Geomorphic Investigation of the State Trunk Highway 63 Bridge over the Mississippi River, Red Wing, Minnesota

S.P. 2515-21 TH63
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16. Abstract (Limit: 200 words) The Highway 63 bridge project near Red Wing, Minnesota, assessed potentials for buried archaeology sites within the Mississippi River valley and surroundings. The project is located in the Sections 29, 30 T113N R14W and Sections 11, 14 T24N R18W. This investigation evaluated the subsurface for geologic ages, and depositional and post-depositional environments, as well as assisted an archaeological team to help define the prehistoric/historic boundaries in Red Wing. Multiple radiocarbon dates, plus one OSL date, combined with detailed geologic descriptions of five cores, and cursory geologic descriptions of 66 archaeological probes, helped to document five landform sediment assemblages (LfSA). These LfSAs include the: 1) floodplain, 2) lower bedrock bench, 3) higher bedrock bench, 4) incised bedrock tributary valley, and 5) abandoned bedrock valley. The LfSAs are of the correct age to contain both pre- and post-Euroamerican Settlement archeological resources; however most of the floodplain and lower bedrock bench LfSAs were developed in too wet an environment to contain intact land-based archaeological resources. Construction may encounter a historic/prehistoric site within the top 2m depths of the floodplain surface. The lower bedrock bench may encounter land-based resources stratigraphically above the early Holocene peats, which were apparently subaerially exposed for much of the mid Holocene warm/dry period. The higher bedrock bench, incised tributary, and abandoned valley LfSAs all have potentials to preserve resources. Prehistoric resources will have better chances for preservation at greater depths.

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Management Summary

Mn/DOT charged Foth with helping to determine the need for more focused archaeological investigations of the proposed U.S.Trunk Highway (TH) 63 Bridge over the Mississippi River near Red Wing, Minnesota. The project is located in the SW¼ SW¼ Section 11 T24N R18W, SE¼ and SW¼ of NW¼ Section 29 T113N R14W, and SE¼ NE¼ Section 30 T113N R14W. Five geomorphic borings were advanced to systematically and cost-effectively assess for deeply buried sites and to build a stratigraphic framework within the area of potential effect. Sixty-six archaeological probes were also advanced in support of the preliminary archaeological investigation being conducted under a separate agreement between Mn/DOT and Two Pines Resources, Inc. The contracted work entails a geomorphic evaluation and assisting with archaeological probing of the area of potential effect. The investigation evaluated the subsurface for geologic ages, depositional environments, and post-depositional environments. This project then interpreted the potentials for geologically-buried "suitable habitats" that could have contained intact cultural resources as part of the sedimentary record. The investigation will then assess the needs for a potentially more field intensive archaeological investigation. Five mostly continuous cores were collected from the area of potential effect between February 28 and March 4, 2011. Six radiocarbon and one optically stimulated luminescence dates, and five borings and 66 probes, helped to identify five significant landform-sediment assemblages (LfSAs). These five LfSAs include the: 1) Mississippi River Floodplain; 2) Red Wing Main Bedrock Bench; 3) Red Wing Lesser Bedrock Bench, 4) Incised Tributary Bedrock Valley; and 5) Abandoned Elevated Bedrock Valley. The investigation concluded that all five LfSAs were of the correct age to contain archaeological resources, however some sedimentary packages were formed in too high of an energy environment, were perpetually wet, were disturbed by historic construction, or were in a dynamically aggrading or degrading land surface; and therefore, not likely to contain intact land-based archaeological resources. Although the possibility exists for sunken vessels to occur in the Mississippi River Floodplain LfSA, the chances of finding one remain low. The best chances for finding intact historic/prehistoric archaeological resources are as follows. The uppermost 1-2 m (3-7 ft.) of the near-surface for the majority of the Mississippi River Floodplain LfSA (away from the road fills) may contain either late prehistoric or historic materials. The Main Red Wing Bedrock Bench LfSA and its overlying mantle of unconsolidated material have better chances for preserving historic- versus prehistoric-aged resources. If prehistoric aged resources are preserved, the better chances will be on the bench where deeper mantles may protect them from historic-aged disturbances. These deeper areas will be closer to either the incised bedrock tributary valley, or in areas on the bench that may have preserved any older bedrock channel forms. The Red Wing Lesser Bedrock Bench LfSA's relatively thin unoxidized CO(p?)-horizon located stratigraphically between the unoxidized sawdust and gleyed fluvial sediments at 5.5 m (18 ft.) depth may be the boundary between the historic and prehistoric aged strata. The extremely compacted and oxidized peat bed that overlies this Lesser Bedrock Bench and dates from approximately 7,500-10,300 ^{14}C yrs. B.P. (8,200-12,380 cal. yrs. B.P.) existed through the mid-Holocene warm and dry period, and were likely subaerially exposed from approximately 7,500 to at least 5,240 ^{14}C yrs. B.P. (6,170 to at least 5,920 cal. yrs. B.P.). These two stratigraphic areas present a moderate chance for finding preserved archaeological resources within the Lesser Bedrock Bench LfSA. The Incised Tributary Bedrock Valley LfSA and related natural spring have both apparently attracted people across prehistoric and historic times. The tributary fill's documented age of 0-5,240 ^{14}C yrs. B.P., and depositional environments indicate that prehistoric and historic archaeological resources may be preserved between the tributary banks. Significant and *in situ* prehistoric-aged resources within the Abandoned Elevated Bedrock Valley LfSA will likely be found within its deepest parts where thicker mantles of unconsolidated materials protect resources. Local springs occur within this bedrock valley, and would have attracted people during prehistoric and historic times. These springs are now covered by historic-aged structures and are likely outside of the area of potential effect.

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1 Introduction

1.1 Purpose

Geomorphology is a geologic discipline that studies the form and evolution of both ancient and present-day landscapes. Fundamentally, cultural resources become part of the geologic record when deposited on the ground surface and subsequently buried. Understanding how landscapes evolved helps determine where such resources might have been buried and left undisturbed. On the other hand, the prehistoric people who deposited these cultural resources utilized specific landscapes to acquire their essential needs; such as food, water, shelter, tools, and safety. The landscape also influenced the spiritual aspects of their cultures. Understanding the geology and geomorphology is therefore critical to understanding cultural resource patterns (Hudak and Hajic 1999).

One of three goals for this project was to develop a working knowledge of the ages, depositional environments, and post-depositional environments of the strata within the floodplain, levee, and bench landform sediment assemblages in and near the City of Red Wing, Minnesota (Figures 1-2; also note that Appendices A and B provide a list of abbreviations and a glossary of terms, respectively, that are applied in the body of this report). After achieving this initial goal, the second goal was to interpret the potentials for geologically buried "suitable habitats" that might have contained and preserved cultural resources as part of the sedimentary record beneath this floodplain landform. This investigation's third goal was to determine the need for a potentially more intensive archaeological investigation at or beneath the subject property's land surface. These potentials were interpreted by examining three factors associated with each stratum: geologic age, depositional environment, and post-depositional environment. Determining age can help eliminate strata from archaeological consideration because they may be too old or too young to contain *in situ* archaeological resources in this part of the Upper Midwestern United States. Identifying the depositional environment can help determine archaeological potential by assessing the energy it took to create the sedimentary deposit and whether cultural resources might have been moved as detritus in the process. Determining post-depositional environments helps to identify alterations, such as bioturbation or other soil forming processes that may have adversely affected a cultural resource's original position. The latter two factors mentioned above may also assist with an assessment of the drainage conditions, such as being too wet to have supported a more permanent cultural use, like a campsite or village. The latter two factors also help with assessing an archaeological site's integrity.

1.2 Scope of Work

Mn/DOT charged Foth with helping to determine the need for more focused archaeological investigations at the proposed Trunk Highway (TH) 63 Bridge area of potential effect (APE). The project is located in parts of the SW¼ Section 11 T24N R18W, NW¼ Section 29 T113N R14W, and NE¼ Section 30 T113N R14W. Neither the exact bridge location nor design was developed at the time of this work. Several deep borings were planned to systematically and cost-effectively assess the APE. The final report was intended to recommend where and where not to be concerned for potential archaeological properties. In addition to this geomorphic work, Mn/DOT charged Foth with helping the State's archaeological consultants probe the City of Red Wing and identify the boundaries between the historic and prehistoric natural strata, or man-made fill and natural strata.

1.3 Regulatory Considerations

In most cases, to be eligible to the National Register of Historic Places, an archaeology "site" must be *in situ.* Said differently, the artifact assemblage must be in its original environmental context (i.e., depositional environment) and not severely disturbed by post-depositional processes. Archaeologists must consider whether they are examining redeposited cultural material. Archaeological properties that have been removed from their original locations by, for example, colluvial or alluvial processes are rarely considered significant. An essential component of a geomorphic project either in support of, or prior to, a Phase I archaeological investigation, therefore, is to identify locations where natural processes have reduced the potential for an intact "site" to occur. Given the proper conditions, a scientifically sound geomorphic assessment can substantially reduce, or even eliminate the need for a Phase I archaeological investigation.

2 Background Information

Mn/DOT's area of potential effect (APE) boundary is shown as an orange line on Figures 1 and 2. The specific APE includes the current Red Wing Bridge and an irregular area extending around the current bridge into Wisconsin, and the City of Red Wing, Minnesota. The proposed bridge piers' piling locations and depths are unknown at the time of our current work in 2011. The current project therefore planned on extending the geomorphic coring to either bedrock or the maximum depths of safety when using a hollow-stem auger drill-rig. Preliminary geotechnical information collected before the current bridge was built, and provided to Foth during this project, indicated that the depths could exceed 100 feet in depth, which is beyond the normally safe operational depths of hollow-stem coring under these subsurface hydraulic conditions.

Existing geomorphic investigations of these landforms around the Red Wing bridge, and similar nearby landforms either did not exist, or were not comprehensive or detailed enough (i.e., geotechnical logs), or were too far away and unique to other studies in the Mississippi Valley to be relied upon with certainty.

Completion of the geologic borings provided a coarse framework for the subsequent archaeological probing. Mn/DOT's archaeological consultant, Two Pines Resources, supervised the collection and description of 66 probe samples from existing parking lots around the City of Red Wing. Two Pines LLC described the probes for the purposes of assessing the potentials for both historic and prehistoric resources. Foth's geologist briefly described the probe cores in "real-time" in the field for the purposes of assessing both natural and man-made fills, and the boundaries between these fills as an affirmation of the archaeologists' interpretations (see Archaeological Probe Field Notes and parking lot location map in Appendix D). Probing was completed on June 21-24, and August 9, 2011.

3.1.3 Geologic Core Descriptions

Each geologic core profile was described by a geologist with experience in soil descriptions using USDA and standard geological terminology (Appendix C). Incomplete sample recovery prevented the use of some USDA descriptive standards such as sequential numbering of different master horizons (e.g., different parent materials). Core segments were split longitudinally by inserting a trowel edge slightly into the fine-grained core samples and twisting the trowel to "pop" open a core segment. This largely natural breakage exposes undisturbed soil and sedimentary structures for description. This method also helped to prevent cross-contamination between potential radiocarbon samples that might be collected from different parts of the core sample.

The core was described in its moist or wet state using primarily standard pedologic and sedimentologic techniques and terminology (Soil Survey Staff 1994, Hallberg et al. 1978). The core was initially divided into soil horizons and, beneath the solum, weathering zones. Weathering zones are essentially extensions of the soil profile well below the soil profile as traditionally recognized by the USDA for agricultural purposes. Soil horizon, soil color, texture, mottling, soil structure, ped coatings, sedimentary structure and bedding characteristics, moist consistency, effervescence (carbonates), roots and pores, pore coatings, and inclusions such as organic material or shell fragments were noted (if present) for each soil horizon on a form designed for the purpose of using standard USDA terminology. Core samples were also examined for particle-sizes and sedimentary structures to help determine if the landform has been created, buried, disturbed, or destroyed by eolian, fluvial, colluvial, soil-forming, freeze-thaw, or bioturbation processes.

A modification to the standard terminology has been added to accommodate multiple buried soils and emphasize their significance. Whereas the Soil Survey Staff (1994) recognizes the use of a "b" for a buried genetic horizon in mineral soils, the Mn/Model project (Hudak and Hajic 1999) extended its use to buried organic soils as well and, where practicable, this usage was continued into this report.

A graphic sediment/soil log was constructed after the horizons were described (see for example Figures 3-4). The graphic log illustrates vertical sedimentological trends, which helped to interpret lithofacies and depositional environments. The sedimentary textures are displayed on a histogram, with the vertical axis (i.e., y-axis) of the histogram representing core depth. Each histogram bar width (y-axis), therefore, represents the depth of each geologic/pedologic unit. The length of each bar (x-axis) represents a specific texture or grouping of textures. Figures 5-7 show three geologic cross-sections constructed for this project with graphic textural logs. Spacesaving measures on these graphics necessitated the grouping of less common, but similar textures.

Soil horizons, soil texture, horizon color shading, sedimentary structures and bedding characteristics, location and relative abundance of inclusions, and the character of soil horizon boundaries and sediment contacts are represented on the log. Although sedimentological characteristics are noted, the USDA soil texture terminology was used throughout because it is more precise than sedimentological terminology and allows subdivision of the generic 'muds' of sedimentologists. Interpretations of stratigraphic units, depositional environments, correlations to other cores, etc., are noted on the graphic sediment logs shown on the cross-section.

Some cores were allowed to dry before being re-described. Sometimes drying enhances pedogenic and sedimentologic features that are not evident in the moist state. These are duly noted with an indication that they were observed in the dry state.

Organic matter in the core that could potentially yield a radiocarbon age was sampled. Sampling techniques vary depending on the kind and amount of material available. In general, individual fragile charcoal fragments were picked out of the core with a small amount of surrounding matrix, wrapped in aluminum foil, and then sealed in a plastic bag. More sturdy uncarbonized organic matter (e.g., wood twigs, roots, logs, etc.) was sampled in appropriate length segments of core, wrapped in aluminum foil, and then sealed in a plastic zip-lock bag. The aluminum wrapping around each potential radiocarbon sample was marked with a felt-tipped pen, and the markings included the date of collection (e.g., 3/28/11), Foth project number (e.g., 11M018), core number according to Mn/Model's geoarchaeological standards (e.g., 11GD-03, which translates to the core being advanced during the year 2011, in the location of Goodhue County, and the core number that was collected in this county during the year 2011), and finally depth as measured by the drillers to maintain consistency between drillers and field geologist (e.g., 28.9-29.9 feet). One core was collected on the Wisconsin side of the Mississippi channel, however we kept the core numbering as if it were in Goodhue County, Minnesota, to avoid possible confusion with another Minnesota county with the same Wisconsin county initials.

3.1.4 Geologic Cross-Sections

Cross-sections provide a quick glimpse of the subsurface for the cultural resource manager. Three geologic (Mn/Model standardized) Microstation CADD cross-sections were constructed from the five cores logged during this project, and also from four Minnesota County Well Index logs (Figures 5-7). These cross-sections graphically represent both the textural data of the logs and the interpreted stratigraphic units or depositional environments. Radiocarbon and OSL data are also displayed at their collection depths on these logs. The textural key is found near each figure's title block. The textural keys are usually standardized for each specific project area and they can vary between project areas to better accentuate the local textural variations.

3.1.5 Archaeological Probe Descriptions

Foth assisted Two Pines LLC by helping to define the natural and man-made strata, and boundaries between historic and prehistoric boundaries from each of 66 probes collected during this project. Foth's probe field notes were recorded more simplistically than were the geologic logs, and consisted primarily of color, texture, and stratigraphy (Appendix D). Other standout natural or man-made features were noted in the probe notes when they may help to define the natural vs. man-made, or prehistoric vs. historic contexts of the probes' strata. The probe identification system starts with the number of the parking lot (e.g., 15A) followed by the sequential lettering of these probes collected from each parking lot (e.g., 15A-A, 15A-B, etc.). Appendix D includes a parking lot location map graciously provided by Two Pines LLC.

3.1.6 Previous Mn/Model Mapping

Geomorphic mapping of Landform Sediment Assemblages (LfSA's) is a tool that can be used for evaluating landscape evolution in Minnesota and can serve as a context for predicting the potential locations of geologically buried prehistoric cultural resources. The LfSA's are the basic mapping unit of Mn/DOT's Mn/Model Landscape Suitability Models. These LfSA's are informal map units that recognize that specific landforms of a given geomorphic position, within a given geomorphic region or subregion, tend to be underlain by a sediment sequence of characteristic lithofacies. The correlation or mapping of lithofacies may be aided by both relative and absolute dating techniques. Mapping the LfSAs provides some factual, on-the-ground basis for assigning Landscape Suitability Rankings to the map units (geomorphic surfaces and underlying deposits) based on ages and depositional/post-depositional environments. "Suitable landscapes" are those ancient landscapes, either buried or surficial, that are of the appropriate geological ages and environments to both contain and preserve archaeological properties. Landscape Suitability Rankings can be assigned a range from no potential (i.e., too old, too young, too wet, too disturbed) to low, moderate and high potentials to contain and preserve these properties. Such mapping was done for Mn/Model because maps of Holocene alluvium at the scale and level of detail required by archaeologists and planners had not yet been published for Minnesota. The current project is in an area that was recently mapped for Mn/Model (Hajic et al. in prep., Hajic et al. 2011). Consequently, this project was necessary to test the great depths of strata underlying this floodplain landform. This ground truthing step will be used to reconstruct evidence for depositional environments, post-depositional environments, and geologic ages under this landform.

3.1.7 Absolute Chronology

Radiocarbon-dating and other forms of absolute chronological dating are extremely important for the success of this project. Both absolute and relative dating principles help to bracket the landforms and potential cultural components in time. Mn/Model and other recently unpublished works have indicated that organics for radiocarbon dating are available in the valley fills of Minnesota (Hudak and Hajic 1999).

Two quality control (QC) measures have typically been used on validating the radiocarbon dates from the valley fills investigated during previous projects. The first QC measure is identifying the plant matter (e.g., wood, seeds, etc.) to help in the selection of samples for radiocarbon dating. Subaerial plant parts are currently interpreted as having the best chances for a reliable radiocarbon date on their surrounding sedimentary matrix. This QC process checks the date against the well known paleoecology of that particular time in that particular landscape. The second QC measure is comparing the relatively large numbers of radiocarbon and OSL dates against each other. The aberrant dates will be recognized after enough dates have been collected from each of the important lithofacies in different landform sediment assemblages. The current project used the latter QC method because, since the time that Hudak and Hajic (1999) published these QC procedures, the price and time expended to professionally identify the organics has surpassed the cost of normal AMS assays. In addition, this project provided an ample supply of quality samples for AMS radiocarbon assays, which would hopefully satisfy the second QC measure described above.

A single OSL and multiple organic samples were collected from the five geologic cores and 66 archaeological probes. Field and laboratory work yielded: eight (8) new radiocarbon dates (six AMS assays and two radiometric); and one (1) new OSL date. Beta Analytic, Inc., and University of Illinois-Chicago laboratory reports are found in Appendices E and F, respectively. All radiocarbon dates are chronologically consistent with their relative geomorphic and stratigraphic positions within each and between all the cores. The one OSL date is approximately 3,000 calendar years out of stratigraphic order with one radiocarbon date on clam shells, and is discussed in greater detail in Section 4.2.2. A master list of organics and their yielded radiocarbon and AMS dates are presented in Table 1. A master list of OSL sample data are provided in Table 2.

3.1.8 Geomorphological Quality Assurance

The geomorphology QC plan followed the Mn/Model's Section 12.2.8 "Geomorphological Quality Assurance" plan when feasible (Hudak and Hajic 1999). Continuous sampling proved challenging with a hollow-stem auger because of the hydraulic heads that were encountered deep within the sands of Mississippi Valley trench. The lake clays provided better core recoveries.

3.1.9 Photographic Log

The Principal Investigator kept a photographic log of the geologic field work to help record the work effort and the key or potentially key core samples. Photographs were digitally recorded and documented each day field work was conducted. Selected photographs of both the borehole locations and core samples in the split-spoon samplers are presented in Appendix G.

4 Discussion

4.1 General Geology Discussion

4.1.1 Introduction

Multiple significant geological events that have a bearing on the mode and timing of glacial meltwater discharge down the Mississippi River Valley are recorded by the Landform Sediment Assemblages (LSAs) along the Upper Mississippi Valley (UMV) of eastern Minnesota between the cities of St. Paul and Red Wing. General summaries of the geological events of this area have been published elsewhere (e.g., Hudak et al. 2011, Blumentritt et al. 2009, Clayton and Moran 1982). Both recent detailed mapping of the valley landscape and initial radiocarbon and optical spectral luminescence (OSL) dating of landform sediment assemblages (noted in ^{14}C yrs. B.P. and cal. yrs. B.P. for radiocarbon and OSL age yrs., respectively) begin to provide the linkage between glacial ice, glacial lake, and Gulf of Mexico records of discharge. These events also played a role in subsequent Holocene valley landscape evolution and the disposition of the archaeological record.

4.1.2 Bedrock Geology and Buried Valleys

Modern valleys in the UMV area are carved into glacial drift and the underlying Paleozoic bedrock. Relevant units are the gently dipping and beveled Platteville Limestone, St. Peter Sandstone, Prairie du Chien Dolomite and Cambrian sandstones that occur on the northern side of the Twin Cities structural basin. Carbonate units are resistant and alternate with the easily eroded sandstones, leading to escarpments along modern valleys such as that marked by St. Anthony Falls on the UMV above the mouth of the Minnesota River Valley (MRV), and in buried paleolandscape positions. Along the modern course of the Mississippi River downstream of St. Paul, differential bedrock resistance played a role during catastrophic flooding resulting in buried bedrock ledges that flank a narrower inner flood channel.

Late Wisconsin glacial drift buries multiple generations of pre-existing bedrock valley segments cut into these bedrock units. Some of the youngest bedrock valley segments maintain some expression of relief on the modern land surface; however, most are buried without any hint of surface expression. Those valleys not entirely filled are now completely abandoned or carry underfit streams, or are occupied by a chain of lakes. Occupation, re-occupation, modification and exhumation of different bedrock valley reaches varied spatially and temporally as glacial advances, retreats and isostatic rebound altered river courses. Down-valley from St. Paul, the modern UMV re-utilizes older bedrock valley reaches, although the bedrock valley morphology has been altered by Late Wisconsin and earliest Holocene catastrophic floods. For the most part, buried bedrock valley locations and fill sequences are only known from generalized well-driller logs. Efforts to reconstruct the history of the buried bedrock drainage network development have relied upon these logs (Schwartz 1936, Bloomgren et al. 1990, Blumentritt et al. 2009). Pre-Late Wisconsin glacial deposits were recognized in the region (Matsch 1972, Baker et al. 1983, Hobbs et al. 1990). Most of these deposits have been interpreted from upland landscape positions to the south, and buried bedrock valleys; and Hudak et al. (2011) interpret at least one stratigraphic unit in a cored bedrock valley to be pre-Late Wisconsin in age.

4.1.3 Quaternary Geology and Catastrophic Floods

East-central Minnesota was impacted by glacial lobes derived from distinct eastern (Labradorean) and western (Keewatin) source areas of the Laurentide Ice Sheet in Canada. The Superior lobe (and related sublobes) advanced southwestward through the Lake Superior basin, scouring iron- and copper-rich bedrock that imparts a reddish brown hue to its glacial drift. Superior lobe till is further characterized by sandy loam diamicton textures and an absence of Cretaceous shale clasts (Hobbs et al. 1990). A balance between ice flow and melting was achieved to produce the St. Croix end moraine in and around the Twin Cities metropolitan area sometime between 20,000 and 15,000 ^{14}C yrs. B.P. (23,890 and 18,250 cal. yrs. B.P.[all calibrated dates within Section 4.1.3 are determined by CALIB 6.0.2], Mickelson et al. 1983). The slightly younger Des Moines lobe advanced southward through the Red River lowlands of western Minnesota, then southeastward, building lateral moraines in western and northern Dakota County, and then southward into Iowa. As the Des Moines lobe was stagnating in Iowa (Kemmis 1991), the Grantsburg sublobe advanced northeastward, just north of the Twin Cities, about 11,900 ^{14}C yrs. B.P. (13,750 cal. yrs. B.P.; Wright and Rubin 1956, Meyer 1998, Hajic et al. 2009). Des Moines lobe till is characterized by loam to clay loam diamicton textures, gray (fresh) to yellowish brown to olive (oxidized) colors, and sparse to abundant Cretaceous shale clasts (Hobbs et al. 1990). Moraines, till and outwash from advances of these three lobes occur in Dakota County (see Hudak et al. 2011: Figure 1). Evidence presented by Hudak et al. (2011) also indicates that one or more tongues of Des Moines lobe ice (or an older Keewatin lobe ice) extended beyond the generally accepted ice margin limit.

Deglacial events were instrumental in shaping landscape elements of the valleys, as well as establishing the baseline for Holocene landscape evolution. These deglacial events resulted in buried paleolandscapes, which are critical to understanding the location, integrity and age of buried prehistoric cultural deposits, if present. Configuration of the modern MRV is primarily the result of one or more catastrophic floods emanating from Lake Agassiz, an enormous proglacial lake that occupied the Red River lowlands following retreat of the Des Moines lobe. Lake Agassiz drained southward through a broad spillway cut through the Big Stone Moraine (of the Des Moines lobe) which forms the drainage divide between the Minnesota and Red rivers. On geomorphic evidence, Hudak and Hajic (1999) concluded that the incised MRV formed by catastrophic flooding, sharing many landforms characteristic of spillway valleys formed or modified by deglacial catastrophic floods (Kehew and Lord 1986). MRV-forming catastrophic flood(s) pre-date 10,400 ^{14}C yrs. B.P. (12,270 cal. yrs. B.P.) based on several radiocarbon ages from the base of valley-bottom alluvial fans and underlying fluvial deposits in the New Ulm and Mankato vicinities (Hudak and Hajic 1999, Hudak and Hajic 2005). Alluvial fans were deposited along the length of the MRV as tributaries incised in response to the rapid cutting. Fisher (2003) used sedimentology and radiocarbon ages from cores to determine that the spillway occupied by Big Stone Lake was initially abandoned at its maximum depth of erosion around 10,800 ^{14}C yrs. B.P. (12,700 cal. yrs. B.P.). Lake Agassiz discharges later shifted to eastern and then northwestern outlets. The age of initial catastrophic flooding that carved the MRV remains open to question, but had to occur after the advance of the Grantsburg Sublobe, or about 11,900 ^{14}C yrs. B.P. (13,750 cal. yrs. B.P.). Fisher (2003) concluded that the spillway through the Big Stone Moraine was effectively inactive between about 10,800 (12,700 cal. yrs. B.P.) and at least 9,920 ^{14}C yrs. B.P. (11,320 cal. yrs. B.P.) as indicated by a combination of absolute dates from: (1) lacustrine sediments within Big Stone Lake; (2) valley-bottom strata within the MRV (Hudak and Hajic 1999); and (3) forest elements from the Lake Agassiz basin near Moorhead. That latter set of dates indicated that Lake Agassiz was north of Moorhead at a relative low stand (Yansa et al. 2002) during the Moorhead Phase (Fisher 2003, Fisher et al. 2008). Additional radiocarbon ages that lend support to this interpretation, particularly the ages of Yansa et al. (2002) and Yansa and Ashworth (2005), come from approximately 17 km (10.6 miles) farther north of Moorhead in the Lake Agassiz basin near Georgetown, MN, (Hudak and Hajic 1999) and elsewhere in the basin (summarized in Fisher et al. 2008).

The southern outlet was reactivated sometime between 9,900 and 9,400 ^{14}C yrs. B.P. (11,300 and 10,630 cal. yrs. B.P.), but most likely initiation of this second phase of discharge occurred during the last few centuries of this interval with little if any further incision of the Big Stone Lake spillway (Fisher 2003). Hudak and Hajic (1999) documented the preservation of older valley-bottom alluvial fans and terraces (ca. 10,330-10,400 ^{14}C yrs. B.P.; 12,170-12,270 cal. yrs. B.P.), which lack evidence of catastrophically-carved paleochannels and therefore indicate that subsequent Holocene-aged discharges were likely orders of magnitude less than the earlier discharge that carved the MRV. This latter phase of flow(s) from Lake Agassiz must have been a relatively low discharge, perhaps with seasonal fluxes.

Upstream from the MRV/UMV confluence, the Mississippi River was mostly a broad, braided outwash stream that drained along the inner St. Croix glacial end moraine. The UMV was later supplied by outwash carried by the Grantsburg sublobe and Des Moines lobe meltwaters. Hajic (2002) suggested that the Mississippi River may have debouched across the Anoka Sand Plain at one point, and may have fed an earlier course of the St. Croix River until the Minneapolis North Gap opened sometime between 11,400 and 11,800 ^{14}C yrs. B.P. (13,270 and 13,640 cal. yrs. B.P.). Catastrophic flow from Lake Agassiz down the MRV was augmented by the Mississippi River at Fort Snelling and followed a new course to St. Paul, where it entered an old valley of the Mississippi River, forming a waterfall over flat-lying Paleozoic rocks. The resulting waterfall migrated upstream, and as it passed the confluence with the Mississippi River at Fort Snelling about 10,800 ^{14}C yrs. B.P. (12,700 cal. yrs. BP) the waterfall divided into two (Wright, H.E., Jr. 2011 personal communication). The Mississippi branch migrated upstream as St. Anthony Falls, causing third-order falls to develop along its smaller tributaries, and remains visible near downtown Minneapolis (Wright 1972). The Minnesota River branch migrated upstream until it reached the western edge of the Paleozoic caprock that maintained the waterfall (Wright 1972).

Glacial Lake Duluth formed in the western Lake Superior basin during retreat of the Superior lobe (Emerson Phase). Major outlet valleys were the Kettle River in the Duluth vicinity, and the Brule River in Wisconsin. These two rivers merge to form the St. Croix River (see Hudak et al. 2011: Figure 1A). The modern St. Croix River Valley (SCV) occurs at two tier levels, separated by Taylors Falls, and enters the UMV near Hastings, Minnesota. Geomorphic evidence indicates that catastrophic flooding from Glacial Lake Duluth, simultaneously down the Kettle and Brule river valleys, shaped the current SCV (Hudak and Hajic 1999, Hajic and Hudak 2005). Evidence supporting this catastrophic origin includes the Taylors Falls' potholes, a collection of more than 100 holes drilled by rotary current-driven sands and gravels into basaltic bedrock (Alexander 1932). Additional evidence includes that the highest terrace level of the upper tier, a suite of cut marginal flood channels in terrace positions that are buried by up to eight meters of Holocene-aged peat (Hudak and Hajic 1999, Hajic and Hudak 2005); and the floor of the lower tier, beneath Lake St. Croix (Lund and Banerjee 1985), share similar bracketing ages around the

Pleistocene – Holocene transition, even though the two levels are separated by at least 48 m elevation difference. Radiocarbon ages from the: (1) lower tier's floor and upper tier's basal peat wood sample of the SCV (Hudak and Hajic 1999, Hajic and Hudak 2005); (2) wood in basal peat beds on buried bedrock ledges that flank the inner UMV channel (data presented herein); (3) basal fill within the inner and deeper UMV channel (data presented herein); and, (4) related marker bed in the UMV and central Mississippi Valley (Hajic and Bettis 1997), indicate that the last St. Croix River Valley catastrophic flood(s) most likely date(s) sometime between 9,900 and 9,700 ^{14}C yrs. B.P. (11,300 and 11,140 cal. yrs. B.P.), but could be as old as about 10,100 ^{14}C yrs. B.P. (11,690 cal. yrs. B.P.). Flood magnitude did not approach that of the earliest catastrophic flood from Lake Agassiz that cut the UMV down-valley from Fort Snelling, and much of the flood activity in this St. Paul to Red Wing reach of the UMV was erosional and inset below both the lowest subaerial terrace surfaces and buried bedrock benches within the bedrock gorge (discussed herein below). Waters from Glacial Lakes Aitkin and Upham, large lakes associated with the retreat of the St. Louis sublobe of the Superior lobe, also may have augmented this flood, although the detailed timing of their existence and demise has not been well developed (Farnham et al. 1964). Slightly earlier lakes, predecessors of Glacial Lake Duluth (e.g. Glacial Lake Lind, Johnson et al. 1999), would most likely have contributed discharge down the St. Croix Valley (Blumentritt et al. 2009), although the form and location of the valley at that time would have differed from that of today. Other geomorphic, sedimentologic, and elevation evidence from both the SCV and UMV support an earlier large magnitude flood(s) of unknown origin. The youngest SCV catastrophic flood set the stage for the eventual development of Lake Pepin in the UMV (Winchell and Upham 1888, p. 4-5 quote of Featherstonhaugh 1835, Zumberge 1952, Blumentritt et al. 2009) and Lake St. Croix in the lower SCV, both riverine lakes at or near our project area.

