PHASE I AND II GEOMORPHOLOGICAL INVESTIGATIONS FOR IMPROVEMENTS TO SECTIONS OF TRUNK HIGHWAY US 169 IN NICOLLET COUNTY, MINNESOTA

MnDOT Contract No. 03261
S.P. 5211-59
Strata Morph Geoexploration Report of Investigation No. 240

Prepared for:
Minnesota Department of Transportation
Office of Environmental Stewardship
Cultural Resources Unit
395 John Ireland Blvd., Mail Stop 620
St Paul, MN 55155-1899

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FINAL
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Minnesota Department of Transportation

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February 5, 2014

Sarah J. Beimers
State Historic Preservation Office
Minnesota Historical Society
345 Kellogg Blvd. W.
St. Paul, MN 55101-1906

Regarding: S.P. 5211-59 (TH 169, Nicollet County)
Pavement preservation, vertical grade raising
T. 109 – 110 N., R. 26 – 27 W., Oshawa & Belgrade Twps.
EDA Control Number #0728
SHPO: 2013-1312

Dear Ms. Beimers:

Enclosed please find one (1) copy of a report authored by Michael Kolb entitled *Phase I and II Geomorphological Investigations for Improvements to Sections of Trunk Highway US 169 in Nicollet County, Minnesota*. The findings in this report were summarized in the archaeology report previously submitted to your office on 10/8/2013 and do not change our **no historic properties affected** determination made at that time. Since your office concurred with this determination on 11/8/2013, we do not need a response from you.

Feel free to contact me at 651-366-3614 if you have any questions.

Sincerely,

Craig Johnson
Cultural Resources Unit

enclosure

cc: Zachary Tess, MnDOT District 7
Rebecca Novak, MnDOT District 7 (1 copy)
Robin Bush, EDA/CRO
Scott Anfinson, OSA (1 copy)
Michelle Terrell, Two Pines (1 copy)
Legislative Library (1 copy)

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INTRODUCTION

The project area is located between St. Peter and Mankato, Minnesota along TH US169. MnDOT proposes raising portions of the southbound lanes above the 100-year flood elevation. Geomorphological investigations were conducted at four localities along the route where construction activities associated with raising the road may impact cultural resources. These areas from north to south are: (1) St. Peter Hospital Locality, (2) Seven Mile Creek Locality, (3) River Bluff Road Locality, and (4) Hiniker Creek Locality (Figure 1). Highway US169 is located at the base of the western bluffs of the Minnesota River valley. To the west of the highway the landscape consists of: (1) steep slopes ascending to the uplands or high terraces, (2) alluvial fans at tributary valley mouths, and (3) colluvial slopes. To the east of the highway the landscape consists of: (1) tributary alluvial fans, (2) low terraces, and (3) the floodplain of the Minnesota River. The ROW/work space for the project is very narrow and often does not go far beyond the slope intercept.

The purpose of the geomorphological investigation is to locate soil-stratigraphic contexts that have geologic potential for buried archaeological deposits. Soil-stratigraphic contexts with low-moderate, moderate, or high potential were targeted for archaeological testing. Potential is a qualitative measure of the likelihood that a particular geologic environment will contain archaeological deposits in primary context. Three major geologic criteria are used when assigning a level of potential: (1) age of the deposits, (2) depositional environment, and (3) post-depositional modifications (Hudak and Hajic 2002). Human occupation within the project area occurred from the Late Pleistocene through the Holocene (<14,000 ^{14}C yrs BP). Consequently, sediments deposited during this time span are considered as having chronological potential. In the TH US169 project area the depositional environments most conducive to burying and preserving the primary context of the archaeological assemblage in the alluvial valley setting are vertical accretion alluvium on floodplains and in the valley marginal setting, alluvial fans and colluvial slopes. Post-depositional modifications that may disturb the context of the archaeological deposits are pedogenic processes such as bioturbation and shrink-swell in clayey soils, and historic anthropogenic activities such as mining, agriculture, and urbanization.

The three levels of potential and the criteria for there selection are listed below (modified from Eigenberger et al. 2009, Hudak and Hajic 2002, Monaghan et al. 2006):

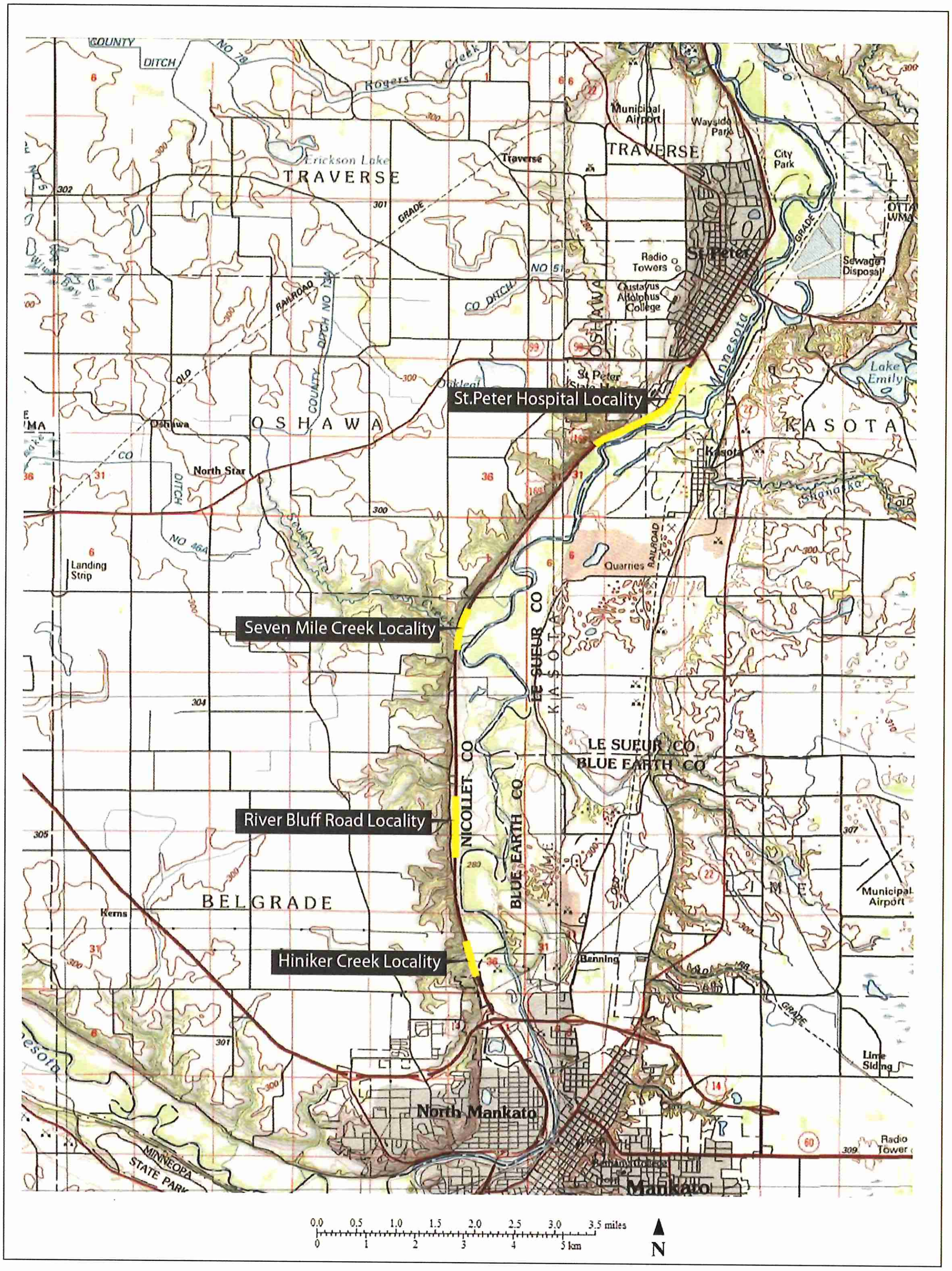

Figure 1. Location of the project area localities plotted on a 1:100,000 scale topographic map

High Potential: landforms where sediment has accumulated in the last 14,000 years in depositional environments where archaeological deposits could be buried and preserved in primary context. Depositional style yields stratigraphic sequences that are conducive to preserving buried archaeological deposits in primary contexts and with the potential for separation of some of the archaeological components in stacked paleosols or in accretionary deposits with relatively high sedimentation rates.

Moderate Potential: landforms with limiting factors such as long-term wet conditions, short duration of sedimentation, young deposits, potential for gaps in the record due to erosion. A depositional style that yields stratigraphic sequences that are conducive to preserving buried archaeological deposits but with possible physical modifications to the primary cultural context. Or landforms that are likely to have potential for buried archaeological deposits but the stratigraphic contexts of these landforms is unknown or geographically variable.

Low Potential: deposits that are too old or too thin to contain buried archaeological deposits in primary context or deposits that accumulated in high-energy depositional environments, fluvial channels for example, where any contained archaeological deposits are likely not in primary context.

Mn Model Sensitivity

Landscape Suitability Maps indicating levels of potential at specific depth intervals in the project area are as follows.

0-1 meter and 1-2 meter depths: high potential for the alluvial fans, and moderate and low potential for the floodplain east of the highway.

2-5 meter depth: potential is high beneath the alluvial fan and low or zero east of the road at depth below the floodplain.

PREVIOUS RESEARCH

Quaternary Deposits

The Quaternary deposits map of Minnesota indicates the project area is Holocene alluvium (Hobbs and Goebel 1982). Upland deposits immediately west of the project area are mapped as Des Moines lobe ground moraine and the terraces east of the east of the project area are mapped as outwash.

Minnesota River Valley

The history of the landscape in the project area begins with the advance and retreat of the De Moines Lobe ice. The chronology of ice retreat in the Minnesota River valley is as follows: The glacial margin was at the Algona recessional moraine in northern Iowa around 12,000-12,500 ^{14}C yrs BP (Kemmis 1981). Ice then retreated north and west to the Gary moraine northwest of the project area in Minnesota by 12,500 ^{14}C yrs BP and the Big Stone moraine yet further northwest by 11,700 ^{14}C yrs BP (Patterson 1997). Thus the project area was deglaciated approximately 12,500 years ^{14}C yrs BP.

With further retreat of the Des Moines Lobe ice Glacial Lake Agassiz formed in front of the ice sheet. When Glacial Lake Agassiz drained through its southern outlet, catastrophic floods in River Warren formed the Minnesota River valley. The large volumes of water carried by River Warren down cut through the till and outwash, then in the valley. The initial incision began about 11,800 ^{14}C yrs BP when Glacial Lake Agassiz first began draining through the southern outlet (Teller 1985) and was completed by 10,800 ^{114}C yrs BP (Fisher 2003). The southern outlet was then abandoned and possibly re-occupied between 9900 and 9400 ^{14}C yrs BP and River Warren re-occupied the spillway with minimal further modification (Fisher 2003). Wright et al. (1998) suggests that perhaps the re-occupation did not occur based on data from Lake Pepin and Lake St Croix. The question remains unresolved. In either case at some point in the early Holocene Lake Pepin extended up the Mississippi River valley to St Anthony Falls and assumedly some distance up the Minnesota River valley as well.

The lowest base levels from River Warren down cutting would have existed between the last flood from Lake Agassiz and the incursion of Lake Pepin into the valley mouth (±9500 BP). Incision in the main valley caused incision and head cutting in the tributary valleys initiating alluvial fan construction (Gran et al. 2009, Hudak and Hajic 2002). Initially fan construction was rapid and only slowed when the tributary channels became adjusted to the lower base level and as base level rose with back flooding and alluvial aggradation in the main valley. Radiocarbon dates from nearby fan and sub-fan contexts (Hudak and Hajic 2002) indicate the construction of fans began between 10,800 and 10,400 ^{14}C yrs BP. The primary fan or highest fan surface may have quickly stabilized with continued adjustment to incision and aggradation in the Minnesota River taking place in the fan channel belt and on the secondary fans farther out in the valley. Hudak andHajic (2005) believe that River Warren catastrophic flooding had ceased in the Minnesota River valley by 10,400 BP.

Paleoenvironment

A number of local and regional paleoenvironmental studies are relevant to the interpretation of the stratigraphy and paleoenvironmental conditions in the project area. Recent work at Roberts Creek in northeast Iowa (Chumbley et al. 1990) and re-evaluation of older studies from the Midwest (Baker et al. 1992) have suggested a sharp ecotone (prairie-forest boundary) between the northern Great Plains down into central Iowa (prairie) and northeast Iowa and Wisconsin (open forest or savanna) during the middle to late Holocene. The dynamic nature of the ecotone is demonstrated by presence of prairie in central Iowa about 1500 years sooner than in northeast Iowa (Baker et al. 1992). Vegetation histories from a few selected (not comprehensive) studies in Iowa and Minnesota indicate a very similar pattern of vegetation history over a broad area.

Paleoenvironmental investigations closest to the project area were conducted at Kirchner Marsh and Lake Carlson (Watts and Winter 1966, Wright et al. 1963) located northeast of the project area in Dakota County. They are to the west or prairie side of Baker et al. (1992) middle Holocene prairie-forest ecotone. The postglacial vegetation history is as follows: After about 10,200 yrs BP the spruce forest was replaced with a closed forest dominated first by birch and alder and then pine. This occurred between 10,200 and 9300 yrs BP. Between 9300 and 7100 yrs BP elm and oak forest dominated as conditions became drier. Between about 7100 and 5200 yrs BP the oak forest was replaced by prairie. After 5200 yrs BP oak again became dominant but the exact nature of the forest is not known.

