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"Systematic Approach to Identifying Deeply Buried Archeological Deposits"

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Part I: Final Report

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1. Introduction

1.1 Scope and Background

This project is designed to assist cultural resource specialists involved in Nebraska Department of Transportation (NDOT) and the Federal Highway Administration (FHWA) project planning and development. The goal was to develop Geographic Information System (GIS) data layers that spatially delineate different landform-sediment assemblages (LSAs) and depict the associated geologic potential for buried cultural deposits in select watersheds in Nebraska. The *Nebraska Buried Sites GIS* resource will allow planners and cultural resource specialists to determine whether future project areas are likely to be free of deeply buried sites or whether subsurface exploration is necessary.

Prior to the early 1980s, most archeologists working in Nebraska and other areas of the Midwest relied on traditional methods of surface surveys to locate prehistoric cultural deposits. Those methods, such as pedestrian surveys and shallow shovel testing, rarely detect buried cultural materials, especially in stream valleys. Bettis and Littke (1987:3) pointed out that inadequate subsurface sampling in stream valleys has led to significant gaps in the record of known prehistoric cultural resources, as well as erroneous conclusions about some aspects of regional cultural history. Many studies (e.g., Mandel, 1996, 1997, 1999, 2002, 2006a, 2009, 2010a, 2010b, 2011, 2012, 2013a, 2013b, 2014, 2015, 2016; Mandel and Bettis, 1995, 2001a, 2003) have demonstrated that stream valleys in Nebraska have extensive geomorphic surfaces that are geologically young (often post-dating 2000 yr B.P.), and that much of the existing record of prehistoric cultures before 2000 years ago or so is deeply buried. Hence there is a need for understanding the age and distribution of different LSAs in order to adequately evaluate the landscape for buried archeological materials. Traditional surface survey, shovel testing, and various means of remote sensing remain highly useful archeological site identification tools for near surface resources. This project is geared to a sharper understanding of deeply buried resources.

LSAs are landforms and underlying genetically related packages of sediment and associated soils with predictable age relationships. The impetus for considering LSAs in an archeological context is the premise that the archeological record is a component of the sedimentary record; hence, physical processes that remove, modify, and bury sediments control the preservation and visibility of the record of the human past (Bettis et al., 1996). Conceptualizing the landscape in this manner provides archeologists with a range of powerful tools for locating, evaluating, and interpreting cultural resources preserved in sediments that constitute the modern landscape (Mandel, 2006a). Other factors, all described below, also must be considered in determining the potential for buried cultural deposits.

1.2 Determining the Potential for Buried Cultural Deposits

In evaluating buried site potential, it is important to consider geomorphic processes, particularly erosion, deposition, and soil development. These processes produce a complex mosaic of LSAs that are differentially but systematically preserved in the landscape, and therefore affect the distribution and detection of archeological materials. For example, LSAs representing areas of net sedimentation (e.g., stream terraces, colluvial footslopes, and alluvial fans) have thick packages of sediment that often span the Holocene. These LSAs are typically formed by pulses of sedimentation punctuated by periods of stability and soil development and are therefore more likely to contain buried cultural deposits. In contrast, LSAs such as floodplains and upland drainageways tend to have relatively thin packages of sediment and are relatively young, often post-dating Euro-American settlement in the Plains.

In this project, determining the geologic potential for buried cultural deposits involved consideration of four factors with respect to different LSAs: (1) the age of sedimentary deposits, (2) the soil stratigraphic record, (3) the depositional environment (high energy vs. low energy), and (4) the drainage conditions (poorly drained vs. well drained).

Buried cultural deposits are limited to LSAs that date to the Holocene and terminal Pleistocene. Although the time when people first arrived in mid-continental North America is uncertain, there is strong evidence of a human presence by as early as 13,500 years ago (Holliday and Mandel, 2006, 2017a). Hence, LSAs that were aggrading anytime during the past 13,500 years have potential for containing buried cultural deposits. On the other hand, LSAs that have been stable for the past 13,500 years are not likely to have *in situ* cultural materials in buried contexts. Instead, they may have cultural deposits representing Early Paleoindian through Historic period occupations on their surfaces.

The presence/absence of terminal Pleistocene and Holocene-age buried soils, especially buried A horizons, is an important factor in evaluating the potential for buried cultural deposits (Mandel, 2006a; Holliday et al., 2017). Buried soils represent previous land surfaces that were stable for a long enough period to develop recognizable soil profile characteristics (Mandel and Bettis, 2001b). If one assumes that the probability of human use of a particular landscape position was equal for each year, it follows that the surfaces that remained exposed for the longest time would represent those with the highest probability for containing cultural materials (Hoyer, 1980). In stream valleys, buried soils dating to the Holocene and terminal Pleistocene represent those surfaces, and evidence for human occupation would most likely be associated with them.

However, prehistoric cultural deposits, even rich ones, also may be found in sediment that has not been modified by soil development (Hoyer, 1980). Hence the presence/absence of buried soils cannot be used as the sole criterion for evaluating the potentials for buried cultural materials. The mere presence of Holocene and terminal Pleistocene deposits beneath a geomorphic surface offers potential for buried cultural materials.

In the past, humans have been attracted to streams, often living on floodplains, terraces, or alluvial fans and exploiting the abundant resources available in alluvial settings. It is likely that prehistoric people were selective in choosing alluvial landforms for habitation, avoiding high-energy depositional environments, such as flood bars in zones of high-energy flooding and lateral accretion, but favoring relatively stable landforms that are elevated above the floodplain, such as terraces, alluvial fans and colluvial aprons (e.g., Mandel and Bettis, 2001b). Although alluvial landscapes are conducive to the initial accumulation of artifacts and their subsequent burial, fluvial processes may restructure the artifact patterns (Rapp and Hill, 2006: 75). For example, where sites are situated on or near the banks of stream channels, high-energy floods tend to modify cultural deposits dramatically by displacing artifacts vertically and horizontally. In some cases, stream erosion may completely remove artifacts, cultural features, and even entire sites, thereby destroying evidence of human occupation (Mandel et al., 2017). On the other hand, vertical accretion, which is a relatively low-energy process compared to lateral accretion, can result in rapid burial and preservation of cultural deposits in alluvial environments.

Drainage conditions also must be considered when assessing buried site potential. Today, wetlands, including marshes, shallow lakes, and wet basins and meadows, are common on the valley floors of streams and in dune fields, and they were present at various times over the past 13,000 years. Although people undoubtedly visited wetlands for hunting and gathering during that period, it is unlikely that they would have spent much time in such wet environments, and ephemeral camps rarely produce an abundant material record. By contrast, well-drained landforms, such as alluvial fans and colluvial aprons would have been attractive locations for long-term human occupations that tend to leave a rich archeological record (e.g., Almy, 1978; Mandel and Bettis 2001b; Saucier, 1966).

1.3 Soil survey data and archeological research

The implementation of systematic soil surveys and soil mapping by national soil survey programs was one of the primary goals in soil-related research through much of the 20th century (Brevink et al., 2016). In the United States, the Natural Resources Conservation Service (NRCS) currently is the primary agency involved in conducting soil surveys and disseminating soil data. The NRCS Web Soil Survey provides online access to a wealth of data on landscapes and geomorphology as well as soils. Engineers, farmers, property appraisers, and others often rely on these data because they either use soil as a material or study its role in the environment (Miller, 2012). Although some scientists have used soil survey data to devise strategies for locating cultural resources (e.g., Beeton and Mandel, 2011; Bettis and Benn, 1984, Mandel, 1992, 2006b; Monger, 1995; Stafford and Creasman, 2002), these data are generally underutilized in archeology, probably because of the agricultural and land-use focus of the surveys (Holliday and Mandel, 2017b). In this study, we use NRCS soil survey data to provide information on the spatial distribution of different LSAs and to determine the associated geologic potential for buried cultural resources. Based on this information, a GIS-based predictive model (Nebraska Buried Sites GIS) was developed for locating buried archeological material in select stream valleys in Nebraska. Data from a large volume of field-based research conducted throughout the region, including soil stratigraphy, lithostratigraphy, and chronostratigraphy, were used to verify the predictive model. A user's guide for the Nebraska Buried Sites GIS is provided with this report (see Part II).