4.2 Project Specific Geology Discussion

4.2.1 Introduction

Figure 1 displays the APE with the locations of all geomorphic borings (11GD01-05), selected archaeological probes (10-B & 15A-A), and selected county well index borings. Figures 5-7 demonstrate that the City of Red Wing, for the most part, rests upon a *bedrock bench* at approximately 215-220 m (705-722 ft.) in elevation (see Section 4.2.3 below). Figure 5 demonstrates the main *Mississippi River Valley floodplain and trench* (see Section 4.2.2 below) north of the currently active river channel, and is characterized by levee, splay, overbank, channel and lacustrine deposits. Figure 5 also demonstrates a second and *less expansive bedrock bench* (see Section 4.2.4 below) geomorphically inset beneath the main Red Wing bench. This inset bench is located between the main Red Wing bench and the currently active Mississippi River channel. Figure 6 demonstrates a right-angle long- and cross-section of a sloping *abandoned elevated bedrock valley* south of Barn Bluff (see Section 4.2.6 below). This bedrock channel landform slopes downward in the same downstream direction as the active Mississippi River. Figure 7 demonstrates an *incised tributary bedrock valley* that cross-cuts the main Red Wing bench from south to north (see Section 4.2.5 below).

4.2.2 Mississippi River Valley Floodplain and Trench

Geomorphically inset beneath both the main Red Wing bench and its lesser bench is the Mississippi River Valley floodplain and its bedrock trench (see the northern half of Figure 5's cross-section). Boring 11GD-01 was advanced to 33.53 m (110 ft) depth and never reached bedrock (Figure 3; Appendix G, Photograph 10). Bedrock is estimated from regional geotechnical borings further upstream to be at approximately 157 m (515 ft) elevation, which is approximately 16.5 m (54 ft) below the terminus of Boring 11GD-01.

Boring 11GD-01 is composed of approximately 3 m of road fill derived from dredged sands near the river islands (confirmed by personal communication with Township road maintenance worker), overlying 2 m of oxidized overbank deposits. Parts of these "overbank deposits" may also be either dredged materials placed here to help raise lower sags in the island landscape, or channel deposits. These oxidized overbank deposits overlie 6-7 m (19.7-23.0 ft.) of gleyed alluvial and fluvial deposits (Appendix G, Photograph 11). The lowermost 1 m (3.28 ft.) of these gleyed strata contained wetland leafy plant matter, which yielded a radiocarbon date of 1,330±30 ^{14}C yrs. B.P. (Appendix G, Photograph 12) These alluvial and fluvial strata gradually grade downward into gleyed lacustrine deposits, and these deposits are continuous for an additional 16-17 m depth (Appendix G, Photograph 13). A giant clam bed was first encountered as auger chatter near the lower boundary of the lacustrine deposits (Appendix G, Photograph 14). A radiocarbon assay on these clam shells yielded a radiocarbon date of 10,070±100 ^{14}C yrs. B.P. (Table 1; 12,050-11,250 cal. yrs. B.P.). This date may be questionable because carbonate shelled animals tend to incorporate older carbon directly from the local bedrock. Underlying this clam shell bed, the strata abruptly changes to medium and very coarse, gleyed fluvial sands. An aliquot of medium-sized quartz sand from the deepest split-spoon sample yielded a date of 8,060±725 OSL age years (UIC-2956; Table 2; Note: OSL ages are already calibrated to calendar years using an 2009 A.D baseline datum). These two kinds of assays yielded calibrated years that are at least 3,000 years apart and out of chronostratigraphic order. Obviously, future work on other projects need to be done to resolve the out-of-sequence dates; however, for the purposes of this report, the dates support each other by indicating that either the late Pleistocene- or early Holocene-aged Mississippi channel/lake bottom(s) were deep within the inner bedrock gorge that currently underlies the floodplain landform sediment assemblage. The small tributary bedrock valley-bottom depths that incised the main Red Wing bedrock bench and mentioned in Section 4.2.5 below, also support our interpretations because the incision occurred prior to 6,100 cal. yrs. B.P.

The archaeological potential around the 11GD-01 boring location is very low to nil for *in situ* land-based sites in any of the gleyed sediments (from 5.0-33.5 m [16.4-110.0 ft.] depths at this boring location); however, the uppermost 1-2 m (3-7 ft.) found immediately underlying the dredged road fill, and presumably the near surface for the remaining majority of the floodplain landform sediment assemblage (away from the road fills) may contain either late prehistoric or historic materials.

4.2.3 City of Red Wing Main Bedrock Bench

One geomorphic boring and multiple archaeological probes sampled the APE within the City of Red Wing boundaries. The majority of these sample points indicate that the City of Red Wing lies mostly upon a shallowly buried bedrock bench (Appendix G, Photograph 1). Typical depths to bedrock on this bench landform-sediment assemblage range from 0-6 m (0-20 ft.) and these variations are related to older channel forms carved into the bedrock and perhaps smaller tributary channel forms. The archaeological probe locations were established in part based upon the locations of active parking lots; therefore the probing was not a perfect systematic sampling of the City of Red Ring bedrock elevations. At least one bedrock tributary valley to the Mississippi River was deeply incised beneath the Red Wing bench level and is discussed below in Section 4.2.5.

An interesting curiosity of the Red Wing bedrock bench is the age of the overlying strata and its interstratification with the often times severely weathered bedrock surface. Probing indicated that multiple horizons of "interstratified" man-made fills, foundations, walls, and floors; along with possible natural alluvium and colluvium make up the materials overlying the bedrock. Two radiocarbon samples were obtained from Probe 10B (Figure 1). These relatively shallowly buried samples yielded radiocarbon dates of 40 ± 30 and 230 ± 30 ^{14}C yrs. B.P. (Beta-304415, Beta-304416; Table 1) from depths of 1.80-1.83 m (5.9-6.0 ft.) and 2.04-2.10 m (6.7-6.9 ft.), respectively. The latter sample was leafy plant matter collected from a peaty muck horizon located stratigraphically above the *in situ* bedrock bench found at 2.9 m (9.4 ft.) depth (see Probe 10B description in Appendix D).

All probes' and Boring 11GD-03's sediments that overlie the Red Wing bedrock bench indicate by their unoxidized colors and weakly developed weathering profiles that these strata are relatively young. Hudak and Hajic (1999) have discussed that all shallowly buried unoxidized alluvium and colluvium in Minnesota are approximately 5,500-5,000 ^{14}C yrs. B.P. or younger, suggesting that these strata overlying the bedrock bench were not subjected for any extended time during the mid-Holocene warming period. The natural strata immediately overlying the *in situ* bedrock have all the characteristics of reworked local bedrock, such as sediment of similar colors and textures that either gradually or abruptly change downward from loose grains, to finer rocks, to coarser blocks, until eventually the blocks are large enough to become indistinguishable in a core or probe sample from the weathered *in situ* bedrock. Many probe samples provided evidence of a "mixing zone" or "pediment" where the underlying strata were clearly worked up into the more recently deposited strata. Usually the appearance of an exotic pebble or pebbles between the slightly reworked bedrock blocks assists with the interpretation of being reworked bedrock versus the *in situ* bedrock.

The bedrock bench surface was probed in numerous locations, and the strata were consistent with the descriptions provided by Runkel (1998) for the Upper Cambrian's Reno Member of the Franconia Formation. Runkel (1998) characterized the Reno Member by its very fine grained to fine-grained glauconitic sandstone interbedded with siltstone and shale, all of which were identified in the probes. Glauconite is a mineral formed under marine conditions and is recognized by its greenish colors (5G or 5GY Munsell hues) amongst the other whiter or brighter colors found in a quartz or feldspathic sandstone or siltstone. The Franconia Formation, in addition, is generally less well cemented than are its surrounding formations, which again is consistent with what was recognized in the field. The field observations also recognized a clay unit overlying the bedrock in some places, which may have been either a regolith developed from the bedrock, or a clay-rich lacustrine Quaternary unit that was deposited after the bench was cut and before the mid to late Holocene-aged strata were deposited on the bench.

Confirmation of either interpretation would require either a more systematic probing or a trench across the bench to better understand the geometry and stratigraphy of this apparently discontinuous unit.

The archaeological potentials on this bedrock bench vary because of the mosaicked pattern of Historic- and Recent-aged disturbances. Both the bedrock bench surface and its overlying Holocene- and Recent-aged strata are impacted sporadically across the City of Red Wing as evidenced by the common historic foundations, wall remnants, stone floors, and other subsurface features found lying directly in contact with or slightly above this bedrock surface. This bedrock bench and its overlying mantle of unconsolidated material has better chances for preserving historic- versus prehistoric-aged resources. If prehistoric aged resources are preserved, the better chances will be on the bench where deeper mantles may protect them from historic-aged disturbances. These deeper areas will be closer to either the incised bedrock tributary valley mentioned below in Section 4.2.5, or in areas on the bench that may have preserved any older channel forms.

4.2.4 City of Red Wing Lesser Bedrock Bench

A second and geomorphically lower bedrock bench is inset beneath the main Red Wing Bench mentioned above in Section 4.2.3, and was documented by Boring 11GD-02 (Figures 1 and 5). This second bench is smaller in areal dimension, and is situated between the main bedrock bench and the active Mississippi River channel (Appendix G, Photograph 4). The lesser bench is mantled by approximately 12 m (39 ft.) of various deposits and the landform-sediment assemblage surface elevation is approximately 2 m (7 ft.) higher than the main elevation of the Mississippi River floodplain surface on the north side of the active channel (see Figure 5). This difference in elevation is in part caused by "made land" as mentioned below in further detail.

Boring 11GD-02 strata are composed of approximately 2.5 m (8.2 ft.) of oxidized levee and/or dredged fill materials. These levee and fill deposits overlie approximately 2.4 m (7.9 ft.) of unoxidized wood chips that were apparently used as fill (Appendix G, Photograph 5). These wood chips overlie approximately 5.7 m (18.7 ft.) of gleyed fluvial deposits (Appendix G, Photographs 6-7) with a thin unit of unoxidized lacustrine marls found at 8.8-9.2 m (28.9-30.1 ft.) depths. The gleyed fluvial deposits overlie approximately 0.5 m (1.7 ft.) of both oxidized and highly compacted fibrous peat (Appendix G, Photograph 8), and unoxidized less compacted peaty muck. A thin gleyed sand lens may separate these two distinct organic horizons, or it may have been slough collected in the split-spoon sampler (see 11GD-02 in Appendix C). The peaty muck overlies 0.2 m of weathered and reworked sandstone bedrock with a few exotic pebbles. The reworked sandstone overlies a CR- and R-horizon composed of brownish yellow (10YR6/6) weathered sandstone bedrock (very fine and fine sands; Appendix G, Photograph 9).

The uppermost and lowermost peat horizons yielded leafy plant materials and a wood log, respectively, and these samples in turn yielded radiocarbon dates of 7,610 ± 70 and 10,310 ± 60 ^{14}C yrs. B.P. (Beta-295700, Beta-295701; Table 1; Figure 5). These dates are of special interest because they are older than the dates recognized up on the main Red Wing bench. In addition, these dates and the appearances of the highly compacted and oxidized peat that overlies the bedrock bench correlate almost perfectly with an elevated bedrock bench found between the Childs and Warner Road intersection and the active Mississippi River channel near St. Paul, Minnesota, or approximately 45 miles further upstream from the current project area (Hudak et al. 2011, Hudak 2010).

Potentials for significant and *in situ* land-based archaeological resources are apparently limited because of the mostly subaquatic depositional environments (i.e., fluvial, alluvial, lacustrine, and wetlands) found on this lesser bedrock bench. The sawdust layers are "made land" by definition (see Appendix B - Glossary), although one core could not determine if this land was intentionally made, or if the surface aggraded as an incidental circumstance because of its position near an old sawmill. The relatively thin unoxidized CO(p?)-horizon located stratigraphically between the unoxidized sawdust and gleyed fluvial sediments at 5.5 m (18 ft.) depth may be the boundary between the historic- and prehistoric-aged strata. One area of note is the extremely compacted and oxidized peat bed that dates from approximately 7,500-10,300 ^{14}C yrs. B.P. (8,200-12,380 cal. yrs. B.P.). The oxidized reddish brown colors of these otherwise well preserved and firm wetland peats indicates that the peat existed through the mid-Holocene warm period, thereby lending support to their above-mentioned radiocarbon chronology. The basal peat was likely subaerially exposed from approximately 7,500 to at least 5,240 ^{14}C yrs. B.P. (6,170 to at least 5,920 cal. yrs. B.P.) during the mid-Holocene warm period, which was also a drier time period. The drier times meant that the Mississippi River surface elevation was below this bedrock bench elevation, and that meant that any human walking on this peat-mantled bench would have been looking down 8-18 m (26-59 ft.) into the Mississippi trench to see the ancient Lake Pepin or Mississippi River surface waters (based upon data from Boring 11GD-01). The 5,240 ^{14}C yrs. B.P. age mentioned above comes from additional data discussed below in Section 4.2.5.

4.2.5 Incised Tributary Bedrock Valley

Multiple archaeological probes sampled an incised tributary bedrock valley that cuts mostly from south to north across the main Red Wing bedrock bench described above in Section 4.2.3 (Appendix D). Those probe depths that went deeper than 15-20 ft. are apparently close to this incised tributary valley. Two Pines LLC provided Foth with the plat map (Appendix D) showing a tributary stream that starts on Block 22, Lot 6, near the intersection of Plum and Fourth Streets. The plat map also shows a natural spring at the head of this tributary, and it is here that Probe15A-A was advanced to a depth of 22.8 ft. terminating in glauconite-rich sandstone bedrock. The overlying stratigraphic sequence from surface to bedrock includes a series of historic-aged fills that included cinders down to a depth of 6.8 ft. The fills are mostly oxidized or deoxidized pebbly sands. Starting at 8 ft. down to 18.7 ft. the strata appear to be naturally aggraded and consist of a series of alternating, gleyed and unoxidized, laminar to thinly bedded, loams and peats. Ash, bone, bark, wood, ash and cinders were documented between 9.0 and 10.5 ft. depths, and were collected by Two Pines LLC for further scrutiny in their laboratory. From 18.7 to 22.5 ft. depths, the sediments change to a series of greenish gray (5G5/1) sandy loams and pebbles alternating with a single, black (10YR2/1), silt loam to silty clay loam at 20.2-21.0 ft., and a single oxidized yellowish brown (10YR5/6) sandy pebble stratum at 21.8-22.5 ft. The pebbles found from 18.7-22.5 ft. depths are a mixture of local angular sandstone and well-rounded exotic clasts.

The black (10YR2/1), silt loam to silty clay loam at 20.2-21.0 ft. contained some leafy wetland plants, which yielded an AMS date of 5,240 ± 30 ^{14}C yrs. B.P. (6,170-6,160, 6,110-6,080, or 6,010-5,920 cal. yrs. B.P.; Beta-304417; Table 1). The dated plant matter came from just 1.5-2.7

ft. above the bedrock bottom of this tributary valley, which means that the main Red Wing bedrock bench and this tributary valley both existed prior to 5,240 ^{14}C yrs. B.P. (~6,100 cal. yrs. B.P.). The basal <u>oxidized</u> pebble unit overlying the bedrock bottom of this tributary valley and underlying the above-mentioned dated horizon indicates that this tributary valley was cut either during or before the mid-Holocene warm and dry period (see discussion above in Section 4.2.4).

The natural spring has apparently attracted people to use this valuable resource across both prehistoric and historic times. This also means that the incised valley was likely a transport route from the Red Wing bench down to the edge of the Mississippi River during this same time span. Both the tributary fill's documented age of 0-5,240 ^{14}C yrs. B.P., and depositional environments indicate that prehistoric and historic archaeological resources may be preserved between the tributary banks.

4.2.6 Abandoned Elevated Bedrock Valley

Borings 11GD-04 and 11GD-05 were logged within the abandoned bedrock valley between Barn Bluff and the main bluff line further to the south of Red Wing (Figures 1 and 6; Appendix G, Photographs 2 and 6, respectively). Boring 11GD-04 was advanced into the ground at the topographically lowest expression of this ancient valley (Appendix G, Photograph 2), the purpose being to explore the thickest Pleistocene stratigraphic sequence. Only 2.59 m (8 ft.) of unconsolidated black to dark gray loam and silt loams with mostly local and angular pebbles and cobbles were present at this location before reaching the dark greenish gray (5GY4/1) weathered sandstone bedrock. The range of sizes of sandstone pebbles, cobbles, and boulders intermixed with the finer textured loams, in combination with their position at the base of Barn Bluff, suggest that these larger clasts are colluvially derived. Boring 11GD-05 encountered bedrock at 1.52 m (5.0 ft.) depth after penetrating what appeared to be reworked sandstone.

An organic sediment sample collected from Boring 11GD-04 just above the bedrock yielded a conventional radiocarbon age of 2,530±30 ^{14}C yrs. B.P. (2,740-2,680 or 2,640-2,500 cal. yrs. B.P.; Beta-295702; Table 1; Appendix G, Photograph 3). No oxidized sediments were recognized at this locality indicating from evidence provided above that these unconsolidated strata were deposited after the mid-Holocene warm and dry period; and the 2,530 ^{14}C yrs. B.P. date is consistent with this observation. The other dates from both the main Red Wing bench (40 & 230 ^{14}C yrs. B.P.) and its incised tributary bedrock valley (5,240 ^{14}C yrs. B.P.) are consistent with either or both erosion and non-deposition occurring during the early to mid Holocene prior to 5,300 ^{14}C yrs. B.P. The degree of weathering recognized within the near-surface bedrock, both here and the main bedrock bench, indicates that the bedrock was exposed to soil-forming processes and was a stable surface for some unknown length of time.

The archaeological potentials on this abandoned bedrock valley vary because of the mosaicked pattern of historic- and recent-aged disturbances. Both the bedrock valley surface and its overlying Holocene- and recent-aged strata are impacted sporadically across the City of Red Wing as evidenced by the common historic foundations, wall remnants, stone floors, and other subsurface features found lying directly in contact with or slightly above this bedrock surface. This bedrock valley and its overlying mantle of unconsolidated material have slightly better chances for preserving both historic- and prehistoric-aged resources. The best chances for finding *in situ* prehistoric-aged resources preserved will be within the deepest or lowest parts of the bedrock valley where deeper mantles of unconsolidated materials may protect them from historic-aged disturbances. Local springs occur within this bedrock valley, as was reported by one City of Red Wing utility location employee during our investigation. These natural springs would have attracted people during prehistoric and historic times, and are now covered by historic-aged structures.

5 Results

5.1 Geology and Geomorphology

Geological events that created the Red Wing bedrock bench and the abandoned bedrock valley are apparently closely related in time based upon the similarities in elevation and the ages of their overlying mantles of sediment. Combine these facts with the ca. 5,240 ^{14}C yrs. B.P. age of the basal unconsolidated sediments found within the tributary valley, which incised the bedrock bench, and this evidence indicates that these bedrock surfaces all pre-date the mid-Holocene. The basal peat from the lesser and geomorphically inset bedrock bench under the current Mississippi River levee indicate that they were subaerially exposed from approximately 7,500 to at least 5,240 ^{14}C yrs. B.P. (6,170 to at least 5,920 cal. yrs. B.P.) during the mid-Holocene warm period, which was also a drier time period. The subaerial exposure meant that the Mississippi River surface elevation was below this bedrock bench elevation. One would normally assume that because this lower bench was carved prior to 7,500 ^{14}C yrs. B.P., that the geomorphically higher bedrock bench must be older; however, given the number and magnitude of known and suspected catastrophic floods in this valley; the principal of downcutting relations may not apply because the catastrophic floodwaters may rise and top and cut new surfaces out of the previously abandoned older surfaces. This catastrophic flood hypothesis may also help to explain the removal of any possible early Holocene-aged strata from the Red Wing bedrock bench; but then this proposal causes another problem by not removing the early Holocene-aged peat bed on the geomorphically lower (lesser) bedrock bench.

The last powerful catastrophic flood originated out of the St. Croix Valley sometime between 9,700 and 10,100 ^{14}C yrs. B.P. and coursed down and eventually receded within the Upper Mississippi Valley. Since this time or possibly even since the last catastrophic flood from Glacial Lake Agassiz, the active Mississippi River and Lake Pepin surface waters had to be at elevations lower than the current levee and its underlying bedrock bench. The river and eventually river-lake beds were obviously lower than the surface waters and has been aggrading throughout the Holocene since the last catastrophic floods receded.

5.2 Archaeology Implications

The archaeological potential for most of the Mississippi Valley floodplain landform sediment assemblage is very low to nil for *in situ* land-based sites in any of the gleyed sediments (from 5.0-33.5 m [16.4-110.0 ft.] depths at this boring location); however, the uppermost 1-2 m (3-7 ft.) of the near-surface for the majority of the floodplain landform sediment assemblage (away from the road fills) may contain either late prehistoric or historic materials.

The archaeological potentials on the City of Red Wing bedrock bench vary because of the mosaicked pattern of historic- and recent-aged disturbances. Both the bedrock bench surface and its overlying Holocene- and recent-aged strata are impacted sporadically across the City of Red Wing as evidenced by the common historic foundations, wall remnants, stone floors, and other subsurface features found lying directly in contact with or slightly above this bedrock surface. This bedrock bench and its overlying mantle of unconsolidated material have better chances for preserving historic- versus prehistoric-aged resources. If prehistoric aged resources are preserved, the better chances will be on the bench where deeper mantles may protect them from historic-aged disturbances. These deeper areas will be closer to either the incised bedrock tributary valley, or in areas on the bench that may have preserved any older bedrock channel forms.

Potentials for significant and *in situ* land-based archaeological resources are apparently limited on the lower bedrock bench because of the mostly subaquatic depositional environments (i.e., fluvial, alluvial, lacustrine, and wetlands) found. The woodchip and sawdust layers are "made land." The relatively thin unoxidized CO(p?)-horizon located stratigraphically between the unoxidized sawdust and gleyed fluvial sediments at 5.5 m (18 ft.) depth may be the boundary between the historic and prehistoric aged strata. The extremely compacted and oxidized peat bed that dates from approximately 7,500-10,300 ^{14}C yrs. B.P. (8,200-12,380 cal. yrs. B.P.) existed through the mid-Holocene warm and dry period, and were likely subaerially exposed from approximately 7,500 to at least 5,240 ^{14}C yrs. B.P. (6,170 to at least 5,920 cal. yrs. B.P.). The drier times meant that the Mississippi River surface elevation was below this bedrock bench elevation, and that meant that any human walking on this relatively stable peat-mantled bench would have been looking down 8-18 m (26-59 ft.) into the Mississippi trench to see the ancient Lake Pepin or Mississippi River surface waters.

The natural spring and incised bedrock tributary valley has apparently attracted people to use this valuable resource across both prehistoric and historic times. This also means that the incised valley was likely a transport route from the Red Wing bedrock bench down to the edge of the Mississippi River. Both the tributary fill's documented age of 0-5,240 ^{14}C yrs. B.P. (~0-6,100 cal. yrs. B.P.), and depositional environments indicate that prehistoric and historic archaeological resources may be preserved between the tributary banks.

The best chances for finding significant and *in situ* prehistoric-aged resources within the abandoned bedrock valley will be within its deepest or lowest parts where thicker mantles of unconsolidated materials may protect these resources from historic-aged disturbances. Local springs occur within this bedrock valley. These natural springs would have attracted people during prehistoric and historic times, and are now apparently covered by historic-aged structures.

6 Recommendations

In our professional opinion, a Phase I archaeological site assessment should be conducted after a detailed engineering design is produced and before the construction starts. The Phase I should cover the pier locations and any other ground disturbance areas along the floodplain landform sediment assemblage that may impact from 0-2 m depths, or where gleyed sediment is first encountered from within the floodplain landform sediment assemblage. Likewise for the lower bedrock bench on the south side of the Mississippi channel if a pier is located here, except that we recommend testing down to just beneath the wood chips and sawdust at approximately 6 m depth, and continue to the oxidized peat beds if the piers go to 13 m depth to reach the bedrock bench. Testing of the main Red Wing bedrock bench should be conducted based upon the Two Pines LLC archaeologists' interpretations, and also if the ground disturbances will impact any of the deeper unconsolidated materials, such as the incised tributary bedrock valley, or the lowest depths of unconsolidated sediment within the abandoned elevated bedrock valley. A field geomorphologist is suggested to examine the floodplain, lower bedrock bench, and incised bedrock tributary valley landform sediment assemblages if trenches are being opened in order to help document disturbances, depositional environments, and geological ages. A field geomorphologist need only be "on-call" for investigating the main Red Wing bedrock bench and abandoned bedrock valley in case the archaeologists encounter any unexpected deviations from what has already been documented within this report.

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Tables

Table 1 Radiocarbon Data from the U.S. Highway 63 Red Wing Bridge Project Area

County	Profile No.	Depth in Feet (Meters)	Dated Material	Conventional Date (^{14}C yrs. B.P.)	Calibrated Date (cal. yrs. B.P.*)	Laboratory I.D.
Pierce, WI	11GD-01	36.3-36.5 (11.06-11.13)	Leafy Wetland Plants	1,330 ± 30	1,300-1,240 & 1,200-1,190	Beta-295697
Pierce, WI	11GD-01	93.8-94.0 (28.59-28.65)	Clam Shell Bed	10,070 ± 100	12,050-11,250	Beta-295699
Goodhue	11GD-02	36.75-36.90 (11.20-11.25)	Peat (leafy matter)	7,490 ± 40	8,390-8,200	Beta-295700
Goodhue	11GD-02	37.7-38.0 (11.49-11.58)	Wood	10,310 ± 60	12,380-11,970 or 11,870-11,840	Beta-295701
Goodhue	11GD-04(a)	6.0-6.4 (1.83-1.95)	Organic Sediment	2,530 ± 30	2,740-2,680 or 2,640-2,500	Beta-295702
Goodhue	Probe-10B	5.9-6.0 (1.80-1.83)	Wood (possible root)	40 ± 30	240, 60-40, or 0	Beta-304415
Goodhue	Probe-10B	6.7-6.9 (2.04-2.10)	Leafy Plant Material	230 ± 30	310-270, 180-150, or 10-0	Beta-304416
Goodhue	Probe-15A-a	20.2-21.0 (6.16-6.40)	Leafy Plant Material	5,240 ± 30	6,170-6,160, 6,110-6,080, or 6,010-5,920	Beta-304417

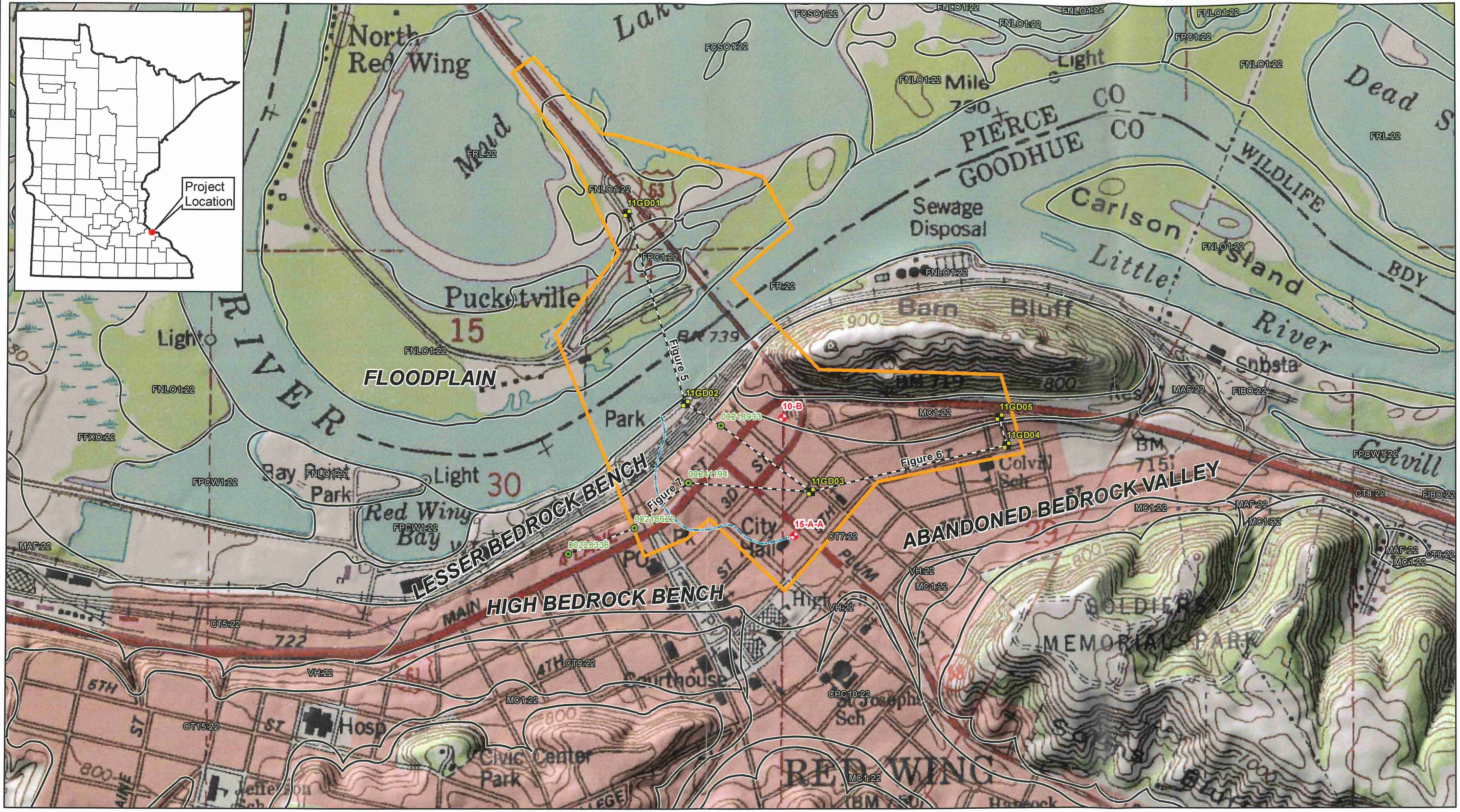
*INTCAL04 Database to two standard deviations was used to achieve "Calendar Years Before Present."

Table 2 Optically Stimulated Luminescence (OSL) Data on Quartz Grains from the U.S. Highway 63 Red Wing Bridge Project Area

County	Profile No.	Depth in Feet (Meters)	Dated Material	Date in OSL age yrs. B.P.*	Laboratory I.D.
Pierce, WI	11GD-01	108.2 (33.0)	Medium-sized quartz sand grains	8,060±725	UIC-2956

* All errors are at 1 sigma and ages from the reference year AD 2009.

