Award Number G10AP00074

Detailed Surficial Geological Mapping for the Kampville and St. Charles 7.5' Quadrangles as a Portion of the St. Louis Area Earthquake Hazard Mapping Project (SLAEHMP)

Collaborative Research with:
United States Geological Survey; Earthquake Hazards Program Office
and
Missouri Department of Natural Resources;
Division of Geology and Land Survey

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7/1/2010 - 6/30/2011

Abstract

The Missouri Department of Natural Resources' Division of Geology and Land Survey (MoDNR' DGLS) proposed and has produced detailed geologic maps of surficial materials for the Kampville and St. Charles 7.5-minute USGS quadrangles as part of the St. Louis Area Earthquake Hazard Mapping Project (SLAEHMP). Surficial materials mapping comprises the first phase of seismic hazard assessment by reducing the uncertainty in the three dimensional distribution of surficial material units and their related physical properties.

DGLS compiled and correlated existing data from multiple databases to characterize the study area. The maps were produced in the Geographic Information System (GIS) geodatabase format to reduce file size and improve the quality and functionality of the final product.

Introduction

The goal of the project for fiscal year 2010 (FY10) was to complete new detailed surficial geologic maps for the Kampville and St. Charles 7.5' quadrangles. Depth to ground water is being addressed by the SLAEHMP Technical Working Group (TWG) to rectify the true potentiometric surface.

Mapping for this project was completed using available subsurface data and stratigraphic profiles developed for the St. Louis Surficial Materials Database, St. Louis Database and correlated with published small-scale surficial material maps (Goodfield, 1965; Lutzen and Rockaway, 1971; Allen and Ward, 1977). Existing small-scale maps and reports indicate that these areas have surficial material units that vary from early Quaternary loess and alluvium, with wide ranges in grain sizes and numerous areas of artificial fill. Boring data was incorporated to develop three-dimensional spatial variation of surficial material unit properties. This analysis will be used to assess the response of the alluvial column and liquefaction potential in response to different magnitude earthquakes and the potential for site amplification to improve the accuracy of earthquake hazard maps being prepared by the SLAEHMP TWG.

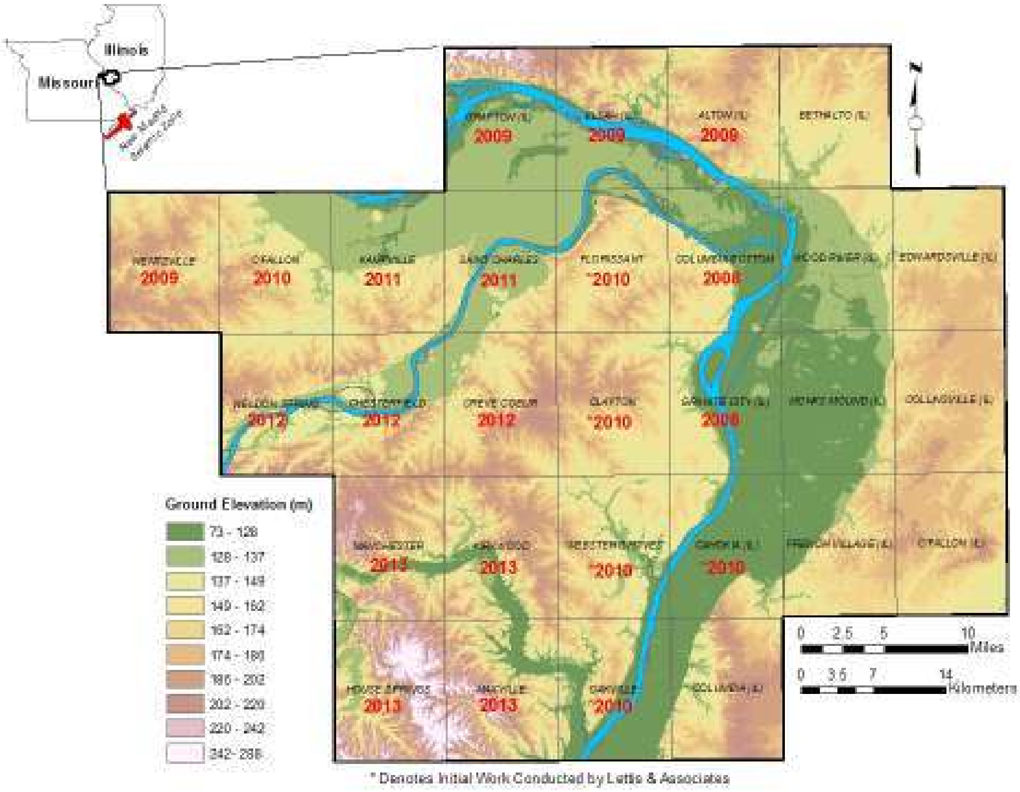


Figure 1. SLAEHMP AREA. The SLAEHMP study area and the proposed mapping priorities for the SLAEHMP TWG. Years listed in red denote the anticipated completion.