2. Methodology

Research in the Central Great Plains involving geomorphology combined with archeology (or *geoarcheology)* has produced a large volume of data in Nebraska. However, before the present investigation, no collective repository or database of this geoarcheological information existed. Hence, the initial step in the creation of the GIS-based predictive model was the identification and gathering of extant technical reports, journal articles, book chapters, and other publications containing pertinent geoarcheological data in and around Nebraska. A literature review that utilized existing databases of published and unpublished reports identified many relevant resources containing geomorphological information. As the primary repository for archeological literature in the state, the Nebraska State Historical Society provided the bulk of this information. Additional resources were identified and collected directly from geomorphologists and their institutions with a history of research in the state, such as Dr. Rolfe Mandel's work with the Nebraska State Historical Society (State

Archeology Office and State Historic Preservation Office), the University of Nebraska, and Augustana College. All resources were converted to digital formats where applicable and compiled in a comprehensive bibliographic database (see Part III of this document). As stratigraphic profiles and associated data from select localities were used in verifying cultural resource potential based on soil survey data, related photographs and profiles were extracted from the referenced reports and added to the GIS as attachments.

A GIS data layer (ESRI shapefile) was developed that spatially depicts the potential for buried cultural resources in select watersheds. Watershed boundary shapefiles at the cataloging unit scale (HUC-8) were obtained from the United States Geological Survey (USGS) watershed boundary dataset (http://nhd.usgs.gov/wbd.html). Certain HUC-8 watershed boundaries were merged to create the boundaries for the watersheds of interest (Fig 1). Soil data from the Soil Survey Geographic database (SSURGO) were obtained via the NRCS Web Soil Survey (http://websoilsurvey.sc.egov.usda.gov). Exported data included spatial data in ESRI shapefile format and associated tabular data. SSURGO data depicts information about the kinds and distribution of soils on the landscape, including textural information as well as generalized geomorphic descriptions, such as flooding frequency, drainage class, and slope. Each shapefile contains discrete map unit polygons that are defined in terms of their soil characteristics. Map units consist of one or more components that represent different soil series and the name of a given map unit is named after the dominant component. For this study, we used the Map Unit Symbol (musym) attribute data, which provides a 4-digit numeric code for each map unit that corresponds to a particular soil series and generalized geomorphic description. For example, musym codes 7051 and 7153 both refer to the Kennebec soil series but are described as frequently flooded and rarely flooded, respectively. The name for the dominant soil series in each map unit and descriptive information is found in the tabular data file (mapunit.txt) obtained from the SSURGO database. Further geomorphic information (e.g., the type of LSAs on which a given soil series occurs) and soil descriptions for relevant soil series were obtained from the NRCS Official Soil Series Descriptions (OSD) database (https://soilseries.sc.egov.usda.gov).

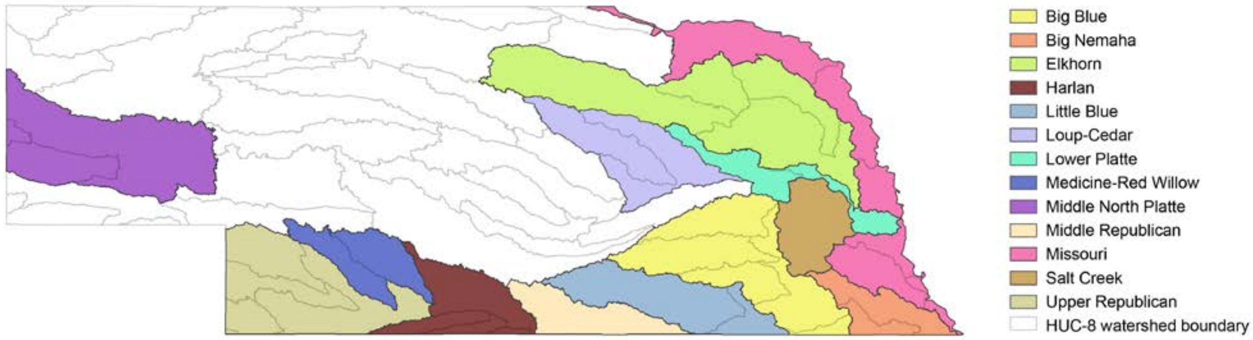

Figure 1. Map of Nebraska showing USGS HUC-8 watersheds and the watershed boundaries used in this study.

Spatial and tabular datasets were downloaded from the SSURGO database by county and clipped to the watershed boundary of interest. Similar map unit polygons (i.e., same musym code) were then merged in ARCGIS using the “dissolve” feature. For each watershed, a new attribute table was constructed that provides information on the assigned category (or potential for buried archeology where applicable) and description for each map unit polygon.

A series of categories were developed based on (1) parent material characteristics (i.e., alluvium, colluvium, loess, eolian sand, and till) and (2) topographic position (i.e., upland). The “upland” category also included soils developed in residuum. Polygons associated with water bodies and anthropogenically modified areas (e.g., landfill, urban land, quarries, and earthen dams), were also assigned to separate categories, i.e., “water” and “urban,” respectively. Discrete categories were also created that depict the different geologic potential for buried cultural deposits. This study specifically focused on delineating different LSAs for alluvial and colluvial map units in stream valleys and assigning an associated geologic potential for buried archeological materials. Potential was also assigned for map units representing playas or closed depressions on loess uplands as these represent environments that are conducive for containing a buried cultural record (Mandel, 2006a).

As previously noted, assigning geologic potential involved consideration of four factors for different LSAs. Information relating to type of LSA and the four factors was obtained from the SSURGO and OSD databases as well as the large volume of geoarcheological research conducted throughout the state. Data from these field studies were used to “ground-truth” the initial assignments of potential for buried cultural deposits based on the SSURGO and OSD data.

(1) The age of sedimentary deposits. For the age factor, we utilized radiocarbon chronologies presented in previous geomorphological investigations. Numerical ages, type of LSA, and specific localities from these studies are provided in a separate GIS data layer (point shapefile). In the eastern-third of Nebraska, the age of alluvial and colluvial LSAs was also inferred by correlating map units with different members of the DeForest Formation (see case study section below).

(2) The soil-stratigraphic record. Generalized soil descriptions from the SSURGO and OSD datasets were supplemented with soil-stratigraphic information gleaned from relevant geoarcheological studies. As previously noted, the potential for buried cultural deposits is partially dependent on the presence or absence of buried soils.

(3) The depositional environment. Textural information (i.e., coarse grained vs. fine-grained deposits) provided in the SSURGO and OSD databases was used to infer high energy vs. low energy environments.

(4) The drainage conditions. Drainage conditions can be generally inferred from the SSURGO database for individual map units (e.g., map units described as frequently flooded are typically poorly drained). Other more explicit descriptions of drainage conditions (e.g., well drained, poorly drained, etc.) are provided in the OSD database for each soil series. Supporting information is provided in the soil horizon descriptions. For example, poorly drained soils typically have gleyed horizons (i.e., Bg horizons) and evidence for redoximorphic concentrations and depletions that indicate shallow, fluctuating water tables.

Based on the four factors discussed above, map unit polygons were assigned one of the following geologic potentials for contained buried cultural deposits: high, low, or variable. A “variable” assignment was used for soil series associated with a range of different landscape positions (i.e., different LSAs) that have varying potential (e.g., upland drainageway vs. terrace). In those cases, the differences are explained in the descriptions for each map unit polygon in the GIS data layer. For example, map units associated with the Nodaway soil series have the following description: terraces and alluvial fans (high potential); floodplain and upland drainageways (low potential). Therefore, knowledge of geomorphic position in a given drainage system is needed to ascertain whether buried cultural deposits are more or less likely to be present for map units in the variable category.

