. Sample 2 came from XU 1, 50-60 cmbs, NE quadrant. The samples consisted of all the clasts retained in a shaker screen with ¼ -inch hardware cloth, so the minimum clast size is about seven millimeters. Sample 1, from sediment with moderate cobble density, filled three one-gallon bags. Sample 2, from sediment with high cobble density, filled 12 one-gallon bags. The samples were later cleaned and rescreened. Field observations indicated that the sediment at 21HE483 is a single deposit, so the lithology should be consistent throughout. Therefore, only Sample 1 was used for the lithologic analysis.

Sample 1 was sorted into a seven to 32 millimeter fraction and a > 32 mm fraction. The seven to 32 millimeter fraction was used for the lithologic analysis, while the > 32 millimeter fraction was used for the toolstone identification analysis. Since the total seven to 32 millimeter fraction was larger than needed to support the lithology analysis, it was randomly split to obtain a subsample of about one liter in volume. This provided a subsample of more than 300 clasts, thus meeting Hobb's suggested sample size. For Sample 2, clasts > 32 mm were separated and used for the toolstone identification analysis. The seven to 32 millimeter fraction was set aside.

This division into large and small fractions was made for two reasons. First, the larger fraction is likely to favor siliceous and other more durable kinds of rock, and thus not ideally representative of the original lithology. The smaller fraction is likely to better preserve less-durable rock types and thus be more representative of the original lithology. Second, the 32 millimeter measure approximates the point at which pebbles become large enough to be useable for bipolar reduction. In other words, it is roughly the threshold for toolstone selection given the lithic reduction techniques historically used in the region.

Although Sample 1 was sufficient for the lithologic analysis, Sample 2 served to enrich the > 32 mm fraction used in the toolstone identification analysis. Increasing the clast count for the > 32 mm fraction helped build a more complete toolstone inventory for this landscape and also helped ensure that raw materials present in small amounts had a better chance of being included in the inventory.

A word on terminology is warranted. Table 5 shows a standard particle size classification used by geologists. Note that clasts in the range of eight to 32 millimeters are called medium and coarse pebbles. The fraction used for the lithologic analysis closely approximates this range, and thus uses the term pebble. Further note that clasts in the 32 to 64 millimeter range are called very coarse pebbles, while those in the 64 to 256 millimeter range are called cobbles. No clasts over 256 millimeters were recovered. For the sake of simplicity, however, discussion of the analysis uses the term pebble for the seven to 32 millimeter fraction and cobble for the entire 32 to 256 millimeter range in order to more clearly distinguish one analysis from the other.

It should be noted that identifications for both the pebble lithology analysis and the toolstone identification study were complicated somewhat by surface staining on many clasts. It affected rock types as disparate as carbonate and siliceous rock. This only became apparent when much of the identification was done. Although some clasts were abraded to allow observation of a fresh surface, it was not practical to attempt this with most clasts, and the staining may have introduced a few problems with identification in some categories. In the case of the toolstone identifications, a fresh surface was sometimes exposed by removal of a flake.

4. RESULTS

The pebble lithology analysis and toolstone identification analysis both indicate that the cobble and gravel deposit at 21HE483 includes components from multiple sources, although the relative importance of different sources can only be estimated. The toolstone analysis indicates that this was a relatively rich raw material source with a diverse set of materials dominated by Prairie du Chien Chert.

4.1 Pebble Lithology

The pebble fraction used for this analysis came from Sample 1 (XU 1, 30-40 cmbs, SE quadrant). The sample split totaled 455 clasts. Table 8 shows the results of the clast identifications by count and weight in terms of Hobb's (1998) analytical categories. The table also shows the average clast weight for each category. The analysis attributes nearly 70 percent of the sample (by count) to Precambrian categories, and almost 20 percent to Paleozoic categories. The Cretaceous and Other categories roughly split the remaining 10 percent.

Table 8. Lithology of the 7 to 32 mm fraction from XU 1, 30-40 cm, SE quadrant, 21HE483.

Group	Class	Grain Type	n =	% n =	g =	% g =	g / n
Precambrian			**306**	***69.5***	**718.8**	***74.1***	**2.34**
	Light	Granite and Gneiss	136	*29.9*	241.1	*24.9*	1.77
		Quartzite	17	*3.7*	27.7	*2.9*	1.62
	Dark*	Mafic Igneous	86	*18.9*	209.0	*21.5*	2.43
		Other Metamorphic	51	*11.2*	143.5	*14.8*	2.79
	Red	Iron Formation	8	*1.8*	21.4	*2.2*	2.68
		Rhyolite and Agate	7	*1.5*	19.4	*2.0*	2.77
		Sandstone	-		-		
	Other		11	*2.4*	56.7	*4.7*	5.15
Paleozoic			**88**	***19.3***	**175.7**	***18.1***	**2.00**
	Carbonate and Chert		65	*14.3*	129.3	*13.3*	1.99
	Sandstone		5	*1.1*	5.6	*0.6*	1.12
	Shale		1	*0.2*	0.5	*0.1*	0.50
	Other		17	*3.7*	39.9	*4.1*	2.35
Cretaceous			**29**	***6.4***	**33.9**	***3.5***	**1.17**
	Western	Shale (gray)	-		-		
	Intermediate	Shale (speckled)	-		-		
		Limestone	-		-		
		Pyrite	-		-		
		Lignite	-		-		
	Eastern	Ostrander Sand	28	*6.2*	33.4	*3.4*	1.19
Other			**22**	***4.8***	**41.6**	***4.3***	**1.89**
	Unknown		21	*4.6*	41.4	*4.3*	1.97
	Secondary		1	*0.2*	0.2	*> 0.0*	0.20
	Other		-		-		
Total			**455**	***100.0***	**970.0**	***100.0***	**2.18**

* Hobbs (1998:198) notes that mafic igneous and other metamorphic "are difficult to separate from each other" and that "for most purposes they are grouped together." The separations here are tentative.

4.1.1 Precambrian group

In the Precambrian group, the Light and Dark classes constitute approximately equal shares of the sample. The Red and Other classes make relatively small contributions. Granite and Gneiss is the single largest category for the whole sample, although it is equaled by the combined Precambrian Dark class (Mafic Igneous plus Other Metamorphic).

Hobbs (1998:198) notes that the Precambrian Quartzite category exists mostly as a place to record Sioux Quartzite clasts in southwestern Minnesota. However, in this case only three clasts were identified as originating from the Sioux Quartzite, and one of these was catlinite (pipestone) rather than quartzite. The remaining 14 quartzite pebbles were variable in color and texture, and of uncertain origin. It is possible that some come from the basal Sioux Quartzite conglomerate, which is known to contain older quartzite clasts (Justin and Radford 1990a, 1990b; Terrell et al. 2005; Bakken 2011), but the diversity of the sample suggests multiple origins. In this context it is helpful to note that the larger toolstone fraction included several quartzite clasts that meet the characteristics described for the Precambrian Quartzite category, but which are clearly unrelated to the Sioux Quartzite. This is discussed further below.

Sorting of the Precambrian Dark class between Mafic Igneous and Other Metamorphic is tentative, and should be regarded as very approximate. Hobbs (1998:198) notes that mafic igneous and other metamorphic clasts "are difficult to separate from each other" and that "for most purposes they are grouped together." In this study, clasts that appeared to show sedimentary structure or metamorphic texture were placed in the Other Metamorphic category, and other clasts were placed in the Mafic Igneous category. Thus, it is likely that the Mafic Igneous category is too large, and that the Other Metamorphic category is more important than the numbers indicate.

The Precambrian Red class (n=8) includes a small set of clasts, nearly equally divided between iron formation and reddish igneous extrusive rock. No agate or sandstone was found.

Many of the clasts in the Precambrian group could originate from a broad area ranging generally from northwest Ontario across central Minnesota and into parts of the Minnesota River valley (Figure 2). The clasts associated with the Sioux Quartzite, however, are clearly derived from farther up the valley. The other quartzite seems more likely to originate from some distance to the northeast, or from other sources whose locations are obscured by multiple vectors of glacial transport. The Precambrian Red class clearly originates from the vicinity of Lake Superior some distance to the northeast.

4.1.2 Paleozoic group

The Paleozoic group consists primarily of carbonate rock and chert, with minor contributions from the Sandstone, Shale and Other classes. The carbonate rock clasts (n=48) tend to be somewhat small, well rounded, and light to medium brown in color, although some are darker or greyish-brown. Many are speckled. This seems to be surficial staining, but the pattern of staining is apparently also reflective of structural characteristics. The chert clasts (n=18) are discussed in greater detail below. A single piece of soft, gray-green shale was identified. A few pieces of weakly cemented sandstone were found (n=5). The Other category consists of sedimentary rocks that could not be specifically identified but which resembled identified Paleozoic clasts more than clasts in the other categories.

Some of the Paleozoic clasts likely originated from glacial till, especially from Des Moines lobe till. It is clear, however, that many originated from local Paleozoic rock that outcrops in the lower Minnesota River valley.

4.1.3 Cretaceous group

The Cretaceous group consists of clasts believed to come from the Ostrander Sand of the Windrow Formation. The Ostrander fraction includes pieces of relatively soft, iron-rich rock (n=18) and of small, rounded and polished pebbles of various kinds of rock (n=10). The iron-rich rock includes both larger, irregularly-shaped fragments of minimally-worn iron concretion, and small, well rounded pebbles, some polished. Although the pebble fraction did not include any Cretaceous limestone, it is worth noting that a very well rounded but broken cobble of Cretaceous limestone containing dense fossil hash, mostly shell fragments, was found in the cobble fraction.

The Ostrander Sand is reported to have a patchy distribution over an area that includes the lower Minnesota River valley (Andrews 1958; Sloan 1964). The presence of so many Ostrander clasts, some of them moderately fragile and minimally worn, suggests a nearby source.

4.1.4 Other group

This diverse group consisted mostly of clasts that could not be identified (thus Other Unknown). However, there was one small, spherical pebble of poorly cemented ocher (Other Secondary). There were also seven small pebbles that may be associated with what regional archaeologists call the Western River Gravels Group (*see* Bakken 2011). This group includes mostly pebbles of siliceous raw materials that originated as far west as the Rocky Mountains and were transported and concentrated in the gravels of east-flowing preglacial rivers (cf. Bluemle 1972). These were subsequently redistributed by glaciers, and thus thinly spread throughout Des Moines lobe tills. Although their origin is generally understood, they are not accommodated in the schema described by Hobbs (1998) and so are placed in the Unknown group.

4.2 Specific Toolstone Identifications

The pebble fraction also provides some information on the presence of specific types of toolstone. This is summarized in Table 9 (together with the results of the toolstone identification analysis). It is important to note that toolstone identification is more difficult with small pieces, especially for certain raw materials. In the list below, Swan River Chert presented the biggest challenge, and it is possible that some of the pieces are misidentified. The other identifications should be reasonably reliable.

Potential toolstone was found in the following lithological categories:

- *Precambrian Quartzite*: Sioux Quartzite Group, unspecified quartzite
- *Precambrian Iron Formation*: Animikie Silicates Group
- *Precambrian Rhyolite and Agate*: Lake Superior Rhyolite
- *Paleozoic Carbonate and Chert*: Prairie du Chien Chert, Swan River Chert, unspecified chert
- *Other Unknown*: Tongue River Silica, Western River Gravels Group

Table 9. Summary of Toolstone Identifications for Sediment Samples from 21HE483.

Raw Material	**n =**	**g =**	**g / n**	**Wear**
Cobble Fraction (Samples 1, 2)				
Animikie Group (*iron form.*)	3	105	35	Rounded to subrounded
Knife Lake Siltstone	1	269	-	Rounded
Lake Superior Rhyolite	2	148	72	Rounded
Prairie du Chien Chert	4	988	247	Well rounded , rounded, subrounded, subangular; one polished
Red River Chert	2	37	19	Rounded to subrounded; one polished
Tongue River Silica	1	42	-	Rounded
Chert	3	240	80	Well rounded to rounded; one polished
Quartzite	10	1,324	132	Well rounded to rounded
TOTAL	26	3,153	121	
Pebble Fraction (Sample 1)				
Animikie Group (*iron form.*)	8	1.8	0.2	
Lake Superior Rhyolite	5	10.9	2.2	
Prairie du Chien Chert	11	15.9	1.4	
Sioux Quartzite Group	2	5.5	2.8	
Swan River Chert	3	2.4	0.8	
Tongue River Silica	1	0.9	-	
Western River Gravels Group	7	7.2	1.0	
Chert	3	2.2	0.7	
Quartzite	14	20.4	1.5	
TOTAL	**54**	**67.2**	**1.2**	

It is hard to evaluate based on the pebble fraction how many different kinds of quartzite might be represented by the clasts generically identified as quartzite, or whether any of them might represent a useable resource. Instead, these questions are addressed below in the presentation of results from the cobble fraction analysis. Also note that only some of the clasts identified as rhyolite seem to be to the Lake Superior Rhyolite (see Mulholland and Klawiter 2009:63).

Following Hobb's schema, clasts of chert were generally included in the Paleozoic Carbonate and Chert category. Some chert, however, was placed in the Ostrander Sand category. The Ostrander sand is not considered a potential toolstone resource since the clasts are generally too small to use, so chert from the Ostrander Sand category is not included in the list above. The Western River Gravel Group, discussed above, also contained a few chert clasts. Finally, Tongue River Silica was placed in the Other Unknown category, since it is of Paleocene age and also a silcrete rather than a chert (see Ahler 1977).

The Precambrian Other Metamorphic category probably contains pieces of siltstone (some possibly Knife Lake Siltstone), but it was impractical to identify that material in the pebble sample. It is instead discussed below in the context of the toolstone identification analysis.

4.3 Other information

A few interesting pieces of information come from the larger clasts in the samples, in addition to the Cretaceous limestone cobble noted above. There was an omar (see Prest et al. 2000), and a cobble of non-siliceous sedimentary rock that appears to preserve a stromatolite fossil.

4.4 Toolstone Identification

The cobble fraction used for this analysis came from both Samples 1 and 2. The toolstone identifications are summarized in Tables 10 (Sample 1) and 11 (Sample 2). Twenty-six pieces of potential toolstone were identified. It appears that about 13 different raw materials are represented, several of which can be more-or-less specifically identified. Each identified raw material identification is discussed below, first the specifically identified followed by the generically identified materials.

Table 10. Toolstone Identifications for Cobble Fraction of Sediment Sample 1 from XU 1, 30-40 cm, SE Quadrant, 21HE483.

Identification	g =	Form	Description
Iron formation	48.0	Sub-angular. Complex shape following irregular banding.	Complex banding, not flat sedimentary laminations. Most is highly silicified. Part speckled (but not pelloidal). Parts dark red, parts bluish grey; the latter show high magnetic susceptibility. Flaking quality probably marginal at best.
Iron formation	31.8	Sub-rounded. Tabular shape.	Banded; flat, parallel sedimentary laminations. Two parallel faces broken along laminations. Some parts more cherty than others. Golden brown. Flaking quality probably marginal at best.
Knife Lake Siltstone	268.7	Sub-rounded; break angular. Compact, subspherical shape.	Relatively fine grained and homogenous. Sedimentary laminations apparent, but fairly subtle. Old break shows typical tendency to fracture along internal planes that do not parallel the sedimentary structure. Surface has a distinct brown tinge, not typical of this material; staining? Not recognizable without examination of a fresh fracture surface. Probably marginal flaking quality.
Lake Superior Rhyolite	31.0	Sub-rounded. Compact, blocky shape.	Numerous small light brown phenocrysts, scattered grey phenocrysts and a reddish-brown matrix. Probably poor to moderate flaking quality.
Prairie du Chien Chert	740	Rounded. Complex form with hollows where weaker rock has eroded.	Very sandy, closer to poorly cemented sandstone. Cement may be both silica and carbonate rock. Fine grains of carbonate rock throughout, some carbonate patches several mm in size. Generally medium brown, with some lighter and darker patches. Not flakeable.
Prairie du Chien Chert	153.7	Rounded; break sub-angular. Complex shape.	Cobble is part dark carbonate, partly intermingled chert. The chert has a chaotic, heterogenous structure. Patches look like typical Prairie du Chien Chert, but most parts do not. Chert generally ocher-brown, lighter and darker in parts. Likely impossible to flake.

Table 10. Continued.

Identification	g =	Form	Description
Prairie du Chien Chert	740	Rounded. Complex form with hollows where weaker rock has eroded.	Very sandy, closer to poorly cemented sandstone. Cement may be both silica and carbonate rock. Fine grains of carbonate rock throughout, some carbonate patches several mm in size. Generally medium brown, with some lighter and darker patches. Not flakeable.
Prairie du Chien Chert	153.7	Rounded; break sub-angular. Complex shape.	Cobble is part dark carbonate, partly intermingled chert. The chert has a chaotic, heterogenous structure. Patches look like typical Prairie du Chien Chert, but most parts do not. Chert generally ocher-brown, lighter and darker in parts. Likely impossible to flake.
Prairie du Chien Chert	84.5	Sub-rounded. Compact, blocky shape.	Pebbly surface represents the poorly-silicified transition between chert and host rock. Texture results from sand grains eroding out, so clast largely retains the original shape of the chert mass. Small particles of carbonate rock throughout; scattered small, solid cherty patches. Medium brown. Moderate to good flaking quality.
Prairie du Chien Chert	58.2	Sub-angular. Highly polished. Compact, blocky shape.	Solid chert, homogenous. Most of surface is smooth, representing interior of original chert mass. Two patches have pebbly texture, preserving the surface of the original chert mass. Mostly medium grey, but part is ochery brown. Highly polished. Probably good flaking quality.
Chert	31.8	Rounded; break sub-angular. Highly polished. Elongated shape.	Fine grained. Two colors with a fairly sharp contact between them. The outer part of the clast is dark grey. The inner part is light brown (on a fresh fracture surface, while the patinated surface is orange brown). Good flaking quality. Not a familiar material.
Chert	13.8	Sub-rounded; break sub-angular. Compact shape.	Fine grained. Fine scale, "turbulent" sedimentary laminations. One face split parallel to laminations but also a set of parallel cracks at ca. 60∞ to laminations. Light brown in color. Not a familiar material.
Quartzite (type A)	314.1	Rounded. Compact, blocky shape.	Most of the rock seems well lithified. Some weaker areas eroded, producing streamlined, rounded pits. Disposition of the pits, subtle differences in color and texture, and parallel surfaces indicate sedimentary bedding. In eroded areas, individual grains are exposed in the round. These are well rounded and near spherical. Flaking quality not tested, but probably poor to moderate. Light brown.
Quartzite (type B)	124.7	Well rounded. Elongated, streamlined shape.	Generally fine grained, with some variation in grain size. Well lithified. Light golden brown.
Quartzite (type C)	16.5	Sub-rounded. Compact, blocky shape.	Fine grained, probably some metamorphic alteration. Well lithified. Generally off-white.
Quartzite (type C)	7.3	Rounded. Elongated, streamlined shape.	Fine grained, probably some metamorphic alteration. Well lithified. Generally light greyish white; patched of pink on one side may be feldspar?
Quartzite (type D)	236.4	Well rounded; break subrounded. Somewhat elongated shape.	Fine grained, possibly metamorphic alteration. Well lithified. Light greyish brown.

Table 11. Toolstone Identifications for Cobble Fraction of Sediment Sample 2 from XU 1, 50-60 cm, NE Quadrant, 21HE483.