Methods

Borehole data derived from the division's St. Louis Surficial Materials Database developed by Jim Palmer as part of the National Earthquake Reduction Program (NEHERP) was supplemented by the St. Louis Database under development by Missouri University of Science and Technology (MS&T). All of the geotechnical information was compiled and correlated with the divisions' water well databases to identify any inconsistencies in depth to bedrock measurements. The corrected data was then imported into the divisions' geodatabase created for each individual quadrangle.

The Geographic Information System (GIS) geodatabase format is preferred over the GIS shapefile format. This change in mapping methodology increases productivity and functionality while reducing file size. The structure of the individual geodatabase includes feature data sets of major layer groups which include feature classes of specified data. An example of this structure is depicted in Figure 2. The Kampville and St. Charles geodatabases contain nine feature data sets. One of the feature data sets is transportation. Within the transportation feature data set are all the feature classes associated with transportation such as roads, railroads and various other transportation networks with their associated buffers. Within the data point feature data sets are five feature classes associated with the type of data point such as geotechnical borings, seismic cone penetrometer test, shallow seismic by method and bedrock penetration.

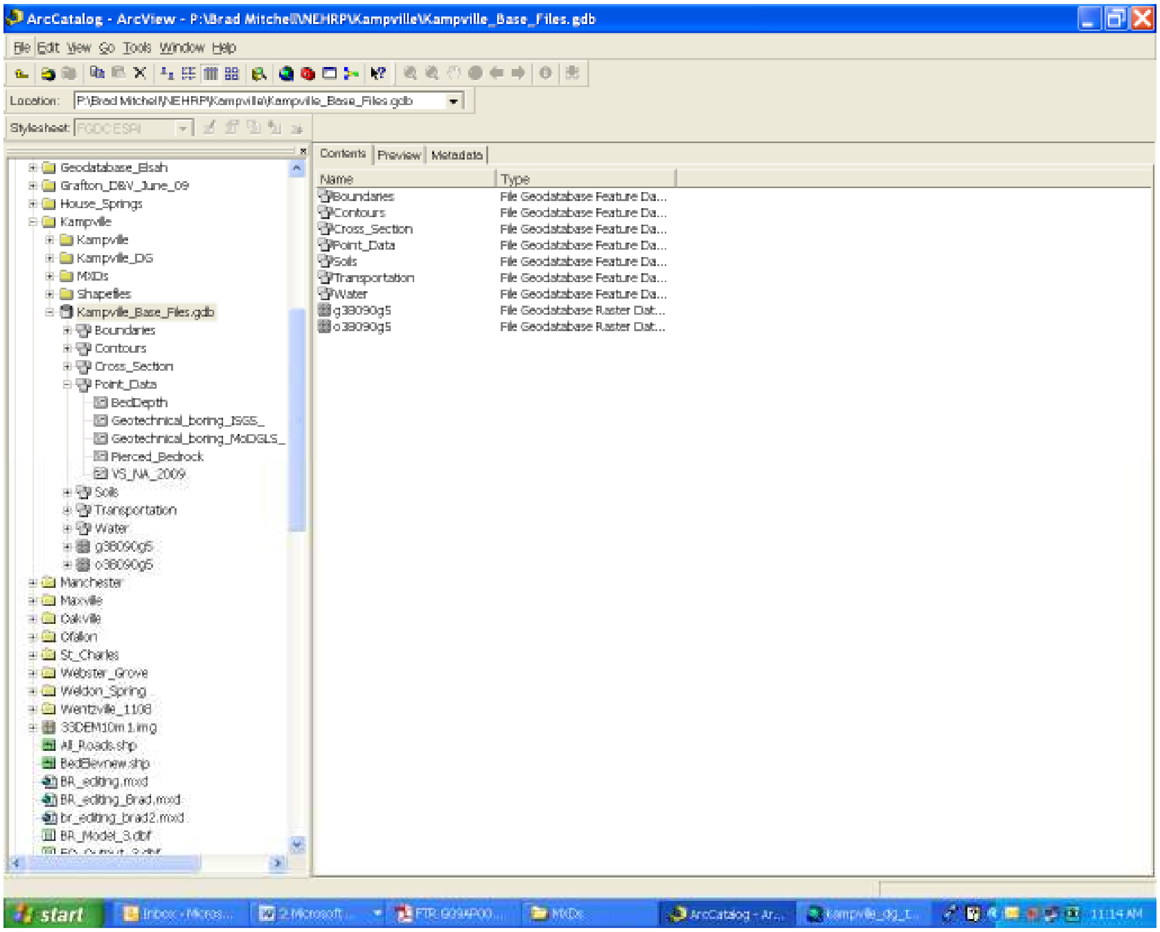


Figure 2. ARC CATOLOG. Screen shot of the structure of the Kampville geodatabase. The feature data sets are shown on the right while the feature classes contained in the feature data set, point data, are shown on the left.