Expected periods of widespread effective regional geomorphic instability based on the known geomorphic and paleoenvironmental history are: (1) early Holocene instability due to valley degradation resulting in tributary head cutting and primary alluvial fan construction, (2) climatically driven geomorphic instability in the middle Holocene resulting in secondary fan construction, and (3) historic instability due to extensive land clearing and agriculture.

Valley Margins: Alluvial Fans and Colluvial Slopes

A number of other archaeological and geomorphological studies have illustrated the potential for alluvial fans to contain buried archaeological deposits in the Minnesota River valley. During the Phase I archaeological survey for the proposed TH 41 Bridge crossing of the Minnesota River at Chaska in Scott and Carver counties (Schoen 2006) alluvial fans in similar geomorphic contexts and with similar stratigraphic patterns were investigated (Kolb 2006). In the New Ulm area buried sites in alluvial fan contexts are present at Frische Creek (Monaghan et al. 2006), in small fans along Highway 14 (Kolb 2005) and in a small alluvial fan downstream of New Ulm (Hudak and Hajic 2002, Kolb 2007).

METHODS

Cores were used to collect subsurface data and construct a stratigraphic framework. This framework was used to determine where in the project area there is potential for buried archaeological sites. Cores measuring 5 cm (2 inches) in diameter were extracted with a Geoprobe® mounted on a pick-up truck. Cores were described in the field using standard systems from soils (Schoeneberger et al. 1998, Soil Survey Staff 1975) and geology (Collinson 1982, Folk 1974), photographed and returned to the borehole. Standard core log descriptions are in Appendix A.

RESULTS

DEPOSITS AND LANDFORMS

The Minnesota River channel belt is confined by the uplands on the west and meltwater stream terraces on the east. The project localities are along the western margin of the Minnesota River valley. They cross tributary alluvial fans, terraces, and floodplain landforms. Tributaries drain the uplands incising tills deposited by the Des Moines lobe (Ellingson 2000, Jennings 2010, Lusardi et al. 2002). The eastern side of the valley is meltwater stream terraces (Johnson et al. 1998, Lusardi et al. 2002). The channel belt and floodplain of the post-glacial Minnesota River valley is characterized by point bars and abandoned point bars with ridge and swale topography, abandoned channels, and flood basins.

Floodplain lakes not in oxbows begin just down stream of Belle Plaine as small lakes and wetlands. From about Carver, Minnesota downstream the floodplain is dominated by lakes. The river reach between St Peter and Mankato, where the project area is located, is dominated by alluvial landforms: ridge and swale complexes on active and abandoned point bars, abandoned channels, and flood basins. This landscape was created by relatively rapid lateral channel migration and channel avulsion. A large meander in the River Bluff Road locality was abandoned by a neck cut-off after 1994 leaving the abandoned channel intact with little post abandonment fill due to it's very recent abandonment. Examination of a series of aerial photos from the 1930's to the 1990's indicate much of the floodplain has been reworked by lateral channel movement in the recent past possibly as a response to increased discharge during the historic period.

Uplands soils are mapped as well-developed mollisols or mollic alfisols (USDA n.d.) formed in till. In the valley bottom the soils are mapped as entisols or poorly drained mollisols formed in alluvium. Along the valley margins most of the soils are mapped as thin moderately-developed mollisols formed in colluvium with one small area of histosols formed in organic sediment (USDA n.d.). The histosol along the valley margin and the poorly drained mollisols on the floodplain are formed in organic sediment and clay in abandoned channels. The remaining areas of the floodplain are generally mapped as Chaska or Minneiska series soils (USDA n.d.). The Minneiska series is moderately well drained with an A-C soil horizon sequence formed in sandy loam, loam, and sand alluvium. The Chaska series is somewhat poorly drained with an A-C soil horizon sequence formed in interstratified silt loam and very fine sandy loam over stratified fine sandy loam and loamy sand (USDA n.d.). These soils are weakly developed.

Deposition in the US 169 project area has occurred in four major depositional environments: (1) Alluvial Fan, (2) Alluvial, (3) Colluvial, and (4) Paludal.

Alluvial Fan Deposits

A number of small tributaries that drain low order drainage basin (1^{st} - 3^{rd} order) enter the Minnesota River valley from the west all along the project area. These tributaries formed by head cutting through glacial deposits and bedrock after River Warren's down cutting in the Minnesota River valley (as demonstrated by Gran et al. (2009) for a nearby Minnesota River tributary. Alluvial fans and tributary channel belts certainly formed at places where the tributaries did not flow directly into the Minnesota River channel when it was at the base of the western bluff. With a few exceptions the lack of alluvial fan morphology indicates the alluvial fans, assuming they formed, have been removed by the lateral migration of the Minnesota River. Alluvial fan deposits vary with the size of the alluvial fan, which is directly tied to the size of the contributing basin, and the distance from the apex of the fan. Stratigraphy in alluvial fans will depend on the magnitude, spatial distribution and timing of run-off generating events as well as the condition of the landscape during those events.

Alluvial fan deposits are divided into the coarser channel and near channel facies and the fine-grained vertical accretion overbank and distal fan facies. In the TH US169 project area the channel and near channel facies are sandy to loamy with gravel. Beneath the upper fan surface they occur as thin stratified fining upward sequences that are capped off with a thin vertical accretion cap. Down fan they occur as isolated beds in vertical accretion alluvium of either tributary or main channel source. The channel and near channel facies also occur in fan channel belts on the floodplain that have little or no alluvial fan morphology. Vertical accretion facies consist of silt and clay that is both massive and thin bedded or laminated. They are thicker down fan where they accumulated at the toe of the fan on the floodplain interstratified or mixed with Minnesota River alluvium.

Alluvium

Minnesota River alluvium also consists of coarse and fine-grained facies. The coarse grained facies accumulated in channel, levee and crevasse splay depositional environments. It consists of sand to loam occasionally with gravel. The fine-grained alluvial facies accumulated, in the project area, in abandoned channels. It consists of vertical accretion silt and clay that is often finely stratified.

Colluvium

Colluvial deposits and alluvial fan deposits at the mouths of low order basins that result from debris flow processes are difficult to distinguish in small excavations or cores. Sediment source is likely variable given the glacial depositional environments and bedrock upslope of the project area. Colluvium identified in the project area is poorly sorted sandy deposits, with gravel that is often the same lithology as the nearby bedrock.

Paludal

Paludal deposits were not encountered during the subsurface investigation but soils with paludal parent material are mapped at the Seven Mile Creek Locality (USDA n.d.). These soils occur as curvilinear bodies in abandoned Minnesota River channels.

ST PETER HOSPITAL LOCALITY

The north end of the St Peter Hospital Locality is 322 m south of the intersection of Highway 99 and US 169 (Figure 1). Here the road is raised for a length of 650 m as it crosses an abandoned channel of the Minnesota River to the bedrock at the base of the terrace scarp. The ROW is at the base of the road fill along both side of the existing highway. Bedrock is exposed along the base of the terrace adjacent to the west side of the highway and the Minnesota River floodplain is along the east side of the highway for an additional 720 m to a point where the upland bluffs form the western valley margin. In this section the ROW is up on the terrace scarp slope on the west side of the road and along the base of the road fill along the floodplain on the east side of the highway. The remainder of the St Peter Hospital Locality is up against the base of the bluff with a steep slope ascending to the uplands and a steep downward slope to the southeast to the Minnesota River floodplain (Figures 1 and 2). The modern channel of the Minnesota River is at the base of the highway fill and has moved there since 1937 when (based on a 1937 aerial photograph) it was farther out in the floodplain to the southeast. Alluvial fan morphology is not well developed at any of the tributaries that enter the valley in this locality. A large 3rd order tributary enters and the valley onto the high terrace where the State Hospital is located and has been channelized along the west edge of the property before it enters the Minnesota River. In 1937 this stream crossed a few hundred meters of floodplain before entering the Minnesota River channel. Southwest of the terrace two small 3rd order streams and a 2nd order stream enter the valley from the uplands. The Minnesota River channel abuts the road fill where it is alternately eroding the bank below the road fill or building sandy point bars that are attached to the bank. No alluvial fans morphology is present in this locality because the active channel of the Minnesota River is at or has recently been at the bluff or terrace scarp base.

Access is very limited within the ROW due to steep slopes and ditches so initial coring took place in the southern half of the locality (Figure 2). Cores 1 and 2 are located at the footslope of the high terrace (Figure 2). Stratigraphy in Core 1 consists of fill to a depth of 0.67 m over C horizons formed in colluvium consisting of medium sand and sand mixed with sandstone (Appendix A). Core refusal occurred at solid rock at a depth of 1.35 m.

Core 2 is located near the mouth of the tributary that drains the terrace and upland adjacent to the state hospital (Figure 2). Stratigraphy consists of fill to a depth of 0.53 m over an Ab-C1-2C2 soil horizon sequence formed in silt loam colluvium over colluvium consisting of sandy loam mixed and interbedded with pieces of local siltstone bedrock and *in situ* weathered siltstone (Appendix A).

Core 3 is located on a small flat valley bottom at the mouth of a tributary valley (Figure 2). Stratigraphy consists of fill to a depth of 0.34 m over a A-BC-2C soil horizon sequence formed in sandy loam with some fine gravel to a depth of 0.53 m over poorly sorted sand with some

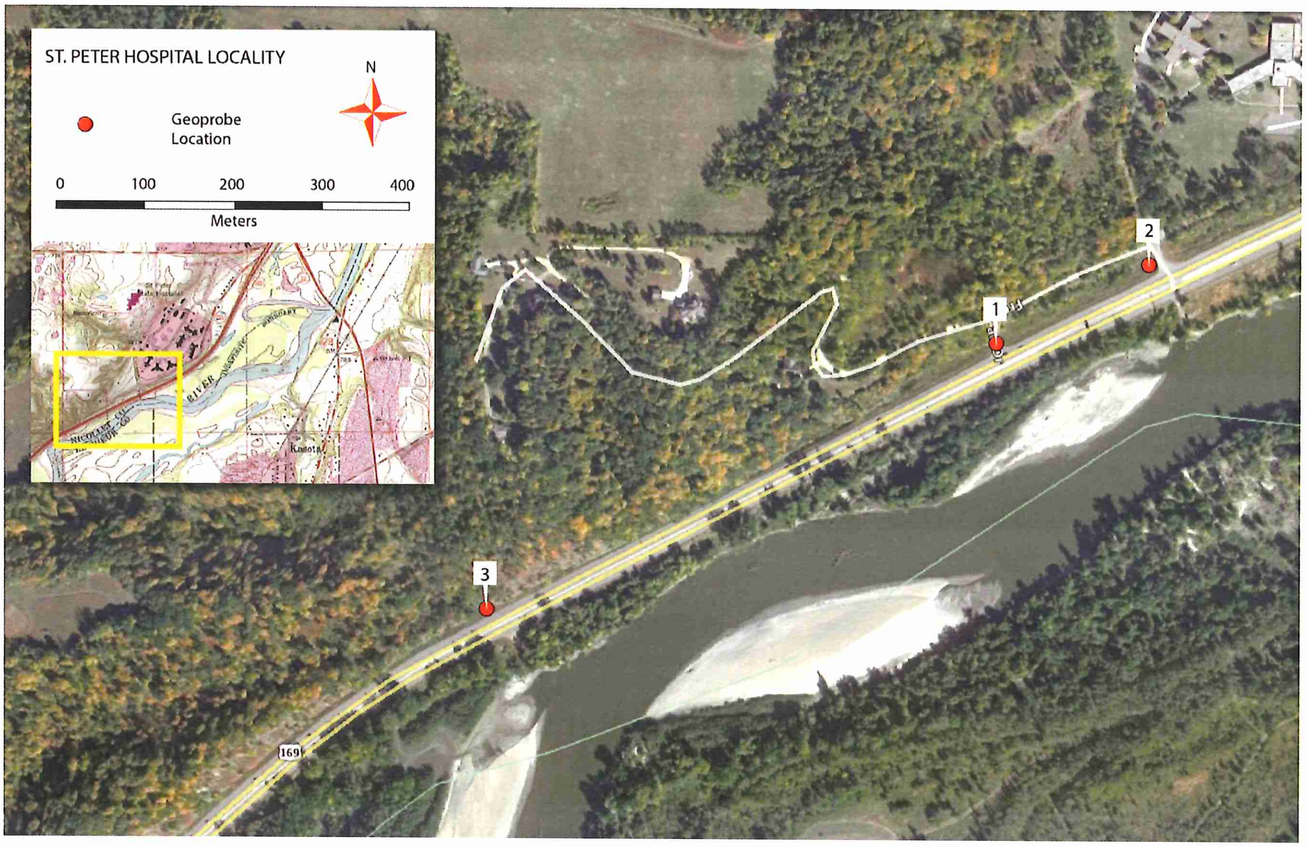

Figure 2. Core locations in the St Peter Hospital Locality plotted on an aerial photograph.

gravel to a depth of 1.36 m, over mixed sand and sandstone colluvium to 1.64 m where there was refusal at solid rock (Appendix A).

