Decision Support Model for Assessing Archaeological Survey Needs for Bridge Replacement Projects in Iowa

by
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2006

sponsored by
the Iowa Highway Research Board
IHRB TR-513

Office of the State Archaeologist
The University of Iowa
Iowa City

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Acronyms Used in Report

AIA	Association of Iowa Archaeologists
APE	Area of Potential Effect
CAD	Computer Assisted Drafting
ERMS	Electronic Records Management System
FHWA	Federal Highway Administration
GIS	Geographical Information System(s)
IDOT	Iowa Department of Transportation
ISPAID	Iowa Soil Properties and Interpretation Database
LANDMASS	Landscape Model for Archaeological Site Suitability
NAD83	1983 North American Datum
NADB	National Archaeological Database
NADB-IA	National Archaeological Database of Iowa
NRCS	Natural Resources Conservation Service
OLE	Office of Location and Environment, Iowa DOT
OSA	Office of the State Archaeologist
OSD	NRCS Official Series Descriptions
PA	Programmatic Agreement
PMAT	Parent Material (ISPAID data field name)
R&C	Review and Compliance
SHPO	State Historic Preservation Office
SHSI	State Historical Society of Iowa
SQI	Survey Quality Index
USGS	United States Geological Survey
UTM	Universal Transverse Mercator

Executive Summary

The Bridges Decision Support Model is a geographic information system (GIS) that assembles existing data on archaeological sites, surveys, and their geologic contexts to assess the risk of bridge replacement projects encountering 13,000- to 150-year-old Native American sites. This project identifies critical variables for assessing prehistoric sites potential, examines the quality of available data about the variables, and applies the data to creating a decision support framework for use by the Iowa Department of Transportation (Iowa DOT) and others. An analysis of previous archaeological surveys indicates that subsurface testing to discover buried sites became increasingly common after 1980, but did not become routine until after the adoption of guidelines recommending such testing, in 1993. Even then, the average depth of testing has been relatively shallow. Alluvial deposits of sufficient age, deposited in depositional environments conducive to human habitation, are considerably thicker than archaeologists have routinely tested.

By contrast, borings taken in advance of bridge construction to assess the engineering properties of soils penetrate much deeper. Comparison of soil/sediment descriptions logged by archaeologists and IDOT bore hole logs indicates that geotechnical borings provides stratigraphic data that is adequate for prehistoric archaeological risk assessment. Data from soil/sediment logs indicate that sedimentary contexts suitable for prehistoric occupation average 2-3 m in thickness in Iowa valleys, and are underlain by coarse-textured channel and bar deposits unlikely to contain prehistoric sites. In proximity to streams, and particularly along the larger streams and rivers, alluvium deposited in the last 150 years often buries prehistoric surfaces to depths of up to 3 m. This poses difficulties in "reading" the ancient landscape and finding buried sites. Especially along the larger rivers, 19th and 20th century channel activity and anthropogenic disturbances may erode away the pre-A.D. 1850 deposits.

With these observations in mind, the Bridges Decision Support Model is a web-based process that links users to interactive databases and maps that provide information from stratigraphic logs, historic maps, previous archaeological survey coverage, and GIS site location models. The model steps the user through a sequence of steps that assesses the risk that prehistoric sites will be present within the area affected by a particular bridge replacement at a particular location in an Iowa stream valley.

The model allows the user to collect these data for submission to the Iowa DOT for a final risk assessment. In addition to risk assessment, the model can be used for archaeological survey planning as well as long-term prescreening of bridge replacement projects. Our recommendation is that the Iowa DOT test the model by using it to assess archaeological survey needs for structures identified in its five year plan for bridge replacements. The project would also result in the compilation of additional bore log and archaeological data for improving and refining the model.

Introduction

PROBLEM STATEMENT

To comply with Section 106 of the National Historic Preservation Act, the Federal Highway Administration (FHWA) and Iowa Department of Transportation (Iowa DOT) are required to determine the effects of federally-assisted transportation undertakings, including bridge replacements, on archaeological sites. In the past 30 years, hundreds of archaeological surveys have been conducted for local- and primary-system bridge replacement projects. These surveys often require costly and time-consuming subsurface excavation to search for sites that may be deeply buried in thick deposits of alluvial (stream-deposited) sediments. An alternative approach would be to use knowledge gained from previous surveys to assess the archaeological potential of a proposed bridge replacement project before, and if possible instead of, committing resources to an archaeological survey.

All the information needed to make such assessments, including archaeology, soils, geomorphology, and land-use history, can be assembled, viewed, and analyzed using Geographic Information Systems (GIS). In this report, the University of Iowa Office of the State Archaeologist (OSA) explores the feasibility of using GIS data to evaluate archaeological survey needs for Iowa DOT bridge replacements. The resultant Bridges Decision Support Model integrates information on archaeological sites, surveys, bridges, and their geological contexts. The model will help streamline the Section 106 process by facilitating communication and information transfer; by providing consistent, well-informed, and uniformly-applied decision criteria; and by improving the cost-effectiveness of cultural resource compliance.

BACKGROUND

Section 106 compliance involves consultation between state and federal transportation agencies and the State Historic Preservation Office (SHPO) at the State Historical Society of Iowa, Des Moines. FHWA, Iowa DOT, SHPO, and if necessary, the President's Advisory Council on Historic Preservation consult on the effects of federally-funded undertakings on historic properties, a term that is defined to include archaeological sites. Consultation may also extend to other interested parties including the public and American Indian tribes. In Iowa, a Programmatic Agreement (PA) executed between FHWA, Iowa DOT, and SHPO (Iowa DOT 2002a, 2002b) identifies specific kinds of undertakings that do and do not require further Section 106 consultation with SHPO. Examples of undertakings that do not require consultation include resurfacing and shouldering projects that do not involve new right-of-way acquisition. In general, undertakings that involve the acquisition of right-of-way require Section 106 review and frequently entail an archaeological survey.

Because bridges and their approaches are built on stream-deposited valley alluvium, they have the potential to disturb archaeological sites buried in alluvium. Iowa's valleys are known to contain great volumes of sediment deposited during the 13,000 years that humans have inhabited the state (Alex 2000; Bettis and Hajic 1995). Numerous deeply buried sites have been discovered in Iowa (Anderson and Semken 1980; Benn 1990, 1996; Bettis and Hoyer 1986) and adjacent states (Hajic 1990; Mandel 1995).

In 1993, the Association of Iowa Archaeologists (AIA) adopted guidelines recommending that Phase I archaeological surveys include subsurface investigation for buried sites when alluvium is present in a project area (AIA 1993). In 1998, these guidelines were adopted by the Iowa SHPO (Kaufmann 1999:3.20-3.25) and have been in effect since then. As implemented by the archaeological community, these investigations most often consist of augering, shovel testing, and mechanical trenching. Sometimes, the archaeological consultant hires a geoscience specialist to describe and interpret alluvial deposits encountered during a project.

There is a common perception among planners and archaeologists that intensive subsurface testing has not been effective in locating buried sites. One reason for this perception is that in many parts of Iowa (but not all, e.g., Benn 1996), archaeological sites are infrequent in alluvial sediments, and when present, are difficult to discover using small diameter test borings.

Although difficult to find, sites discovered in alluvial settings are often evaluated as historically significant. Burial in alluvium tends to enhance the preservation and therefore the historical significance of sites. In uplands, where no significant deposition has occurred since loess stopped accumulating about 14,000 years ago (Prior 1991), artifacts spanning thousands of years of occupation are typically mixed together in the upper 50-100 cm of the soil, where they are subject to disturbance by cultivation and surface erosion. By contrast, in alluvium, artifact-bearing layers representing individual prehistoric occupations are often separated by flood deposits devoid of artifacts, creating “layer cakes” of prehistoric activities. Rapid burial by alluviation often results in better preservation of cultural deposits which would otherwise be disturbed or destroyed if exposed at the ground surface.

Therefore, although a large percentage of bridge-related survey projects have not encountered buried archaeological sites (Artz 2003a), those that have been discovered are among the most significant found. For example, between 1999 and 2004, Iowa DOT let contracts for large-scale excavations at about 30 prehistoric archaeological sites that were considered sufficiently significant to be eligible for the National Register, but could not be avoided by project re-design. Of these sites, 17 were buried in alluvial settings (Artz 2003a).

OBJECTIVES

The Bridges Decision Support Model leverages a 30-year investment in archaeological survey by Iowa DOT and other local, state, and federal entities to create a tool for evaluating the archaeological potential of bridge replacement projects. The objectives of the project are as follows:

1. Evaluate data from previous archaeological surveys with regard to their ability to detect archaeological sites buried in alluvium.
2. Identify critical variables that influence the presence, preservation, and relative age of sites buried in alluvium;
3. Develop a Decision Support Model that applies the critical variables to evaluate the archaeological potential of proposed bridge replacement projects;
4. Develop a web-based resource to link users to data sources and guide them in its application.

Methods

DATUM AND COORDINATES SYSTEMS

Geographic Information Systems (GIS) data exist in vector and raster formats. Vector data represent geographic features as points, lines, and polygons. Raster data are grids of square cells in which each cell represents an area on the ground and is assigned a value for a variable such as elevation or land-use category. Vector data (e.g., shapefiles) are better at representing and analyzing discrete features such as bore holes, archaeological site boundaries, survey area boundaries, and bridges. Raster data (e.g., grids) are better at analyzing phenomenon such as elevation and soils that are continuous across the landscape. Distances from vector locations, for example, the distance from any point on the landscape to the nearest bridge, can also be represented as grids.

GIS data for this report are projected in Zone 15 of the Universal Transverse Mercator (UTM), using the 1983 North American Datum (NAD83). The Iowa DOTs Structure Inventory shapefile, received in decimal degrees of latitude and longitude, was re-projected for use in the study. All raster data used in the report represent data on a grid of 30 x 30 m cells. Horizontal resolution of data sets used in this report are no greater than +/- 14 m, the National Map Accuracy Standard for map scales of 1:24,000.

DATA SOURCES

Data on bridges, sites, survey areas, and stratigraphic logs provide the framework for this study. Each dataset was processed through a number of steps to extract information pertinent to the Bridges Decision Support Model. The following sections summarize these operations. ArcView 3.3 and ArcGIS 9.0 were used for GIS analysis; databases were maintained in Microsoft Access. Charts were created with Microsoft Excel.

Structures Inventory

The Iowa DOT maintains a Structures inventory in the form of a shapefile, Structures2001, and two database tables, str_base_2001.dbf and str_pass_2001.dbf. The shapefile contains 25,400 polyline features, each representing a structure and digitized at a scale of 1:100,000. The data tables can be joined in a one-to-one relationship with the shapefile on the str_lnk and MS_lnk fields, which contain identification numbers shared between the datasets.

The Structures Inventory contains data on culverts, overpasses, and underpasses in addition to bridges. A query isolated 23,574 polylines representing bridge structures that span streams. These were saved in a derivative shapefile, Structures_over_streams.

NADB-Iowa

The unique identification number, or primary key, in this Microsoft Access database is DOC, an integer value that refers to one and only one document archived by the SHPO. Most document numbers refer to reports on archaeological survey (Phase I) and excavation (Phases II-III) projects that have been submitted for SHPO review in compliance with historic preservation legislation including Section 106 of the National Historic Preservation Act. For this project, reports relating to Phase I archaeological surveys were queried from the NADB-IA database.

Another important field in NADB-IA is the SHPOID, an integer value that records the Review and Compliance (R&C) number assigned by SHPO to individual undertakings for which it assumes a regulatory role. DOC and SHPOID share a many-to-many relationship, which is actually a composite of three relationship types.

- One-to-one: one and only one document is on file for an individual R&C undertaking.
- Many-to-one: two or more reports are filed under a single R&C number. For example, an R&C number assigned to a bridge replacement project may include reports on the initial Phase I survey, supplemental surveys of borrow areas or right-of-way changes, and Phase II-III excavations of significant archaeological sites.
- One-to-Many: infrequently, a single document relates to several, separately-filed, R&C undertakings. For example, Peterson (1999) reported Phase I surveys for 10 Department of Natural Resources undertakings. For tracking purposes, SHPO assigned each undertaking its own R&C number.

IowaSurveys

This shapefile, created and maintained by SHPO staff, records the location of archaeological investigations submitted to SHPO. The polygonal shapes are digitized at 1:24,000 on a base map of

USGS, 7.5-min, topographic quadrangles. Each shape has a unique, autonumber, primary key. Multiple SHPOIDs are assigned to a single polygon in cases where survey areas overlap. The polygons have a one-to-many relationship with NADB-IA's SHPOID field. SHPOIDs associated with a polygon are stored in six fields, named Jobid and JobIDb through JobIDe.

Because this project focuses on individual Phase I surveys, IowaSurvey was processed using ArcView's dissolve request to create a shapefile in which polygons have a one-to-one relationship with SHPO-ID. This derivative shapefile is named MergedSurveys.

Iowa Site File

OSA maintains an Access database, DataISF, of recorded archaeological sites in Iowa. The primary key is comprised of unique combinations of the site number and the date on which the information was recorded. Each record therefore represents a single visit to, or investigation of, an archaeological site. This data schema is analogous to the original paper filing system for the Iowa Site File, in which an initial form was filed to document the initial recording of the site, with subsequent visits/investigations filed as "supplemental forms." For purposes of this project, only sites with prehistoric components were utilized.

AllSites

This shapefile, created and maintained by OSA, records the location of archaeological sites in the Iowa Site File. The polygons are digitized at a scale of 1:24,000 on a base map of USGS 7.5 min quadrangles. Site number is the primary key. The polygons therefore have a one to many relationship with records in the Iowa Site File.

LANDLogs

LANDLogs is an Access database developed by OSA as part of its Landscape Model for Archaeological Site Suitability (LANDMASS) project. It compiles information on over 4,300 stratigraphic logs from valley alluvium, acquired from a review of the archaeological and geoarchaeological literature for Iowa. Log locations were digitized into an ArcView shapefile, AllCores, and linked to LANDLogs on the LogID field. The database provides information on stratigraphy, geomorphology, and soils from both archaeological sites and off-site locations.

BoreLogs

For the present project OSA created BoreLogs, a database that compiles stratigraphic information from 2,628 Iowa DOT bore logs from 71 counties. The data are from two sources. A total of 353 bore logs are from "Q-sheets." These are pages from highway design CAD plans that show the locations of soil borings along the proposed highway corridor, and also stratigraphic cross sections developed from these borings. Q-Sheets were retrieved from the Iowa DOT's Electronic Records Management System (ERMS). The remaining bore logs were compiled from a statewide file of logs for soil borings drilled at bridge crossings. These logs are recorded on paper coding forms which Iowa DOT donated to the Iowa Geological Survey for use in statewide geological mapping, and which were borrowed by OSA for this project.

Objective 1: Evaluate Data from Previous Surveys

Identify Survey Areas That Contain Bridges

Of the 6,384 digitized survey areas, 3,248 contain one or more bridges that appear in the Iowa DOT's structures inventory. Linking the R&C numbers for this subset to the NADB-IA bibliographic database produced a list of 3,219 reports on Phase I archaeological survey projects that include a bridge, and therefore areas of alluvial soil, within their Area of Potential Effect (APE). Surveys conducted before 1979 were removed from this list after our initial data recording indicated that prior to 1980, virtually no subsurface testing was conducted during Phase I archaeological surveys. The remaining 2,954 reports were examined for information about subsurface testing conducted during Phase I surveys to search for buried sites in alluvium.

RECORD DATA ON SUBSURFACE SURVEY DATA QUALITY

Of the investigations documented in the 2954 reports:

- 569 (19 percent) were completed with no subsurface survey (surface survey only);
- 1096 (37 percent) were completed primarily with surface survey, with subsurface investigation limited to cutbank inspection (948), probes (54), or both (94);
- 1289 (44 percent) were completed with some form of subsurface excavation other than (or in addition to) cutbank inspection, such as shovel testing, auger testing, or backhoe trenching.

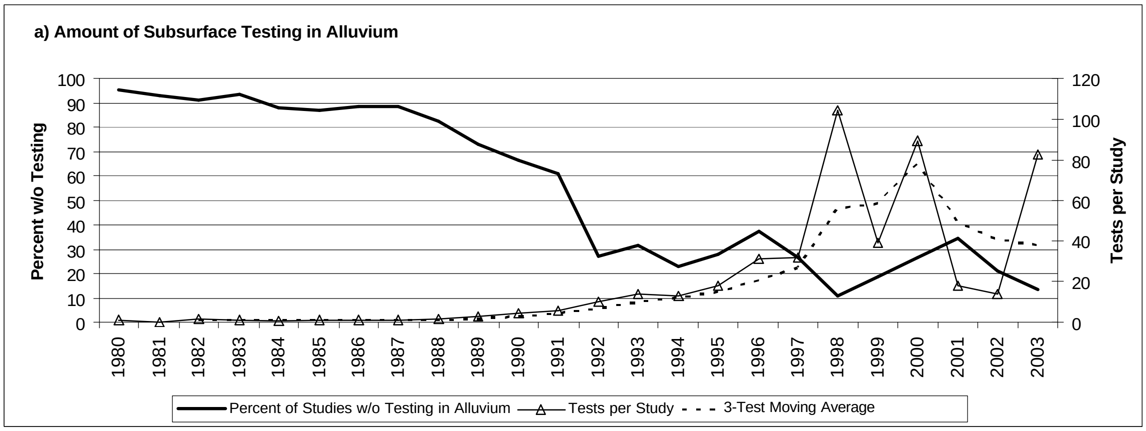
Cutbank inspection is usually not, in and of itself, an adequate subsurface survey technique, and generally needs to be supplemented by some other form of testing to ensure that the stream bank exposure is representative of the project area as a whole. In addition, we found that "cutbank inspection only" reports rarely provide information about bank location, length, height, or stratigraphy. For these reasons, surveys in which subsurface investigation was limited exclusively to cutbank inspection were not considered adequately surveyed for purposes of buried site detection.

Of the 1289 surveys that carried out subsurface investigations other than, or in addition to, cutbank inspection, most provide information on the number of tests (1146 of 1289) and the depth of testing (1104 of 1289). Only 835, however, include maps showing the location of all subsurface tests. This limits our ability to determine the actual areal extent of testing for many projects. Surface testing methods employed by the 1289 surveys include all methods recommended by Association of Iowa Archaeologist guidelines (AIA 1993; Kaufmann 1999). The methods, the number of surveys in which each was used, and typical dimensions and depths of testing as conducted in Iowa, are given in Table 1.