Figures



NOTES

1. USGS 7.5' Series Topographic Quadrangles
2. City of Redwing Shaded Relief generated from 10-foot resolution LiDAR.

LEGEND

- Geologic Boring Locations
- County Well Index Locations
- Cross-Sections
- Platted Historic Stream Valley
- Archaeologic Probe Locations (Approximated)
- Area of Potential Effect
- Geomorphology Polygons (after Hajic et al., 2011)

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This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

N

Mn/DOT

FIGURE 1
PROJECT AREA TOPOGRAPHY WITH CORE AND PROBE LOCATIONS
RED WING, MINNESOTA

Scale: 0 500 1,000 Feet	Date: SEPTEMBER, 2011

Drawn By: BJW1	Checked By: CMH1	Scope: 11M018

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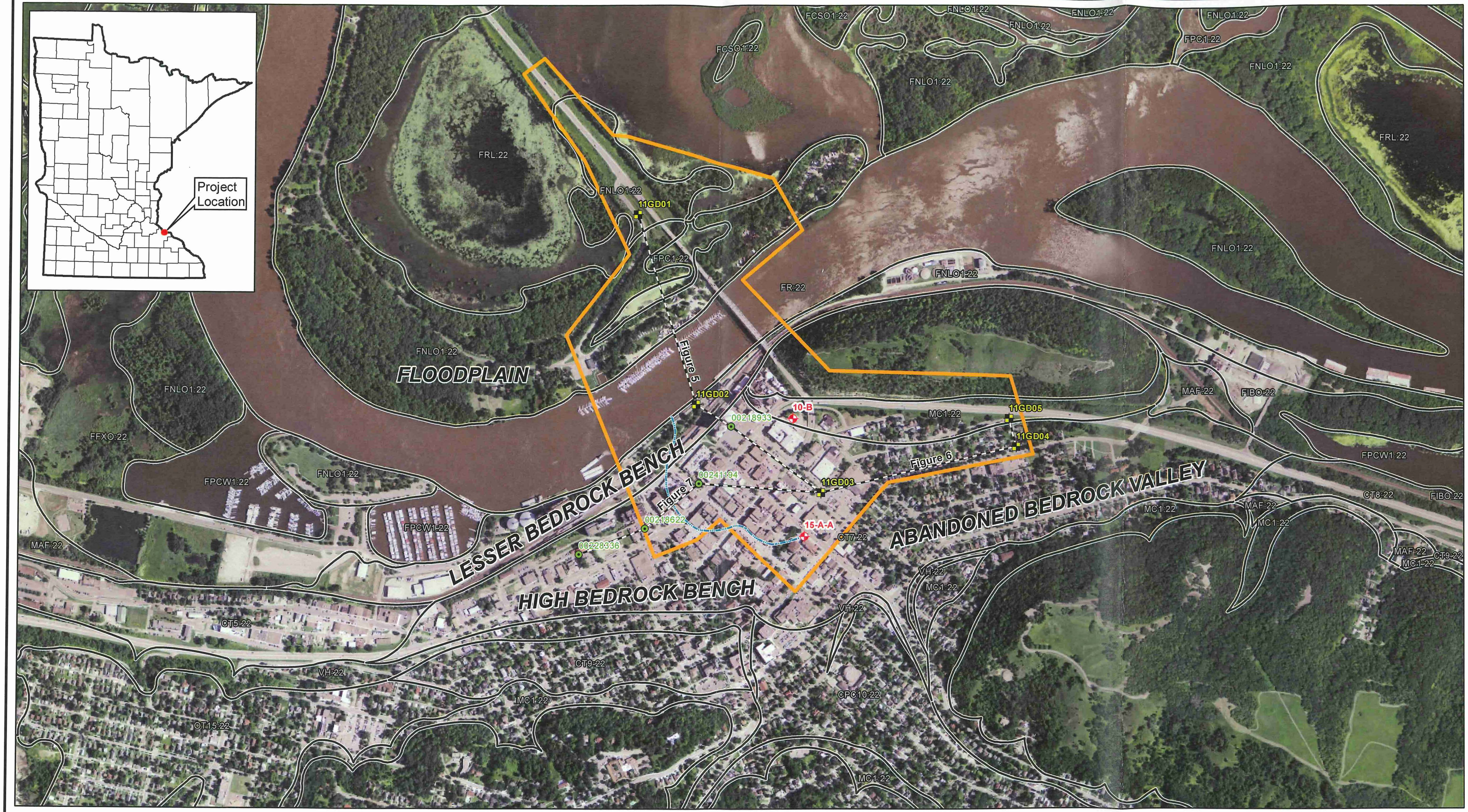

NOTES

Basemap Source: 2010 USDA 1-Meter Aerial Imagery

LEGEND

- Geologic Boring Locations
- County Well Index Locations
- Cross-Sections
- Platted Historic Stream Valley
- Archaeologic Probe Locations (Approximated)
- Area of Potential Effect
- Geomorphology Polygons (after Hajic et al., 2011)

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FIGURE 2

PROJECT AREA AERIAL WITH CORE AND PROBE LOCATIONS
RED WING, MINNESOTA

Scale: 0 500 1,000 Feet	Date: SEPTEMBER, 2011

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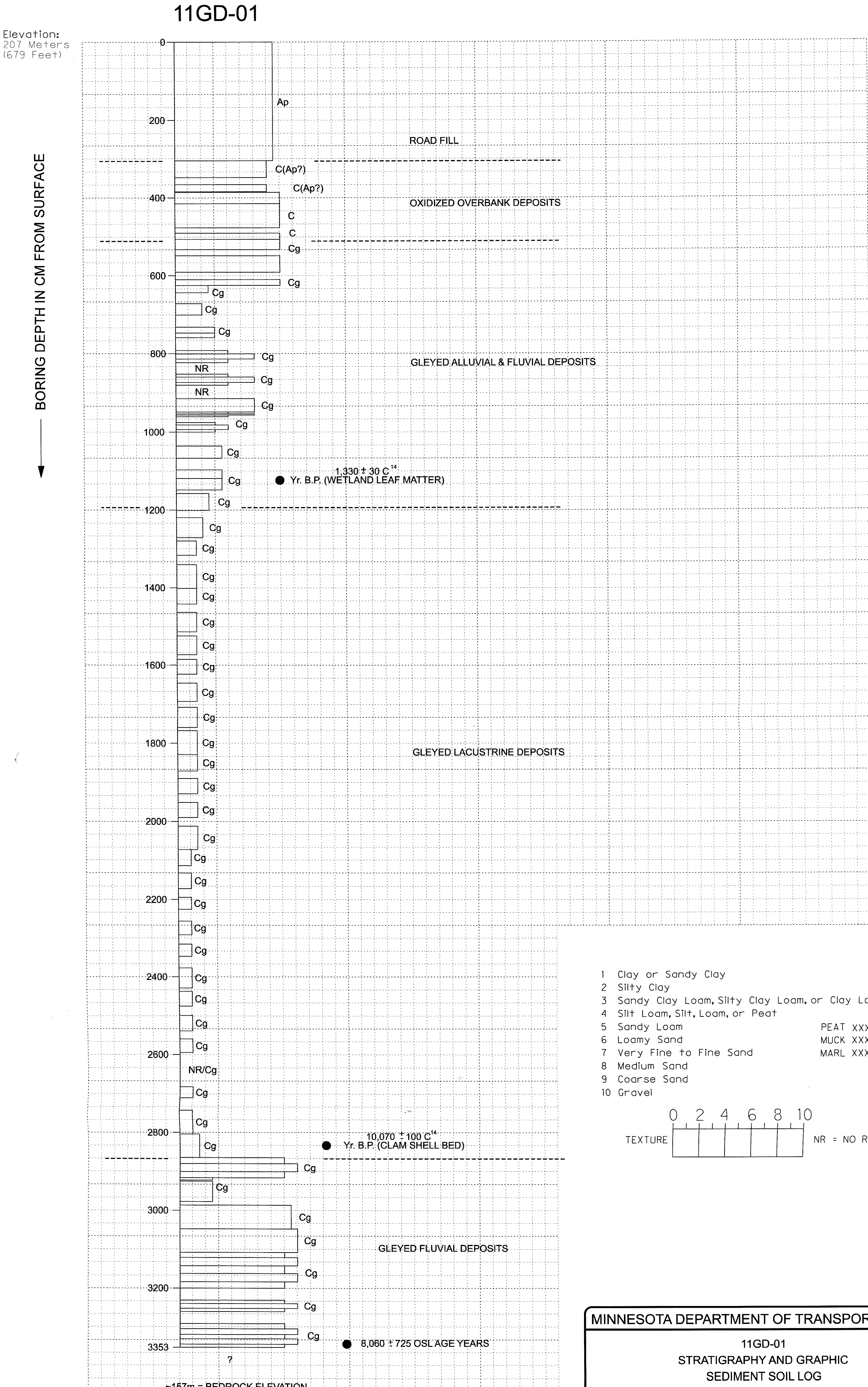

1 Clay or Sandy Clay
2 Silty Clay
3 Sandy Clay Loam, Silty Clay Loam, or Clay Loam
4 Silt Loam, Silt, Loam, or Peat
5 Sandy Loam
6 Loamy Sand
7 Very Fine to Fine Sand
8 Medium Sand
9 Coarse Sand
10 Gravel

PEAT XXXXX
MUCK XXXXX
MARL XXXXX

TEXTURE 0 2 4 6 8 10

NR = NO RECOVERY

MINNESOTA DEPARTMENT OF TRANSPORTATION

11GD-01
STRATIGRAPHY AND GRAPHIC
SEDIMENT SOIL LOG

SCALE AS SHOWN | PROJECT ID 11M018

DATE: 6-8-2011
PREPARED BY: CKV
CHECKED BY: CMH1

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FIGURE NO.
3

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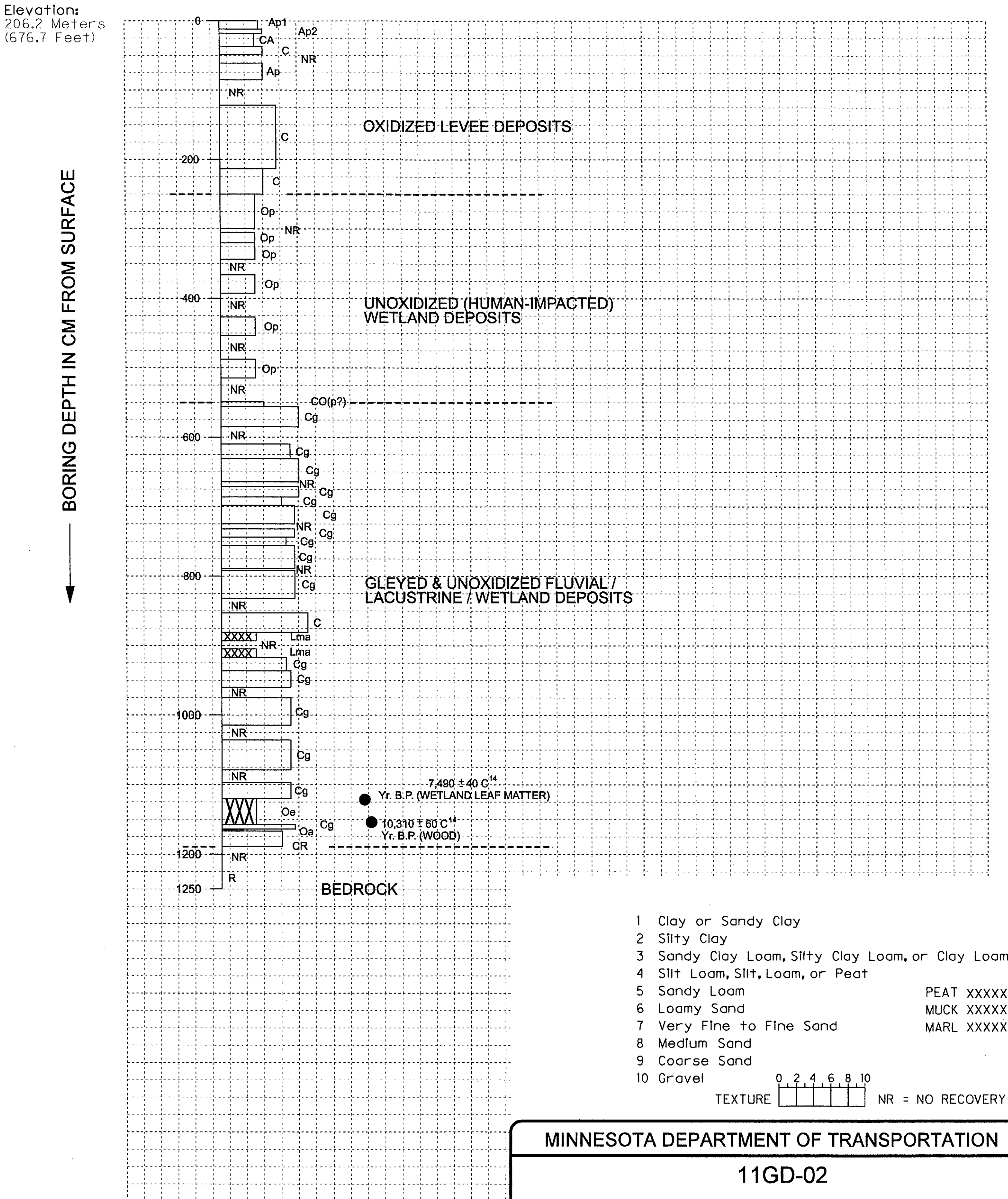
11GD-02



MINNESOTA DEPARTMENT OF TRANSPORTATION

11GD-02

STRATIGRAPHY AND GRAPHIC SEDIMENT SOIL LOG

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CHECKED BY: CMH1	Foth Infrastructure & Environment, LLC	

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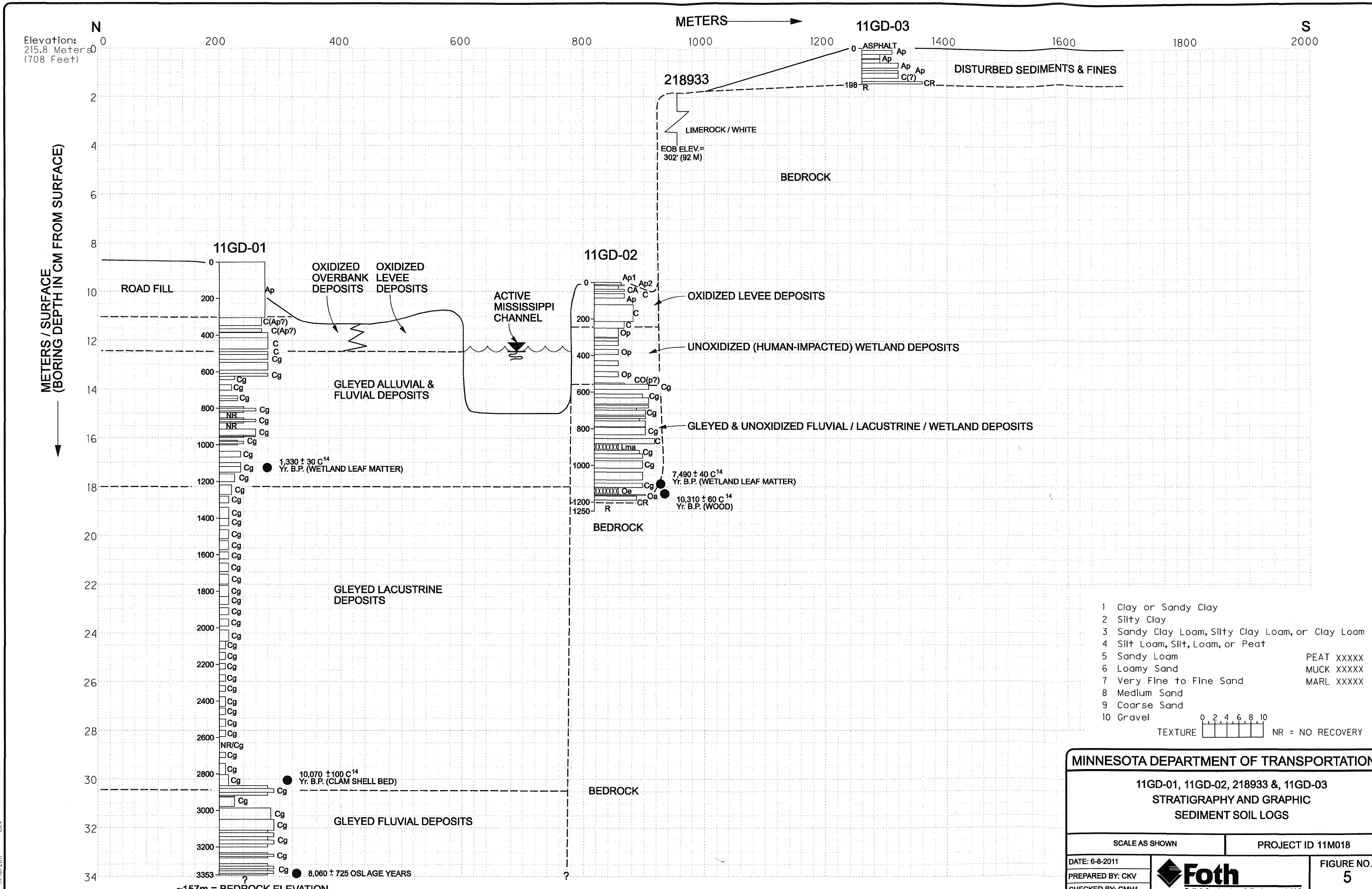

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11GD-01, 11GD-02, 218933 &, 11GD-03 STRATIGRAPHY AND GRAPHIC SEDIMENT SOIL LOGS	
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DATE: 6-8-2011 PREPARED BY: CKV CHECKED BY: CMH1	Foth — Foth Infrastructure & Environment, LLC — FIGURE NO. 5

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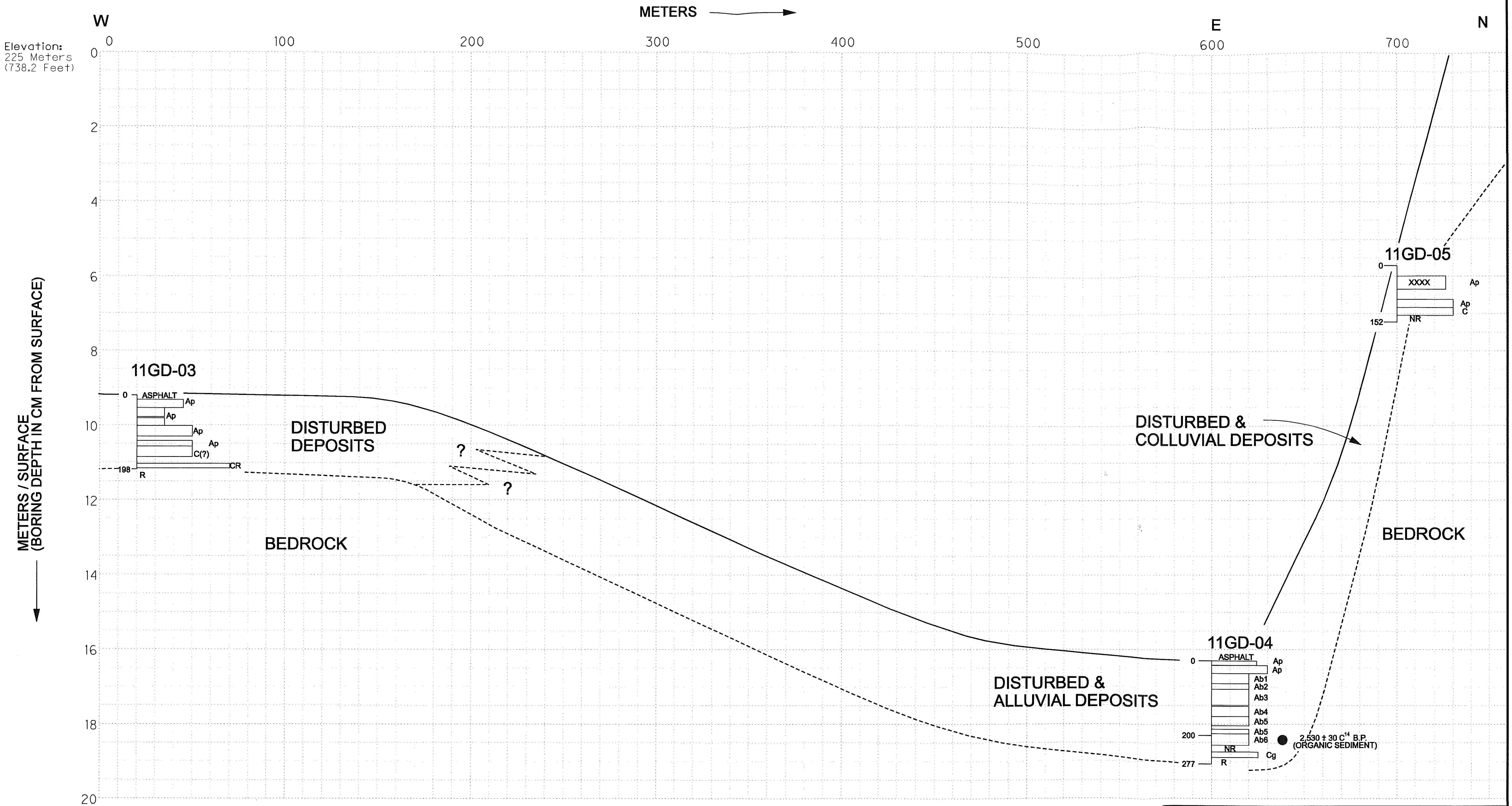

1 Clay or Sandy Clay
2 Silty Clay
3 Sandy Clay Loam, Silty Clay Loam, or Clay Loam
4 Silt Loam, Silt, Loam, or Peat
5 Sandy Loam
6 Loamy Sand
7 Very Fine to Fine Sand
8 Medium Sand
9 Coarse Sand
10 Gravel

PEAT XXXXX
MUCK XXXXX
MARL XXXXX

TEXTURE 0 2 4 6 8 10

NR = NO RECOVERY

MINNESOTA DEPARTMENT OF TRANSPORTATION

11GD-03, 11GD-04 &, 11GD-05
STRATIGRAPHY AND GRAPHIC
SEDIMENT SOIL LOGS

SCALE AS SHOWN | PROJECT ID 11M018

DATE: 6-8-2011
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FIGURE NO. 6

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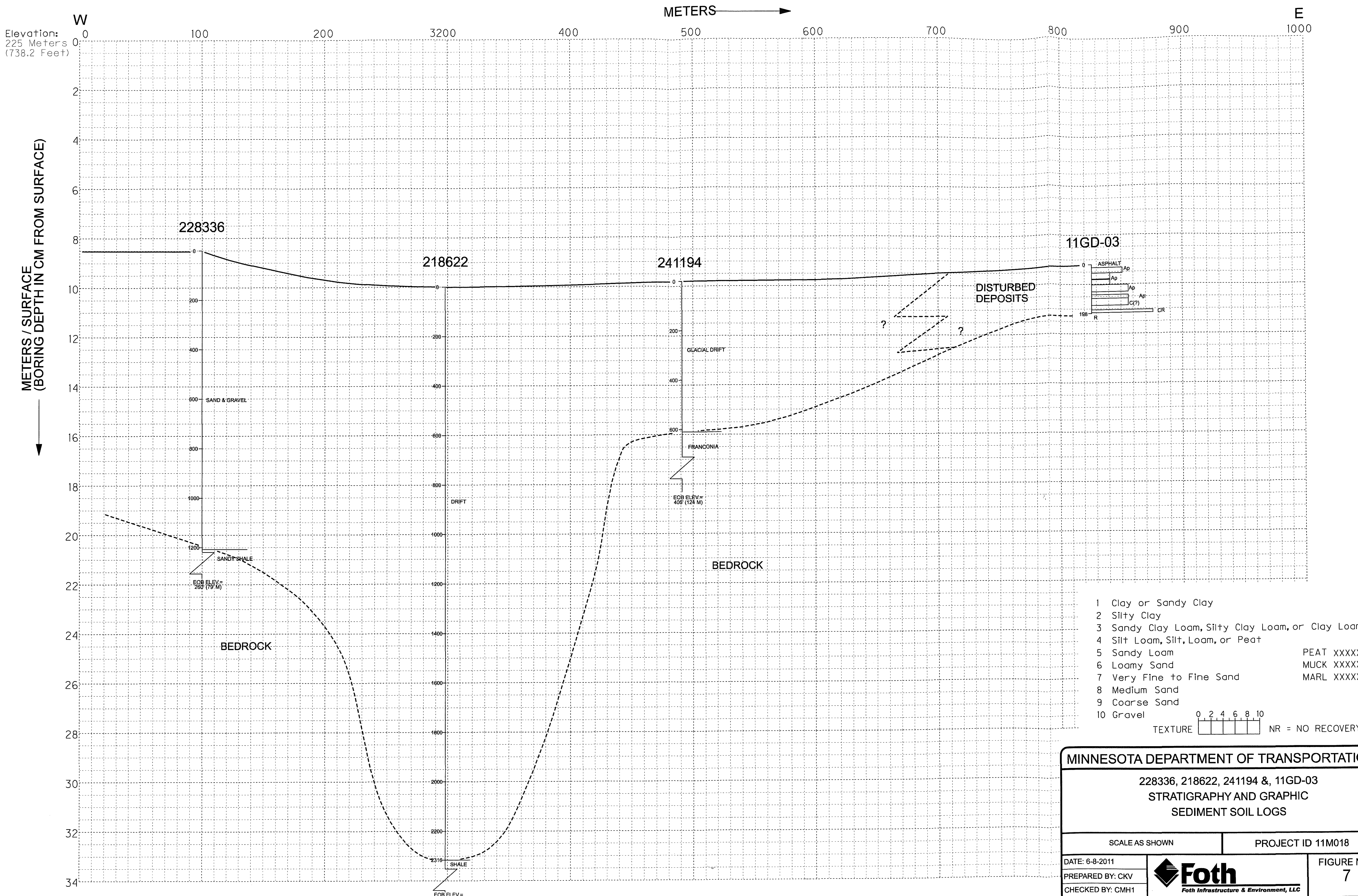

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228336, 218622, 241194 &, 11GD-03
STRATIGRAPHY AND GRAPHIC
SEDIMENT SOIL LOGS

SCALE AS SHOWN | PROJECT ID 11M018

DATE: 6-8-2011
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FIGURE NO. 7

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Appendix A
List of Abbreviations, Acronyms, and Symbols

List of Abbreviations, Acronyms, and Symbols

AMS	Accelerator Mass Spectrometer
B.P.	Before Present (1950 A.D. base datum is used in radiocarbon chronology)
^{14}C	Carbon-14 (radiocarbon)
CAD	Computer aided drafting
cal. yrs. B.P.	Calendar years Before Present where "present" equals 1950 A.D.
drg	Digital Raster Graphic
Foth	Foth Infrastructure & Environment, LLC
GIS	Geographic Information System
GPS	Geographic Positioning System
LfSA	Landform Sediment Assemblages
Mn/DOT	Minnesota Department of Transportation
NRCS	Natural Resource Conservation Service
OSL age yrs.	Optically Stimulated Luminescence age in calendar years
QC	Quality Control
T.H.	Trunk Highway
U.S.	United States
USDA	United States Department of Agriculture
UTM	Universal Transverse Mercator – Coordinate System
WGS84	World Geodetic System 1984

Appendix B
Glossary of Terms

Glossary of Terms

alluvial fan. A low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like an open fan or a segment of a cone, deposited by a stream (esp. in a semiarid region) at the place where it issues from a valley upon a plain or broad valley, or where a tributary stream is near or at its junction with the main stream, or wherever a constriction in a valley abruptly ceases or the gradient of the stream suddenly decreases; it is steepest near the mouth of the valley where its apex points upstream, and it slopes gently and convexly outward with gradually decreasing gradient.

alluvium. A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material, deposited during comparatively recent geologic time by a stream or other body of running water, as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, as a cone or fan at the base of a mountain slope; esp. such a deposit of fine-grained texture (silt or silty clay) deposited during time of flood.

bar [streams]. A ridge-like accumulation of sand, gravel, or other alluvial material formed in the channel, along the banks, or at the mouth, of a stream where a decrease in velocity induces deposition; e.g., a *channel bar* or a *meander bar*.

basement material. The undifferentiated complex of rocks that underlines the rocks of interest in an area.

bluff. A high bank with a broad precipitous, sometimes rounded, cliff face overlooking a plain or a body of water.

catastrophic flood. A sudden, violent, short-lived, flood usually eroding a region or subregion.

chute. A narrow stream or river channel through which water flows rapidly; usually during overflow stages.

colluvium. A general term applied to any unconsolidated sediment deposited by rainwash, sheetwash, slope failure, or slow continuous downslope creep, usually collecting at the base of slopes or hillsides.

core [drill]. A cylindrical section of sediment or rock, usually 5-10 cm in diameter and up to several meters in length, taken as a sample of the interval penetrated by a core bit, and brought to the surface for geologic examination and/or laboratory analysis.

cross-section. (a) A diagram or drawing that shows features transected by a given plane; specifically a vertical section drawn at right angles to the longer axis of a geologic or geomorphic feature, such as the mean direction of flow of a stream. (b) An actual exposure or cut that shows transected geologic features.

delta. The low, nearly flat, alluvial tract of land at or near the mouth of a river, commonly forming a triangular or fan-shaped plain of considerable area, crossed by many distributaries of the main river, perhaps extending beyond the general trend of the coast, and resulting from the accumulation of sediment supplied by the river in such quantities that it is not removed by tides, waves, and currents. Most deltas are partly subaerial and partly below the water. The term was introduced by Herodotus in the 5th Century B.C. for the tract of land, at the mouth of the Nile River, whose outline broadly resembled the Greek capital letter "delta", Δ, with the apex pointing upstream.

depositional environment. The type of environment under which sediments are deposited (e.g., fluvial, eolian, glacial, high energy, low energy). The location of a cultural site in reference to the surrounding landscape plays an important factor in the changes that occur to it over time. Common natural processes that alter the site once it is abandoned include erosion and sedimentation. Lack of deposition may allow many cultures to exist on the same land surface over a great time span. Rapid deposition may diffuse those same cultures over a thick sedimentary sequence.

disturbed area. Any land surface having been disturbed, changed, or modified from its natural condition by, or due to activities related to, recent human actions (e.g., quarries, mines).

exotic. Describes a rock or mineral that is derived from another geographic region and is not derived from the local underlying or adjacent bedrock.

floodplain. (a) The surface or strip of relatively smooth land adjacent to a river channel, constructed by the present river in its existing regimen and covered with water when the river overflows its banks. It is built of alluvium carried by the river during floods and deposited in the sluggish water beyond the influence of the swiftest current. A river has one floodplain and may have one or more terraces representing abandoned floodplains. (b) Any flat or nearly flat lowland that borders a stream and that may be covered by its waters at flood stages; the land described by the perimeter of the maximum probable flood.

geomorphologist. A scientist that studies geomorphology.

geomorphology. (a) The science that treats the general configuration of the Earth's surface; specifically the study of the classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features. The term is esp. applied to the genetic interpretation of landforms, but has also been restricted to features produced only by erosion or deposition. The term was applied widely in Europe before it was used in the U.S., where it has come to replace the term *physiography* and is usually considered a branch of geology; in Great Britain, it is usually regarded as a branch of geography. (b) The science of both ancient and present day landscapes and how they evolved through time.

glaciofluvial. Pertaining to the meltwater streams flowing from wasting glacier ice and esp. to the deposits and landforms produced by such streams, as kame terraces and outwash plains; relating to the combined action of glaciers and streams.

gleyed sediment. Sediment developed under low oxygen conditions, typically under poor drainage or subaquatic environments resulting in reduction of iron and other elements. Gleyed sediments may be gray, blue, green, or olive in color. Abbreviated as a lower case "g" behind a master soil horizon designation in geologic core logs (e.g., Bg or Cg-horizon).

gorge. A narrow and deep valley with very steep to vertical banks and that may have running water at the bottom.

Holocene. An epoch of the Quaternary period, from the end of the Pleistocene, approximately 10,000 years ago, to the present time; also, the corresponding series of rocks and deposits. When the Quaternary is designated as an era, the Holocene is considered to be a period.

Holocene, radiocarbon age. The Holocene radiocarbon age is defined as 10,000 ^{14}C years B.P. to present.

horizons [soil]. A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as structure, color, or texture, or by chemical composition, including content of organic matter or degree of acidity or alkalinity. Soil horizons are generally designated by a capital letter, with or without a numerical annotation (e.g., A-horizon, C1-horizon).

hydrology. The science that deals with global water (both liquid and solid), its properties, circulation, and distribution, on and under the Earth's surface and in the atmosphere, from the moment of its precipitation until it is returned to the atmosphere through evapotranspiration or is discharged into the ocean. In recent years the scope of hydrology has been expanded to include environmental and economic aspects.

infinite date. An age exceeding the maximum detection limits of radiocarbon or other radiometric dating isotopes. The name implies that the age of the sample could go back to a time approaching infinity.

lacustrine. (a) Pertaining to, produced by, or formed in a lake or lakes; e.g., "lacustrine sands" deposited on the bottom of a lake, or a "lacustrine terrace" formed along its margin. (b) Growing in or inhabiting lakes; e.g., a "lacustrine fauna." (c) Said of a region characterized by lakes; e.g., a "lacustrine desert" containing the remnants of numerous lakes that are now dry.

landform. Any physical, recognizable form or feature of the Earth's surface, having a characteristic shape, and produced by natural causes; it includes forms such as plain, hill, terrace, slope, esker, and dune. Taken together, the landforms make up the surface configuration of the Earth.

landform sediment assemblage (LfSA). A landform or set of similar landforms that are linked with the same or similar underlying lithostratigraphic units.

landscape. (a) The distinct set of *landforms*, esp. as modified by geologic forces that can be seen in a single view, e.g., glacial landscape. (b) [Mn/Model] A "major" *landform* or set of *landforms* generated by a particular geologic process; the term "major" refers to the relative size of *landforms,* which is on a sliding scale.

landscape suitability ranking. (a) A ranking used to evaluate the potentials for the land surface and subsurface intervals to have and preserve in situ cultural deposits based upon stratigraphic ages and either post-depositional or depositional environments. This ranking does not predict archaeological site locations, it predicts landscapes and paleolandscapes that could contain or not contain in situ sites. (b) The numerical product of the *age ranking* and *depositional environment ranking*.

levee [streams]. (a) see *natural levee.* (b) An artificial embankment built along the bank of a watercourse or an arm of the sea, to protect land from inundation or to confine streamflow to its channel.

lithofacies. A lateral, mappable subdivision of a designated stratigraphic unit, distinguished from adjacent sub-divisions on the basis of lithology, including all mineralogic and petrographic characters and those paleontologic characters that influence the appearance, composition, or texture of the rock; a *facies* characterized by particular lithologic features. Laterally equivalent lithofacies may be separated by vertical arbitrary-cut-off planes, by intertonguing surfaces, or by gradational changes.

made land [soil]. Spatial areas filled with earth, earth and refuse, or refuse and is typically created under the control of man.

mantle [geol]. A general term for an outer or overlying covering material of one kind or another.

marginal channel. A channel formed by a stream flowing along the outer margin or paleo-margin of a catastrophic flood landscape.

meander [streams]. n. (a) One of a series of regular freely developing sinuous curves, bends, loops, turns, or windings in the course of a stream. It is produced by a mature stream swinging from side to side as it flows across its *floodplain* or shifts its course laterally toward the convex side of an original curve. (b) valley meander.--v. To wind or turn in a sinuous or intricate course; to form a meander.

model. A working hypothesis or precise simulation, by means of description, statistical data, or analogy, of a phenomenon or process that cannot be observed directly or that is difficult to observe directly. Models may be derived by various methods (e.g., by computer, from stereoscopic photographs, or by scaled experiments).

natural levee. A long broad low ridge or embankment of sand, silt, or other material, built by a stream on its floodplain and along both banks of its channel during flood stage when the coarser sediment is deposited as a result of suddenly decreased velocity once spilling over to the floodplain.

optically stimulated luminescence (OSL). A method used to determine the absolute age of an aliquot of minerals. Electrons get trapped in the crystal lattices of minerals after being shielded from the sunlight by overlying sediments. While buried in the dark, a certain amount of electrons continue to slowly and relatively uniformly escape through time. More escape with more time passed. Once a mineral sample is collected in the dark, it may be stimulated in the laboratory again to release the remaining electrons, which are then measured and calculated as a ratio against the expected full capacity of electrons had none ever escaped. This ratio then determines the age of the sample.

overbank deposits. Fine-grained sediment (silt and clay) deposited from suspension on a floodplain by floodwaters that cannot be contained within the stream channel.

oxide. A mineral compound where oxygen is linked with one or more metallic elements like iron or manganese. Iron oxides may give the appearance of "rust" or colors associated with, for example, the Munsell 10 year hue and both higher chromas and values.

paleo-valley. A catch-all term used for ancient valleys that are now occupied by wetlands or underfit streams. Paleo-Valley landscapes could also be included in the Glaciofluvial landscape.

paleochannel. A remnant of a stream channel cut in older sediment or rock and filled by the sediments of younger overlying rock.

peat. An unconsolidated deposit of semicarbonized plant remains in a water saturated environment, such as a bog or fen, and of persistently high moisture content (at least 75 percent).

ped. A naturally formed unit of soil structure, such as granule, block, subangular block, plates, etc.

ped coating. A naturally formed sedimentary layer that partially or wholly envelopes a unit of soil structure. Typically the coat consists of clay particles and is smooth and shiny in appearance to the unaided eye.

pediment. A term used in geomorphology to describe a gently sloping bedrock erosional surface formed by either alluvial or colluvial (e.g., sheetwash) waters under arid or semiarid conditions and at or near the base of a mountain, bluff, or escarpment. The bedrock surface slope may be mantled by a thin veneer of younger alluvium or colluvium derived from the receding mountain or escarpment, and in transit across the surface.

pedologic. A term used in soil classification for the collection of natural earthy materials on the Earth's surface, in places modified or even made by man, containing living matter, and supporting or capable of supporting plants out-of-doors. The lower limit is normally the lower limit of biologic activity, which generally coincides with the common rooting of native perennial plants.

pedology. One of the disciplines of soil science. The study of soil morphology, genesis, and classification.