Predicted potential for buried archaeological site is based on the Landscape Suitability Rankings (LSR). For the 0-1 meter and 1-2 meter depths for the St Peter Hospital Locality the LSR's are: (1) high at the mouth of the tributary where Core 3 is located, (2) moderate on the floodplain opposite the hospital, (3) low in the abandoned channel at the north end of the locality, and (4) none for the terrace scarp and bluff base. For the 2-5 m depths the LSR's are (1) high for the alluvial fan, (2) low for the floodplain, and (3) none for the abandoned channel and for the terrace and upland scarps. Coring indicated that bedrock overlain by recent colluvium is presently close to the modern surface. It is assumed this is also the case in the northern half of the locality where cores were not extracted. Cores were not extracted on the floodplain or abandoned channel in the northern half of the locality either. This is due to a combination of factors. First, the landscape is wet and young decreasing potential for buried sites. Second, the ROW is barely off the base of the road fill and is inaccessible with the core rig.

SEVEN MILE CREEK LOCALITY

The southern end of the locality is at a point where the Minnesota River channel is very near the base of the road fill along the bluff margin (Figure 1). The channel has recently moved into this position destroying much of the Seven Mile Creek alluvial fan upstream of the Seven Mile Creek channel (see Figures 1, 3 and 4 for different channel positions). To the north the locality is in the Seven Mile Creek alluvial fan channel belt and the Minnesota River floodplain. The floodplain at the locality is an abandoned channel the traces of which are still visible on the 1938 aerial photograph just north (downstream) of the locality (Figure 4). On the west or bluff side of the road the ROW is ditch and slope except at the mouth of Seven Mile Creek.

Stratigraphy at the Seven Mile Creek Locality consists of two major deposits sequences: (1) vertical accretion alluvium in abandoned channels or flood basins and (2) alluvium in the tributary channel belt. The abandoned channel vertical accretion alluvium consists of silt facies and clay facies that are distributed differently in two soil-sediment packages. One soil-sediment package is at the southern end of the cross-section 2-3 meters below the modern surface (Figure 5). It consists of silt facies or silt facies over clay facies. Wood and plant fragment interpreted as float are present at the upper contact of the soil-sediment package in Cores 4 and 15 (Appendix

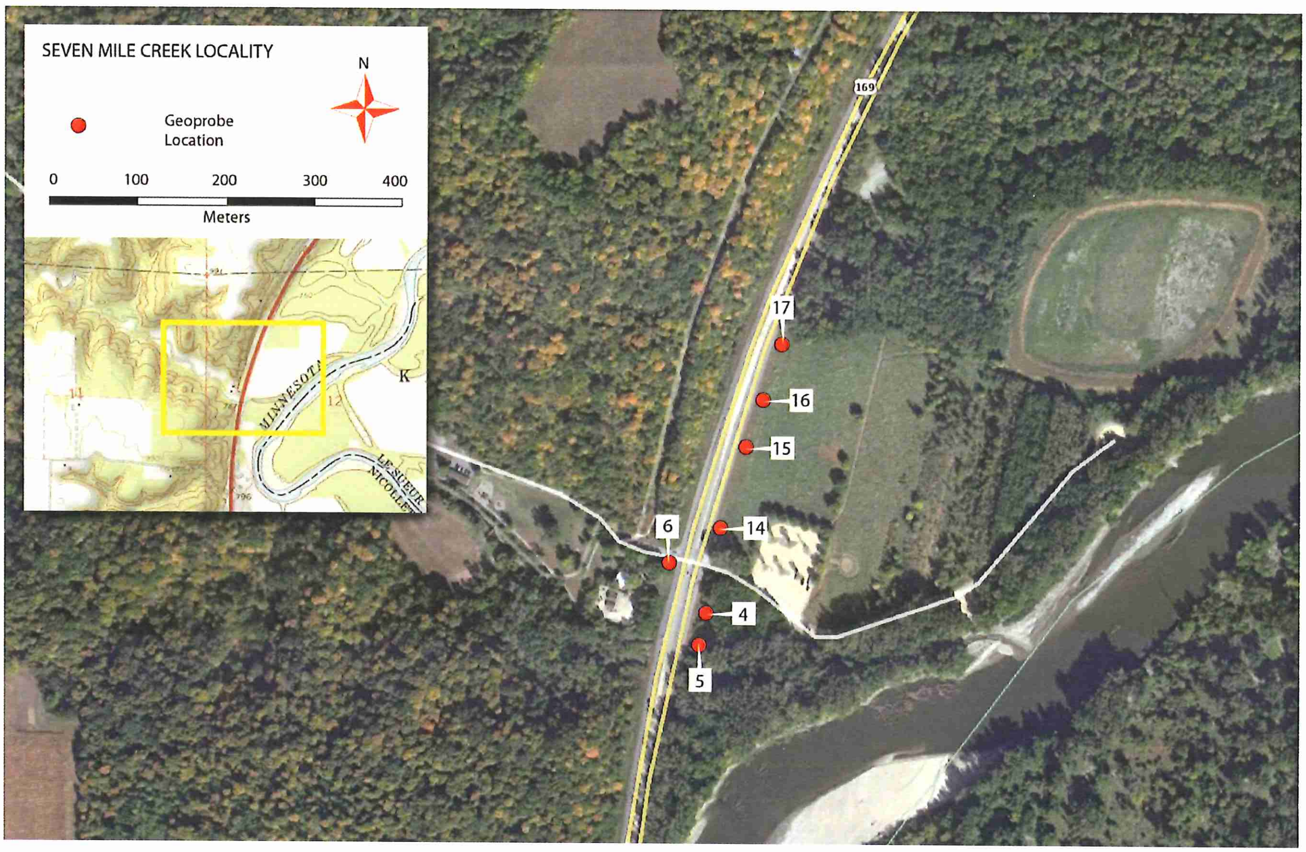

Figure 3. Core locations in the Seven Mile Creek Locality plotted on an aerial photograph.

Figure 4. Seven Mile Creek Locality plotted on a 1938 aerial photograph.

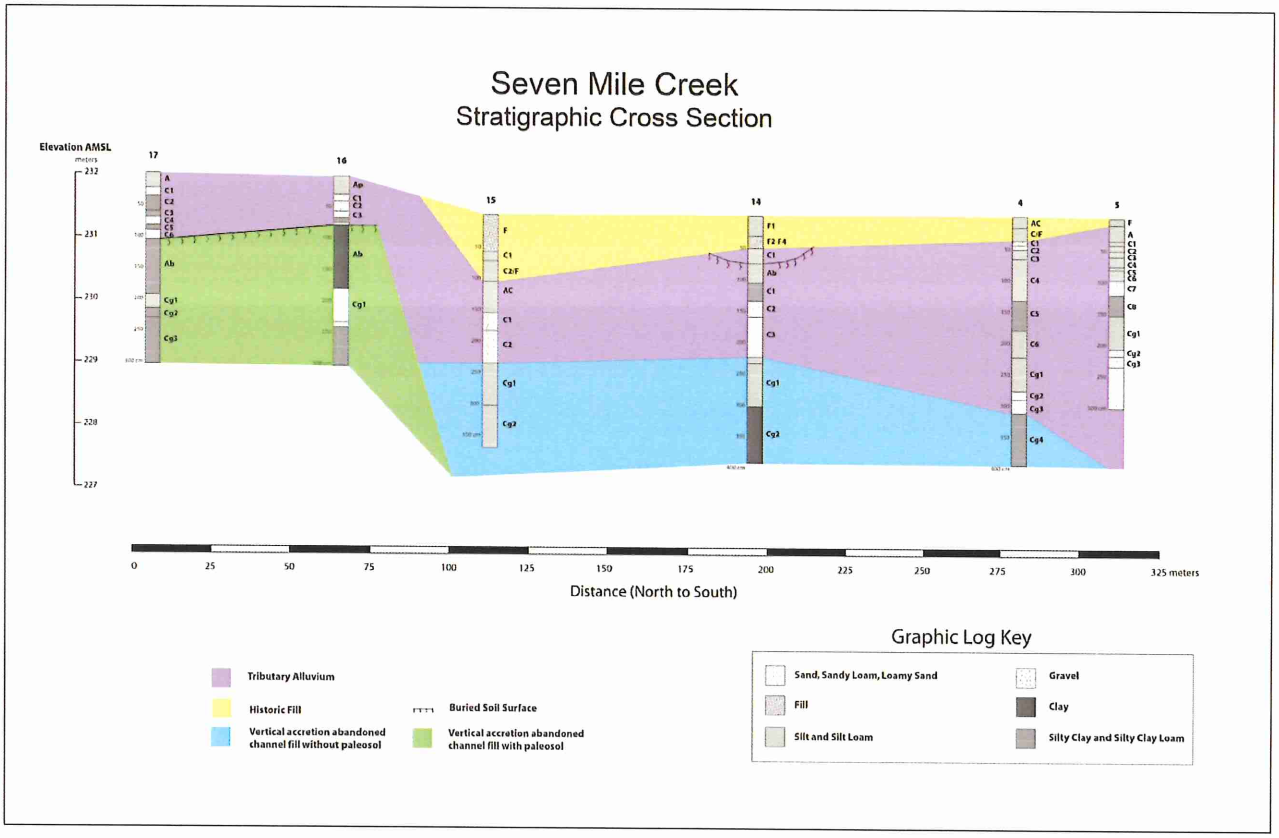

Figure 5. Stratigraphic cross-section at the Seven Mile Creek Locality constructed from cores taken on the east side of US 169 (see Figure 3 for core locations).

A, Figure 5). No buried soil is present and sediment colors indicate an unoxidized, possibly anoxic, geochemical environment. The lack of soil development and the unoxidized environment indicates the deposits accumulated in a floodplain lake or pond and were never exposed at the landscape surface. The second soil-sediment package is at the northern end of the cross-section. It consists of clay facies over siltier facies with some sand interbeds. A soil is formed at the top of the packages but there are no paleosols within the package. This is interpreted as vertical accretion alluvium in an abandoned channel. The abandoned channel fill deposits or other floodplain deposits associated with the abandoned channel were incised by the tributary channel or by a later channel of the Minnesota River.

The abandoned channel deposits are overlain by tributary channel alluvium (Figure 5). These deposits consist of interbedded sandy and silty deposits with a general trend of sandier with depth. Some of the beds form fining upward couplets. A weakly developed soil with an ACb or Ab-C-Cg horizon sequence is formed from the top of the deposit sequence that is buried by historic deposits. No buried soils occur within the tributary alluvial sequence.

Core 6 is located on the west side of US 169 on the floodplain (Figure 3). Stratigraphy consists of fill to a depth of 1.8 m over a soil with an Ab-BCb-C1-C2 horizon sequence formed in silty clay loam alluvium grading down to silty clay alluvium to a depth of 4.87 m (Appendix A). The buried soil beneath the fill has a cumulic A horizon over a weakly developed BC horizon. There is moderate potential for buried archaeological deposits especially in the Ab horizon.

Landscape Suitability Rankings for 0-1 meter depth and 1-2 meter depth are: (1) high in the area of tributary alluvium, (2) moderate on the floodplain north of the tributary channel belt, and (3) none in the abandoned channel north of the floodplain segment at the north end of the locality. For the 2-5 meter depth the ranking is (1) high for the tributary channel belt, (2) low for the floodplain and (3) none for the abandoned channel. Subsurface investigations indicate the tributary channel belt is underlain by young relatively coarse tributary channel alluvium with no internal paleosols. Potential for buried sites only exists at the top of the sequence beneath the fill and these site would be young possibly historic. The buried vertical accretion abandoned channel sequence in the northern 2/3 of the cross-section (see Figure 5) are interpreted as deposits that accumulated in a pond or oxbow lake and were never or rarely exposed at the landscape surface (always subaqueous). They therefore have low potential for buried archaeological deposits. The higher level (terrace) of abandoned channel vertical accretion alluvium does have a hydric paleosol at the top of the sequence under a relatively thin (0.8-1.0 m) unit of tributary channel belt alluvium. There is low-moderate potential for buried archaeological deposit at this location.

RIVER BLUFF ROAD LOCALITY

The Bluff Road Locality is located near the base of the bluff along the west side of the Minnesota River valley (Figure 1). A relatively large alluvial fan is located just outside the northern end of the project area. South of the alluvial fan the highway is on the floodplain for 1066 m (3500 feet). The floodplain consists of an abandoned Minnesota River channel that is visible on an aerial photo as a black arc right at the base of the bluff and is, in part, mapped as Muskego muck, a linear soil body of thin muck over pond sediment (oxbow lake) (USDA n.d.). Ridge and swale topography associated with the abandoned channel is visible on aerial photographs just east of the locality. A number of 1st and 2nd order streams enter the valley along this segment building small alluvial fans that do not extend to the highway. The southern end of the locality is between the base of the bluffs and a recently abandoned channel of the Minnesota River. An alluvial fan at the mouth of a small 3rd order valley has created high ground along the edge of the floodplain within the highway ROW. Cores 7-13 were extracted from the northern half of the fan and the adjacent abandoned channel to the north (Figure 6). The coring portion of the geomorphic investigation indicated the alluvial fan at the locality had potential for buried archaeological deposits so trenching was undertaken to determine if archaeological deposits were present.