The maps consist of a 1:24,000 scale surficial material geologic map, a 1:24,000 scale cross section, a 1:52,800 scale Surficial Material Thickness map with material thickness contours overlaying a USGS Digital Elevation Model (DEM), a 1:52,800 scale bedrock elevation map with contours overlying a USGS DEM and a 1:52,800 scale data point location map showing the spatial distribution of the types of data used in producing the maps and pertinent information for various points. An example of the surficial material geologic maps is depicted in Figure 3.

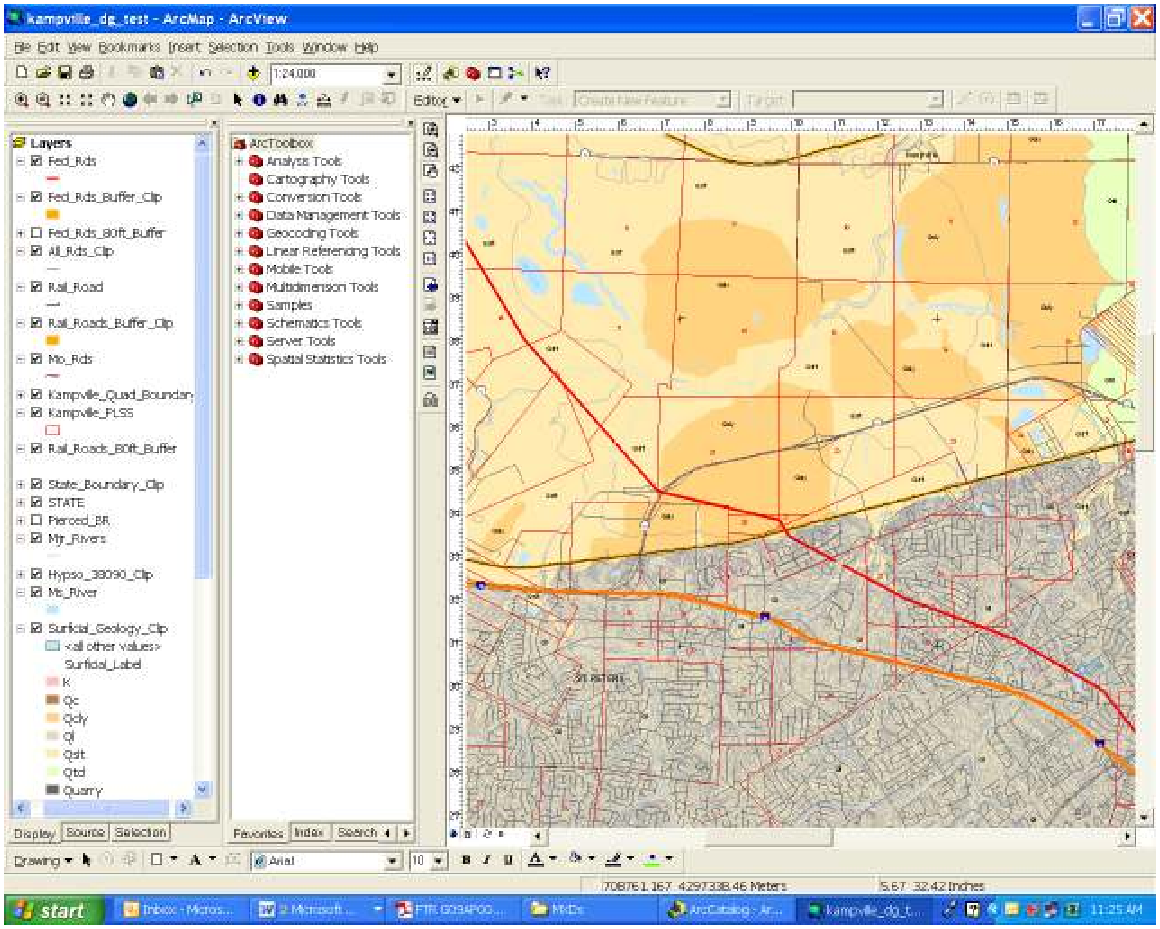
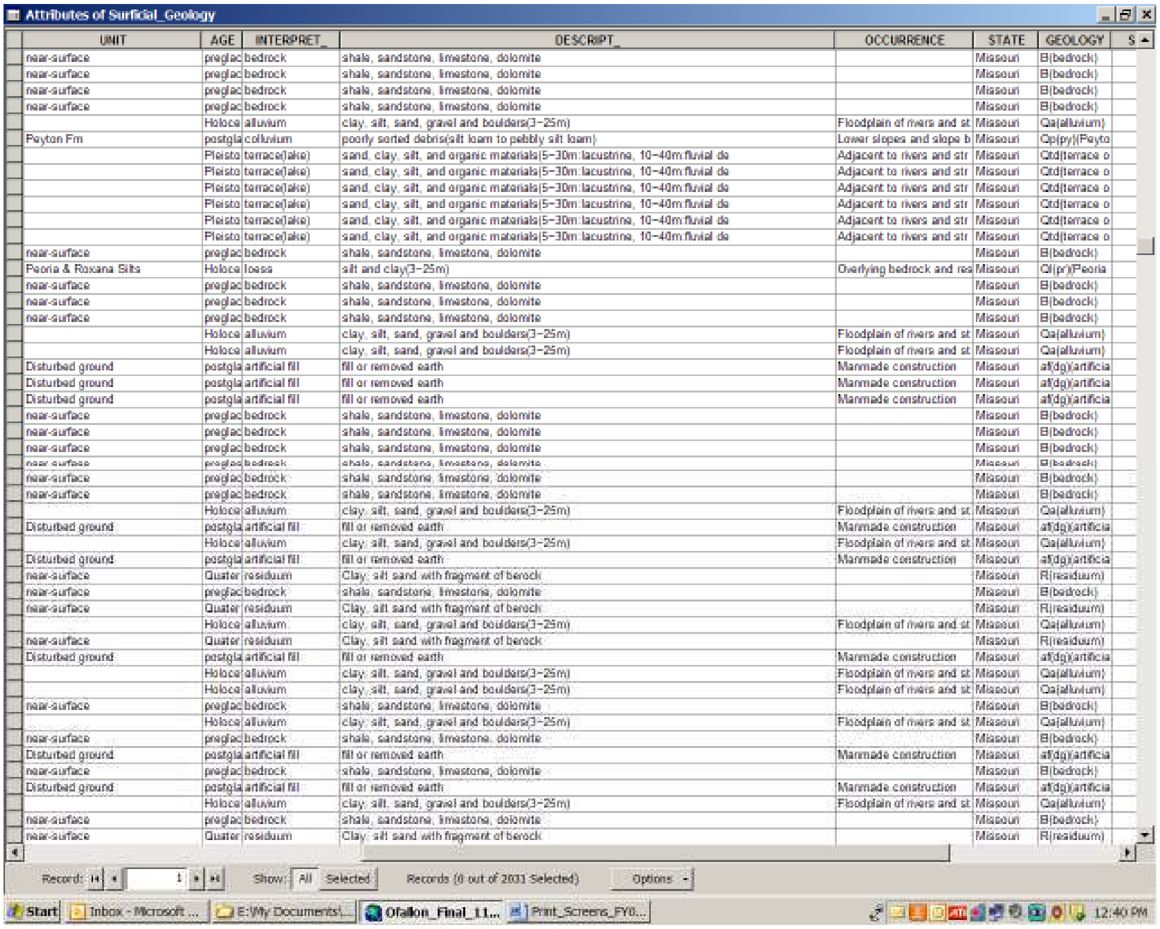