In sum, each map unit polygon was assigned to one of the following integer categories:

1 – Low potential
2 – Variable potential
3 – High potential
4 – Loess
5 – Eolian sand
6 – Till
7 – Upland
8 – Water
9 – Urban

Each of these categories is described in more detail in the following case study section.

3. Case study: The Big Nemaha River, southeastern Nebraska.

This section provides an example from the Big Nemaha River watershed, located in southeastern Nebraska, illustrating how the potential for buried cultural resources was assigned to different SSURGO map units and associated LSAs (see Fig. 2 for illustration of final shapefile product). Some of the problems encountered are presented, but the overall strengths and limitations of this study are discussed in a separate section.

Alluvial/Colluvial LSAs – All deposits of fine-grained alluvium in eastern Nebraska can be assigned to a single lithostratigraphic unit: the DeForest Formation (Dillon and Mandel, 2008; Mandel, 1994, 1996; Mandel and Bettis, 1992, 1995, 2001a). Five members of the formation – the Camp Creek, Honey Creek, Roberts Creek, Gunder and Corrington – occur in this region. The typical physical, soil, and chronological characteristics of these different members are summarized in Table 1. Geoarcheological studies in eastern Nebraska have utilized this stratigraphic framework to assess the potential for buried archeological material associated with different cultural periods (e.g., Mandel, 2002, 2009, 2010a, 2010b, 2011, 2012, 2013a, 2013b, 2014; Mandel and Bettis, 2001a, 2003).

In the Big Nemaha River valley, map unit polygons associated with the Muir, Reading, Olmitz, and Tully soil series were assigned high potential. These soils are well drained, developed in fine-grained alluvium, and are associated with LSAs (i.e., stream terraces, alluvial fans, and footslopes) that have high potential for containing buried cultural deposits. Based on the type of LSA and soil morphology (e.g., A-Bt horizonation), the Muir

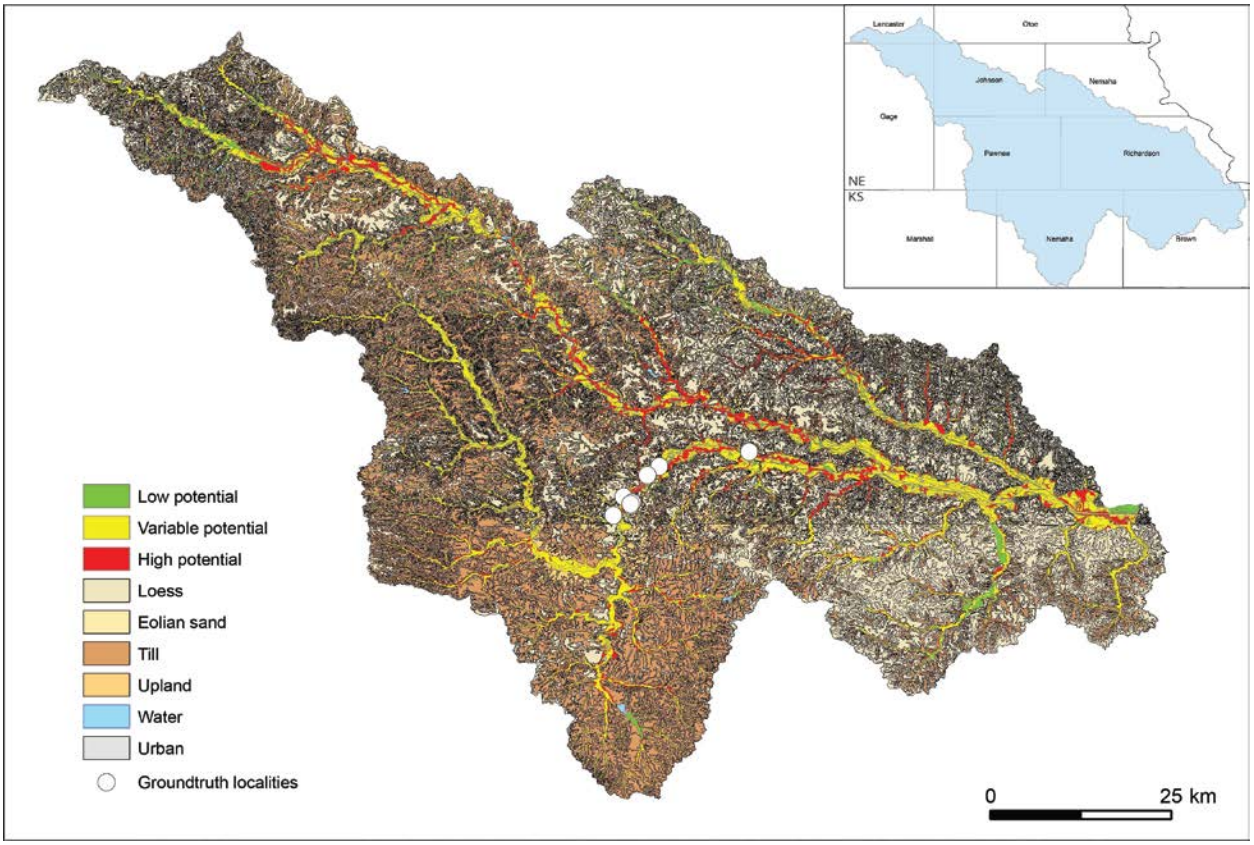

Figure 2. Map of Big Nemaha River watershed showing category assignments of map units and locations of sites used for groundtruthing. Inset map shows counties in the Big Nemaha River watershed.

and Reading series correspond to the Gunder Member of the DeForest Formation, whereas the Olmitz and Tully series correspond to the Corrington Member. Given that the Gunder and Corrington members typically date from about 10,500 to 4000 yr B.P. and 9000 to 2500 yr B.P., respectively (Table 1), these map units have potential for containing Paleoindian and Archaic cultural deposits. Although no groundtruth data exist in the Big Nemaha River watershed for the Muir, Reading, Olmitz, and Tully soil series, the Gunder Member has been shown to contain both buried soils and cultural deposits in this watershed (e.g., Mandel and Bettis, 2001a, 2003) and other watersheds in eastern Nebraska (e.g., Mandel, 2009, 2010a, 2013). Similarly, the Corrington Member has been shown to contain buried soils and archeological materials in the Elkhorn, Lower Platte, and Squaw Creek watersheds (Mandel, 2002, 2014). In those watersheds, the Judson soil series corresponds to the Corrington Member and would therefore have high potential for buried cultural deposits. The Judson series, however, is also mapped as occurring in upland drainageways, which have low potential. Therefore, map units associated with the Judson series were assigned to the "variable potential" category.

One of the most common alluvial soils in the Big Nemaha River watershed is the Kennebec series, which is described in the OSD database as consisting of very deep, moderately well drained soils formed in silty alluvium on floodplains and upland drainageways. Kennebec soils typically have ~1 m-thick very dark grey (10YR 2/1) A horizons with silt loam texture and moderate granular and subangular blocky structure. This soil is typical of the Roberts Creek Member of the DeForest Formation (Table 1). The Colo and Zook soil series are very similar to the Kennebec series, except that they are poorly drained, and also represent the Roberts Creek Member. Given the age range of the Roberts Creek Member, corresponding map units have the potential to yield Late Archaic and Early Woodland cultural material in buried contexts.