The River Bluff stratigraphic cross-section begins at its south end on an alluvial fan that overlies and abandoned channel, crosses an abandoned alluvial channel filled with coarse grained alluvium and ends at its north end in an abandoned channel of the Minnesota River filled with fine grained alluvium (Figure 7). At the north end it is very close to the abandoned ridge and swale topography at the proximal end of the point bar.

Alluvial fan deposits consists of fining upward sequences with a lower channel and near channel facies (CNC) and an upper vertical accretions facies (VA). The CNC facies consist of sand, loam, sandy loam, often with gravel, deposited relatively rapidly during floods on the alluvial fan surface or channel belt. They have linear or lobate geometries and do not blanket the

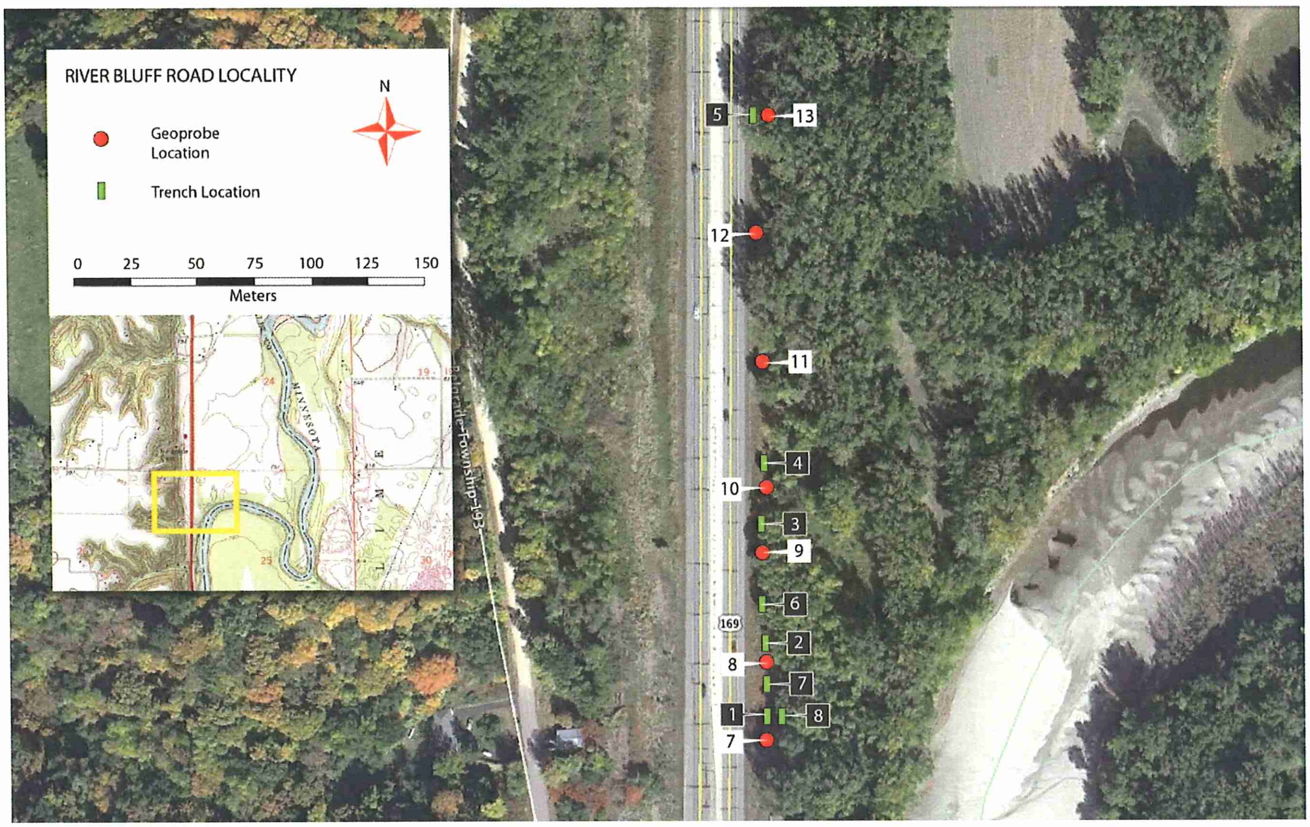

Figure 6. Core and trench locations in the River Bluff Road plotted on an aerial photograph.

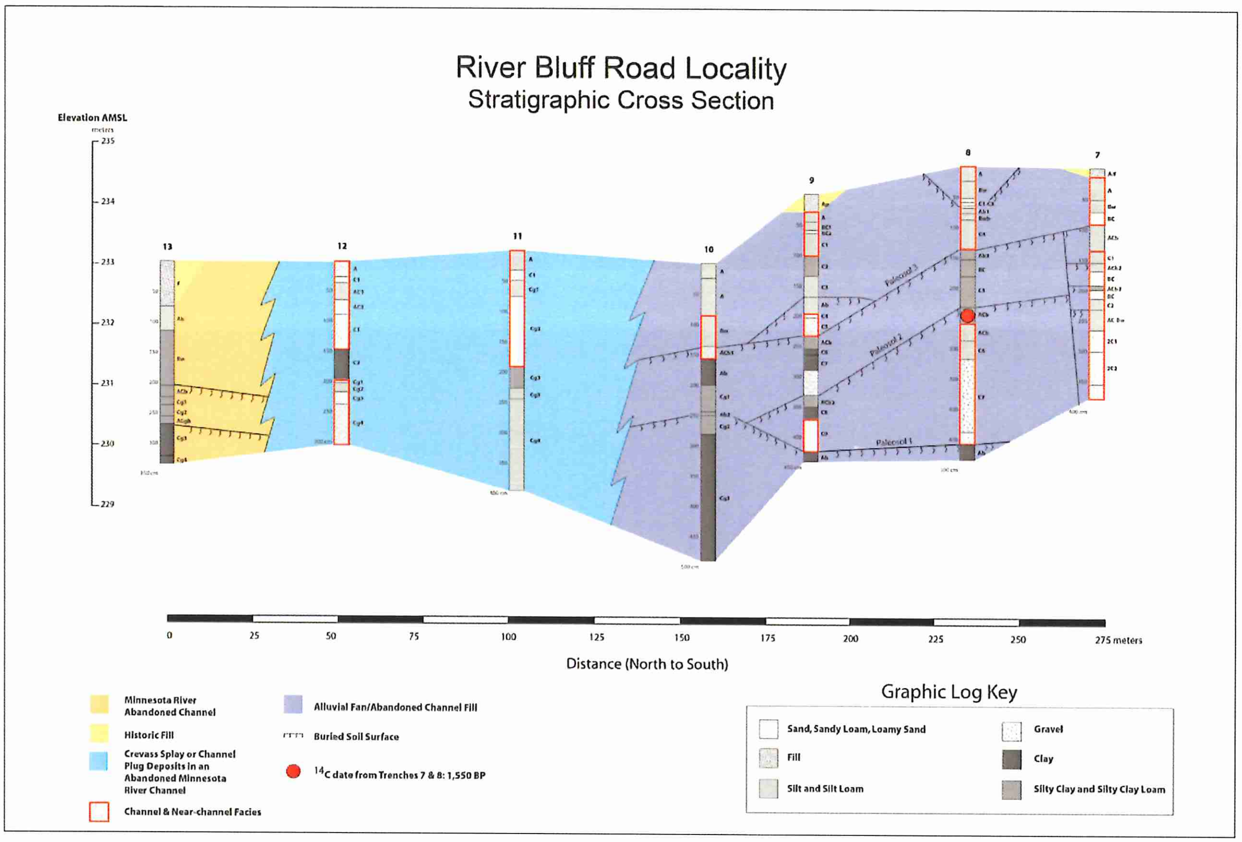

Figure 7. Stratigraphic cross-section located at the River Bluff Road Locality.

fan surface but are spatially circumscribed. The VA facies are heavy silt loam and silty clay loam. They occur as thin caps on the fining upward sequences that become thicker down fan. They were deposited more slowly as overbank sequences (on the fan or from the river) or as down fan fine-grained facies. Weakly developed soils are formed in the fining upward sequence with the A or AC horizon formed in the vertical accretion deposits. A Bw horizon is formed in the surface sequence on the fan. All of the buried soils have A-C or AC-C horizon sequences. A relatively thick CNC facies was deposited above the clayey vertical accretion alluvium in the abandoned Minnesota River channel as the fan prograded out into the valley (Figure 7). This occurred prior to 1550 ^{14}C years BP after the channel was abandoned and at least partially infilled with clay.

Alluvial fan stratigraphy consists of three soil-sediment packages are bounded by soils. The base of the alluvial fan is marked by Paleosol 1, which is formed in abandoned channel vertical accretion deposits (Figure 7). Above Paleosol 1 the alluvial fan consists of three soil-sediment packages the tops of which are marked by Paleosols 2 and 3, and the surface soil. Core 7 at the south end of the cross-section is in the fan channel belt. Paleosols are more numerous in the aggrading alluvial fan channel belt where floods are more discretely recorded in the sedimentary record. These paleosols cannot be correlated with paleosols down fan with the data at hand. Paleosol 2 is the lowest in the alluvial fan. It consists of an ACb-C soil horizon sequence formed in thin VA deposits over CNC deposits. This paleosol contains the archaeological site located in nearby trenches. Two radiocarbon assays on charcoals from the ACb horizon of this paleosol in the trenches yielded two identical dates of 1550 ±30 ^{14}C years BP. Paleosol 3 is also formed in a fining upward sequence but the CNC facies are not as coarse grained. A soil with an Ab-BCb, ACb-C, or ACb-Ab-Cg horizon sequence is formed in these fining upward deposits. The surface soil-sediment package consists of a soil that is slightly better developed with an A or Ap-Bw-C or an A-BC-C horizon sequence.

Off the alluvial fan to the north is an abandoned channel of the Minnesota River that is infilled with crevasse splay or channel plug deposits (Figure 7). Stratigraphy in Cores 11 and 12 consists of a weakly developed hydric soil formed in very fine sand and very fine sandy loam-silt alluvium to depths of 1.80 m and 1.47 m respectively. These strata overlie silty clay loam, loam, and laminated silt in Core 11 and a clay strata over very fine sandy loam and loam in Core 12.

Both these cores are: (1) unoxidized at depth with preserved plant fragment and shell, (2) stratified, and (3) have no paleosols. The sequence is interpreted as young, possibly historic crevasse splays or channel plugs (sensu Saucier 1994) in the abandoned Minnesota River channel. Fine-grained channel fill is assumed to be present below 4 meters.

Core 13 is on the point bar edge of the abandoned channel. Stratigraphy consists of fill to a depth of 0.76 m over a buried soil with an Ab-Bwb horizon sequence formed in silt loam and silty clay loam grading to clay vertical accretion alluvium to a depth of 2.0 m (Figure 7, Appendix A). Below 2.0 m there are two weakly developed hydric paleosols formed in silty clay loam and clay vertical accretion alluvium that accumulated in an abandoned channel.

Deep Testing: Trenching

Potential for deeply buried archaeological sites exist at this locality so trenches were excavated to sample the deposits for buried archaeological material. A buried site (21NL0147) was located at the south end of the locality within the alluvial fan (see archaeology report Terrell et al. 2013).

A total of eight trenches were excavated along the east side of the ROW where coring indicated there was potential for deeply buried archaeological deposits. Initially a trench was excavated at or near the location of each core where buried site potential existed (Figure 7). No trenches were excavated at the locations of Cores 11 or 12 because there is low potential for buried archaeological deposits and the area was wet on the days the trenches were excavated. Profiles in trenches located where cores were extracted were not described in detail but instead notes were taken on the core log forms. Profiles in trenches on the archaeological site were described as the trenches were excavated (see Appendix A). Bone was found in a buried soil in Trench 1 so that trench was bracketed. Trench 7 to the north of Trench 1 was culturally sterile. Trench 8 to the east of Trench 1 and its eastern extension yielded bone and a single projectile point (see Archaeology section of the report for details).