Figure 3. SURFICIAL GEOLOGY. The surficial material geologic map above displays the layered structure of the maps on the left. On the right is an example of the main map.

The surficial material geologic maps are in a layered format that includes all the pertinent information for the base maps. The base mapping was created at DGLS by editing features from the USGS 7.5' topographic maps, aerial photography from the National Agriculture Imagery Program (NAIP) 2007 and NAIP 2009 to represent annual surface water variations. NAIP 2008 was considered an editing source but inconsistencies in the imagery were identified so it wasn't used as a source. Using multiple imagery sets for editing keep the maps current as surface changes become apparent. The associated information of surficial material type and characteristics are included in the attributes table as shown in Figure 4.



Attributes of Surficial_Geology

UNIT	AGE	INTERPRET_	DESCRIPT_	OCCURRENCE	STATE	GEOLOGY	S
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
Peyton Fm	postgla	colluvium	poorly sorted debris(silt loam to pebbly silt loam)	Lower slopes and slope b	Missouri	Qp(py)(Peyto	
	Pleisto	terrace(lake)	sand, clay, silt, and organic materials(5~30m:lacustrine, 10~40m:fluvial de	Adjacent to rivers and str	Missouri	Qtd(terrace o	
	Pleisto	terrace(lake)	sand, clay, silt, and organic materials(5~30m:lacustrine, 10~40m:fluvial de	Adjacent to rivers and str	Missouri	Qtd(terrace o	
	Pleisto	terrace(lake)	sand, clay, silt, and organic materials(5~30m:lacustrine, 10~40m:fluvial de	Adjacent to rivers and str	Missouri	Qtd(terrace o	
	Pleisto	terrace(lake)	sand, clay, silt, and organic materials(5~30m:lacustrine, 10~40m:fluvial de	Adjacent to rivers and str	Missouri	Qtd(terrace o	
	Pleisto	terrace(lake)	sand, clay, silt, and organic materials(5~30m:lacustrine, 10~40m:fluvial de	Adjacent to rivers and str	Missouri	Qtd(terrace o	
	Pleisto	terrace(lake)	sand, clay, silt, and organic materials(5~30m:lacustrine, 10~40m:fluvial de	Adjacent to rivers and str	Missouri	Qtd(terrace o	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
Peoria & Roxana Silts	Holoce	loess	silt and clay(3~25m)	Overlying bedrock and res	Missouri	Ql(pr)(Peoria	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
Disturbed ground	postgla	artificial fill	fill or removed earth	Manmade construction	Missouri	af(dg)(artificia	
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Disturbed ground	postgla	artificial fill	fill or removed earth	Manmade construction	Missouri	af(dg)(artificia	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
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	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
Disturbed ground	postgla	artificial fill	fill or removed earth	Manmade construction	Missouri	af(dg)(artificia	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
Disturbed ground	postgla	artificial fill	fill or removed earth	Manmade construction	Missouri	af(dg)(artificia	
near-surface	Quater	residuum	Clay, silt sand with fragment of berock		Missouri	R(residuum)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
near-surface	Quater	residuum	Clay, silt sand with fragment of berock		Missouri	R(residuum)	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
near-surface	Quater	residuum	Clay, silt sand with fragment of berock		Missouri	R(residuum)	
Disturbed ground	postgla	artificial fill	fill or removed earth	Manmade construction	Missouri	af(dg)(artificia	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
Disturbed ground	postgla	artificial fill	fill or removed earth	Manmade construction	Missouri	af(dg)(artificia	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
Disturbed ground	postgla	artificial fill	fill or removed earth	Manmade construction	Missouri	af(dg)(artificia	
	Holoce	alluvium	clay, silt, sand, gravel and boulders(3~25m)	Floodplain of rivers and st	Missouri	Qa(alluvium)	
near-surface	preglac	bedrock	shale, sandstone, limestone, dolomite		Missouri	B(bedrock)	
near-surface	Quater	residuum	Clay, silt sand with fragment of berock		Missouri	R(residuum)	