Identification	g =	Form	Description
Cf. iron formation	25.4	Sub-rounded. Pyramidal shape.	Fairly homogenous in color, structure. Fairly fine grained; not completely silicified. Pelloidal structure. Dark ocher brown.
Red River Chert	32.8	Sub-angular. Elongated disk shape with thin edges.	Very fine grained, homogenous. Fossils as inclusions and molds, including crinoid stem fragments. Very light brown. High flaking quality.
Red River Chert	4.3	Sub-angular. Polished. Compact, blocky shape.	Very fine grained. Fossils as inclusions and molds, including crinoid stem fragments. Light grey; color weakly banded. High flaking quality.
Lake Superior Rhyolite	117.0	Sub-rounded. Compact, blocky shape.	Somewhat grainy, but has a conchoidal fracture. Several internal cracks. Reddish brown.
Tongue River Silica	42.4	Rounded. Compact, blocky shape.	Moderately fine grained. Apparent root molds. Medium brown, slightly darker than typical for this material.
Chert (brecciated)	194.4	Sub-rounded. Compact, blocky shape.	Includes angular to subangular agate clasts; largest ca. 3 cm on longest axis. Also other clasts, in fine grained matrix. Abundant small vugs of irregular shape. Scattered grains of other minerals. Somewhat coarse grained when flaked, moderate flaking quality. Medium brownish grey, with slight greenish tint in areas. Completely unfamiliar material.
Quartzite (type B)	530	Rounded. Compact, blocky shape.	Grains indistinguishable in parts; other parts show variation in grain size, although generally fine grained. Scattered angular grains. Color patterning reflects sedimentary layering, also reflected in some fracture surfaces. Numerous incomplete hertzian fractures. Generally light golden brown color, with some variation; small areas show a slight pink tinge.
Quartzite (type B)	48.8	Rounded. Compact, blocky shape.	Generally fine grained, with some variation in grain size. Scattered angular grains. Appears to be cemented. Well lithified. Parallel faces and internal fractures suggest weak sedimentary bedding. Light golden brown.
Quartzite (type B)	17.7	Well rounded. Elongated plano-convex shape.	Fine grained; individual grains hard to distinguish. Well lithified. Light golden brown.
Quartzite (type B)	15.6	Well rounded; break sub-angular. Elongated plano-convex shape.	Generally fine grained, although some variation in grain size. Scattered angular grains. Well lithified. Light golden brown.
Quartzite (type B)	13.6	Rounded. Compact, blocky shape.	Fine grained; individual grains hard to distinguish. Well lithified. Light yellowish brown.

4.4.1 Animikie Silicate Group (iron formation) (n=3)

This is a diverse set of specimens, which is not unexpected since iron formation shows a wide range of characteristics. The largest piece (Table 10, 48.0 g) is part dark red and part bluish grey; the latter parts are strongly attracted to a magnet. Parts of the rock are speckled. The specimen shows complex banding that may reflect the structure of an algal stromatolite. The texture does not seem to be pelloidal, as would be common in some Animikie Silicates. Most but not all is highly silicified. The clast is subangular. The shape is complex, following the irregular banding.

A second piece is nearly as large (Table 10, 31.8 g) and golden brown. It is banded, with parallel sedimentary laminations. Some parts seem to be more cherty than others. The clast is sub-rounded. The shape is tabular, with two broad faces broken along bedding planes.

A third and smaller piece (Table 11, 25.4 g) is more homogenous than the others. It is dark ocher brown, and does not seem to be completely silicified. The texture seems pelloidal. The clast is sub-rounded. The shape might be described as squat pyramidal.

These pieces have undergone extensive glacial transport and been introduced into the river gravels from till. Many pieces of iron formation are prone to breaking into blocky pieces, and these clasts are probably angular because they have been broken during glacial transport. The two larger pieces are probably unflakeable. The third piece may be flakeable, but utility is limited by its small size.

4.4.2 Knife Lake Siltstone (n=1)

This specimen (Table 10, 268.7 g) is relatively fine grained and homogenous. Sedimentary bedding is apparent but subtle. Old breaks show a typical tendency to fracture along planes that do not parallel the sedimentary structure. A freshly fractured surface shows that this material is dark grey in color. The surface is much lighter and has a brown tinge. While this material typically develops a light-colored weathering rind, the brown tinge is not typical and is probably surface staining. The clast is sub-rounded; a break is angular. The shape is compact and sub-spherical.

Knife Lake Siltstone originates from greenstone belts in parts of northeastern Minnesota and nearby parts of Ontario, and has a wide downstream glacial dispersal (Nelson 1992, 2003; Bakken 1997, 2011; cf. Mulholland 2002:5-9). It is conceivable that this piece could have originated from other metasedimentary strata close to the site, although this seems the less likely option given the specific characteristics of the material. This piece has probably undergone extensive glacial transport and been introduced into the river gravels from till. Flaking quality is probably poor to moderate, although it is difficult to be sure without testing the sample since the quality of siltstone varies greatly.

4.4.3 Lake Superior Rhyolite (n=2)

These specimens (Table 10, 31.0 g; Table 11, 117.0 g) are broadly similar. Both are reddish brown in color. The smaller specimen has numerous light brown phenocrysts and scattered grey phenocrysts; the larger piece has only the scattered grey phenocrysts. The larger piece has several cracks. Both are sub-rounded and have a compact, blocky shape. The fracture of the larger piece is conchoidal, although the fracture surface is somewhat grainy.

These pieces have undergone extensive glacial transport and been introduced into the river gravels from till. The flaking quality of both is probably poor. Lake Superior Rhyolite is a marginal quality raw material, and saw limited use even in its primary source area (Mulholland and Klawiter 2009:63). Thus, these pieces would not represent a significant toolstone resource.

4.4.4 Prairie du Chien Chert (n=4)

These specimens show a degree of variation, but within the range that is seen in artifacts and raw material samples. The smallest piece (Table 10, 58.2 g) is solid chert, and typical of the material seen in artifacts. Two patches with rough, pebbly texture are part of the surface of the original chert mass. The texture results from sand grains eroding from a poorly-silicified zone around the edge of the solid chert. The rest of the clast has a smooth, highly polished surface that would originally have been in the interior of the chert mass. Most of this sample is medium to light grey, but part is an ocher brown. The clast is rounded. The shape is complex.

The other three cobbles are interesting because they are only partly chert or not completely silicified. The largest (Table 10, 740 g), in fact, is very sandy, and closer to poorly cemented sandstone than to chert. (Note that it is not unusual to find Prairie du Chien Chert that is sandy, sometimes so sandy it might better be called quartzite.) The cement may be both carbonate rock and silica. The space between the grains is not completely filled. There are fine carbonate particles throughout the rock, and scattered carbonate patches a centimeter or so across. It is generally medium brown, with some slightly lighter or darker areas. This rounded cobble has worn to a complex, streamlined form because weaker sections have weathered out.

The third sample (Table 10, 153.7 g) is partly dark brown carbonate, partly ocher-brown chert. The chert has a chaotic, heterogenous structure. Patches look like typical Prairie du Chien Chert, but most parts do not. The clast is rounded, and the shape is complex.

The fourth sample (Table 10, 84.5 g) is curious. The pebbly surface represents the edge of the chert mass as it formed (as discussed above), so this piece retains the full shape of that mass. Part of the space between oolitic grains is filled with carbonate rock. The color is a fairly homogenous medium brown; the color comes from the finely dispersed carbonate. This clast is sub-rounded. The shape is compact and blocky. Despite the carbonate component, the sample flakes well, producing flakes with a reasonably strong edge.

The smallest piece likely eroded from the carbonate host rock much longer ago, and also has been transported farther. Some combination of weather and transport has fragmented the original chert mass, leaving this clast of solid, apparently good quality chert. This fragmentation was not recent, since the breaks are sub-rounded and the surface has been highly polished. This piece may have weathered out of bedrock farther upstream, and later been transported downriver. One possible source is the Mankato area, where Prairie du Chien Chert pebbles and cobbles are reported to be common to abundant in lag deposits and river gravels (J. Reichel, personal comm. 2014).

The two largest pieces are relatively weak in parts, and in general would be expected to wear more quickly. They have probably seen less weathering and transport, and may have come from closer to the sample location. It is conceivable that they were eroded during the formation of the valley, although this suggestion cannot be strongly supported. The fourth piece may have a more recent and local origin like the two largest pieces, or may lie in between the two extremes of weathering and transport. The two smaller pieces would have some utility as toolstone, although that utility is compromised by the combination of relatively small size and compact, blocky shape. Because of the shape, they lack good striking platforms and would have to be cracked open before primary reduction, thus further reducing the size. The two larger samples lack any utility as toolstone, both because the rock is generally weak and because the fracture is unlikely to be conchoidal.

4.4.5 Red River Chert (n=2)

These specimens (Table 11, 32.8, 4.3 g) are typical of the raw material type. Both are fine grained. One is very light grey and shows some subtle mottling. The other is a generally homogenous light brown with small patches of near white. Both have fossils in the form of inclusions and molds, including sections of crinoid stem. Both are sub-angular. The larger has an elongated disk shape and much of the edge is thin. The smaller piece has a compact, blocky shape, probably reflecting the tendency of some Red River Chert pieces to break into blocky chunks. This smaller piece is polished.

These pieces have undergone extensive glacial transport and were introduced into the river gravels from till. They are relatively angular because they have been broken during transport; Red River Chert tends to be somewhat brittle, and many pieces are prone to breaking into blocky pieces. The smaller piece is too small to be useable as toolstone. The larger is effectively shaped much like a flake blank, and could possibly be made into a small tool.

4.4.6 Tongue River Silica (n=1)

This specimen (Table 11, 42.4 g) is medium brown, somewhat darker than is typical for this material. This could be surface staining. The specimen is moderately fine grained, and apparent root molds are present. It is well lithified. The specimen is rounded, and has a compact, blocky shape.

This piece has undergone multiple vectors of glacial transport and been introduced into the river gravels from till. This piece is too small to be of much value as toolstone, especially since Tongue River Silica is a relatively poor quality toolstone until heat treated. Its presence, however, indicates that larger Tongue River Silica clasts could be present in river valley sources.

4.4.7 Chert (n=3)

These specimens represent three different materials with few characteristics in common. Two are distinctive but unfamiliar, and cannot be identified with any regularly-occurring regional raw materials. The third in general characteristics resembles many other regional kinds of chert, but in specific characteristics is not identifiable as any of them. The origins of the clasts are not clear. It is possible that one or two may come from the basal conglomerate of the Sioux Quartzite, although this was not specifically investigated and the suggestion should be considered speculative.

The first specimen (Table 10, 31.8 g) is fine grained and shows two colors with a sharp contact between them. The first color is dark grey, and is found near the surface of the clast. This shows that the clast largely preserves the original form of the chert nodule, although part has been broken off. The second color is light brown on a fresh fracture surface, although the patinated surface is orange brown. The color patterning is reminiscent of Hudson Bay Lowland Chert, although it otherwise does not resemble that material. The clast is rounded; a break is sub-angular. The elongated shape reflects the original form of the nodule. The surface is highly polished.

The second specimen (Table 11, 13.8 g) has fine-scale laminations, probably reflecting sedimentary structure, but these are "turbulent" in detail. That is, although the lines are parallel over their length, each line is full of small curves that are not parallel with the line. There are scattered small grains that also appear cherty, and possible small, scattered fossil fragments. There is a series of parallel cracks that do not follow the apparent bedding. Thus, while the piece resembles some other regional cherts in general terms, it is quite different in its details. The flaking quality is undetermined, but the small size means this piece has little utility. The clast is sub-rounded; a break is sub-angular. The shape is compact and blocky.

The third specimen (Table 11, 194.4 g) is medium brownish grey, with a slight greenish tint in areas. This piece is notable for having a brecciated structure. The matrix is fine grained. There are clasts of various sizes scattered throughout. Curiously, many of these are banded agate fragments; the largest of these is ca. 3 cm long. There are also abundant small vugs of irregular shape, and what appear to be scattered grains of other minerals. The clast is sub-rounded. The shape it compact and blocky.

As noted, it is difficult to determine how these specimens came to be in the river gravels. Flaking quality of the first piece seems generally good, although the fracture is diverted by cracks or small flaws that are not readily seen. The fracture texture of the second piece is somewhat coarse, and flaking quality is probably moderate. It is too small and blocky to be of much use, although bipolar reduction might conceivably yield a few expedient flake tools. The third piece is somewhat coarse grained when flaked, and probably of moderate flaking quality. The first and third specimens would likely have some utility as toolstone.

4.4.8 Quartzite (n=10)

These specimens probably represent four different kinds of quartzite, here called A, B, C and D. Type A is represented by one specimen (Table 10, 314.1 g). It is light brown in color and fine grained. Much of the rock seems well lithified. Some weakly cemented areas have eroded, however, producing streamlined, rounded pits. Disposition of the pits, subtle differences in color and texture, and parallel surfaces indicate sedimentary bedding. In eroded areas, individual grains are exposed in the round. These are well rounded and nearly spherical. The clast is rounded. The shape is compact and blocky. Type B, the most abundant, is represented by six specimens. The largest of these (Table 11, 530 g) provides the best description for the material since it best shows the range of variation. The general color is light golden brown, with some variation; small areas can show a slight pink tinge. The color patterning reflects sedimentary bedding, and the bedding is also reflected in some fracture surfaces. Individual grains are indistinguishable in parts of the rock; other parts show some variation in grain size, although the material is generally fine grained. There are scattered angular grains. There is no obvious cement between grains. The material is well lithified. The clasts are rounded to well rounded. A broken surface on one of the pieces is sub-angular. Shape is variable. Note, however, that two pieces have a plano-convex shape that could result from breakage along sedimentary bedding. Numerous incomplete hertzian fractures can be seen on the largest specimen. Weights range from 13.6 to 530 g and average 107.0 g.

Type C is represented by two specimens (Table 10, 16.5 g and 7.3 g). It is actually not clear that these share a common origin, but they are grouped together because of their general similarity. The general color is off-white to pale greyish white. They are fine grained, well lithified, and may display some metamorphic texture. The clasts are sub-rounded to rounded. Shape is variable.

Type D includes a single specimen (Table 10, 236.4 g). It is light greyish brown in color, fine grained, and may display some metamorphic texture. The clast is rounded; a break is sub-rounded. The shape is somewhat elongated.

There are many sources of quartzite around the region, and associating these samples with potential sources is beyond the scope of this study. The consistent rounded to sub-rounded shapes, however, suggests that the clasts have undergone significant transport or otherwise spent considerable time in an abrasive environment. In addition, these pieces resemble pebbles and cobbles that are commonly seen in various tills. Thus, it seems likely that these pieces have been introduced into the river gravels from till. Their utility as toolstone probably varies. Generally speaking, "till quartzite" clasts like these tend to be hard to flake or produce weak flakes, and were not commonly used. Type A likely has low utility because of the bedding and weakly cemented areas. Type B seems to have better potential, although this would have to be evaluated by experimental flintknapping. The flaking quality of types C and D was not evaluated, but the potential is probably not outstanding.

5. Discussion

The results of the pebble lithology analysis and toolstone identification analysis help explain the provenance of the sample and clarify the nature of the toolstone resources at 21HE483. These results complement information from the 21HE483 artifact assemblage. Comparing these results with the raw material profile of the assemblage provides insights into the practices and preferences of the flintknappers who quarried the 21HE483 deposits.

5.1 Lithology of Sample 1

Results of the pebble lithology analysis are summarized in Table 8. This analysis provides useful insights into the nature of the toolstone source at 21HE483. It is clear that distant and proximate sources – bedrock, till, and other unconsolidated deposits – made contributions to the sampled sediment. For example, the Precambrian Red clasts were glacially transported from the vicinity of Lake Superior, Sioux Quartzite clasts came from bedrock further up the Minnesota River valley, and Ostrander Sand clasts probably from local deposits.

What is less clear is the relative importance of these two sources. Since the river apparently eroded more glacial till than bedrock, we might be safe in thinking that more of the clasts come from till. Beyond that, the data in Table 8 do not provide much help. Many of the igneous clasts, for example, could have come from either kind of source. It seems likely that the Precambrian Other Metamorphic clasts are reworked from glacial sediments, but as noted above this category is separated with difficulty from the Mafic Igneous category; those numbers should be treated as approximate, and do not bear much interpretation.

If we posit that most of the clasts were likely introduced from glacial tills, the next question is which tills and in what proportions. Table 3 shows the three main tills currently exposed in the valley. We might expect these to be the main contributors to the sampled deposit, although it is helpful to bear in mind that minor (and poorly known) tills are likely also represented. A caveat is also warranted. The valley was initially deeper, and we have limited information on what buried tills might have been exhumed and therefore be represented. That said, a comparison of the general lithology of the sample and the tills is informative.

One of the most interesting characteristics of the sample is the relatively small proportion of carbonate rock, which constitutes just over 10 percent of the clasts. Tills of Riding Mountain or Winnipeg provenance are generally rich in carbonate. In addition, any or all of the carbonate clasts in the sample could have come from erosion of Prairie du Chien Group bedrock which crops out along the valley from the vicinity of Mankato to the junction with the Mississippi in St. Paul. In fact, the carbonate clasts in the sample seem to resemble the Prairie du Chien rock more than they resemble the generally fine-grained, more homogenous limestone and dolomite from the Winnipeg lowlands. This at least suggests that most, perhaps even all, of the carbonate clasts are of local rather than glacial derivation.

Toolstone clasts identified in the pebble fraction tend to bear out this interpretation. Over 60 percent of the chert clasts (11 of 18) are chert from the Prairie du Chien Group bedrock. A little over 20 percent (three of 18) are types associated with Des Moines lobe tills of Riding Mountain or Winnipeg provenance. The lack of Cretaceous shale might suggest that the New Ulm till was not an important contributor, although it is probably more likely that the shale simply did not survive the high-energy fluvial environment.

This leads to the question of the importance of contributions from Superior provenance till. The Precambrian Red class clearly indicates a contribution, but the class is small. Certainly, some of the Precambrian Granite and Gneiss category came from Superior till, but it is hard to know what proportion; some could have come from bedrock farther upstream. The same could be said for the problematic Precambrian Dark class; the Other Metamorphic category is likely associated with Superior provenance till, but the count and percentage are not authoritative. The low percentage of carbonate rock, however, is characteristic of Superior till but not the northwestern tills. This information suggests that Superior provenance till could be the more important contributor.

To summarize, the lithology of Sample 1 indicates first that till, bedrock, and unconsolidated local deposits contributed to the deposit at 21HE483. Further, it indicates that tills of Superior, Riding Mountain, and Winnipeg provenance are all represented. The relative importance of these contributions is not completely clear. However, if we posit that the river eroded more till than bedrock, then more of the clasts could have come from till. It is also possible that the contribution from Superior provenance till predominates.

5.2 Raw Materials in the Sediment Samples

Results of the toolstone identification analysis are summarized in Tables 9, 10, and 11. Although the primary toolstone information came from the cobble fraction, Table 9 also summarizes toolstone identifications for the pebble fraction of Sample 1. The latter are included because the pebble fraction included additional raw materials. The combined sets of information give a clearer picture of which raw materials occur in the deposit at 21HE483 and of their characteristics, as well as a clearer picture of the nature of this deposit and why it was quarried.

The analyses produced samples of nine more-or-less specifically identifiable materials, plus samples that were placed in two generic categories. The latter probably represent seven additional raw materials, for an approximate total of 16 different kinds of toolstone. This is a relatively diverse sample, especially when viewed in terms of where the various materials originated. Prairie du Chien Chert and the Sioux Quartzite Group come from essentially local sources. The Animikie Silicate Group, Knife Lake Siltstone, and Lake Superior Rhyolite come from tills of Superior provenance, and originated some distance to the northeast. Red River Chert, Swan River Chert, Tongue River Silica, and the Western River Gravels Group come from tills of Riding Mountain or Winnipeg provenance, and originated some distance to the northwest (see Bakken 1997, 2011). As hypothesized, multiple bedrock and till types have contributed to the deposit.

It is somewhat surprising to find 26 clasts of potential toolstone (excluding the pebble fraction) in a sample that comes from only one quadrant of a 10 cm level in a one by one meter XU. This is even more surprising when you consider the total would be higher had the better quality clasts not already been removed by the flintknappers who did the quarrying, and rejected cobbles removed by the archaeologists who did the excavation. The point is reinforced by data from the pebble fraction, where potential toolstone constitutes 11.9 percent of the sample by count and 6.9 percent by weight. This clearly points to why the deposit was quarried: it was rich, at least in terms of toolstone sources in a largely glaciated landscape.