Table 1. Subsurface Investigations Methods Employed by 1289 Phase 1 Surveys in Iowa.

Method	No. of Surveys*	Dimension	Max Depth
Cutbank Inspection	647	Highly variable	3–4 m
Bucket augers:	713	20 cm diameter	600+ cm
Posthole diggers:	157	20–30 cm diameter	110–130 cm
Shovel tests:	678	30–50 cm dia or square	60–100 cm
Test Units:	25	1 x 1 to 1 x 2 m	150 cm
Backhoe Trenches	34	Highly variable	300–600 cm
Giddings/Geoprobe:	14	2.5–7.6 cm diameter	1000+ cm

Figure 1 indicates time trends in subsurface testing of alluvium as documented in the 1,870 reports. Between 1980 and 1987, relatively little subsurface testing was done. Subsurface testing gradually became more common after 1987, and since 1991 has been conducted in about 7 out of 10 surveys of alluvial bottomlands. The marked increase in testing in 1991 is almost certainly due to the fact that in that year, the Association of Iowa Archaeologists adopted professional guidelines requiring subsurface testing of alluvium in Phase I surveys conducted in Iowa. As for the apparent beginning of the trend ca. 1987, it can be noted that this is the year that Bettis and Littke (1987) published their widely-disseminated and frequently-cited overview of Holocene alluvium in eastern Iowa. This publication gave archaeologists an



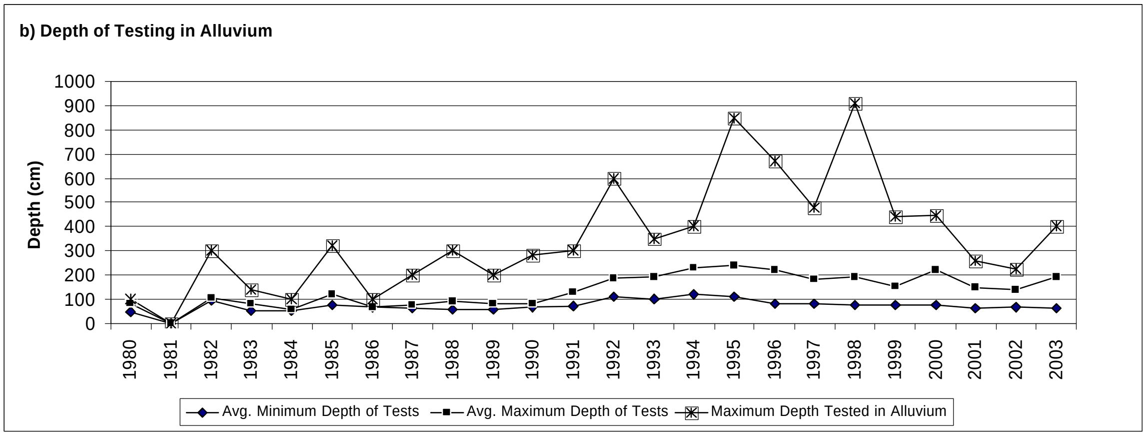


Figure 1. Trends in Phase I subsurface testing of valley alluvium in Iowa, 1980–2003.

easily-understood lithostratigraphic and pedologic framework for evaluating the archaeological potential of alluvial deposits in Iowa.

The average maximum depth of testing also increased after 1991, from less than 1 m prior to 1991 to a yearly average that fluctuated between 1.25 and 2.5 meters thereafter. The minimum depth of testing has remained between 50 and 100 cm from 1980 on, although it trended slightly above 100 cm in the four years following 1991. The maximum depth to which testing was extended in a given year also increased markedly between 1991 and 1998, but after that date decreased considerably. Fluctuations are due to the relatively small sample sizes reporting maximum depth in some years.

The 2954 Phase I surveys contain documentation on over 25,978 subsurface tests excavated in valley alluvium in search of buried archaeological sites. Intersection of the GIS data for surveyed areas and alluvial soils indicates that 101,000 ha (390 mi^2) of alluvium is included in the survey areas. Figure 2 indicates a weak positive correlation between the number of tests and surveyed area in alluvium.

EVALUATE SURVEY DATA QUALITY

For purposes of the Bridges Project, survey quality is defined as the adequacy of subsurface testing to detect buried cultural deposits. It is a function of method, minimum depth, maximum depth, and density (tests per unit area) of testing for a given survey. Values for each variable were determined for the 2954 Phase I reports, and rank-ordered on a scale of 0-4 (Table 2). The survey quality index (SQI) is calculated as the sum of the rank-ordered scores for each variable. The SQI can range from 0 (no testing conducted) to 20 (scores of 4 for all five variables). In the report sample, the highest SQI for any project is 18.

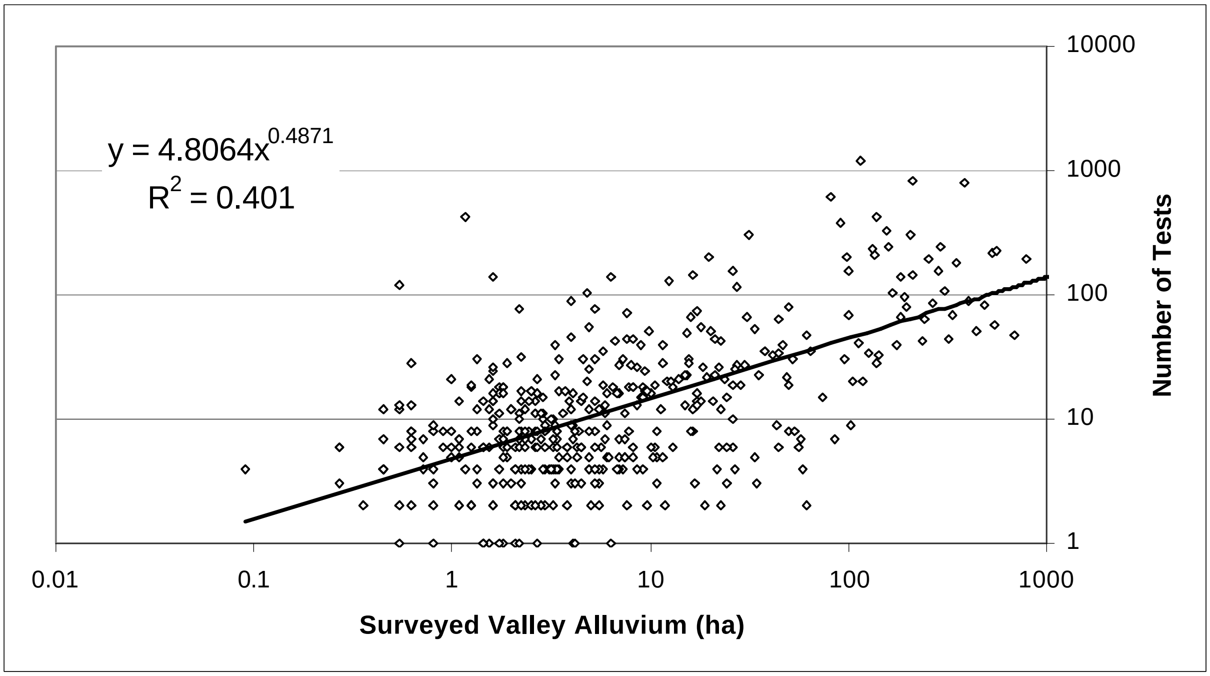


Figure 2. Bivariate plot of survey area versus number of subsurface tests (note logarithmic scales on both axes.

Three aspects of the SQI deserve note. First, if a project employed more than one testing method, the score was based on the method capable of deepest penetration. Thus, bucket augers took precedence over posthole diggers, both of which took precedence over shovel tests as the testing method used in calculating the SQI.

Second, allowance was made for missing data. Projects for which method, depths, or number of tests are not reported were assigned the minimum possible score for that variable.

Third, although the SQI is calculated as a simple sum of five variables, the method variable is, in effect, given more weight because the two depth variables are themselves a function of testing method. For example, a survey employing only shovel tests (method score 4) will score low on the depth variables, since these cannot be excavated deeper than 60-100 cm. Bucket augers can reach greater depths and are therefore more likely to score high on both depth scores.

Descriptive statistics for the SQI variables are given in Tables 3 and 4. Frequency distributions are shown in Figure 3.

The medians for minimum and maximum depth indicate that the depth of testing in alluvium has been relatively shallow. Half the surveys penetrated deeper than 60 cm, but half penetrated no deeper than 120 cm. The maximum depth reached by a Phase 1 subsurface test was 910 cm, but the sample mean of 138 cm indicates that such depths are atypical. The standard deviations for the two depth statistics indicate that most subsurface tests undertaken during Phase I have reached maximum depths of 46–130 cm and minimum depths of 29–120 cm.

Testing concentration was calculated as the number of tests divided by total area (ha) of alluvial soils within a survey area and multiplying by 10 to result in the number of tests per 10 ha. This value ranges from <1 to 1000 tests per 10 ha.

Another way to express test concentration is as the square root of the tested area divided by test number. For example, 1000 tests per 10 ha is equivalent to 100 m^2 per test. The square root of this quantity yields a “grid equivalent,” defined as the distance apart tests would be spaced if arranged in a

Table 2. Variable Scoring Used in Survey Quality Index.

Method: the maximum of the following four values	
4	Bucket auger
3	Posthole digger
2	Shovel test
1	Testing conducted but method not reported
0	Surface survey only
Geomorphological Study:	
4	Conducted as part of Phase I.
1	Not conducted as part of Phase I.
0	Surface survey only
Minimum Depth	
4	>200 cm
3	121-200 cm
2	61-120 cm
1	<60 cm
1	Testing conducted but no minimum depth given
0	Surface survey only
Maximum Depth	
4	> 200 cm
3	121-200 cm
2	61-120 cm
2	Maximum depth not given, but posthole diggers or bucket augers employed
1	<=60 cm
1	Maximum depth not given, but shovel testing employed
1	Testing conducted but maximum depth and method not reported
0	Surface survey only
Testing Concentration	
4	100-1000 tests per 10 ha (n=144)
3	10-100 tests per 10 ha (n=624)
2	1-10 tests per 10 ha (n=214)
1	< 1 tests per 10 ha (n=20)
1	Testing conducted but number of tests not reported
0	Surface survey only

Table 3. Descriptive Statistics for Continuous SQI Variables

	Min. Depth (cm)	**Max. Depth (cm)**	**Concentration: (tests/10 ha)**	**Concentration (m^2/test)**	**Grid Equivalent (m)**
Count	898	1085	998	998	998
Minimum	2	6	0.29	344,827	587
Maximum	380	910	1000	100	10
Median	60	120			
Mode	60	60			
Mean	78.9	138.2	55.3	1808	42.5
St. Deviation	49.9	92.2	94.2	1061	32.8

square grid pattern in a square the size of the surveyed valley area. For the present sample of reports, the maximum testing concentration of 1000 tests per 10 ha, or 100 m^2 per test, is equivalent to spacing tests 10 m apart on a rectangular grid. The mean coverage is considerably larger: 1808 m^2/test, (grid equivalent 43 m).

The best recommended procedures in current SHPO guidelines (Kaufmann 1999:3.27) stipulate testing of alluvial deposits by excavating tests on a 15 m grid within a project's Area of Potential Effect (APE). As shown in Figure 3, most surveys have an estimated grid spacing larger than 15 m.

Table 4. Relative Frequency of Discrete SQI Variables.

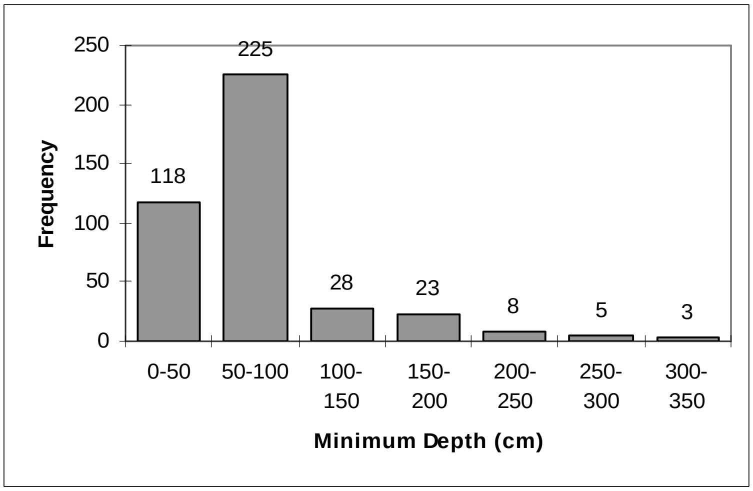
Method	No. of Reports	% of Reports
Surface Survey Only	1669	56%
Subsurface Testing	1285	44%
Total	2954	
Geomorph. Study	57	4.4%
Bucket Auger	720	56.0%
Posthole Digger	157	12.2%
Shovel Tests	686	53.4%
Test Units	25	1.9%
Backhoe Trenches	34	2.6%
Giddings Probes	14	1.1%
Method Not Reported	6	0.5%

One reason for this apparent discrepancy is that archaeologists rarely if ever distribute tests uniformly across an entire project area. Disturbed areas, historic channel belts, and wetlands are usually not tested. The depth statistics probably also reflect factors such as the vertical dimension of the APE, elevated water tables, and impenetrable strata that may limit the depth of testing. On the other hand, it seems clear from the frequency distributions in Figure 3 that most surveys have tested to depths of no more than 1–2 m. As discussed in the following section, the total thickness of Holocene alluvium in Iowa valleys is commonly 3–4 m or more. Thus, even for survey areas where subsurface testing was conducted, the available data may only be useful for evaluating the archaeological potential of the upper 1–2 m of Holocene alluvium in a previously surveyed project area.

Figures 4-6 show state-wide patterns in survey quality. Figure 4 shows the total amount of valley area in each county that has been subject to archaeological survey. The pie charts compare the area of alluvium soils surveyed with and without subsurface testing in each county. The size of the circles indicate the amount of valley alluvium contained within survey areas. Shading within the circle indicates the relative proportion of testing versus surface-only methodologies employed in these valley bottom surveys. As can be seen, the total area surveyed is not as good an indicator of survey quality as the amount of survey conducted with subsurface testing. For example, Boone County was the location of large-scale surveys of the Des Moines River valley prior to construction of Saylorville Lake, but few of these surveys included subsurface testing. By contrast, Polk County has less total surveyed area than Boone, but subsurface testing was conducted in ca. 80 percent of that area (Figure 4).

Counties can also be compared in terms of average SQIs, calculated from values for individual reports. The average SQIs for survey areas (Figure 5) within counties ranges from 5, the minimum possible score, to 12.7. This map provides a rapid assessment of overall survey quality for a county. Figure 6 shows county averages for each of the five SQI factors, showing the contribution of each to the overall score. Method contributes most to the county scores, with 64 of 99 counties scoring above 3. Specialist geoarchaeology studies are so rarely undertaken that they do not contribute to the county averages.

a)



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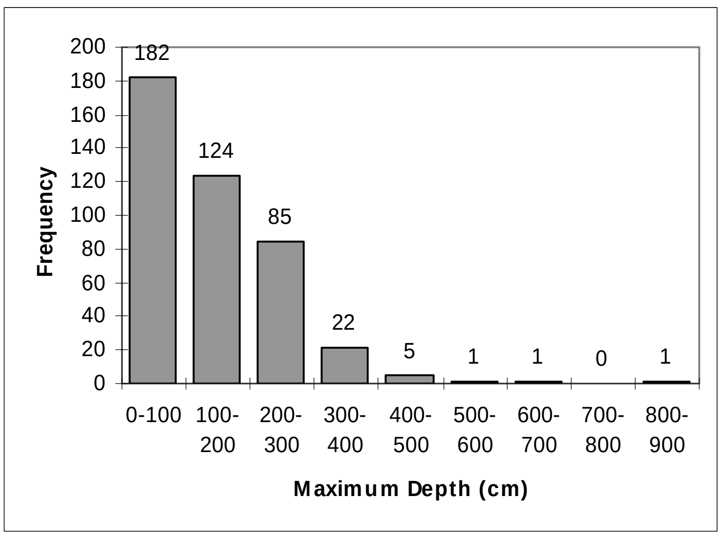

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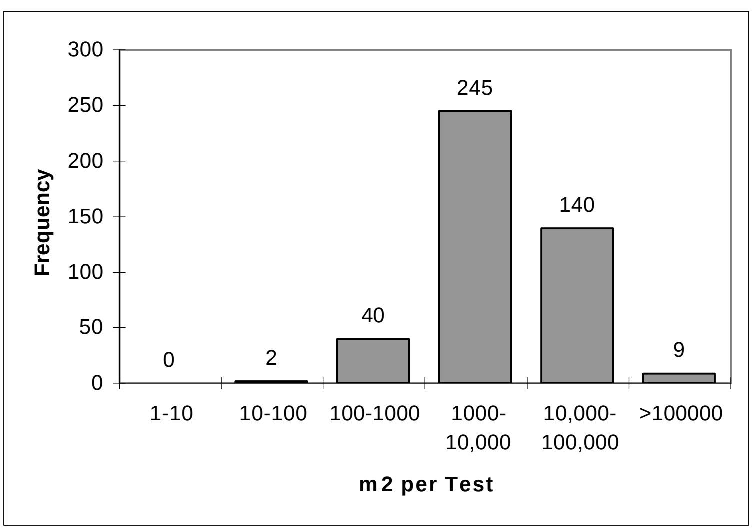


Figure 3. Frequency distributions of a) minimum depth, b) maximum depth, and c) testing coverage.