Although described as occurring on floodplains, field research indicates that the Kennebec series is associated with the T-1 terrace in the South Fork of the Big Nemaha watershed (Mandel and Bettis, 2001a). A similar relationship was also found in the Elkhorn, New York Creek, and Salt Creek watersheds in Nebraska (Mandel, 2002, 2012, 2013a), as well as in small watersheds in northeast Kansas (Layzell and Mandel, 2014). Furthermore, similar soil series (i.e., Colo and Zook) are described in the OSD database as occurring on stream terraces. Part of this discrepancy may be related to ambiguities in correctly identifying the hydrologic or active floodplain vs. terrace surfaces in incised channels. Alluvial channels responding to environmental or anthropogenic forcing pass through a sequence of six discrete phases known as the stages of channel evolution, each characterized by the dominance of a particular process (Simon, 1989). In eastern Nebraska, streams have undergone severe incision and subsequent widening (stages III and IV, according to Simon's [1989] stage of channel evolution classification scheme) in response to human modification during the last half of the 20th century. Channelization and/or straightening of stream channels have created knickpoints that migrate headward and isolate the floodplains (now terraces) from the stream channel. Under stage III and IV conditions the hydrologic floodplain is actually confined within the incised channel, but there is no geomorphic evidence of floodplain deposition. Therefore, the ability to correctly identify hydrologic floodplain vs. terrace surfaces under stage III and IV conditions may explain some of the discrepancies found in the OSD data and highlights the subjective nature of soil surveys, which are dependent on the training and experience of the soil mapper. Also, upstream reaches in these stream valleys may not have undergone entrenchment because knickpoints have not yet reached them. In sum, because of the geomorphic processes operating in these stream valleys, the association of certain soil series (e.g., Kennebec) with floodplain LSAs may only be applicable in the uppermost reaches of the drainage network (i.e., upland drainageways).

In the South Fork of the Big Nemaha River valley, the picture is complicated further by the fact that the alluvium beneath the T-1 surface consists of a complex mosaic of Holocene and late Pleistocene laterally-inset valley fills (Mandel and Bettis, 2001a). For example, at the Farwell locality the Honey Creek and Gunder members of the DeForest Formation are laterally inset beneath the T-1 surface (Fig. 3a). At one section, the Roberts Creek and Camp Creek members fill a shallow flood chute cut into the Gunder Member (Fig. 3b). Archeological testing at the Farwell locality revealed buried Middle Archaic, Late Archaic, and Woodland components associated with the different alluvial fills; the oldest evidence for human occupation dates to ca. 4600 yr B.P. Although there is field evidence for Camp Creek, Honey Creek, Roberts Creek, and Gunder Member deposits associated with the T-1 LSA at the Farwell locality, the entire T-1 surface is mapped as the Kennebec series. It is therefore impossible to predict detailed temporal and spatial patterns of buried cultural deposits associated with this LSA without conducting detailed field investigations.

Table 1. Typical geomorphic, sedimentological, and chronological properties of the members of the DeForest Formation.

	Camp Creek Member[a]	**Roberts Creek Member**	**Honey Creek Member**	**Gunder Member**	**Corrington Member**
Facies	Fluvial: overbank	Fluvial: channel fills and sometimes flood drapes	Fluvial: overbank facies coarsening downward to gravelly channel facies. Multiple entrenched channel fills	Fluvial: overbank. Lower parts may be reduced and/or coarse grained	Alluvial fan[b] and colluvial apron
Color	Brown to dark brown and dark grayish brown	Very dark gray to grayish brown	Dark grayish brown	Yellowish brown to brown (oxidized); dark brown, dark gray, light olive gray (reduced)	Very dark brown to yellowish brown
Texture	Silt loam to clay loam, though some deposits may be coarser	Loam to clay loam	Silt loam	Loam to silt loam	Loam to clay loam with interbedded lenses of sand and gravel
Thickness	Variable; few cm to >2 m	1-2 m	Typically 3 to >6 m	>6 m	Typically 3 to >6 m
Surface soils	Entisols	Mollisols[c]	Mollisols, Entisols, and Inceptisols	Mollisols	Mollisols
Horizonation	A-C	A-C or A-Bw	Cumulic A-C or A-Bw	A-Bt	A-Bt
Buried soils	None	Common	Common	Uncommon	Common
Stratigraphic relationships	Inset into or unconformably overlies Gunder, Corrington, Honey Creek, and Roberts Creek Members	Overlies Gunder and Corrington Members, coarse-grained older alluvium, loess, and till. Separated from Camp Creek Member by either a fluvial erosion surface or an unconformity marked by a buried soil	Draped over or laterally inset against the Gunder Member. Often mantled by the Camp Creek Member. Stratigraphic relationship between Roberts Creek and Honey Creek Members is not clearly understood	Unconformably overlies coarse-grained and often organic-rich older alluvium, loess, glacial till, or bedrock. Separated from younger members by a fluvial erosion surface or an unconformity marked by a buried soil	Buries coarse-grained older alluvium, glacial till, loess, or bedrock, and can grade laterally into Gunder Member deposits.
Age	Less than ca. 500 B.P.	ca. 3000 to 500 B.P.	ca. 3700 to 400 B.P.	ca. 10,500 to 4000 B.P.[d]	ca. 9000 to 2500 B.P.

[a]The Camp Creek Member encompasses deposits that were formerly and informally referred to as ‘post-settlement alluvium.’

[b]Fans are located along the margins of valley floors where small streams (first- through third-order) enter large valleys.

[c]Surface soils developed in the Roberts Creek Member are morphologically less well expressed and have darker colored B and C horizons than soils developed in the Honey Creek, Gunder, and Corrington Members.

[d]The Gunder Member is often represented in two separate fills: a strongly oxidized fill (early Gunder; ca. 10,500 B.P. to 6000 B.P.) and a moderately oxidized fill (late Gunder; ca. 6000 B.P. to ca. 4000 B.P.).