The observations of both diversity and richness should be tempered somewhat, however, by emphasizing the word *potential* – in terms of both potential toolstone and potential utility. All toolstone is not created equal, and a closer look at the clasts in these samples helps us refine our picture of the resource represented by this deposit.

5.3 Major Resource Potential

Prairie du Chien Chert is common in the sediment samples and, to restate a point made earlier, would be even more abundant if many pieces had not been removed courtesy of flintknappers and archaeologists. In addition, Prairie du Chien Chert is the single most important raw material in archaeological assemblages over a good part of southern Minnesota. Thus, this raw material represents the major resource at this site.

5.4 Secondary Resource Potential

Swan River Chert and Tongue River Silica are both important raw materials in some regions. Generally, however, this seems to be the case in regions where one or the other is the main available raw material. In regions where other materials are available in sufficient quantity, Swan River Chert and Tongue River Silica tend to be little used. Adding to the uncertainty in the present case is their relatively minor presence in the sediment sample. It seems advisable to consider them of secondary importance in this context; suitable pieces would be used when available but would probably not be common, and other materials would be preferred when available in sufficient quantity.

5.5 Minor Resource Potential

It is hard to evaluate the potential utility of the generic chert category. Small pebbles of unidentified chert are not uncommon in regional tills or gravels; these are often too small to be of any use, although a few might be suited for bipolar reduction. There is a larger clast of unidentified chert in the cobble fraction, however, and it seems flakeable. Thus, this category might be considered a minor resource.

Red River Chert is generally a good quality material and is commonly found in archaeological assemblages. However, it seems to fragment fairly easily in transport; larger clasts are more common nearer the source area in the Winnipeg Lowlands, but increasingly uncommon with distance from the primary source area. And, as with the Animikie Silicates, Red River Chert has a tendency to break into blocky chunks. Still, one of the two clasts from the cobble sample looks useable, and the second might be. Thus, Red River Chert represents a real but minor resource.

The Western River Gravels Group is in any case a minor resource in the state. The constituent materials occur mostly as pebbles suited for little outside of bipolar reduction. In addition, the pebbles are relatively uncommon.

Knife Lake Siltstone tends to be used most intensively in the Paleoindian period and possibly earlier parts of the Archaic. Later use is sporadic. In addition, intensive use seems to be confined to northeastern to east-central Minnesota, where supplies of the material are more abundant (Mulholland 2002). In later time periods and in much of the state, this material sees only limited use.

As discussed above, the quartzite in the sample probably represents four different materials. Some of these materials may be essentially unusable because they fracture unpredictably or because they produce flakes with weak edges. None of the materials are likely to be of good flaking quality. Based on observations at other archaeological sites, such "till quartzites" were occasionally used, sometimes for making chopping tools, but were never an important resource.

5.6 Dubious Resource Potential

Some of the raw materials in the samples would be of dubious value to a flintknapper. Mulholland and Klawiter (2009:63) tell us, for example, that good quality Lake Superior Rhyolite is rare, and that the material was used only occasionally. Thus, it is likely that the clasts of this material do not represent a significant resource. Much the same could be said of Sioux Quartzite, which was rarely flaked.

The iron formations of northeastern Minnesota are heterogenous in character; only parts are well silicified, and only some of the silicified material is knappable. Furthermore, it seems that transported clasts of even the better varieties of iron formation often break into blocky chunks when flaked, and are thus essentially unfit for flaking. For example, of the three clasts identified in the cobble sample, only one seems to have any potential for being flakeable. Therefore, while the presence of iron formation clasts in the sample points to the potential for useful Animikie Silicate Group cobbles in the deposit, that potential is effectively low.

5.7 Comparison with Raw Materials in the Artifact Assemblage

The raw material composition of the artifact assemblage from 21HE483 can help us better understand how the toolstone deposit at the site was exploited. The degree to which the composition of the artifact assemblage reflects the composition of the deposit can tell us something about the practices and preferences of the flintknappers who worked there. In turn this can help us refine our perspective on the toolstone resources of the region, and better understand the perspectives of the early tool makers.

5.7.1 Metrics Used in the Comparison

The first step in this comparison is to determine a suitable metric. In most lithic analyses, whether archaeological or geological, such comparisons use clast counts. In this case, however, counts are unlikely to give good results. The basic problem is clast size, or more specifically variation in clast size: there is a basic incompatibility between counts from the cobble fraction and counts from the pebble fraction. The cobble fraction represents at least potentially useable toolstone, whereas the pebble fraction does not. A flintknapper would be interested in how many cobbles were found since each cobble is useful in its own right, and difference in size (and weight) between cobbles is generally of secondary importance unless the difference is relatively large. The flintknapper would not care, however, about how many pebbles were found because the pebbles are not useable.

However, the pebble fraction includes raw materials that are not represented in the cobble fraction so it seems advisable to use the data from both fractions. Since the pebble fraction has high counts but represents essentially no useable toolstone, the counts do not provide a good characterization of the relative importance of different materials in the overall sample. The alternative is to use the total weight of the clasts of each raw material type. This is not entirely satisfactory either, since as noted above weight differences between cobbles are not especially significant unless the differences are relatively large. However, weight would seem to be the better of the two options.

The artifact collections from both Phase II investigations were used for this comparison. A few artifacts were excluded from the assemblage data because they were made of raw materials that would not be represented in the sediment sample data. These included one piece of Burlington Chert, since this exotic material would not occur in the deposit at the site, and 76 artifacts of materials that were present in the deposit but not quantified in the sample. These marginal-quality materials were typically used as hammerstones or to make chopping tools. Examples include basalt, schist, and various metasedimentary rock types. Twelve pieces of tested but unflakeable stone (e.g., iron concretion, limestone) were excluded for similar reasons.

Most of the sample clasts and artifacts were weighed to the nearest 0.1 g. However, since clasts and artifacts over 400 g were weighed to the nearest five grams, it would be misleading to present the weight data to an implied accuracy of 0.1 g. Instead, weights were rounded to the nearest one gram, which should be an acceptable approximation of the overall accuracy of the aggregated numbers.

Although the percentage figures are presented to one decimal place as a matter of convenience and habit, the significance of small differences in percentage should not overestimated. Cumulative (if modest) uncertainty from sampling, subsampling, different degrees of precision in weighing, and other factors suggests that small differences in these data cannot bear great interpretive weight. As a rule of thumb, this analysis adapts the cautious position that difference under *about* five percent should be interpreted with care.

5.7.2 Comparison of the Data Sets

With these caveats in mind, Table 12 shows the weight and percentage by weight for each raw material category, for both the sediment sample and the combined Phase II artifact assemblage. The final column shows the difference between the percentage figures for the sample and those for the artifact assemblage. The format is artifact percentage minus sample percentage, so a *negative* number means that the material is *less* abundant in the artifact assemblage than in the sediment sample, and a *positive* number means that the material is *more* abundant in the artifact assemblage than in the sediment sample.

The first interesting characteristic of the data is the degree of similarity in the composition of the sample (geological) and the assemblage (archaeological). Of the 12 materials represented in the sample, 11 are also represented in the assemblage. Seven additional materials are found in the assemblage but not the sample, but these occur in very small amounts. The absence of these materials from the sample is plausibly attributed to sample size. The assemblage is around two orders of magnitude larger than the sample, by weight or by count, and thus more likely to include pieces of relatively rare raw material. It is reasonable to think that a larger sediment sample would contain pieces of these rare materials, especially since each of the missing material shares provenance and vectors of transport with raw materials that *are* represented in the sample. The overall impression is that the assemblage generally is a good reflection of the composition of the deposit. The exceptions, discussed below, are instructive.

Second, it is notable that one material present in the sample, Lake Superior Rhyolite, is missing from the assemblage. Its complete absence from the set of tested material suggests that the flintknappers did not consider it potential toolstone.

Third, quartzite and Knife Lake Siltstone are less common in the assemblage than in the samples, and the difference for quartzite is striking. Quartzite was the most common potential toolstone in the sample, but is of minor importance in the assemblage, suggesting that the flintknappers ignored most – although not all – of the quartzite cobbles. Apparently prior experience had taught them that only a few quartzite cobbles were even worth testing. The difference for Knife Lake Siltstone is much smaller, and harder to interpret. It may simply reflect the fact that a single relatively large piece of this material was found in the sample, or it may be that the flintknappers were not especially interested in the material.

Fourth, Prairie du Chien Chert is the most important resource at the site. It constitutes nearly a third of the sample, and nearly 80 percent of the assemblage. This was clearly an important raw material, and indeed the single most important resource at the site. The large difference in percentage between the sample and assemblage is discussed below.

Table 12. Toolstone Composition of Sediment Sample and Artifact Assemblage from Phase II Excavations, by Grams and Percentage, 21HE483.

Raw Material Category	Samp g =	Samp % =	Ph II g =	Ph II % =	Diff %
South Agassiz Region Materials	**39**	**1.2**	**1,310**	**6.5**	**+ 5.3**
Swan River Chert	2	0.1	483	2.4	+ 2.3
Red River Chert	37	1.1	898	4.5	+ 3.4
Silicified Wood			9	< 0.1	+ < 0.1
West Superior Region Materials	**266**	**8.3**	**123**	**0.6**	**- 7.7**
Animikie Silicate Group	107	3.3	89	0.4	- 2.9
Biwabik Silica			3	< 0.1	+ < 0.1
Jasper Taconite			24	0.1	+ 0.1
Gunflint Silica					
Hudson Bay Lowland Chert					
Kakabeka Chert					
Lake Superior Agate					
Lake Superior Rhyolite	159	4.9			- 4.9
Fat Rock Quartz			7	< 0.1	+ < 0.1
Pipestone Region Materials					
Gulseth Silica					
Hollandale Region Materials	**1004**	**31.2**	**15,891**	**79.3**	**+ 48.1**
Cedar Valley Chert					
Galena Chert					
Grand Meadow Chert					
Prairie du Chien Chert	1004	31.2	15,891	79.3	+ 48.1
Shell Rock Chert					
Tongue River Silica	**43**	**1.3**	**51**	**0.3**	**- 1.0**
Border Lakes Greenstone Group	**269**	**8.4**	**15**	**0.1**	**- 7.3**
Knife Lake Siltstone	269	8.4	8	< 0.1	- 8.3
Lake of the Woods Rhyolite			7	< 0.1	+ < 0.1
Indeterminate BLG Group					
Sioux Quartzite Group	**6**	**0.2**	**48**	**0.2**	**=**
Western River Gravels Group	**7**	**0.2**	**18**	**0.1**	**- 0.1**
Quartz			**206**	**1.0**	**+ 1.0**
Generic Identifications	**1586**	**49.3**	**2,387**	**11.9**	**- 37.4**
Chert	242	7.5	1078	5.4	- 2.1
Quartzite	1344	41.7	1044	5.2	- 36.5
Unidentified			265	1.3	+ 1.3
TOTAL	**3220**		**20,049**		

Finally, no materials were found in the sample that should not be there according to our present understanding of raw material distributions and sources. This includes materials like Grand Meadow Chert and Galena Chert, for example. These materials often occur in small amounts at nearby archaeological sites, and come from regional sources that are at no great distance. However, regional geology gives us no reason to expect them to occur naturally in the Minnesota River Valley or environs. The same can be said for exotics like Burlington Chert or Hixton Quartzite (although Knife River Flint plausibly could be found here in trace amounts).

It was noted above that some unflakeable materials and some marginal materials used to make chopping tools were present in the assemblage but not included in the comparison. It is worth returning to these materials briefly. The production of chopping tools follows a different technological trajectory than other kinds of tool production. Chopping tools are often thought of as expedient technology – produced when needed, used, and then discarded on the spot. The presence of such marginal materials in an early-stage quarry assemblage like this, however, suggests that the flintknappers *may* have been provisioning themselves with material for chopping tools in anticipation of future needs. However, other interpretations are also possible. These include that chopping tools were needed at the site (although none were found), that the materials were simply being tested as potential toolstone, or that some pieces were detached from hammerstones. In any case, it is important to note that these materials had some place in the procurement process.

The presence of essentially unflakeable materials in the artifact assemblage is also instructive. These materials were as diverse as gneiss, iron concretion and limestone. However, what many of these pieces had in common was surface characteristics that mimicked toolstone. It seems that once in a while a flintknapper was essentially fooled by the appearance of a piece of rock. In these cases, brief testing should have served to reveal the mistake.

5.7.3 Differences in Raw Material Proportions

Although the sample and assemblage contain substantially the same set of raw materials, the proportions of the materials vary between the two data sets (Table 12, right hand column). The small differences might not seem significant, but the larger differences do. Prairie du Chien Chert, for example, comprises not quite a third of the sample but almost 80 percent of the assemblage. This difference is striking and seems to warrant some examination.

First, it is important to keep in mind that the sediment sample has been depleted of toolstone. At one stage, the flintknappers carried away an unknown amount of better quality toolstone, leaving behind poor quality tested cobbles, flaking debris, and a few missed cobbles. Later, archaeologists removed the tested cobbles and flaking debris, further depleting the sample. Thus, the raw material percentages for the sample do not reflect the original composition of the deposit. It might be tempting to add the archaeological data back into the sample as a way of compensating for the toolstone removed by archaeologists. However, this is unlikely to give meaningful results. Artifacts are not scattered at random around a site like this one. Instead, they tend to be concentrated at workstations where cobbles would be gathered and tested, and where discarded cobbles and flaking debris would accumulate disproportionately. There is no way to know which pieces originated where or to redistribute the contents of a workstation to where the stone originated in the landscape. Thus, we are left with a set of numbers that describe the composition of a depleted toolstone source.

Second, in some sense the percentages for the assemblage give us a different perspective on the toolstone proportions in the deposit, and one that is closer to the flintknappers own perspective. It is a sample that they produced from the source, based on what they considered toolstone or at least potential toolstone. It is also a depleted sample, however, since the better-quality cobbles are also missing from this set. In addition, it is not an impartial sample. It reflects the technological practices and resource requirements of that group at that time. An earlier or later group with different technologies and different resource requirements might have made a different selection of materials from the same pristine source.

From this perspective, the difference between the sample percentage and the assemblage percentage can be thought of as a rough indication of the value of each raw material to the flintknappers. The differences in proportion thus provide useful information. It is also good to keep in mind that the most useful product of this study is the list of what materials occur in the deposit. Furthermore, we have a fair sense of the relative abundance of the different materials. It would be interesting to have better numbers for the original proportions of each material, but that information is of secondary importance compared to the information we could glean from the sample.

That said, a sample from an unquarried deposit would provide a clearer indication of the original proportions of different materials. It is not clear, however, where such a pristine sample would come from. It seems likely that most if not essentially all of the accessible deposit at 21HE483 was quarried. Looking for a spot that was not quarried would require further formal excavation, since simply digging away would damage parts of the archaeological site. Pristine gravel and cobble deposits are no doubt buried under varying depths of overlying sediment in other parts of the terrace. These could be hard to sample, however, given the need for large excavating machinery and for permission from one or more of the parties charged with responsibility for this landscape.

In summary, the artifact assemblage generally reflects the composition of the sediment sample. Comparison of these two data sets provides some insights into the strategies and preferences of the flintknappers, and both the similarities and differences are instructive. The flintknappers gathered a lot of Prairie du Chien Chert from the site, and seemed happy to take other kinds of toolstone that turned up in smaller amounts. This may have included a few pieces of marginal materials suited to chopping tool production. They did not seem to have very much interest in till quartzite, and we might surmise that they didn't even consider Lake Superior Rhyolite as potential toolstone. And, once in a while, they were fooled by surface appearance into thinking that an unflakeable kind of rock might be toolstone.

5.7.4 Comparison with Raw Materials in Assemblages from Other Sites

Finally, the raw material profile for the artifact assemblage from 21HE483 can be compared to the profiles from other sites along the Minnesota River valley. In order to provide a broader context for this comparison, the sites used for this comparison represent the middle and lower stretches of the river valley, beginning somewhat upstream from Mankato and ending at 21HE483. The sites are summarized in Table 13, and the raw material data from the sites in Table 14. In Table 14, the sites are listed in their approximate upstream to downstream locations.

Table 13. Summary Information for Sites Used in Comparative Analysis.

Site	Function	Components	References
21-BE-5, Owen D, Jones	Village	Cambria	Wilford 1946
21-BE-21, Eagle Lake I	Artifact scatter	Woodland	Nystuen 1971; Peterson et al. 1991, 1993
21-BE-72, Bartsch	Lithic scatter	–	Peterson et al. 1988
21-BE-93, Mills Lake	Artifact scatter, burials	Late Archaic to Early Woodland	Justin: 1991; Peterson et al. 1992, 1994
21-BE-95, Fleming Field	Lithic scatter	–	Justin: 1991; Peterson et al. 1991
21-BE-121, Hanel II	Lithic scatter	–	Justin: 1991; Peterson et al. 1992, 1994
21-BE-122, Rush Lake	Lithic scatter	–	Justin: 1991; Peterson et al. 1992, 1994
21-BE-137, Sandon	Artifact scatter	Multicomponent	Skaar 1993a
21-BE-259	Lithic quarry, workshop	Multicomponent	Forsberg et al. 1999
21-BE-271	Lithic workshop	Archaic	Withrow 2003
21-BE-303	Habitation	Archaic, Woodland, Plains Village	Foss et al. 2016
21-BE-304	Habitation	Archaic, Woodland	Foss et al. 2016
21-CR-155	Stratified habitations	Early Plains Archaic, Late Archaic, Late Woodland	Florin et al. 2015
21-LE-59, Hayes	Lithic workshop	–	Harrison 1995
21-NL-58, Altman	Stratified habitations	Multicomponent, data from Middle Archaic	Terrell et al. 2005; Kolb 2005; Justin and Radford 1990
21-NL-59, New Ulm Conglomerate	Lithic quarry (Sioux Quartzite conglomerate)	–	Terrell et al. 2005; Justin and Radford 1990
21-NL-64, Heymans Creek	Redeposited from nearby habitation(s)	Middle to Late Woodland	Skaar 1993b; Peterson 1993
21-NL-69, Trivium	Artifact scatter	Woodland	MHS 1993-300 93-7-5
21-NL-120	Temporary camp	Woodland	Forsberg et al. 1999
21-SB-6	Mounds, artifact scatter	Woodland	Winchell 1911
21-SC-52, Blackberry Patch Mounds and Habitation	Mounds, habitation	Archaic, Woodland, Plains Village	Radford et al 1998

For the sake of discussion, we can roughly divide this length of the river valley into three segments based on raw material profiles. The first ("upstream") segment begins some ways upstream from Mankato and continues until roughly the Brown-Blue Earth County line. The three upstream sites have under 50 percent PdC plus moderate percentages of South Agassiz and "other" raw materials. Three sites are, of course, not adequate to characterize this area, but they do provide some hint at the character of lithic assemblages in that area. In addition, they serve to bracket the next area and give a general idea of where it begins.

The second ("Mankato-St. Peter") segment begins roughly at the Brown-Blue Earth County line and continues past St. Peter, ending perhaps where the northern edge of Nicollet County meets the river. The Mankato-St. Peter area assemblages, with a couple of exceptions, are similar to each other. PdC constitutes generally 90 percent or more of the assemblages, with modest amount of everything else.

The third ("downstream") segment continues from perhaps where the northern edge of Nicollet County meets the river to the confluence with the Mississippi. The assemblages in this area are much more variable. PdC ranges from roughly 30 to 80 percent in this selection of data, with 10 to 25 percent South Agassiz materials and varying amounts of everything else.