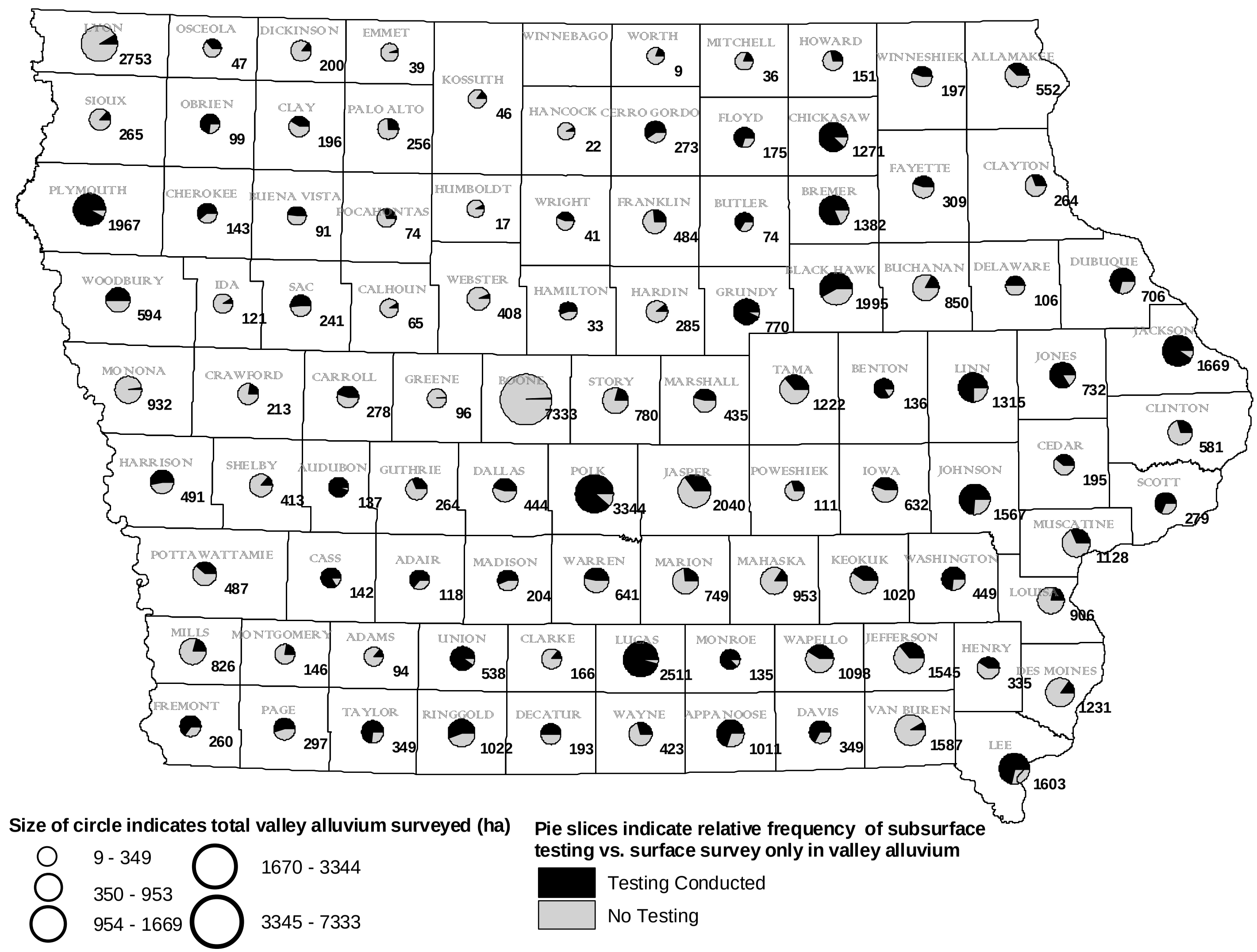
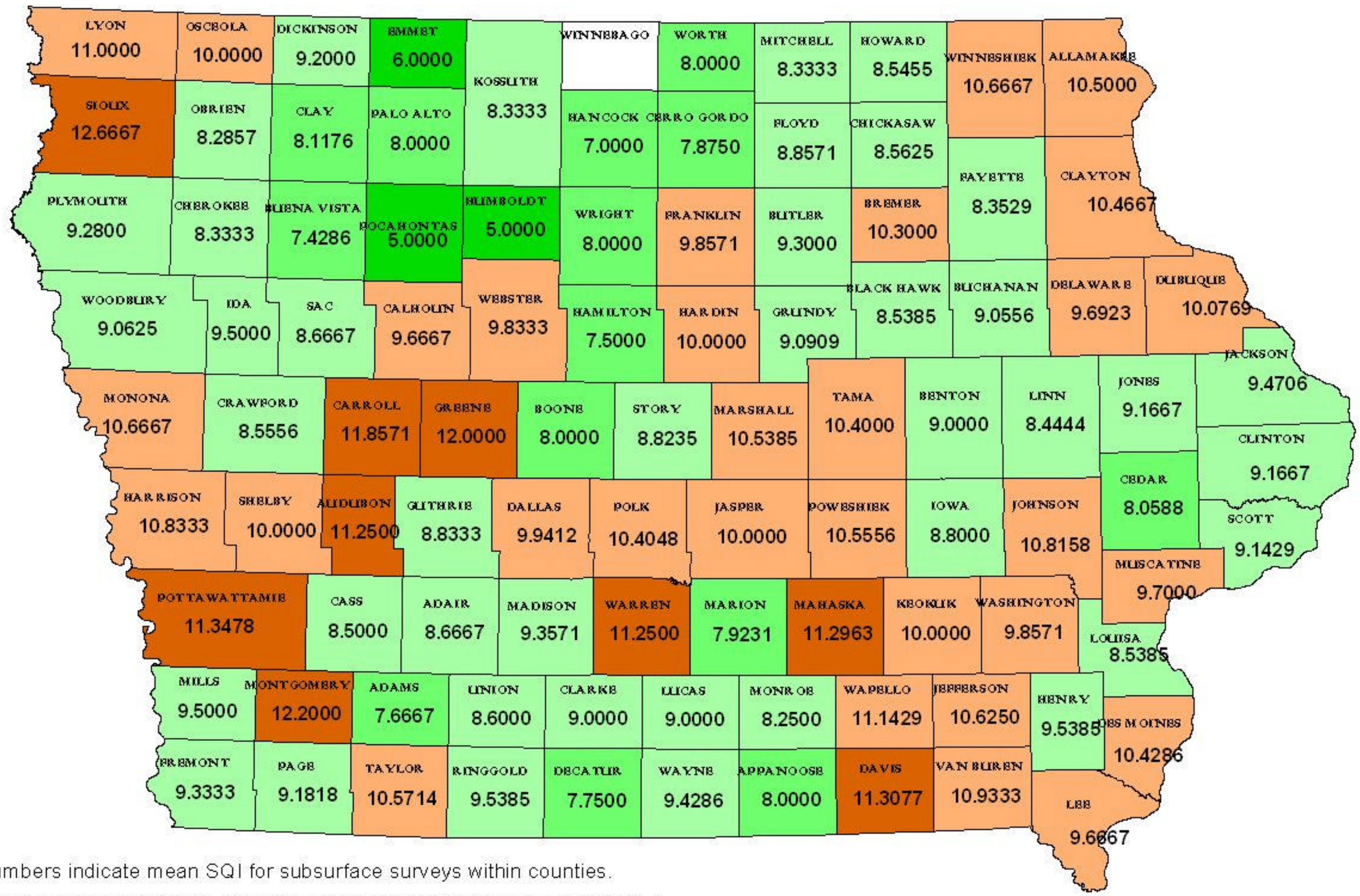


Figure 4. Statewide patterns in Phase I survey methodology. oldface numbers indicate total hectares of surveyed valley alluvium in the county.



Numbers indicate mean SQI for subsurface surveys within counties.

Survey Quality is the sum of five factors, each ranked on a scale of 1 to 4.
The factors are Testing Method, Minimum Testing Depth, Maximum Testing Depth, Test Density, and Geological Study.

Method	Geological Study as Part of Phase 1	Minimum and Maximum Depth	Tests per 10 ha
4 = bucket auger	4 = yes	4 = >200 cm	4 = 100-1000
3 = posthole digger	1 = no	3 = 121-200 cm	3 = 10-100
2 = shovel test		2 = 61-120 cm	2 = 1-10
1 = method not given		1 = <=60 cm	1 = <1

Figure 5. Average survey quality index for surveys of valley alluvium in which subsurface testing was conducted.

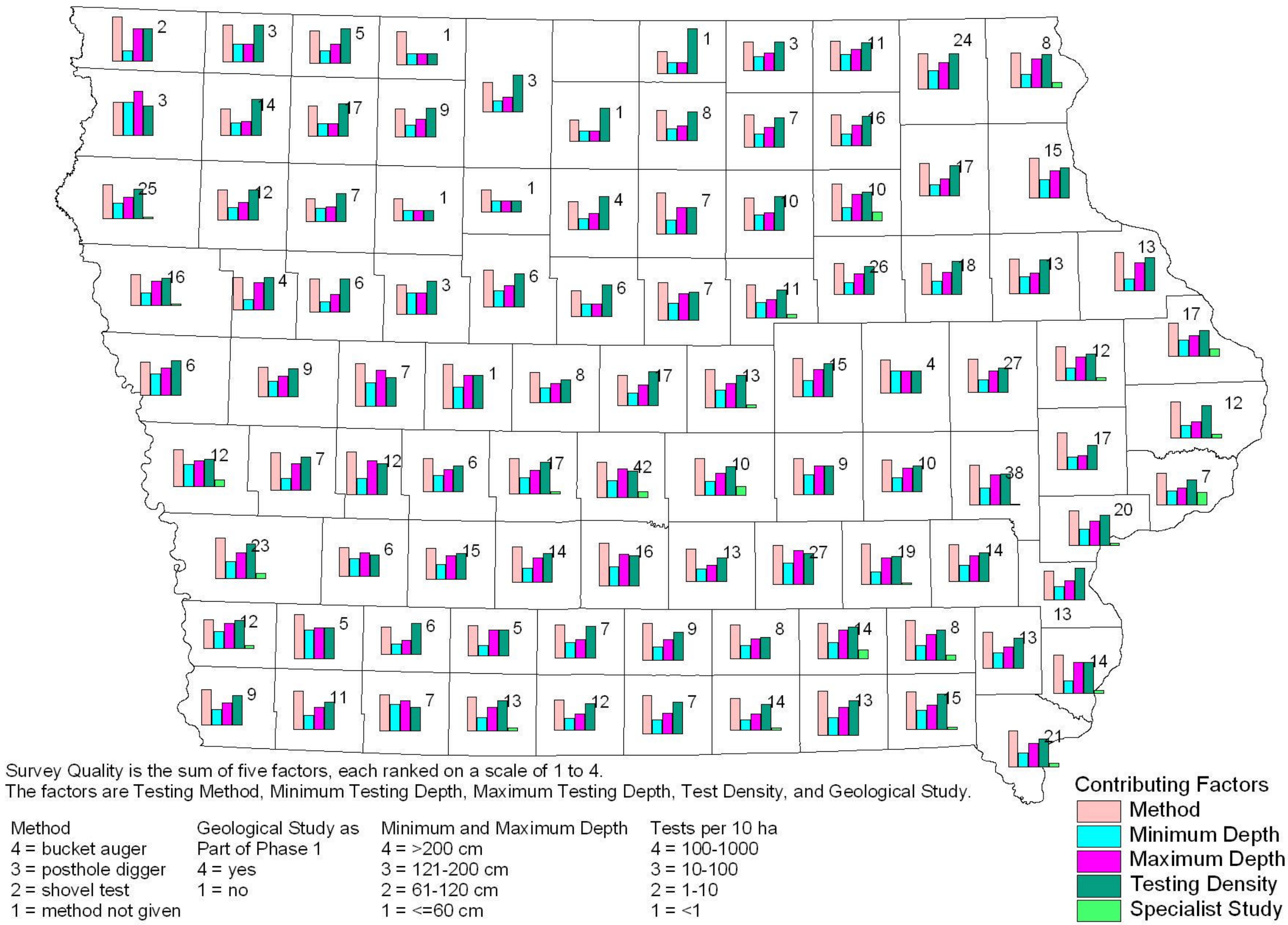


Figure 6. County averages for each of the five factors contributing to SQI. Numbers beside bar charts indicate the number of survey reports for which SQI factors were averaged. Bar values range from 0 to 4.

Objective 2: Identify Critical Variables

The purpose of this section is to identify variables that are critical to evaluating the archaeological potential of a proposed bridge replacement. Data sources for each set of variables is identified, and data quality and accessibility are discussed. The goal is to identify data sources that can be used by the Decision Support Model to determine survey needs. The following critical variables are identified:

- Area of Potential Effect
- Relative Age of Alluvium
- Thickness and Extent of Historic Alluvium
- Thickness and Extent of Holocene Alluvium
- Depositional Environment and Habitability of Holocene Alluvium
- Local and Regional Site Density and Site Suitability

AREA OF POTENTIAL EFFECT

The APE refers to the horizontal and vertical dimensions of the bridge replacement undertaking. The horizontal and vertical limits of a bridge replacement project determine the three-dimensional volume which needs to be considered in planning and implementing an archaeological survey for prehistoric sites. **For decision support purposes, identification of the APE is a critical step in the early stages of Section 106 consultation, and its dimensions are essential to survey planning and needs assessment.**

RELATIVE AGE

Relative age of alluvium determines whether the APE contains sediment of the appropriate age to contain prehistoric sites. Humans have inhabited Iowa for at least 13,000 years (Alex 2000). Any sediment older than 150-200 years and younger than 13,000 years has the geologic potential to contain prehistoric archaeological sites. Most of this time period falls within the Holocene, the postglacial period beginning 10,000 years ago and extending to the present.

Relative-age categories for Holocene alluvium can be assessed from weathering properties and internal stratification (Table 5). In Iowa and adjacent states, these age-morphological criteria serve to define mappable lithostratigraphic units of the DeForest Formation, including the Corrington and Gunder (early-middle Holocene), Roberts Creek and Honey Creek (late Holocene), and Camp Creek (historic) members (Bettis 1990; Bettis and Littke 1987; Bettis and Thompson 1982; Daniels and Jordan 1966).

For decision support purposes, the Bettis (1992) age-morphological criteria can be applied to stratigraphic logs that describe bedding, color, and redoximorphic (mottling) features. The criteria can also be applied to soils mapped on the landscape by the Natural Resources Conservation Service (NRCS) (Artz 2005).

Evaluation of the relative age of alluvium within the APE also entails recognizing Earlier Wisconsinan and pre-Wisconsinan stratigraphic units. Holocene alluvium either overlies, or is inset as terraces against, these units, which are recognized by their stratigraphic relationships and lithologic properties. In Iowa, pre-Holocene sediments include Wisconsinan alluvium (Henry and Noah Creek formations), Wisconsinan glacial deposits (Dows, Sheldon Creek formations), and Wisconsinan loess (Peoria and Pisgah formations, as well as pre-Wisconsinan glacial, alluvial, and bedrock sediments (Prior 1991). Pre-Holocene glacial, eolian, and alluvial deposits can be recognized from parent materials and landscape positions in NRCS-mapped soils (Artz 2005).

Table 5. Age-Morphological Criteria for Holocene Alluvium in Iowa (after Bettis 1992).

	Age-Morphological Group		
	EMH	**LH**	**HIST**
Geologic Period	early-middle Holocene	late Holocene	Historic
Chronology (years before present)	10,000-4000	4000-150	<150
Presence of Bedding			
in upper part	no	usually not	yes
in lower Part	yes	yes	yes
Weathering Zone	oxidized, reduced, or unoxidized	dark colors because of high organic carbon content	oxidized, or reduced
Redoximorphic Features (Mottles)	common	rare	variable
Surface Soil Horizon Sequence	A-E-Bt; A-Bt	A-Bw	A-C
DeForest Fm Unit	Gunder, Corrington	Roberts Creek, Honey Creek	Camp Creek

HISTORIC ALLUVIUM

"Historic," in conventional North American archaeological usage, refers to the time period following the late 17th century arrival of Euroamericans (Alex 2000). In the geological record, the Historic period begins ca. AD 1850, by which time land clearing and cultivation were in progress across the state, leading to widespread deposition of Historic alluvium, sometimes referred to as "postsettlement" alluvium (Daniels and Jordan 1966).

Historic alluvium is present as recent bar, levee, and in-channel deposits in the modern floodplain, and in channels and meander belts abandoned during the Historic period. Historic channel activity can erode prehistoric alluvial deposits, potentially destroying prehistoric archaeological sites. Historic sediments can also be present as a surface veneer on prehistoric alluvium. When historic surface deposits bury older, prehistoric-period sediments, prehistoric sites can only be discovered by subsurface testing. Where active river-channel migration has occurred during the historic period, prehistoric alluvium may have been eroded or completely removed by historic-period channel activity, and the preservation potential for prehistoric sites will be very low.

Historic-period land-use practices create a stratigraphic record analogous to the natural processes noted above. Human-emplaced fill units of construction rubble, stone, debris, and earth materials can bury prehistoric surfaces, and historic-period excavations, such as borrow pits, can remove prehistoric deposits.

For decision support, information from maps and subsurface logs can provide estimates of extent and thickness of historic alluvium. Twentieth century aerial photographs and 19th-20th century county atlases and survey plats often show stream locations with sufficient accuracy to determine whether a bridge replacement APE is located in a historic-period meander belt that would have destroyed evidence of prehistoric habitation. Sediments deposited during the historic period have characteristic lithologic properties (Bettis 1992) that can be identified in subsurface logs and on NRCS soil maps. Anthropogenic fills and excavations can also be identified in borings and excavation profiles, and on maps and aerial photographs.

Thickness and Extent of Holocene Alluvium

As discussed above, Holocene and pre-Holocene stratigraphic units exposed at the ground surface can be recognized from soil properties, and therefore their areal extent can be estimated from NRCS-mapped soils. Application of stratigraphic, lithologic, and weathering zone criteria to subsurface logs can be used to determine the thickness of Holocene alluvium, and trace its extent laterally in the subsurface.

Depositional Environment and Habitability

Within Holocene alluvial packages, prehistoric site potential varies with depositional environment. Lateral and vertical facies changes reflect depositional environments. Baker et al. (1996) identified the major facies in Holocene alluvium and their sedimentological character (Table 6).

Table 6. Major Lithofacies in Holocene Alluvium (simplified from Baker et al. 1996).

Lithofacies	Description	Depositional Environment	Lithology
Top Stratum			
O	overbank	distal to channel belt	silts and clays, not bedded
L	levee	proximal to channel belt	laminated or planar-bedded loam, silt loam, or sand
Bottom Stratum			
CB-1	channel belt	riffles, lag	crudely bedded to imbricated gravel and sand
CB-2	"	bars	cross-bedded sand and gravel with occassional silty zones
CB-3	"	pools	planar-bedded to massive sand, pebbly sand, or organic fines

For humans, the most habitable environments are those that provide a well-drained, infrequently flooded occupation surface such as levees, floodbasins, alluvial fans, and colluvial slopes. These are low-energy depositional regimes dominated by fine textures (silts, clays, loams). High-energy regimes, such as channels and point bars, lack long-term habitability potential. Such deposits are also subject to frequent reworking, reducing the preservation potential of prehistoric cultural deposits. Channel and point bar deposits are dominated by coarse-textured sands and gravels, or by interbedded fine- and coarse-textured strata.