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Figure 4. SURFICIAL GEOLOGY ATTRIBUTES. The surficial geology attributes table provides information about the materials being mapped. Displayed are common material types for the study area.

The attribute table lists the pertinent information for that feature class. The surficial material attribute table lists the type of feature, polygon, point or line, as well as symbol, description, interpretation, geologic setting, state, size and age of the surficial material if known. The project area contains approximately 2004 surficial material descriptions. The principle components of the thematic map contain attributes for the entire project area while periphery components are clipped to only contain the subject quadrangles. Characteristics of the surficial material are listed in the geotechnical data attributes table discussed later in this section.

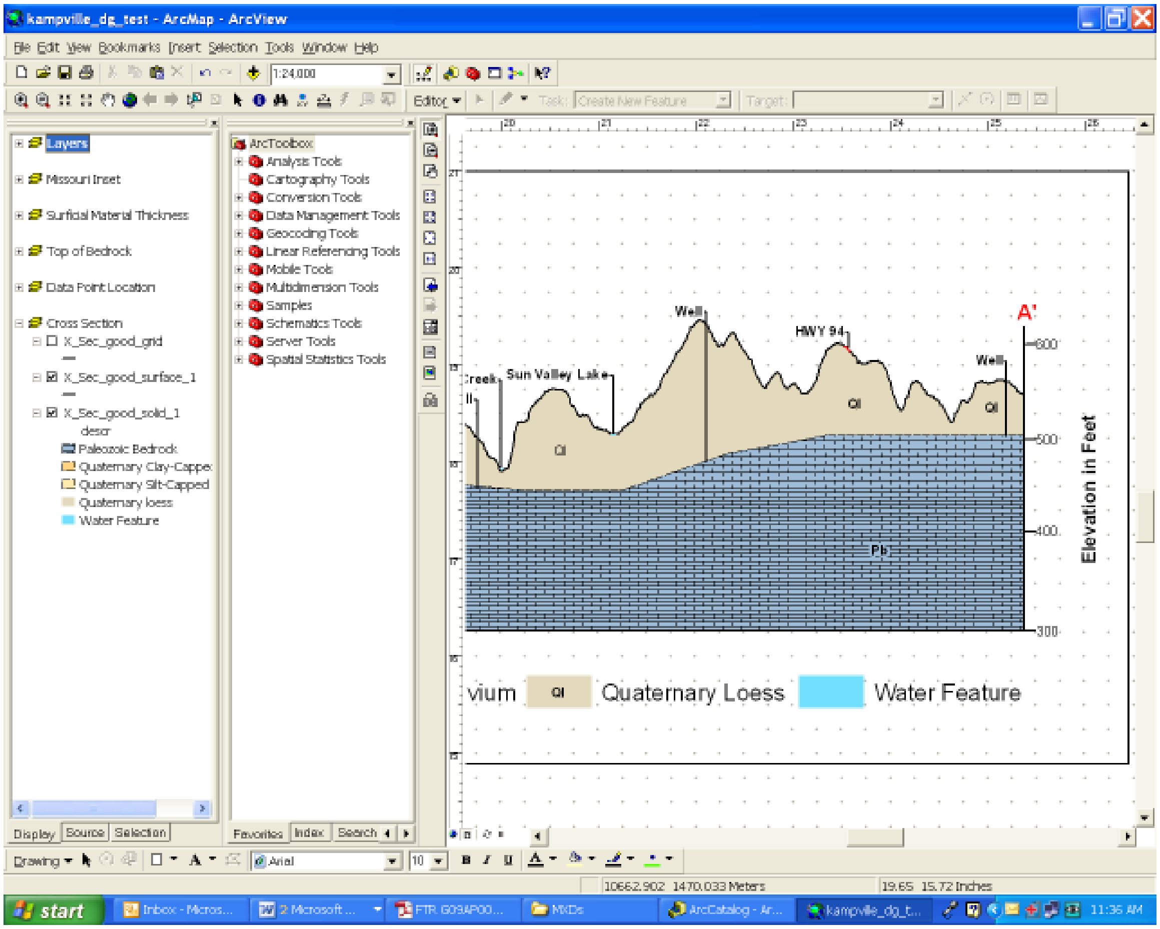

Figure 5. UPLAND CROSS SECTION. The 1:24,000 scale cross section provides a side view of the subject area. Above is the uplands portion of the depicted cross section. The cross section exhibits a 20X vertical exaggeration highlighting small variations in vertical change.