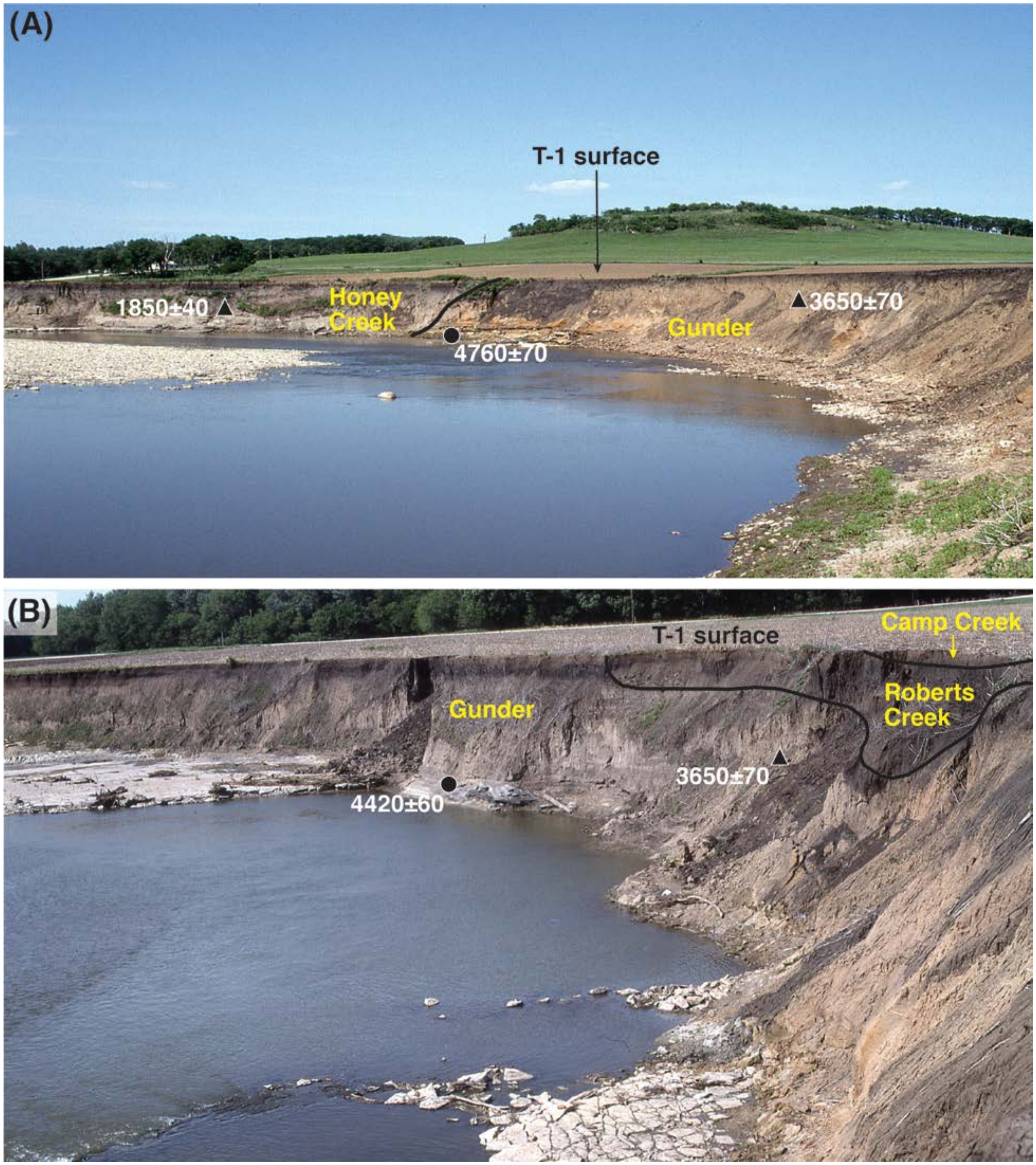

Figure 3. Different Holocene-aged alluvial fills (members of the DeForest Formation) beneath the T-1 surface at the Farwell locality, Big Nemaha watershed.

One helpful way to differentiate between floodplain, terrace, and upland drainageway LSAs is from the SSURGO descriptions of the frequency of flooding (i.e., rarely, occasionally, and frequently flooded). In the watersheds that were evaluated, soil series described as rarely flooded were consistently associated with the T-1 terrace and were therefore assigned high potential for buried cultural deposits. Soil series that are frequently flooded appear to be associated with floodplains and upland drainageway LSAs and were therefore assigned low potential. More field studies are needed, however, to fully validate this relationship. Soil series described as occasionally flooded were also found to be consistently associated the T-1 terrace, with the exception of one site in the Lower Platte River valley, and were therefore assigned high potential.

Another helpful way to distinguish between floodplain and terrace LSAs is from the SSURGO notations of "channeled" map units. The Nodaway soil series is described as occurring on floodplains, upland drainageways, and alluvial fans. Nodaway soils are characterized by thin, weakly developed A-C profiles developed in stratified alluvium, and are typical of the Camp Creek Member of the DeForest Formation (Table 1). Given the young age of the Camp Creek Member it is unlikely to contain buried cultural deposits. However, field studies in eastern Nebraska have shown that the Camp Creek Member often lies immediately beneath the T-1 surface, mantling other members of the DeForest Formation (e.g., Mandel, 2009, 2013). In the South Fork of the Big Nemaha River valley, for example, the Camp Creek member overlies the Roberts Creek Member at the Farwell locality (Mandel and Bettis, 2001a). Therefore, as with the Kennebec series, depending on the degree of incision in a given stream valley, the Nodaway series may be associated with floodplain/upland drainageways or terrace LSAs. Unlike the Kennebec series, there are no map units described as rarely flooded for the Nodaway series. Similar map units representing the Camp Creek Member in other watersheds include the Cass and Janude series. Given that the Nodaway series is found on a variety of LSAs and that no groundtruth data exists in the Big Nemaha watershed for this soil series, it was assigned variable potential. Some map units, associated with Nodaway soils described as "channeled" in the SSURGO dataset are, however, associated with historic floodplain or alluvial fan deposits. Those soils were assigned low potential for buried cultural deposits.

Other soil series typically associated with the modern floodplain and/or upland drainageway LSAs were all assigned low potential in the Big Nemaha watershed. For example, the Albaton, Kezan, Muscotah, and Onawa soil series are all poorly drained soils with evidence of redoximorphic concentrations or iron and manganese concretions. The Sarpy series is a soil formed in sandy alluvium and is associated with high-energy fluvial depositional environments (i.e., scroll bars).

Loess – Peoria Loess is the dominant surficial deposit on uplands and Pleistocene terraces in Nebraska. The thickness of this loess is extremely variable but tends to be thickest near major river valleys (Bettis et al., 2003). A large body of radiocarbon and luminescence ages (TL, OSL, IRSL) indicate that the Peoria Loess began to accumulate near its source areas around 23,000 ^{14}C yr B.P. and continued to accumulate across the Great Plains until about 12,000 ^{14}C yr B.P. (Bettis et al., 2003). Cultural material is often found in deposits of Peoria Loess but in a shallow context (i.e., less than 50 cm below the surface). The potential for deeply buried cultural deposits in Peoria Loess is relatively low. In the Big Nemaha River watershed, for example, Middle Archaic and Woodland cultural materials occur in deposits of Peoria Loess at the Koester site. These archeological deposits, however, were recorded in the plow zone. Given the spatial distribution of loess deposits, assigning potential for buried cultural material was beyond the scope of this study.

In the Big Nemaha River watershed, the following soil series are associated with loess deposits: Crete, Butler, Geary, Aksarben, Otoe, Yutan, Wymore, Monona, and Pohocco. In the SSURGO database, these series are differentiated by slope. In our analysis, it was determined that some upland drainageways, with low potential for buried cultural deposits are mapped as upland loess soil series. Therefore, loess map units were differentiated by slope in order to maintain the polygon boundaries for upland drainageways and more accurately highlight spatial patterns. We used the following arbitrary slope ranges for different geomorphic surfaces: 0-3% interfluves; 3-6% interfluves and sideslopes; >6% sideslopes. Some loess map units are associated with loess-mantled terraces (e.g., Crete soil series), upland swales (e.g., Butler soil series), or are described as loess overlying either till (e.g., Otoe soil series) or residuum (e.g., Padonia-Martin soil series). Hence, these map units were also differentiated on the basis of landscape and stratigraphic position within the loess category.

Eolian sand – It is likely that Holocene-age eolian sand deposits in Nebraska have high potential for buried soils and cultural resources (e.g., Muhs et al., 1997; Stokes and Swinehart, 1997). Such potential was not assigned, however, due to (1) the scope of this project, and (2) the lack of geoarcheological investigations (i.e., groundtruthing data) available to verify possible correlations between map units and potential for buried cultural resources in dune fields and eolian sand sheets. There are no eolian-sand map units in the Big Nemaha River watershed. However, in watersheds where these map units occur, they were differentiated based on their geomorphic position. For example, in the Elkhorn River watershed of northeastern Nebraska, map units representing soils developed in eolian sands on uplands (e.g., Elsmere soil series) were differentiated from those on both uplands and stream terraces (e.g., Dunday and Valentine soil series) as well as soils developed in swales or interdune areas (e.g. Loup soil series).

Till – The till category represents map units corresponding to the Burchard, Steinauer, Malmo, Mayberry, Morrill, Pawnee, and Shelby soil series in the Big Nemaha watershed. These soil series consist of deep to very deep, moderately to well-drained soils formed in pre-Illinoian glacial tills. Their geomorphic position is typically on uplands. Deposits associated with at least two and as many as five pre-Illinoian glacial episodes have been investigated from localities in eastern Nebraska and southeastern Kansas (Mandel and Bettis, 2001a; Roy et al., 2004). Given the middle to early Pleistocene age (ca. 0.6 to 2.5 Ma) of the till and the concomitant lack of potential for buried cultural deposits these map units were not differentiated. Instead, all till polygons were merged.