Pleistocene. An epoch of the Quaternary period, after the Pliocene of the Tertiary and before the Holocene; also, the corresponding worldwide series of rocks. It began two to three million years ago and lasted until the start of the Holocene some 10,000 years ago. When the Quaternary is designated as an era, the Pleistocene is considered to be a period.

Pleistocene, terminal, radiocarbon age. The end of the Pleistocene is defined as 10,000 years B.P.

radiocarbon. Radioactive carbon.

radiocarbon dating. A method of determining an age in years by measuring the concentration of carbon-14 remaining in an organic material, usually formerly living matter, but also water bicarbonate, etc. The method, worked out by Willard F. Libby, U.S. chemist, in 1946-1951, is based on the assumption that assimilation of carbon-14 ceased abruptly on removal of the material from the Earth's carbon cycle (i.e., on the death of an organism) and that it thereafter remained a closed system. Most carbon-14 ages are calculated using a half-life of 5730±40 years or 5568±30 years. Thus the method is useful in determining ages in the range of 500 to 30, 000 or 40,000 years, although it may be extended to 70,000 years by using special techniques involving controlled enrichment of the sample in carbon-14.

redox condition. (a) shorthand for reduction-oxidation. Oxidation is the loss of electrons or an increase in oxidation state by a molecule, atom or ion. Reduction is the gain of electrons or a decrease in oxidation state by a molecule, atom or ion. In sediments, oxidized colors are typically have 10YR and 7.5YR or redder Munsell hues (reds, browns and yellows), and reduced colors tend to come more from the 5Y, 5GY, 5G, 5BG, and 5B Munsell hues (grays, greens and blues).

sedimentary rock. (a) A rock resulting from the consolidation of loose sediment that has accumulated in layers; e.g., a clastic rock (such as conglomerate or tillite) consisting of mechanically formed fragments of older rock transported from its source and deposited in water or from air or ice; or a chemical rock (such as rock salt or gypsum) formed by precipitation from solution; or an organic rock (such as certain limestones) consisting of the remains or secretions of plants and animals.

slough [mining] pron. *sluff.* Fragmentary rock or aggregate material that has crumbled and fallen away from the sides of a borehole and is typically seen at the top of the core sample when the sampling tool is opened.

soil profile. A vertical section of a soil that displays all its horizons.

solum. The upper part of a soil profile, typically the A and B horizons.

stratigraphic unit. A stratum or body of adjacent strata recognized as a unit in the classification of a rock sequence with respect to any of the many characters, properties, or attributes that rocks may possess (ISG, 1976, p. 13), for any purpose such as description, mapping, and correlation. Rocks may be classified stratigraphically on the basis of lithology (lithostratigraphic units), or properties (such as mineral content, radioactivity, seismic velocity, electric-log character, chemical composition) in categories for which formal nomenclature is lacking.

stratigraphy. (a) The science of rock strata. It is concerned not only with the original succession and age relations of rock strata but also with their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties -- indeed, with all characters and attributes of rocks as *strata;* and their interpretation in terms of environment or mode of origin, and geologic history. All classes of rocks, consolidated or unconsolidated, fall within the general scope of stratigraphy. (b) The arrangement of strata, esp. as to geographic position and chronologic order of sequence.

terrace [geomorph]. (a) Any long, narrow, relatively level or gently inclined surface, generally less broad than a plain, bounded along one edge by a steeper descending slope and along the other by a steeper ascending slope; a large bench or steplike ledge breaking the continuity of a slope. The term is usually applied to both the lower or front slope (the riser) and the flattish surface (the tread), and it commonly denotes a surface of a valley-contained, aggradational form composed of unconsolidated material as contrasted with a *bench* eroded in solid rock or till, for example. A terrace commonly occurs along the margin and above the level of a body of water, marking a former water level; e.g., a *stream terrace.* (b) A term commonly but incorrectly applied to the deposit underlying the trend and riser of a terrace, esp. the alluvium of a stream terrace; "this deposit ... should more properly be referred to as a fill, alluvial fill, or alluvial deposit, in order to differentiate it from the topographic form" (Leopold et al. 1964, p. 460).

thalweg. The line of deepest points along a streambed. Typically a smaller deeper channel within the overall streambed channel.

trench [geomorph]. A steep-sided valley, canyon, gorge or other depression eroded by running water such as a river.

topography. (a) The general configuration of a land surface or any part of the Earth's surface, including its relief and the position of its natural and man-made features. (b) The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

UTM. Universal Transverse Mercator Coordinate System.

Appendix C
Geologic Core Logs

and

County Well Index Logs

Core/Profile: 11GD-01
Date: 3/3/2011& 3/4/2011
Location: Pierce County
Legal description: SW¼ SW¼ SW¼ Section 11 T24N R18W
Latitude/Longitude: 44.5729 / -92.5375 (WGS84 horizontal datum)
County: Pierce
Parent material: Road Bed (asphalt)
Vegetation: Asphalt
Slope: 5-9%
Elevation: 207.0 meters (679.0 ft)
Topo. Map: Red Wing, MN
Remarks: Used alternate location because primary hole may have had artesian conditions, which was later confirmed by the landowner, but within the bedrock and not the late Wisconsinan/Holocene strata. Augered through first 3.05 meters (10 ft) because of built-up road bed. Township worker indicated that this roadbed was made from Mississippi River channel dredged materials while he was very young (ca. 1960s).

Depth meters (ft)	Horizon or Zone	Description
0.0-3.05 (0.0-10)	Ap	road bed fill; augered through frozen soil and unfrozen fine to medium sands without collecting samples; local township maintenance worker indicated that this was all dredged spoil materials used to build the road grade sometime during in the 1960s.
3.05-3.48 (10.0-11.4)	C(Ap?)	yellowish brown (10YR5/4) fine sand; many very thin slightly finer-grained dark yellowish brown (10YR4/4) beds; thin faint bedding to single grain; loose; non-effervescent; unknown lower boundary; possible dredge spoil used to build up road grade.
3.66-3.84 (12.0-12.6)	C(Ap?)	same as above except abrupt lower boundary.
3.84-3.86 (12.6-12.7)	C	dark grayish brown to dark brown to brown (10YR4/2-4/3) silt loam; few thin faint dark grayish brown (2.5Y4/2) beds and few thin faint brown to dark brown (7.5YR4/2) beds; thin bedding; friable; non-effervescent; abrupt lower boundary.
3.86-4.15 (12.7-13.6)	C	dark grayish brown to brown to dark brown (10YR4/2-4/3) medium sand with few very coarse sands; faint bedding; loose consistency; non-effervescent; unknown lower boundary; Post-Euroamerican Settlement-aged alluvium based upon bedding, colors, and stratigraphic position; wet.
4.15-4.76 (14.0-15.6)	C	sands same as above except with very few fine mollusk shell fragments.
4.9-5.06 (16.0-16.6)	C	sands same as above except abrupt lower boundary.
5.06-5.33 (16.6-17.5)	Cg	dark greenish gray (5GY4/1) medium sand with few thin coarse sand lenses; thin to medium bedding; loose; spotty effervescence; unknown lower boundary; common fine shell fragments; photographed.
5.49-5.91 (18.0-19.4)	Cg	sands same as above except common thin coarse sand lenses.
6.10-6.25 (20.0-20.5)	Cg	sands same as above except few thin coarse sand lenses; abrupt lower boundary.
6.25-6.43 (20.5-21.1)	Cg	black (2.5Y2/0) silty clay loam to silty clay; faint thin bedding; very firm; spotty to slight effervescence; unknown lower boundary; collected sample; photographed.
6.71-7.01 (22.0-23.0)	Cg	very dark gray (5Y3/1) silty clay; few fine to medium prominent dark reddish brown (5YR3/2) mottles; faint bedding, very firm consistency; spotty to slight effervescence; unknown lower boundary; collected photographs.
7.32-7.47 (24.0-24.5)	Cg	very dark gray to very dark grayish brown (5Y-2.5Y3/1) silty clay loam; few very thin prominent light gray (2.5Y7/2) laminae of very fine to fine sand; laminar to thin bedding; firm consistency; slight effervescence; abrupt lower boundary; few thin to laminar black (N/0) organic lenses; few washed and fragmented fine shell laminae.
7.47-7.59 (24.5-24.9)	Cg	silty clay loams the same as above except coarser silty clay loam, unknown lower boundary; collected 24.0-24.9 feet.

Depth meters (ft)	Horizon or Zone	Description
7.92-8.23 (26.0-27.0)	Cg	dark greenish gray (5GY4/1) alternating coarse silt loams and very fine loamy sands; few to common thin very dark gray (2.5Y3/0) beds; thin to laminar bedding; friable and loose; slight effervescence; unknown lower boundary; collected photos.
8.53-8.81 (28.0-28.9)	Cg	alternating silts and sands the same as above except few decayed rootlets; collected for possible C-14.
9.14-9.48 (30.0-31.1)	Cg	dark greenish gray (5GY-5G4/1) fine loamy sand; faint thin bedding; loose; slight effervescence; clear lower boundary; few fine shell fragments.
9.48-9.60 (31.1-31.5)	Cg	dark greenish gray (5GY-5G4/1) alternating coarse silt loams and very fine loamy sands; thin and laminar bedding, friable and loose; slight effervescence; unknown lower boundary, few fine shell fragments.
9.75-10.00 (32.0-32.8)	Cg	alternating dark greenish gray (5GY-5G4/1) silty clay loams and coarse silt loams; many prominent gray (2.5Y2.5/1) laminar beds; laminar; friable; slight effervescence; unknown lower boundary; collected three photos.
10.36-10.67 (34.0-35.0)	Cg	silty clay loams and silt loams the same as above, except mottles are almost 50% of the core sample.
10.97-11.19 (36.0-36.7)	Cg	silty clay loams and silt loams the same as above, except abrupt lower boundary; delicate leafy wetland plants yielded conventional radiocarbon age of 1,330±30 B.P. (Beta-295697).
11.19-11.49 (36.7-37.7)	Cg	silty clay loams and silt loams the same as above, except with thin to medium beds of very fine sand, also common single laminar peat lenses interbedded with coarse silt loams and very fine sand between 36.95 and 37.20 feet; pencil in photo points to a single peat lamina; unknown lower boundary; three photos collected.
11.58-12.01 (38.0-39.4)	Cg	dark greenish gray (5GY4/1) silty clay loam to silty clay; few laminar distinct lighter gray (5Y6/1) coarse silt loam and very fine loamy sand beds; thin to laminar bedding; very firm; slight effervescence; unknown lower boundary; few peat laminae, few wood fragments.
12.19-12.71 (40.0-41.7)	Cg	very dark gray (5Y3/1) silty clay; few laminar distinct lighter gray (5Y6/1) coarse silt loam and very fine loamy sand beds; thin to medium bedding; very firm; slight effervescence; unknown lower boundary; few peat laminae; shore margin or near-shore subaquatic lacustrine environment.
12.80-13.17 (42.0-43.2)	Cg	same as above except black (5Y2.5/1) silty clay to clay; massive to faint very thin bedding; lacustrine.
13.41-14.02 (44.0-46.0)	Cg	black clays same as above except some whole very fine clam shells, one weathered Co_3 pebble at 13.90 m (45.6 ft.; pebble has strong effervescence); lacustrine; see pencil in photo at pebble location.
14.02-14.42 (46.0-47.3)	Cg	black clays same as above except no pebble and unknown lower boundary.
14.63-15.13 (48.0-49.7)	Cg	black clays same as above.
15.24-15.73 (50.0-51.6)	Cg	black clays same as above except few fine to medium snails and clam shells.
15.85-16.23 (52.0-53.3)	Cg	black clays same as above.
16.46-16.92 (54.0-55.5)	Cg	black clays same as above except slight to spotty effervescence.
17.07-17.60 (56.0-57.8)	Cg	same as above except clay (not clay loam); four giant clam shells were exposed by this split-spoon sampler; photographed.
17.68-18.29 (58.0-60.0)	Cg	black clay same as above except bed of fine to medium-sized clams at upper edge of core sample; no apparent giant clams.
18.29-18.71 (60.0-61.4)	Cg	black clay same as above; left sample intact for future processing.
18.90-19.29 (62.0-63.3)	Cg	black clay same as above; left sample intact for future processing.
19.51-19.90	Cg	black clay same as above; left sample intact for future processing.

Depth meters (ft)	Horizon or Zone	Description
(64.0-65.3)		
20.12-20.73 (66.0-68.0)	Cg	black clay same as above except Munsell color = 2.5Y2/0.
20.73-21.15 (68.0-69.4)	Cg	black (2.5Y2/0) fat clay; massive to faint very thin bedding; extremely firm; slight to spotty effervescence; unknown lower boundary; lacustrine.
21.34-21.73 (70.0-71.3)	Cg	black clay same as above.
21.95-22.25 (72.0-73.0)	Cg	black clay same as above.
22.56-22.92 (74.0-75.2)	Cg	black clay same as above.
23.16-23.47 (76.0-77.0)	Cg	black clay same as above except wood at 76.3 ft depth.
23.77-24.29 (78.0-79.7)	Cg	same as above except no apparent wood (temporarily halted drilling at night due to darkness at 6:00 p.m. on 3/3/2011).
24.38-24.75 (80.0-81.2)	Cg	black clay same as above (continued drilling at 8:00 a.m. on 3/4/2011)
24.99-25.39 (82.0-83.3)	Cg	clay same as above except dark greenish gray to very dark gray (5GY4/1-5Y3/1) and although still slightly effervescent, sample was noticeably more reactive than core string above.
25.60-25.95 (84.0-85.2)	Cg	dark greenish gray clays same as above.
26.21-26.82 (86.0-88.0)	Cg	no recovery (all slough).
26.82-27.10 (88.0-88.9)	Cg	dark greenish gray clays same as last sampled (25.60-25.95 m [84.0-85.15 ft.]) interval above.
27.43-28.04 (90.0-92.0)	Cg	dark greenish gray clays same as above except many laminar to thinly bedded faint gray to greenish gray (5Y5/1-5GY5/1) mottles.
28.04-28.65 (92.0-94.0)	Cg	dark greenish gray to very dark gray (5GY4/1-5Y3/1) clay to silty clay; clays were deformed in upper part of split-spoon sampler; collected entire 28.04-28.65 m (92.0-94.0 ft) sample interval, but only bottom 28.54-28.65 meter (93.65-94.0 ft) interval was not deformed; auger chatter occurred at approximately 28.5-28.6 meters (93.6-93.8 ft) on clam bed consisting of many medium to large individual clams; each clam shell is up to at least 6.0 cm (0.2 feet) in diameter and each valve is up to 0.5 cm thick (valves were recently fragmented by the split-spoon because they were larger than the 2-inch spoon's diameter); auger behaved as if the bit had engaged gravel; auger chatter may have caused some of this deformity in upper core sample; the shells are apparently *in situ* because of their bedded nature, their size compared to their surrounding clay matrix, and being well preserved (not water worn); clam shells yielded a conventional radiocarbon age of 10,070±100 B.P. (Beta-295699).
28.65-29.17 (94.0-95.7)	Cg	very dark grayish brown to dark olive gray (2.5Y-5Y3/2) alternating beds of medium and very coarse sands; single grain; loose; slight effervescence; abrupt lower boundary; photographs.
29.17-29.24 (95.7-95.9)	Cg	dark greenish gray to very dark gray (5GY4/1-5Y3/1) silty clay loam to silty clay; massive; very firm; slight effervescence; unknown lower boundary with whole fine clam shells.
29.28-29.79 (96.0-97.7)	Cg	same as 28.65-29.17 m (94.0-95.7 ft) interval above except with increasingly subrounded exotic pebbles toward lower boundary; thin silty clay lenses near lower boundary
29.87-30.48 (98.0-100.0)	Cg	collected this interval for possible OSL date; however the light seal caused some light contamination; medium to coarse pebbly sand at top of barrel and coarse well-rounded pebbles and fine cobbles at bottom up to 4.5x3.5x2.5 cm in size.
30.48-31.09 (100.0-102.0)	Cg	poor recovery; trace of very dark grayish brown to dark olive gray (2.5Y-5Y3/2) very coarse sands.

Depth meters (ft)	Horizon or Zone	Description
31.09-31.70 (102.0-104.0)	Cg	dark greenish gray to very dark gray (5GY4/1-5Y3/1) alternating medium to coarse sands and very coarse sands with pebbles; bedded to single grain; loose; slight effervescence; unknown lower boundary; two overall fining-upward sequences within this split-spoon sample; thin silt loam lenses near upper boundary of uppermost fining-up sequence at 31.24 m (102.5 ft.).
31.70-32.00 (104.0-105.0)	Cg	dark greenish gray to very dark gray (5GY4/1-5Y3/1) alternating medium to coarse sands and very coarse sands with pebbles; bedded to single grain; loose; slight effervescence; unknown lower boundary.
32.31-32.61 (106.0-107.0)	Cg	dark greenish gray sands same as above
32.92-33.53 (108.0-110.0)	Cg	OSL Sample collected; appeared same dark greenish sands as above; good tight seal prevented light contamination; drillers exhausted their auger string at 110 feet and boring ended at this depth. Elevation of this interval equals 174.1-173.5 m (581.0-579.0 ft.).

Core/Profile: 11GD-02
Date 3/1/2011
Location: Levee City Park
Legal description: NW¼ SE¼ NE¼ Section 30 T113N R14W
Latitude/Longitude: 44.5682 / -92.5355 (WGS84 horizontal datum)
County: Goodhue
Parent material: Alluvium/Overbank deposits
Vegetation: Grass Lawn
Slope: 3-5%
Elevation: 206.2 meters (676.7 ft)
Topo. Map: Red Wing, MN
Remarks: City of Red Wing's Levee park on east side near ADM facility. Refusal on sandstone bedrock at 12.5 m (41ft) depth. Also, reworked and weathered sandstone bedrock boulders with few cobbles/pebbles interbedded amongst these reworked blocks at bottom..

Depth meters (ft)	Horizon or Zone	Description
0.0-0.12 (0.0-0.4)	Ap1	black (10YR2/1) sandy loam to loam; few very fine prominent yellow red (5YR5/6) tile or brick fragments, massive; frozen; non-effervescent, abrupt lower boundary, sod
0.12-0.18 (0.4-0.6)	Ap2	yellowish brown (10YR5/6) pebbly sandy loam; common medium prominent black (10YR2/1) mottles; single grain; loose; slight effervescence; abrupt lower boundary; sod base; weathered carbonate clasts.
0.18-0.37 (0.6-1.2)	CA	dark brown (10YR3/3) silt loam; few fine distinct strong brown (7.5YR5/6) mottles; faint laminar bedding; friable; non-effervescent; abrupt lower boundary.
0.37-0.49 (1.2-1.6)	C	brown to dark brown (10YR4/3) sandy loam; massive; very friable; violent effervescence; unknown lower boundary; many yellowish red (5YR5/6) broken and varied brick or clay tile fragments.
0.61-0.85 (2.0-2.8)	Ap	dark brown (10YR3/3) pebbly sandy loam; many fine faint yellowish brown (10YR5/4) mottles; massive; very friable; slight effervescence; unknown lower boundary, fill materials with CO_3 pebbles and cobbles
1.22-2.13 (4.0-7.0)	C	yellowish brown (10YR5/6) fine loamy sand to sand; many fine faint dark yellowish brown (10YR3/6) mottles; faint to prominent thin bedding, loose; non-effervescent; abrupt lower boundary; few very thin lenses of finer textures (coarse silt loam); moist.
2.13-2.50 (7.0-8.2)	C	brown to dark brown (10YR5/3-4/3) medium sandy loam to sand; many medium distinct dark brown (7.5YR3/4) mottles; faint thin bedding; loose; non-effervescent; abrupt lower boundary; wet; mottles may be caused by old decayed and weathered roots.
2.50-2.99 (8.2-9.8)	Op	black (N/0) wood chips with pebbles, single grain, loose; non-effervescent; unknown lower boundary; appears to be saw mill waste products.
3.05-3.20 (10.0-10.5)	Op	wood chips same as above
3.20-3.44 (10.5-11.3)	Op	whole log - collected – wood did not float.
3.66-3.93 (12.0-12.9)	Op	black wood chips same as 2.50-2.99 m (8.2-9.8 ft) above except one small (5.5x3.5x2 cm) cobble of angular man-made reddish brown(2.5YR4/4) brick or tile at 3.84 m (12.6 ft.).
4.27-4.54 (14.0-14.9)	Op	black wood chips same as 2.50-2.99 m (8.2-9.8 ft) above.
4.88-5.15 (16.0-16.9)	Op	black wood chips same as 2.50-2.99 m (8.2-9.8 ft.) above except CO_3 cobble at 5.06-5.12 m (16.6-16.8 ft.) and broken clam shell at 5.12-5.15 m (16.8-16.9 ft.).
5.49-5.56 (18.0-18.3)	CO(p?)	black (N/0) organic sandy loam; massive; friable; slight effervescence; abrupt lower boundary; common clam shell fragments; collected entire sample for possible C-14; few wood fibers.
5.56-5.85 (18.3-19.2)	Cg	very dark grayish brown (2.5Y3/2) pebbly coarse sand; single grain; loose; slight to spotty effervescence; unknown lower boundary; well-rounded basalt cobbles up to 5x4x3 cm; angular CO_3 cobbles up to 3.5x2.5x2.0 cm; fining-up sequence.
6.10-6.31	Cg	dark grayish brown to dark gray (2.5Y4/2-5Y4/1) medium sand with thin to medium

(20.0-20.7)		coarse sand lenses; single grain; loose; spotty effervescence; abrupt lower boundary.
6.31-6.64 (20.7-21.8)	Cg	dark grayish brown (2.5Y4/2) pebbly coarse sand; single grain; loose; spotty effervescence; unknown lower boundary; red granite cobble 6x4x4 cm in dimension; milky quartz cobble 4x3x3 cm in dimension.
6.71-6.86 (22.0-22.5)	Cg	dark grayish brown coarse sands same as above except abrupt lower boundary and no apparent cobbles.
6.86-6.98 (22.5-22.9)	Cg	dark grayish brown to grayish brown (2.5Y4/2-5/2) fine sands; single grain; loose; spotty effervescence; abrupt lower boundary, common fine rootlets at upper and lower boundaries and one fragment of wood spanning 6.86-6.95 m (22.5-22.8 ft.); collected.
6.98-7.25 (22.9-23.8)	Cg	dark grayish brown (2.5Y4/2) pebbly medium to very coarse sand; single grain; loose; ; spotty effervescence; unknown lower boundary; common well rounded exotic cobbles up to 4x3x3 cm and chert cobbles up to 7x4.5x2.5 cm; photograph.
7.32-7.44 (24.0-24.4)	Cg	dark grayish brown sands same as above except no cobbles; abrupt lower boundary.
7.44-7.56 (24.4-24.8)	Cg	dark grayish brown (2.5Y4/2) fine to medium sand, single grain; loose; spotty effervescence; abrupt lower boundary; very fine shell fragments.
7.56-7.89 (24.8-25.9)	Cg	dark grayish brown (2.5Y4/2) pebbly medium to very coarse sand; single grain; loose; spotty effervescence; well rounded chert cobble broken by split-spoon sampler is greater than 7x5x3.5 cm in size; well rounded black basalt greater than 5.5x5x4 cm in size.
7.92-8.32 (26.0-27.3)	Cg	dark grayish brown sands same as above except includes rounded CO_3 cobbles up to 6x6x3 cm
8.53-8.81 (28.0-28.9)	C	brown to dark brown (7.5YR4/4) pebbles; single grain; loose; non-effervescent; abrupt lower boundary; uniformly well sorted pebbles; clast supported; few sand clasts.
8.81-8.93 (28.9-29.3)	Lma	dark gray to dark grayish brown (2.5Y4/0-4/2) lake marl with cobbles and pebbles; massive; friable; strong effervescence; unknown lower boundary, collected; photographed; common fine whole snail and clam shells.
9.14-9.17 (30.0-30.1)	Lma	dark gray lake marls same as above except abrupt lower boundary.
9.17-9.36 (30.1-30.7)	Cg	dark gray to very dark gray (2.5Y4/0-3/0) fine to medium sand with few pebbles; single grain; loose; non-effervescent; clear lower boundary
9.36-9.60 (30.7-31.5)	Cg	dark grayish brown to grayish brown (2.5Y4/2-5/2) medium sand with pebbles; single grain; loose; non-effervescent; unknown lower boundary.
9.75-10.15 (32.0-33.3)	Cg	dark grayish brown sands same as above
10.36-10.79 (34.0-35.4)	Cg	dark grayish brown sands same as above
10.97-11.20 (36.0-36.75)	Cg	dark grayish brown sands same as above except very few pebbles; abrupt lower boundary.
11.20-11.58 (36.75-38.0)	Oe	reddish gray (5YR2.5/2) moderately fibrous peat, matted structure, highly compacted; extremely firm; non-effervescent; unknown lower boundary; photographed; collected whole sample; leafy peat plants from 11.20-11.25 m (36.75-36.9 ft) yielded a conventional radiocarbon age of 7,490±40 B.P. (Beta-295700); wood log at 11.49-11.58 meters (37.7-38.0 ft) yielded a conventional radiocarbon age of 10,310±60 B.P. (Beta-295701); wood log was also broader than the core barrel diameter.
11.58-11.64 (38.0-38.2)	Cg	dark grayish brown (2.5Y4/2) medium to coarse sand; single grain structure; loose; non-effervescent; abrupt lower boundary; this horizon may have been slough in the split-spoon.
11.64-11.67 (38.2-38.3)	Oa	black (10YR2/1) peaty muck; thin bedding; friable; non-effervescent; abrupt lower boundary; collected.
11.67-11.89 (38.3-39.0)	CR	brownish yellow (10YR6/6) very fine and fine sands; few coarse distinct strong brown (7.5YR5/6) mottles; crude faint bedding; friable; non-effervescent; unknown lower boundary; reworked weathered sandstone bedrock; few beds with pebbles.
12.19-12.50 (40.0-41.0)	R	brownish yellow (10YR6/6) weathered sandstone bedrock (very fine and fine sands); common coarse distinct strong brown (7.5YR5/6) mottles; massive; friable; non-effervescent; unknown lower boundary.

Core/Profile: 11GD-03
Date 2/28/2011
Location: City of Red Wing 4th Street W and Potter Street
Legal description: SW¼ SW¼ NW¼ Section 29 T113N R14W
Latitude/Longitude: 44.5660 / -92.5311 (WGS84 horizontal datum)
County: Goodhue
Parent material:
Vegetation: Asphalt Road
Slope: 5-9%
Elevation: 215.8 meters (708.0 ft)
Topo. Map: Red Wing, MN
Remarks: Hole drilled on West 4th Street just SW of corner with Potter Street; used Mobile B-59 HSA drill rig; also moved 10 feet west of current hole and the auger was rejected at 8 feet depth.

Depth meters (ft)	Horizon or Zone	Description
0.0-0.12 (0.0-0.4)	Ap	Asphalt
0.12-0.34 (0.4-1.1)	Ap	dark brown (10YR3/3) sandy loam; frozen moderate medium platy; friable; strong effervescence; abrupt lower boundary; road subgrade.
0.34-0.58 (1.1-1.9)	Ap	dark brown (10YR3/3) sandy clay loam; frozen; massive; firm; slight effervescence; unknown lower boundary; common exotic quartz pebbles; many sandstone pebbles/cobbles (local bedrock).
0.61-0.82 (2.0-2.7)	Ap	dark brown to brown (7.5YR3/4-4/4) sandy clay loam; common coarse reddish yellow (7.5YR6/8) mottles consisting of local weathered sandstone bedrock; frozen; massive; firm; spotty effervescence; abrupt lower boundary.
0.82-1.10 (2.7-3.6)	Ap	dark yellowish brown (10YR4/4) pebbly loamy sand; single grain; loose; non-effervescent; unknown lower boundary; common coarse sandstone pebbles/cobbles.
1.22-1.37 (4.0-4.5)	Ap	dark yellowish brown sands same as above except abrupt lower boundary.
1.37-1.65 (4.5-5.4)	C (?)	brown to dark brown (10YR4/3) pebbly loamy sand; single grain; loose; slight effervescence; unknown lower boundary; exotic rounded cobbles of basalt and red granites up to 2x4x3 cm.
1.83-1.95 (6.0-6.4)	CR	poor recovery; weathered sedimentary carbonate bedrock; slightly effervescent; drilled through possible boulder or weathered bedrock.
1.98 (6.5)	R	auger refused on bedrock at 1.98 m (6.5 ft). End of Boring

Core/Profile: 11GD-04 & 11GD-04(a)
Date: 2/28/2011
Location: 5th Street East/Arkin Street
Legal description: NE¼ SE¼ NW¼ Section 29 T113N R14W
Latitude/Longitude: 44.5671 / -92.5243 (WGS84 horizontal datum)
County: Goodhue
Parent material: I
Vegetation: Asphalt Road
Slope: 5-9%
Elevation: 208.7 meters (684.9 ft)
Topo. Map: Red Wing, MN
Remarks: Recollected 11GD-04(a) at approximately 4 feet north of 11GD-04 for organics. The 11GD-04(a) 6.0-6.4 depth interval collected is equal to the 11GD-04 7.0-7.4 depth interval. Organic sediment yielded a conventional radiocarbon age of 2,530±30 B.P. (Beta-295702) just above the sandstone bedrock.