The 1:24,000 scale cross section in Figure 5 and Figure 6 was constructed using the same method as the surficial material geologic maps. The cross section lines were drawn from data point to data point across the subject quadrangles. The location of the cross section lines were selected to show geomorphic characteristics of the mapped areas and intersecting bedrock borings to allow better correlation of the bedrock surface. The topographic surface lines were generated from a DEM. The bedrock surfaces were interpreted from borings that intersect bedrock or that outcrop at the surface. Due to the changes in topography from the dissected uplands to the floodplain, a 20X vertical exaggeration was chosen so identification of low areas of relief could be recognized and mapped accordingly. Often, slight changes in topography within a floodplain can create higher or lower potentiometric surface values.

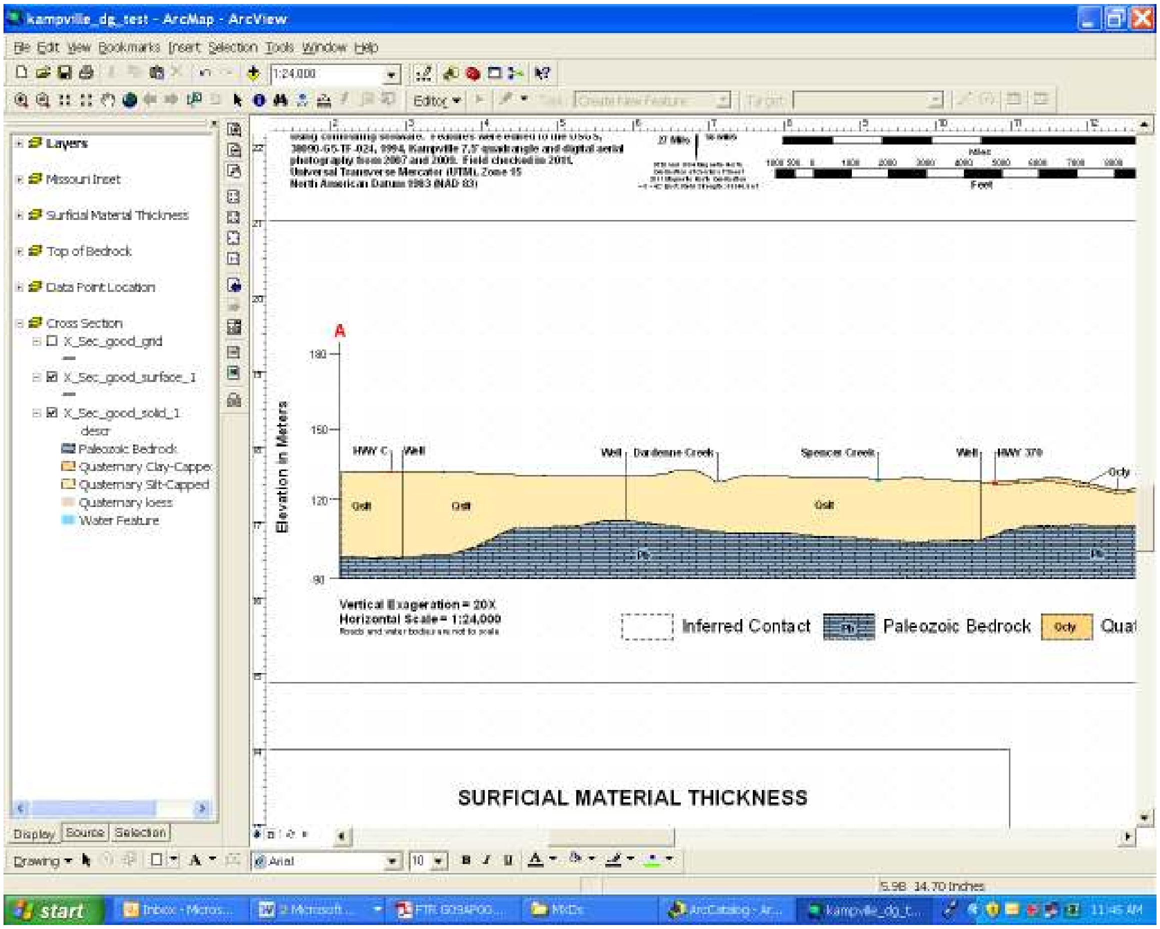

Figure 6. FLOODPLAIN CROSS SECTION. The 1:24,000 scale cross section provides a side view of the subject area. Above is the floodplain portion of the depicted cross section. The cross section exibits a 20X vertical exaggeration highlighting small variations in vertical change.