Alluvial depositional environments can be identified at the surface from maps, including NRCS soil maps, and aerial photographs. Identification from stratigraphic logs is more difficult, and often requires continuous trenching or close interval drilling to reconstruct their vertical and horizontal extent. On the other hand, alluvium typically exhibits a fining-upward sediment sequence, with the coarsest textures at the base, representing basal lags and in-channel sediments, and the finest textures at the top, representing levees and floodbasins.

Allen (1965) divides the sequence into a fine-textured top stratum, representing the low energy levee, floodbasin, and valley margin fans and foot slope environments, and a coarse textured top stratum, representing the higher energy bar and in-channel environments. Baker et al.'s (1996) lithofacies can be grouped into top and bottom stratum facies (Table 6), which can be recognized in subsurface sediment logs.

For decision support purposes, the fine-texured top stratum deposits have higher prehistoric site potential than the bottom stratum. Recognizing the thickness and horizontal extent of Holocene top stratum deposits in an APE is therefore fundamental to evaluating buried site potential. For decision support purposes, determining top stratum thickness is more critical than identifying soil horizonation and DeForest Formation lithostratigraphy.

Within the top stratum, inferences about habitability can be strengthened by evidence of long-term surface stability (as indicated by soil horizonation), water table positions (as indicated by redoximorphic features), and landscape position (as reconstructed from bore hole transects, or by aerial imagery or map interpretation). **For decision support, LANDLogs records and NRCS maps can provide pedogenic evidence of surface stability and soil drainage, and stratigraphic logs, maps, and aerial photographs can be used to examine landscape positions.**

SITE DENSITY AND SUITABILITY

The frequency and areal extent of prehistoric sites varies across Iowa on both local and regional scales. Data on these spatial phenomena have been produced as part of OSA's LANDMASS project, utilizing the distribution of known prehistoric sites in areas that have been the object of intensive archaeological survey.

Site density and distribution patterns provide a means of assessing the probability that prehistoric sites will be present in a project's APE. An archaeological survey represents a sampling of this regional landscape that has one of two outcomes. Sites are either present or absent, and the probability of site presence can be estimated from the binomial distribution. For any given area, such as a county, the expected frequency, or prior probability, of site presence is

$$p(S) = A_p/A_s$$

where As is the total area of archaeological surveys in the county, and Ap is the total area of prehistoric sites in the survey areas. For Iowa counties, p(S) ranges from 0.0001 to 0.0872. In Pocahontas County, where p(S) = 0.0001, 1 acre of site, on average, can be expected to be found for every 10,000 acres surveyed. In Johnson County, where p(S) =0.0872, 8.7 acres of site can be expected to be found for every 100 acres surveyed.

Prehistoric sites are not distributed uniformly across the landscape, occurring in higher densities in some landscape settings than others (Artz 1997a; Schermer 1982; Lensink 1984; Gourley 1983; Hirst 1985). OSA's LANDMASS model evaluates this spatial patterning, classifying 30 x 30 m cells in the landscape on a scale of 0 to 1. Values approaching 0 are landscape setting where sites are rarely found. Values approaching 1 are settings where they are often found.

Objective 3: Applying Critical Variables

This section discusses the applicability of the critical variables to the task of assessing prehistoric site potential in bridge replacement APEs. For the APE itself, application requires an understanding of how a project's vertical and horizontal dimensions change through time in the Iowa DOT design process, and at what point the APE becomes the basis for Section 106 consultation. For the variables involving the Holocene geology of the APE, application involves examining existing bore and excavation logs and map data to identify stratigraphic and geomorphic patterns relevant to bridge replacement decision support. Applying site density and suitability patterns requires a consideration of site, survey area, and LANDMASS suitability distributions.

AREA OF POTENTIAL EFFECT

The horizontal and vertical extent of construction are critical variables for archaeological survey needs assessment. The Programmatic Agreement executed by Iowa DOT, FHWA, and SHPO (IDOT 2002:11-12) identifies criteria to be considered in determining the APE for an undertaking prior to Phase I survey. For bridge replacements, these include the dimensions and boundaries of permanent and temporary easements for constructing the bridge, its approaches, and channel modifications. In addition, the APE can also include wetland mitigation and borrow areas.

The horizontal and vertical extent of construction is defined, refined, and revised throughout the bridge design process. The process is complex, but all Primary Roads bridge replacement projects follow a general procedure set forth in manuals from the DOT's Offices of Bridges and Structures (2000), Design (2004), and Right of Way (2001).The basic steps are as follows:

- Project concept statement
- Preliminary situation plan
- Aerial photography
- Field survey and field exam
- Final R/W and design plans
- Plan revisions
- Final "as built" plans.

The following discussion applies to Primary Roads (i.e., state and federal highways). Local Systems projects, undertaken by cities and counties, pass through a similar sequence, although there are generally fewer steps. Field surveys and exams, for example, are generally not undertaken as a separate step, but rather conducted on an as-needed basis. Aerial photography is usually not flown for local systems projects.

The Section 106 process can be initiated at any stage in the design process. Initiation occurs when the Iowa DOT Office of Location and Environment (OLE) examines plans and determines that an undertaking exists under terms of the Programmatic Agreement.

The specificity with which the APE is identified at the time Section 106 consultation begins varies with the project's stage in the design process. The project concept statement, for example, states basic information on location, channelization requirements, and right-of-way needs. If used as a basis for defining the APE, the horizontal extent of the project must be overestimated to ensure that it contains the entire extent of project impacts from the final design (OLE personal communication 2006).

Preliminary situation plans further pin down project impacts by specifying need lines for construction and channel modification. Although preliminary plans do not show right-of-way lines, the Office of Right-of-Way manual has guidelines that can be used to estimate right-of-way dimensions. For example, the manual states that right-of-way lines should be at least 15 feet from project need lines. If used as a basis for defining an APE for Section 106 purposes, the full horizontal extent of the project must still be estimated, because right-of-way and other determinations have not yet been finalized.

Aerial photography is flown to aid the field exam and survey for the project. These photographs, flown at an altitude of 3000 ft, provide a first look at existing ground conditions. They would be sufficient for a trained eye to determine the presence of geomorphological features such as paleochannels that would affect site preservation and habitability within the APE as estimated from preliminary plans.

During survey and field exams, engineers and right-of-way personnel generate documents that might help planners assess field conditions relevant to archeological potential. Field exams, for example, include notes on bank conditions and erosion which might be valuable for determining geomorphic and site-preservation potential of a project. Right-of-way field teams sometimes photograph streams, probably to gauge whether there might be landowner issues with drainage and back erosion that would affect easement acquisition. These photographs might provide insights into stream and floodplain morphology useful for initial evaluation of archaeological potential.

Final plans show construction limits and right-of-way lines in greatest detail, but may not be completed until after the initial Phase I survey is done. In general, the most detailed documents that are usually available to SHPO, OLE, and archaeological consultants for APE determination and Phase I survey planning are situation plans or early-stage design plans.

The Decision Support system must be flexible because there is not a specific stage in the design process when Section 106 process is initiated. Its use cannot be tied to any particular design stage or process. Rather, the system needs to provides tools for evaluating risks and determining survey needs at any point in the design process,

UTILITY OF GEOTECHNICAL BORELOGS

This report advocates a greater use of Iowa DOT bore logs in geoarchaeological evaluation. Archaeologists and other involved in the Section 106 process often consider bore logs inadequate for this purpose, Because the logs do not utilize NRCS terminology or identify formal lithostratigraphic (e.g., DeForest Formation) units, archaeologists perceive them as falling short of the conventional standards for describing Holocene stratigraphy, which in Iowa have historically (Bettis 2000) been heavily influenced by geologists with training in pedology and Quaternary stratigraphy (e.g., Bettis and Thompson 1980; Parsons et al. 1962; Ruhe 1969).

As previously discussed, sediment texture is a key critical variable for determining buried site potential. Along with thickness and stratigraphic position, texture is used to differentiate top stratum (overbank facies) with relatively high archaeological potential from bottom stratum (channel facies) with negligible buried site potential. Bore logs nearly always describe soil texture, and thus should be adequate for differentiating top stratum from bottom stratum deposits, at the very least.

The initial purpose for BoreLogs was as a proof-of-concept to determine whether geotechnical logs could provide data adequate for geoarchaeological purposes. For comparison, four OSA archaeological surveys with intensive subsurface testing were selected, along with two studies in which geoscience specialist conducted a geoarchaeological study in advance of survey (Table 7).

Table 7. Q-sheets Obtained for LandLogs – BoreLogs Comparisons.

Highway	Counties	Drainage	Reference	No. of IDOT Bores From Q Sheets	No. of LandLogs within 200 m of IDOT Bore
Archaeological Surveys					
US 65	Jasper, Polk	Indian Cr.; Skunk R.	Artz 1994; 1997b	82	327
US 30	Crawford	Boyer R.	Hedden 1993	85	86
US 71	Audubon, Carroll	E. Nishnabotna R. & tribs.	Artz 1996	122	163
Iowa 22	Washington	English R.	Perry 1993	27	17
Specialist Studies					
US 60	Plymouth	Little Sioux R.	Mandel 1997	8	3
US 34	Mills	Missouri R.	Hajic 1993	29	1

OLE staff obtained Q-sheets for these projects from as-built CADD plans stored in ERMS. Results of record recovery from ERMS was variable. The US 65, US 71, and US 30 corridors returned complete sets of Q-sheets containing a total of 289 bore logs. By contrast, ERMS requests for the other three highway segments returned 54 bore logs from relatively small areas. The Iowa 22 request, for example, returned bore logs for six small bridge replacements.

The Q-sheet plans were georeferenced and bore hole locations were digitized. A GIS query identified 597 LANDLogs records within 200 m of a BoreLogs record, comprising a set of archaeological descriptions to compare to the geotechnical descriptions. Comparisons were not possible for the US 30 records. Most of the US 30 bore holes were taken through the existing pavement and road grade fill into the underlying alluvium, while the archaeological tests were placed in the fields alongside the road.

Comparisons were not possible without determining the difference in elevation between the pavement and field surfaces, which was not possible with available information.

The most continuous and extensive data for comparison are from the US 65 project. Figure 7 compares geotechnical and geoarchaeological cross sections of the US 65 Indian Creek crossing in Jasper County. Figure 7a is constructed from Iowa DOT bore logs as presented on Q-sheets. Figure 7b is constructed from logs of subsurface tests from Phase I archaeological surveys (Artz 1993, 1995). The Indian Creek valley at this transect has a relatively narrow Late Holocene to Historic channel belt at the east end, and a broad complex of outwash terraces in the middle of the valley. At the west end, the transect crosses the present and former channel belts of a tributary, Byers Branch.

As indicated by arrows, the same geomorphic features and sediment packages can be identified from both sets of subsurface data. This example demonstrates the utility of geotechnical borings for identifying the horizontal and vertical extent of Holocene alluvium, and in particular of high potential top stratum sediments prior to archaeological field investigation.

To further test comparability, a database query was created to determine the texture at 50 cm depth intervals from the surface (0 cm) to 450 cm for each Q sheet log, and for the nearest LANDLog, with proximity determined by a GIS query. Textures were converted to a numeric ranking where 1 is clay and 10 is bouldery gravel. The query identified 727 BoreLogs/LANDLogs pairings, which were compared by subtracting the Iowa DOT log texture from the corresponding depth interval of the nearest LANDLog (Figure 8). The comparisons ranged from 9 to -9, with a strong central tendency (mean = 0.05; s.d. = 2.04).

The disparity between the two sources of log data increases with the distance between pairs of holes. Figure 9 illustrates the percent agreement (i.e., bore log texture same as LANDLog texture) at 50 cm depth intervals, and plots separate distributions based on 10 m increments of hole proximity. The diagram shows that for pairs located <10 m apart, agreement is ca. 70-80 percent. Agreement remains over 50 percent at separations of up to 60 m. In holes separated by >60 cm, agreement is lower, particularly at depths of >150 cm.

The data suggest two relationships. First, there is less variability with distance in sediments at 100-150 cm. This probably reflects the tendency for the upper part of the top stratum to be primarily and relatively uniformly fine grained. However, at distances of 50 to 60 m agreement begins to diverge. This suggests that the upper 150 cm of the alluvial package is less variable in textures than the next 150 cm. The upper 150 cm in many valleys is predominantly fine-textured overbank sediments deposited by low energy overbank floods. At depth, sediments coarsen, reflecting higher transport energy, and also tend to vary more both vertically (e.g., fine texture interbeds) and horizontally (i.e., thick, clayey, abandoned channel deposits.

These comparisons illustrate that, for identifying the geologic context of alluvial valley APEs, Iowa DOT bore logs, if available, can be used in advance of fieldwork to anticipate the texture and thickness of Holocene alluvium. However, long distance extrapolation of bore hole data to a proposed bridge replacement survey will probably be more reliable for the upper 150 cm, and less so at depths below that.

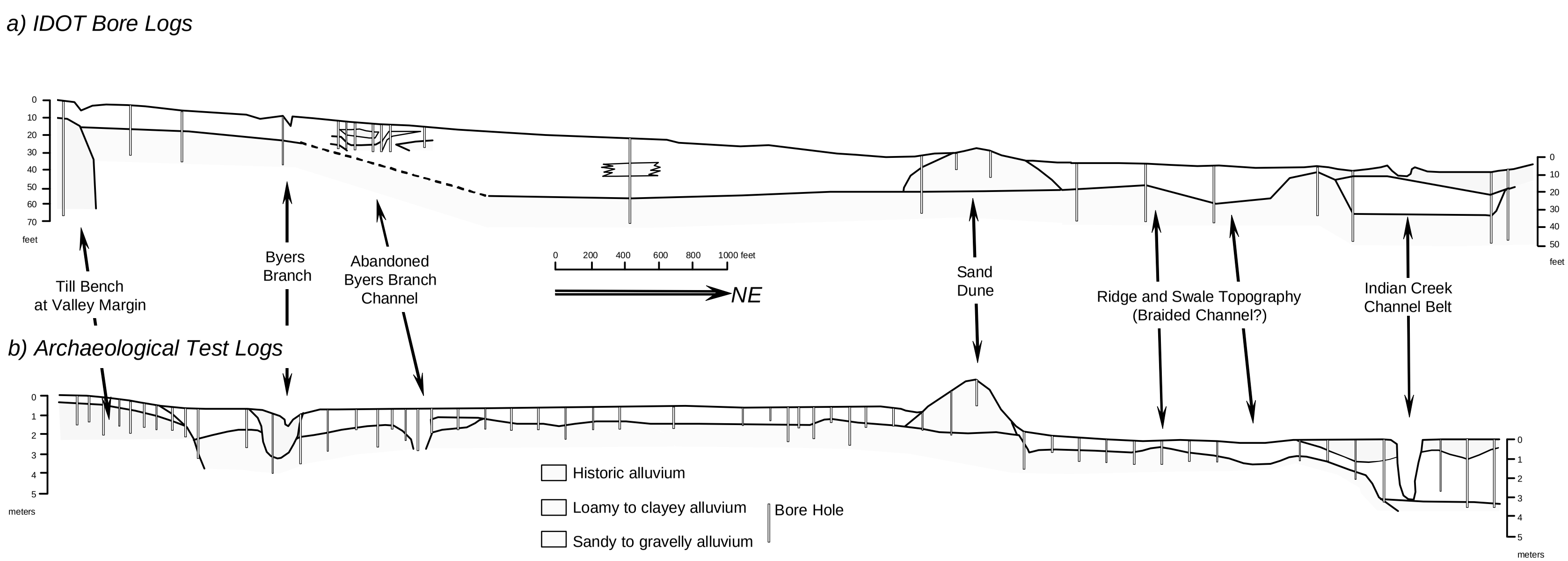


Figure 7. Stratigraphic cross sections of the Indian Creek valley along US 65 in Jasper County, Iowa: a) constructed from Iowa DOT bore logs; b) constructed from archaeological subsurface test logs.

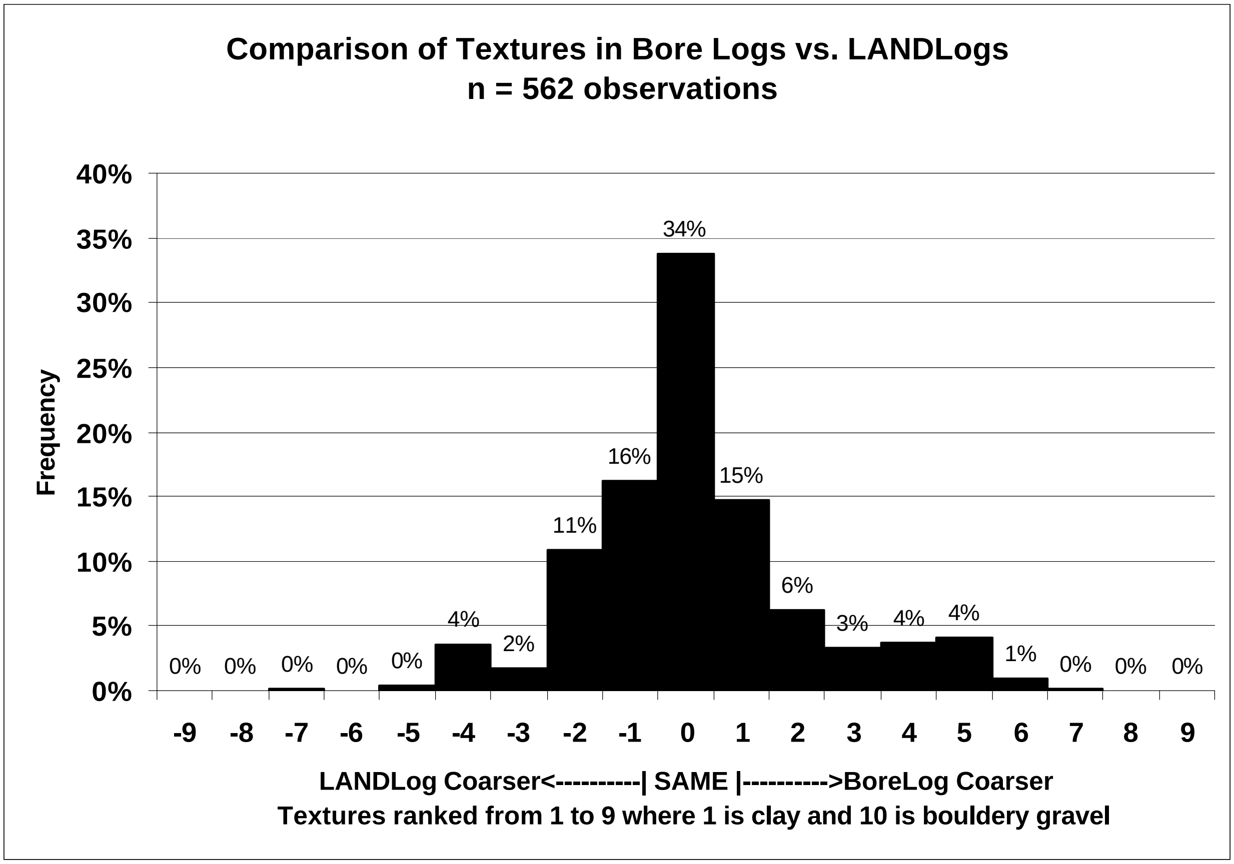


Figure 8. Graphic comparison of sediment textures in geotechnical vs. archaeological logs

THICKNESS OF HOLOCENE ALLUVIUM

In this section, the LANDLogs and BoreLogs databases are used to estimate the thickness of sediments with potential to contain prehistoric cultural deposits in Iowa valleys. The ability of an individual record to provide thickness data depends on the nature of the deepest stratum recorded. Logs that bottom out in Historic-period alluvium or fill can obviously provide no information on the thickness of Holocene alluvium. The total thickness of top stratum deposits can be determined from any log that penetrates deeper than the top stratum. The total thickness of Holocene alluvium can be determined from any log that penetrates through both top- and bottom strata (Table 8).