Depth meters (ft)	Horizon or Zone	Description
0.0-0.12 (0.0-0.4)	Ap	Asphalt
0.12-0.34 (0.4-1.1)	Ap	light yellowish brown to very pale brown (10YR6/4-7/6) pebbly loamy sand; single grain; loose; slight effervescence; abrupt lower boundary; fine to medium exotic rounded pebbles; coarse angular pebbles and cobbles of weathered sedimentary bedrock.
0.34-0.61 (1.1-2.0)	Ab1	black (10YR2/0) loam with fine pebbles; few thin laminar lenses of light yellowish brown (10YR6/4) fine sand; laminar to thin bedding; firm; non-effervescent; unknown lower boundary; pebbles are both local and exotic rock.
0.61-0.76 (2.0-2.5)	Ab2	black (10YR2/0) loam with medium pebbles; few very coarse distinct very pale brown to yellow (weathered) sandstone cobbles; massive; friable; non-effervescent; abrupt lower boundary.
0.76-1.19 (2.5-3.9)	Ab3	black (10YR2/0) loam with pebbles; few medium faint very dark brown (10YR2/2) fine sand lenses; faint thin bedding; friable; non-effervescent; unknown lower boundary; two photos.
1.22-1.49 (4.0-4.9)	Ab4	black loam same as above except silt loam; abrupt lower boundary; wood root collected at 4.5 feet depth.
1.49-1.74 (4.9-5.7)	Ab5	very dark gray to black (2.5YR3/0-2/0) silt loam to loam; many fine distinct dark red to red (10R3/6-4/8) mottles; massive; firm; non-effervescent; unknown lower boundary.
1.83-1.95 (6.0-6.4)		very dark loams same as above except abrupt lower boundary.
1.95-2.26 (6.4-7.4)	Ab6	very dark gray to dark gray (10YR3/1-4/1) silt loam to loam; many medium to fine very pale brown to yellow (10YR7/4-7/6) sandstone pebbles; massive; friable; non-effervescent; unknown lower boundary; mostly coarse angular sandstone (weathered) bedrock; single coarse rounded 7x6x3 cm basalt cobble at 2.16-2.20 (7.1-7.2 ft); this interval was recollected from an adjacent core hole and the organic sediment sample yielded a conventional radiocarbon age of 2,530±30 B.P. (Beta-295702).
2.44-2.59 (8.0-8.5)	Cg	dark greenish gray (5GY4/1) coarse sandy loam with pebbles; massive; friable; non-effervescent; abrupt lower boundary; wet.
2.59-2.77 (8.5-9.1)	R	dark greenish gray (5GY4/1) weathered sandstone; laminar to thin bedding; hard; non-effervescent; unknown lower boundary.
2.77 (9.1)	R	auger refused at 2.77 m (9.1 ft) on bedrock End of Boring

Core/Profile: 11GD-05
Date: 3/4/2011
Location: Arkin Street and 4th Street East
Legal description: NE¼ SE¼ NW¼ Section 29 T113N R14W
Latitude/Longitude: 44.5678 / -92.5245 (WGS84 horizontal datum)
County: Goodhue
Parent material: Roadbed
Vegetation: Asphalt
Slope: 9-12%
Elevation: 219.3 meters (719.4 ft.)
Topo. Map: Red Wing, MN
Remarks: Initially drilled this location on the assumption that the landform was a colluvial slope originating off of Barn Bluff to the north. Drilling indicated that this is a bedrock channel form with perhaps minor amounts of colluvium from Barn Bluff. Started sampling at 3-5 feet beneath the road's frozen subgrade. Bedrock was encountered soon after.

Depth meters (ft)	Horizon or Zone	Description
0.0-0.91 (0.0-3.0)	Ap	Augered through road-bed and frozen subgrade.
0.91-1.13 (3.0-3.7)	Ap	strong brown (7.5YR5/6) fine loamy sand; many variable-sized prominent very dark grayish brown (10YR3/2) mottles of soft sedimentary clasts; massive structure; very friable consistency; non-effervescent; abrupt lower boundary; asphalt pebbles at 1.10 m (3.6 ft); fill.
1.13-1.34 (3.7-4.4)	C	strong brown (7YR5/6) fine loamy sand; very fine prominent very dark grayish brown to dark grayish brown (10YR3/2-4/2) mottles; faint bedding; very friable; slight effervescence; unknown boundary; possible older fill or colluvium that has characteristics of sandstone bedrock.
1.52 (5.0)	R	auger abruptly refused at 1.52 m (5.0 ft) depth on bedrock. End of Boring

Minnesota Unique Well No.

241194

County Goodhue
Quad Red Wing
Quad ID 86D

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING RECORD

Minnesota Statutes Chapter 103I

Entry Date 07/29/1992
Update Date 04/20/2010
Received Date

Well Name OLD NYBO BUILDING WELL

Township Range Dir Section Subsections Elevation 706 ft.

113 14 W 30 ADCABD **Elevation Method** 7.5 minute topographic map (+/- 5 feet)

Well Depth 300 ft. **Depth Completed** 300 ft. **Date Well Completed**

Drilling Method --

Well Address

RED WING MN 55066

Drilling Fluid --

Well Hydrofractured? Yes No From Ft. to Ft.

Use Abandoned **Status** Sealed

Geological Material	Color	Hardness	From	To
GLACIAL DRIFT			0	20
FRANCONIA FORMATION			20	24
IRONTON-GALESVILLE FORMATIONS			24	76
EAU CLAIRE FORMATION			76	216
MT. SIMON FORMATION			216	300

Casing Type Steel (black or low carbon) **Joint** No Information **Drive Shoe?** Yes No **Above/Below** ft.

Casing Diameter 6 in. to 72 ft. **Weight** lbs./ft. **Hole Diameter**

Open Hole from 72 ft. to 300 ft.

Screen NO **Make** **Type**

Diameter **Slot/Gauze** **Length** **Set Between**

Static Water Level
20 ft. from Land surface Date Measured 05/21/1987

PUMPING LEVEL (below land surface)
ft. after hrs. pumping g.p.m.

Well Head Completion
Pitless adapter manufacturer Model
Casing Protection 12 in. above grade
At-grade (Environmental Wells and Borings ONLY)

REMARKS
GAMMA LOGGED 5-21-1987.
SAME AS UNIQUE NO. 437910.
KIMMES-BAUER INC. SEALED WELL 10-12-1987.

Grouting Information Well Grouted? Yes No

Located by: Minnesota Geological Survey
Method: Digitized - scale 1:24,000 or larger (Digitizing Table)
Unique Number Verification: Information from owner
Input Date: 06/26/1995
System: *UTM - Nad83, Zone15, Meters* X: 536895 Y: 4934867

Nearest Known Source of Contamination
_feet _direction _type
Well disinfected upon completion? Yes No

Pump Not Installed Date Installed
Manufacturer's name Model number __ HP _ Volts
Length of drop Pipe _ ft. Capacity _g.p.m Type Material

Abandoned Wells Does property have any not in use and not sealed well(s)? Yes No

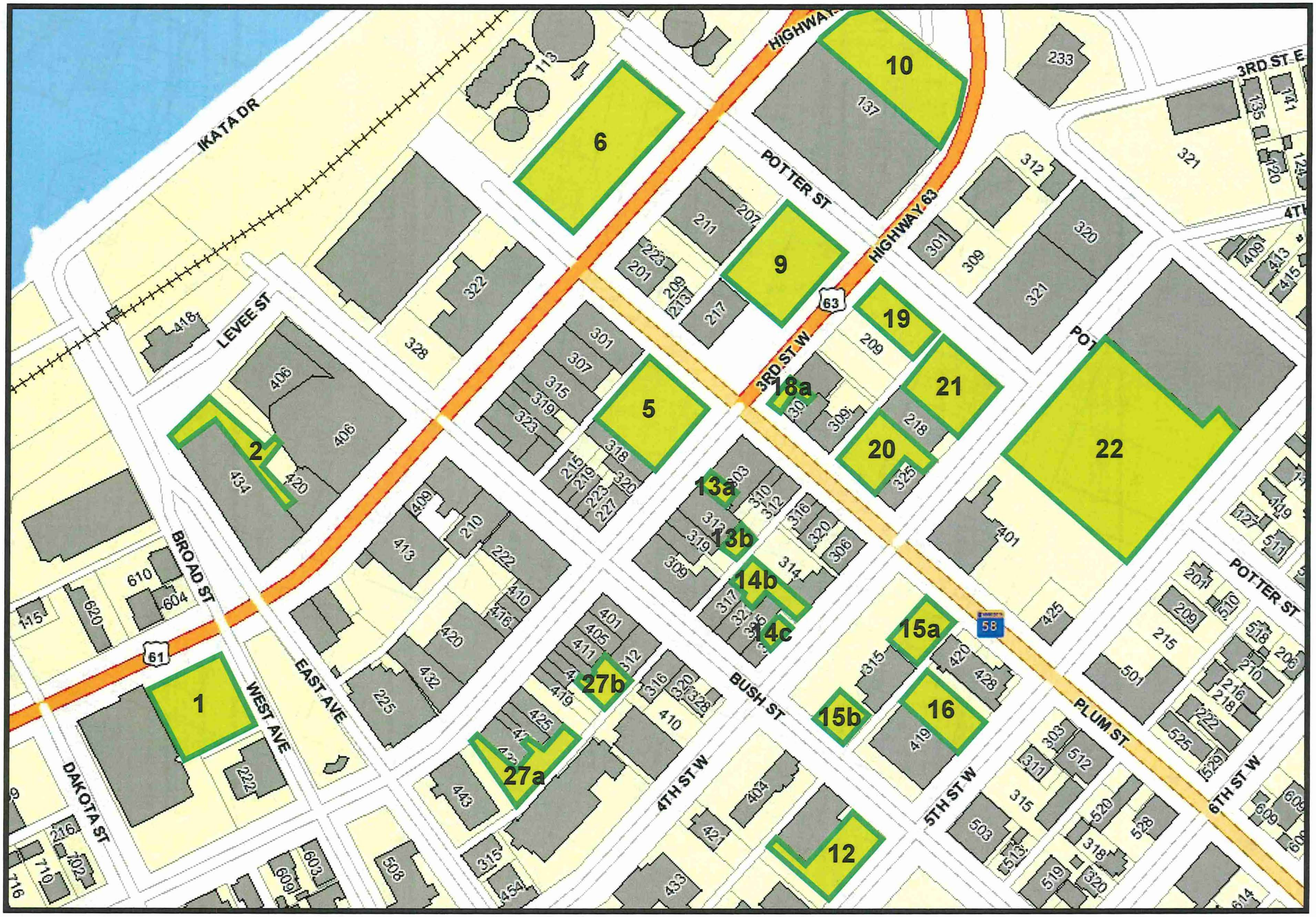
Variance Was a variance granted from the MDH for this well? Yes No

Borehole Geophysics Yes
First Bedrock Franconia
Last Strat Mt.Simon
Aquifer Multiple
Depth to Bedrock 10 ft.

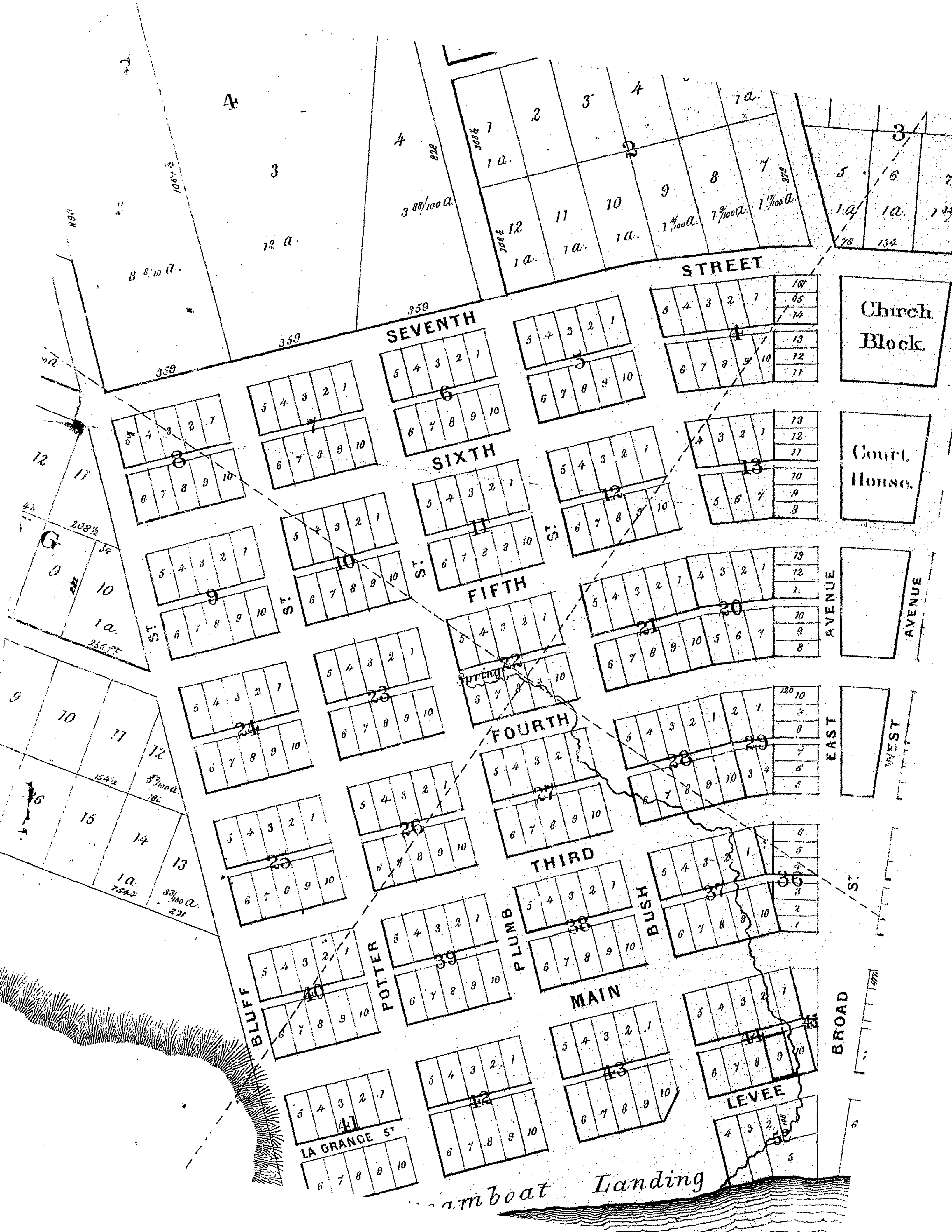
Well Contractor Certification
Minnesota Geological Survey — License Business Name
MGS — Lic. Or Reg. No.
Name of Driller

County Well Index Online Report **241194** Printed 10/3/2011 HE-01205-07

Appendix D
Archaeological Probe Field Notes,
Location Map,
and
Plat Map



IKATA DR
LEVEE ST
HIGHWAY 63
POTTER ST
3RD ST W
3RD ST E
BROAD ST
WEST AVE
EAST AVE
DAKOTA ST
BUSH ST
4TH ST W
5TH ST W
6TH ST W
PLUM ST
1
2
5
6
9
10
12
13a
13b
14b
14c
15a
15b
16
18a
19
20
21
22
27a
27b



SEVENTH STREET
SIXTH
FIFTH
FOURTH
THIRD
MAIN
LEVEE
LA GRANGE ST
BLUFF
POTTER
PLUMB
BUSH
ST.
EAST AVENUE
WEST AVENUE
BROAD ST.
Church Block.
Court House.
Spring
G
Steamboat Landing

ft.	Probe # 1A	Color	Texture	Notes, Historic/Prehistoric Boundary
–0.6		asphalt		
0.6–1.5		10YR5/4	Sa.L w/pebbles	subbase fill
1.5–2.8		10YR5/4	alt. f.L.Sa + c.Si.L.	bedded
2.8–3.2		10YR3/4-3/2	f.L.Sa.	disturbed bedding
3.2–3.3		10YR5/4-6/3	c.Si.L.	
3.3–4.0	NR			
4.0–4.1		10YR5/4	f.Sa.L	disturbed/fill
4.1–4.5		asphalt		
4.5–5.4		10YR4/4	pebbles & c.Sa.	subbase fill
5.4–8.0	NR			
8.0–8.5		10YR 5/4	f.Sa.L	fill
8.5–9.0		10YR5/4	alt. asphalt & Sa.L	fills/driveways - coarse clasts at lower boundary
9.0–9.2		10YR5/4	pebbles & cobbles	coarse angular CO_3 pebbles - subbase?
9.2–11.4		10YR4/4	v.c.Sa. w/pebbles	
11.4–12.0	NR			
12.0–12.4		same as above		
12.4–13.1		10YR5/4-6/4	v.f.L.Sa.	fill, violent effervescence
13.1–16.0		same as above except non-effervescent		
16.0–20.0		same as above with various exotic & local pebbles/gravel; sandstone cobble floor at 19.5 feet		
20.0–20.6		10YR5/4	cobbles	coarser than core barrel
20.6–24.0	NR			

	~~Probe#~~	~~Color~~	~~Texture~~	~~Notes, Historic/Prehistoric Boundary~~
24.0–24.1		Sandstone "floor"		
24.1–25.7		10YR6/3	m.Sa.	occasional clay loam lens w/ silt loam pebble-sized clasts; subbase for "floor" above to facilitate drainage.
25.7–25.8		10YR2/2	Sa.C.L.	possible AC-horizon; clear lower boundary
25.8–26.2		7.5YR4/6	m.Sa.	natural horizon.

ft.	Probe # 1B	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0		asphalt		
0.6		10YR4/4	Sa.L. w/pebbles	subbase for driveway
1.3		10YR5/4	f.Sa.L to L.Sa.	fill; disturbed "bedding"
3.5	NR			
4.0		10YR 5/4	alt. f.L.Sa and Sa.L	fill; " " ; abrupt lower boundary
6.7		7.5 YR3/2	f. Sa.L. w/pebbles;	CA-horizon; brick fragments; roots
7.0	NR			
8.0		10YR 5/3	f.L.Sa.	fill
8.3		7.5YR3/4	Sa.C.L w/pebbles	
10.2	NR			
12.0		same as above		
12.2		Sandstone	bedrock	(basement floor?)
12.5		10YR5/3	alt. gravel and Sa.C.L. w/pebbles	
13.3	NR			
16.0		10YR4/4 + 5/3	alt. f.Sa.L & C. Sa. C.L.	fill
16.5	NR	probe refused at		19.0 ft.
19.0				

ft.	Probe# 1C	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.6		assorted colors &	textures	fill
2.1		asphalt		
2.4		assorted colors &	textures	fill; red brick cobble
2.8		10YR2/1	Sa.L	Ab-horizon
3.4	NR			
4.0		10YR2/2	f.L.Sa.	C-horizon; gradual lower boundary
5.0		10YR2/2-2/1	f.L.Sa.	CA-horizon
6.1	NR			
8.0		10YR4/4	f.L.Sa.	
9.1		10YR4/4	c. pebbly Sa.	possible fill
10.1	NR			
12.0		same as above	; looks like fill because of disturbed "bedding"	
14.3	NR			
16.0		same as above		
17.9	NR			
20.0		same as above		
20.5		sandstone	bedrock wall and foundation w/mortar	
21.6		10YR5/4	c.L.Sa. w/pebbles;	pebbles are rounded and exotic.
22.8	NR			
24.0		10YR3/2	f.Sa.L w/pebbles	
24.6		10YR2/1-2/2	f.Sa.L	compacted CAb-horizon w/brick fragments
24.7		metamorphic	cobble	
24.8		10YR4/3	m.Sa.	
25.9		7.5YR5/6	Sa.L.	contained weathered SS pebble with glauconite green colors
26.1				

A.

Probe # 1D	Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.6	10YR5/3	Sa.L.w/pebbles	; 1 brick fragment
1.0	10YR4/3	Sa.L w/pebbles	; wood at 1.7 ft.; brick fragment at 2.7 ft.
2.8	10YR6/3	pebbly L.Sa	
3.1	NR		
4.0	Stone & mortar		
4.5	10YR3/1	Sa.C.L w/pebbles	; fill
5.3	10YR3/1	alt. Si.L.&Sa.L	fill
5.7	10YR4/3-4/1	f.L.Sa.	many various mottle colors; fill
6.9	10YR2/1	f.Sa.L-L.	with thinly bedded peats (low fiber)
7.0	10YR4/6	f.Sa.	with Sandstone cobbles; stratified
7.4	NR		
8.0	10YR4/3-5/3	f.L.Sa.	Strata
10.4	7.5YR4/4	L.-c.Si.L.	
11.6	7.5YR4/4	Sa.C.L. diamicton	
11.8	NR		
12.0	7.5YR4/4	pebbly Sa.C.L. diamicton	
13.5	NR		
16.0	10YR4/3-4/4	pebbly Sa.L.	common, rounded, local & exotic pebbles
17.8	NR		
20.0			

Probe# 2A	Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.5	10YR6/3	Sa.L	fill
1.1	assorted colors & textures		fill with cinders and charcoal
1.9	Mortar & stone		
2.3	10YR-7.5YR 4/3	f.Sa.L.	fill w/ cinders and charcoal
3.1	NR		
4.0	same as above	with Sandstone (SS) clasts	
4.9	7.5YR4/4-4/3	f.Sa.	
5.9	greens, browns, & reds	weathered SS bedrock clasts	
6.9	NR		
8.0	10YR4/3	c.-v.c. Sa.	oxidized
8.4	N4/0	c.-v.c.Sa.	gleyed
8.8	10YR2/2	peat	fibric, matted, moderately dense w/ man-made wood chips
9.5	NR		
12.0	N4/0	v.c. gravel	well-rounded exotics
12.7	NR		
16.0	same as above		
16.2	SS bedrock	; in situ	; soft.
20.0			

ft.	Probe # 5A	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.3		7.5YR 7/6	weathered	Sandstone cobble or boulder
0.7		10YR 4/3	pebbly Sa.L	common roots at lower boundary
2.5		10YR 2/1-2/2	L.	common roots; possible "made" soil.
3.1	NR			
4.0		Red brick & mortar		
6.6	NR			
8.0		same as above		
9.0		sandstone bedrock;		in situ; weathered.
10.7				

ft.	Probe# 5B	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.3		Sandstone, weathered		
0.8		asphalt		
1.1		10YR 5/3	Sa.L w/ pebbles	
2.6		10YR 3/2	L.	
2.8		mortar		
3.1	NR			
4.0		10YR 2/2	Sa.C.L.	
4.5		brick & mortar		
7.8	NR			
8.0		mortar		
9.0		sandstone		weathered; in situ
10.5				

ft.	Probe # 5C Color	Texture	Notes, Historic/Prehistoric Boundary
0–0.4	asphalt		
0.4–1.0	weathered sandstone ~~boulders~~		
1.0–1.3	asphalt		
1.3–2.1	10YR 4/3 - 3/3	pebbly Sa.L	fill
2.1–3.2	10YR5/3 - 5/4	SS cobbles	weathered CR-horizon
3.2	Refused at 3.2 ft		

ft.	Probe# 5D Color	Texture	Notes, Historic/Prehistoric Boundary
0–0.2	asphalt		
0.2–0.5	weathered SS		
0.5–0.8	asphalt		
0.8–1.4	10YR 4/3 - 4/4	pebbly Sa.L	fill
1.4–1.7	Limestone cobbles or possible floor or foundation or wall		
1.7–3.2	10YR 4/4	pebbly LSa.	
3.2–4.0	NR		
4.0–4.9	10YR 6/3 - 7/3	c. pebbles	weathered SS bedrock
4.9–5.9	sandstone bedrock foundation(?) or boulder		
5.9–8.0	NR		
8.0–8.4	10YR 2/1 - 2/2	v.f. Sa.L	Ab horizon w/historic debris (brick, cinders, etc)
8.4–11.0	10YR - 7.5YR 4/4	v. f. Sa.L	9.0-9.1 & 10.6-10.9 ft. had slightly darker stained (10YR 3/3) organics or older groundwater fronts
11.0–12.0	NR		
12.0–12.2	granite cobble or boulder blocked better recovery		
12.2–16.0	NR		

ft.	Probe # 6A	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0		asphalt		
0.3		10YR 3/3	pebbly L.Sa.	fill; brick fragments
1.4		N/0	L.-Si.C.L. w/pebbles	Ab horizon; subrounded to rounded 4x3x2 cm igneous pebbles; wood fragment collected at 1.9 ft.
2.1		7.5YR 5/6 - 5G 4/1 - 10YR 7/2	weathered cobbles/boulders	CR-horizon; flaggy, bedded, carbonates
2.4		bedrock		R-horizon; carbonate bedrock, insitu
2.5				

Probe# ______	Color	Texture	Notes, Historic/Prehistoric Boundary

Depth	Probe # 6-B	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0		Asphalt		
0.9		L.S. aggregate		
1.2		10YR3/1	pebbly L.Sa	
1.6		10YR4/1	pebbly c.SiL	Possible cap over industrial soil
2.3		10YR2/1-2/2	v.f. Sa.L	
2.4		10YR4/1	c.SiL Sa.C.L	weathered bedrock clast?
2.7	Ab	10YR2/1	L-SiC.L	Topsoil
3.1	NR			
4.0		as above	~~SiCL~~	
4.1				weathered bedrock or Clay from waning floods
4.6	Bedrock - weathered			

Depth	Probe# 6-C	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0		asphalt		
0.7		10YR3/1	pebbly L.Sa	fill
1.7	CA	10YR3/2	L	possible weakly developed soil or detrital C-rich horizon
2.1		7.5YR 4/4; 5/4		
2.4		alt. colors of weathered bedrock	alt bedded textures	possible SiL lenses were introduced within reworked bedrock
3.7	NR			
4.0		same as above		
4.4	R			

Probe # 6-D

Depth		Color	Texture	Notes, Historic/Prehistoric Boundary
0.0		Asphalt		
0.8		LS aggregate		
1.1		10YR2/1	L-SiCL	w/ common mottles of 10YR6/3 weathered LS. fill
2.2		10YR4/2	L-SiCL w/ pebbles	
2.7		10YR-2.5Y 5/3	L-Sa.C.L w/pebbles	many mottles (clods) of 10YR2/1; many mottles of 7.5Y[illegible]
3.0	NR			
4.0		same as above		— copper frag @ 4.1 ft (modern) dragged down to bedrock by bit
5.0	CR	weathered bedrock		
5.2	R	bedrock		
5.5				

Probe# 6-E

Depth		Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.8		10YR2/1-2/2	pebbly sa.	fill
1.5		Concrete slab		
3.0		10YR3/4	m-c pebbly sa	
3.2	NR			
4.0		Concrete slab		
4.9		10YR 5/3	M.Sa w/pebbles	fill
5.6	NR			
8.0		weathered Concrete		
9.2		10YR5/4	m.Sa.	
10.0		Green (off Munsell charts)	SS	glauconitic sandstone
10.6				

8/9/2011

ft.	Probe #9-A	Color	Texture	Notes, Historic/Prehistoric Boundary
0.3		asphalt		
0.7		10YR 7/6	Sa. flagstone (weathered); violent eff.	
0.8		10YR 2/1	Sa.L	Historic layer w/ coal slag; violent eff.
1.7		10YR4/4	CR	regolith, noneffervescent; iron oxide ~~nodule~~ concretion
		10YR5/3-5/4	RC	weathered siltstone and CO_3 bedrock (insitu) laminar & thin bedding
3.8	NR			
4.0		same as above		
6.0				

	Probe# 9-B	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0		asphalt		
0.2		10YR 2/1-2/2	sandy pebbles	historic debitage; brick fragment; many multicolored mottles; violent effervescence; clinker
1.3		10YR5/8	CR	weathered bedrock; ~~regolith~~; strong eff.; ~~insitu~~ siltstone + CO_3;
1.9		10YR5/3-5/4	RC	weathered siltstone bedrock; thin to laminar bedding
4.0				

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Close to water pipe trench and elevated US 63 bridge approach

Probe # 10-E (depth)	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0–0.1	asphalt		
0.1–0.2	gravel lot		
0.2–0.4	10YR 2/1	pebbly SaL	fill; viol. eff.
0.4–0.7	10YR 4/3-4/4	pebbly SaL	fill; viol. eff.
0.7–3.2	alt. 5GY-5G 6/1 & 10YR 2/1	alt. SaL & pebbly L	"fill or mixing zone" with bedrock slump (glauconite) spotty efferv.
3.2–4.0	NR		
4.0–6.0	same as above except brown glass shards at 5.8-6.0 ft.		
6.0–8.0	NR		
8.0–8.2	same as above except		no glass; abrupt lower
8.2–8.7	10YR 2/1-2/2	L w/ few pebbles	few laminar 5G 6/1 mottles; might be fill; abrupt lower
8.7–10.4	2.5Y-5Y 5/2	CR	reworked bedrock (partially in situ)

Probe# 10-F (depth)	Color	Texture	Notes, Historic/Prehistoric Boundary
0–0.2	asphalt		
0.2–3.2 ~~3.8~~	assorted fills of various colors and with variable clast size	~~sand~~ mostly	
3.2–4.0	NR		
4.0–5.3	as above		
5.3–6.0 ~~5.8~~	10YR 3/3	f. SaL	few pebbles; abrupt lower; strong efferv.
6.0–6.5	N/0	peat	w/ few shells; gradual lower [collected]
6.5–7.1	N/0	SiC to C	few subangular to subrounded fine pebbles
7.1–8.0	NR		
8.0–8.45	2.5Y 2/0-3/0 ABb	SiC-SiCL	very fine weak subang. blocky;
8.45–9.1	2.5Y 3/1 C	~~[illegible]~~	Mucky SaCL - abrupt, angular lower,
9.1–9.7	alt. 5GY 5/1 + 10YR?/	SiL + SiCL	"mixing zone" - pediment(?); clear lower
9.7–10.5	5Y 5/2-5/3	CR	weathered in situ bedrock (siltstone)

EOB

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Probe # 10-G	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0	asphalt		
0.1	gravel road		
0.3	assorted fills and textures; SS cobble at 2.8-2.9 ft.		
~~3.0~~ 2.9	NR		
4.0	as above		
(5.2) ~~5.4~~ 5.2	CO_3 cobble or foundation		
5.5	10YR3/2	f.Sa.L	
5.7	N/0	Peat	} collected
6.1	N/0	CL	} collected
6.55	NR		
8.0	10YR2/1-2/2	Sa.C.L	few medium 5G6/1 mottles; abrupt lower
lifted 9.2	5G6/2	CL to Clay	many medium prominent 10YR5/6 mottles; few thin or patchy v.f.Sa lenses; possible clay from weathered bedrock and/or lake clays before organics developed in local ~~ecosystem~~
9.6	~~50~~ 5Y5/3-5/2	CR weathered	laminar to thinly bedded siltstones
11.0			

Probe# ______	Color	Texture	Notes, Historic/Prehistoric Boundary

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ft.	Probe # 12E	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.5		gravel limestone roadbed		
0.8		N/0	L.-Sa.L.	A-horizon
2.7		10YR 2/2-3/3	f. Sa.L. w/few pebbles	pebble lag at 2.9 ft.; CA-horizon
3.3				

ft.	Probe# 13A-a	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.7		L.S. aggregate roadbed		
1.0		10YR 2/2	Sa.C.L.	historic debris down to at least 1.2 ft.
1.8		10YR3/4	Si.C.L	common coarse 7.5YR 4/6 mottles.
2.2		10YR4/3 & 6/4	Si.C.L.&f.Sa.	alt. beds
2.6	NR			
4.0		10YR6/3	m. Sa.	few well rounded pebbles
6.0	NR			
8.0		10YR6/3	m.-c. Sa.	part of fining-upward sequence
9.6		2.5Y 5/2 & 7.5YR 5/6	sandy pebbles	reworked bedrock clasts
10.2		alt. colors of rip-up clasts	alt. textures but mostly v.f.Sa. w/ rip-up pebbles	
10.9				

ft.	Probe # 13B-a Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.3	Limestone aggregate		
0.6	10YR2/2	L,-Sa,L.	fill; glass & brick fragments
0.8	10YR4/1 & 5/6	pebbly f.Sa.L.	alluvially reworked bedrock from gullies(?)
2.9	10YR6/4	SiL	faintly bedded; non-effervescent.
3.2	NR		
4.0	same as above		
5.0	same as above except no apparent bedding; gradual lower boundary; many 7.5YR4/6 mottle banding; slight effervescence.		
6.0	2.5Y5/2	Si,L.	deoxidized colors; loess or alluvium(?); many 7.5YR4/6 mottles; wet at 8.0 ft.; strong effervescence.
8.0			

	Probe# 13B-b Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.3	10YR3/4-3/3	pebbly Sa.L	fill
0.6	variable colors	pebbly Sa.L	assorted fill; multiple colors; bedrock cobbles/gravel
3.5	NR		
4.0	Same as above		fill or gully-washer deposits
7.2	NR		
8.0	same as above		strong effervescence
8.5	reworked SS & LS bedrock including flaggy LS cobbles; matrix mostly non-effervescent!		
11.6			

Probe # 14B-a (depth)	Horizon	Color	Texture	Notes, Historic/Prehistoric Boundary
0–0.3		asphalt		
0.3–1.2		LS aggregate		
1.2–2.2		10YR2/1	Sa.L.	assorted fill; multiple mottle colors; cinder & brick fragments
2.2–4.0	NR			
4.0–4.3		Stone		possible foundation
4.3–4.8	Ab	10YR2/1	SiL-SiCL	Ab-horizon
4.8–5.6	AC-CA	10YR2/1-2/2	SiL-SiCL	grading from AC- to CA-horizon; some bedding; gradual lower boundary.
5.6–6.5	C	10YR5/4-5/6	SiL	mostly massive; single 0.2ft thick CA-horizon (bedded); non-eff.;
6.5–8.0	NR			
8.0–10.0		same as above		
10.0–10.8		2.5Y 5/2	SiL	common coarse 7.5YR5/6 mottles
10.8–12.0	NR			
12.0–12.6		same as above; abrupt lower boundary		
12.6–13.8		5GY7/1	pebbly Sa.L	common 7.5YR4/6 mottles (clasts of both SS + LS)
13.8–14.5		2.5Y5/4	SiL	many v.f. sand laminae of 5GY7/1 color - heavy mineral sorting.