Table 14. Lithic Raw Material Profiles for Selected Sites in and near the Minnesota River Valley. (table shows percentage of total lithic assemblage for indicated raw material or raw material category)

Site	n=	PdC %	Overall Raw Material Profile					
			S Ag %	W Sup %	Holl %	Qtz %	Ex+nL* %	Other %
Upstream of Mankato-St. Peter Area								
21-NL-58	146	47.9	8.3	3.4	67.8	2.7	7.5	10.3
21-NL-59	495	5.6	6.3	3.6	34.7	16.4	1.0	38.0
21-NL-64	190	38.9	10.0	2.1	43.7	18.4	3.2	22.6
Mankato-St. Peter Area								
21-BE-5	307	88.3	6.2	–	89.9	–	2.3	1.6
21-BE-95	291	99.3	–	–	99.7	–	–	0.3
21-BE-93	1,107	93.0	2.1	–	93.9	0.6	0.2	3.2
21-BE-122	223	87.9	2.2	–	89.2	–	0.9	7.6
21-BE-121	438	67.8	20.1	0.2	68.3	3.2	0.5	7.8
21-BE-303	551	67.2	18.9	1.8	69.0	0.4	1.1	8.9
21-BE-271	9,804	98.1	1.1	–	98.6	–	0.1	0.2
21-BE-304	7,891	91.7	1.9	0.2	91.9	0.2	0.9	4.8
21-BE-137	3,038	93.8	0.3	0.1	96.9	0.4	0.2	2.1
21-NL-120	96	88.5	2.1	1.0	91.7	–	–	5.2
21-BE-259	240	97.1	0.8	–	97.5	0.4	–	1.2
21-NL-69	149	99.3	–	–	99.3	0.7	–	–
21-BE-72	1,208	94.5	0.2	0.2	94.5	0.4	0.2	4.6
21-LE-59	138	100.0	–	–	100.0		–	–
21-BE-21	103	87.4	–	–	92.2	2.9	–	4.9
Downstream of Mankato-St. Peter Area								
21-SB-6	99	65.7	16.2	1.0	71.7	1.0	4.0	6.1
21-SC-52	267	82.8	12.0	0.4	83.1	0.7	2.6	1.1
21-CR-155 ca. 400 BP	128	31.2	27.4	7.8	35.2	7.0	1.6	21.1
21-CR-155 ** 6100 BP (AB)	573	81.7	11.7	3.1	81.8	–	–	3.3
21-CR-155 *** 6100 BP (H)	114	41.2	10.5	12.3	48.2	4.4	7.9	16.7
21-CR-155 7100 BP	502	56.0	14.6	2.2	58.2	6.2	14.7	4.2
21-HE-483 (n)	879	72.4	5.5	1.6	72.5	2.8	0.1	17.6
*Exotic and other nonlocal ** Assemblage dominated by lithic reduction workshop. *** General habitation.								

The differences between the three areas are instructive. While various factors no doubt contribute to differences between individual assemblages, the overall regional pattern is more easily explained by differences in raw material sources. It seems likely that most of the sites in the Mankato-St. Peter area, for example, are provisioned from sources with abundant PdC – and possibly little else. In fact, the abundance and apparent easy access of PdC dominates the lithic profiles at most sites and largely overwrites the signals from other raw material sources (cf. Bakken 2011, 2014).

This is not the case with the downstream assemblages, however. This is a heterogenous set, with considerably more variability between assemblages. Some of the downstream profiles do generally resemble the profiles from 21HE483. One of these is especially interesting. The assemblage from 21CR155 (ca. 6100 BP, Areas A-B) comes from a primary reduction feature (Florin et al. 2015). This context is thus functionally similar to the context at 21HE483. In addition, the 21CR155 assemblage reflects a deposit created over a short time instead of representing average provisioning activity over an extended period. Even in this case, however, there are some differences. The 21CR155 assemblage, for example, has a higher percentage of PdC and South Agassiz materials, but a lower percentage of materials in the "other" category. Some of the difference may reflect inclusion of a few artifacts from the general habitation of the same age, and also a few artifacts from an elusive and minor Late Archaic component found near the top of the sediment column in the same part of the site.

The assemblages from 21SB6 and 21SC52 are also fairly similar to the 21HE483 assemblage. In these cases, the reason for the resemblance is not clear. A closer look at these sites and the excavation contexts might help explain the resemblance. Unfortunately, such an examination is beyond the scope of the current study.

Other assemblages do not resemble 21HE483 in terms of raw material profile. Instead they have lower percentages of PdC, higher percentages of South Agassiz materials in particular, and somewhat greater diversity in terms of the number of raw materials present. This suggests that although alluvial cobble deposits may have contributed to these assemblages, other sources also played a role. The larger percentages of South Agassiz materials in particular (and to a lesser extent West Superior materials) suggests use of diffuse, till-based sources outside of the valley. In addition, the presence of essentially nonlocal Hollandale materials from farther to the south – Cedar Valley, Grand Meadow and Galena cherts – indicates use of focal sources at a moderate distance, whether directly or second hand. These sources are probably lag and similar deposits closely associated with their primary geologic contexts. Generally, minor amounts of exotic materials reflect sources at a still greater distance, with such materials probably acquired through some kind of exchange.

In sum, it seems likely that the downstream assemblages reflect provisioning from a broader range of raw material sources, including alluvial cobble deposits. These sources include glacial till outside of the river valley, single-material lag or related deposits at a moderate distance and – to a more limited degree – distant sources yielding exotic raw materials. Such provisioning would produce assemblages that were a sort of "average" of the different sources – somewhere in between the composition of river valley alluvial source and upland glacial sources, for example. The degree to which such sources contribute to individual assemblages seems to vary from one site to another, thereby producing the variation between assemblages.

6. Summary

There has been some research on toolstone availability in the middle reaches of the Minnesota River valley, but the topic remained largely unexplored for the lower valley. Thus, the discovery of a toolstone procurement site was especially welcome, and offered an opportunity to better our understanding of local patterns of landscape and resource use. At this site, toolstone was quarried from a cobble-rich gravel deposit exposed by the erosion of an old river terrace. Samples of the gravel and cobble deposit were analyzed in order to provide information on the origin and composition of the deposit. This included identification of clast lithology for a pebble fraction of the sample, and identification of specific toolstone types present in both pebble and cobble fractions.

These analyses were designed to address four sets of research questions. These are reviewed below. The answers to the questions provide a summary of the research presented above.

6.1 Research Questions: Geology

One set of questions concerned the geology of the locale and the region. Can we gain a better understanding of the nature of this deposit and its origin, in order to better understand the larger picture of toolstone availability in the valley? Does the composition of this deposit match what we would expect given the hypothesis that the constituent clasts originated from nearby bedrock and from a variety of glacial tills?

Briefly, the answer to each of these questions is yes. Review of the geological literature shows that the site occupies an eroded part of a river terrace. The erosion exposed a coarse channel deposit associated with Glacial River Warren and the formation of the Minnesota River valley. Deposits like this are probably widespread along the sides of the valley, although exposures may not be common. General clast lithology and specific toolstone identifications show that, as expected, the deposit includes materials from tills of Riding Mountain, Winnipeg, and Superior provenance. Bedrock from farther upstream and nearby was also represented, along with the local unconsolidated Ostrander Sand.

6.2 Research Questions: Raw Material Distribution and Availability

A second set of questions revolved around broader issues of the distribution and regional availability of various raw materials. For example, Swan River Chert is associated with the South Agassiz Resource Region to the northwest and Knife Lake Siltstone is associated with the West Superior Resource Region to the northeast (Bakken 2011), and both occur in the 21HE483 assemblage. Previous models assume that these (and other) materials should occur in the region of 21HE483, which is downstream in a glacial sense from the source regions. Is this assumption supported by analysis of the gravel deposit?

Yes, previous models are supported. As predicted, the deposit was found to contain raw materials associated with the South Agassiz, West Superior and Hollandale resource regions. Most expected materials were present and, importantly, materials which the models said should not occur were not found (e.g., Burlington Chert, Grand Meadow Chert).

6.3 Research Questions: Tertiary Raw Material Sources

Related to this is the nature of what might be termed tertiary raw material sources. We consider bedrock and related sources (e.g., lag) as primary sources. In this context we can speak of glacially distributed sediments as secondary sources. Further fluvial redistribution produces what we might call a tertiary raw material source. Although the existence of such sources is recognized, the sources themselves are uncommon and poorly understood. 21HE483 provides an opportunity to study an example.

The analyses suggest that the most important characteristic of this kind of tertiary source is its richness. Fluvial processes produced a concentration of toolstone clasts in a small area, at a density that is much higher than we would generally expect to find in a glacial landscape. The relative richness of this source justified the work needed to quarry the deposit. An added benefit in this case was the diversity of raw material types, since different raw materials are suited to different uses.

6.4 Research Questions: Toolstone Exploitation

Finally, there was a set of more immediately-archaeological questions revolving around the exploitation of this toolstone source and the nature of the activities carried out at this site. For example, how does the suite of raw materials available in the cobble deposit correspond to the suite of raw materials represented in the lithic assemblage? What can this tell us about raw material selection? How do the toolstone types at 21HE483 compare to other nearby sites in the Minnesota River valley where materials were likely procured from similar fluvial deposits? Do these other sites seem to reflect similar procurement patterns and procurement from similar fluvial deposits?

The inventory of toolstone types found in the sample is generally mirrored by the composition of the artifact assemblage. The exceptions are informative, and give us insight into the practices and preferences of the flintknappers who worked this deposit. For example, some raw materials that we might consider potential toolstone were missing from the artifact assemblage, indicating that the flintknappers did not consider these materials to be workable. Some materials were less common in the artifact assemblage than in the sample, suggesting that these materials were not of much interest. Finer grain, highly siliceous materials were generally more common in the artifact assemblage than in the sample. This suggests that the flintknappers sought such materials, as would be expected, and had largely removed them from the deposit.

There is considerable variation in the raw material composition of assemblages from other sites near this part of the Minnesota River valley. Some resemble the assemblage from 21HE483, such as an assemblage from a primary reduction feature at 21CR155. This suggests that the latter assemblage may well reflect provisioning from an alluvial cobble deposit. Some other assemblages from nearby sites, however, do not resemble the profile seen at 21HE483. These tend to have lower percentages of PdC, higher percentages of South Agassiz materials, and variable amounts of other materials. This doesn't preclude provisioning from alluvial cobble deposits. In fact, fluvial cobble deposits are a likely source for the PdC in these assemblages. The variable profiles do, however, suggest that provisioning also included other kinds of sources, and that the different sources vary in importance from site to site. The higher percentages of South Agassiz materials suggest provisioning from glacial till, the presence of Cedar Valley, Grand Meadow, and Galena cherts indicates provisioning from more distant deposits. The relative importance of the various sources is hard to assess without a closer look at a broader data set.

6.5 Future Research

Answers beget questions it seems, and it can be helpful to point out a few of these questions as potential avenues for future research. First of course are questions that were posed but not answered: How do the toolstone types at 21HR483 compare to other nearby sites in the Minnesota River valley where materials were likely procured from similar fluvial deposits? Do these other sites seem to reflect similar procurement patterns and procurement from similar fluvial deposits?

Related to this, some of the comparative analysis included in this report could be carried further. For example, part of the discussion involves tested but unflakeable materials and materials used for making chopping tools. This discussion could be strengthened by taking a closer look at the raw material composition of hammerstones and tested cobbles in the assemblage.

It could be interesting, although not essential, to sample a similar gravel and cobble deposit that had not been quarried, in order to get a clearer idea of the relative proportions of different raw materials, and the overall abundance of toolstone. This would probably have to be opportunistic, possibly coming from a gravel quarry or construction excavation.

Finally, it could also be interesting to compare different deposits and see how much they vary in composition. It might be, for example, that the contributions from different tills and from bedrock varied through time as the valley was progressively eroded. This could lead to differences in the lithology and toolstone content for different deposits. Such variability could affect how the raw material composition of nearby lithic assemblages was interpreted.

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APPENDIX B:

U.S. FISH AND WILDLIFE SERVICE ARPA PERMIT AND SPECIAL USE PERMIT

United States Department of the Interior

FISH AND WILDLIFE SERVICE

5600 American Boulevard West, Suite 990
Bloomington, Minnesota 55437-1458

IN REPLY REFER TO:

FWS/NWRS-VSO

APR 1 2016

Mr. Frank Florin
Florin Cultural Resource Services, LLC
N12902 273rd Street
Boyceville, Wisconsin 54725

Dear Mr. Florin:

Enclosed please find the Federal Archaeological Resources Protection Act (ARPA) Permit No. **2016-MN/3-1** as requested on your application for limited testing on lands in Minnesota owned by the Federal Government within the Long Meadow Lake Unit of the Minnesota Valley National Wildlife Refuge for the 21HE483 Phase II Evaluation Project. Please use this number on all correspondence with this office pertaining to this permit. **Also, please put this number on the cover of the final report**.

This archaeological permit is between you as the archaeologist and the U.S. Fish and Wildlife Service as the authorizing agency. Additionally, you must receive from the Acting Refuge Manager a Special Use Permit (SUP) prior to commencement of field work. Also please inform the Regional Historic Preservation Officer (RHPO) by e-mail (james_myster@fws.gov) of actual field work dates so that he can observe the work in the field if the opportunity becomes available. Neither this permit nor the SUP constitutes any approval for construction or any other project or activity by any person or organization.

Materials derived from this archaeological investigation are to be deposited with, and prepared in accordance with the requirements of the Minnesota Historical Society.

Completion of the project under this ARPA permit requires, unless other arrangements are made, an acceptable final report by no later than the end of the permit date. **The permit requires you to submit a draft report to the RHPO for 15 day review and two (2) hard copies of the final report to the RHPO and one (1) hard copy to the Refuge Manager after corrections.**

Initiate no contacts with the media or any other organizations or persons for the purpose of disseminating information relating to the investigation until the final report is approved. Questions from the media shall be referred to the RHPO. Make no independent distribution of interim, letter, draft, or final reports until the final report is approved by the RHPO.

If human remains, funerary objects, sacred objects, or items of cultural patrimony as defined in the Native American Graves Protection and Repatriation Act are found, your archaeologists must cease work immediately and notify the Acting Refuge Manager, Bridget Olson, at 952-858-0722 and the RHPO, James Myster, at 612-713-5439.

Sincerely,

Charles M. Wooley
Acting Regional Director

Enclosure: Signed permit

Please use this number
when referring to this permit

No.: **2016-MN/3-1**

DI Form 1991 (Rev Sept 2004)
OMB No. 1024-0037
Exp. Date (01/31/2009)

United States Department of the Interior

PERMIT FOR ARCHAEOLOGICAL INVESTIGATIONS

To conduct archeological work on Department of the Interior lands and Indian lands under the authority of:

X The Archaeological Resources Protection Act of 1979 (16 U.S.C. 470aa-mm) and its regulations (43 CFR 7).
X The Antiquities Act of 1906 (P.L. 59-209; 34 Stat. 225, 16 U.S.C. 431-433) and its regulations (43 CFR 3).
☐ Supplemental regulations (25 CFR 262) pertaining to Indian lands.
☐ Bureau-specific statutory and/or regulatory authority: Sec. 302(b) of P.L. 94-579, October 21, 1976, 43 U.S.C. 1732

1. Permit issued to Frank Florin	2. Under application dated March 29, 2016
3. Address Florin Cultural Resource Services, LLC N12902 273rd Street Boyceville, Wisconsin 54725	4. Telephone number(s) (715) 643-2918 5. E-mail address(es): florin@pressenter.com
6. Name of Permit Administrator Same as above Telephone number(s): Same as above Email address(es): Same as above	7. Name of Principal Investigator(s) Same as above Telephone number(s): Same as above Email address(es): Same as above
8. Name of Field Director(s) authorized to carry out field projects Same as above	Telephone number(s): Same as above Email address(es): Same as above

9. Activity authorized
- Survey and Recordation
- XX Limited Testing and/or Collection
- Excavation and/or Removal

10. On lands described as follows: Phase II evaluation of site 21HE483 within the Long Meadow Lake Unit of the Minnesota Valley NWR, Section 13, T27N, R24W in Hennepin County, Minnesota

11. During the duration of the project From April 4, 2016 To December 31, 2016

12. Name and address of the curatorial facility in which collections, records, data, photographs, and other documents resulting from work under this permit shall be deposited for permanent preservation on behalf of the United States Government.
Minnesota Historical Society, St. Paul, MN

13. Permittee is required to observe the listed standard permit conditions and the special permit conditions attached to this permit.

14. Signature and title of approving official: Regional Director, U.S. Fish and Wildlife Service Charles M. Wooley Acting Regional Director	15. Date 4/1/16

15. Standard Permit Conditions

a. This permit is subject to all applicable provisions of 43 CFR Part 3, 43 CFR 7, and 25 CFR 262, and applicable departmental and bureau policies and procedures, which are made a part hereof.

b. The permittee and this permit are subject to all other Federal, State, and local laws and regulations applicable to the public lands and resources.

c. This permit shall not be exclusive in character, and shall not affect the ability of the land managing bureau to use, lease or permit the use of lands subject to this permit for any purpose.

d. This permit may not be assigned.

e. This permit may be suspended or terminated for breach of any condition or for management purposes at the discretion of the approving official, upon written notice.

f. This permit is issued for the term specified in 11 above.

g. Archeological project design, literature review, development of the regional historic context framework, site evaluation, and recommendations for subsequent investigations must be developed with direct involvement of an archeologist who meets the Secretary of the Interior's Standards for Archeology and Historic Preservation; fieldwork must be generally overseen by an individual who meets the Secretary of the Interior's Standards for Archeology and Historic Preservation.

h. Permittee shall immediately request that the approving official (14. above) make a modification to accommodate any change in an essential condition of the permit, including individuals named and the nature, location, purpose, and time of authorized work, and shall without delay notify the approving official of any other changes affecting the permit or regarding information submitted as part of the application for the permit. Failure to do so may result in permit suspension or revocation.

i. Permittee may request permit extension, in writing, at any time prior to expiration of the term of the permit, specifying a limited, definite amount of time required to complete permitted work.

j. Any correspondence about this permit or work conducted under its authority must cite the permit number. Any publication of results of work conducted under the authority of this permit must cite the approving bureau and the permit number.

k. Permittee shall submit a copy of any published journal article and any published or unpublished report, paper, and manuscript resulting from the permitted work (apart from those required in items o. and p., below), to the approving official and the appropriate official of the approved curatorial facility (item 12 above).

l. Prior to beginning any fieldwork under the authority of this permit, the permittee, following the affected bureau's policies and procedures, shall contact the field office manager responsible for administering the lands involved to obtain further instructions.

m. Permittee may request a review, in writing to the official concerned, of any disputed decision regarding inclusion of specific terms and conditions or the modification, suspension, or revocation of this permit, setting out reasons for believing that the decision should be reconsidered.

n. Permittee shall not be released from requirements of this permit until all outstanding obligations have been satisfied, whether or not the term of the permit has expired. Permittee may be subject to civil penalties for violation of any term or condition of this permit.

o. Permittee shall submit a clean, edited draft final report to the agency official for review to insure conformance with standards, guidelines, regulations, and all stipulations of the permit. The schedule for submitting the draft shall be determined by the agency official.