Nearly half (1619 of 3643) the LANDLogs records do not completely penetrate top stratum deposits, but total top stratum thickness can be determined for 55 percent (1994 of 3643). Total DeForest Formation thickness can be determined for 22 percent (n=789).

A much higher proportion of BoreLogs reach pre-Holocene sediments or bedrock (1007 of 2623, 38 percent). Holocene top stratum thicknesses can be determined for 1995 borings (76 percent). The Iowa DOT borings penetrate deeper (mean = 14.53 m) than the LANDLogs records (mean = 2.62). When calculated from the LANDLogs data, the frequency distributions for total top stratum and total DeForest Formation thickness differ little from the maximum depth distribution (Figure 10). The similarity of the three distributions suggests that the LANDLogs data are not sampling the entire thickness of Holocene alluvium. This conclusion would be consistent with previous findings concerning subsurface testing in Phase I surveys.

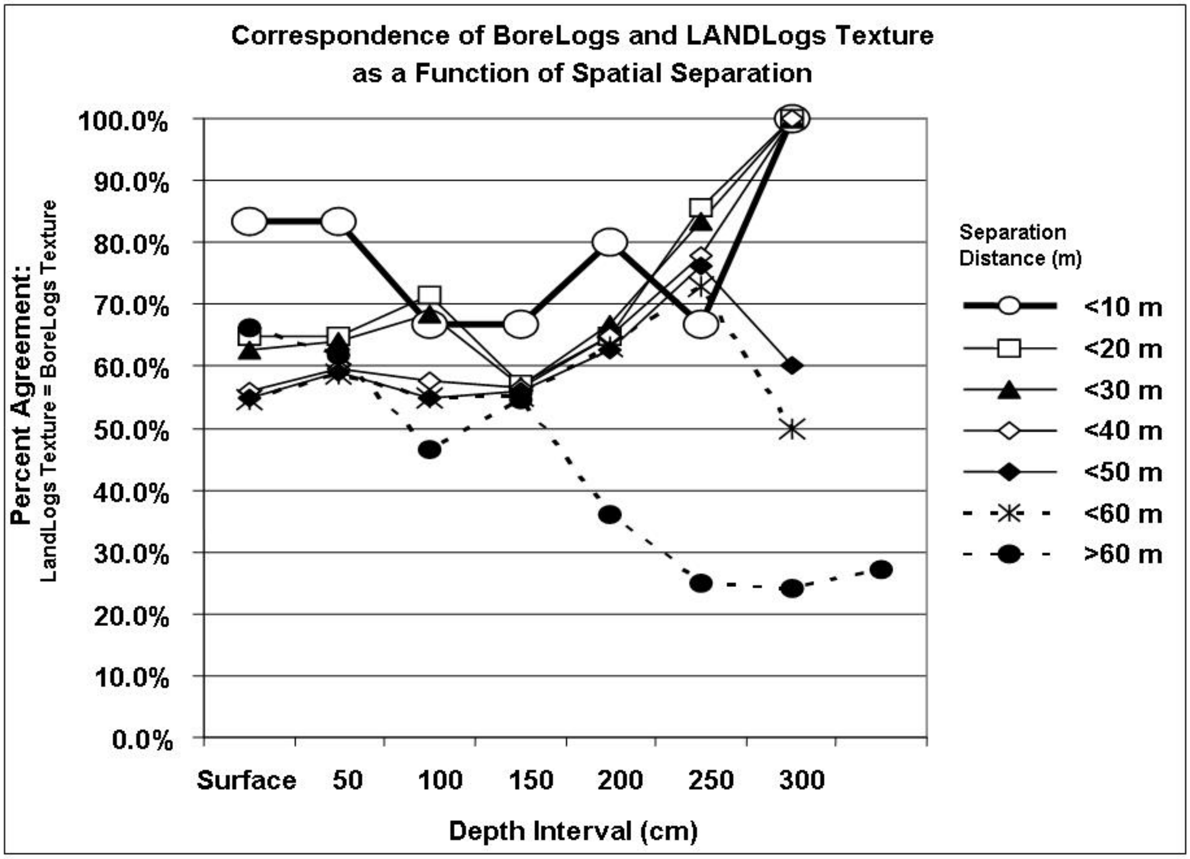


Figure 9. Agreement between sediment textures in geotechnical vs. archaeological logs as a function of hole proximity and depth interval.

Table 8. Tabulation of Deepest Strata Penetrated by LANDLogs and BoreLogs Records

	Number of Logs		Thickness Information Yield***	
Basal Stratum	**LandLogs**	**BoreLogs**	**Top Stratum Thickness**	**DeForest Formation Thickness**
DeForest Fm				
Historic Alluv or Fill		148	None	None
Top Stratum	1619	447	Minimum	None
Bottom Stratum	1205	988**	Total	Minimum
Pre-Holocene*	721	567	Total	Total
Bedrock	68	440	Total	Total
Uncertain/Missing Data	30	33	None	None
Total	3643	2623		

* Includes Wisconsinan alluvium and Wisconsinan and pre-Wisconsinan tills

** May include Wisconsinan as well as Holocene alluvium

*** None = total thickness cannot be estimated because these logs to do not penetrate deep enough

Minimum = logs gives a minimum thickness only, because the log did not penetrate deep enough.

Total = log penetrates completely through the stratum, so a total thickness can be determined

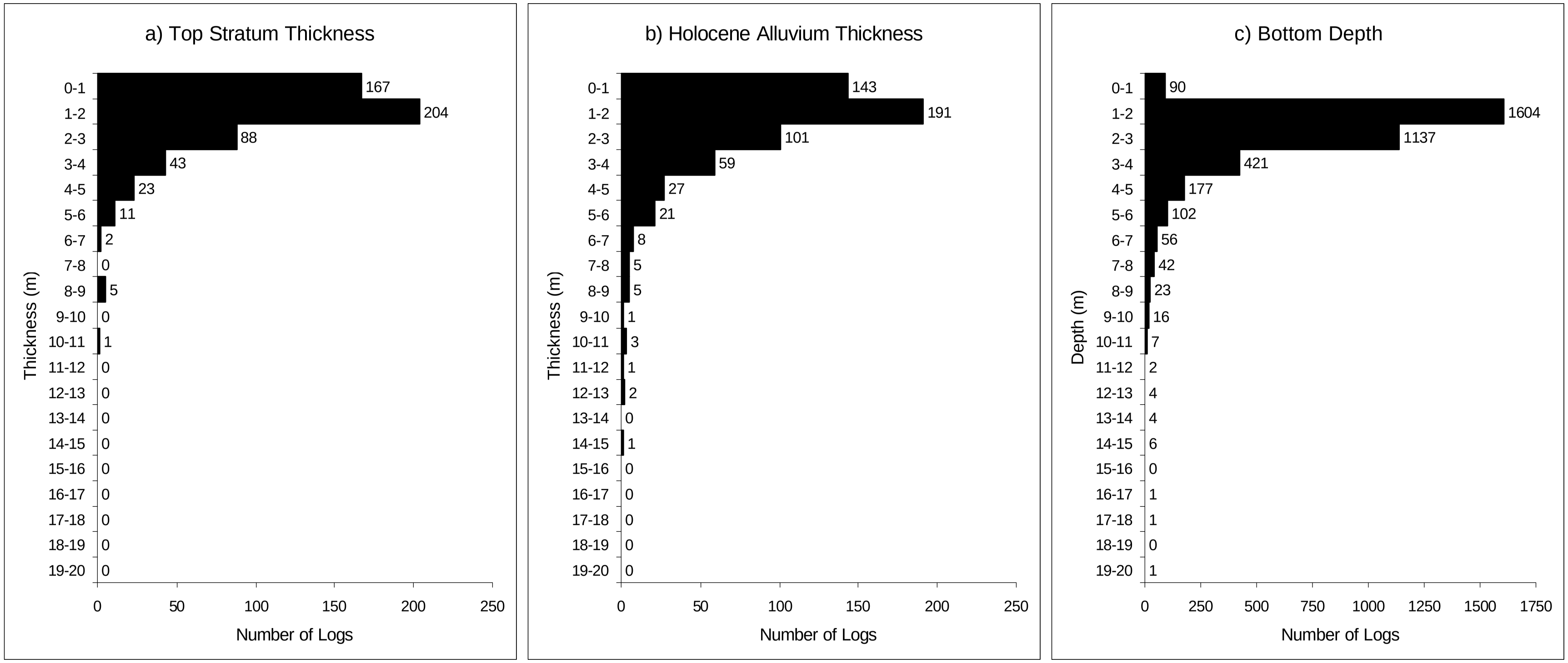


Figure 10. Frequency distributions from the LANDLogs data set: a) Holocene top stratum thickness; b) combined thickness of Holocene top and bottom strata; c) maximum depth of LANDLogs records.

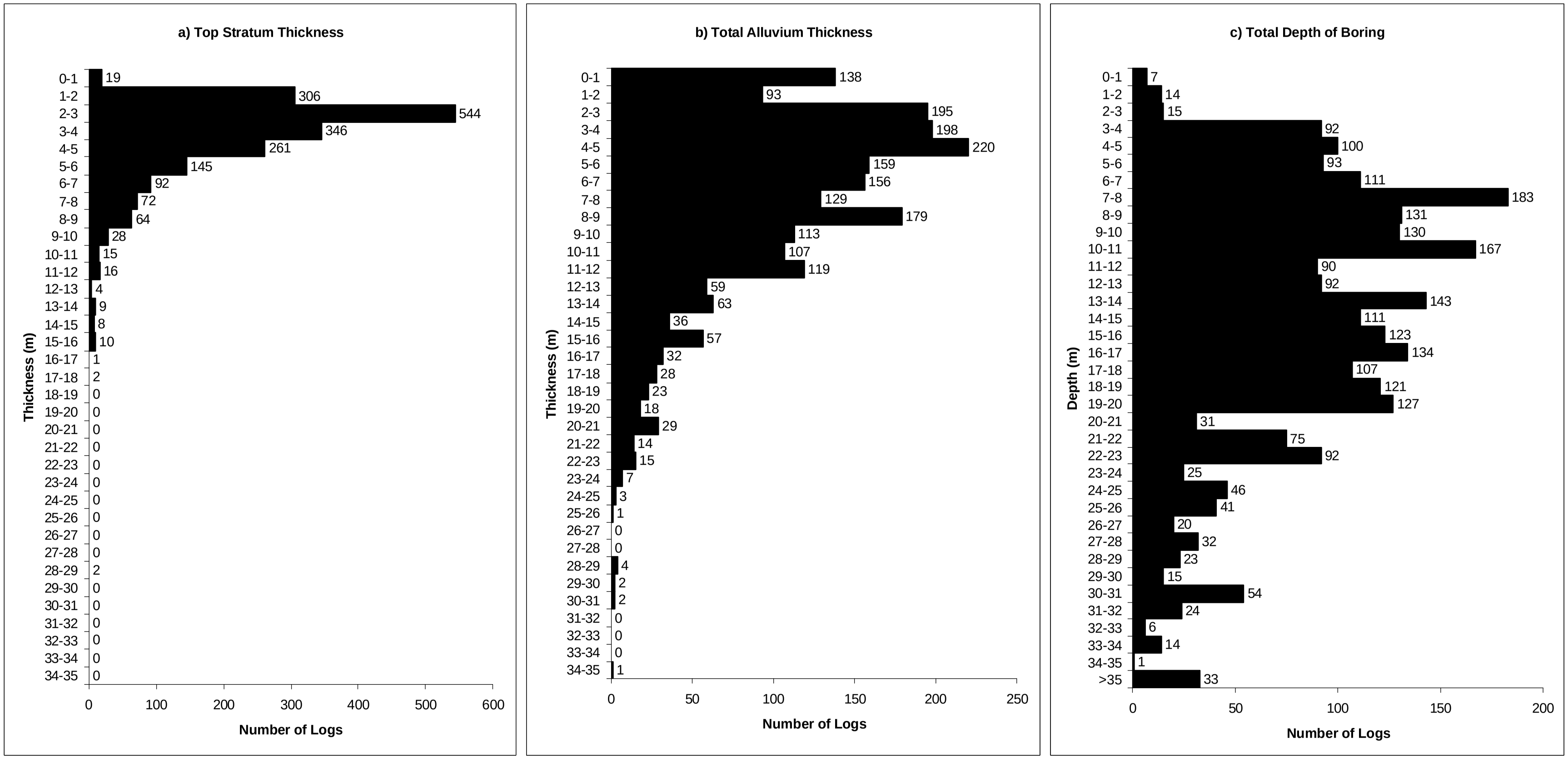


Figure 11. Frequency distributions from the BoreLogs data set: a) Holocene top stratum thickness; b) combined thickness of Holocene through Wisconsinan top and bottom strata; c) maximum depth of Iowa DOT bore logs. .

By contrast, for the Iowa DOT borings, the frequency distribution of top stratum thickness is much different from that for maximum depth (Figure 11). As discussed above, only part of this total thickness has archaeological potential by offering the kind of low-energy, fine-textured, overbank-dominated depositional facies suitable for prehistoric habitation. These top stratum sediments, recognized in 1944 of the 2663 bore logs, ranged from <1 to 38.40 m thick (mean 3.26 m; standard deviation 3.05 cm). The coarser-textured bottom strata sediments, recognized in 1835 logs, are <1 to up to 52 m thick (mean 7.40; standard deviation 6.99 m)

In this sample of bore logs, the valley alluvium is up to 35 m thick. The frequency distribution, however, is left-skewed (mean = 7.70 m; standard deviation = 5.54 m). For 95 percent of the observations, the valley alluvium is less than 18-19 m thick. These logs are for borings that ended in till, bedrock, or bouldery basal lag deposits, and exclude 500 logs that did not penetrate to these basal strata.

From bore logs, it is not always possible to determine where the boundary between Holocene- and Pleistocene-age sediments occurs, and even in the field such determinations can be difficult. For this reason, the top and bottom strata thicknesses are likely to include pre-Holocene as well as Holocene alluvium. **For decision support purposes, however, the available data indicate that Holocene top stratum thickness will often not exceed 6.31 m (i.e., 1 standard deviation from the mean). The top stratum deposits will most often be less than 3 m thick.**

ARCHAEOLOGICAL POTENTIAL IN THE TOP STRATUM

Although exceptions can occur, archaeological sites are most detectable in the solum. Soil does not begin to develop beneath the surface of an alluvial deposit until sedimentation has slowed or ceased. In most cases, the rate of top stratum aggradation slows progressively and exponentially through time. This is illustrated by a radiocarbon dated sequence from the Riley site, 13HN273, in Henry County, Iowa (Figure 12). Particularly in the final, slowest stages of aggradation, the surface is relatively stable for centuries, increasing the opportunity for multiple occupations of the surface, resulting in an increasing density through time of artifacts and features (Ferring and Peter 1987).

Soil formation, or pedogenesis, is a process that transforms parent material (the C horizon) into the distinct layers, or horizons of the soil. Unaltered parent material comprises the C horizon. The A, E, and B horizons, collectively, comprise the solum, where pedogenesis occurs. A total of 868 LANDLog stratigraphic logs completely penetrated a solum formed in late through early Holocene alluvium (Figure 13). In most of these, the solum is 50-150 cm thick (mean, 128 cm, standard deviation, 71 cm). As was the case with the greatest top stratum thickness, sola up to 6 m thick occur primarily in vertically-stacked alluvial sequences in western Iowa valleys (Bettis and Hajic 1995) and alluvial fans (Hoyer 1980; Bettis and Hoyer 1986). The thick sola are actually comprised of multiple, vertically stratified sola that occur in the sediment sequence.

If there is indeed a correlation between solum thickness and buried archaeological components, then on average such components should occur in the upper 150 cm of the Holocene alluvium. Figure 13c suggests that this is the case. To construct this histogram, we examined 285 reports in OSA's Project Completion Report and Contract Completion Report series, compiling information on the depths at which buried components were recorded. These investigations discovered 117 buried components, nearly half at depths of 50-100 cm. The deepest was found 450-500 cm below surface.