Probe# 14B-b (depth)	Horizon	Color	Texture	Notes, Historic/Prehistoric Boundary
0–0.3		asphalt		
0.3–1.3		aggregate (LS)		
1.3–1.5		10YR2/1	pebbly Sa.L	Ap-horizon
1.5–2.4		brick & mortar		
2.4–3.1		10YR2/1	Sa.L	Apb-horizon
3.1–4.0	NR			
4.0–4.2		10YR3/3	pebbly Sa.L	fill
4.2–5.2		flaggy L.S.	boulder	
5.2–5.4		10YR3/3	pebbly Sa.L	fill; glass shard at 5.4 ft.
5.4–8.0	NR			
8.0–8.3		10YR2/1	SiC.L.	Abp-horizon; disturbed topsoil; clear lower boundary
8.3–10.6		multicolored gray, greens, oranges, & browns	Sa.C.L	possible natural "gully washer" deposit; reworked local bedrock types; single, well rounded

ft.	Probe # 14C-a Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.4	10YR 5/6	m. Sa.	
0.8	10YR 2/2	L.	
0.9	5Y 5/2	v.f. Sa.L w/ pebbles	disturbed bedding; many mottles
2.5	10YR 2/1 - 2/2	v.f. Sa. - L.	disturbed soil (?)
2.6	NR		
4.0	variable colors	L. - Sa.C.L.	brick fragments; abrupt lower boundary; non-effervescent
4.5	5Y 5/2	L. - v.f. Sa.L.	many mottles; black thin wood & peat lens at lower bound.
7.2	NR		
8.0	10YR 2/1	peat	many wood fragments
8.2	10YR 2/2	L.	many 5Y 5/2 mottles; wood at 8.9 ft.
9.2	10YR 2/1	muck	few fibers (collected)
9.6	5Y 4/1	CO_3 pebbles w/ f.Sa.L matrix	reworked local bedrock angular pebbles; almost clast-supported. [collected 8.0-10.5 ft.]
10.5			

ft.	Probe# 15A-a Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.6	aggregate road bed		
1.7	10YR 2/1 - 2/2	pebbly Sa.L - L.	fill materials
3.4	NR		
4.0	2.5Y 5/2	Sandy Pebbles	angular
5.0	10YR 2/1	pebbly Sa.L.	rounded exotics; angular local pebbles
5.9	10YR 5/6 + many mottle colors	pebbly v.f. Sa.	reworked bedrock w/ local pebbles
6.7	cinders		
6.8	NR		
8.0	alt. 7.5YR 4/6 & 2.5Y 3/2	alt. peat & SiL lamina	decayed (oxidized) fibers
9.2	5Y 3/1	SiL - L.	ash/bone @ 9.3'; bark @ 9.5'; wood @ 10.3-10.5'; ash & cinders @ bottom
10.5	NR		
12.0	5Y 3/1	SiL. - L.	
12.4	5G - 5GY 5/1	Sa. pebbles	angular reworked local SS pebbles
13.1	alt. 10YR 2/1 & 3/1	alt. SiL & f.Sa.	
13.5	NR		
16.0	10YR 2/1	SiL - L.	few minor peat lamina and common rootlets
17.7	alt. 10YR 2/1 & 5GY 5/1	alt. SiL & f.Sa.	laminar bedding
18.7	5G 5/1	pebbly f. Sa.L	bedded; common rounded exotics; pebble lag at top boundary
18.9	NR		
20.0	5G 5/1	f. Sa. pebbles	
date → 20.2	10YR 2/1	SiL - SiCL.	lower 0.2 ft have reworked pebbles from below [Collected]
21.0	5G 5/1 - 5GY 5/1	v.f. Sa.L - L	many multicolored mottles; reworked SS sand grains
21.8	10YR 5/6	Sa. pebbles	well rounded exotics; abrupt lower boundary
22.5	5GY 5/1 - 5G 5/1	SS bedrock	weathered; in situ although slightly reworked at top boundary
22.8			

→ 5,240 ± 30 ^{14}C yrs B.P. (AMS date on plant matter [leafy wetland plants])
(Beta-304417)

ft.	Probe # 15A-b Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.5	aggregate base or old pavement		
1.6	10YR3/3-4/3	m. Sa.	fill
1.7	10YR6/4	f.-m. Sa.	fill
2.4	10YR5/6	pebbles	angular; local bedrock
2.7	10YR4/4	f.-m. Sa.	fill
2.8	NR		
4.0	same as above		
4.2	10YR2/2	pebbly Sa.L - Sa.C.L.	many mottles are clods of sediment of other textures.
5.1	10YR4/4	pebbly Sa.L.	abrupt lower boundary
5.7	10YR2/1	L.	shell fragments; many oxidized roots
5.9	NR		
8.0	10YR2/1	pebbles	angular
8.2	10YR2/2-2/3	peat (fibric)	matted; wood at bottom
8.6	10YR2/1	SiL	
8.9	10YR2/1	peat (fibric)	w/ wood
9.2	10YR2/1	SiL-L	wood fragments
9.5	NR		
12.0	5G5/1	reworked m.	Sand from sandstone bedrock
12.2	10YR5/6 & 5G5/1	weathered SS	insitu bedrock
13.0			

ft.	Probe# 15B-a Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.3	aggregate (CO_3)		
0.6	10YR3/4	pebbly Sa.L.	fill
1.2	10YR2/1	alt. CO_3 pebbles & pebbly Sa.L	fill; cinders; similar pattern to that found in Probe 16B
2.1	weathered SS bedrock block or boulder		
2.5	10YR3/4	pebbly Sa.L	ceramic fragment @ 2.8 ft.
3.5	weathered SS bedrock block or cobble		
3.7	NR		
4.0	reworked SS, CO_3, & Siltstone bedrock gravel		
4.7	ash lens w/ fired rock fragments		
4.85	10YR3/3-3/2	SiC.L	
5.2	10YR5/6	v.f. Sa.	sand is from reworked SS bedrock
6.2	weathered bedrock		insitu; fine-grained laminar CO_3 lenses (strong effervescence) interbedded w/ sandstone (non-effervescent).
6.6			

Probe #15B-b

ft.	Log	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.3		aggregate		
0.9		10YR3/4	pebbly Sa.L	
1.7		2.5Y-5Y4/1	f.Sa	many mottles; few SS cobbles (placed or reworked?)
3.2		10YR2/1	pebbly f.Sa.L	fill; very friable SS pebbles (10YR7/3)
3.5	NR			
4.0		5GY4/1	SiL	
4.3		2.5Y3/2	pebbly SiL-L	few CO_3 pebbles
5.0		Cinders & Mortar		
6.1		2.5Y4/2	pebbly Sa.L	w/ cinders
6.2	NR			
8.0		same as above	except w/	mortar
8.2		2.5Y4/2	pebbles	clast-supported; angular CO_3; ceramic fragment at 8.5 ft.
9.3	NR			
12.0		10YR2/1	SiC.L.	lacustrine(?) organic silts & clays w/ plant matter; non-effervescent.
13.6		alt. 5GY5/1 & 10YR2/1	v.f.Sa.-L.	reduced & unoxidized
14.7	NR			
16.0		weathered and	slightly reworked	SS bedrock
18.9				

Probe# 16-A

ft.	Log	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.4		aggregate base		
0.9		10YR4/4	pebbly Sa.L.	fill
1.8		10YR3/3	pebbly Sa.C.L.	disturbed
3.5		10YR2/1-3/1	L.	appeared undisturbed soil but no ped development
3.7	NR			
4.0		10YR2/1 & 7.5YR4/6	alt. L. & L.Sa.	angular & rounded gravel in L.Sa. strata.
5.0		10YR2/1	L w/pebbles	exotic rounded pebbles; charcoal & cinders at 5.5 ft.
6.2	NR			
8.0		10YR-2.5Y3/2	SiL	many 7.5YR4/6 & 2.5Y4/6 mottles; Post-Settlement Alluvium
9.2		10YR3/3	SiL-L	" " " " " " "
11.3	NR			
12.0		reworked local	bedrock	
12.3		weathered	bedrock	(in situ)
15.0				

ft.	Probe # 16-B	Color	Texture	Notes, Historic/Prehistoric Boundary
0. – 0.5		asphalt		
0.5 – 0.9		aggregate		
0.9 – 2.2		5GY 5/1	f. Sa.L	reworked cobbles of SS bedrock that are calcareous (strong effervescence)
2.2 – 4.0	NR			
4.0 – 5.0		10YR3/4	f. Sa.L w/ pebbles;	could be fill or flood deposits
5.0 – 5.2		10YR2/1	cinders	
5.2 – 5.7		multicolored	pebbly Sa.L.	fill or disturbed strata
5.7 – 8.0	NR			
8.0 – 10.8		weathered SS bedrock; non-effervescent; in situ.		

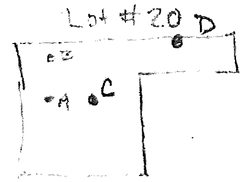
ft.	Probe# 16-C	Color	Texture	Notes, Historic/Prehistoric Boundary
0 – 0.3		asphalt		
0.3 – 1.8		10YR3/4	pebbly Sa.L	
1.8 – 2.1		10YR3/4	coarse pebbles;	rounded exotics including red granites
2.1 – 2.4		10YR-2.5Y 3/1	Sa.C.L.	dense; extremeley firm.
2.4 – 2.5		Granite cobble		
2.5 – 4.0	NR			
4.0 – 4.8		reworked SS & CO_3 bedrock; bedded		
4.8 – 6.1		weathered SS & Siltstone bedrock; in situ; strong effervescence		

ft.	Probe # 18-A	Color	Texture	Notes, Historic/Prehistoric Boundary
0		concrete		
0.3		10YR3/4	m. Sa.	subgrade for concrete
0.6		10YR5/2 & 5/6	alt. SiL & v.f. Sa.	laminar bedding; strong effervescence at 3.0 ft.
3.3	NR			
4.0		same as above;		abrupt lower boundary w/ stone lag
5.8		5Y5/3	C.L.	extremely firm; strong effervescence; regolith(?) [collected]
6.0				

Probe# ______	Color	Texture	Notes, Historic/Prehistoric Boundary

Probe # 19-A	Color	Texture	Notes, Historic/Prehistoric Boundary
	gravel lot		
0.3	7.5YR 5/4	Sa.L w/ pebbles	abrupt lower; Historic fill on bedrock large exotic cobble on top of bedrock
2.2	10YR 5/6-5/4	CR	weathered bedrock; few pebbles (exotic)
2.5	2.5Y-5Y 3/2	CR(?)	weathered bedrock; clay diamicton w/ few rounded pebbles
2.8			refusal at 3.0 ft.

Probe# 19-B	Color	Texture	Notes, Historic/Prehistoric Boundary
	gravel lot		
0.5	10YR ~~2/3~~-2/4	L.-Sa.L	Hist fill; many mottles; common pebbles
1.1	10YR 4/4	M. Sa.	no bedding; possibly disturbed natural horizon
1.8	10YR 3/2-3/3	f.Sa.-Si.L	natural thin bedding; common 10YR 4/6 mottles along beds;
3.1	NR		
4.0	10YR 3/4-4/4	Pebbly Sa.L-L	almost clast supported; few rounded exotics; many rounded local pebbles;
5.0	10YR 5/2-5/3	CR	weathered bedrock (in situ) siltstone + CO_3's
5.9			



Probe # 20-A (depth)	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0	aggregate		
0.4	10YR 4/3	C. Sa.	fill
1.7	10YR 2/2	pebbly C. Sa. L	Historic debris; brick frag.
2.0	multicolored reworked bedrock and weathered in situ bedrock		
2.8			

Probe# 20-B (depth)	Color	Texture	Notes, Historic/Prehistoric Boundary
0	alt aggregate and asphalt		
0.6	cinders		
0.9	2.5Y-5Y 4/2	SiCL	
1.3	2.5Y-5Y 4/2	SiL	laminar bedding Wood at 2.4-2.5 ft. [Collected]
2.6	2.5Y 5/4	Sih to Siltstone	weathered, insitu; hard; brittle
3.9	Limestone bedrock		
4.0			

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Depth	Probe # 20-C Color	Texture	Notes, Historic/Prehistoric Boundary
0	aggregate		
0.2	~~5YR~~ 7.5YR4/3	m. Sa	few pebbles, clean fill
2.1	10YR2/1	Sa.C.L	historic, tile frag.
2.2	reworked L.S. flagstone		
3.1	multicolored	pebbly Sa.L	reworked LS
3.2	bedrock rejection		
~~NR~~			

Depth	Probe# 20-D Color	Texture	Notes, Historic/Prehistoric Boundary
0.0	10YR2/1	pebbly Sa.L	historic Ap-horizon;
0.9	10YR3/3	pebbly Sa.C.L	historic fill; multiple mottle colors
1.2	Limestone cobble		
1.5	reworked bedrock		2.5-2.7' looked like oolites; need microscope
3.2	NR		
4.0	weathered bedrock, bedded, multicolored		
8.0			

Probe # 21-A	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0	asphalt		
0.4	10YR 2/2	pebbly SaL	
1.0	reworked siltstone		ss, carbonates; laminar bedding
2.5	weathered siltstone		; insitu
3.4	EOB @ 4 ft.		

Probe# 21-B	Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
0.4	10YR3/3	pebbly SaL	fill
0.7	aggregate + sand – historic		; well rounded erratics; angular CO_3's + siltstones
1.2	7.5YR5/6	Silt	reworked weathered siltstone
2.1	2.5Y5/1	siltstone	weathered, insitu
3.9	EOB @ 4'		

Probe # 21-C **Color** **Texture** **Notes, Historic/Prehistoric Boundary**

Depth	Color	Texture	Notes, Historic/Prehistoric Boundary
0 – 0.5	asphalt		
0.5 – 0.7	~~pebbly~~ 10YR 3/3	pebbly Sa.L	
0.7 – 0.9	~~granite~~ Metamorphic stones (flagged)		
0.9 – 2.4	reworked bedrock with SS pebbles; angular and thin sandy lower boundary		
2.4 – 3.5	weathered bedrock (siltstone)		

Probe# 21-D **Color** **Texture** **Notes, Historic/Prehistoric Boundary**

Depth	Color	Texture	Notes, Historic/Prehistoric Boundary
0 – 0.7	asphalt		
0.7 – 1.1	10YR 4/6	pebbly Sa.C.L	Capping layer?
1.1 – 1.9	10YR 4/4 4/6	pebbly V.f. Sa.L to loam	(high silt content); SS pebbles very thin med. sandy lens at lower angular boundary
1.9 – 3.3	weathered bedrock (siltstone); carbon fleck at 2.4 ft. maybe root remnant.		

Probe # 21-E	Color	Texture	Notes, Historic/Prehistoric Boundary
	asphalt		filled in pl.
1.9	10YR3/3	pebbly Sa.C.L	
2.0	10YR 2/1	pebbly Sa.C.L	bone, glass, cinders, egg shell
3.7			
NR			
4.0			

Probe# 22-A	Color	Texture	Notes, Historic/Prehistoric Boundary
	asphalt		
0.7	aggregate pavement		
1.6	7.5YR 4/3	pebbly Sa.L	fill
1.7	10YR5/4 + 2/1	~~T~~ SiL w/pebbles	fill/cap
2.1			
Ap	10YR 2/1	pebbly Sa.L	historic; glass
3.3	reworked/weathered		bedrock in bit
3.6			

Depth	Probe # 22-B Color	Texture	Notes, Historic/Prehistoric Boundary
0	asphalt		
1.7	aggregate		
2.5	alt. 10YR2/1 & 5GY5/1	SiL + Limestone Layer	
3.0	10YR2/1	C. Sa with cinders	
3.3	10YR2/1-2/2	Sa.C.L.	thick mollusk shell frags; abrupt lower
3.8	5GY5/1-4/1	v.f. sa	reworked bedrock
4.0	same as above		
4.1	alt. 10YR2/1 & 5Y4/1	alt. L & pebbly f.sa.	3 complete fining up sets of "gullywashers" overlain by black loams; some lamination bedding
4.5	same 10YR2/1	L-SiCL	roots
5.2	NR		
8.0	10YR2/1-2/2	SiCL	2/1 at top
10.5	NR		
12.0	same as above	except 2/2	and rootlets
13.2	2.5-5Y4/1	SiCL	rootlets; angular lower boundary marked by organics
13.9	5GY5/1+3/1	v.f. sa	reworked bedrock
14.2			weathered bedrock
14.4			

Collected 12.7–14.0 ft.

Depth	Probe# 22-C Color	Texture	Notes, Historic/Prehistoric Boundary
	Asphalt		
0.6	aggregate		
1.0			
1.3	10YR2/1 + 10YR5/6	alt. L & pebbly f.sa.	2 complete fining up rounded exotics, local angular
2.3	10YR2/1 & 2.5Y3/2	bedded	fine 10YR6/3 sand at lower boundary
2.8	10YR2/1	Loam w/few coarse sand	calcareous lens at 3.7-3.8ft. w/ charcoal
3.4	NR		
4.0	10YR2/1		upper most 0.5 ft is slightly lighter and more "disturbed" than lower horizon
5.5	reworked	bedrock	
6.6	weathered	bedrock	
7.6			

Depth	Probe # 22-D	Color	Texture	Notes, Historic/Prehistoric Boundary
0.0		asphalt		
0.6		aggregate		
1.1		10YR2/1	pebbly SaL	
1.3		7.5YR-10YR4/4	M. Sa	fill
1.7		10YR3/3	pebbly SaL	
2.1		10YR5/4	pebbly SaL	
2.4	Ab	10YR2/1	Loam	
2.9		10YR6/3-6/4	M. Sa	fill
3.4	NR			
4.6		same as above		
6.3		10YR2/2	SiL	bedded w/pebble or two
6.5		LS ~~ag~~ pebbles - clast supported; angular		
6.7	NR			
8.0		Carbonate rock - possible wall or floor		
8.9		10YR2/1-2/2	SiL	mottled; disturbed
9.2		2.5Y3/2	SiL	
10.9	NR			
12.0				

Depth	Probe# 22-D Cont.	Color	Texture	Notes, Historic/Prehistoric Boundary
12.0		reworked bedrock - multi colored; mottled; local bedrock clods or clasts.		
13.1		weathered bedrock - 5G4/1 + 5YR5/8.		
15.0				

Depth	Probe # 22-E	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.4		aggregat		
1.4		10YR3/3	pebbly SaL.	
2.2		10YR4/3-6/3	alt. pebbly SaL and m.sa.	
3.2	NR			
4.0		10YR4/4	m.sa	fill
4.7		10YR4/4	sandy pebbles	well rounded exotics
5.5		Bedrock @ 6.0'		

Depth	Probe# 22-F	Color	Texture	Notes, Historic/Prehistoric Boundary
0		asphalt		
0.6		aggregate		
1.1		alt. 10YR2/1 & 10YR7/2	pebbly SaL + SS pebbles	wood in darker ~~zones~~ horizons mortar; few SS pebbles in darker horizon
3.0		10YR5/4-4/4	reworked	sediment
3.2		10YR2/1	L-fSaL	
3.7	NR			
4.0		Same as above except increasing 10YR4/3-3/3 mottles and fold exotics; abrupt		
5.5		reworked bedrock, of various sed rocks (Cc?, SS.		
7.3	NR			
8.0		same as above except coarsening down & introduction of more well rounded exotics		
10.1		weathered SS bedrock		
12.0				

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Probe # 27A-A	Color	Texture	Notes, Historic/Prehistoric Boundary
0	Concrete		
0.3	10YR5/4	M-C. Sa	
0.6	2.5Y3/2	Sa.L. w/pebbles	
0.8	10YR2/1	Sa pebbles	clast supported
1.0	10YR3/3 & 4/2	M.+C. sands	fills
1.2 NR			
4.0	10YR5/6 w/mottles	sandy pebbles	both exotic + local; angular local rounded exotic
5.4 NR			
8.0	10YR5/6-5/2	alt. lamina SiL & f.-m. sands	many 7.5YR5/6-5/8 mottles
11.0			

Probe# 27A-B	Color	Texture	Notes, Historic/Prehistoric Boundary
0	Concrete		
0.3	10YR4/4	m. Sa	fill
1.8	10YR4/4 + 4/2	M. Sa	bedded(?)
2.2 NR			
4.0	alt. 10YR4/4 + 4/2	SiL + SiCL	abrupt lower
5.7	10YR5/3	M-C. Sa w/pebbles	lag at top
6.6 NR			
8.0	same as above		
8.4	5YR5/8	sandy pebbles	pebble clast supported
9.1	10YR5/4	"	" " " ; abrupt lower
9.3	10YR6/3	f. Sa. - L. Sa.	
10.2	10YR5/3	M-C. Sa.L w/few pebbles; bedded	
10.6	10YR5/3	SiL	few coarse 7.5YR5/6 mottles along joints [collected]
10.9			

6/23/11

Depth	Probe # 27B-A Color	Texture	Notes, Historic/Prehistoric Boundary
0.0	concrete		
0.3	10YR4/4	pebbly SaL	
0.9	10YR3/3	pebbly SaL	
1.4	10YR2/1	f.SaL-L	
1.7	10YR 2/2-3/2	SaL w/ few	pebbles (natural?) bedded
2.7	alt. 10YR2/1 + 5/6	fSaL + f.sa	bedded
3.0			
3.2	NR		
4.0	10YR3/3	m. Sa.	
	same as above w/ brick frag.		
4.6	10YR2/1	SaL w/pebbles	& mortar frag.
5.1	alt. 10YR3/2 + 4/4	alt. f.Sa.L + m.Sa.	
5.7	10YR2/1	f.SaL w/pebbles + cinders	
5.9	2.5Y5/4	pebbly f.sa	
6.2	10YR2/2	c.Sa. w/cinders/coal	
6.3	NR		
8.0	same as above	- pebble lag at bottom	
8.8	2.5Y5/4-5/2	f.SaL w/few	coarse angular local rock pebbles; abrupt, irregular lower
9.8	10YR2/1	SiCL.	9.8-10.3 weak granular ped (a few shells); lacustrine
10.8	NR		
12.0	same as above	- getting lighter downward (natural)	
13.4			

~~Probe# Color Texture Notes, Historic/Prehistoric Boundary~~

Depth	Color	Texture	Notes
13.4	2.5Y4/6	pebbly f.sa	many coarse exotic + local pebbles (all rounded)
14.2	NR		
16.0	10YR2/1	peaty Loam	wood root at 17.1; fining up sequence; abrupt lower boundary
17.7	2.5Y4/2		
18.0	2.5Y4/2	SiL	
18.2	2.5Y3/2	m-c Sa.	
18.9	NR		
20.0	10YR5/3	f.sa	w/ coarse sand lenses
20.7	alt. 10YR4/1 + 2/1	alt. SiL + v.f.sa	- shells (collected.)
21.1	10YR6/2	pebbly f.SaL	exotic pebble lag at top boundary; many 7.5YR5/6 mottles
21.5	10YR4/2	pebbly Sa.C.L	many well rounded sedimentary + exotic pebbles
21.9	NR		
24.0	~~pebbly Love~~ 2.5Y4/2	pebbly SiL	
24.3	2.5Y4/2	SiL	• collected for screening
25.3	2.5Y4/2	pebbly SiL	
24.3	reworked bedrock		
27.2			

Appendix E
Radiocarbon Analytical Data

BETA

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Beta@radiocarbon.com
www.radiocarbon.com

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

April 19, 2011

Mr. Curtis M. Hudak
Foth Infrastructure & Environment, LLC
8550 Hudson Boulevard North
Suite 105
Lake Elmo, MN 55042
USA

RE: Radiocarbon Dating Results For Samples 11GD-01 36.3-36.5 ft, 11GD-01 93.8-94.0 ft, 11GD-02 36.75-36.90 ft, 11GD-02 37.7-38.0 ft, 11GD-04(a) 6.0-6.4 ft

Dear Mr. Hudak:

Enclosed are the radiocarbon dating results for five samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the American Express card provided. A receipt is enclosed with the mailed report copy. 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

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MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Curtis M. Hudak — Report Date: 4/19/2011

Foth Infrastructure & Environment, LLC — Material Received: 3/14/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 295697	1360 +/- 30 BP	-26.8 o/oo	1330 +/- 30 BP

SAMPLE : 11GD-01 36.3-36.5 ft
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 650 to 710 (Cal BP 1300 to 1240) AND Cal AD 750 to 760 (Cal BP 1200 to 1190)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 295699	9790 +/- 90 BP	-8.1 o/oo	10070 +/- 100 BP

SAMPLE : 11GD-01 93.8-94.0 ft
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (shell): acid etch
2 SIGMA CALIBRATION : Cal BC 10100 to 9300 (Cal BP 12050 to 11250)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 295700	7510 +/- 40 BP	-26.2 o/oo	7490 +/- 40 BP

SAMPLE : 11GD-02 36.75-36.90 ft
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (peat): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 6440 to 6250 (Cal BP 8390 to 8200)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 295701	10330 +/- 60 BP	-26.4 o/oo	10310 +/- 60 BP

SAMPLE : 11GD-02 37.7-38.0 ft
ANALYSIS : Radiometric-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 10430 to 10020 (Cal BP 12380 to 11970) AND Cal BC 9920 to 9890 (Cal BP 11870 to 11840)

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.

BETA

BETA ANALYTIC INC.

DR. M.A. TAMERS and MR. D.G. HOOD

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beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Curtis M. Hudak

Report Date: 4/19/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 295702	2430 +/- 30 BP	-18.8 o/oo	2530 +/- 30 BP

SAMPLE : 11GD-04(a) 6.0-6.4 ft
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 790 to 730 (Cal BP 2740 to 2680) AND Cal BC 690 to 540 (Cal BP 2640 to 2500)

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=-26.8:lab. mult=1)

Laboratory number: **Beta-295697**

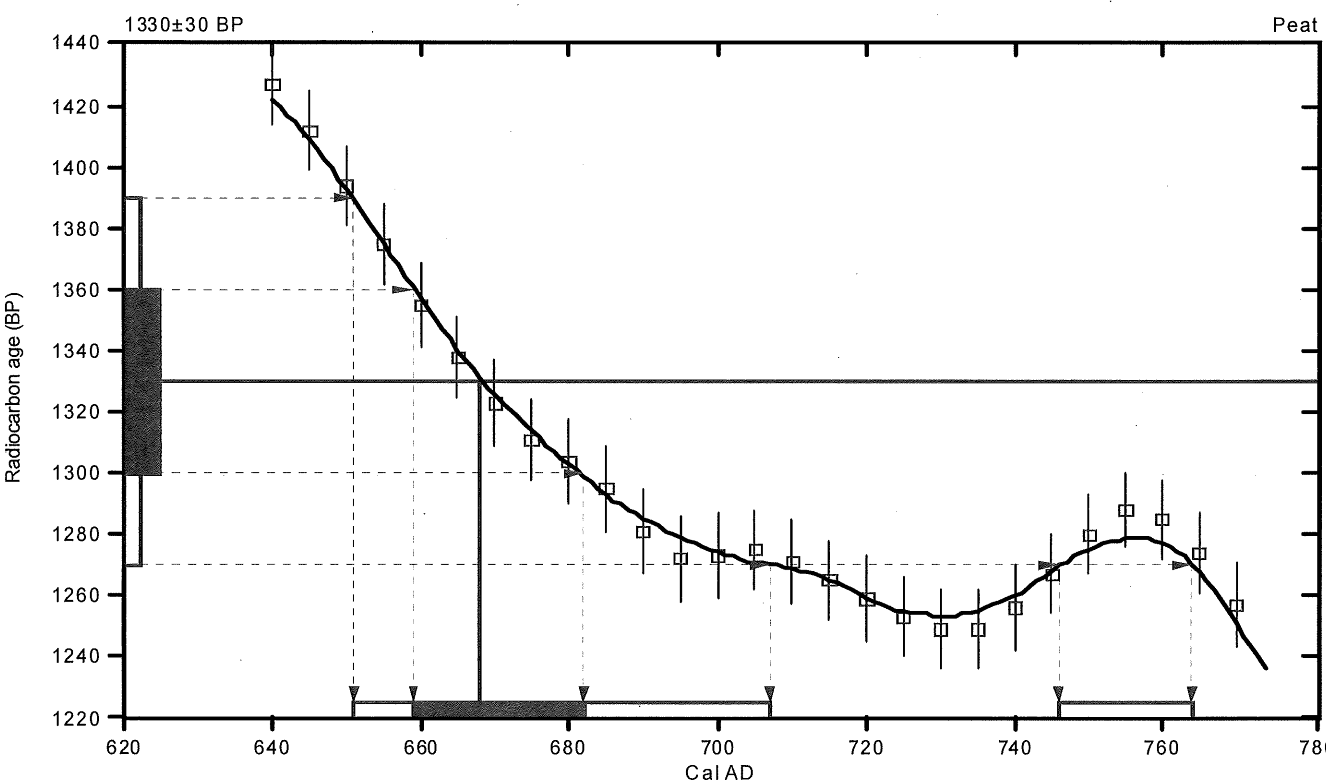
Conventional radiocarbon age: **1330±30 BP**

2 Sigma calibrated results: (95% probability) **Cal AD 650 to 710 (Cal BP 1300 to 1240) and Cal AD 750 to 760 (Cal BP 1200 to 1190)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 670 (Cal BP 1280)

1 Sigma calibrated result: (68% probability) Cal AD 660 to 680 (Cal BP 1290 to 1270)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-8.1:lab. mult=1)

Laboratory number: **Beta-295699**

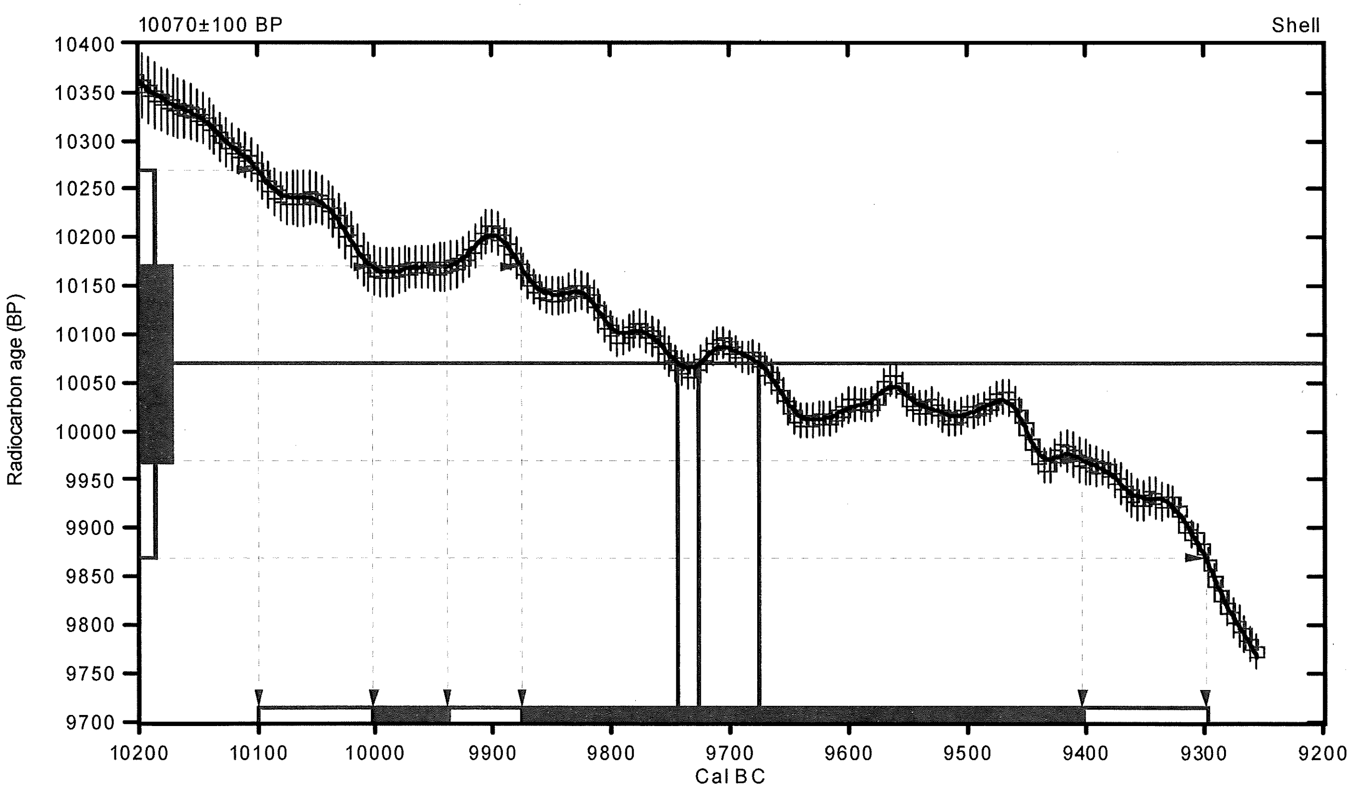
Conventional radiocarbon age: **10070±100 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 10100 to 9300 (Cal BP 12050 to 11250)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 9740 (Cal BP 11690) and
Cal BC 9730 (Cal BP 11680) and
Cal BC 9680 (Cal BP 11630)