15. Standard Permit Conditions (continued)

p. Permittee shall submit a final report to the approving official not later than 120 days after completion of fieldwork. If the size or nature of fieldwork merits, the approving official may authorize a longer timeframe for the submission of the final report as specified in Special Permit Condition q.

q. The permittee agrees to keep the specific location of sensitive resources confidential. Sensitive resources include threatened species, endangered species, and rare species, archeological sites, caves, fossil sites, minerals, commercially valuable resources, and sacred ceremonial sites.

r. Permittee shall deposit all artifacts, samples and collections, as applicable, and original or clear copies of all records, data, photographs, and other documents, resulting from work conducted under this permit, with the curatorial facility named in item 12, above, not later than 90 days after the date the final report is submitted to the approving official. Not later than 120 days after the final report is submitted, permittee shall provide the approving official with a catalog and evaluation of all materials deposited with the curatorial facility, including the facility's accession and/or catalog numbers.

s. Permittee shall provide the approving official with a confirmation that artifacts and samples collected under this permit were deposited with the approved curatorial facility, signed by an authorized curatorial facility official, stating the date materials were deposited, and the type, number and condition of the collected museum objects deposited at the facility. For permits issued by the Bureau of Land Management's Arizona State Office, the permittee shall complete a "Confirmation of Museum Collections' Deposition Statement" for all museum collections curated and shall submit this statement to the Arizona State Director within 10 days after the collections are accepted by the curatorial facility.

t. Permittee shall not disclose archaeological site locational information, collected under the authority of this permit, to any other entity, public or private, at any time, except with the specific approval of the Federal permitting agency. The permittee shall not publish, in printed format, on the internet, on film, or though other methods, without the approving official's prior permission, any locational or other identifying archeological site information that could compromise the Government's protection and management of archeological sites.

u. For excavations, permittee shall consult the OSHA excavation standards which are contained in 29 CFR §1926.650, §1926.651 and §1926.652. For questions regarding these standards contact the local area OSHA office, OSHA at 1-800-321-OSHA, or the OSHA website at http://www.osha.gov.

v. Special Permit Conditions attached to this permit are made a part hereof.

16. Special Permit Conditions

1. Archaeological Resources Protection Act (ARPA) – prohibits unauthorized disturbance of archeological resources on Federal and Indian land; and other matters. Permittee Principal Investigator shall control the action personnel (employees, subcontractors, and volunteers) to ensure archeological sites are not damaged.
2. Native American Graves and Repatriation Act (NAGPRA) – provides for the protection of Native American graves, and for other purposes. In event of discovery of human remains, funerary objects, or objects of cultural patrimony, activity in the vicinity of the discovery shall immediately cease; Permittee Principal Investigator shall immediately secure and protect these remains and notify the District Manager.
3. Prework Conference - Permittee Principal Investigator will arrange with the District Manager, a time to meet on the Refuge prior to the start of work; to ensure a clear understanding of the scope of the investigation, documentation requirements, inspection schedules; to obtain the telephone numbers (during and after office hours) to contact in event of discovery of human remains; and to request a special use permit from the Manager.
4. Permittee shall not initiate nor allow personnel to contact the media, the SHPO, nor any other organization or person for the purpose of disseminating information relating to the study until the final report is approved. Questions from the media shall be referred to the RHPO. Permittee shall make no independent distribution of interim, letter, draft, or final reports until the final report is approved by the Regional Historic Preservation Officer.
5. Maps will be from the relevant USGS 7.5 minute quadrangle map printed or reproduced at a scale of 1 mile equals 2.62 or 2&5/8 inches (1:24,000).
6. Archeological materials from U.S. Fish and Wildlife Service lands shall be collected and limited to those of archeological interest as defined in 43 CFR 7.3.
7. Tested areas will be restored to pre-survey conditions.
8. The collection including artifacts, ecofacts, photographs and negatives, field notebooks, field maps, and site survey forms is the property of the U.S. Government and shall be prepared for long-term storage. Permittee will clean, identify, and catalog archeological materials collected from FWS land, in a manner acceptable to the institution accepting the materials for curation and storage.
9. Permittee will provide the FWS with a draft and a final report.
10. Environmental and cultural background (if required by State SHPO) must be limited to the county or adjacent counties of the area being investigated. General or "boiler plate" descriptions will not be accepted.
11. **Number of acres investigated** on FWS land will be included in the report.
12. Maps, drawings, and other visual representations are to be clean, clear, and easily reproducible. Maps and sketches will be north-oriented to the top of the page and will contain appropriate scale and identification symbols. With rare and justified exception and approved by the RHPO, maps will be based on the USGS 7.5 minute quadrangle map(s).
13. Each cultural resource site and isolated find shall be located to at least the nearest 1/4 1/4 1/4 section and according to the Universal Transverse Mercator Grid System measured to the nearest 10 meters, and located on a map. Boundaries will be defined as described in National Register Bulletin 12. For new sites, obtain the official state site numbers and complete and include the state site forms. State site numbers will be used in the final report.
14. A list and **number of artifacts collected** from each site will be included in the report.
15. Recommendations by Permittee Principal Investigator for additional investigation (e.g., a phase 2 or evaluation study) will be provided to the RHPO as a research design proposal, not in the final report of this investigation.
16. If the investigation authorized under this permit is not accomplished, permittee shall notify the Regional Director in writing no later than the expiration date of this permit.

General Activities Special Use Permit

OMB Control Number 1018-0102
Expiration Date: XX/XX/2017

Station #: 32590 **(For Official Use Only)** **Permit #: 2014 –** 32590-16-15

Permit Term: From 4/15/16 To 6/1/16

1) Permittee Name/Business: Frank Florin, Florin Cultural Resources Services, LLC

2) Permit Status: a) Approved: (●) If approved, provide special conditions (if any) in the text box below.

b) Denied: ( ) If denied, provide justification in the text box below.

[Type in additional Special Conditions or Justification for Denied Permit in the space provided]

See attached General Conditions (see application) and Special Conditions.

Also, fully comply with ARPA Permit No. 2016-MN/3-1.

When excavations are not being actively attended, they shall be encircled with safety fence.

Excavations shall be backfilled by permittee by the permit expiration date unless otherwise specifically exempted by Refuge Project Manager.

3) Are there additional special conditions attached to the permit? Yes (●) No ( )

4) Are other licenses/permits required, and have they been verified? Yes (●) No ( ) N/A ( )

5) Are Insurance and/or Certification(s) required, and have they been verified? Yes (●) No ( ) N/A ( )

6) Record of Payments: Full ( ) Partial ( ) Exempt (●)

Amount of full payment: ______ Record of partial payments: ______

7) Is a surety bond or security deposit required? Yes ( ) No (●) N/A ( )

This permit is issued by the U.S. Fish and Wildlife Service and accepted by the applicant signed below, subject to the terms, covenants, obligations, and reservations, expressed or implied herein, and to the notice, conditions, and requirements included or attached. A copy of this permit should be kept on-hand so that it may be shown at any time to any refuge staff.

8) **Permit approved/issued by:** (Signature and title)

____

Date: __________

9) **Permit accepted by:** (Signature of permittee)

____

Date: __________

SPECIAL CONDITIONS
SPECIAL USE PERMIT 32590-16-15

1. The primary USFWS contact for activities related to this permit is Gerry Shimek, Refuge Project Manager (Cell: 651.357.5939).
2. This permit expires June 1, 2016.
3. This permit authorizes Phase II Cultural Resources field surveys and investigations at the Old Cedar Avenue vicinity, Long Meadow Lake Unit, Minnesota Valley NWR (Sec 12, Sec 13 T27N R24W Hennepin Co. Mn)
    a. This permit does not authorize excavations more disruptive than shovel tests or meter square pit excavations.
4. ARPA Permit No. 2016-MN/3-1 is incorporated into this authorization.
    a. This Special Use Permit (32590-16-15) includes general and special conditions in addition to those required as per ARPA Permit No. 2016-MN/3-1.
5. The Permittee shall notify the Refuge Project Manager a minimum of 1 calendar day prior to initiating activities authorized via this permit.
6. A copy of this permit and all attachments, including ARPA Permit No. 2016-MN/3-1, shall be present at the project site.
7. The work will be performed during daylight hours, Monday through Friday.
    a. Work outside of the times above may be authorized via the Refuge Project Manager.
8. For noxious and invasive species control purposes, all equipment shall be cleaned (scraped and brushed or spray-washed) prior to entering property managed by the USFWS.
    a. Cleaning shall remove all mud, dirt, snow, grease, vegetation, and other materials capable of transporting invasive plants or animals.
    b. Particular attention shall be paid to tracks and undercarriage area of equipment. .
9. The Permittee shall report all damage to USFWS lands (including construction activities occurring beyond authorized work areas identified in this permit) or injury to the public or wildlife as soon as possible but in no instance more than 24 hours after the incident.
    a. Damage includes, but is not limited to, chemical or fuel spills in the same drainage area or watershed as Refuge lands.
    b. Damage also includes sediment deposition, erosion, vegetation clearing, or equipment operation outside the work area limits as approved by the Refuge Project Manager.
    c. In the event a damaging event occurs, the Permittee shall take immediate action to stop the source of the damage.
    d. The Permittee shall contact the Refuge Project Manager before cleanup or remediation is initiated.
10. The Permittee shall not service or fuel large equipment (e.g., skid steer) on Refuge lands.
    a. Hand tools (e.g., chainsaws) may be serviced and fueled on Refuge lands provided this work is in a suitably contained area.
    b. Small amounts of fuels and lubricating supplies for hand tools may be stored on Refuge lands in suitable contained areas.
11. The Permittee may leave equipment at the work site during period of performance so long as care is taken to minimize negative impact on the natural surroundings of the Refuge Unit. However, the USFWS will assume no responsibility for this equipment if it is lost, stolen, or damaged.
12. The Permittee may clear small amounts of vegetation from sampling locations.
    a. The amount of vegetation cleared at any specific sampling location shall not exceed an area measuring 6 ft. by 6 ft.
    b. The Permittee shall not cut woody vegetation greater than 3 in. dbh without specific additional authorization from the Refuge Project Manager

c. All woody material resulting from vegetation clearing will be disposed onsite as follows or removed from lands managed by the USFWS.
    i. All stumps must be flat-topped and cut flush with surrounding mineral soil.
    ii. All woody material resulting from vegetation clearing that is not removed from Refuge lands will be lopped and scattered so that it lies within 12 inches of the ground surface.

13. The public will not have access to the Refuge during the project period.
    a. The Permittee will have the authority to exclude the public from the vicinity of operations.
    b. When excavations are not being actively attended, they shall be encircled with safety fence.
14. The Permittee shall leave areas described in this permit in a condition acceptable to the Refuge Project Manager.
    a. Excavations shall be backfilled by permittee by the permit expiration date unless otherwise specifically exempted by Refuge Project Manager.
        i. This action shall include replacing vegetative plugs to restore surface conditions.
15. The Permittee shall remove from areas described in this permit all materials, equipment, rubbish, and temporary structures prior to project suspension or completion.
16. The Permittee shall provide the Refuge Manager with an updated map and GPS coordinates of all sites sampled no later than 10 business days following the completion of field sampling.
    a. This map and coordinate list of sampling sites is in addition to the draft and final reports identified in ARPA Permit No. 2016-MN/3-1.

<u>Contact List</u>: United States Fish & Wildlife Service, Minnesota Valley National Wildlife Refuge
The primary USFWS contact for activities related to this permit is Gerry Shimek, Refuge Project Manager. Alternate contacts, in order of preference are listed below.

Name/Title	Work phone	Home phone	E-mail
Gerry Shimek, Refuge Project Manager	651-357-5939(cell) 952-858-0705(desk)	651-895-5068	gerry_shimek@fws.gov
Vicki Sherry, Refuge Biologist	952-858-0723(desk) 612-916-6139 (cell)		vicki_sherry@fws.gov
Bridget Olson, Deputy Refuge Manager	952-858-0722 612-791-6204 (cell)		bridget_olson@fws.gov
Tim Bodeen, Refuge Manager	952-858-0701 612-718-6863 (cell)		tim_bodeen@fws.gov

Scott Pariseau, Refuge Officer, also has full inspection and enforcement authority on USFWS properties and easements.

General Activities
Special Use Permit Application

Refuge: Minnesota Valley NWR

Address: 3815 American Blvd. E.

Attn: (Refuge Official) Gerry Shimek

E-Mail: gerry_shimek@fws.gov

Phone #: 952-858-0705

For Official Use Only:

Permit #:

Station #:

Permit Term: from ____ to ____

Note: We do not require all information for each use. See instructions at the end of the notice and contact the refuge identified above to determine applicability of a particular item. Attach additional sheets to the application if the text spaces provided are inadequate.

1) Identify the type of Permit you are applying for: **New** (●) **Renewal** ( ) **Modification** ( ) **Other** ( )

Applicant Information

2) Full Name: Frank Florin

3) Organization: Florin Cultural Resources Services, LLC

4) Street Address: N12902 273rd ST

5) City/State/Zip: Boyceville, WI 54725

6) Phone #: 715 643 2918

7) Fax #:

8) E-mail: florin@pressenter.com

9) List known assistants/subcontractors/subpermittees: (Only required if the assistants/subcontractors/subpermittees will be operating on the refuge without the permittee being present.)

Name/Business	Address	Phone #
City of Bloomington	1700 W 98th St. Bloomington, MN 55431	952 563-4865

Activity Information

10) Activity type: ( ) **Event** ( ) **Wood Cutting** ( ) **Group Visit** ( ) **Educational Activity** ( ) **Cabin/Subsistence Cabin** (●) **Other** Phase II Archaeological Testing

Note: Depending on the activity for which you are requesting a permit, we may ask you for the following activity information. Please contact the specific refuge where the activity is being conducted to determine what information is required.

11) Specifically identify timing, frequency, and how the activity is expected to proceed:

see attachment

) Activity/site occupancy timeline: (Specifically identify beginning and ending dates, site occupation timeline, hours, clean-up, and other major events.)

an approximate one week period (monday-friday) between April 18- May 15, depending on when permits are received. on site 8:30 am to 6 pm.

13) Expected number of participants, if applicable: Children (1-18) [ ] Adults 9 Total 9

14) Grade level of educational group, if applicable: Grade [ ]

15a) Will staff time/assistance be required for group activities? Yes ○ No ◉ N/A ○

15b) If yes, what's the anticipated time frame? [ ]

16a) Plan of Operation required? Yes ○ No ◉ N/A ○ 16b) Plan of Operation attached? Yes ○ No ◉

17) Specifically identify location(s): (GPS location(s) preferred)

N4964155 E480615 (NAD 1983)

18a) Is map of location(s) required? Yes ◉ No ○ N/A ○

18b) Is map of location(s) attached? Yes ◉ No ○

Insurance Coverage/License/Certifications/Permits

Note: Contact the specific refuge headquarters office where the activity is going to be conducted to determine if any type of insurance, certification(s), or permit(s) will be required. We may process this Special Use Permit while the applicant obtains them.

19) List any **insurance coverage** you have such as general liability, aviation, grounding liability, contaminants applicator, medical evacuation, or others, if required:

Insurance Type	Carrier Name	Policy Number	Copy Attached? Yes or No
general liability	state farm	99-B0-T290-8	no
workers compensation	state farm	99-MD-A139-7	no
professional liability	swett & crawford	MG843349	no

20) Identify licenses, certifications, and permits, if required:

License/Certification/Permit Type	Number (if applicable)	Issued to:	Copy Attached? Yes or No
ARPA	2016-MN/3-1	Frank Florin	yes
MN Annual License	16-035	Frank Florin	yes

Logistics and Transportation

Note: Not all information is required for each use. Please contact the specific refuge where the activity is being conducted to determine what information is required. Attach additional sheets to the application if the text spaces provided are inadequate.

21) Does activity require personnel to stay overnight onsite? Yes ○ No ◉

22) List names of personnel involved:

List Names	List Names	List Names
see attachment		

23) Specifically describe all major equipment/gear and materials used, if required:

1- mechanical jackhammer to remove asphalt
2-Vactor truck for removing the class 5 gravel fill under asphalt
3- archaeological materials include shovels and portable wood screens

24a) Provide detailed information on the logistics for onsite, intersite, and/or ship-to-shore transportation to or on the refuge, if required:

24b) Provide descriptions, license plate, or I.D. numbers of vehicles used for onsite, intersite, and/or ship-to-shore transportation, if required:

Type of transportation (onsite, intersite, or ship-to-shore)	Equipment Type	License/I.D./Registration Numbers
Ford Ranger		WI FR4881
Toyota Prius		WI 625 TPG
Chevy Suburban		WI 324 TMA

25) Specifically describe onsite work and/or living accommodations:

N/A

26) Specifically describe onsite hazardous material storage or other onsite material storage space:

N/A

Sign, date, and print this form and return it to the refuge for processing.

30) Signature of Applicant: ______________________ Date of Application: 4/11/16

Notice

In accordance with the Privacy Act (5 U.S.C. 552a) and the Paperwork Reduction Act (44 U.S.C. 3501), please note the following information:

The issuance of a permit and collection of fees on lands of the National Wildlife Refuge System are authorized by the National Wildlife Refuge System Administration Act (16 U.S.C. 668dd-ee) as amended, and the Refuge Recreation Act (16 U.S.C. 460k-460k-4).

The information that you provide is voluntary; however, we require submission of requested information to evaluate the qualifications, determine eligibility, and document permit applicants under the above Acts. It is our policy not to use your name for any other purpose. We maintain the information in accordance with the Privacy Act. We will consider all information you provide in reviewing this application. False, fictitious, or fraudulent statements or representations made in the application may be grounds for revocation of the Special Use Permit and may be punishable by fine or imprisonment (18 U.S.C. 1001). Failure to provide all required information is sufficient cause for the U.S. Fish and Wildlife Service to deny a permit.

No Members of Congress or Resident Commissioner shall participate in any part of this contract or to any benefit that may arise from it, but this provision shall not pertain to this contract if made with a corporation for its general benefit.

The Permittee agrees to be bound by the equal opportunity "nondiscrimination in employment" clause of Executive Order 11246.

Routine use disclosures may also be made: (a) to the U.S. Department of Justice when related to litigation or anticipated litigation; (b) of information indicating a violation or potential violation of a statute, rule, order, or license to appropriate Federal, State, local, or foreign agencies responsible for investigating or prosecuting the violation or for enforcing or implementing the statute, rule, regulations, order, or license; (c) from the record of the individual in response to an inquiry from a Congressional office made at the request of the individual (42 FR 19083; April 11,1977); and (d) to provide addresses obtained from the Internal Revenue Service to debt collection agencies for purposes of locating a debtor to collect or compromise a Federal Claim against the debtor, or to consumer reporting agencies to prepare a commercial credit report for use by the Department of Justice (48 FR 54716; December 6, 1983).

An agency may not conduct or sponsor and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number. OMB has approved this information collection and assigned control number 1018-0102. The public reporting burden for this information collection varies based on the requested specific refuge use. We estimate the relevant public reporting burden for the General Activity Special Use Permit Application form to average 0.5 hours per response, including time for reviewing instructions, gathering and maintaining data, and completing and reviewing the form. Mail comments on this form to the Information Collection Clearance Officer, U.S. Fish and Wildlife Service, 4401 N. Fairfax Drive, MS 2042-PDM, Arlington, Virginia, 22203.

General Conditions and Requirements

1) Responsibility of Permittee: We shall consider the permittee, by operating on the premises, to have accepted these premises with all facilities, fixtures, or improvements in their existing condition as of the date of this permit. At the end of the period specified or upon earlier termination, the permittee shall give up the premises in as good order and condition as when received except for reasonable wear, tear, or damage occurring without fault or negligence. The permittee will fully repay the Service for any and all damage directly or indirectly resulting from negligence or failure on his/her part, and/or the part of anyone of his/her associates, to use reasonable care.

2) Operating Rules and Laws: The permittee shall keep the premises in a neat and orderly condition at all times, and shall comply with all municipal, county, and State laws applicable to the operations under the permit as well as all Federal laws, rules, and regulations governing national wildlife refuges and the area described in this permit. The permittee shall comply with all instructions applicable to this permit issued by the refuge official in charge. The permittee shall take all reasonable precautions to prevent the escape of fires and to suppress fires and shall render all reasonable assistance in the suppression of refuge fires.

3) Use Limitations: The permittee's use of the described premises is limited to the purposes herein specified and does not, unless provided for in this permit, allow him/her to restrict other authorized entry onto his/her area; and allows the U.S. Fish and Wildlife Service to carry on whatever activities are necessary for: (1) protection and maintenance of the premises and adjacent lands administered by the U.S. Fish and Wildlife Service; and (2) the management of wildlife and fish using the premises and other U.S. Fish and Wildlife Service lands.