Stratigraphy at the site consists of a surface sequence of channel and near channel facies over vertical accretion facies that are underlain by channel and near-channel facies (Figure 8). The surface soil-sediment package has a weakly to moderately-developed soil with an A-AB-Bw-BC-C or A-AC-C horizon sequence formed in sandy and gravelly CNC facies. It overlies Paleosol 3 that consists of a compound soil with an Ab-C-ACb horizon sequence formed in a

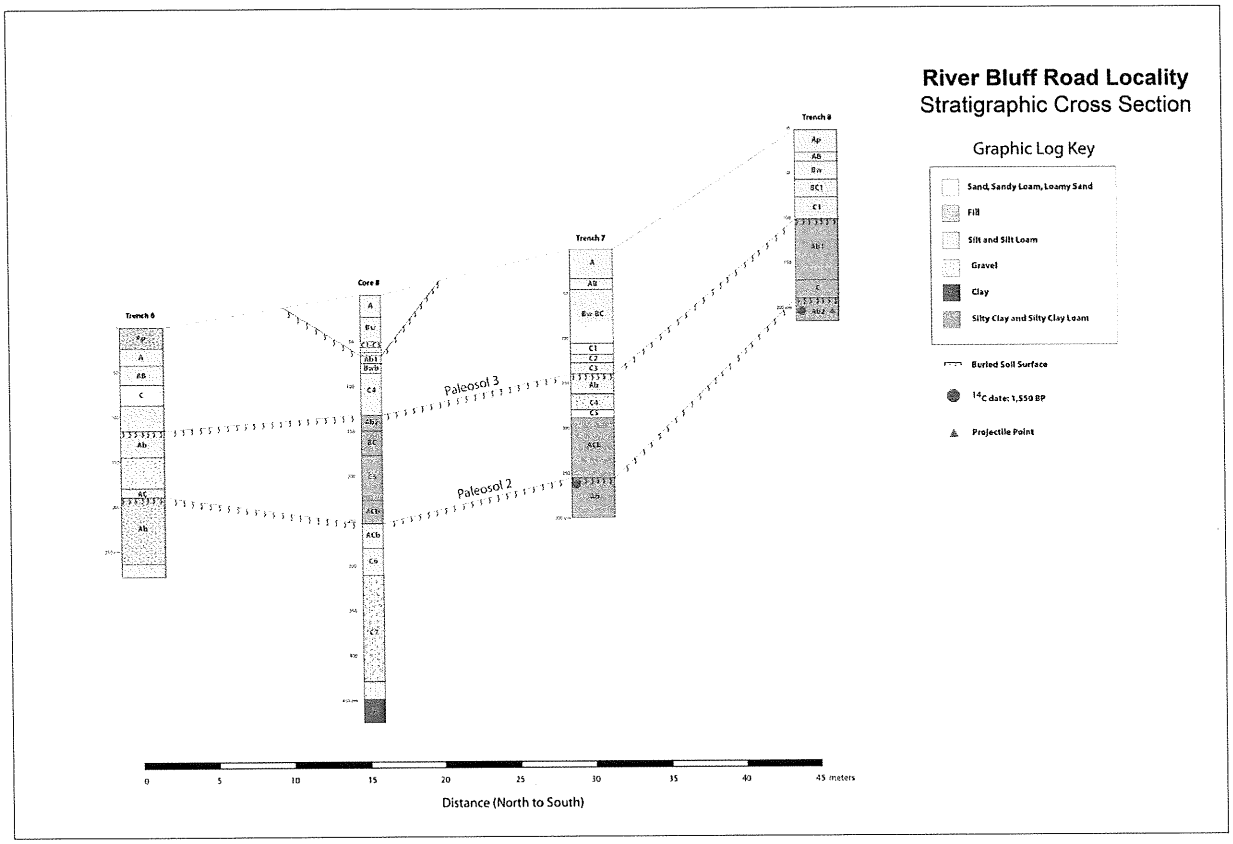

Figure 8. Stratigraphic cross-section located at the River Bluff Road Locality constructed from a core and trenches excavated at the Belgrade Terrace site (21NL0147). This cross-section is a detail of the south end of the longer cross-section at the locality (see Figure 6 for core and trench locations).

thin fining upward stratum over vertical accretion facies (Figure 8). The ACb horizon is cumulic in nature. Paleosol 2 is beneath Paleosol 3. In Trenches 7 and 8 Paleosol 2 has an Ab horizon formed in silty clay loam VA facies deposits. In Core 8 it has a thick cumulic ACb horizon over a C horizon formed in sandy CNC facies deposits (Figure 8). Down slope to the north in Trench 6 Paleosols 2 and 3 are formed in poorly sorted CNC facies that may have been deposited as debris flows in a secondary channel. The archaeological deposits consisting of bone and a single artifact are located in the Ab horizon of Paleosol 2. This horizon is a very dark gray silty clay loam with ± 5% very fine and occasional gravel. Charcoal and shell fragments are also present. Charcoal obtained from Paleosol 2 in Trenches 7 and 8 yielded identical AMS dates of 1550±30 ^{14}C years BP (Cal AD 430-580) (Appendix B). Below the dated paleosol in Core 8 is another unit of channel and near channel facies over another paleosol at a depth of 4.6 m formed in vertical accretion deposits (Figure 8).

HINIKER CREEK SECTION

The Hiniker Creek Locality is on the floodplain of the Minnesota River/tributary channel belt and a terrace at the mouth of a small 3rd order drainage basin (Figure 1). The west side of the locality is right at the base of the bluff. In the southern end of the locality there is a triangular shaped terrace along an abandoned Minnesota River channel. Both the terrace (lighter color tones) and the abandoned channels are visible on the 1938 aerial photograph. Soil maps show the terrace as Dickson series (USDA n.d.): a mollisol formed in eolian sand. The terrace in the project area appears to be undergoing surface modification of the 1973 aerial photo. The point bar associated with the abandoned channel south and east of the locality is being mined for sand on 1973 and 1994 aerial photographs. Cores 18 and 19 were extracted from the terrace surface and 20 and 21 from the floodplain/alluvial channel belt (Figure 9).

Four cores were extracted across the mouth of the valley (Figure 9). Core 18 is farthest south and closest to the abandoned Minnesota River channel. Stratigraphy consists of fill over silt loam alluvium to 1.43 m, over a sequence of silty clay loam and clay alluvium with sand interbeds to 3.34 m, over medium sand alluvium to 3.96 m (Appendix A). The surface soil is truncated and the remaining soil horizon sequence is C and Cg horizons. Deposits and stratigraphy indicate the sequence is the result of vertical accretion on the floodplain with episodic crevasse splay deposition during large floods.

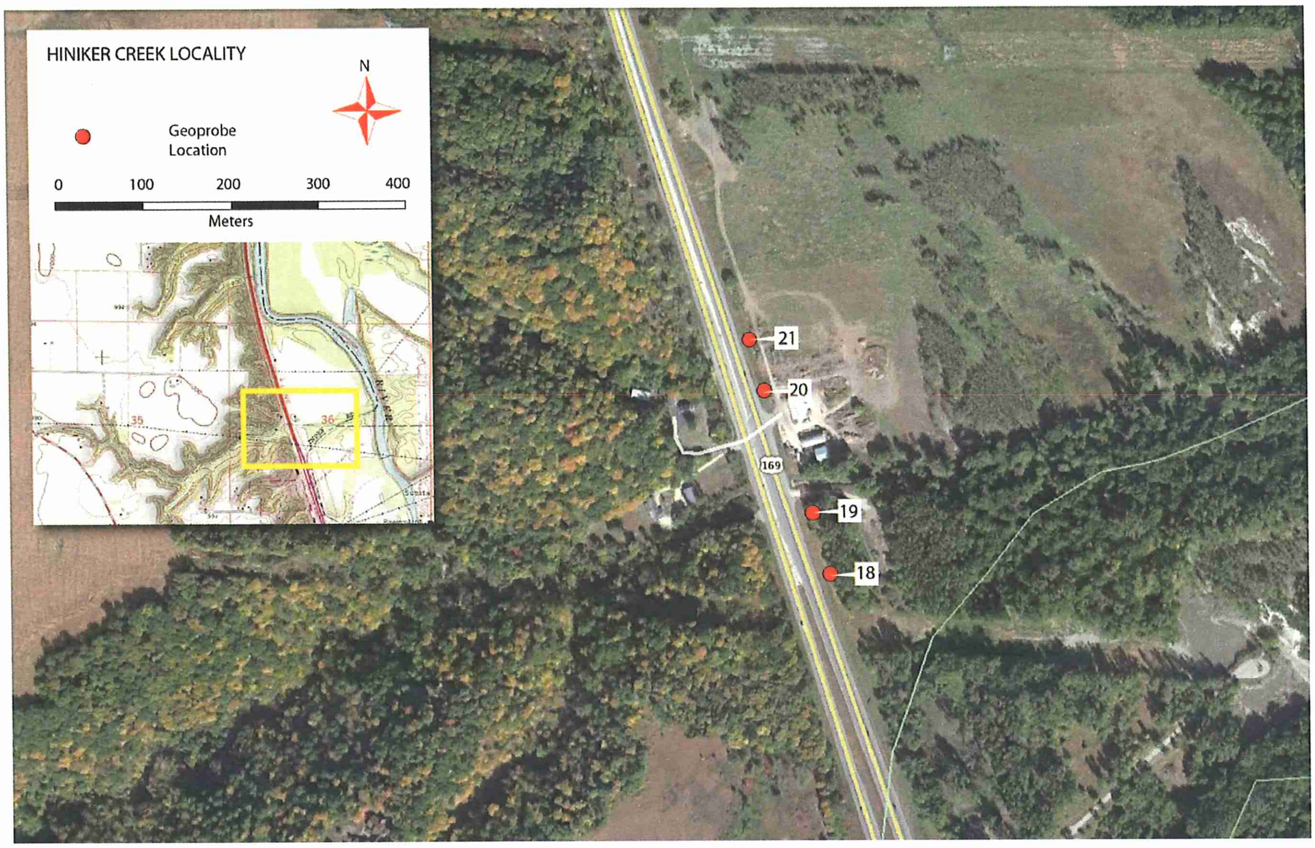

Figure 9. Core locations in the Hiniker Creek Locality plotted on an aerial photograph.

Core 19 is north of Core 18 on a higher landscape surface (Figure 9). Stratigraphy consists of a soil with a Bt-Bw horizon sequence formed in gravelly sandy loam over sandy loam alluvium to a depth of 1.50 m, over a Bw horizon and a series of BC-C horizons formed in stratified silt loam and very fine sandy loam with occasional gravel to a depth of 2.85 m over interbedded laminated silt loam and medium to very coarse sand (Appendix A). The degree of soil development and the deposit stratigraphy indicate the sequence is a meltwater stream terrace remnant or possibly an early primary alluvial fan remnant.

Core 20 is in the tributary channel belt (Figure 9). The surface soil is truncated and there is 6 cm of fill at the surface. The fill overlies a thin diamicton over gravelly sandy loam and sandy loam beds to a depth of 0.60 m over laminated silt loam tributary channel belt deposits to a depth of 1.38 m. The alluvial fan deposits very abruptly overlie gravelly sand, over interbedded sand and sandy loam, over silt loam, over gravelly sand alluvial channel or meltwater stream deposits. Weakly developed BC horizons are present just below the fill otherwise there is no soil development.

Core 21 is farther away from the alluvial fan apex but still in the alluvial fan channel belt (Figure 9). Stratigraphy consists of fill to a depth of 0.80 m over a sequence of interbedded silt loam and very fine sandy loam and laminated silty clay loam with a few coarse and medium sand interbeds to a depth of 2.51 m over laminated very fine sand to a depth of 3.96 m. The sequence is the result of vertical accretion of alluvium on the floodplain with episodic deposition of coarser tributary alluvium or crevasse splay alluvium creating the observed stratigraphy. Crevasse splays originating from the abandoned channel south of the locality on 1938 air photo are evidence for main channel flooding onto the low floodplain in the northern portion of the locality.

The modern landscape surface is disturbed as evidenced by the truncated soil profiles in all of the cores. A well-developed subsoil consisting of Bt and Bw horizons is present in Core 19 indicates the terrace could correlate with other meltwater stream terraces across the valley and therefore may be as old as late Pleistocene to early Holocene. Core 18 is also on the terrace but the solum is missing. A well-developed soil may also have been present in the area of Core 18 but was removed by historic land-use activity. Potential for deeply buried archaeological deposits beneath the terrace surface are low due to the estimated age of the terrace and the lack of fine-grained vertical accretion depositional environments.

Cores 20 and 21 in the tributary channel belt/floodplain have very weak soil development and no buried soils are present in either of the cores. These deposits are interpreted as having accumulated on the floodplain with episodic influx of tributary alluvium and crevasse splay alluvium. The presumed young age (lack of soil development and association with crevasse splay surface morphology) indicates the potential for deeply buried archaeological deposits are low.

LSR's for the Hiniker Creek Locality are, for 0-1 and 1-2 meter depths, moderate for the floodplain and none for the abandoned channel and for 2-5 m are low for the floodplain and none for the abandoned channel.

DISCUSSION AND CONCLUSIONS

The Holocene evolution of the project area is discussed in the context of a series of regional and local events that elicited geomorphic response. It begins between 10,000 and 11,000 years ago with the creation of the Minnesota River valley. Large floods issuing from Glacial Lake Agassiz down River Warren incised the valley. Incision of the main valley then led to development of the tributaries as they adjusted to the new lower base level by down-cutting the headward extension of their channels. This would create incised valleys not only in the uplands but also along the bluff margins and in the high terraces. The reach of the Minnesota River valley where the project area is located is fluvially-dominated consisting of meltwater stream/catastrophic flood terraces with an incised channel belt that is predominately active and abandoned point bars (ridge and swale topography) and channels with associated levees and crevasse splays. Lakes that dominate the valley landscape south of Carver are not present. Potential for deeply buried archaeological deposits is diminished because the alluvial landforms in the Minnesota River channel belt between Mankato and St Peter are young. Minor incision and lateral channel migration has removed older landscape surfaces. Evidence for a young alluvial valley bottom is as follows.

First, with a few exceptions soils encountered in the trenching and coring are weakly developed. Profiles had A-C or A-Cg horizon sequences at most localities. The A horizons were often thin or when lower on the landscape, cumulic. The exceptions are the surface soil on the alluvial fan at the River Bluff Road Locality where thin Bw horizons underlie A or Ap horizons and at the Hiniker Creek Locality where, on a terrace or primary fan remnant, there is a relatively well developed Bt horizon formed from the modern surface. Soils mapped on the floodplain in the project area valley reach are also weakly developed with A or Ap-C or Cg horizon sequences (USDA n.d.).