The floodplain portion of a cross section is depicted in Figure 6. The depth to alluvium (cap thickness) is quite variable and not well identified in boring logs. Therefore, the descriptions depicted on the cross sections are the symbology of the sediment cap. Seismic Cone Penetration Tests (SCPT) were performed on both quadrangles. The SCPT logs show various layered deposits of clay, silt, sand and gravels in variable amounts. This will be discussed later in the results section of the report.

The map layouts each contain 3 large scale inset maps showing the surficial material thickness, bedrock surface and data point locations. The inset maps are 1:52,800 scale maps, two of which use a DEM as a base layer while the third uses a surficial material geologic layer as a base layer. The inset maps are shown in Figures 7, 8 and 9.

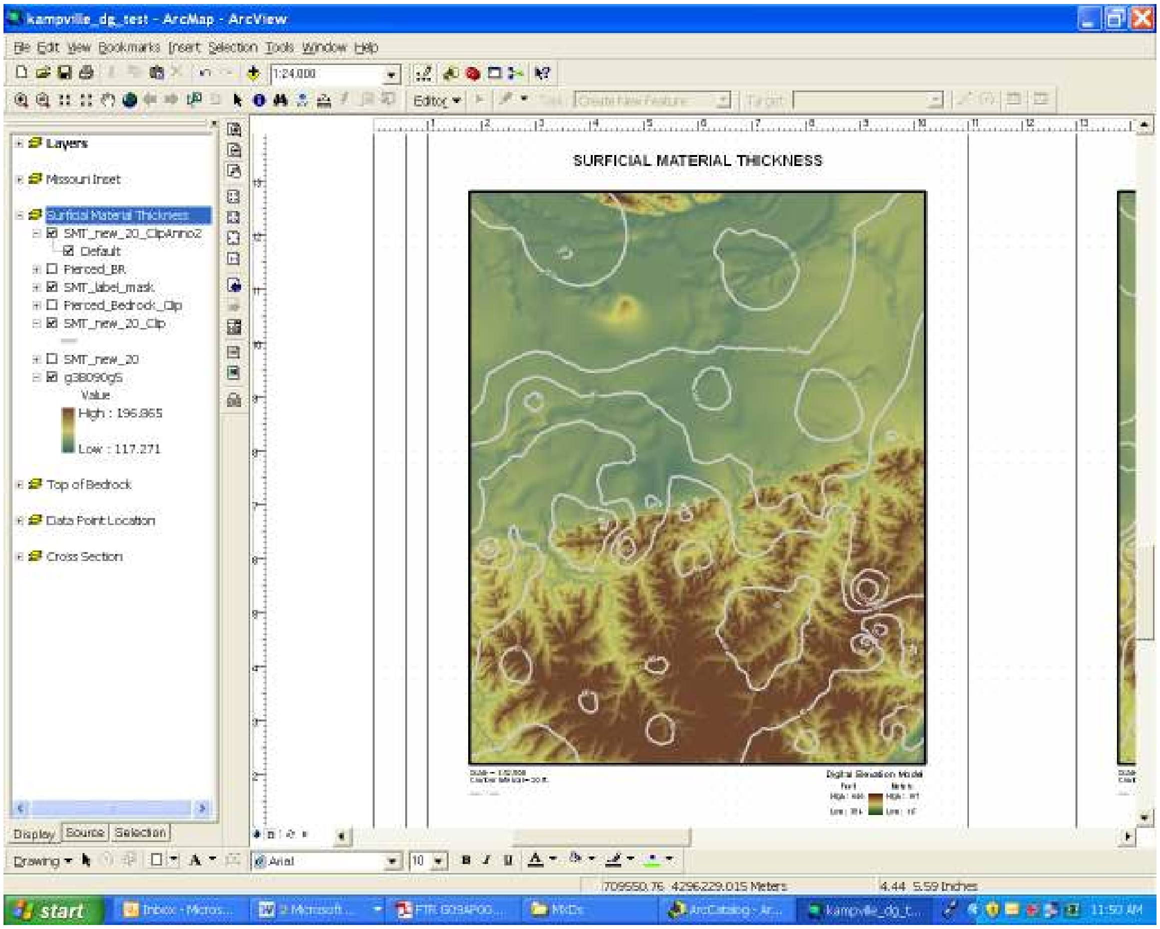

Figure 7. SURFICIAL MATERIAL THICKNESS. The 1:52,800 scale inset map displays the contoured thickness of the surficial material. The inset map has a 20 foot contour interval.