4) Transfer of Privileges: This permit is not transferable, and no privileges herein mentioned may be sublet or made available to any person or interest not mentioned in this permit. No interest hereunder may accrue through lien or be transferred to a third party without the approval of the Regional Director of the U.S. Fish and Wildlife Service and the permit shall not be used for speculative purposes.

5) Compliance: The U.S. Fish and Wildlife Service's failure to require strict compliance with any of this permit's terms, conditions, and requirements shall not constitute a waiver or be considered as a giving up of the U.S. Fish and Wildlife Service's right to thereafter enforce any of the permit's terms or conditions.

6) Conditions of Permit not Fulfilled: If the permittee fails to fulfill any of the conditions and requirements set forth herein, the U.S. Fish and Wildlife Service shall retain all money paid under this permit to be used to satisfy as much of the permittee's obligation as possible.

7) Payments: All payment shall be made on or before the due date to the local representative of the U.S. Fish and Wildlife Service by a postal money order or check made payable to the U.S. Fish and Wildlife Service.

8)Termination Policy: At the termination of this permit the permittee shall immediately give up possession to the U.S. Fish and Wildlife Service epresentative, reserving, however, the rights specified in paragraph 11below. If he/she fails to do so, he/she will pay the U.S. Fish and Wildlife Service, as liquidated damages, an amount double the rate specified in this permit for the entire time possession is withheld. Upon yielding possession, we will still allow the permittee to reenter as needed to remove his/her property as stated in paragraph 11below. The acceptance of any fee for the liquidated damages or any other act of administration relating to the continued tenancy is not to be considered as an affirmation of the permittee's action nor shall it operate as a waiver of the U.S. Fish and Wildlife Service's right to terminate or cancel the permit for the breach of any specified condition or requirement.

9) Revocation Policy: The Regional Director of the U.S. Fish and Wildlife Service may revoke this permit without notice for noncompliance with the terms hereof, or for violation of general and/or specific laws or regulations governing national wildlife refuges, or for nonuse. It is at all times subject to discretionary revocation by the Director of the Service. Upon such revocation the U.S. Fish and Wildlife Service, by and through any authorized representative, may take possession of said premises for its own and sole use, and/or may enter and possess the premises as the agent of the permittee and for his/her account.

10) Damages: The U.S. Fish and Wildlife Service shall not be responsible for: any loss or damage to property including but not limited to crops, animals, and machinery; injury to the permittee or his/her relatives, or to the officers, agents, employees, or any other(s) who are instructed to be on the premises; the sufferance from wildlife or employees or representatives of the U.S. Fish and Wildlife Service carrying out their official responsibilities. The permittee agrees to hold the U.S. Fish and Wildlife Service harmless from any and all claims for damages or losses that may arise to be incident to the flooding of the premises resulting from any associated government river and harbor, flood control, reclamation, or Tennessee Valley Authority activity.

11) Removal of Permittee's Property: Upon the expiration or termination of this permit, if all rental charges and/or damage claims due to the U.S. Fish and Wildlife Service have been paid, the permittee may, within a reasonable period as stated in the permit or as determined by the U.S. Fish and Wildlife Service official in charge, but not to exceed 60 days, remove all structures, machinery, and/or equipment, etc., from the premises for which he/she is responsible. Within this period the permittee also must remove any other of his/her property including his/her acknowledged share of products or crops grown, cut, harvested, stored, or stacked on the premises. Upon failure to remove any of the above items within the aforesaid period, they shall become the property of the U.S. Fish and Wildlife Service.

Instructions for Completing Application

You may complete the application portion verbally, in person, or electronically and submit to the refuge for review. Note: Please read instructions carefully as not all information is required for each activity. Contact the specific refuge headquarters office where the activity is going to be conducted to determine applicability of a particular item. We may add special conditions or permit stipulations to permit prior to approval.

1) Identify if permit application is for new, renewal, or modification of an existing permit. Permit renewals may not need all information requested. Contact the specific refuge headquarters office where the activity is going to be conducted if you have questions regarding the applicability of a particular item.

2-8) Provide full name, organization (if applicable), address, phone, fax, and e-mail.

9) Provide known names and addresses of assistants, subcontractors or subpermittees. Names and address are only required if the assistants, subcontractors or subpermittees will be operating on the refuge without the permittee being present. Volunteers, assistants, subcontractors or subpermittees that are accompanied by the permittee need not be identified.

10) Activity type: check one of the following categories:

- Event;
- Wood cutting;
- Group visit;
- Cabin/Subsistence cabin (subsistence cabins are only allowed on Alaska Refuges);
- Educational activity; or
- Other—any other activity(s) not mentioned above. Please describe "other" activity.

11) Provide detailed information on the activity, including times, frequency, and how the activity is expected to proceed, etc. Permit renewals may not need activity description if the activity is unchanged from previous permit. Most repetitive activities, such as group visits, do not require an activity description for each visit. Contact the specific refuge headquarters office where the activity is going to be conducted to determine if we require an activity description.

12) Identify beginning and ending dates, site occupation timeline, hours, clean-up, and other major events. Permit renewals may not need an activity/site occupancy timeline, if the activity is unchanged from previous permit. Most repetitive activities, such as group visits, do not require an activity/site occupancy timeline for each visit. Contact the specific refuge headquarters office where the activity is going to be conducted to determine if we require an activity/site occupancy timeline.

13-14) Provide an estimate of the number of adults, and children and grade level of group, if applicable.

15a-15b) Identify if group activities will require onsite refuge staff and the anticipated time frame, if applicable.

16a-16b) Identify and attach a Plan of Operation, if required. Most repetitive activities, such as group visits, do not require a Plan of Operation for each visit. In addition, permit renewals may not require a Plan of Operation if the activity is essentially unchanged from the previous permit. Contact the specific refuge headquarters office where the activity is going to be conducted to determine if a Plan of Operation is required.

17) Identify specific location (GPS coordinates preferred), if not a named facility. Most repetitive activities, such as group visits, do not require a location. In addition, permit renewals may not require a location if the activity is essentially unchanged from the previous permit. Contact the specific refuge headquarters office where the activity is going to be conducted to determine if we require a location.

18a-18b) Attach a map of location, if required, and if the activity is not conducted at a named facility. Most repetitive activities, such as group visits, do not require a map. In addition, permit renewals may not require a map if the activity is essentially unchanged from the previous permit. Contact the specific refuge headquarters office where the activity is going to be conducted to determine if we require a map.

19) Provide name, type, and carrier of insurance, if required. Contact the specific refuge headquarters office where the activity is going to be conducted to determine if we require insurance and type of insurance.

20) Specifically identify type(s) and number(s) of other licenses, certifications or permits, if required. Contact the specific refuge headquarters office where the activity is going to be conducted to determine the type(s) of licenses, certifications or permits required, and to coordinate the simultaneous application of several types of licenses, certifications or permits. We may or may not issue this Special Use Permit (SUP) while the permittee obtains other licenses, certifications, and/or permits.

21-22) Provide name(s) of any personnel required to stay overnight, if applicable.

23) Identify all equipment and materials that will be used, if required. Most repetitive events, such as group visits, do not require a list of equipment. In addition, permit renewals may not require a list of equipment if the event is essentially unchanged from the previous permit. Contact the specific refuge headquarters office where the activity is going to be conducted to determine if we require a list of equipment.

24a-24b) Provide vehicle descriptions and license plate or identification numbers of all vehicles, including boats and airplanes, if required. We only require motor vehicle descriptions for permittee vehicle, and/or if the vehicle will be operated on the refuge without the permittee being present. Motor vehicles accompanied by the permittee as part of a group (convoy) activity need not be identified if cleared in advance by the refuge supervisor. Specifically describe ship-to-shore, intersite (between islands, camps, or other sites) and onsite transportation mechanisms, and license plate or identification numbers, if required.

25) Specifically describe onsite work and/or living accommodations, if applicable.

26) Specifically describe onsite hazardous material storage, or other onsite material storage space (including on and offsite fuel caches).

27) Sign, date, and print the application. Click on the Print button to print the application (if using the fillable version). The refuge official will review and, approved, fill out the remaining information, sign, and return a copy to you for signature and acceptance.

**This application form is not valid as a permit
but may be used as a reference document attached to the official permit.
Only official refuge personnel may assign a valid permit number and permit term
to this application form after the permit has been approved.**

Attachment – Florin Application

11. The Phase II archaeological testing at site 21HE483 is in a parking lot and a 20 foot perimeter around the parking lot on the south side of Long Meadow Bridge, also known as the Old Cedar Avenue Bridge, within the Long Meadow Lake Unit of the U.S. Fish and Wildlife Service's (USFWS) Minnesota Valley National Wildlife Refuge in T27N R24W S1/2 NW NW Section 13, with UTM coordinate centerpoint N4964155 E480615 (NAD 1983). The work is sponsored by the Minnesota Department of Transportation and City of Bloomington.

Site 21HE483 is a Precontact Lithic Scatter that was previously investigated by Christina Harrison of Archaeological Research Services. However, her work did not include portions of the site in the parking lot and adjacent areas where project impacts may occur.

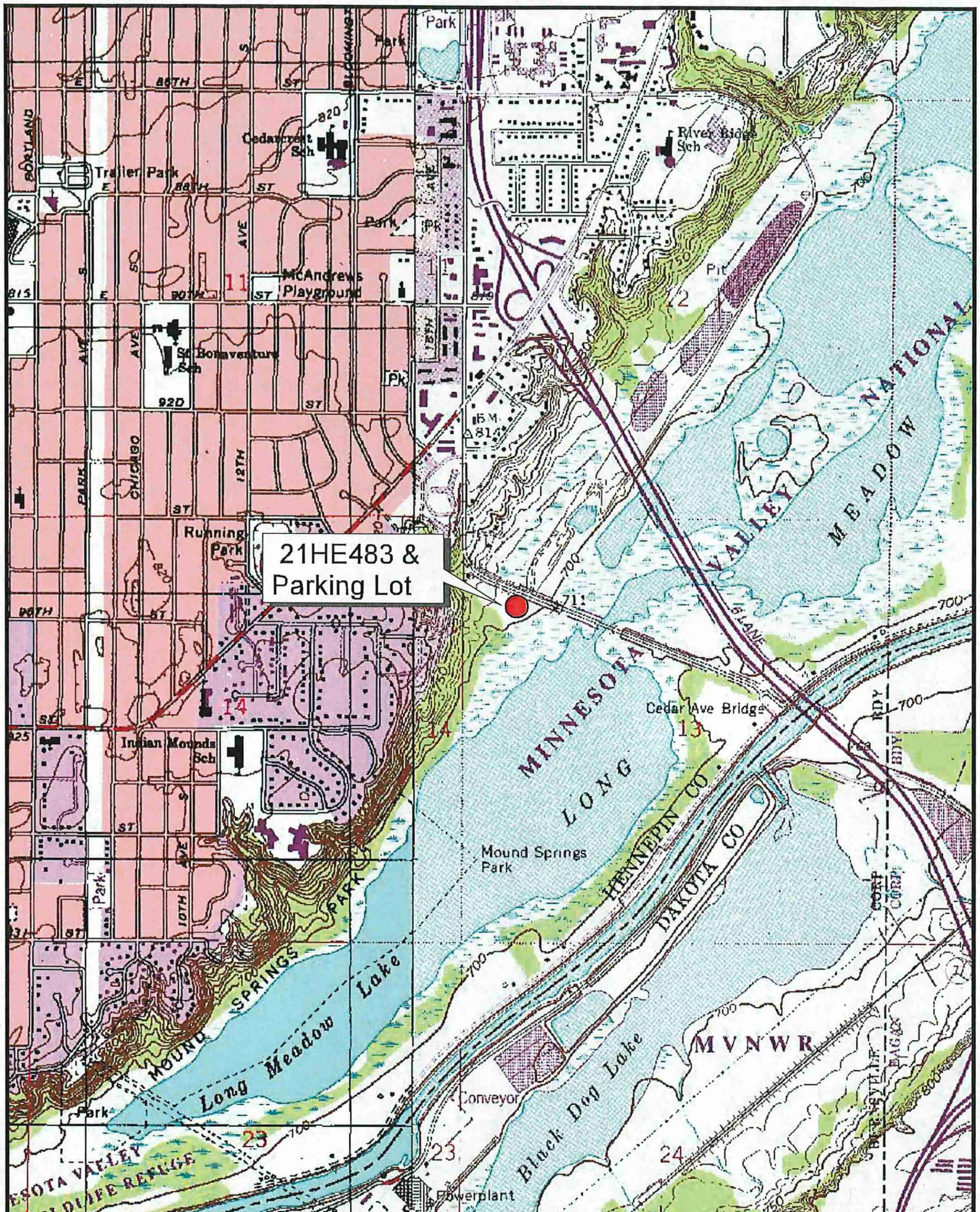
Archaeological investigations will include Phase II testing at site 21HE483. Proposed fieldwork will include three XUs (1x1 meter each) and approximately 35 shovel tests in the parking lot area. The evaluation is needed as part of an effort by the City of Bloomington to rehabilitate the Long Meadow Bridge, which includes the adjacent parking lot and site area.

It would be best to close the parking lot to the public for safety reasons during our work, as the asphalt and fill will first be removed from out test holes and then the holes will be temporarily open while we are digging them.

Field methods will include shovel testing and excavation of three 1 x 1 meter units that will be excavated in 10 cm levels. Testing will be conducted by removing asphalt and fill at the locations of the tests. All tests will be backfilled immediately upon completion by replacing the asphalt or vegetative plug to restore surface conditions. Any tests not completed at end of the day will be secured with safety fencing. All soil will be screened through ¼" mesh.

A technical report will be produced that documents the investigation results and recommendations. The goal of the evaluation is to determine if site 21HE483 has integrity and is eligibility for the National Register of Historic Places and to provide management recommendations for the site.

22. Personnel involved: Frank Florin, Kent Bakken, Mike Bradford, Gregg Felber, Frank Koep, James Lindbeck, Amanda Peterson, Kevin Reider, and Mike Straskowski



T27N R24W Section 13

N

300 0 300 600 Meters

Old-Cedar-Ave-S
Area of Phase II
Evaluation of
21HE483

ACORD®

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY) 03/30/2016

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
SAM GEARING AGENCY LLC
2201 SCHNEIDER AVE
MENOMONIE, WI 54751

State Farm

CONTACT NAME: SAM GEARING
PHONE (A/C, No, Ext): 715-235-4145 FAX (A/C, No): 715-235-6755
E-MAIL ADDRESS: SAM.GEARING.RZW6@STATEFARM.COM

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : State Farm Mutual Automobile Insurance Company	25178
INSURER B : State Farm Fire and Casualty Company	25143
INSURER C :	
INSURER D :	
INSURER E :	
INSURER F :	

INSURED
FLORIN CULTURAL RESOURCE SERVICES LLC
N12902 273RD ST
BOYCEVILLE, WI 54725

COVERAGES — CERTIFICATE NUMBER: — REVISION NUMBER:

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
	X COMMERCIAL GENERAL LIABILITY	Y		99-BT-B883-1 F	09/28/2015	09/28/2016	EACH OCCURRENCE	$ 1,000,000
	CLAIMS-MADE / OCCUR						DAMAGE TO RENTED PREMISES (Ea occurrence)	$
							MED EXP (Any one person)	$
							PERSONAL & ADV INJURY	$
	GEN'L AGGREGATE LIMIT APPLIES PER:						GENERAL AGGREGATE	$ 2,000,000
	X POLICY / PRO-JECT / LOC						PRODUCTS - COMP/OP AGG	$
	OTHER:							$
	AUTOMOBILE LIABILITY	Y		147 0487-E01-49 -001	11/01/2015	11/01/2016	COMBINED SINGLE LIMIT (Ea accident)	$
	ANY AUTO						BODILY INJURY (Per person)	$ 1,000,000
	X ALL OWNED AUTOS / SCHEDULED AUTOS						BODILY INJURY (Per accident)	$ 1,000,000
	HIRED AUTOS / NON-OWNED AUTOS						PROPERTY DAMAGE (Per accident)	$ 1,000,000
								$
	UMBRELLA LIAB / OCCUR						EACH OCCURRENCE	$
	EXCESS LIAB / CLAIMS-MADE						AGGREGATE	$
	DED / RETENTION $							$
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y/N			99-MD-A117-1	1/28/2015	09/28/2016	PER STATUTE / OTH-ER	
	ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH)	N / A					E.L. EACH ACCIDENT	$ 100,000
	If yes, describe under DESCRIPTION OF OPERATIONS below						E.L. DISEASE - EA EMPLOYEE	$ 100,000
							E.L. DISEASE - POLICY LIMIT	$ 500,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)

CERTIFICATE HOLDER

ashley.duran@state.mn.us

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE

Appendix C:

21HE483 Artifact Catalog – 2016 Phase II

21HE483 Artifact Catalog- 2016 Phase II

Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.1.1	1	ST F 4	23-43	Tested cobble	Prairie du Chien Chert	1625.0
IL2017.2.1.2	1	ST F 4	23-43	Flake	Siltstone	179.7
IL2017.2.1.3	1	ST F 4	23-43	Flake	Siltstone	73.5
IL2017.2.1.4	1	ST F 4	23-43	Fragment	Limestone	137.8
IL2017.2.1.5	1	ST F 4	23-43	Flake	Prairie du Chien Chert	56.8
IL2017.2.1.6	1	ST F 4	23-43	Fragment	Basaltic rock	9.8
IL2017.2.1.7	1	ST F 4	23-43	Flake	Basaltic rock	13.5
IL2017.2.1.8	1	ST F 4	23-43	Flake	Prairie du Chien Chert	7.8
IL2017.2.1.9	1	ST F 4	23-43	Flake	Prairie du Chien Chert	5.9
IL2017.2.1.10	1	ST F 4	23-43	Flake	Basaltic rock	4.9
IL2017.2.1.11	1	ST F 4	23-43	Flake	Prairie du Chien Chert	6.2
IL2017.2.1.12	1	ST F 4	23-43	Shatter	Basaltic rock	5.8
IL2017.2.1.13	1	ST F 4	23-43	Shatter	Prairie du Chien Chert	7.3
IL2017.2.1.14	1	ST F 4	23-43	Flake	Basaltic rock	3.2
IL2017.2.1.15	1	ST F 4	23-43	Flake	Basaltic rock	0.7
IL2017.2.1.16	1	ST F 4	23-43	Shatter	Granitic rock	0.6
IL2017.2.1.17	1	ST F 4	23-43	Shatter	Quartz	0.3
IL2017.2.1.18	1	ST F 4	23-43	Hammer stone	Granitic rock	1650.0
IL2017.2.2.1	1	ST F 4	43-63	Tested cobble	Prairie du Chien Chert	166.1
IL2017.2.2.2	1	ST F 4	43-63	Fragment	Granitic rock	75.1
IL2017.2.2.3	1	ST F 4	43-63	Flake	Prairie du Chien Chert	70.3
IL2017.2.2.4	1	ST F 4	43-63	Flake	Granitic rock	39.1
IL2017.2.2.5	1	ST F 4	43-63	Shatter	Basaltic rock	17.1
IL2017.2.2.6	1	ST F 4	43-63	Shatter	Basaltic rock	11.7
IL2017.2.2.7	1	ST F 4	43-63	Flake	Basaltic rock	4.8