Second, alluvial fans are small or absent at the tributary valley mouths because the main channel of the Minnesota River has episodically meandered up against the base of the bluff removing older alluvial fan sequences. Subsequent flooding in the tributary valleys have created channel belts or very low angle alluvial fans out in the floodplain.

Third, a recent investigation (Gran et al. 2009) has documented (1) an incision event 1540 years ago that may have initiated a period of late Holocene channel migration and incision in the Minnesota River valley, (2) a trend to river channel widening and higher channel migration rates since Euro-American settlement, and (3) an increase in channel width and rate of lateral migration of the Minnesota River channel over the last 60-70 years.

The late Holocene incision event is documented by an OSL date from a terrace at the mouth of the Le Sueur River on the west side of Mankato. The date is 1.54 ±0.23 ka cal years BP (1,540 ±230 years ago or AD 473 with a range of AD 243-703) (Gran et al. 2009). This incision may also have initiated channel instability and a period of channel migration. The dates of the incision correspond closely with the dates from the alluvial fan at the River Bluff Road Locality (1550±30 ^{14}C years BP; cal AD 430 – 580). The date from the alluvial fan marks the time when the alluvial fan prograded over an abandoned and filled channel of the Minnesota River. Activation of the alluvial fan channel and progradation of the fan onto the floodplain may have been initiated by the late Holocene incision event.

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APPENDIX A: CORE LOGS

(gray fill indicates buried landscape surfaces)

Core 1

Depth	Horizon	Description
0-14	AC	*Fill* Very dark grayish brown (10YR 3/2) SANDY LOAM topsoil; fine grained; very abrupt boundary.
14-50	F1	Brown – dark grayish brown (10YR 4/3 – 4/2) SAND – SANDY LOAM with gravel; abrupt boundary.
50-67	F2	Olive green (5Y 4/2) poorly sorted, over-compacted diamicton with red clay inclusions; very abrupt boundary.
67-78	C1	*Colluvium* Yellowish brown (10YR 5/4) medium SAND over very pale brown (10YR 6/2) SAND; bedrock source sand.
78-135	C2	Mixed SAND and SANDSTONE; refusal.

Core 2

Depth	Horizon	Description
0-12	AC	*Fill* Topsoil.
12-20	F	Mixed SANDY LOAM, SAND, and SANDSTONE GRAVEL; very abrupt boundary.
20-53	F	Very dark grayish brown (10YR 3/2) CLAY LOAM diamicton; very abrupt boundary.
53-105	**Ab**	*Alluvium* Black (N 2.5/) SILT LOAM; common snail shell fragments; common faint redox features; weak pedo-structure; few lighter colored soil inclusions below 85cm; flat-lying sandstone at 59cm.
105-138	C1	Mixed brown, dark grayish brown and yellowish brown (10YR 5/3, 4/2 & 5/4) poorly sorted SILT LOAM; very abrupt boundary.
138-213	Cr	*Colluvium/Weathered Bedrock* Brown (10YR 4/3) SANDY LOAM interbedded and mixed with light gray (5Y 7/2) weathered siltstone and shale; bedrock source colluvium.

Core 3

Depth	Horizon	Description
0-21	F1	*Fill* Very dark gray (10YR 3/1) SAND and GRAVEL; road fill; abrupt boundary.
21-27	F2	Rock.
27-34	F3	Very dark grayish brown (10YR 3/2) medium – very coarse SANDY LOAM; abrupt boundary.
34-53	A	*Alluvium/Colluvium* Dark gray – very dark gray (10YR 4/1 – 3/1) SANDY LOAM; 2% fine gravel; very abrupt boundary.
53-136	BC	Brown (10YR 4/3) poorly sorted SAND with 3% fine gravel; abrupt boundary.
136-165	Cr	*Colluvium/Weathered Bedrock* Grayish brown – dark grayish brown (10YR 5/2 – 4/2) SAND and SANDSTONE; colluvium/weathered sandstone; refusal at bedrock.

Core 4

Depth	Horizon	Description
0-16	AC	*Alluvium* Very dark grayish brown – very dark gray (10YR 3/2 – 3/1) SILT LOAM; moderate medium and fine angular blocky structure; abrupt boundary.
16-38	C/F	*Fill* Very dark grayish brown (10YR 3/2) heavy SILT LOAM with 2% gravel; unleached.
38-47	C1	*Alluvium* Cobble-pebble gravel; unleached; abrupt boundary.
47-50	C2	Sand bed; unleached; very abrupt boundary.
50-63	C3	Very dark grayish brown – very dark gray (10YR 3/2 – 3/1) SILT LOAM; 10% very fine sand; few laminae; unleached; abrupt boundary.
63-132	C4	Very dark grayish brown (10YR 3/2) SILT LOAM; 15% very fine sand; unleached; abrupt boundary.
132-180	C5	Dark gray – very dark gray (10YR 4/1 – 3/1) light SILTY CLAY LOAM; few very thin lamella; roots; few faint redox features; unleached; abrupt boundary.
180-224	C6	Dark gray – dark grayish brown (10YR 4/1 – 4/2) heavy SILT LOAM; few distinct thin laminae; platy parting; common distinct redox features on bed planes; unleached; abrupt gradational boundary.
224-268	Cg1	Interbedded dark gray (2.5Y 4/1) SILT LOAM, olive brown (2.5Y 4/3) very fine SAND and LOAMY SAND; unleached; abrupt gradational boundary.
268-290	Cg2	Dark greenish gray (10Y 4/1) very fine LOAMY SAND; few silt laminae; unleached.
290-312	Cg3	Olive green (5Y 4/2) fine SAND; unleached; very abrupt boundary.
312-396	Cg4	Dark greenish gray (10GY 4/1) SILTY CLAY LOAM; plant fragments; homogeneous color; leached; platy parting.

Core 5

Depth	Horizon	Description
0-11	F	*Fill* Fill from asphalt path construction; very abrupt boundary.
11-39	A	*Alluvium* Very dark gray – very dark grayish brown (10YR 3/1 – ¾) SILT LOAM – very fine SANDY LOAM; medium angular pedo-structure; very abrupt boundary.
39-44	C1	Laminated SILT LOAM and very fine SANDY LOAM; very abrupt boundary.
44-51	C2	Dark gray (10YR 4/1) SILT LOAM; common distinct redox features; abrupt gradational boundary.
51-61	C3	Dark gray – dark grayish brown (10YR 4/1 – 4/2) laminated SILT LOAM & very fine SANDY LOAM.
61-75	C4	Dark gray (10YR 4/1) SILT LOAM; common distinct redox features; abrupt gradational boundary.
75-77	C5	Dark gray – dark grayish brown (10YR 4/1 – 4/2) laminated SILT LOAM & very fine SANDY LOAM.
77-94	C6	Dark gray – dark grayish brown (10YR 4/1 – 4/2) SILT LOAM; common faint redox features; very abrupt boundary.
94-122	C7	Brown (10YR 4/3) medium SANDY LOAM; very abrupt boundary.
122-155	C8	Dark gray (2.5Y 4/1) – dark grayish brown (2.5Y 4/2) SILTY CLAY LOAM; common distinct redox features; platy parting; very abrupt boundary.

155-210	Cg1	Greenish gray (10Y 5/1) stratified heavy SILT LOAM and fine LOAMY SAND.
210-220	Cg2	SAND.
220-237	Cg3	Dark gray (N 3/) – dark greenish gray(10Y 5/1) .
237-304	Cg4	Dark greenish gray (10Y 4/1) medium SAND.

Core 6

Depth	Horizon	Description
0-188	F	*Fill* Mixed natural source fill; sand with some clayey inclusions; occasional gravel; large pebble/cobble at base; very abrupt boundary.
188-240	**Ab**	*Alluvium* Very dark gray (10YR 3/1) heavy SILT LOAM – SILTY CLAY LOAM; 5-10% sand; few very coarse grains and granules; few pebbles; medium granular structure; abrupt boundary.
240-285	BCb	Very dark grayish brown (10YR 3/2) SILTY CLAY LOAM; weakly bioporous; charcoal at 256cm.
285-345	C1	Dark grayish brown – very dark grayish brown (10YR 3/2 – 4/2) SILTY CLAY LOAM; massive; bioporous.
345-487	C2	Dark grayish brown (10YR 4/2) SILTY CLAY; slightly darker between 430 and 445 cmbs.

Core 7

Depth	Horizon	Description
0-12	A/F	*Fill* SANDY LOAM with pebbles; unleached; fill.
12-50	A	*Alluvial Fan* Very dark gray – very dark grayish brown (10YR 3/1 – 3/2) SILT LOAM; medium sand with few pebbles; unleached; moderate pedo-structure; abrupt boundary.
50-71	Bw	Very dark grayish brown (10YR 3/2) SILT LOAM – LOAM; weak medium prismatic parting to medium and fine angular blocky structure; 5% granules; unleached; clear boundary.
71-92	BC	Dark grayish brown (10YR 4/2) SANDY LOAM – sticky LOAM; occasional granules – fine pebbles; unleached; abrupt boundary.
92-137	**ACb**	Brown (10YR 4/3) heavy SANDY LOAM mixed with darker-colored soil below 122cm; charcoal; unleached; **C14 sample taken.**
137-154	C1	Laminated light olive brown (2.5Y 5/3) SILT LOAM with very fine sand mode; unleached; unleached.
154-163	**ACb2**	Dark grayish brown (10YR 4/2) heavy SILT LOAM; white masses; unleached.
163-186	BC	Olive brown (2.5Y 4/3) SANDY LOAM; indistinct bedding at base; unleached; very abrupt boundary.
186-198	**ACb3**	Very dark gray (10YR 3/1) SILTY CLAY LOAM; white masses; bone; abrupt boundary; **C14 sample taken.**
198-213	BC	Olive brown (2.5Y 4/3) SANDY LOAM; weak pedo-structure.
213-231	C2	Laminated light olive brown (2.5Y 5/3) SILT LOAM; very abrupt boundary.
231-261	AC-Bw	Very dark grayish brown (10YR 3/2) SILT LOAM over brown (2.5Y 4/3) SILT LOAM – LOAM; moderate pedo-structure; common shell; abrupt gradational boundary.
261-300	C3	Medium SAND with some gravel laminated with bedded SILT LOAM, very fine SANDY LOAM.
300-356	C4	Coarse and very coarse SAND with fine pebbles from 310-315 cmbs;

		laminated SILT LOAM from 338-354cm.
356-375	C5	SAND with few gravel clasts.

Core 8

Depth	Horizon	Description
0-22	A	*Alluvial Fan* Very dark gray (10YR 3/1) SILT LOAM; 5% very fine sand; moderate fine angular blocky structure; clear boundary.
22-52	Bw	Very dark grayish brown (10YR 3/2) SILT LOAM – LOAM; fine pebbles and small coarse and very coarse sand mode; 5% gravel; very abrupt boundary.
52-55	C1	LOAMY SAND with few rounded pebbles.
55-63	C2	Very dark grayish brown (10YR 3/2) very fine SANDY LOAM – SILT LOAM.
63-65	C3	SANDY LOAM bed.
65-71	**Ab1**	Very dark gray (10YR 3/1) heavy SILT LOAM; very abrupt boundary.
71-85	Bwb	Brown (10YR 4/3) SILT LOAM – LOAM; poorly sorted; weak pedo-structure.
85-137	C4	Layered SILT LOAM – LOAM; sand bed at 130cm; very abrupt boundary.
137-155	**Ab2**	Very dark grayish brown (10Yr 3/2) SILTY CLAY LOAM; poorly sorted; 10% sand; charcoal; very fine sand bed at base; very abrupt boundary.
155-182	BC	Dark grayish brown – brown (10YR 4/2 – 4/3) SILTY CLAY LOAM; poorly sorted; 3% sand; gravelly sand at base.
182-233	C5	Brown (10YR 4/3) SILTY CLAY LOAM; 1-2% sand; laminae at base; very abrupt boundary.
233-260	**ACb**	Variegated color; very dark gray, brown and very dark grayish brown; shell and charcoal; charcoal at 253 cm; sandy at base.
260-290	ACb	Darker with sandier beds.
290-320	C6	Grayish brown (10YR 5/2) SILT LOAM; clear boundary.
320-440	C7	Stratified SAND and GRAVELLY SAND with fine silty clay loam beds.
440-460		Stratified SANDY LOAM with occasional loam beds.
460-487	**Ab**	*Alluvium* SILTY CLAY LOAM

Core 9

Depth	Horizon	Description
0-23	Ap	*Alluvial Fan* Topsoil fill from road construction; ; unleached; very abrupt boundary.
23-46	A	Very dark gray (10YR 3/1) SILT LOAM; very abrupt boundary.
46-59	BC1	Brown – dark brown (10YR 4/3 – 3/3) SILT LOAM – LOAM; unleached; clear gradational boundary.
59-66	BC2	Brown – dark brown (10YR 4/3 – 3/3) SANDY LOAM with sand laminae at base; unleached; very abrupt boundary.
66-100	C1	Brown – dark brown (10YR 4/3 – 3/3) SILT LOAM – LOAM; unleached; poorly sorted.
100-136	C2	Mixed dark grayish brown and brown (10YR 4/2 & 4/3) SILTY CLAY LOAM; unleached; abrupt boundary.
136-167	C3	Brown – dark brown (10YR 4/3 – 3/3) SILT LOAM; ; unleached; 5% sand.
167-194	**Ab**	Very dark grayish brown – very dark gray (10YR 3/2 – 3/1) heavy SILT LOAM; moderate medium subangular blocky parting to fine angular blocky structure; unleached; clear boundary.
194-205	C4	Brown (10YR 4/3) LOAM; unleached; very abrupt boundary.
205-231	C5	Brown – dark brown (10YR 4/3 – 3/3) LOAM; unleached; stickier with depth; very abrupt boundary.
231-256	**ACb**	Dark gray – dark grayish brown (10YR 4/1 – 4/2) SILTY CLAY LOAM – CLAY; unleached; clear gradational boundary.
256-264	C6	Dark gray – dark grayish brown (10YR 4/1 – 5/2) CLAY with 1-5% sand; unleached; very abrupt boundary.
264-290	C7	Dark grayish brown (10YR 4/2) CLAY; 1-2% sand.
290-330	C8	Brown and dark grayish brown (10YR 4/3 & 5/2) CLAY LOAM and CLAY; all poorly sorted; unleached; very abrupt boundary.
330-350	**ACb2**	Dark gray – dark grayish brown (10YR 4/1 – 4/2) SILTY CLAY LOAM – CLAY; unleached; abrupt boundary.
350-370	C9	Stratified CLAY and LOAM; unleached.
370-423	C10	Brown (10YR 4/3) light SANDY LOAM with gravel unleached.
423-440	**Ab**	*Alluvium* CLAY with sandy laminae at top; unleached.