***Upland* –** This category is based on topographic position and contains all map units that are described as being located on uplands (e.g., Filley and Ladysmith soil series), with the exception of map units with soils developed in loess and glacial till. Within the upland category, soils developed in residuum (e.g., Kipson and Sogn soil series) were differentiated.

***Water* –** The category includes map units labeled in SSURGO as “water,” representing water in stream valleys and ponds as well as those labeled “miscellaneous water” such as sewage lagoons.

***Urban* –** This category includes map units described in SSURGO as “urban land” and other anthropogenically modified areas such as earthen dams, quarries, gravel pits, and landfills.

4. Summary of strengths and limitations

One of the main strengths of the approach taken in this study is the ability to readily identify LSAs from SSURGO and OSD datasets. In particular, OSD data include descriptions of where particular soil series occur in the landscape, e.g., floodplains, alluvial fans, terraces, upland drainageways, colluvial footslopes, etc. This information is valuable because geoarcheological studies have shown that specific LSAs are more likely to contain buried soils and therefore buried cultural deposits than others. Field data indicate that there may be some ambiguity, however, in these descriptions of geomorphic settings. For example, depending on the degree of stream entrenchment in a given river valley, some soil series described as occurring on floodplains may actually occur on stream terraces. Also, some soil series (e.g., Kennebec and Nodaway) are found in a variety of landscape positions (i.e., different LSAs) that have different potential for buried cultural deposits. Nevertheless, in such cases the specific LSA associated with a given map unit can still be determined with knowledge of geomorphic position in the landscape. Also, it is possible to differentiate between floodplain/upland drainageway and stream terrace LSAs based on the descriptions of flooding frequency (e.g., rarely, occasionally, and frequently flooded) and notations of "channeled" in the SSURGO database.

Another major strength of this study is the ability to correlate certain soil series with alluvial stratigraphic units, i.e., members of the DeForest Formation. For example, field research indicates that the Nodaway, Kennebec, Reading, and Judson soil series correlate with the Camp Creek, Roberts Creek, Gunder, and Corrington members, respectively. These correlations facilitate evaluation of the likelihood for buried soils and buried cultural resources. Also, the potential associated with a particular cultural period can be inferred because the members of the DeForest Formation have specific age ranges. However, given the spatial distribution of the DeForest Formation, these correlations are only applicable to eastern and central Nebraska.

The presence/absence of Holocene-age and terminal Pleistocene buried soils is an important factor in evaluating the potential for buried cultural deposits. One of the major limitations of the SSURGO and OSD datasets, however, is that only the upper 1-2 m of soil parent materials are considered. Buried soils in alluvial settings in Nebraska often occur at greater depths and, therefore, key information pertaining the presence/absence of buried soils is missing. Information on types of deposits below ~2 m is important because of the nature of the alluvial stratigraphic record. For instance, unconformable stratigraphic relationships are often present in alluvial deposits and therefore the age of sediments at depth may be significantly greater than at the surface (Mandel, 2008). The Camp Creek Member is a case in point. Packages of Historic-age (generally post-modern settlement) sediment comprising the Camp Creek Member are often more than 2 m thick and may mantle early-Holocene deposits comprising the Gunder Member.

A second major limitation is the spatial scale of the soil survey mapping. The prioritization of different landscape features and soil types is inherently different at different spatial scales (Hudson and Culver, 1994; Miller and Schaetzl, 2015). The SSURGO database contains information collected at scales ranging from 1:12,000 to 1:63,360. These scales permit a minimum size for delineating map units of 0.57 ha to 16.2 ha (Soil Survey Division Staff, 1993). Consequently, the scale of most map units as well as the variability inherent in those mapping units is greater than the scale of many archeological sites (Holliday and Mandel, 2017b). A majority of map units in the SSURGO database are mapped as "consociations," meaning that delineated areas are dominated by a single soil series. As a rule, at least half of the area must be represented by the series that provides the name for the map unit. Some map units, however, contain a mix of soil series. For example, "complexes" consist of two or more dissimilar components occurring in a regular pattern, whereas "undifferentiated groups" consist of two or more components that are not consistently associated geographically. Also, the discrete borders of map units may not denote actual soil boundaries because soils do not have sharp contacts and typically grade from one type into another (Holliday and Mandel, 2017b). Finally, many mapping decisions are subjective because soil survey mappers are called upon to make judgment calls based on whether a particular soil can be mapped consistently and whether it meets the objectives of the survey. For example, having too many map unit delineations may in some cases reduce the overall usefulness of a soil map. Therefore, the degree to which soil survey data accurately depicts soil-geomorphic relationships will vary depending on the training and experience of the soil mapper. Comparing soil maps across county and state boundaries can reveal the effects of this subjectivity (e.g., Sorenson et al., 1987). Also, although mappers attempt to map soil types consistently, the maps often suffer from a lack of rigorous testing to assess their accuracy (Brevink et al., 2016).

In sum, the fundamental issue of scale in soil survey mapping is that the actual soils associated with a given map unit may not necessarily be those indicated on the map, even in the best-case scenario where a map unit represents a consociation. Hence, the potential for buried cultural resources in a given map unit may not be accurate. Such is the case in the South Fork of the Big Nemaha River valley. As previously noted, the T-1 surface at the Farwell locality (see Mandel and Bettis, 2001a) is mapped as the Kennebec soil series, which corresponds to the Roberts Creek Member, but the deposits directly beneath the T-1 surface include the Camp Creek, Honey Creek, Roberts Creek, and Gunder members of the DeForest Formation. This complexity makes it impossible to predict the temporal and spatial pattern of the archeological record and necessitates detailed subsurface investigations.

The limitations of the soil survey data provided above has hindered their use in archeological surveys. In this study, we attempted to overcome some of these limitations by groundtruthing the initial assignments of potential for buried cultural deposits that are based on soil survey data. Specifically, information gleaned from detailed geomorphic and geoarcheological studies were incorporated in the assessment of buried-site potential. Although previous studies are an invaluable resource, their spatial extent is restricted;

hence more groundtruthing would greatly improve the predictive power of the GIS resource presented here.

This project has shown that specific soil series are associated with particular LSAs throughout Nebraska as well as different members of the DeForest Formation in eastern and central Nebraska. Therefore, the developed GIS data layers, together with the associated detailed repository of geoarcheological information, can be used as a helpful screening tool to determine whether certain areas are likely to be free of deeply buried cultural deposits or whether subsurface exploration is necessary. Because soil survey data are generalized, they should only be used to establish first approximations of buried-site potential. Detailed field investigations are necessary to confirm and elaborate on those approximations and to establish more appropriate spatial and temporal scales.

We view this project as a beginning and the current product as fluid. Several large areas of Nebraska are not covered because available data was simply too limited. These areas include the following major drainage basins: Niobrara, White, central segments of the Platte, South Platte, and portions of the Loup (including the vast Sand Hills region drained by the North Loup, South Loup, Middle Loup, Dismal and Calamus rivers as well as numerous lakes). If funding remains available, continued data gathering in these drainages is recommended. We also recommend that select portions of basins that are covered in this project are in need of expanded fieldwork to collect additional radiocarbon dates and systematic soil profiles from deep exposures, cores, and backhoe trenches. As more data is amassed and incorporated into the GIS, the more reliable its predictive potential becomes.

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Part II: Nebraska Buried Sites GIS – User's Guide

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DISCLAIMER:

This project is designed to evaluate the geologic ***potential*** for buried cultural deposits in select watersheds in Nebraska. This GIS resource is simply a tool to determine whether proposed areas of potential effect (APE) possess a greater or lesser likelihood of requiring additional subsurface exploration to establish the presence of buried archeological properties. The product should not be used solely to offer determinations about the definitive presence or absence of cultural resources from the perspective of compliance with Section 106 of the National Historic Preservation Act and any other related state or federal laws and regulations. The Nebraska State Historical Society and the University of Kansas does not assume professional liability for parties using this product to make Section 106 determinations without additional investigations.