1 Sigma calibrated results: (68% probability) Cal BC 10000 to 9940 (Cal BP 11950 to 11890) and
Cal BC 9880 to 9400 (Cal BP 11830 to 11350)



References:
Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.2:lab. mult=1)

Laboratory number: **Beta-295700**

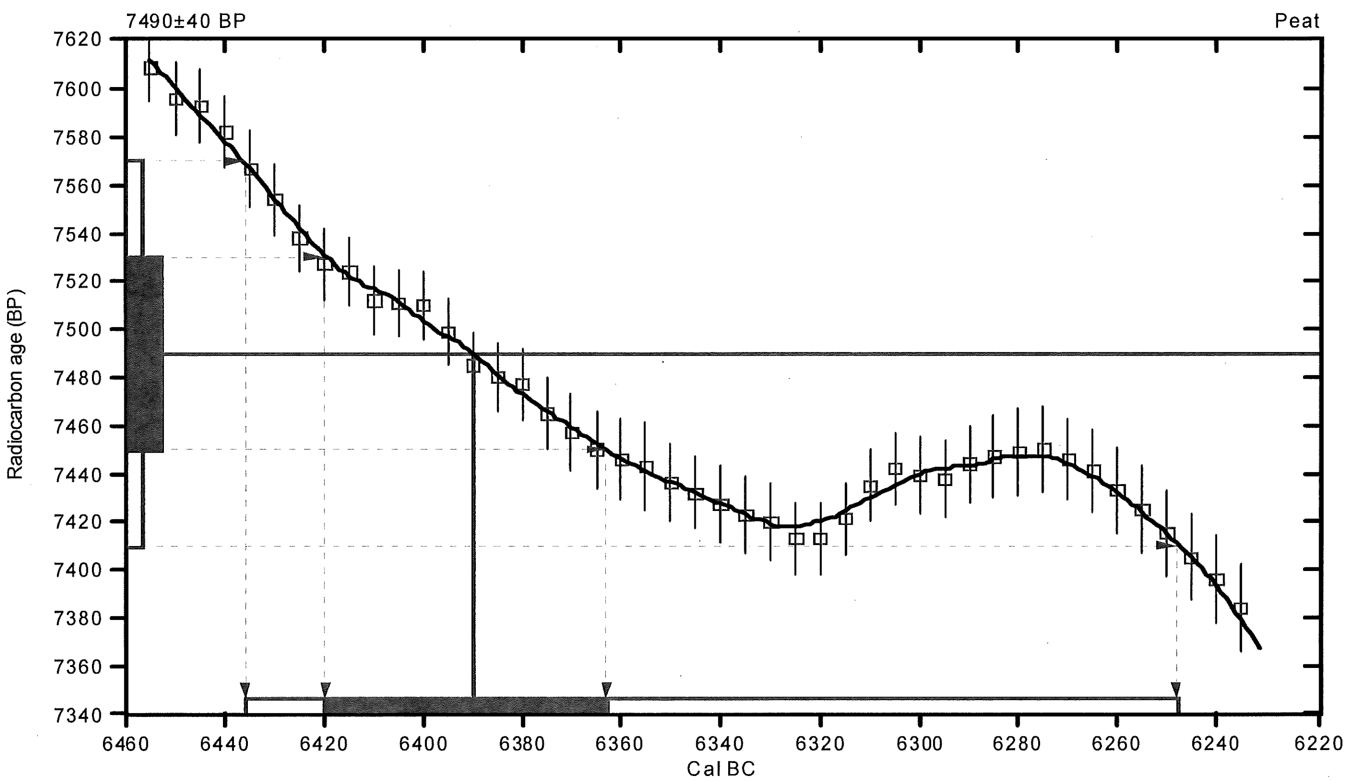
Conventional radiocarbon age: **7490±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 6440 to 6250 (Cal BP 8390 to 8200)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 6390 (Cal BP 8340)

1 Sigma calibrated result: (68% probability) Cal BC 6420 to 6360 (Cal BP 8370 to 8310)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.4:lab. mult=1)

Laboratory number: **Beta-295701**

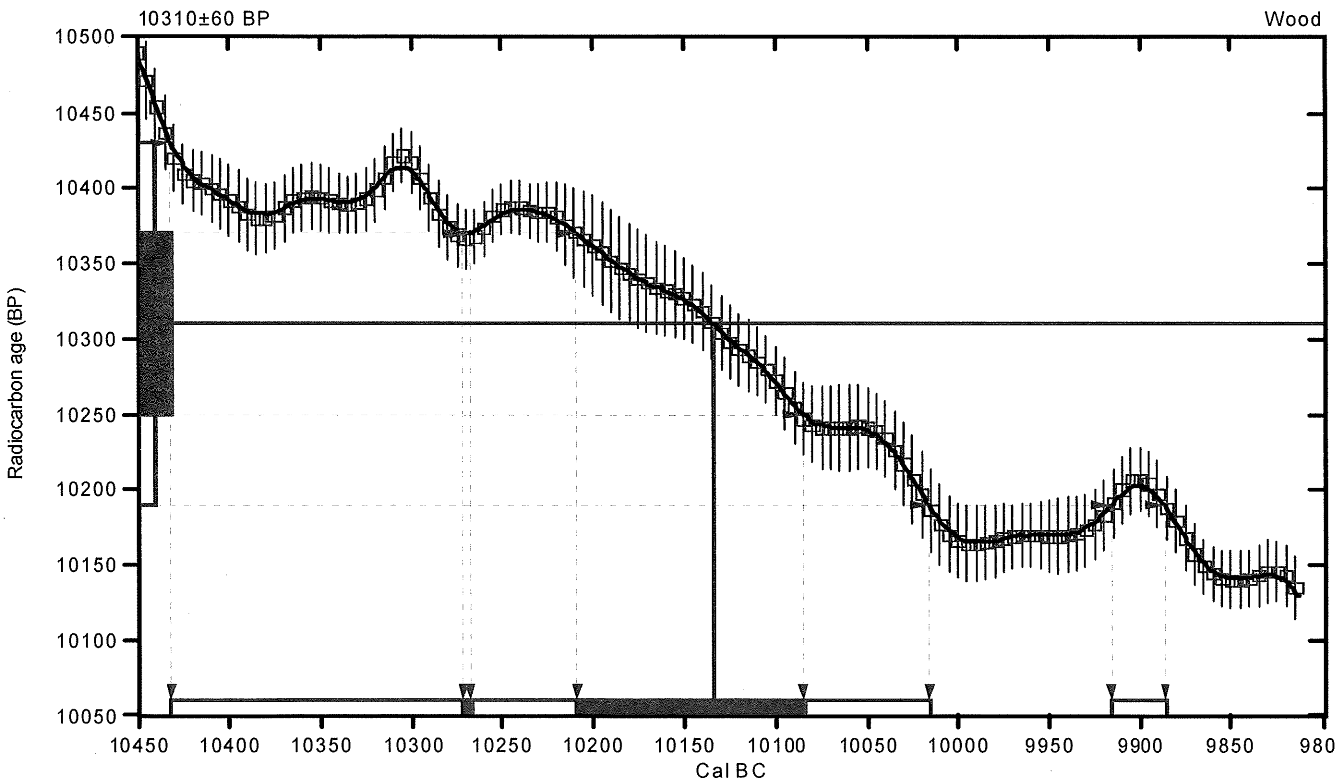
Conventional radiocarbon age: **10310±60 BP**

2 Sigma calibrated results: **Cal BC 10430 to 10020 (Cal BP 12380 to 11970) and**
(95% probability) **Cal BC 9920 to 9890 (Cal BP 11870 to 11840)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 10130 (Cal BP 12080)

1 Sigma calibrated results: Cal BC 10270 to 10270 (Cal BP 12220 to 12220) and
(68% probability) Cal BC 10210 to 10080 (Cal BP 12160 to 12040)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-18.8:lab. mult=1)

Laboratory number: **Beta-295702**

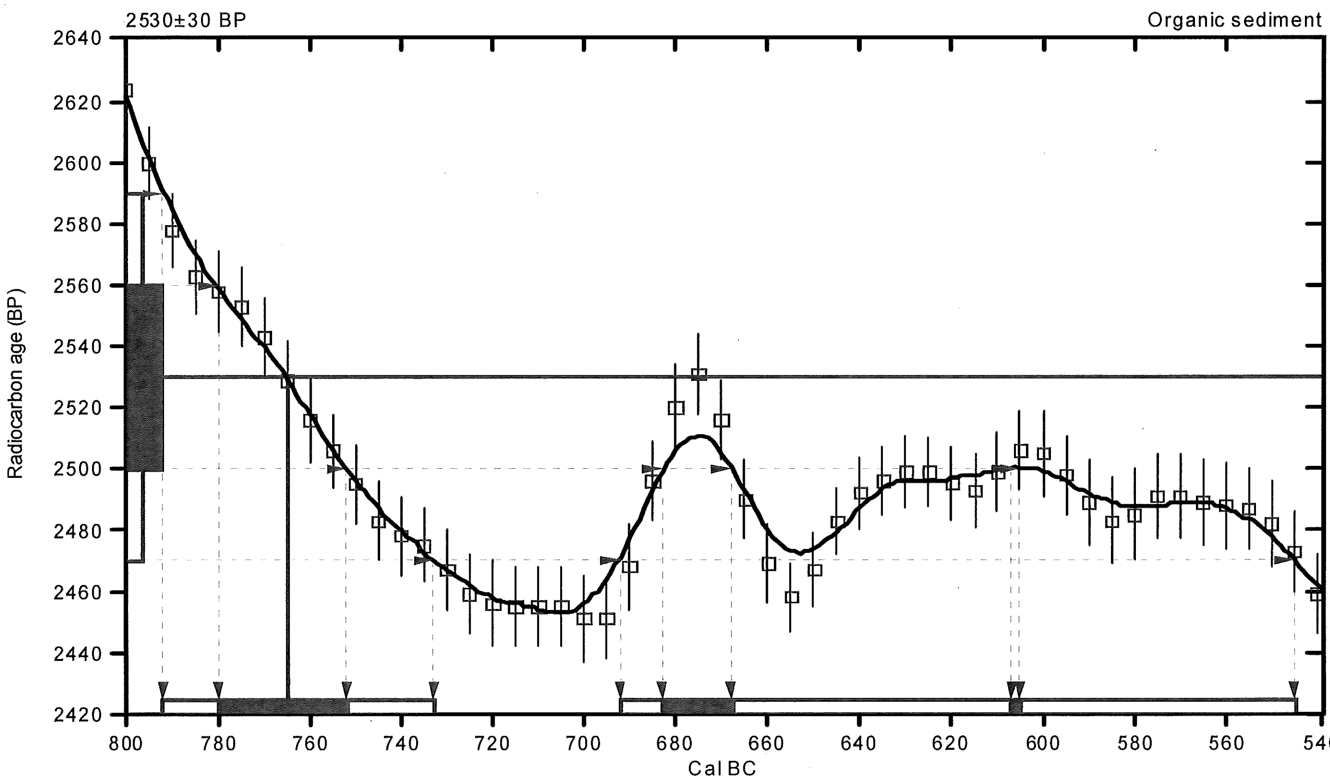
Conventional radiocarbon age: **2530±30 BP**

2 Sigma calibrated results: (95% probability) **Cal BC 790 to 730 (Cal BP 2740 to 2680) and Cal BC 690 to 540 (Cal BP 2640 to 2500)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 760 (Cal BP 2720)

1 Sigma calibrated results: (68% probability) Cal BC 780 to 750 (Cal BP 2730 to 2700) and Cal BC 680 to 670 (Cal BP 2630 to 2620) and Cal BC 610 to 600 (Cal BP 2560 to 2560)



References:

Database used
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Calibration Database
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IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

September 7, 2011

Mr. Curtis M. Hudak
Foth Infrastructure & Environment, LLC
8550 Hudson Boulevard North
Suite 105
Lake Elmo, MN 55042
USA

RE: Radiocarbon Dating Results For Samples 11M018-10B 5.9-6.0 ft, 11M018-10B 6.7-6.9 ft, 11M018-15A-a 20.2-21.0 ft

Dear Mr. Hudak:

Enclosed are the radiocarbon dating results for three samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the American Express card provided. A receipt is enclosed with the mailed report copy. 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 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. Curtis M. Hudak — Report Date: 9/7/2011

Foth Infrastructure & Environment, LLC — Material Received: 8/22/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 304415	40 +/- 30 BP	-24.7 o/oo	40 +/- 30 BP

SAMPLE : 11M018-10B 5.9-6.0 ft
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1710 to 1710 (Cal BP 240 to 240) AND Cal AD 1880 to 1910 (Cal BP 60 to 40)
Cal AD 1950 to beyond 1960 (Cal BP 0 to 0)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 304416	270 +/- 30 BP	-27.5 o/oo	230 +/- 30 BP

SAMPLE : 11M018-10B 6.7-6.9 ft
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1640 to 1680 (Cal BP 310 to 270) AND Cal AD 1770 to 1800 (Cal BP 180 to 150)
Cal AD 1940 to 1950 (Cal BP 10 to 0)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 304417	5240 +/- 30 BP	-25.2 o/oo	5240 +/- 30 BP

SAMPLE : 11M018-15A-a 20.2-21.0 ft
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 4220 to 4210 (Cal BP 6170 to 6160) AND Cal BC 4160 to 4130 (Cal BP 6110 to 6080)
Cal BC 4060 to 3980 (Cal BP 6010 to 5920)

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=-24.7:lab. mult=1)

Laboratory number: **Beta-304415**

Conventional radiocarbon age: **40±30 BP**

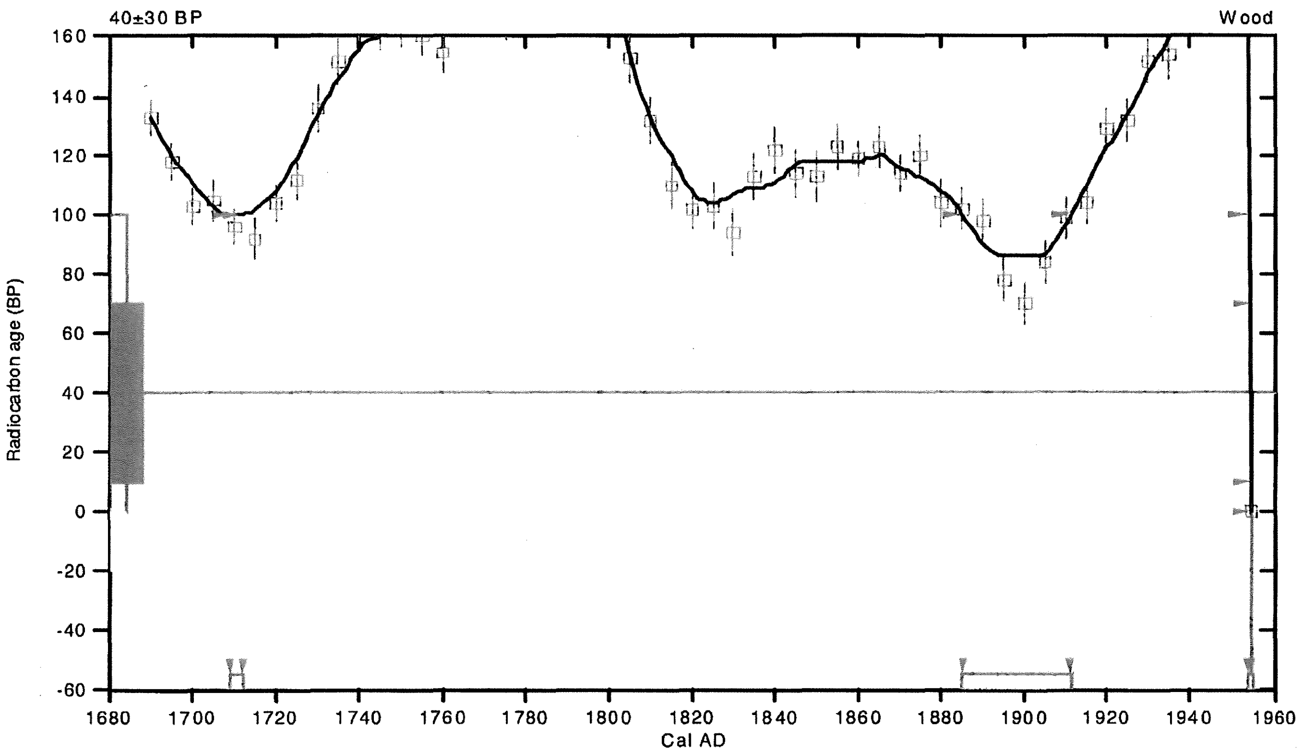
2 Sigma calibrated results[2]: (95% probability) **Cal AD 1710 to 1710 (Cal BP 240 to 240) and Cal AD 1880 to 1910 (Cal BP 60 to 40) and Cal AD 1950 to beyond 1960 (Cal BP 0 to 0)**

[2] 2 Sigma range being quoted is the maximum antiquity based on the minus 2 Sigma range

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1960 (Cal BP 0)

1 Sigma calibrated result: (68% probability) Cal AD 1960 to 1960 (Cal BP 0 to 0)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.5:lab. mult=1)

Laboratory number: **Beta-304416**

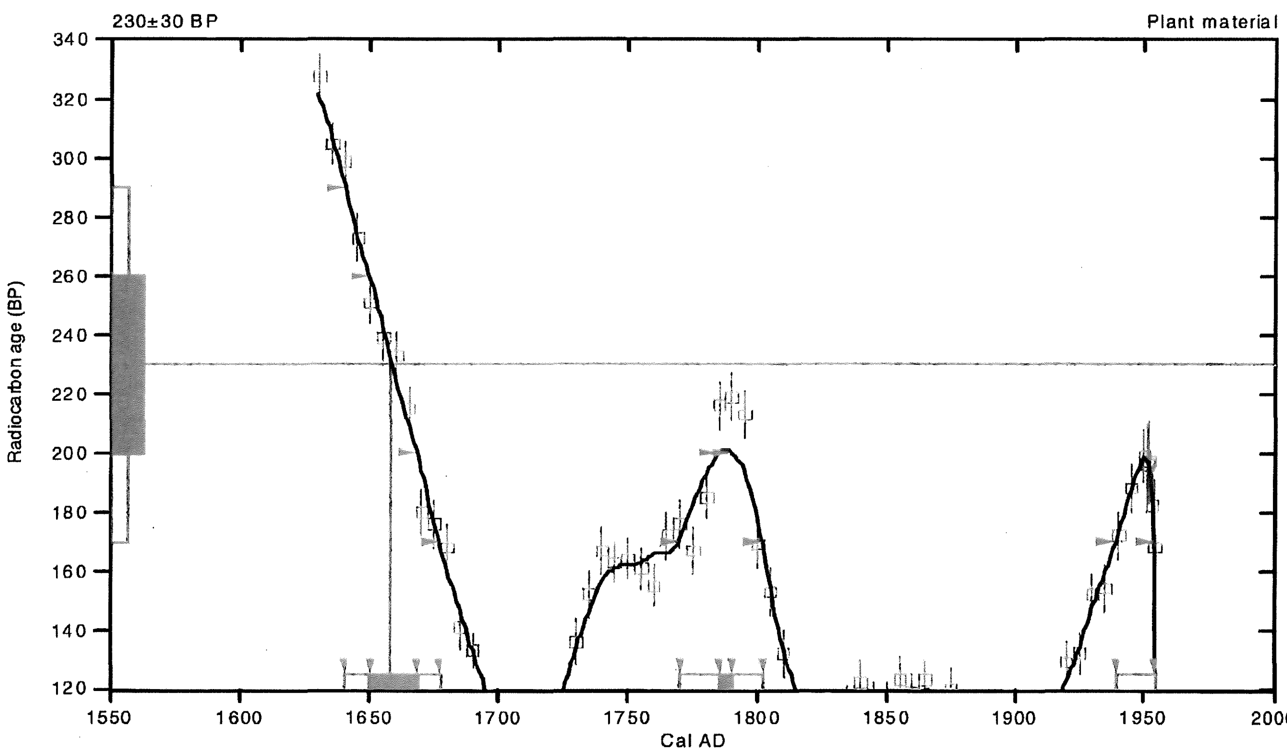
Conventional radiocarbon age: **230±30 BP**

2 Sigma calibrated results: **Cal AD 1640 to 1680 (Cal BP 310 to 270) and**
(95% probability) **Cal AD 1770 to 1800 (Cal BP 180 to 150) and**
Cal AD 1940 to 1950 (Cal BP 10 to 0)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1660 (Cal BP 290)

1 Sigma calibrated results: Cal AD 1650 to 1670 (Cal BP 300 to 280) and
(68% probability) Cal AD 1780 to 1790 (Cal BP 160 to 160)



References:

Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.2:lab. mult=1)

Laboratory number: **Beta-304417**

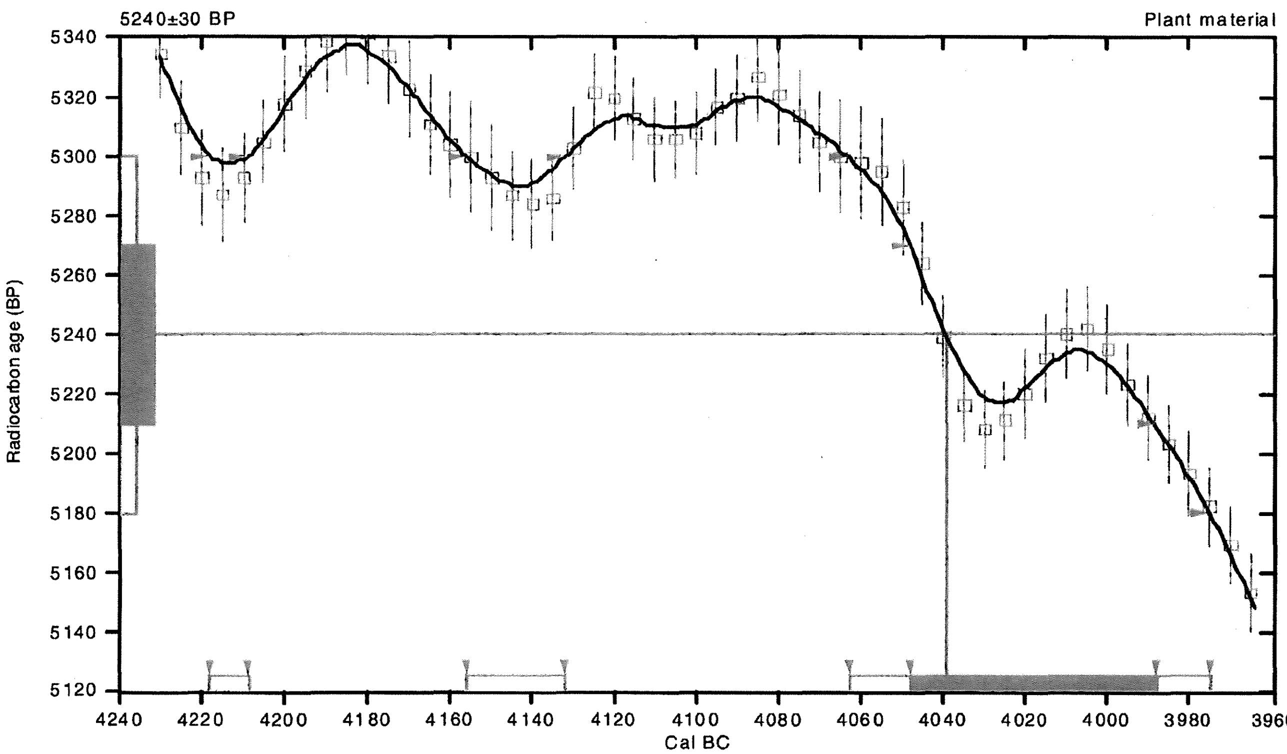
Conventional radiocarbon age: **5240±30 BP**

2 Sigma calibrated results: **Cal BC 4220 to 4210 (Cal BP 6170 to 6160) and**
(95% probability) **Cal BC 4160 to 4130 (Cal BP 6110 to 6080) and**
Cal BC 4060 to 3980 (Cal BP 6010 to 5920)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 4040 (Cal BP 5990)

1 Sigma calibrated result: Cal BC 4050 to 3990 (Cal BP 6000 to 5940)
(68% probability)



References:

Database used
INTCAL04
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The Radiocarbon Laboratory Accredited to ISO-17025 Testing Standards (PJLA Accreditation #59423)

Final Report

The final report is accessed as a PDF via a secure personal directory on our website. UserID and password are initially provided to you, which you can change to values of your choosing (letters and numbers only). A mailed copy is also sent to you including a statement outlining our analytical procedures, a glossary of pretreatment terms, calendar calibration information, and billing documents. In addition to the analytical result, the final report sheet includes the individual analysis method, the delivery basis, the material type and the individual pretreatments applied.

Pretreatment

Pretreatment methods are reported along with each result. All necessary chemical and mechanical pretreatments of the submitted material were applied at the laboratory to isolate the carbon, which may best represent the time event of interest. When interpreting the results, it is important to consider the pretreatments. Some samples cannot be fully pretreated, making their ^{14}C ages more subjective than samples, which can be fully pretreated. Some materials receive no pretreatments. Please look at the pretreatment indicated for each sample and read the pretreatment glossary to understand the implications.

Analysis

Results reported using the AMS technique were derived from reduction of sample carbon (after pretreatment) to graphite (100 %C), along with standards and backgrounds, with subsequent detection in one of two AMS instruments here in our facilities. Results reported using the radiometric technique were analyzed by synthesizing sample carbon (after pretreatment) to benzene (92% C), measuring for ^{14}C content in one of 53 scintillation spectrometers. If the Extended Counting Service was used, the ^{14}C content was measured for a greatly extended period of time.

The Radiocarbon Age and Calendar Calibration

The Conventional ^{14}C Age and related "percent modern carbon" (pMC) is the result after applying $^{13}C/^{12}C$ corrections to account for isotopic fractionation differences between the sample and modern reference. Always cite both this age and the 13C/12C ratio in your reports and papers (as well as the laboratory number). The Conventional Radiocarbon Age is cited with the units "BP" (Before Present). "Present" is defined as AD 1950 for the purposes of radiocarbon dating. Results are reported as pMC for samples containing more ^{14}C than the modern reference standard. pMC results indicate the material was respiring carbon after the advent of thermo-nuclear weapons testing and is less than ~ 60 years old.

Calendar calibrations are included for applicable materials. If calibrations are not included for a result, it means it was too young, too old, or inappropriate for calibration. The calibration database and mathematics used are cited at the bottom of each calibration printout. The most appropriate approximation of age is the "2 sigma calibrated result". Be sure to cite this as well as the calibration database and mathematics used in your reports and papers.

PRETREATMENT GLOSSARY
Standard Pretreatment Protocols at Beta Analytic

Unless otherwise requested by a submitter or discussed in a final date report, the following procedures apply to pretreatment of samples submitted for analysis. This glossary defines the pretreatment methods applied to each result listed on the date report form (e.g. you will see the designation "acid/alkali/acid" listed along with the result for a charcoal sample receiving such pretreatment).

Pretreatment of submitted materials is required to eliminate secondary carbon components. These components, if not eliminated, could result in a radiocarbon date, which is too young or too old. Pretreatment does not ensure that the radiocarbon date will represent the time event of interest. This is determined by the sample integrity. Effects such as the old wood effect, burned intrusive roots, bioturbation, secondary deposition, secondary biogenic activity incorporating recent carbon (bacteria) and the analysis of multiple components of differing age are just some examples of potential problems. The pretreatment philosophy is to reduce the sample to a single component, where possible, to minimize the added subjectivity associated with these types of problems. If you suspect your sample requires special pretreatment considerations be sure to tell the laboratory prior to analysis.

"acid/alkali/acid"

The sample was first gently crushed/dispersed in deionized water. It was then given hot HCI acid washes to eliminate carbonates and alkali washes (NaOH) to remove secondary organic acids. The alkali washes were followed by a final acid rinse to neutralize the solution prior to drying. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of the sample. Each chemical solution was neutralized prior to application of the next. During these serial rinses, mechanical contaminants such as associated sediments and rootlets were eliminated. This type of pretreatment is considered a "full pretreatment". On occasion the report will list the pretreatment as "acid/alkali/acid - insolubles" to specify which fraction of the sample was analyzed. This is done on occasion with sediments (See "acid/alkali/acid - solubles"

Typically applied to: charcoal, wood, some peats, some sediments, and textiles "acid/alkali/acid - solubles"

On occasion the alkali soluble fraction will be analyzed. This is a special case where soil conditions imply that the soluble fraction will provide a more accurate date. It is also used on some occasions to verify the present/absence or degree of contamination present from secondary organic acids. The sample was first pretreated with acid to remove any carbonates and to weaken organic bonds. After the alkali washes (as discussed above) are used, the solution containing the alkali soluble fraction is isolated/filtered and combined with acid. The soluble fraction, which precipitates, is rinsed and dried prior to combustion.

"acid/alkali/acid/cellulose extraction"

Following full acid/alkali/acid pretreatments, the sample is bathed in (sodium chlorite) $NaClO_2$ under very controlled conditions (Ph = 3, temperature = 70 degrees C). This eliminates all components except wood cellulose. It is useful for woods that are either very old or highly contaminated.

Applied to: wood

"acid washes"

Surface area was increased as much a possible. Solid chunks were crushed, fibrous materials were shredded, and sediments were dispersed. Acid (HCI) was applied repeatedly to ensure the absence of carbonates. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of each sample. The sample was not be subjected to alkali washes to ensure the absence of secondary organic acids for intentional reasons. The most common reason is that the primary carbon is soluble in the alkali. Dating results reflect the total organic content of the analyzed material. Their accuracy depends on the researcher's ability to subjectively eliminate potential contaminants based on contextual facts.

Typically applied to: organic sediments, some peats, small wood or charcoal, special cases

PRETREATMENT GLOSSARY
Standard Pretreatment Protocols at Beta Analytic
(Continued)

"collagen extraction: with alkali" or "collagen extraction: without alkali"

The material was first tested for friability ("softness"). Very soft bone material is an indication of the potential absence of the collagen fraction (basal bone protein acting as a "reinforcing agent" within the crystalline apatite structure). It was then washed in de-ionized water, the surface scraped free of the outer most layers and then gently crushed. Dilute, cold HCl acid was repeatedly applied and replenished until the mineral fraction (bone apatite) was eliminated. The collagen was then dissected and inspected for rootlets. Any rootlets present were also removed when replenishing the acid solutions. "With alkali" refers to additional pretreatment with sodium hydroxide (NaOH) to ensure the absence of secondary organic acids. "Without alkali" refers to the NaOH step being skipped due to poor preservation conditions, which could result in removal of all available organics if performed.

Typically applied to: bones

"acid etch"

The calcareous material was first washed in de-ionized water, removing associated organic sediments and debris (where present). The material was then crushed/dispersed and repeatedly subjected to HCl etches to eliminate secondary carbonate components. In the case of thick shells, the surfaces were physically abraded prior to etching down to a hard, primary core remained. In the case of porous carbonate nodules and caliches, very long exposure times were applied to allow infiltration of the acid. Acid exposure times, concentrations, and number of repetitions, were applied accordingly with the uniqueness of the sample.

Typically applied to: shells, caliches, and calcareous nodules

"neutralized"

Carbonates precipitated from ground water are usually submitted in an alkaline condition (ammonium hydroxide or sodium hydroxide solution). Typically this solution is neutralized in the original sample container, using deionized water. If larger volume dilution was required, the precipitate and solution were transferred to a sealed separatory flask and rinsed to neutrality. Exposure to atmosphere was minimal.

Typically applied to: Strontium carbonate, Barium carbonate
(i.e. precipitated ground water samples)

"carbonate precipitation"

Dissolved carbon dioxide and carbonate species are precipitated from submitted water by complexing them as ammonium carbonate. Strontium chloride is added to the ammonium carbonate solution and strontium carbonate is precipitated for the analysis. The result is representative of the dissolved inorganic carbon within the water. Results are reported as "water DIC".

Applied to: water

"solvent extraction"

The sample was subjected to a series of solvent baths typically consisting of benzene, toluene, hexane, pentane, and/or acetone. This is usually performed prior to acid/alkali/acid pretreatments.

Applied to: textiles, prevalent or suspected cases of pitch/tar contamination, conserved materials.

"none"

No laboratory pretreatments were applied. Special requests and pre-laboratory pretreatment usually accounts for this.

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Calendar Calibration at Beta Analytic

Calibrations of radiocarbon age determinations are applied to convert BP results to calendar years. The short-term difference between the two is caused by fluctuations in the heliomagnetic modulation of the galactic cosmic radiation and, recently, large scale burning of fossil fuels and nuclear devices testing. Geomagnetic variations are the probable cause of longer-term differences.