The depth of recorded archaeological sites, however, is dependent not only on Holocene top stratum thickness, but also on the depth of archaeological testing. Figure 13b, based on the NADBBridges sample of Phase I investigations, is almost identical to that shown in Figure 13c. From the similarity of the two histograms, it can be suggested that the success rate for discovering buried sites is primarily a function of how deep archaeologists are seeking such sites. The data suggest that deep testing in Holocene alluvium will encounter buried sites in proportion to the maximum depth the tests penetrate. The shallow mean

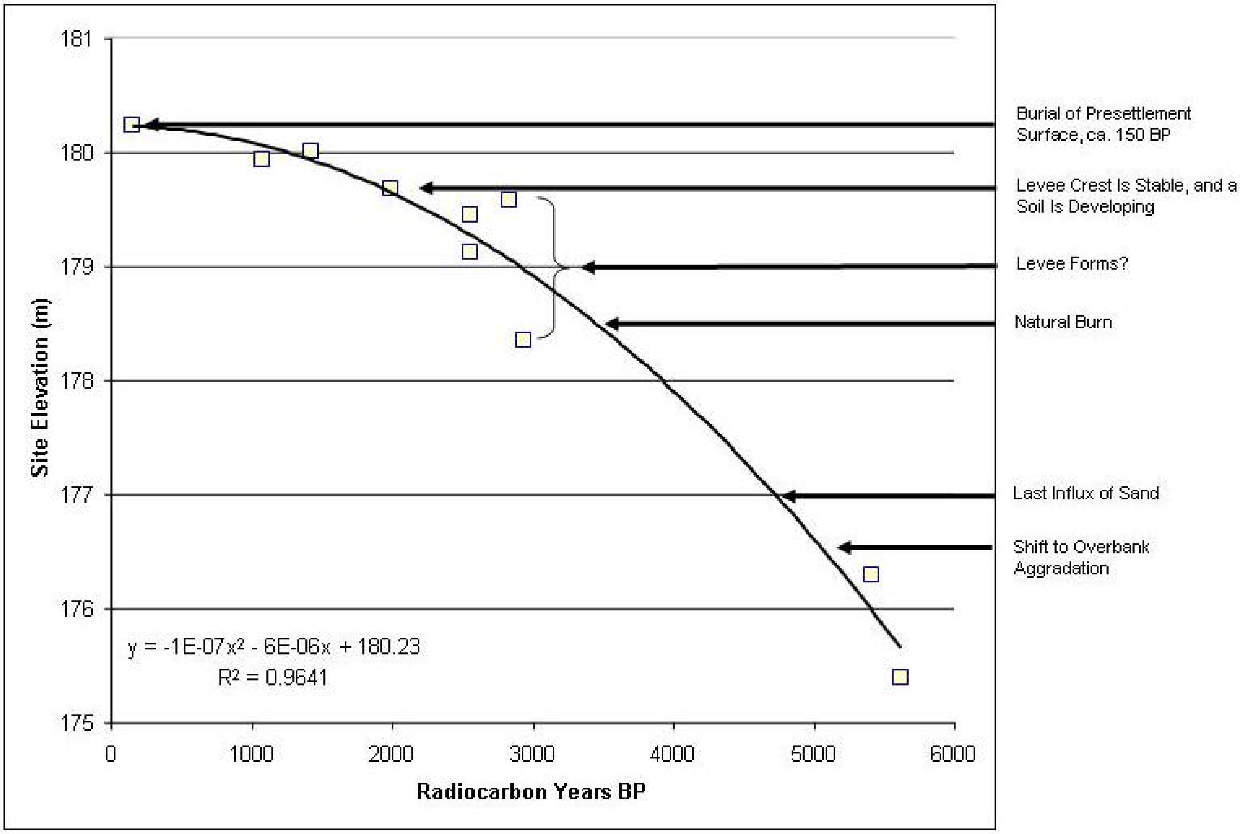


Figure 12. Rate of Late Holocene alluvial aggradation at the Riley site, 13HN273, indicating decreasing sedimentation and increased occupation intensity through time (from Artz 2003b).

depth of buried components is less a factor of the archaeological record and more a factor of archaeological methodology.

THICKNESS OF HISTORIC ALLUVIUM

Of the 2628 bore logs tabulated for this study, 1070 describe surface deposits referred to as "fill" Archaeologists use the term "fill" to describe deposits that were emplaced by historic-period human activities, such as land-filling or construction. Some bore log descriptions refer to this criterion, but in many, the thickness and textural descriptions of the "fill" units seem more similar to those of stratified, loamy textured historic alluvium than human-created, artificial fill. In the tabulated bore logs, surface deposits of fill (including both human- and fluvially-emplaced deposits) range from <1 to 12.2 m in thickness (mean 2.43; standard deviation 1.52). Most will fall within 3.95 m of the surface, i.e., within 1 standard deviation of the mean.

Of the 4343 LandLogs records, 1824 encountered historic alluvium or fill ranging from <1 to 8 m thick. The mean thickness is 98 cm (standard deviation 83 cm). The greater thickness of historic alluvium in the BoreLogs database may reflect the predominance in that dataset of bore holes taken in close proximity to existing bridges , where historic alluvium in the modern channel belt would be expected to be thicker.

For decision support, historic sediments with thicknesses exceeding the project's depth of impact will sometimes, but not always be present. Particularly on large rivers, it is quite likely that a

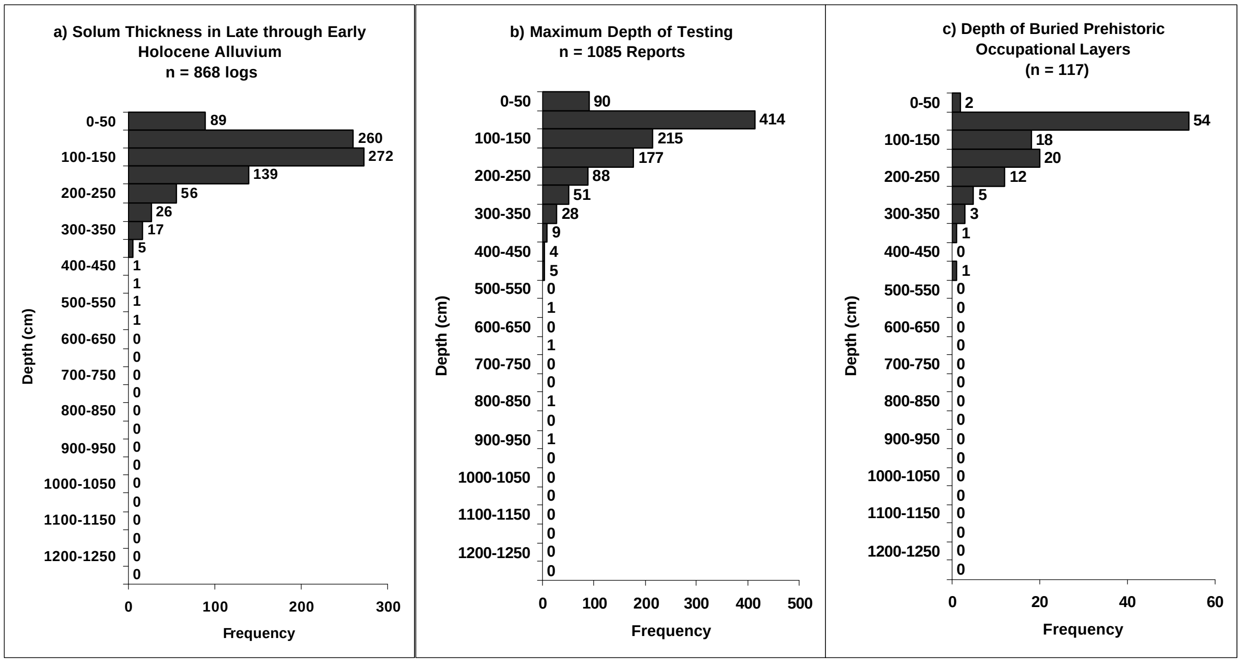


Figure 13. Frequency distributions related to top stratum habitability potential: a) solum thickness in 868 LANDLogs records; b) maximum depth of testing in 1085 Phase I reports; c) depth distribution of 117 buried prehistoric archaeological occupation layers.

considerable portion of the APE will be located in the historic-period channel belt, where prehistoric deposits will not be expected to be preserved.

AREAL EXTENT OF ALLUVIAL SEDIMENT PACKAGES

NRCS soil survey maps are available for all Iowa counties and can be used in evaluating subsurface archaeological potential for any bridge replacement projects to depths of 1.5-2 m. The Ackmore to Zwingle web site (Artz 2005) is a resource to help archaeologists and geoscientists interpret the lithology, relative age, and stratigraphic nomenclature of the surface geologic materials in which the soils of Iowa are formed. The page classifies soil series according to their parent materials as described in the NRCS' Official Series Descriptions (OSDs; Soil Survey Staff 2004) and by the PMAT [parent material] field in the Iowa Soil Properties and Interpretation Database (ISPAID). Artz's (2005) classifications are generalized for series that formed predominantly in Wisconsinan and earlier geologic materials in uplands. Series that formed predominantly in Holocene alluvium are assigned as appropriate to a lithostratigraphic unit of the DeForest Formation.

The classifications provide a first approximation of the surface geologic materials that might be expected at a location where an NRCS map unit indicates the occurrence of a given soil series. The classifications were applied to AllStateSoil, a 30 m raster dataset compiled from the digitized soil surveys. The resultant classifications were used to create AllStateOSA, a grid that assigns 30 x 30 m cells to a probable surface geologic material.

Prehistoric Potential at Surface as a Function of Distance from Bridges

Figure 14 illustrates spatial patterns in mapped soils in relation to their proximity to bridges. Proximity is expressed in 25 m increments of distance from Structures Inventory bridge, to a maximum radius of 1000 m. Because bridges are most often centered on streams, the proximity data can also be interpreted as a measure of distance from streams.

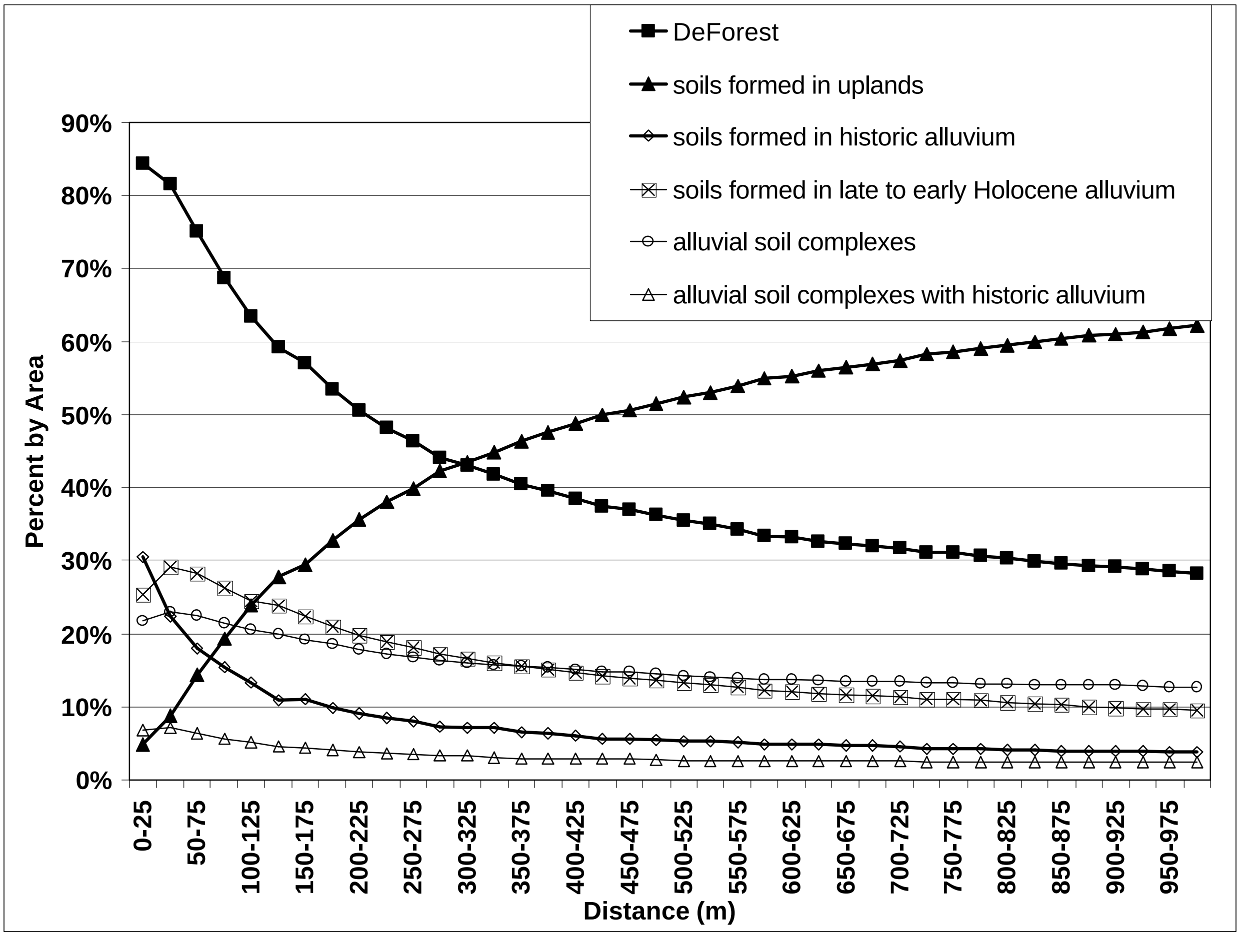


Figure 14. Surface soil/sediment relationships plotted as a function of distance from Structure Inventory bridges. Sources: allstatesoils; Structures Inventory.

As shown, upland map units comprise about 5 percent of the soils, by area, within 0-25 m of a bridge, and the remaining 95 percent are valley map units. By contrast, uplands soils comprise ca. 60 percent of the mapped soils within 975-1000 m of bridges, with alluvial soils comprising 40 percent. The two distance curves intersect at 300-325 m; beyond this distance, upland soils comprise the larger proportion of the area within 1 km of bridges.

A second set of curves in Figure 14 breaks down the DeForest Formation soil map units into those formed in historic alluvium, those formed in late to early Holocene alluvium, alluvial soil complexes, and alluvial soil complexes that include historic alluvium. Soil complexes are mapping units used by the NRCS in areas where the mosaic of individual soils types is too complex to be represented at map scales of ca. 1:20,000. In valleys, these complexes are often mapped in narrow tributary valleys extending into uplands, and into channel belts bordering large streams.

Within 50 m of bridges, historic and Holocene alluvial map units are present in equivalent proportions of 20-30 percent. Beyond this distance, the area mapped as historic alluvium rapidly declines, comprising less than 10 percent of DeForest Formation alluvium at distances greater than 200 m, and less than 5 percent at distances greater than 500 m.

Figure 14 also shows the relative frequency of Wisconsinan outwash and loess-mantled terraces. These map units comprise relatively little of the area within 1000 m of bridges. Although not common, such landforms have relatively high prehistoric site potential, because they are have well-drained surface elevated above the reach of both Holocene and historic flooding.

Figure 14 could be employed in decision support to anticipate Phase I survey methods. For example, the further the APE for a bridge replacement project extends from its stream crossing, the less historic alluvium will be present at the surface, and the more likely that prehistoric sites may be encountered by surface walk-over. As the area mantled by historic alluvium increases, survey methods will need to rely more and more on subsurface testing to discover prehistoric sites. **Small bridges (e.g., those with APEs that extend no more than 50 m from the proposed structure) will on average have a surface mantle of historic alluvium over about 20-30 percent of the APE. For larger bridges, with longer approach grading requirements, the proportion of the APE mantled with historic alluvium will often not exceed 5-10 percent, except within 200 m of the stream.**

Prehistoric Potential at Surface as a Function of Bridge Length and Valley Width

In the Midwest and central Plains, strong relationships have been identified between valley size and the valley-fill stratigraphy (Bettis and Thompson 1980, Mandel 1995). Simply stated, narrow, low-order valleys near the headwaters of the drainage network tend to have higher proportions of early-middle Holocene sediments, while the broader, high-order valleys along major rivers have a full complement of lithostratigraphic units.

OSA presently lacks adequate data for ordering valleys using GIS. Instead, bridge length as recorded in the Structures Inventory, is used as a proxy for valley width. This follows from the reasonable assumption that, the longer the bridge, the wider the stream, and consequently the wider the valley through which the stream flows.

Figure 15 indicates how mapped soils within 1 km of bridges vary with bridge length. The chart shows a positive correlation between bridge length and the area mapped as historic alluvium map units, increasing from 10 percent in the shortest structures (<10 m long) to over 60 percent in structures longer than 200 m. The opposite is true of the area mapped as early-late Holocene, which is negatively correlated with bridge length. About 70 percent of the area within 1 km of a short structure will be mapped as early-late Holocene units, compared to only 20 percent for areas within 1 km of the longest structures.

At a length of 50 m, the area within 1 km mapped as surficial historic alluvium begins to exceed that mapped as surficial early-late Holocene deposits. Bridges over 130 m in length have increased frequency of Wisconsinan terrace deposits within a kilometer.

For purposes of decision support, Figure 15 indicates that the longer the proposed bridge, the larger the proportion of the APE mantled by historic alluvium, and the less the potential for discovering surface-visible prehistoric sites.

Prehistoric Potential as a Function of Historic Sediment Thickness

Because NRCS soil surveys only map soil/sediment relationships within 150-200 cm of the surface, they are not adequate for determining the thickness of Holocene lithostratigraphic units. In particular, the preceding sections, in discussing the areal extent of surface deposits of historic alluvium, do not differentiate between situations where the historic sediments are a relatively thin veneer that mantles early-to-late Holocene deposits, or whether the historic sediments comprise a thick package that represents the complete removal of earlier deposits by historic-period channel activity.