1. Introduction

1.1 Scope and Purpose

This user's guide is intended as an introduction to the use of the *Nebraska Buried Sites GIS*, developed by the Nebraska State Historical Society and the Kansas Geological Survey under NTRC Grant Project SRP-P1(16) M048, "Systematic Approach to Identifying Deeply Buried Archeological Deposits" in Nebraska.

This GIS is intended for use by cultural resources specialists in the initial phase of determining whether targeted investigations for deeply buried sites are necessary during project planning and development. The GIS is designed to enhance the ability to predict where these types of resources may or may not occur. It is specifically intended for use in Nebraska Department of Transportation (NDOT) and the Federal Highway Administration (FHWA) undertakings, but is anticipated to also prove useful for cultural resource specialists in other agencies, as well as geomorphologists conducting research in the state.

1.2 Software Requirements

The *Nebraska Buried Sites GIS* was developed using ESRI ArcGIS 10.3 for Desktop (Advanced License). Access to ESRI ArcMap software is required for use of this GIS at this time, with the aim of access via ArcGIS Online or ArcExplorer anticipated in the future.

ESRI ArcGIS began using Map Package files (see **Download** section below) in version 10, so older versions of the ArcMap software can not open .mpk files at this time. As a result, ArcMap 10.0 or later is required to access this map.

An ESRI Basemap (USA_Topo_Maps) is included as a layer on the map. Connection to the internet is necessary in order to view/access this basemap layer.

2. Download/Installation

2.1 Download

The *Nebraska Buried Sites GIS* is currently available as an ArcGIS Map Package (.mpk) file. This file type bundles the map (.mxd) file and all the referenced data into a single .mpk file. The file should be saved locally (C: Drive recommended).

File Sizes:
Version 10.3 = 3.8 GB *Version All (10.0 and later) = 5.68 GB*

2.2 Installation

There are several options available to open and extract the contents of the .mpk file. *[Note: some users may have success with one option and not another, depending on local settings.]*

2.2.1 From Windows Explorer:
Double-click the file to launch ArcMap and unpack all the data in the package.

2.2.2 From ArcCatalog:

1. Browse to the local drive location of the .mpk file.
2. Right-click the file, and select 'Unpack' from the dropdown menu.

2.2.3 From ArcMap:
Drag and drop the .mpk file into an ArcMap document.

{or}

1. Start ArcMap and open the toolbox.
2. Navigate to Data Management Tools > Package > Extract Package. This will start the Extract Package tool as shown.
3. Browse to the saved .mpk file under 'Input Package'.
4. Specify your destination folder as the second option.

2.3 Accessing the Map

File contents will be unpacked and saved on your hard drive in the user's documents library, in the *\Documents\ArcGIS\Packages* folder. To open the map, navigate to the folder in Windows Explorer or ArcCatalog and the user will find the map documents and data. The folder may include sub folders for different versions of ArcGIS. The user may need to navigate into these sub-folders to find the *Nebraska Buried Sites GIS* map document.

3. Navigation

3.1 Find

The *Nebraska Buried Sites GIS* can be easily navigated via the Find tool  , using the Reference Layers to pinpoint a particular location or area of interest.

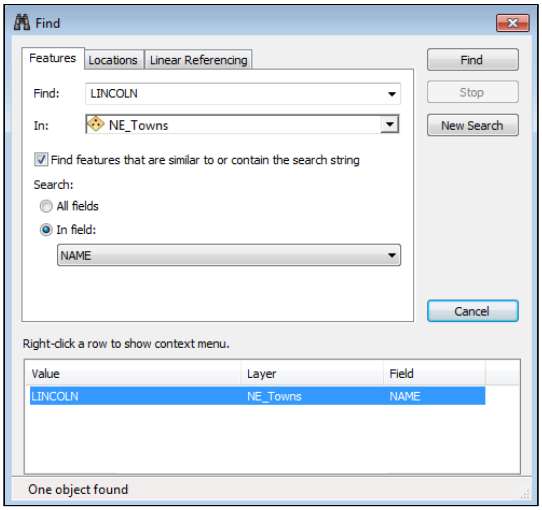
Reference Layers:
NE_Towns – Search by town/city name in ALL CAPS, i.e. LINCOLN, in NAME field.
Counties – Search by county name in ALL CAPS, i.e. LANCASTER, in COUNTY_NAM field.
Legal – Section Township Range – Search by legal description in Sec_T_R field.

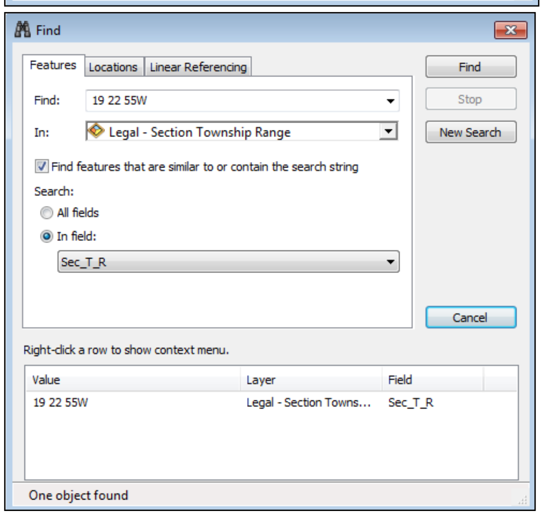
Note - Search must match field character format. Examples:

-Section 2, Twn 9N, Rng 7E = 2 9 7E [2_9_ _7E, when _ represents a space]

-Section 10, Twn 10N, Rng 7E = 10 10 7E [10_10_ _7E, when _ represents a space]

-Section 19, Twn 22N, Rng 55W = 19 22 55W [19_22_55W, when _ represents a space]





Right-click on search result to select or navigate to location.

- Options include: *Select*, *Flash*, *Zoom To*, and *Pan To* Location.

3.2 Zoom to: Area of Interest

3.2.1 Select Watershed/Locality

1. Right-click watershed of interest, and select *Zoom To Layer* from dropdown menu.
2. Right-click {Watershed}_Localities, and *Open Attribute Table*. Right-click the locality of interest and select *Zoom To* from the dropdown menu.

*The Find tool can also be used to navigate to watersheds and localities.

[Note: Depending on the extent of a specific watershed, locality symbols and the layer depicting the potential for cultural resources may not appear upon

zooming to the watershed, due to set scale ranges on these layers. Locality layers are set to appear when zoomed in beyond 1:399,999. Watershed potential layers are set to appear when zoomed in beyond 1:250,000. These ranges may be changed, but changes may affect map performance.]

3.2.2 Adding Shapefiles

Shapefiles depicting an area of interest may be added to the map and navigated to by right-clicking the added layer in the Table of Contents and selecting *Zoom To Layer*.

4. The Geoarcheological Data

4.1 Layers

The geoarcheological data is organized by watershed. Each watershed group layer contains two layers*, one depicting referenced localities and one depicting the potential for buried cultural resources.

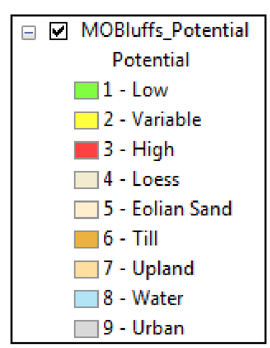
Localities are areas where geoarcheological field data is available from previous research conducted in the state. The data from these sites were referenced in the assignment of potential for buried cultural resources. This data typically includes a detailed description of the soil-stratigraphic record of a particular location, along with photos and illustrated soil profiles. This data is based on the in-field examination of soil cores, backhoe trench wall profiles, cuts along stream banks, and other eroded areas by a geomorphologist.