The parameters used for the corrections have been obtained through precise analyses of hundreds of samples taken from known-age tree rings of oak, sequoia, and fir up to about 10,000 BP. Calibration using tree-rings to about 12,000 BP is still being researched and provides somewhat less precise correlation. Beyond that, up to about 20,000 BP, correlation using a modeled curve determined from U/Th measurements on corals is used. This data is still highly subjective. Calibrations are provided up to about 19,000 years BP using the most recent calibration data available.

The Pretoria Calibration Procedure (Radiocarbon, Vol 35, No.1, 1993, pg 317) program has been chosen for these calendar calibrations. It uses splines through the tree-ring data as calibration curves, which eliminates a large part of the statistical scatter of the actual data points. The spline calibration allows adjustment of the average curve by a quantified closeness-of-fit parameter to the measured data points. A single spline is used for the precise correlation data available back to 9900 BP for terrestrial samples and about 6900 BP for marine samples. Beyond that, splines are taken on the error limits of the correlation curve to account for the lack of precision in the data points.

In describing our calibration curves, the solid bars represent one sigma statistics (68% probability) and the hollow bars represent two sigma statistics (95% probability). Marine carbonate samples that have been corrected for $^{13}C/^{12}C$, have also been corrected for both global and local geographic reservoir effects (as published in Radiocarbon, Volume 35, Number 1, 1993) prior to the calibration. Marine carbonates that have not been corrected for $^{13}C/^{12}C$ are adjusted by an assumed value of 0 %0 in addition to the reservoir corrections. Reservoir corrections for fresh water carbonates are usually unknown and are generally not accounted for in those calibrations. In the absence of measured $^{13}C/^{12}C$ ratios, a typical value of -5 %0 is assumed for freshwater carbonates.

(Caveat: the correlation curve for organic materials assume that the material dated was living for exactly ten years (e.g. a collection of 10 individual tree rings taken from the outer portion of a tree that was cut down to produce the sample in the feature dated). For other materials, the maximum and minimum calibrated age ranges given by the computer program are uncertain. The possibility of an "old wood effect" must also be considered, as well as the potential inclusion of younger or older material in matrix samples. Since these factors are in determinant error in most cases, these calendar calibration results should be used only for illustrative purposes. In the case of carbonates, reservoir correction is theoretical and the local variations are real, highly variable and dependent on provenience. Since imprecision in the correlation data beyond 10,000 years is high, calibrations in this range are likely to change in the future with refinement in the correlation curve. The age ranges and especially the intercept ages generated by the program must be considered as approximations.)

Appendix F
Optically Stimulated Luminescence Analytical Data

Table 1: Optically stimulated luminescence (OSL) ages on quartz grains from fluvial sediments, upper Mississippi Valley for Foth Infrastructure & Environmental, LLC

Sample number	Depth (m or ft)	Quartz size (μm)	Laboratory number	Aliquots	Equivalent dose (Gray)[a]	U (ppm)[d]	Th (ppm)[d]	K (%)[d]	H_20 (%)	Cosmic dose (mGray/yr)[e]	Dose rate (mGray/yr)	OSL age (yr)
SB-01/10DK-01	2.7-3.4 m	425-500	UIC2767	30	63.91 ± 5.69[b]	1.0 ± 0.1	3.3 ± 0.1	2.19 ± 0.02	7.5 ± 3	0.148 ± 0.015	1.80 ± 0.09	35,460 ± 4180
SB-01/10DK-01	18.0.-18.6m	150-250	UIC2766	30	258.20 ± 14.11[b]	0.8 ± 0.1	2.8 ± 0.1	1.37 ± 0.01	15 ± 5	0.033 ± 0.003	1.46 ± 0.07	176,540 ± 17,350
SB-02/10DK-02	2.4-3.7 m	425-500	UIC2755	29	31.41 ± 2.93[b]	0.7 ± 0.1	2.3 ± 0.1	1.24 ± 0.01	30 ± 5	0.148 ± 0.015	1.11 ± 0.06	28,210 ± 3370
SB-03/10DK-03	3.7-4.9 m	425-500	UIC2663	30	21.21 ± 0.78[c]	1.0 ± 0.1	5.6 ± 0.1	1.51 ± 0.01	30 ± 5	0.130 ± 0.013	1.30 ± 0.06	18,890 ± 1635
SB-04/10DK-04	2.4-3.7 m	Too coarse	UIC2760									Undatable
SB-05/10DK-05	2.4-3.7 m	100-150	UIC2754	30	28.45 ± 1.00[c]	0.6 ± 0.1	1.9 ± 0.1	0.97 ± 0.01	7.5 ± 3	0.148 ± 0.015	1.13 ± 0.06	25,080 ± 1920
SB-05/10DK-05	7.8-7.9 m	100-150	UIC2764	30	34.09 ± 3.70[c]	0.8 ± 0.1	2.5 ± 0.1	1.31 ± 0.01	30 ± 5	0.082 ± 0.008	1.13 ± 0.06	26,885 ± 3580
SB-06/10DK-06	1.2-2.4 m	250-355	UIC2756	30	5.10 ± 0.40[b]	0.9 ± 0.1	2.5 ± 0.1	1.16 ± 0.01	7.5 ± 3	0.180 ± 0.018	1.49 ± 0.07	3415 ± 350
SB-07/10DK-07	3.7-4.9 m	150-250	UIC2759	30	53.65 ± 3.31[b]	0.8 ± 0.1	2.6 ± 0.1	1.21 ± 0.01	15 ± 5	0.130 ± 0.013	1.40 ± 0.07	38,180 ± 3815
SB-08/10DK-08	2.4-3.7 m	425-500	UIC2749	30	Poor precision	0.7 ± 0.1	2.4 ± 0.1	0.99 ± 0.01	15 ± 5	0.148 ± 0.015	1.11 ± 0.06	Undatable
SB-09/10DK-09	1.2-1.9 m	425-500	UIC2751	26	29.82 ± 1.09[c]	1.0 ± 0.1	3.2 ± 0.1	1.43 ± 0.01	7.5 ± 3	0.180 ± 0.018	1.69 ± 0.08	17,680 ± 1540
SB-10/10DK-10	1.2-2.4 m	425-500	UIC2762	30	37.74 ± 3.98[b]	0.7 ± 0.1	2.7 ± 0.1	1.29 ± 0.01	7.5 ± 3	0.180 ± 0.018	1.48 ± 0.07	25,420 ± 3070
SB-10/10DK-10	6.1-7.3 m	425-500	UIC2761	28	27.09 ± 5.19[c]	0.8 ± 0.1	2.8 ± 0.1	1.16 ± 0.01	15 ± 5	0.096 ± 0.001	1.23 ± 0.06	21,995 ± 4550
SB-12/10DK-12	11.4-11.5 m	425-500	UIC2750	24	10.06 ± 0.74[b]	1.1 ± 0.1	4.4 ± 0.1	1.92 ± 0.02	15 ± 5	0.059 ± 0.006	1.90 ± 0.09	5300 ± 580
SB-14/10DK-14	8.5-9.5 m	Too coarse	UIC2765									Undatable
11GD-O1(108-110ft)	108' 2"+ft	250-355	UIC2956	29	12.50 ± 0.45[c]	0.8 ± 0.1	3.3 ± 0.1	1.53 ± 0.02	15 ±5	0.013 ± 0.001	1.55 ± 0.08	8060 ± 725
11DK-O1(20-24ft)	20.50+ft	250-355	UIC2980	29	19.03 ± 0.64[c]	0.9 ± 0.1	3.2 ± 0.1	1.21 ± 0.01	7.5 ± 3	0.085 ± 0.001	1.49 ± 0.08	12,730 ± 965
11DK-O1(8-12ft)	8.75+ft	250-355	UIC2981	30	4.14 ± 0.16[c]	0.7 ± 0.1	2.6 ± 0.1	1.00 ± 0.01	7.5 ± 3	0.141 ± 0.010	1.45 ± 0.07	2850 ± 225
11DK-O2(4-8ft)	4.9-5.0 ft	250-355	UIC2982	30	3.80 ± 0.13[c]	0.9 ± 0.1	3.2 ± 0.1	1.21 ± 0.01	7.5 ± 3	0.172 ± 0.020	1.56 ± 0.08	2440 ± 180

[a] quartz fraction analyzed under blue-light excitation (470 ± 20 nm) by single aliquot regeneration protocols (Murray and Wintle, 2003).
[b]Ages calculated using the central age model of Galbraith et al. (1999).
[c]Ages calculated using the minimum age model of Galbraith et al. (1999).
[d]U, Th and K content analyzed by inductively coupled plasma-mass spectrometry analyzed by Activation Laboratory LTD, Ontario, Canada.
[e]From Presott and Hutton (1994). All errors are at 1 sigma and ages from the reference year AD 2010.

References

Galbraith, R. F., Roberts, R. G., Laslett, G. M., Yoshida, H., and Olley, J. M. (1999). Optical dating of single and multiple grains of quartz from Jinmium rock shelter, northern Australia, part 1, Experimental design and statistical models. *Archaeometry* **41,** 339-364.

Murray, A. S., and Wintle, A. G. (2003). The single aliquot regenerative dose protocol: potential for improvements in reliability. *Radiation Measurements* **37,** 377-381.

Prescott, J. R., and Hutton, J. T. (1994). Cosmic ray contributions to dose rates for luminescence and ESR dating: large depths and long-term time variations. *Radiation Measurements* **23,** 497-500.

Appendix G
Photograph Log

Photographic Log

Client's Name: Minnesota Department of Transportation and Federal Highway Administration	Site Location: Red Wing	Project No. 11M018

Photo No. 1	**Date:**
Direction Photo Taken: Northeast	
Photo Taken By:	
Description: View looking northeast at the drilling location for Boring 11GD03 near the intersection of Potter and 4th Streets. Barn Bluff is in the background.	

Photo No. 2	**Date:**
Direction Photo Taken: North	
Photo Taken By:	
Description: View looking north at the drilling location for Boring 11GD04 near the intersection of Arkin and East 5th Streets. Barn Bluff is in the background.	

Foth

Photographic Log

Client's Name: Minnesota Department of Transportation and Federal Highway Administration	Site Location: Red Wing	Project No. 11M018

Photo No. 3	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD04 core sample showing late Holocene-aged sediment overlying weathered glauconitic sandstone bedrock.	

Photo No. 4	Date:
Direction Photo Taken: Southwest	
Photo Taken By:	
Description: View looking southwest at the drilling location for Boring 11GD02 near Ikata Drive and the Mississippi River channel shoreline. Levee Park is in the background.	

Photographic Log

Client's Name: Minnesota Department of Transportation and Federal Highway Administration	Site Location: Red Wing	Project No. 11M018

Photo No. 5	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD02 core sample showing historic-aged woodchips and sawdust.	

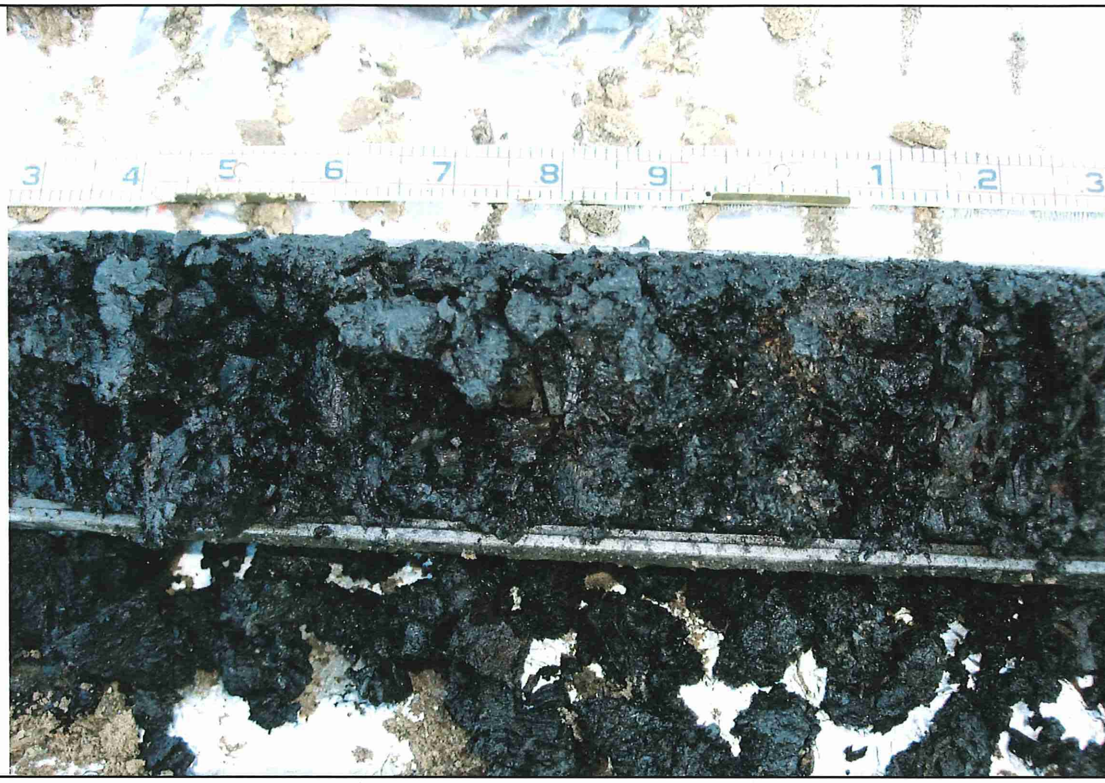
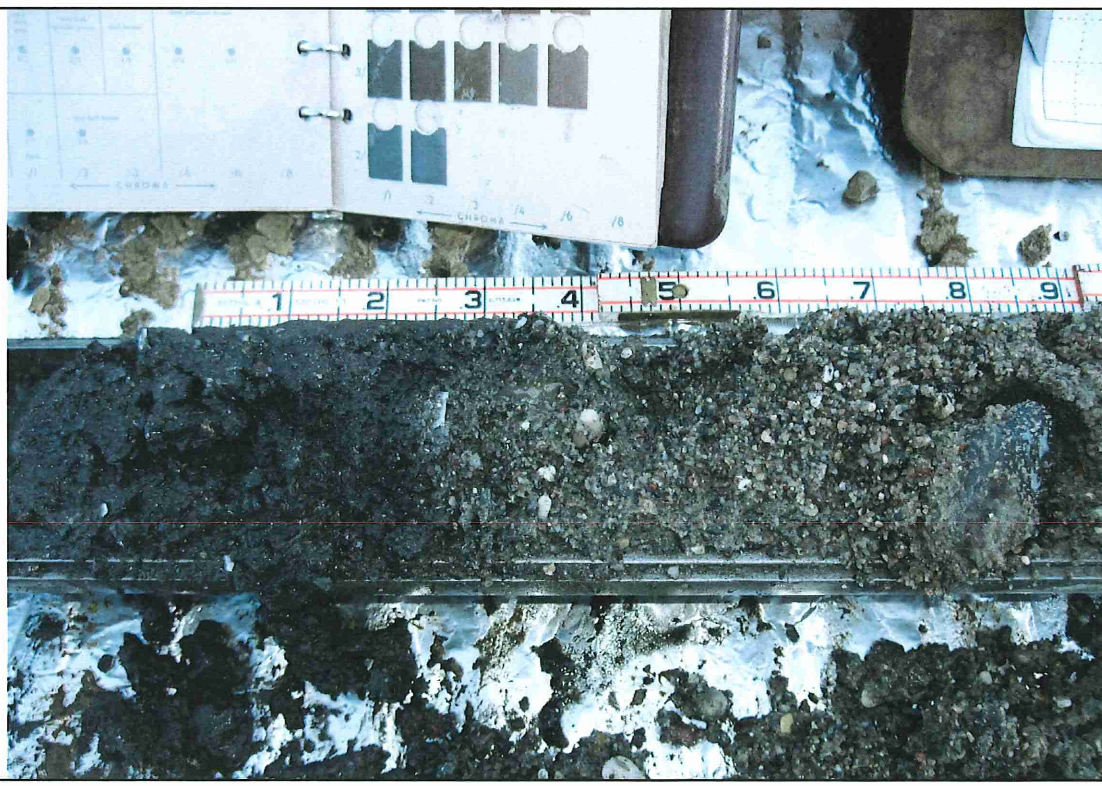


Photo No. 6	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD02 core sample showing the boundary between the historic-aged woodchips and the older natural fluvial sediments.	



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Photographic Log

Client's Name: Minnesota Department of Transportation and Federal Highway Administration	Site Location: Red Wing	Project No. 11M018

Photo No. 7	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD02 core sample showing a fine sand unit overlain and underlain by pebbly coarse sands at 6.71-7.25 m (22.0-23.8 ft.) depth interval.	

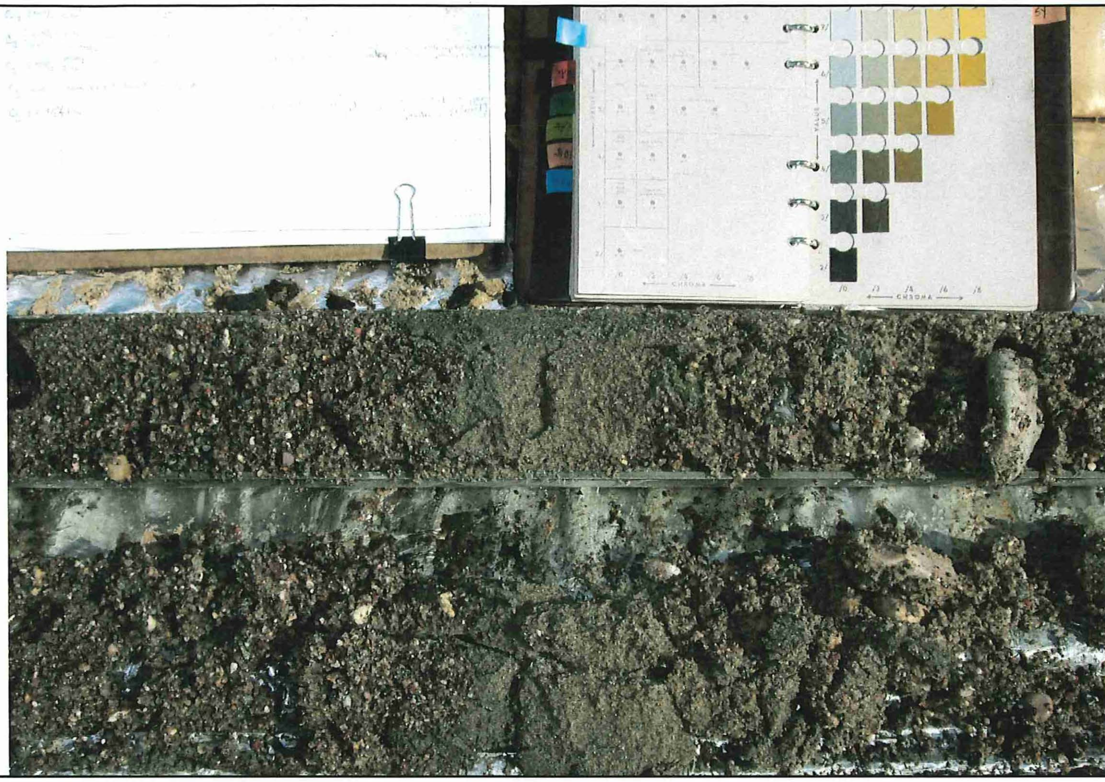
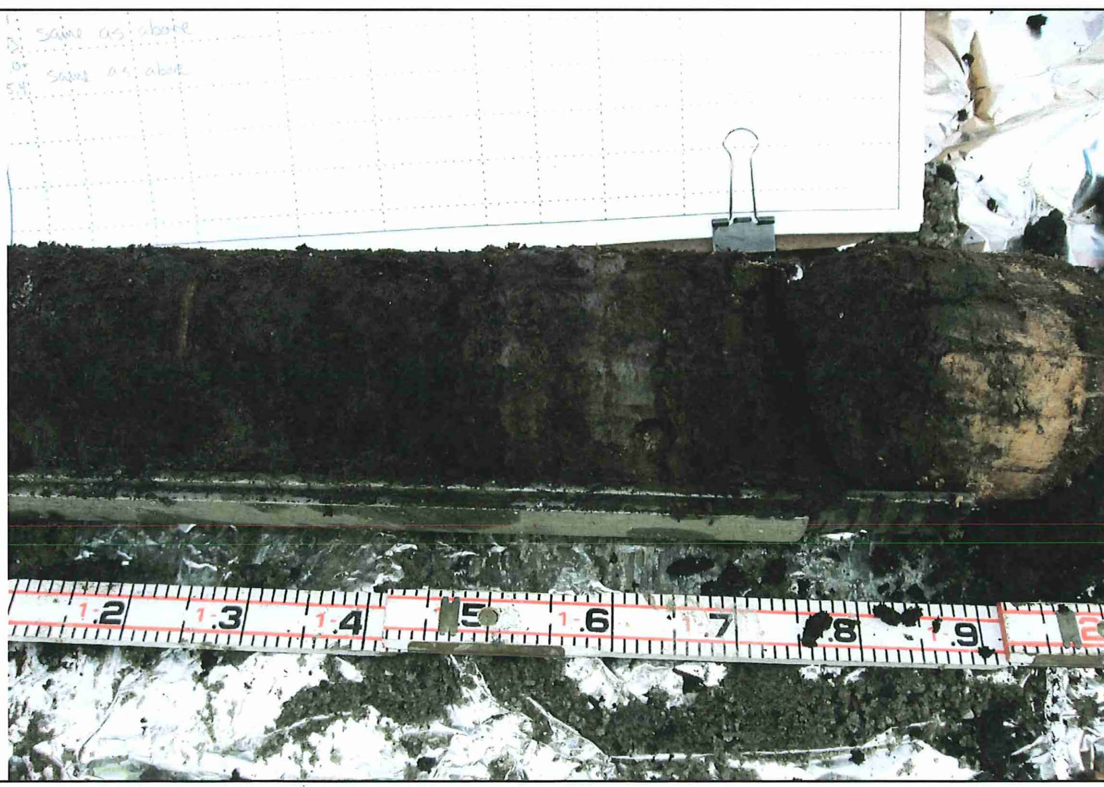


Photo No. 8	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD02 core sample showing an early Holocene-aged, compacted peat bed and wood log at 11.20-11.58 m (36.75-38.0 ft.) depth interval.	



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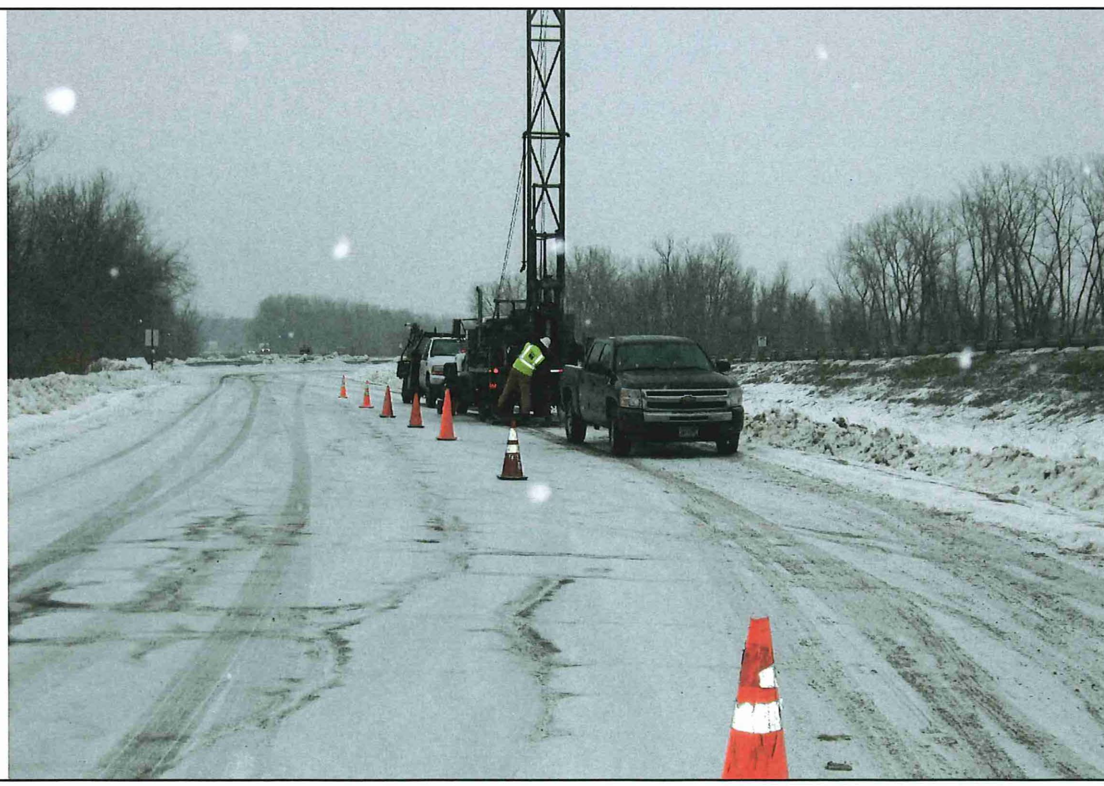
Photographic Log

Client's Name: Minnesota Department of Transportation and Federal Highway Administration	Site Location: Red Wing	Project No. 11M018

Photo No. 9	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD02 core sample showing basal Holocene-aged strata overlying slightly reworked sandstone bedrock (CR-horizon) at 11.58-11.89 m (38.0-39.0 ft.) depth interval.	

Photo No. 10	Date:
Direction Photo Taken: Northwest	
Photo Taken By:	
Description: View looking northwest at the drilling location for Boring 11GD01 along 825th Street. US Highway 63 is to the right and in the background of boring location.	



Photographic Log

Client's Name: Minnesota Department of Transportation and Federal Highway Administration	Site Location: Red Wing	Project No. 11M018

Photo No. 11

Date:

Direction Photo Taken:
Right-click here

Photo Taken By:

Description:
Boring 11GD01 core sample showing the redox boundary in strata very close to where the dredged sands overlie the natural sediments.

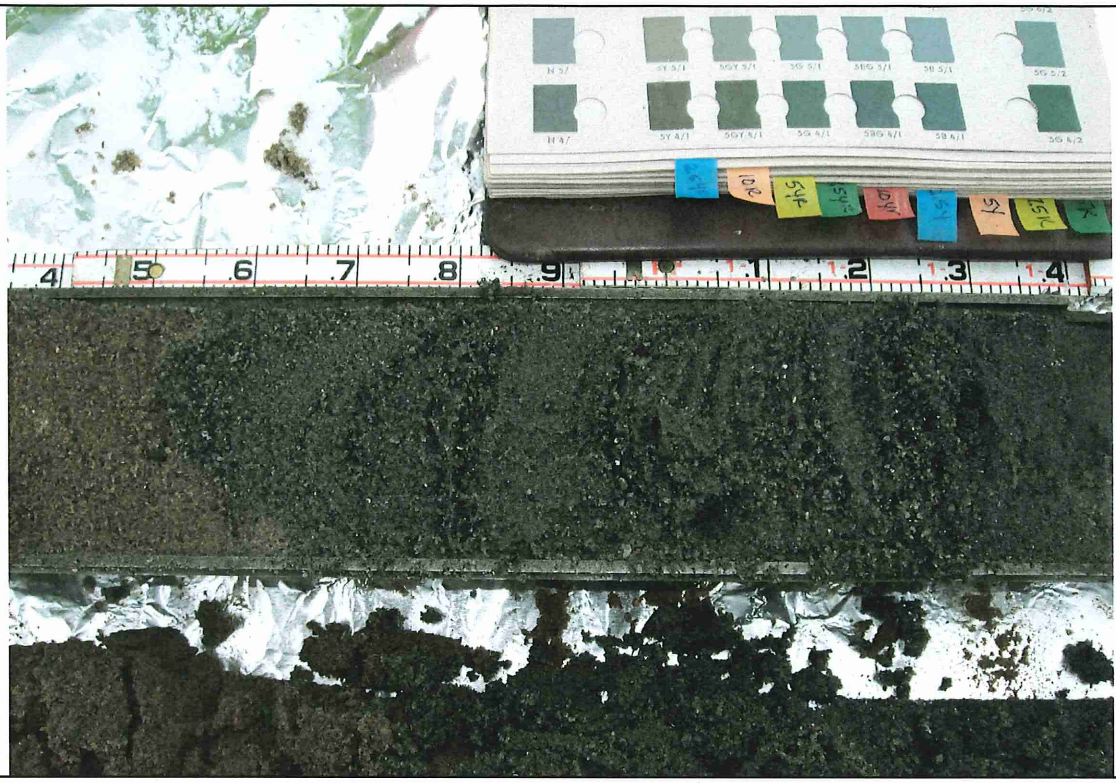


Photo No. 12

Date:

Direction Photo Taken:
Right-click here

Photo Taken By:

Description:
Boring 11GD01 core sample showing alternating laminae of late Holocene-aged silty clay loams and clay loams. Pencil tip points to a radiocarbon-dated peat laminar bed that contains 1,330±30 ^{14}C yrs. B.P. wood fragments.

Photographic Log

Client's Name: Minnesota Department of Transportation and Federal Highway Administration	Site Location: Red Wing	Project No. 11M018

Photo No. 13	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD01 core sample showing Holocene-aged lacustrine clays with small mollusk shells at 15.24-15.73 m (50.0-51.6 ft.) depth interval.	

Photo No. 14	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD01 core sample showing Holocene-aged lacustrine clays with large clam shells at 17.07-17.60 m (56.0-57.8 ft.) depth interval.	

Foth

Photographic Log

Client's Name: Minnesota Department of Transportation and Federal Highway Administration	Site Location: Red Wing	Project No. 11M018

Photo No. 15	Date:
Direction Photo Taken: Right-click here	
Photo Taken By:	
Description: Boring 11GD01 core sample showing dark grayish brown to dark olive gray Holocene-aged fluvial deposits at 28.65-29.17 m (94.0-95.7 ft.) depth interval.	

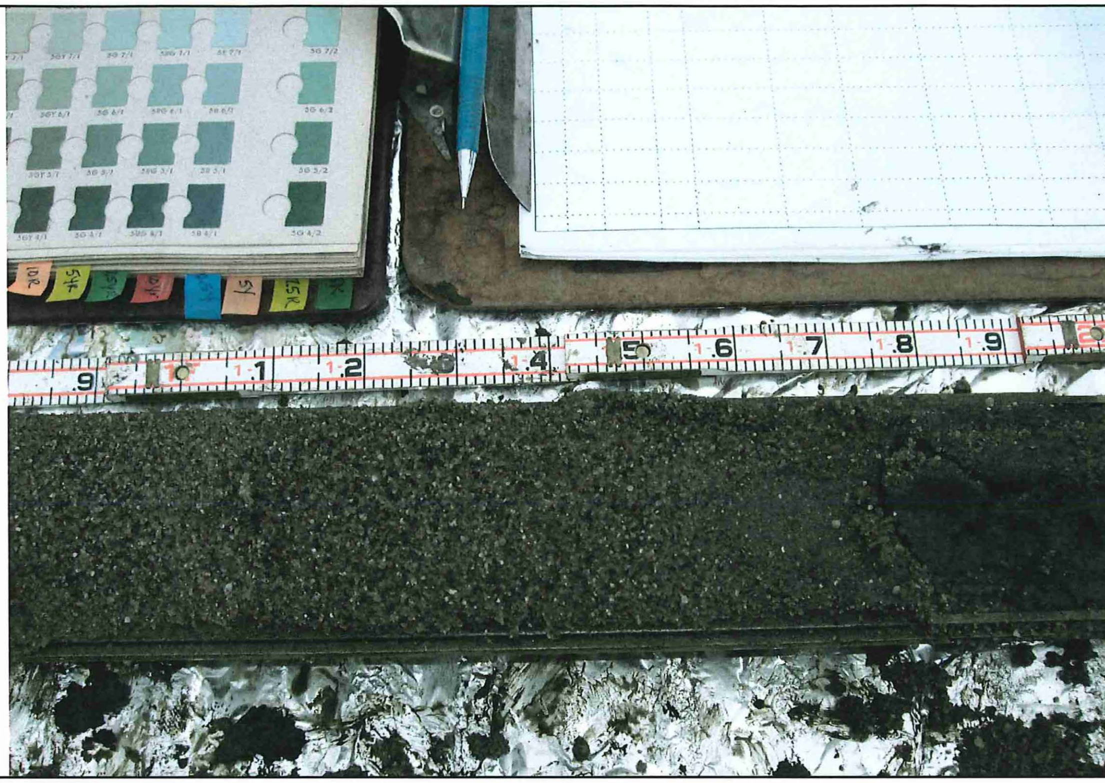


Photo No. 16	Date:
Direction Photo Taken: North	
Photo Taken By:	
Description: View looking north at the drilling location for Boring 11GD05 near the intersection of Arkin and East 4th Streets. Barn Bluff is in the background.