The LANDLogs database can be used to address this problem. Figure 16 plots the thickness of historic alluvium against bridge proximity. The correlation of the variables is weakly negative. The relationship is best viewed as one in which bridge proximity determines a maximum expected thickness for historic alluvium. For example, LANDLogs indicates that within 100 m of a bridge, historic alluvium will be up

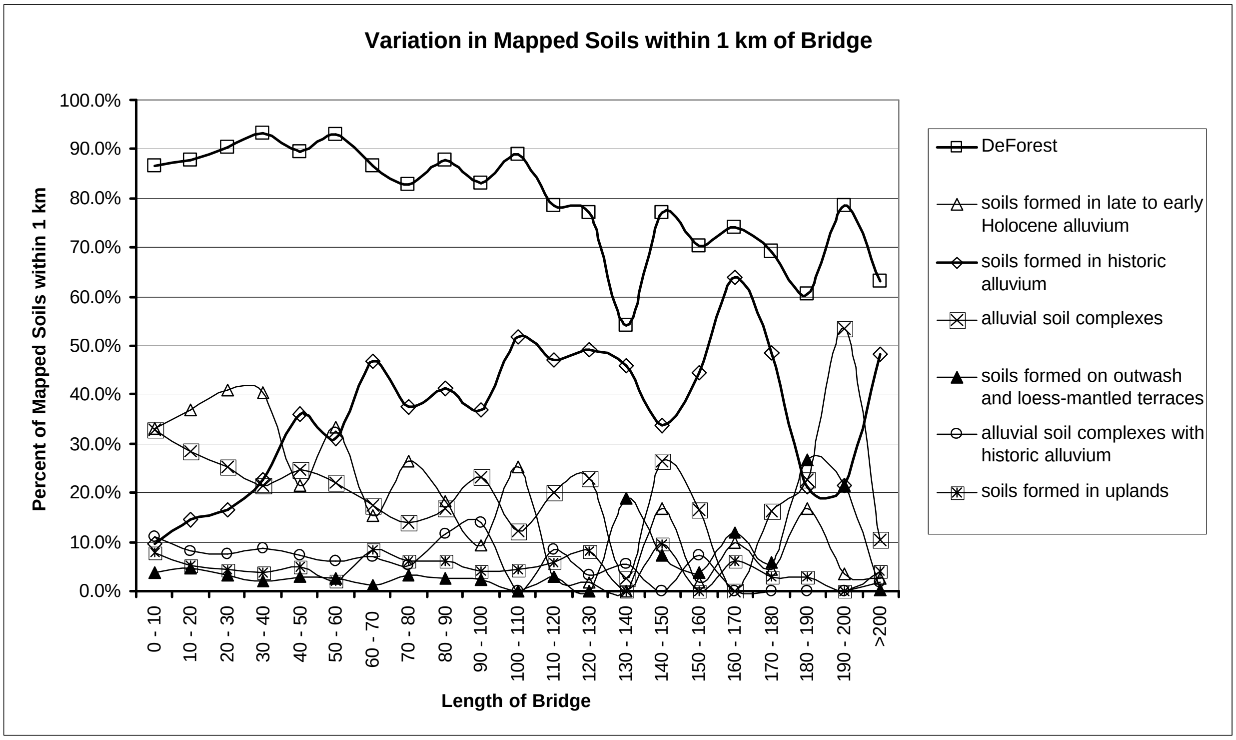


Figure 15. Soil/sediment relationships plotted as a function of bridge length, which is used as a proxy for valley width. Sources: AllstateSoils, Structures Inventory.

to 3 m thick and occasionally >3 m. At 500 m, historic alluvium will be encountered less frequently, and will most often be >1.5 m thick.

As previously discussed, the average thickness of Holocene top stratum sediments is 2-3 m. This suggests that any bridge replacement APE located within a 100 m radius of the proposed structure may encounter historic alluvium sufficiently thick to indicate complete removal of prehistoric sediments by historic channel activity. This likelihood decreases with increasing distance. At distances of >250 m, the thickness of historic alluvium is less than the average Holocene top stratum thickness, and will thus most likely comprise a historic veneer, rather than complete removal of prehistoric deposits.

Archaeological survey results provide evidence that possibly supports this conclusion. Using data from IowaSurveys and AllSites, archaeological survey areas and archaeological site areas were summed for 30-m bridge proximity classes (Figure 18). The data were filtered to include only survey areas located on alluvium, and only those sites located within those survey areas. This dataset is the same as that used previously to evaluate survey quality.

The drop-off of prehistoric site density within 120 m of bridges is a relationship that has been noted in other GIS studies (Hudak 2001, 2003; Artz et al. 2003). It has often been interpreted as evidence for the removal of prehistoric deposits by historic channel activity, or their burial by surface mantles of alluvium. While plausible, and probably true, to some extent, this interpretation must be made with caution. As previously discussed, given survey quality data presented in previous sections, the actual density of sites buried beneath surface veneers of historic alluvium is probably higher than present survey results would indicate.

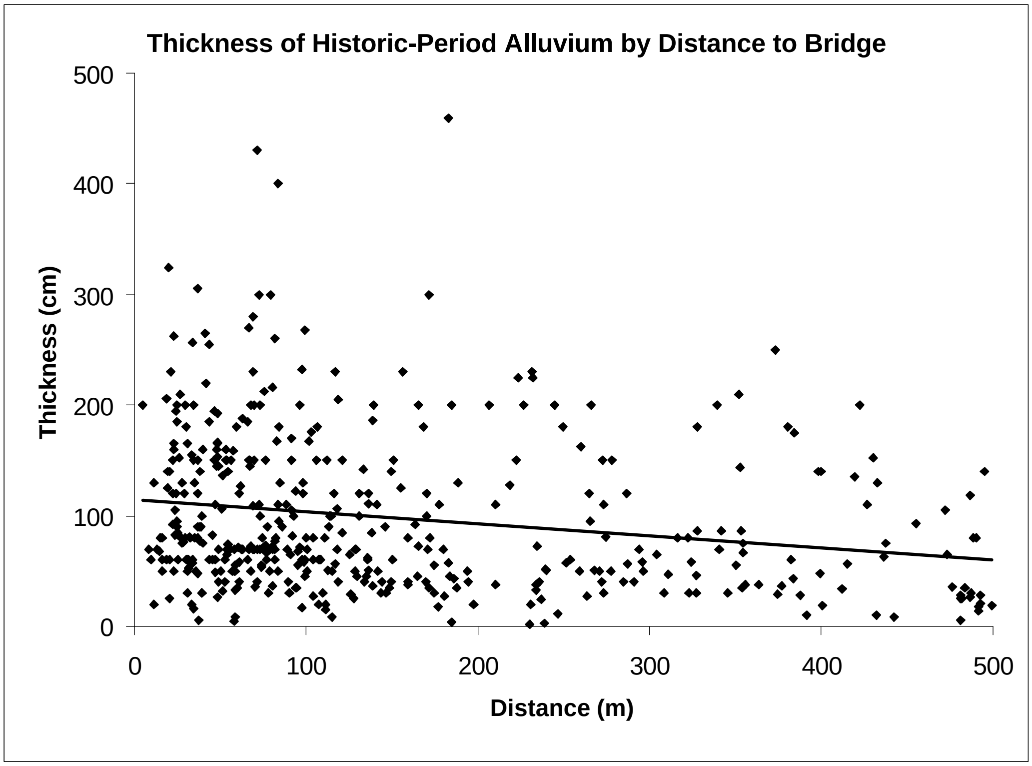


Figure 16 Historic alluvium thickness plotted against distance to bridge.

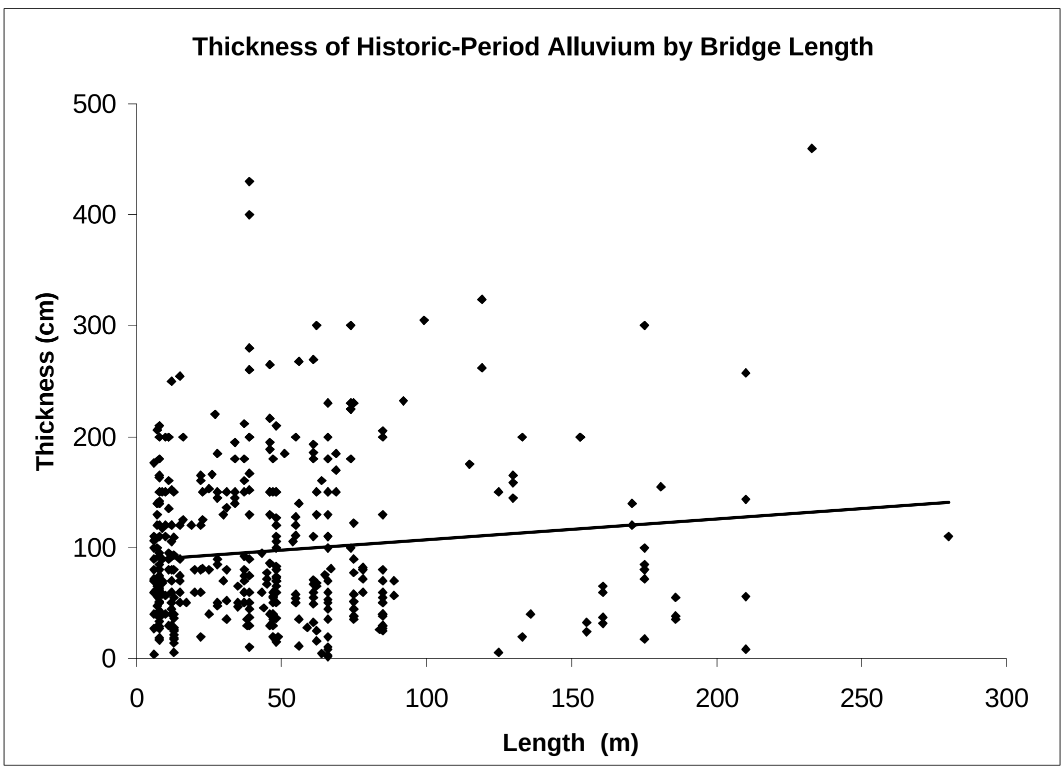


Figure 17. Historic alluvium thickness plotted against bridge length, as a proxy of valley size.

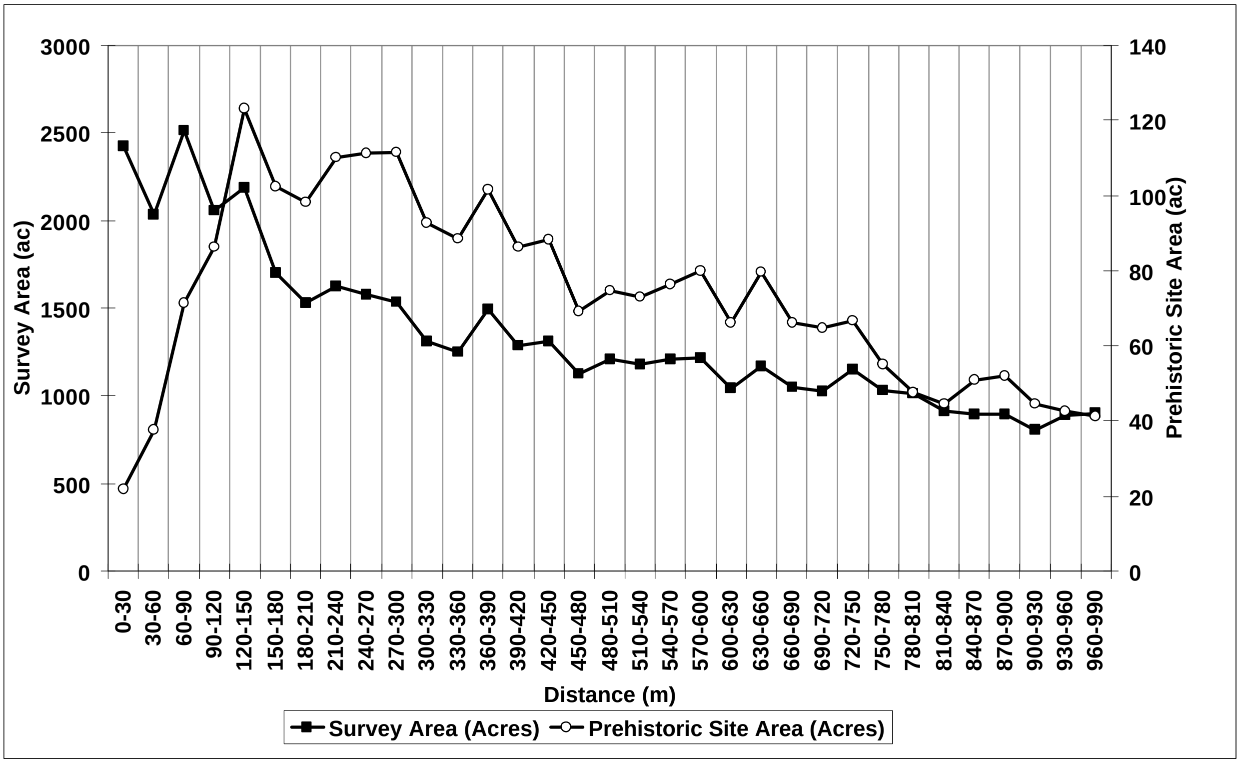


Figure 18. Prehistoric site area and archaeological survey area as a function of distance to nearest Structures Inventory bridge.

SITE DISTRIBUTION AND DENSITY

Prehistoric site location data is more certain for uplands, where sites are not deeply buried and can be detected by surface walk-over and shallow subsurface testing. LANDMASS suitability values are therefore calculated only for uplands. In valley settings, as previously discussed, many buried prehistoric sites have gone undetected by surveys, and therefore site densities and spatial patterns cannot be reliable calculated.

Nevertheless, in a statewide dataset of all prehistoric sites that fall within digitized survey areas, there is a positive correlation of site density in uplands and valleys (Figure 19). **For decision support purposes, the probability of encountering prehistoric sites in a bridge replacement APE will be proportional to the range of probabilities in the nearest uplands. LANDMASS suitability values in these nearby uplands can be used to assess the potential archaeological sensitivity of the APE.**

Although GIS models like LANDMASS are sometimes referred to as “predictive models,” the purpose of LANDMASS is not to predict actual site locations, but rather to determine, based on known patterns of site distribution, where such sites are most likely to occur. Site suitability is evaluated on a scale of 0 to 1. Suitability values approaching 0 are the kinds of locations (e.g., low-relief uplands far from water sources) where prehistoric sites have rarely been encountered by intensive archaeological surveys. Values approaching 1 are the kinds of locations (e.g., high-relief terrain on the margins of stream valleys) where such surveys have most often found prehistoric sites.

Artz et al. (2006) suggest that measures of suitability (whether or not a location would have been suitable for occupation in the past) could be converted to a measure of probability (the chance that a site will actually be present) based on known regional site density, expressed as total site area divided by total survey area. However, a variety of factors other than regional site density affect whether a site will be encountered, including the size of the APE and survey methods. Until such factors are taken into account,

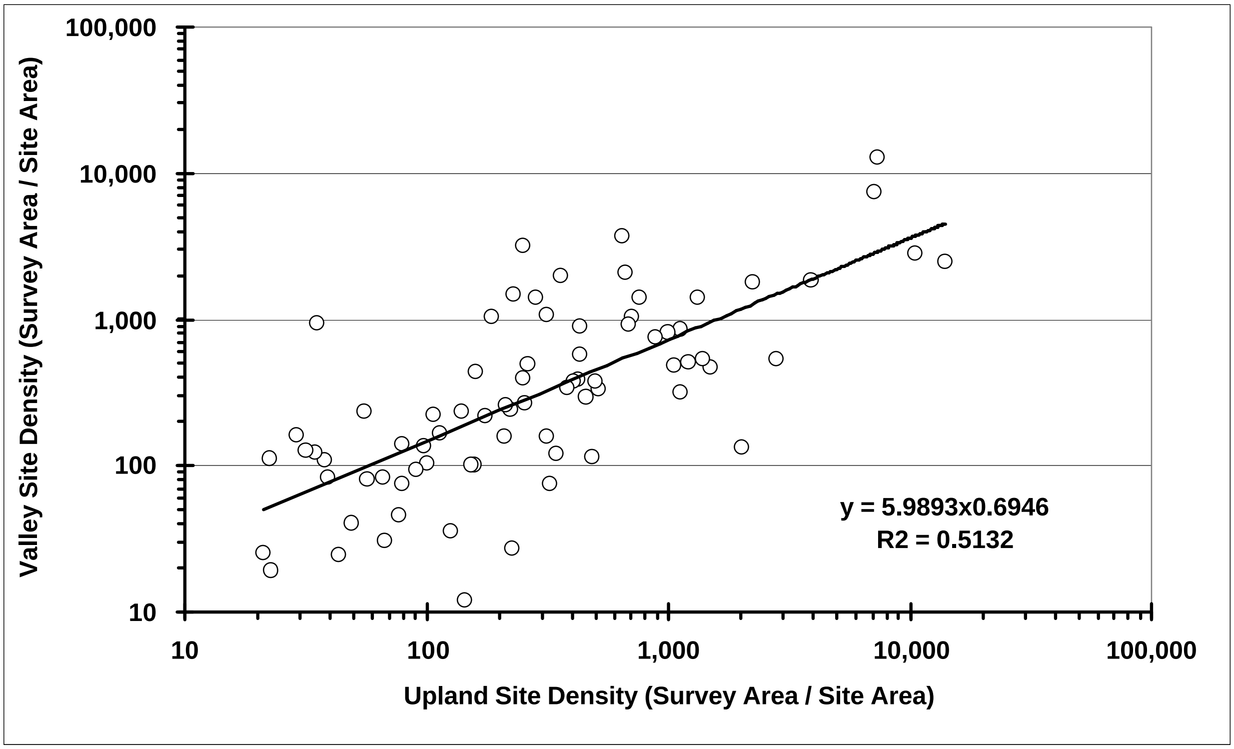


Figure 19. Bivariate plot of prehistoric site density in uplands and valleys for 77 of Iowa's 99 counties. Only sites lying within digitized survey areas are plotted.

the relationship between suitability and probability is poorly understood, cannot reliably be applied in modeling at this time. OSA intends to pursue this research in the future to improve the applicability of the LANDMASS model.

Decision Support Model

The process of risk assessment for proposed bridge replacements is a matter of making information about prehistoric site potential available to planners at virtually any stage in the bridge design process. The information includes not only data but also a conceptual framework for interpreting the data. We have identified numerous existing datasets and discussed their relationship to bridge replacement risk assessment and survey planning. that can be applied to bridge replacement risk assessment and archaeological survey design, and we have evaluated the quality and applicability of those data. In the process, we have created a conceptual framework for putting these data to work in evaluating the prehistoric site potential in alluvial deposits in Iowa.

Overview

The Decision Support Model for Bridge Replacement Projects is a process that marshals existing data for use at virtually any stage in the Iowa DOT design process. The three principal steps are APE definition, risk assessment, and OLE review (Table 9). Risk assessment involves a multi-step data-gathering and decision-making process (Figure 20).

Table 9. Principal Steps in the Bridges Decision Support Model.

Task	Responsible Party
1. Define the APE	Office of Design or County Engineers
2. Risk Assessment • Examine NADB-Iowa to determine survey quality in APE, if previously surveyed. • Examine historic maps to determine if APE is located in a historic channel belt. In process might also identify possible historic sites affected by project). • Examine NRCS soil maps for indication of historic and Holocene-age alluvium in the APE • Examine LANDLogs, bore logs, or as-built Q-sheets, if any, to determine top stratum thickness. • If no logs exist, estimate potential geologic parameters from charts in this document, given bridge length.	Primary Projects: OLE Local Projects: local engineers or their consultants obtain information and provides to OLE at Iowa DOT
3. OLE Review • No potential: (no survey) • Uncertain potential (geoarchaeological survey required) • Potential exists (Phase I survey)	Primary Projects: OLE Local Projects or district offices: provide documentation to OLE

APE definition is based on decisions made for primary roads projects by the Offices of Design and Right-of-Way at Iowa DOT for primary road projects, and for secondary roads and city streets by local county and city engineers or their consultants. It represents the initial input into the Decision Support Model. If the depth of cutting below the ground surface is known, it should be provided in the APE definition.