The geologic **potential** for buried cultural resources, as depicted for each watershed, was assigned to different landform-sediment assemblages (LSAs) based on consideration of four factors, including 1) the age of sedimentary deposits, 2) the soil-stratigraphic record, 3) the depositional environment, and 4) the drainage conditions. For more information on LSAs, the methodology used in the creation of the potential layers, and descriptions of the nine assigned categories, see the final project report in Part I of this document.

*[*Note: The Upper Republican dataset does not include referenced localities, only a layer depicting the potential for buried cultural resources.]*

4.2 Visibility

The Watershed layers are visible depending on the extent to which a user is zoomed in on the map. Locality layers are set to appear when zoomed in beyond 1:399,999. Watershed potential layers are set to appear when zoomed in beyond 1:250,000. *[These ranges may be changed, but changes may affect map performance.]*

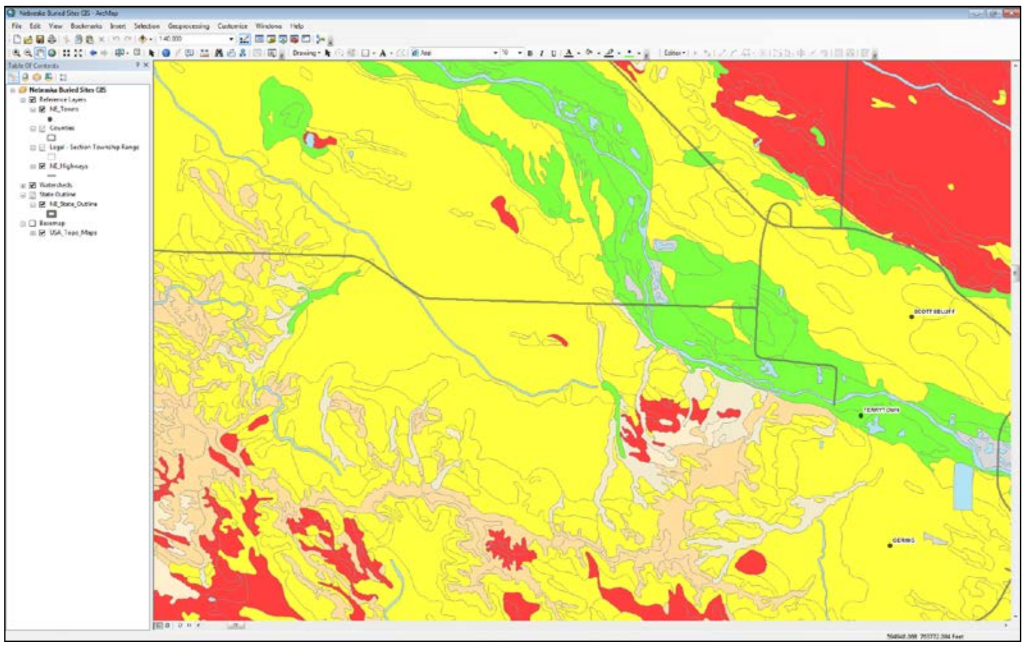


4.3 Exploring the Georcheological Data

4.3.1 {*Watershed*} Potential Layer

- Potential Field

  The geologic potential for buried cultural resources of a given area is depicted based on the assignment of nine categories: Low, Variable, High, Loess, Eolian Sand, Till, Upland, Water, and Urban. Each unique category is depicted in a different color, with the color scheme maintained throughout each of the watersheds. If the color key is not visible in the Table of Contents, expand the layer by clicking the + next to the layer.



- Unit Field

  This field indicates the map unit for each polygon, including the parent material characteristics (i.e., alluvium) and the topographic position (i.e., upland). This information is located in the Attribute Table, and can also be accessed via the Identify tool  .

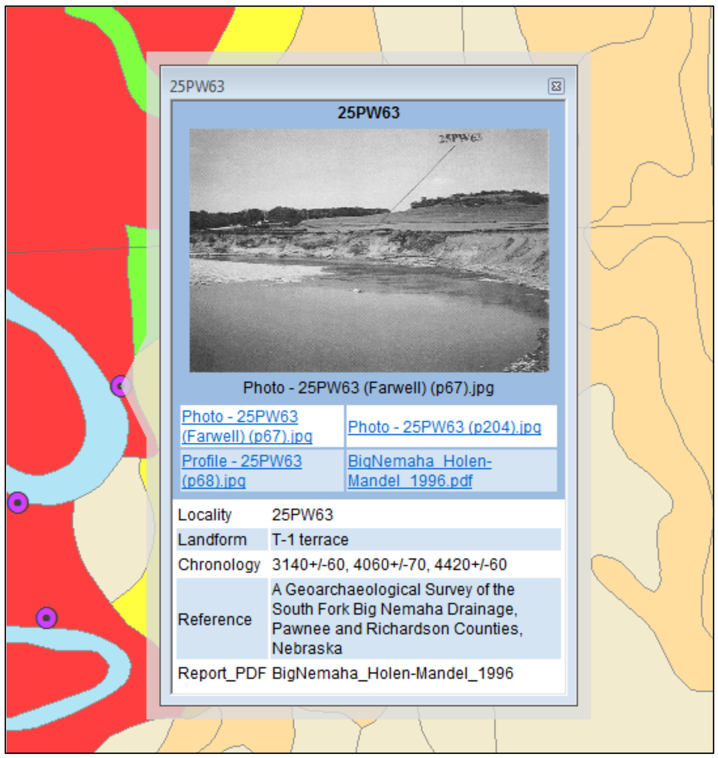
- MUSYM (Map Unit Symbol) Field

  This field contains a 4-digit numeric code for each map unit that corresponds to a particular soil series and generalized geomorphic description. At this time, not every watershed includes this attribute data, but this field will be added to each watershed's potential layer in the future.

4.3.2 {*Watershed*} Localities Layer

Localities are organized by the watershed in which they are located. To explore the data available for each specific locality, utilize the HTML Popup

Tool . With this tool highlighted in the toolbar, click a locality feature on the map to launch the popup. Each popup will contain the available data for a locality, including its name, landform type, and chronologic dates available for associated buried soils, the report reference, and any photo, profile, and report attachments. Click the .jpg and/or .pdf links to view these file attachments in a new window. *[Page numbers included in attachment file names (i.e., p67, p204, etc.) indicate page location of photo/profile in attached referenced report.]*



Note: Not all fields and attachment types will be available for each locality. For example, some localities may not have an associated radiocarbon chronology, due to the absence of datable material during the original research visit. Others may not have photos and/or profiles, if these were not included in the final report, as referenced. In addition, be aware that the quality of the image and report attachments is dependent on the quality of the original hard-copy or scanned document available, with some being less than ideal.

5. Exporting Data and Maps

5.1 Layout

In Layout view, the user can add map elements such as north arrows, legends, and scale bars, as well as frames that contain the geographic data or the maps themselves. The layout is able to be customized to fit user needs; however, please include reference to the *Nebraska Buried Sites GIS 2017* somewhere on the final map layout.

5.2 Export

Maps may be exported in a variety of formats, including PDF, JPG, AI, etc. via File > Export Map. Due to the size and amount of data contained within the GIS, the time to export a map layout may be considerable. It is recommended that users select the lowest resolution and image quality necessary if extended export time is a limitation.

6. Additional Information

6.1 Updates

As future funding, research, and time allow, the *Nebraska Buried Sites GIS* is anticipated to be updated with increased watershed coverage, updated values of geologic potential, and additional geoarcheological locality data. These updates are the best means of ensuring that the data presented in the GIS is as accurate as possible for use in cultural resource planning. Please contact the State Archeology Office at the Nebraska State Historical Society for any updates that may be available (see contact information below).

6.2 Questions and Comments

Questions and comments concerning the *Nebraska Buried Sites GIS* may be directed to the State Archeology Office at the Nebraska State Historical Society:

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Part III: Bibliography of Nebraska Geoarcheology

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