Core 10

Depth	Horizon	Description
0-26	A1	*Alluvial Fan* Very dark gray (10YR 3/1) SILT LOAM; unleached; very abrupt boundary at sandy loam bed.
26-84	A2	Very dark gray (10YR 3/1) – very dark grayish brown (10YR 3/2) SILT LOAM; 1-2% sand; moderate medium subangular blocky parting to fine subangular blocky structure; unleached; few very fine pebbles; charcoal at 95cm; clear gradational boundary.
84-136	Bw	Brown (10YR 4/3) SILT LOAM – LOAM – SANDY LOAM; moderate medium subangular blocky structure; very abrupt boundary.
136-153	ACb1	Very dark grayish brown – dark brown (10YR 3/2 – 3/3) LOAM; unleached; massive; very abrupt boundary.
153-200	**Ab**	Very dark gray (10YR 3/1) CLAY; trace of sand.
200-237	Cg1	Dark grayish brown (2.5Y 4/2) SILTY CLAY LOAM; trace of sand; few faint redox features; unleached; very abrupt boundary.
237-248	**Ab2**	*Alluvium* Very dark grayish brown (2.5Y 3/2) with small layer of very dark gray (7.5Y 3/2) at top SILTY CLAY LOAM; unleached; abrupt boundary.

248-280	Cg2	Olive brown – light olive brown (2.5Y 4/3 – 5/3) SILTY CLAY LOAM; unleached; chert pebbles.
280-487	Cg3	Dark gray (2.5Y 4/1) CLAY; common distinct redox features; 10-15% olive brown, increasing with depth; unleached.

Core 11

Depth	Horizon	Description
0-30	A	*Alluvium* Very dark grayish brown (10YR 3/2) SILT LOAM; 15% very fine sand; very abrupt boundary.
30-48	C1	Bedded SANDY LOAM with gravel; very abrupt boundary.
48-74	Cg1	Dark gray – very dark gray (10YR 3/1 – 4/1) laminated SILT LOAM; many distinct redox features; abrupt boundary.
74-190	Cg2	Dark greenish gray (10Y 4/1) very fine SAND – SILT; redox to 134 cmbs; homogeneous color below 134 cmbs; increase in silt % with depth.
190-226	Cg3	Greenish gray (10Y 5/4) SILTY CLAY LOAM.
226-242	Cg3	Dark greenish gray (10Y 4/1) SILT LOAM over LOAM; very abrupt boundary.
242-396	Cg4	Very thin laminated gray (N5/) and olive (5Y 4/3); many distinct redox features below 330cmbs; shell and plant fragments above 251cmbs.

Core 12

Depth	Horizon	Description
0-24	A	*Alluvium* Very dark grayish brown (10YR 3/2) LOAM; unleached; very abrupt boundary.
24-37	C1	Brown (10YR 4/3) SANDY LOAM; clay inclusion at 36 cm; unleached; very abrupt boundary.
37-65	AC1	Very dark gray – very dark grayish brown (10YR 3/1 – 3/2) SILT LOAM; laminae at base and 54cm; unleached; laminae are silt and sand with more clay; very abrupt boundary.
65-88	AC2	Very dark grayish brown – very dark gray (10YR 3/2 – 4/1) very fine SANDY LOAM and SILT LOAM; stratified; unleached; very abrupt boundary.
88-147	C2	Dark gray (10YR 4/1) very fine SANDY LOAM – SILT LOAM; common distinct redox features; roots; unleached; clear boundary.
147-194	C3	Dark grayish brown (10YR 4/2) CLAY; common distinct redox features; bioporous; unleached; very abrupt boundary.
194-198	Cg	Dark gray – dark grayish brown (10YR 4/1 – 4/2) very fine SANDY LOAM; common distinct redox features; unleached.
198-218	Cg	Dark gray – dark grayish brown (10YR 4/1 – 4/2) SILT LOAM; common distinct redox features; unleached.
218-236	Cg	(10GY 5/1 & 4/1) laminated very fine SANDY LOAM; unleached.
236-304	Cg	Dark greenish gray (10GY 4/1) LOAM; all silt, very fine sand and clay; indistinct fine laminae; unleached.

Core 13

Depth	Horizon	Description
0-76	F	*Fill* Natural source FILL; very abrupt boundary.
76-118	**Ab**	*Alluvium* Very dark grayish brown (10YR 3/2) SILT LOAM; 15% very fine sand; moderate medium subangular blocky structure.
118-204	Bw	Dark brown (10YR 3/3) SILTY CLAY LOAM grading to CLAY; common faint redox features; very abrupt boundary.
204-225	ACb	Very dark grayish brown (10YR 3/2) SILTY CLAY LOAM; abrupt gradational boundary.
225-233	Cg1	Brown – olive brown (10YR 4/3 – 2.5Y 4/3) SILT LOAM – SILTY CLAY LOAM; 5% very fine sand; common faint redox features.
233-258	Cg2	Very dark gray (2.5Y 3/1) SILTY CLAY LOAM – CLAY; few – common faint redox features; abrupt boundary.
258-270	ACgb	Very dark gray (N 3/) heavy SILTY CLAY LOAM; few shell fragments; few faint redox features.
270-320	Cg3	Dark gray – very dark gray (2.5Y 4/1 – 3/1) CLAY; shell; homogeneous color.
320-330	Cg4	Dark gray (2.5Y 4/1) CLAY.

Core 14

Depth	Horizon	Description
0-32	F1	*Fill* Very dark gray (10YR ¾) heavy SILT LOAM.
32-50	F2-F4	Wash from road.
50-73	C1	Very dark gray (10YR 3/1) with lighter soil inclusions; abrupt boundary.
73-108	**Ab**	*Alluvium* Very dark gray (10YR 3/1) heavy SILT LOAM.
108-136	C1	Very dark grayish brown (10YR 3/2) SILTY CLAY LOAM; 10% very fine sand; very abrupt boundary.
136-160	C2	Laminated medium and fine SAND with gravelly sand beds; very abrupt boundary.
160-226	C3	Dark yellowish brown (10YR 4/6) coarse and very coarse SAND with granules and fine pebbles.
226-232	C4	Laminated SILT LOAM – very fine SANDY LOAM; very abrupt boundary.
232-304	Cg1	Dark greenish gray (10Y 3/1 – 4/1) heavy SILT LOAM; wood fragments.
304-396	Cg2	(10Y 4/1) CLAY; common distinct redox features.

Core 15

Depth	Horizon	Description
0-61	F	*Fill* Mixed natural source FILL; gravelly between 30 & 40 cm; very abrupt boundary.
61-72	C1	Olive brown (2.5Y 4/3) SILT LOAM over sticky SANDY LOAM; very abrupt boundary.
72-105	C2/F	Very dark grayish brown mixed with very dark gray (10YR 3/2 – 10YR 3/1) SILT LOAM – SILTY CLAY LOAM.
105-158	ACb	*Alluvium* Very dark grayish brown (10YR 3/2) heavy SILT LOAM; 5% very fine sand; weak angular blocky over platy structure; common faint redox features; very abrupt boundary.

158-182	C1	Laminated and thin bedded SAND; abrupt gradational boundary.
182-234	C2	Coarse SAND with granules.
234-304	Cg	Very dark gray – very dark grayish brown (2.5Y 3/1 – 3/2) SILT LOAM.

Core 16

Depth	Horizon	Description
0-31	Ap	*Alluvium* Very dark gray (10YR 3/1) heavy SILT LOAM; very abrupt boundary.
31-41	C1	Brown (10YR 4/3) gravelly SANDY LOAM.
41-54	C2	Laminated SANDY LOAM; very abrupt boundary.
54-64	C3	Brown (10YR 4/3) gravelly SANDY LOAM.
64-69	C4	Very dark gray SILTY CLAY LOAM.
69-73	C5	SANDY LOAM; very abrupt boundary.
73-180	**Ab**	Very dark gray (2.5Y 3/1) CLAY; common faint redox features; very abrupt boundary.
180-231	Cg1	Dark greenish gray (10Y 4/1) inter –stratified SANDY LOAM and SILTY CLAY LOAM; many distinct redox features.
231-239	Cg2	(10Y 5/1) medium SAND.
239-304	Cg3	SILTY CLAY LOAM.

Core 17

Depth	Horizon	Description
0-22	A	*Alluvium* Very dark grayish brown (10YR 3/2) SILT LOAM.
22-35	C1	SANDY LOAM with gravel; indistinct bedding; very abrupt boundary.
35-60	C2	Laminated very dark gray LOAM and SILTY CLAY LOAM with 10% sand.
60-69	C3	SILTY CLAY LOAM; very abrupt boundary.
69-76	C4	SANDY LOAM with few pebbles.
76-85	C5	SILTY CLAY LOAM.
85-108	C6	heavy SILT LOAM
108-192	**Ab**	Black (2.5N/) – dark gray (7.5Y 4/1) SILTY CLAY LOAM – CLAY; very abrupt boundary.
192-213	Cg1	Dark greenish gray (10Y 4/1) heavy SILT LOAM; 5% very fine sand.
213-230	Cg2	Very dark gray (N3/1) SILTY CLAY LOAM – CLAY; very abrupt boundary.
230-304	Cg3	(10Y 4/1) SILTY CLAY LOAM.

Core 18

Depth	Horizon	Description
0-15	A/F	*Fill* Topsoil; one piece of gravel; very abrupt boundary.
15-70	F1	Mixed SILT LOAM over gravelly SANDY LOAM; truncated.
70-143	C1	*Alluvium* Grayish brown – dark grayish brown (10YR 5/2 – 4/2) SILT LOAM; 20% very fine sand; very abrupt boundary.
143-152	C2	Medium – very coarse SAND with granules; very abrupt boundary.
152-160	C3	Grayish brown (10YR 5/2) heavy SILT LOAM; very abrupt boundary.
160-195	C4	Brown (10YR 4/3) medium SAND.
195-238	Cg1	Grayish brown – dark grayish brown (2.5Y 5/2 – 4/2) SILTY CLAY LOAM; few distinct laminae; platy parting; common distinct redox features; abrupt boundary.
238-263	Cg2	Dark grayish brown (2.5Y 4/2) CLAY; common distinct redox features; very

		abrupt boundary.
263-270	C4	Medium SAND.
270-312	Cg3	Dark grayish brown (2.5Y 4/2) CLAY; common distinct redox features; abrupt gradational boundary.
312-334	Cg4	Grayish brown (2.5Y 5/2) SILTY CLAY LOAM; common distinct redox features; very abrupt boundary.
334-396	C5	Grayish brown – brown (10YR 5/2 – 5/3); laminated intervals; 1 silt loam laminae.

Core 19

Depth	Horizon	Description
0-63	Bt	*Meltwater Stream Alluvium or Alluvial Fan* Very dark grayish brown – dark brown (10YR 3/2 – 3/3) gravelly SANDY LOAM; diamicton.
63-100	Bw1	Very dark grayish brown (10YR 3/2) SANDY LOAM; unleached.
100-150	Bw2	Dark brown (7.5Y 3/2) SANDY LOAM; slightly sticky; occasional gravel; unleached; abrupt boundary.
150-160	Bw3	Dark gray (10YR 4/1) very fine and fine SAND; platy parting; unleached; very abrupt boundary.
160-180	BC1	Brown – dark grayish brown (10YR 4/3 – 4/2) stratified SILT LOAM & very fine SANDY LOAM – SILT LOAM; platy parting; distinct very fine sand laminae; unleached.
180-201	BC2	Yellowish brown (10YR 5/4) SILT and very fine SAND; few silty laminae; unleached.
201-213	C1	Gravelly SILT LOAM; unleached.
213-245	BC3	Laminated brown and grayish brown SILT and very fine SAND.
245-265	BC4	Brown (10YR 4/3) SILT LOAM; few granules; weak pedo-structure; unleached; clear boundary.
265-290	BC5	Brown (10YR 4/3) gravelly SANDY LOAM – SILT LOAM; unleached.
290-396	C2	Interstratified laminated pale brown (10YR 6/3) SILT LOAM and medium – very coarse SAND; unleached.