Risk assessment involves gathering and evaluating data. The bridges decision support website provides links to historic maps, aerial photography, mapped soils, archaeological surveys, and the LANDLogs, and BoreLogs databases. With web availability, Iowa DOT and local roads departments will be able to access data that were formerly only available to archaeologists and other cultural resource specialists. The first steps in risk assessment can probably be conducted by nonspecialists. The website enables users to examine a proposed APE and determine whether historic alluvium is present, whether survey coverage or stratigraphic logs exist, and whether the proposed project is located in areas where the historic channel has shifted dramatically through time.

In certain cases, a nonspecialist check may be sufficient to determine that the proposed project poses no risk to archaeological sites. For example, historic maps might show the APE located entirely within an area of significant meandering during the historic period, or existing bore logs would demonstrate that the APE is underlain by historic alluvium with thicknesses that exceed the project's vertical depth of impact. In other cases the field exam undertaken during design might document the presence of extensive channeling or other disturbances that preclude the preservation of prehistoric materials.

In most cases, however, we foresee the nonspecialist role being in the gathering of data to be submitted to OLE archaeologists for a final risk assessment. OLE review comprises the third step of the Decision Support model. For secondary roads projects, risk assessments might also be conducted by an archaeological consultant, as is currently done for many county bridge. The final risk assessment will determine whether or not a field survey is required to move forward the Section 106 consultation.

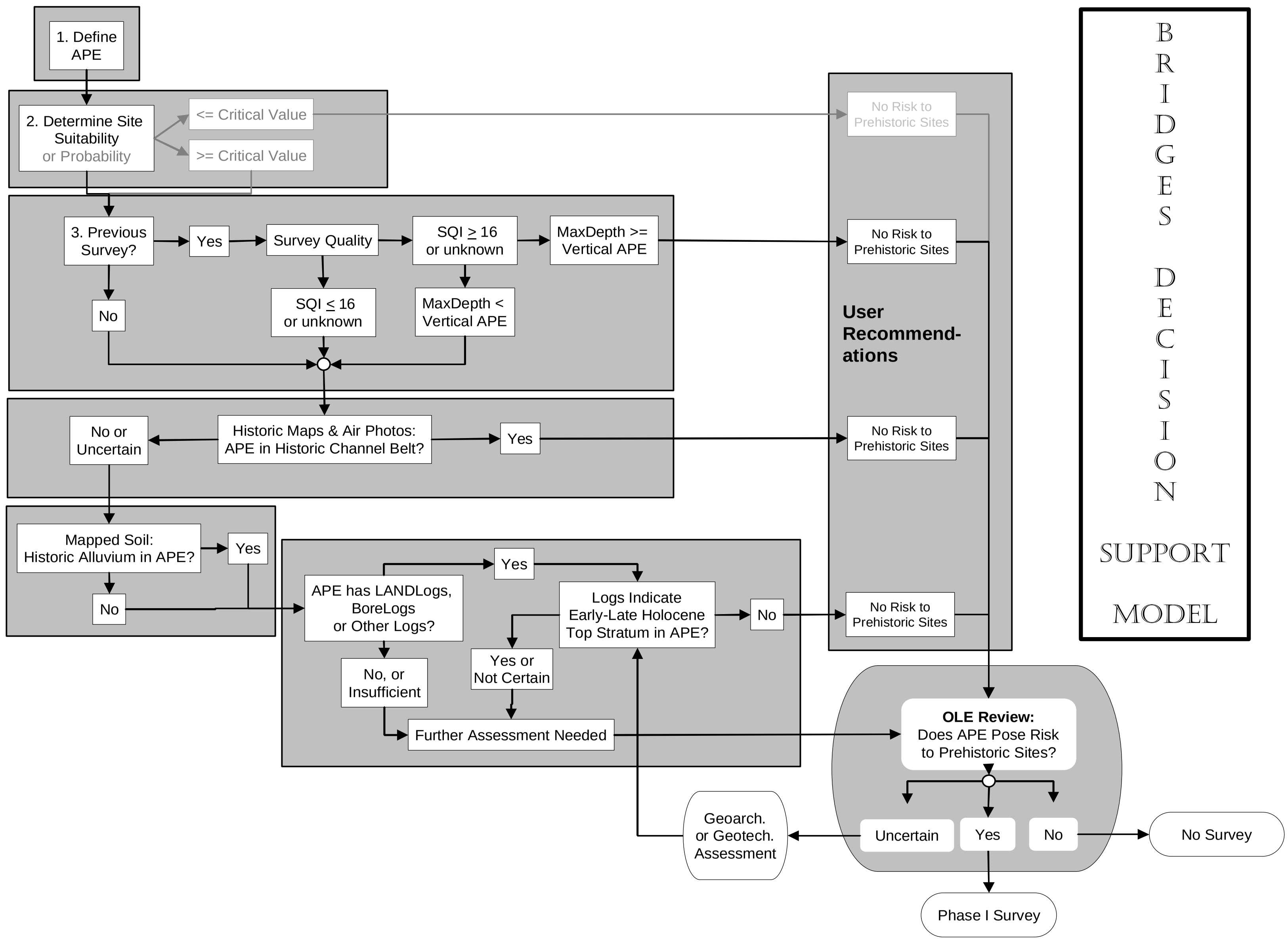


Figure 20. Flowchart for the Bridges Decision Support system.

STEP-BY-STEP

Once an APE is identified, the sequence of actions shown in Figure 20 is initiated.

Suitability/Probability

Prehistoric site suitability is determined from maps displayed on the LANDMASS website. Suitability is presently modeled only for uplands. The user first browses to the APE location, then to the nearest valley edge. The user records the maximum suitability value displayed within 0.25 mi of this valley edge point. The nearer the value is to 1, the higher the likelihood of encountering prehistoric sites in the APE.

OSA envisions replacing suitability values with estimates of the actual probability of a site being present in the APE. Achieving this, however, requires a better understanding of the many factors that determine whether a buried site is not only present, but also detectable by subsurface testing methods. Once these factors are better understood, OSA would recommend that Iowa DOT consult with SHPO to identify an acceptable probability beneath which the probability of a site being present is so low that a survey need not be undertaken. This critical value would be written into the Programmatic Agreement between the two agencies as a criterion for identifying project excluded from Section 106 consultation. Since we are not yet at this point, references in the flow chart to probability modeling are grayed out.

Previous Surveys

For this step, the user activates the Archaeological Surveys layer in the Web interface to determine whether the APE lies within an area previously surveyed for archaeological sites. Many future bridge replacements will lie in unsurveyed areas. In such cases, the user proceeds to the next step. If the APE is in an area previously surveyed, the user examines the database record(s) attached to the survey area(s) to evaluate survey quality.

Survey quality is high if the Survey Quality Index is 16 or greater. This value indicates that testing was conducted to depths of greater than 2 m, and that testing density was >100/10 ha. Survey quality is evaluated as low or indeterminate if:

1) there are no values for survey quality;
2) the SQI index is < 16; or
3) the survey was conducted prior to 1980, when subsurface testing was not routinely conducted.

If survey quality is high, and the vertical extent of the proposed APE is less than the depth of testing undertaken in the previous survey, then the APE may have already been adequately tested for prehistoric sites. In this case, the user will recommend that the bridge replacement poses no risk to prehistoric sites.

Historic Maps and Aerial Photographs

The Bridges Decision Support website links to 19th and 20th century maps of Iowa counties that are part of the Iowa Digital Heritage Collections project. Following these links to the county of interest, the user pans and zooms to the APE and examines the maps for evidence for marked lateral shifts of the stream within the APE during the historic period. The user will also follow links to the Iowa Geographic Map Server (http://cairo.gis.iastate.edu), examining aerial photographs the 1930s, 1990s, and 2000s for evidence of stream channelization, modern borrowing, cutting/filling, or other disturbances within the APE. If the APE appears to be located entirely within an area of historic-period channel shifts or land-use disturbance, the user will recommend that the bridge replacement poses no risk to prehistoric sites.

Mapped Soils

The user will activate the NRCS-Mapped Soils layer in the web map interface and browse to the APE location. The mapped soils layer will indicate the extent of soils mapped as historic alluvium, early-late

Holocene alluvium, and late-Wisconsinan terraces. Late Wisconsinan terraces, if present, have the potential for surface and near-surface, but less risk for deeply buried archaeological sites. The risk in areas mapped as Holocene or Historic alluvium depends on the thickness of the respective sediment packages. Because NRCS mapping and map interpretation only extends to depths of 150-200 cm, additional subsurface information is needed to assess risk to prehistoric sites. The user will proceed to the next step.

Stratigraphic Logs

By activating the web map's LANDLogs and BoreLogs layers, the user will learn whether the Decision Support Model contains information about subsurface stratigraphy in or near the APE. The LANDLogs and BoreLogs databases are not exhaustive. Engineers at the local level may have, or know of, other bore log data, from sources as wide-ranging as road borings to privately drilled wells. At the local level, it might be possible to "piggyback" the buried-site risk assessment onto an initial phase of geotechnical borings. Although available only to Iowa DOT users, ERMS offers a searchable interface (Figure 21) that links to scanned, "as-built," CAD plans that in turn would reference previous soils and geotechnical drilling.

If LANDLogs, BoreLogs, or other log information are available for the APE, they must be of sufficient depth and quality to estimate the thickness of Historic alluvium and of Holocene topstratum deposits within the APE. If the records indicate that an early Holocene top stratum is not present in the APE, the user will recommend that the bridge replacement poses no risk to prehistoric sites. If Wisconsinan terraces or Holocene top strata are present, then further risk assessment is required.

OLE Review

As the users work through the decision flow chart process, they will complete an on-line form with the information they discover. This information will include LANDMASS suitability values, NADB identification numbers for previous surveys, URLs of historic maps, and identification numbers from the BoreLogs and LANDLogs database. The user will also be able to determine the distance to, and geologic context of, the nearest BoreLog or LandLog data point. User-acquired data will be submitted and stored for review by OLE. The user will also have the opportunity to submit supplemental materials, such as photographs, field exams, or additional bore logs to support their risk recommendations.

OLE will review the submitted materials and reach one of three conclusions. If the Decision Support Model indicates that there is little risk of the bridge replacement encountering prehistoric sites, in which case an archaeological survey is not required.

Alternatively, the Decision Support Model evidence may indicate that the APE contains Holocene topstratum deposits with the potential to contain prehistoric sites, or Wisconsinan terraces with the potential for surface or near surface sites. In this case, a Phase I survey will be required to meet Section 106 requirements.

As a third alternative, the Decision Support Model may yield insufficient or inconclusive evidence regarding prehistoric site potential. This would be the case if no existing subsurface information was available from the APE or vicinity. To reach a conclusion, OLE will first turn to the various charts summarizing the horizontal and vertical extent of Historic alluvium and Holocene topstrata provided in this report (Figures #-#). The horizontal extent of the APE can be used to derive estimates from charts that plot critical variables in relationship to distance from bridge (i.e., distance from stream crossing). In a similar fashion, the length of the proposed structure can be used to derive estimates from charts that plot critical variables against bridge length, as a proxy for stream size.

If these results are inconclusive, OLE will recommend a geoarchaeological or geotechnical study to obtain bore logs from the APE sufficient to reach a conclusive risk assessment.

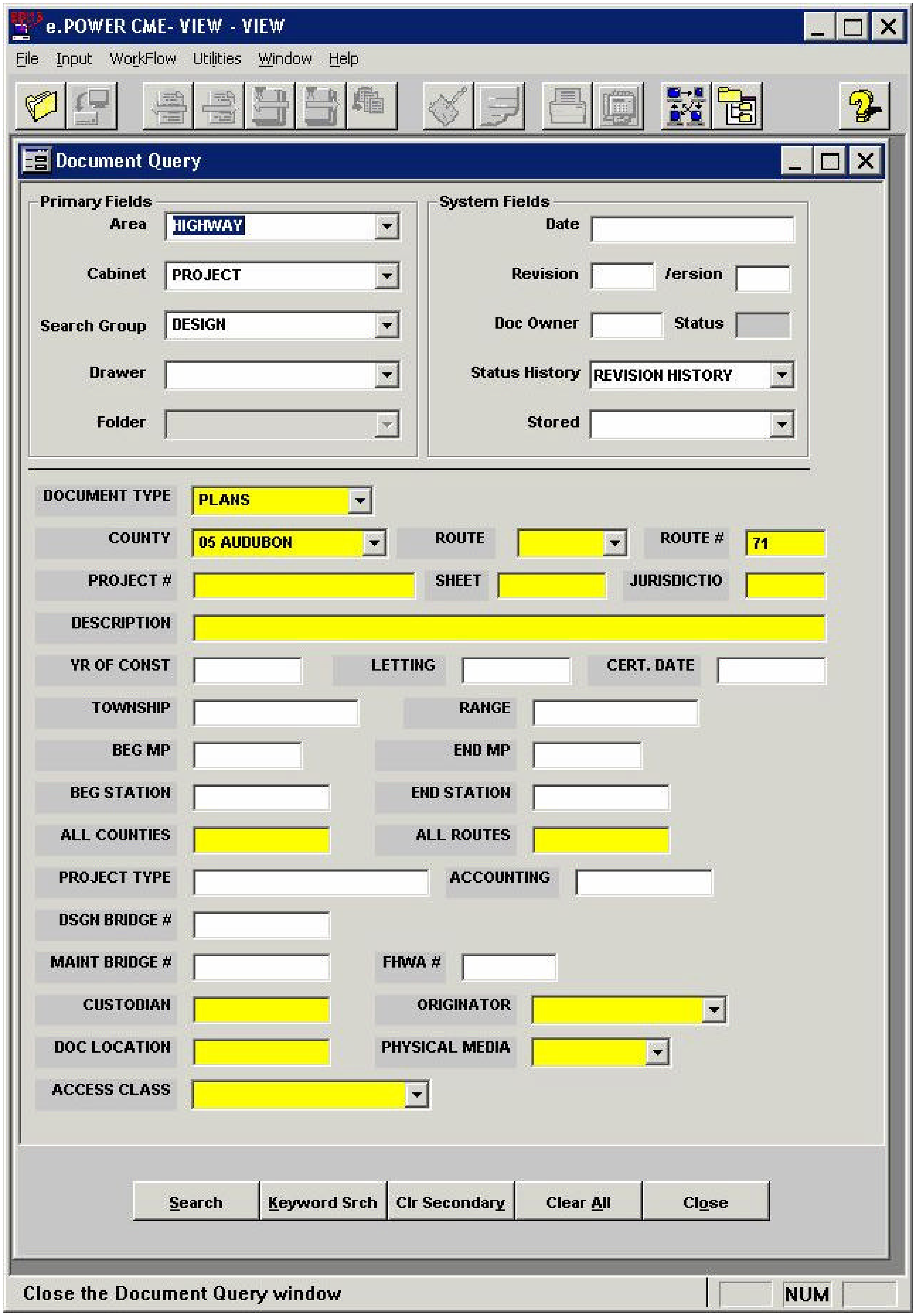


Figure 21. Screenshot of the EMRS search form, taken by Michele Fields (GIS specialist, OLE) in the process of searching for US 71 design plans for use in the present project.

BEYOND RISK ASSESSMENT

Use of the Bridges Decision Support Model is not limited to risk assessments conducted during planning and design. Its web-based datasets can also be used by OLE and archaeological consultants to prepare research designs and respond to requests for proposals. Virtually all the information used for risk assessment can also be used for archaeological survey planning. For example, estimates of Holocene top stratum thickness and the presence and thickness of historic alluvium will help determine the kinds of survey methods to be used, and the amount of effort and kinds of tools required to penetrate the potential culture bearing strata. Estimates of sediment texture can also influence cost and time estimates, because finer textured silty and clayey soils are slower to excavate and screen than loams and sandy loams.

We anticipate that SHPO and other agencies will use the model for project review and compliance activities. We also anticipate the model will prove useful for long-term planning, to “prescreen” bridge replacement projects well in advance of actual design and construction.

Perhaps the greatest contribution of this kind of model is that it makes the same kinds of data available in the same format to all parties and in all phases of the bridge replacement process. We anticipate that he model will help streamline this process by promoting effective and efficient communication and information flow.

Another advantage of this kind of model is that it can be expanded and refined as more and better information becomes available. Models like LANDMASS and the Bridges Decision Support Model have the advantage of being based on statewide information on archaeological surveys and sites that are continually being updated. GIS technology has also evolved to the point that the data entry and model update processes can be automated.

FUTURE RESEARCH

At present the Bridges Decision Support Model depends on data that are not as well-suited to the task at hand than they might be. As this report’s discussion of survey quality indicates, archaeologists have not tested the complete thickness of Holocene sediments. Much remains to be learned about where buried sites occur and do not occur in Iowa alluvium.

Another shortcoming is the relative paucity of bore hole data on which to base estimates of critical geological variables. This report’s discussion of critical variables revealed relatively strong trends in an initial synthesis of bore hole and geoarchaeological test data. Spatial variability with valley size and physiographic region have yet to be addressed.

To address these issues, we recommend that the Bridges Decision Support Model be used as a framework to obtain and examine additional data on the Holocene geology of valley alluvium in the vicinity of bridges in Iowa. We recommend a project to apply the model to structures identified in the Iowa DOT’s five-year plan for bridge replacements. Such a project would simultaneously expand the database, refine the model, and “prescreen” a large number of structures for archaeological potential at a very early point in the planning process.

Acknowledgments. This project had its beginnings in a presentation I gave to a meeting of the Iowa DOT's and SHPO's Cultural Interchange Team. Their support, and in particular that of Larry Jesse, is much appreciated. SHPO and Iowa DOT staff too numerous to mention contributed ideas and insights that benefited this project. I am indebted to my staff, Melanie Riley and Chad Goings, for assembling and analyzing data, and to Colleen Eck and Angela Collins for report production. Carl Merry, John Doershuk, and Blane Nansel provided useful comments on the report. Art Bettis and Deb Quade provided geological advice, and Michele Fields provide EMRS documents. Patrick Brown and Pipat Reunsung at the Iowa State University GIS Facility were invaluable in web site creation and maintenance. Finally, the support of the Highway Research Board is very gratefully acknowledged.

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