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.2.8	1	ST F 4	43-63	Flake	Granitic rock	4.5
IL2017.2.2.9	1	ST F 4	43-63	Shatter	Basaltic rock	1.0
IL2017.2.2.10	1	ST F 4	43-63	Flake	Prairie du Chien Chert	0.3
IL2017.2.3.1	1	ST F 4	63-83	Shatter	Basaltic rock	10.6
IL2017.2.3.2	1	ST F 4	63-83	Shatter	Basaltic rock	5.8
IL2017.2.4.1	1	ST F 6	36-56	Flake	Swan River Chert	343.7
IL2017.2.4.2	1	ST F 6	36-56	Shatter	Chert	43.6
IL2017.2.4.3	1	ST F 6	36-56	Shatter	Prairie du Chien Chert	1.5
IL2017.2.5.1	1	ST F 6	56-76	Flake	Prairie du Chien Chert	3.1
IL2017.2.5.2	1	ST F 6	56-76	Flake	Basaltic rock	2.5
IL2017.2.5.3	1	ST F 6	56-76	Shatter	Quartzite	1.6
IL2017.2.5.4	1	ST F 6	56-76	Hammer stone	Granitic rock	199.6
IL2017.2.6.1	1	ST F 7	30-50	Tested cobble	Quartzite	337.2
IL2017.2.6.2	1	ST F 7	30-50	Shatter	Prairie du Chien Chert	19.0
IL2017.2.6.3	1	ST F 7	30-50	Shatter	Basaltic rock	6.5
IL2017.2.7.1	1	ST F 7	50-70	Shatter	Granitic rock	143.1
IL2017.2.7.2	1	ST F 7	50-70	Shatter	Granitic rock	1.5
IL2017.2.8.1	1	ST F 7	70-90	Flake	Quartzite	12.7
IL2017.2.8.2	1	ST F 7	70-90	Shatter	Quartzite	10.9
IL2017.2.8.3	1	ST F 7	70-90	Shatter	Quartzite	3.4
IL2017.2.8.4	1	ST F 7	70-90	Shatter	Quartzite	0.2
IL2017.2.9.1	1	ST F 8	40-55	Shatter	Basaltic rock	14.2
IL2017.2.9.2	1	ST F 8	40-55	Flake	Swan River Chert	12.5
IL2017.2.9.3	1	ST F 8	40-55	Flake	Prairie du Chien Chert	0.9
IL2017.2.9.4	1	ST F 8	40-55	Fragment	Granitic rock	63.7

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.10.1	1	ST F 8	55-75	Tested cobble	Quartz	138.4
IL2017.2.10.2	1	ST F 8	55-75	Flake	Prairie du Chien Chert	22.3
IL2017.2.10.3	1	ST F 8	55-75	Flake	Tongue River Silica	12.6
IL2017.2.10.4	1	ST F 8	55-75	Tool	Chert	8.8
IL2017.2.10.5	1	ST F 8	55-75	Flake	Basaltic rock	5.6
IL2017.2.10.6	1	ST F 8	55-75	Flake	Chert	2.5
IL2017.2.10.7	1	ST F 8	55-75	Shatter	Quartz	2.9
IL2017.2.10.8	1	ST F 8	55-75	Shatter	Quartz	2.9
IL2017.2.10.9	1	ST F 8	55-75	Flake	Prairie du Chien Chert	1.1
IL2017.2.10.10	1	ST F 8	55-75	Shatter	Quartz	1.4
IL2017.2.11.1	1	ST F 8	75-90	Flake	Basaltic rock	30.0
IL2017.2.12.1	1	ST F 10	20-40	Flake	Basaltic rock	130.1
IL2017.2.12.2	1	ST F 10	20-40	Fragment	Unidentified rock	63.3
IL2017.2.12.3	1	ST F 10	20-40	Shatter	Basaltic rock	13.8
IL2017.2.12.4	1	ST F 10	20-40	Fragment	Unidentified rock	7.3
IL2017.2.12.5	1	ST F 10	20-40	Shatter	Prairie du Chien Chert	3.7
IL2017.2.13.1	1	ST F 10	40-60	Flake	Siltstone	20.8
IL2017.2.13.2	1	ST F 10	40-60	Shatter	Quartzite	21.6
IL2017.2.13.3	1	ST F 10	40-60	Shatter	Prairie du Chien Chert	5.8
IL2017.2.14.1	1	ST F 10	60-80	Tested cobble	Quartzite	76.0
IL2017.2.14.2	1	ST F 10	60-80	Flake	Prairie du Chien Chert	1.5
IL2017.2.14.3	1	ST F 10	60-80	Shatter	Chert	1.6
IL2017.2.14.4	1	ST F 10	60-80	Shatter	Prairie du Chien Chert	1.0
IL2017.2.14.5	1	ST F 10	60-80	Flake	Prairie du Chien Chert	0.6
IL2017.2.15.1	1	ST F 10	80-100	Fragment	Siltstone	113.4

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.15.2	1	ST F 10	80-100	Fragment	Siltstone	32.9
IL2017.2.15.3	1	ST F 10	80-100	Fragment	Iron concretion	8.8
IL2017.2.15.4	1	ST F 10	80-100	Flake	Prairie du Chien Chert	4.8
IL2017.2.15.5	1	ST F 10	80-100	Flake	Prairie du Chien Chert	4.0
IL2017.2.15.6	1	ST F 10	80-100	Flake	Prairie du Chien Chert	2.3
IL2017.2.15.7	1	ST F 10	80-100	Hammer stone	Granitic rock	253.5
IL2017.2.16.1	1	ST F 11	60-80	Tested cobble	Prairie du Chien Chert	124.4
IL2017.2.16.2	1	ST F 11	60-80	Flake	Chert	17.6
IL2017.2.16.3	1	ST F 11	60-80	Flake	Chert	15.5
IL2017.2.16.4	1	ST F 11	60-80	Fragment	Basaltic rock	12.9
IL2017.2.16.5	1	ST F 11	60-80	Shatter	Prairie du Chien Chert	19.0
IL2017.2.16.6	1	ST F 11	60-80	Flake	Prairie du Chien Chert	9.1
IL2017.2.16.7	1	ST F 11	60-80	Flake	Prairie du Chien Chert	9.0
IL2017.2.16.8	1	ST F 11	60-80	Shatter	Prairie du Chien Chert	10.0
IL2017.2.16.9	1	ST F 11	60-80	Flake	Basaltic rock	4.1
IL2017.2.16.10	1	ST F 11	60-80	Shatter	Prairie du Chien Chert	3.7
IL2017.2.16.11	1	ST F 11	60-80	Fragment	Schist	2.9
IL2017.2.16.12	1	ST F 11	60-80	Shatter	Prairie du Chien Chert	2.1
IL2017.2.16.13	1	ST F 11	60-80	Shatter	Prairie du Chien Chert	2.0
IL2017.2.16.14	1	ST F 11	60-80	Flake	Basaltic rock	0.8
IL2017.2.16.15	1	ST F 11	60-80	Shatter	Unidentified rock	0.8
IL2017.2.16.16	1	ST F 11	60-80	Shatter	Prairie du Chien Chert	0.4
IL2017.2.16.17	1	ST F 11	60-80	Flake	Prairie du Chien Chert	0.2
IL2017.2.16.18	1	ST F 11	60-80	Shatter	Prairie du Chien Chert	0.2
IL2017.2.16.19	1	ST F 11	60-80	Shatter	Prairie du Chien Chert	0.0

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.17.1	1	ST F 11	80-84	Flake	Limestone	6.9
IL2017.2.17.2	1	ST F 11	80-84	Flake	Prairie du Chien Chert	2.0
IL2017.2.17.3	1	ST F 11	80-84	Shatter	Red River Chert	0.6
IL2017.2.17.4	1	ST F 11	80-84	Shatter	Prairie du Chien Chert	0.2
IL2017.2.18.1	1	ST F 12	40-60	Flake	Quartzite	45.0
IL2017.2.19.1	1	ST F 16	50-60	Shatter	Prairie du Chien Chert	9.3
IL2017.2.20.1	1	ST F 24	0-10	Flake	Basaltic rock	1.2
IL2017.2.21.1	1	ST F 24	30-40	Shatter	Chert	1.6
IL2017.2.22.1	1	ST F 24	50-60	Flake	Prairie du Chien Chert	35.4
IL2017.2.22.2	1	ST F 24	50-60	Flake	Prairie du Chien Chert	2.4
IL2017.2.23.1	1	ST F 24	60-70	Fragment	Granitic rock	92.1
IL2017.2.24.1	1	ST F 27	0-20	Flake	Swan River Chert	3.2
IL2017.2.25.1	1	ST F 27	20-40	Fragment	Granitic rock	59.7
IL2017.2.25.2	1	ST F 27	20-40	Fragment	Granitic rock	43.9
IL2017.2.25.3	1	ST F 27	20-40	Shatter	Prairie du Chien Chert	60.0
IL2017.2.25.4	1	ST F 27	20-40	Flake	Prairie du Chien Chert	19.8
IL2017.2.25.5	1	ST F 27	20-40	Flake	Prairie du Chien Chert	1.1
IL2017.2.26.1	1	ST F 27	40-60	Flake	Prairie du Chien Chert	42.6
IL2017.2.26.2	1	ST F 27	40-60	Flake	Basaltic rock	23.4
IL2017.2.26.3	1	ST F 27	40-60	Flake	Chert	5.0
IL2017.2.26.4	1	ST F 27	40-60	Flake	Prairie du Chien Chert	5.1
IL2017.2.26.5	1	ST F 27	40-60	Flake	Prairie du Chien Chert	3.5
IL2017.2.26.6	1	ST F 27	40-60	Flake	Swan River Chert	2.9
IL2017.2.26.7	1	ST F 27	40-60	Shatter	Prairie du Chien Chert	3.6
IL2017.2.26.8	1	ST F 27	40-60	Fragment	Granitic rock	2.2

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.26.9	1	ST F 27	40-60	Shatter	Prairie du Chien Chert	0.6
IL2017.2.27.1	1	ST F 27	60-80	Tested cobble	Unidentified rock	118.9
IL2017.2.27.2	1	ST F 27	60-80	Flake	Prairie du Chien Chert	54.4
IL2017.2.27.3	1	ST F 27	60-80	Flake	Prairie du Chien Chert	28.0
IL2017.2.27.4	1	ST F 27	60-80	Shatter	Prairie du Chien Chert	18.6
IL2017.2.27.5	1	ST F 27	60-80	Shatter	Prairie du Chien Chert	14.9
IL2017.2.27.6	1	ST F 27	60-80	Flake	Prairie du Chien Chert	12.9
IL2017.2.27.7	1	ST F 27	60-80	Flake	Silicified wood	8.7
IL2017.2.27.8	1	ST F 27	60-80	Flake	Prairie du Chien Chert	12.0
IL2017.2.27.9	1	ST F 27	60-80	Flake	Prairie du Chien Chert	9.7
IL2017.2.27.10	1	ST F 27	60-80	Flake	Red River Chert	9.2
IL2017.2.27.11	1	ST F 27	60-80	Flake	Red River Chert	5.5
IL2017.2.27.12	1	ST F 27	60-80	Fragment	Basaltic rock	5.1
IL2017.2.27.13	1	ST F 27	60-80	Shatter	Basaltic rock	5.8
IL2017.2.27.14	1	ST F 27	60-80	Shatter	Prairie du Chien Chert	3.0
IL2017.2.27.15	1	ST F 27	60-80	Flake	Knife Lake Siltstone	2.5
IL2017.2.27.16	1	ST F 27	60-80	Flake	Prairie du Chien Chert	0.5
IL2017.2.27.17	1	ST F 27	60-80	Shatter	Prairie du Chien Chert	0.3
IL2017.2.27.18	1	ST F 27	60-80	Flake	Prairie du Chien Chert	0.3
IL2017.2.27.19	1	ST F 27	60-80	Shatter	Red River Chert	0.2
IL2017.2.27.20	1	ST F 27	60-80	Flake	Prairie du Chien Chert	0.2
IL2017.2.27.21	1	ST F 27	60-80	Shatter	Red River Chert	0.2
IL2017.2.27.22	1	ST F 27	60-80	Shatter	Prairie du Chien Chert	0.2
IL2017.2.27.23	1	ST F 27	60-80	Hammer stone	Granitic rock	201.9
IL2017.2.27.24	1	ST F 27	60-80	Hammer stone	Granitic rock	160.9

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.27.25	1	ST F 27	60-80	Fragment	Basaltic rock	14.4
IL2017.2.27.26	1	ST F 27	60-80	Fragment	Basaltic rock	9.0
IL2017.2.28.1	1	ST F 27	80-100	Tested cobble	Prairie du Chien Chert	96.4
IL2017.2.28.2	1	ST F 27	80-100	Flake	Prairie du Chien Chert	28.4
IL2017.2.28.3	1	ST F 27	80-100	Tested cobble	Prairie du Chien Chert	38.7
IL2017.2.28.4	1	ST F 27	80-100	Flake	Prairie du Chien Chert	11.3
IL2017.2.28.5	1	ST F 27	80-100	Flake	Prairie du Chien Chert	11.0
IL2017.2.28.6	1	ST F 27	80-100	Tested cobble	Red River Chert	12.5
IL2017.2.28.7	1	ST F 27	80-100	Flake	Red River Chert	7.4
IL2017.2.28.8	1	ST F 27	80-100	Flake	Red River Chert	3.3
IL2017.2.28.9	1	ST F 27	80-100	Flake	Prairie du Chien Chert	2.0
IL2017.2.28.10	1	ST F 27	80-100	Flake	Prairie du Chien Chert	1.2
IL2017.2.28.11	1	ST F 27	80-100	Shatter	Prairie du Chien Chert	1.1
IL2017.2.28.12	1	ST F 27	80-100	Shatter	Prairie du Chien Chert	0.9
IL2017.2.28.13	1	ST F 27	80-100	Shatter	Prairie du Chien Chert	0.4
IL2017.2.28.14	1	ST F 27	80-100	Flake	Basaltic rock	0.4
IL2017.2.28.15	1	ST F 27	80-100	Flake	Prairie du Chien Chert	0.4
IL2017.2.28.16	1	ST F 27	80-100	Shatter	Prairie du Chien Chert	0.1
IL2017.2.28.17	1	ST F 27	80-100	Spall	Prairie du Chien Chert	0.1
IL2017.2.28.18	1	ST F 27	80-100	Flake	Prairie du Chien Chert	0.1
IL2017.2.29.1	1	ST F 27	100-110	Flake	Basaltic rock	62.6
IL2017.2.29.2	1	ST F 27	100-110	Flake	Basaltic rock	15.0
IL2017.2.29.3	1	ST F 27	100-110	Shatter	Basaltic rock	6.3
IL2017.2.30.1	1	ST F 29	0-20	Flake	Prairie du Chien Chert	4.2
IL2017.2.30.2	1	ST F 29	0-20	Flake	Basaltic rock	2.8

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.30.3	1	ST F 29	0-20	Shatter	Basaltic rock	0.9
IL2017.2.30.4	1	ST F 29	0-20	Flake	Red River Chert	0.7
IL2017.2.31.1	1	ST F 29	20-40	Tested Cobble	Basaltic rock	85.0
IL2017.2.31.2	1	ST F 29	20-40	Tested Cobble	Prairie du Chien Chert	71.8
IL2017.2.31.3	1	ST F 29	20-40	Flake	Prairie du Chien Chert	8.3
IL2017.2.31.4	1	ST F 29	20-40	Tool	Prairie du Chien Chert	3.3
IL2017.2.31.5	1	ST F 29	20-40	Shatter	Basaltic rock	1.9
IL2017.2.31.6	1	ST F 29	20-40	Flake	Prairie du Chien Chert	0.8
IL2017.2.31.7	1	ST F 29	20-40	Shatter	Granitic rock	0.7
IL2017.2.32.1	1	ST F 29	40-60	Tested Cobble	Prairie du Chien Chert	111.6
IL2017.2.32.2	1	ST F 29	40-60	Core	Sioux Quartzite	47.9
IL2017.2.32.3	1	ST F 29	40-60	Shatter	Chert	2.6
IL2017.2.32.4	1	ST F 29	40-60	Flake	Chert	0.5
IL2017.2.32.5	1	ST F 29	40-60	Shatter	Red River Chert	0.2
IL2017.2.33.1	1	ST F 29	60-80	Tested Cobble	Prairie du Chien Chert	1815.0
IL2017.2.33.2	1	ST F 29	60-80	Flake	Quartzite	19.2
IL2017.2.33.3	1	ST F 29	60-80	Flake	Prairie du Chien Chert	9.4
IL2017.2.33.4	1	ST F 29	60-80	Flake	Prairie du Chien Chert	10.2
IL2017.2.33.5	1	ST F 29	60-80	Shatter	Quartz	4.7
IL2017.2.33.6	1	ST F 29	60-80	Shatter	Prairie du Chien Chert	2.4
IL2017.2.33.7	1	ST F 29	60-80	Shatter	Prairie du Chien Chert	2.0
IL2017.2.33.8	1	ST F 29	60-80	Flake	Prairie du Chien Chert	2.0
IL2017.2.33.9	1	ST F 29	60-80	Flake	Quartz	1.8
IL2017.2.33.10	1	ST F 29	60-80	Shatter	Quartz	0.3
IL2017.2.33.11	1	ST F 29	60-80	Shatter	Prairie du Chien Chert	0.2

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.33.12	1	ST F 29	60-80	Shatter	Quartz	0.2
IL2017.2.33.13	1	ST F 29	60-80	Fragment	Basaltic rock	6.6
IL2017.2.34.1	1	ST F 29	80-100	Flake	Prairie du Chien Chert	103.9
IL2017.2.34.2	1	ST F 29	80-100	Flake	Prairie du Chien Chert	26.8
IL2017.2.34.3	1	ST F 29	80-100	Shatter	Prairie du Chien Chert	28.2
IL2017.2.34.4	1	ST F 29	80-100	Flake	Prairie du Chien Chert	6.7
IL2017.2.34.5	1	ST F 29	80-100	Flake	Quartzite	3.6
IL2017.2.34.6	1	ST F 29	80-100	Shatter	Red River Chert	3.6
IL2017.2.34.7	1	ST F 29	80-100	Flake	Prairie du Chien Chert	0.7
IL2017.2.34.8	1	ST F 29	80-100	Shatter	Red River Chert	1.0
IL2017.2.34.9	1	ST F 29	80-100	Flake	Prairie du Chien Chert	0.2
IL2017.2.34.10	1	ST F 29	80-100	Shatter	Prairie du Chien Chert	0.3
IL2017.2.34.11	1	ST F 29	80-100	Shatter	Quartz	0.3
IL2017.2.34.12	1	ST F 29	80-100	Flake	Knife Lake Siltstone	0.2
IL2017.2.34.13	1	ST F 29	80-100	Fragment	Basaltic rock	3.2
IL2017.2.34.14	1	ST F 29	80-100	Fragment	Basaltic rock	0.9
IL2017.2.35.1	1	ST F 29	100-120	Tested Cobble	Prairie du Chien Chert	87.8
IL2017.2.35.2	1	ST F 29	100-120	Flake	Prairie du Chien Chert	29.6
IL2017.2.35.3	1	ST F 29	100-120	Flake	Swan River Chert	12.9
IL2017.2.35.4	1	ST F 29	100-120	Shatter	Prairie du Chien Chert	5.0
IL2017.2.35.5	1	ST F 29	100-120	Flake	Prairie du Chien Chert	2.8
IL2017.2.35.6	1	ST F 29	100-120	Flake	Prairie du Chien Chert	2.9
IL2017.2.35.7	1	ST F 29	100-120	Flake	Red River Chert	1.7
IL2017.2.35.8	1	ST F 29	100-120	Flake	Basaltic rock	1.5
IL2017.2.35.9	1	ST F 29	100-120	Flake	Prairie du Chien Chert	1.0

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Catalog #	Count	Location	Depth (cmbs)	Object	Raw Material	Weight (g)
IL2017.2.35.10	1	ST F 29	100-120	Flake	Prairie du Chien Chert	0.7
IL2017.2.35.11	1	ST F 29	100-120	Shatter	Prairie du Chien Chert	0.3
IL2017.2.35.12	1	ST F 29	100-120	Flake	Prairie du Chien Chert	0.2
IL2017.2.35.13	1	ST F 29	100-120	Flake	Prairie du Chien Chert	0.0
IL2017.2.35.14	1	ST F 29	100-120	Flake	Basaltic rock	0.9
IL2017.2.35.15	1	ST F 29	100-120	Fragment	Basaltic rock	50.4
IL2017.2.35.16	1	ST F 29	100-120	Fragment	Basaltic rock	52.4
IL2017.2.35.17	1	ST F 29	100-120	Fragment	Granitic rock	8.3
IL2017.2.35.18	1	ST F 29	100-120	Fragment	Granitic rock	7.3
IL2017.2.35.19	1	ST F 29	100-120	Fragment	Granitic rock	6.9
IL2017.2.35.20	1	ST F 29	100-120	Fragment	Basaltic rock	5.3
IL2017.2.35.21	1	ST F 29	100-120	Fragment	Basaltic rock	4.5
IL2017.2.35.0	1	ST F 29	100-120	Faunal - Ondatra zibethicus (muskrat) - right ilium fragment - sent to Beta & destroyed during radiocarbon dating		0.3
IL2017.2.36.1	1	ST F 30	80-100	Core	Animikie Silicate	88.6

APPENDIX D:

SOIL PROFILES FROM SHOVEL TESTS AT 21HE483

FCRS 2016 Shovel Test Profiles at 21HE483

	Depth of Fill and Disturbance is Shaded

Site 21HE483 Shovel Test F1 Soil Profile.