Core 20

Depth	Horizon	Description
0-35	F	*Fill* Very dark gray – very dark grayish brown (10YR 3/1 – 3/2) SILT LOAM diamicton; 6cm of fill at top; unleached.
35-45		Gravelly SANDY LOAM; unleached; abrupt boundary.
45-60	BC1	Fine – medium SAND; unleached; very abrupt boundary.
60-100	BC2	Dark grayish brown (10YR 4/2) SILT LOAM; unleached.
100-138	C1	Dark grayish brown (10YR 4/2) SILT LOAM; 15-20% very fine sand; laminated; redox at boundary; unleached; very abrupt boundary.
138-168	C2	SAND & GRAVEL; unleached.
168-185	C3	SANDY LOAM; unleached.
185-258	C4	Interbedded dark grayish brown (10YR 4/2) SAND and SILT LOAM; unleached; very abrupt boundary.
258-330	C5	Dark gray (10YR 4/1) SILT LOAM; 20% sand; unleached.
330-396	C6	Brown – dark grayish brown (10YR 4/3 – 4/2) gravelly SANDY LOAM; unleached.

Core 21

Depth	Horizon	Description
0-80	F	*Fill* SILT LOAM fill.
80-89	C1	*Alluvium* Laminated dark gray – very dark gray (10YR 4/1 – 3/1) SILT LOAM.
89-130	C2	Coarse SAND.
130-142	Cg1	Dark grayish brown and dark greenish gray (10YR 4/2 & 4/1 – 5/1) laminated very fine SANDY LOAM; common distinct redox features; very abrupt boundary.
142-148	C3	Medium SAND.
148-170	Cg2	Laminated dark grayish brown and dark greenish gray (10YR 4/2 & 4/1 – 5/1) SILT LOAM and very fine SANDY LOAM; common distinct redox features.
170-251	Cg3	Grayish brown – dark grayish brown (10YR 5/2 – 4/2) SILTY CLAY LOAM; common distinct redox features; few laminae.
251-280	C4	Laminated very fine SAND.
280-314	C5	Laminated brown – dark grayish brown (10YR 4/3 – 4/2) very fine SANDY LOAM and pale brown (10YR 6/3) fine SAND.

Trench 1

Depth	Horizon	Description
0-37	A	Very dark gray (10YR 3/1) heavy SILT LOAM; clear boundary.
37-51	A	Very dark grayish brown (10YR 3/2) SILT LOAM – LOAM; sticky; clear boundary.
51-92	C1	Stratified SANDY lenses (beds) and LOAM with occasional gravels; charcoal; weak pedo-structure; sand lenses usually contain gravel.
92-118	ACb	Dark grayish brown – brown (10YR 4/2 – 4/3) LOAM; poorly sorted; occasional gravel.
118-124	**Ab1**	Very dark gray (10YR 3/1) SILTY CLAY LOAM; ±10% sand & fine gravel; ±3% coarser grained; variegated color (krotavina); carbonate filaments.

Trench 6

Depth	Horizon	Description
0-22	Ap	Mixed A Horizon with subsoil and fill & gravel.
22-43	A	Very dark grayish brown – black (10YR 3/1 – 2/1) heavy SILT LOAM; 15% sand; occasional gravel; clear boundary.
43-65	AB	Very dark gray mixed with very dark grayish brown heavy SILT LOAM – LOAM; moderate pedo-structure; clear boundary.
65-87	C1	Indistinct stratified brown (10YR 4/3) SANDY LOAM with ±3% gravel; gravel at base; abrupt boundary.
87-117	C2	Dark grayish brown – very dark grayish brown (10YR 4/2 – 3/2) LOAM; sticky; occasional gravel; abrupt wavy boundary.
117-146	**Ab**	Very dark gray (10YR 3/1) LOAM; 3-5% gravel.
146-180	C	SAND & GRAVEL; very abrupt boundary.
180-192	AC	Dark grayish brown (10YR 4/2) LOAM.
192-260	**Ab**	CLAY LOAM – CLAY with shell and gravel
260-270	Cg1	LOAM – CLAY LOAM with gravel
270-280	Cg2	LOAM with a single clay bed; mussel shell and snails

Trench 7

Depth	Horizon	Description
0-32	A	Very dark gray (10YR 3/1) SILT LOAM; 10% sand; 2% gravel; abrupt boundary.
32-43	AB	Very dark grayish brown (10YR 3/2) SILT LOAM – LOAM; 2-3% fine gravel; small amount of mixed lighter soil; weak pedo-structure.
43-106	Bw-BC	Very dark grayish brown – dark grayish brown (10YR 4/2 – 3/2) LOAM to ±80cm; weak grading to SANDY LOAM; occasional gravel; upper 10cm has weak – moderate medium prismatic parting to fine angular blocky structure; very abrupt boundary.
106-117	C1	Coarse SAND and granules; very abrupt boundary.
117-127	C2	Dark grayish brown (10YR 4/2) heavy SILT LOAM; carbonate filaments; mixed with brown (10YR 5/3) silt loam; very abrupt boundary.
127-140	C3	Dark grayish brown – brown (10YR 4/2 – 4/3) LOAM; very abrupt boundary.
140-162	**Ab**	Very dark grayish brown (10YR 3/2) sticky LOAM – SILT LOAM; ±1% gravel; charcoal and snail shells; **14C sample taken.**
162-180	C4	Gravelly SANDY LOAM.
180-185	C5	SAND bed.
185-258	ACb	Brown – dark grayish brown (10YR 4/3 – 4/2) SILTY CLAY LOAM; ±2% sand; poorly sorted with increase in sand % with depth to 5%.
258-300	**Ab**	Very dark grayish brown (10YR 3/2) SILTY CLAY LOAM; common carbonate masses; mussel shell; charcoal; gets lighter to (10YR 4/2) heavy SILTY CLAY LOAM; snail shells; no redox features; **14C sample taken from 250-270cm.**

Trench 8

Depth	Horizon	Description
0-26	Ap	Very dark gray (10YR 3/1) heavy SILT LOAM; ±10% sand; ±1% fine gravel; very abrupt boundary.
26-36	AB	Very dark grayish brown (10YR 3/2) heavy SILT LOAM; clear boundary.
36-56	Bw	Dark grayish brown (10YR 4/2) SILT LOAM; ±15% sand; occasional pebbles; weak – moderate medium prismatic parting to medium and fine angular blocky structure.
56-78	BC1	Brown (10YR 4/3) LOAM; weak coarse subangular blocky parting to medium subangular blocky structure; occasional gravel; abrupt boundary.
78-102	C1	Mixed dark grayish brown LOAM and brown (10YR 5/3) SANDY LOAM; coarser gravel; weak pedo-structure; very abrupt boundary.
102-170	**Ab1**	Very dark grayish brown (10YR 3/2) SILTY CLAY LOAM; many krotavina; shell fragments; charcoal.
170-190	C	Brown (10YR 4/3) SILTY CLAY LOAM.
190-216	**Ab2**	Very dark gray – very dark grayish brown (10YR 3/1 – 3/2) heavy SILTY CLAY LOAM; ±5% sand; occasional fine gravel; charcoal; bone; **projectile point recovered and 14C sample taken.**

APPENDIX B
RADIOCARBON ASSAY DATA SHEETS

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Michael F. Kolb

Report Date: 8/15/2013

Strata Morph Geoexploration, Incorporated

Material Received: 7/31/2013

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 355534	1540 +/- 30 BP	-24.5 o/oo	1550 +/- 30 BP
SAMPLE : SMG-MN169-8			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 430 to 580 (Cal BP 1520 to 1370)			
Beta - 355535	1590 +/- 30 BP	-27.2 o/oo	1550 +/- 30 BP
SAMPLE : SMG-MN169-9			
ANALYSIS : AMS-Standard delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 430 to 580 (Cal BP 1520 to 1370)			

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=-24.5:lab. mult=1)

Laboratory number: **Beta-355534**

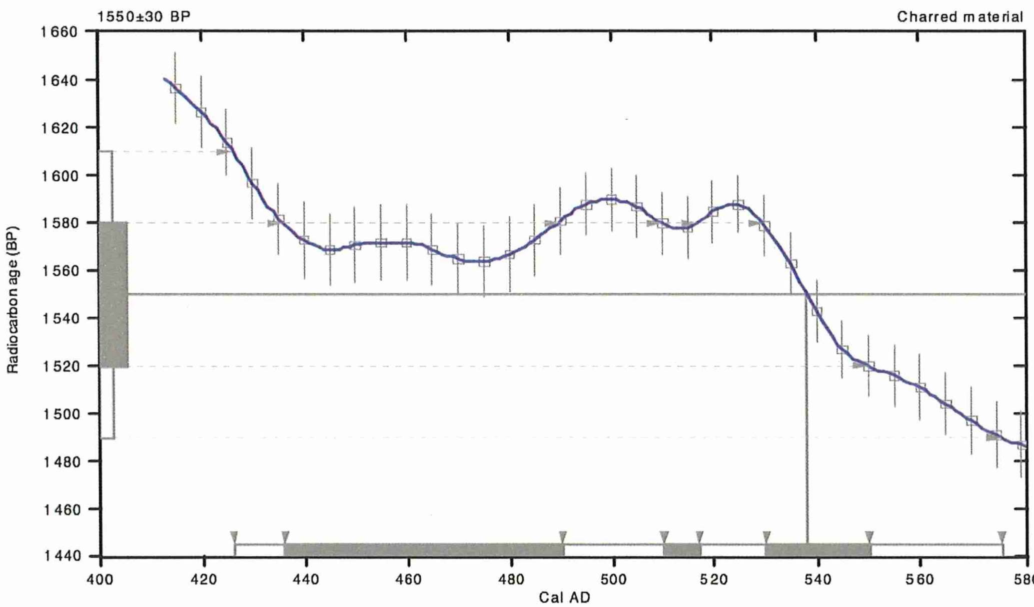
Conventional radiocarbon age: **1550±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 430 to 580 (Cal BP 1520 to 1370)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 540 (Cal BP 1410)

1 Sigma calibrated results: (68% probability) Cal AD 440 to 490 (Cal BP 1510 to 1460) and
Cal AD 510 to 520 (Cal BP 1440 to 1430) and
Cal AD 530 to 550 (Cal BP 1420 to 1400)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.2:lab. mult=1)

Laboratory number: **Beta-355535**

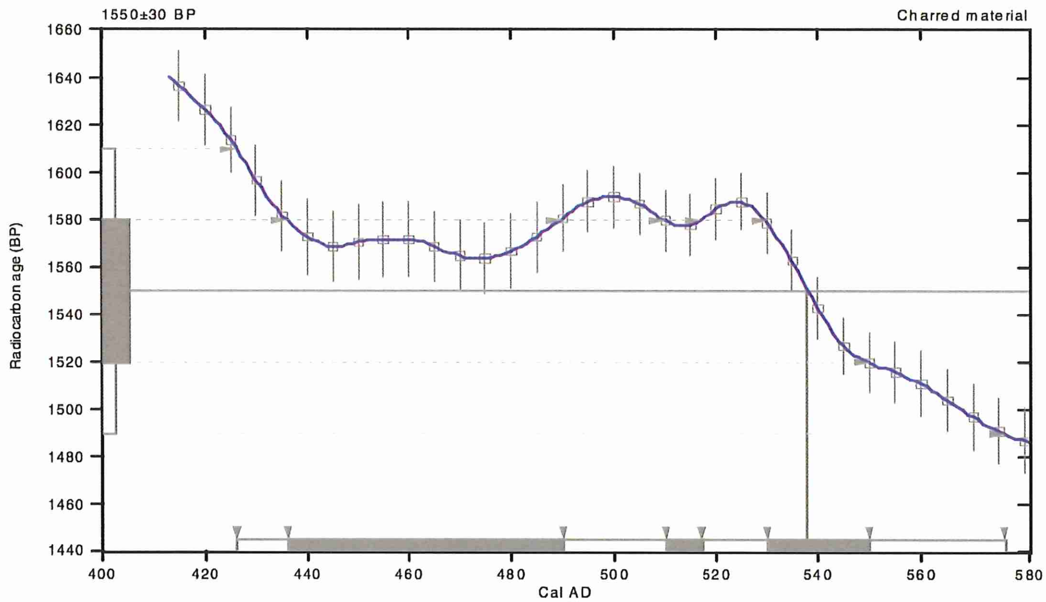
Conventional radiocarbon age: **1550±30 BP**

2 Sigma calibrated result: **Cal AD 430 to 580 (Cal BP 1520 to 1370)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 540 (Cal BP 1410)

1 Sigma calibrated results: Cal AD 440 to 490 (Cal BP 1510 to 1460) and
(68% probability) Cal AD 510 to 520 (Cal BP 1440 to 1430) and
Cal AD 530 to 550 (Cal BP 1420 to 1400)



References:

Database used
INTCAL09
References to INTCAL09 database
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Mathematics used for calibration scenario
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Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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