Below Surface cm	Description
0-6	Asphalt
6-17	Class 5 gravel; fill
17-23	Yellowish brown (10YR 5/4) clay; fill
23-44	Brown (10YR 4/3) sandy clay loam; fill
44-90	Very dark gray (10YR 3/1) loamy sand; asphalt, large limestone chunks; fill
90-115	Very dark gray (10YR 3/1) loamy sand; fill or disturbed top soil; gravelly with asphalt; asphalt found at 105-110cmbs; large rocks at 90 cmbs

Site 21HE483 Shovel Test F2 Soil Profile.

Below Surface cm	Description
0-8	Asphalt
8-20	Class 5 gravel; fill
20-37	Very dark gray (10YR 3/1) loamy sand; fill or disturbed and bladed; abrupt boundary
37-70	Brown (7.5YR 5/4) sand; cobbly; intact soil
70-90	Light yellowish brown (10YR 6/4) sand; cobbly; intact soil

Site 21HE483 Shovel Test F3 Soil Profile.

Below Surface cm	Description
0-9	Asphalt
9-23	Class 5 gravel; fill gravel
23-33	Brown (10YR 4/3) sandy clay loam; fill
33-84	Very dark gray (10YR 3/1) sandy loam; fill ; rocky with gray limestone
84	Large rock across bottom of hole; impenetrable; fill

Fill includes asphalt and nails; nail found at 80cmbs; boulder at 26-40 cmbs

Site 21HE483 Shovel Test F4 Soil Profile.

Below Surface cm	Description
0-7	Asphalt
7-19	Class 5 gravel; fill
19-30	Very dark gray (10YR 3/1) loamy sand; fill with clay pockets; abrupt boundary
30-64	Brown (7.5YR 4/4) loamy sand; intact soil; cobbly
64-86	Yellowish brown (10YR 5/4) cobbly sand; intact soil

FCRS 2016 Shovel Test Profiles at 21HE483

Site 21HE483 Shovel Test F5 Soil Profile.

Below Surface cm	Description
0-7	Asphalt
7-21	Class 5 gravel; fill
21-36	Brown (10YR 4/3) sandy clay loam; fill
36-63	Very dark gray (10YR 3/1) sandy loam with clay pockets & large limestone rocks; fill
63	Large rock across bottom of hole; impenetrable; fill

Site 21HE483 Shovel Test F6 Soil Profile.

Below Surface cm	Description
0-8	Asphalt
8-18	Class 5 gravel; fill
18-28	Olive brown (2.5Y 4/3) sandy loam; fill
28-36	Black (10YR 2/1) sandy loam with clay pockets; fill; abrupt boundary
36-80	Brown (7.5YR 4/4) loamy sand; cobbly; intact soil
80-96	Yellowish brown (10YR 5/4) sand; cobbly; intact soil

Site 21HE483 Shovel Test F7 Soil Profile.

Below Surface cm	Description
0-8	Asphalt
8-18	Class 5 gravel; fill
18-29	Very dark gray (10YR 3/1) sandy loam; probably disturbed/bladed; abrupt boundary
29-71	Brown (7.5YR 4/4) loamy sand; cobbly; intact soil
71-90	Strong brown (7.5YR 4/6) sand; intact soil

Site 21HE483 Shovel Test F8 Soil Profile.

Below Surface cm	Description
0-7	Asphalt
7-19	Class 5 gravel; fill
19-49	Black (10YR 2/1) sandy loam; intact soil
49-53	Very dark grayish brown (10YR 3/2) sandy loam; intact soil
53-72	Brown (7.5YR 4/4) loamy sand; cobbly; intact soil
72-90	Dark yellowish brown (10YR 4/4) loamy sand; intact soil

FCRS 2016 Shovel Test Profiles at 21HE483

Site 21HE483 Shovel Test F9 Soil Profile.

Below Surface cm	Description
0-6	Asphalt
6-18	Class 5 gravel; fill
18-55	Dark yellowish brown (10YR 4/4) sand with lots of large limestone rocks; fill
55	Impenetrable rocks; fill

Site 21HE483 Shovel Test F10 Soil Profile.

Below Surface cm	Description
0-7	Asphalt
7-20	Class 5 gravel; fill
20-60	Light & dark bands and pockets; large rocks; fill
60-81	Black (10YR 2/1) sandy loam; intact soil; gravels
81-100	Very dark grayish brown (10YR 3/2) loamy sand; intact soil; gravels

Site 21HE483 Shovel Test F11 Soil Profile.

Below Surface cm	Description
0-7	Asphalt
7-21	Class 5 gravel; fill
21-35	Dark yellowish brown (10YR 4/4) sandy loam; fill
35-51	Very dark grayish brown (10YR 3/2) loamy sand mottled with dark yellowish brown (10YR 4/4); fill; abrupt boundary
51-69	Brown (7.5YR 4/4) loamy sand; intact soil
69-85	Light yellowish brown (10YR 6/4) cobbly sand; 1 clinker found at 80-84 cmbs (possibly knocked in from above); intact soil

Site 21HE483 Shovel Test F12 Soil Profile.

Below Surface cm	Description
0-7	Asphalt
7-30	Class 5 gravel; fill
30-63	Very dark gray (10YR 3/1) sandy loam; very cobbly; fill; soil has mucky smell; compact & impenetrable rocks

FCRS 2016 Shovel Test Profiles at 21HE483

Site 21HE483 Shovel Test F13 Soil Profile.

Below Surface cm	Description
0-15	Very dark gray (10YR 3/1) loam; fill
15-35	Pale brown (10YR 6/3) silty clay; gravelly; fill
35-50	Very dark grayish brown (10YR 3/2) sandy loam; fill
50-65	Mixed layers of light & dark; fill
65-90	Very dark grayish brown (10YR 3/2) sandy loam with lighter and darker mottles & bands; fill; impenetrable large chunk of asphalt at 90 cmbs

Site 21HE483 Shovel Test F14 Soil Profile.

Below Surface cm	Description
0-10	Very dark gray (10YR 3/1) loam; fill
10-35	Very dark grayish brown (2.5Y 3/2) clay; fill
35-60	Very dark grayish brown (10YR 3/2) loamy sand with lots of large limestone rocks; fill
60	Impenetrable rocks; fill

Site 21HE483 Shovel Test F15 Soil Profile.

Below Surface cm	Description
0-12	Very dark grayish brown (10YR 3/2) silt loam; fill
12-22	Yellowish brown (10YR 5/4) loamy sand; fill
22-53	Light & dark loamy sand; fill
53-72	Very dark grayish brown (10YR 3/2) loamy sand; compact; gravelly; intact soil
72-80	Very dark grayish brown (10YR 3/2) loamy sand; slightly looser than above; cobbly; intact soil

Site 21HE483 Shovel Test F16 Soil Profile.

Below Surface cm	Description
0-10	Very dark gray (10YR 3/1) silty clay loam; fill
10-90	Mixture of sandy and clayey layers & pockets of dark & light brown colors; fill; large rocks and asphalt
90	Impenetrable large rock at bottom; 1 clinker in fill

Site 21HE483 Shovel Test F17 Soil Profile.

Below Surface cm	Description
0-10	Very dark gray (10YR 3/1) silty clay loam; fill
10-40	Light olive brown (2.5Y 5/3) clay with gravel; fill; dark lenses present
40-60	Very dark gray (10YR 3/1) sandy loam; fill; large limestone rocks
60	Impenetrable large rocks at bottom

FCRS 2016 Shovel Test Profiles at 21HE483

Site 21HE483 Shovel Test F18 Soil Profile.

Below Surface cm	Description
0-10	Very dark gray (10YR 3/1) silty clay loam; fill
10-35	Light olive brown (2.5Y 5/3) clay with gravel; fill
35-55	Very dark gray (10YR 3/1) sandy loam; fill; large limestone rocks
55	Impenetrable large rocks; fill

Site 21HE483 Shovel Test F19 Soil Profile.

Below Surface cm	Description
0-8	Asphalt
8-18	Class 5 gravel; fill
18-26	Light olive brown (2.5Y 5/3) clay and very dark grayish brown (10YR 3/2) loam with gravels; fill
26-60	Very dark grayish brown (10YR 3/2) sandy clay loam with light layers and large limestone rocks; fill
60	Impenetrable large rocks; fill

Site 21HE483 Shovel Test F20 Soil Profile.

Below Surface cm	Description
0-15	Very dark grayish brown (10YR 3/2) silty clay loam; fill
15-30	Light olive brown (2.5Y 5/3) clay and very dark grayish brown (10YR 3/2) loam with gravels; fill
30-60	Very dark grayish brown (10YR 3/2) sandy clay loam with large limestone rocks; fill
60	Impenetrable rocks; fill

Site 21HE483 Shovel Test F21 Soil Profile.

Below Surface cm	Description
0-7	Asphalt
7-25	Class 5 gravel; fill
25-45	Greenish gray (5/10Y gley) loam with asphalt chunks; fill
45-60	Dark olive gray (5Y 3/2) sand with gray (5Y 5/1) and brown (7.5YR 4/4) lenses; mixed layers and large rocks; fill
60	Impenetrable large rock at bottom; fill

FCRS 2016 Shovel Test Profiles at 21HE483

Site 21HE483 Shovel Test F22 Soil Profile.

Below Surface cm	Description
0-6	Asphalt
6-20	Class 5 gravel; fill
20-50	Greenish gray (5/10Y gley) clay loam; fill; abrupt boundary
50-90	Very dark gray (10YR 3/1) loamy sand with lenses of greenish gray (5/10Y gley) with rocks and asphalt; fill
90	Impenetrable rocks and asphalt; fill

Site 21HE483 Shovel Test F23 Soil Profile.

Below Surface cm	Description
0-9	Asphalt
9-18	Class 5 gravel; fill; gravel; pale yellow (2.5Y 7/3)
18-28	Greenish gray (5/10Y gley) clay loam; fill; abrupt boundary
28-70	Very dark gray (10YR 3/1) loamy sand with lenses of greenish gray (5/10Y gley) with rocks; fill
70	Impenetrable rocks; fill

Site 21HE483 Shovel Test F24 Soil Profile.

Below Surface cm	Description
0-28	Very dark gray (10YR 3/1) loam fill
28-45	Dark yellowish brown (10YR 4/4) sand with concrete slab; fill
45-75	Very dark gray (10YR 3/1) loamy sand; intact soil; low gravels; very dark grayish brown (10YR 3/2) loamy sand; very cobbly at base; intact soil
75	Impenetrable cobble layer; intact soil

Small concrete fragments throughout

Site 21HE483 Shovel Test F25 Soil Profile.

Below Surface cm	Description
0-9	Asphalt
9-18	Class 5 gravel; fill gravel
18-47	Greenish gray (5/10Y gley) clay loam; fill
47-75	Very dark grayish brown (10YR 3/2) sandy loam with some lighter and darker layers; large rocks; fill
75	Impenetrable rock layer at bottom; fill

FCRS 2016 Shovel Test Profiles at 21HE483

Site 21HE483 Shovel Test F26 Soil Profile.

Below Surface cm	Description
0-6	Asphalt
6-17	Class 5 gravel; fill gravel
17-50	Very dark grayish brown (2.5Y 3/2) sandy loam with lighter bands and patches; rocks and asphalt; fill
50	Impenetrable large rocks across bottom; fill

Site 21HE483 Shovel Test F27 Soil Profile.

Below Surface cm	Description
0-15	Very dark grayish brown (10YR 3/2) loam; fill/disturbed
15-35	Very dark gray (10YR 3/1) sandy loam; fill/disturbed
35-70	Black (10YR 2/1) loamy sand; gravelly with cobbles; intact soil
70-110	Very dark gray (10YR 3/1) loamy sand; gravelly with cobbles; intact soil

one asphalt chunk found at 20-40cmbs

Site 21HE483 Shovel Test F28 Soil Profile.

Below Surface cm	Description
0-13	Light yellowish brown (2.5Y 6/3) loamy sand and gravel; fill
13-55	Very dark grayish brown (10YR 3/2) sandy loam with lighter patches and large rocks; fill
55	Impenetrable large rock across bottom; fill

Site 21HE483 Shovel Test F29 Soil Profile.

Below Surface cm	Description
0-30	Very dark gray (10YR 3/1) sandy loam; probably redeposited soil or fill
30-120	Black (10YR 2/1) loamy sand transitioning to very dark gray (10YR 3/1) loamy sand with depth; gravels and cobbles; intact soil

Site 21HE483 Shovel Test F30 Soil Profile.

Below Surface cm	Description
0-100	Light yellowish brown (2.5Y 6/3) gravelly loam fill; Very dark gray (10YR 3/1) gravelly loamy sand; very compact upper with natural cobbles; lighter patches of clay & mottles, indicating disturbed or fill; asphalt chunks at 70cmbs; fill

FCRS 2016 Shovel Test Profiles at 21HE483

Site 21HE483 Shovel Test F31 Soil Profile.

Below Surface cm	Description
0-20	Very dark gray (10YR 3/1) loam; fill
20-55	Light olive brown (2.5Y 5/3) clay; fill
55-80	Very dark gray (10YR 3/1) loamy sand with lighter and darker patches; rocks and asphalt; fill

Site 21HE483 Shovel Test F32 Soil Profile.

Below Surface cm	Description
0-95	Very dark grayish brown (10YR 3/2) sandy clay loam with light olive brown (2.5Y 5/3) clay layers & pockets; asphalt at 90cmbs; fill
95	Impenetrable large rock at bottom; fill

plastic found at c.80cmbs.

Site 21HE483 Shovel Test F33 Soil Profile.

Below Surface cm	Description
0-18	Very dark grayish brown (10YR 3/2) silt loam; fill
18-50	Light olive brown (2.5Y 5/3) clay mottled with very dark gray (10YR 3/1) loam; asphalt; fill
50-85	Very dark gray (10YR 3/1) sandy loam; fill
85-90	Pale brown (10YR 6/3) sand; fill
90-106	Very dark grayish brown (10YR 3/2) loamy sand; probable fill

plastic piece found at c.80cmbs.

Appendix E:

Radiocarbon Dating Reports from Beta Analytic Inc.

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

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. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

June 7, 2016

Mr. Frank Florin
Florin Cultural Resource Services
N12902 273rd Street
Boyceville, WI 54725
USA

RE: Radiocarbon Dating Result For Sample 21HE483

Dear Mr. Florin:

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C was measured separately in an IRMS (isotope ratio mass spectrometer). It is NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

The cost of the analysis was charged to the American Express card provided. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Frank Florin — Report Date: 6/7/2016

Florin Cultural Resource Services — Material Received: 5/16/2016

Sample Data	Measured Radiocarbon Age	d13C	Conventional Radiocarbon Age(*)
Beta - 437528	1990 +/- 30 BP	-20.2 o/oo d15N= +5.9 o/oo	2070 +/- 30 BP

SAMPLE : 21HE483
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal BC 170 to 20 (Cal BP 2120 to 1970) and Cal BC 10 to AD 0 (Cal BP 1960 to 1950)

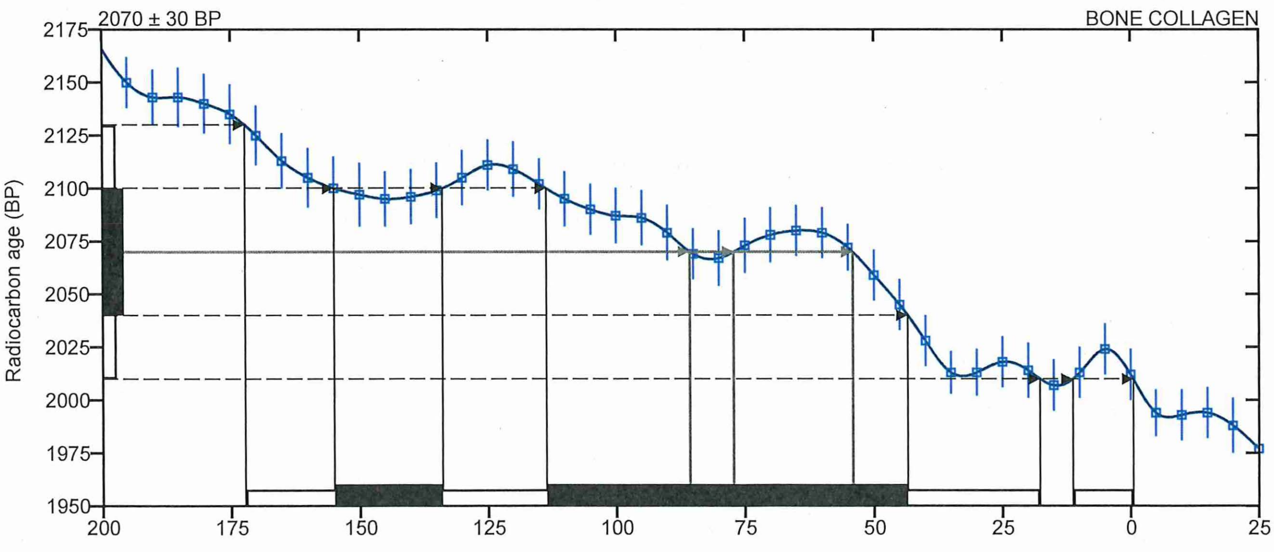
Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -20.2 o/oo : lab. mult = 1)

Laboratory number	**Beta-437528 : 21HE483**
Conventional radiocarbon age	**2070 ± 30 BP**
Calibrated Result (95% Probability)	**Cal BC 170 to 20 (Cal BP 2120 to 1970)** **Cal BC 10 to AD 0 (Cal BP 1960 to 1950)**
Intercept of radiocarbon age with calibration curve	Cal BC 85 (Cal BP 2035) Cal BC 75 (Cal BP 2025) Cal BC 55 (Cal BP 2005)
Calibrated Result (68% Probability)	Cal BC 155 to 135 (Cal BP 2105 to 2085) Cal BC 115 to 45 (Cal BP 2065 to 1995)



Database used

INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887., 2013.

Beta Analytic Radiocarbon Dating Laboratory

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Mr. Darden Hood
President

Mr. Ronald Hatfield
Mr. Christopher Patrick
Deputy Directors

The Radiocarbon Laboratory Accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423

Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990B and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation.

Report Date: June 07, 2016
Submitter : Mr. Frank Florin

QA MEASUREMENTS

Reference 1	Expected Value:	129.41 +/- 0.06 pMC
	Measured Value:	129.17 +/- 0.37 pMC
	Agreement:	Accepted
Reference 2	Expected Value:	96.69 +/- 0.50 pMC
	Measured Value:	97.07 +/- 0.30 pMC
	Agreement:	Accepted
Reference 3	Expected Value:	2.30 +/- 0.20 pMC
	Measured Value:	2.29 +/- 0.04 pMC
	Agreement:	Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Darden Hood   Date: June 07, 2016