The surficial material thickness inset maps were constructed at a 1:52,800 scale and use a USGS DEM as the base layer. Thickness of surficial material was derived from the difference in elevation and depth to bedrock. The data was then processed using contouring software to interpret surficial material thickness. The contours were drawn using Inverse Distance Weighting (IDW) which provided generalities of the thickness. The contours were then hand edited to account for geomorphic and geologic influences. Older large and small scale maps were also referenced along with the divisions' water well databases. The types and characteristics of surficial material exist in the surficial geology attribute table and the geotechnical boring attribute table.

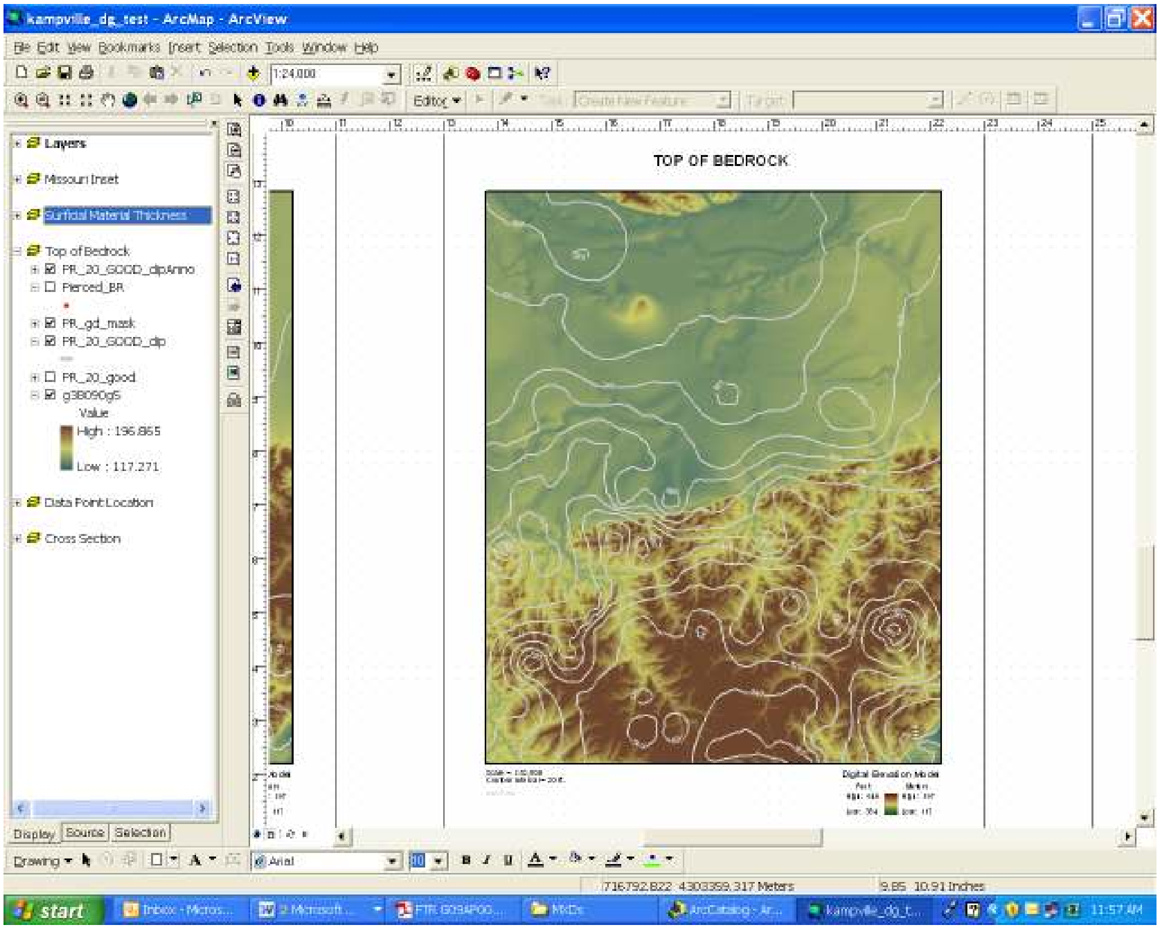

Figure 8. TOP OF BEDROCK. The 1:52,800 scale top of bedrock inset map displays the bedrock surface contours. The inset map has a 20 foot contour interval.

The top of bedrock inset maps were constructed at a 1:52,800 scale and use a USGS DEM as the base layer. The depth to bedrock determination was made by correlating drilling logs, shallow seismic surveys and water well databases from DGLS. The data was then processed using contouring software to interpret the bedrock surface. The contours were drawn using IDW which provided generalities in the bedrock surface. The contours were then hand edited to account for geomorphic and geologic influences. Older large and small scale maps were also referenced. The bedrock borings and lithological characteristics are depicted in the bedrock attribute table.

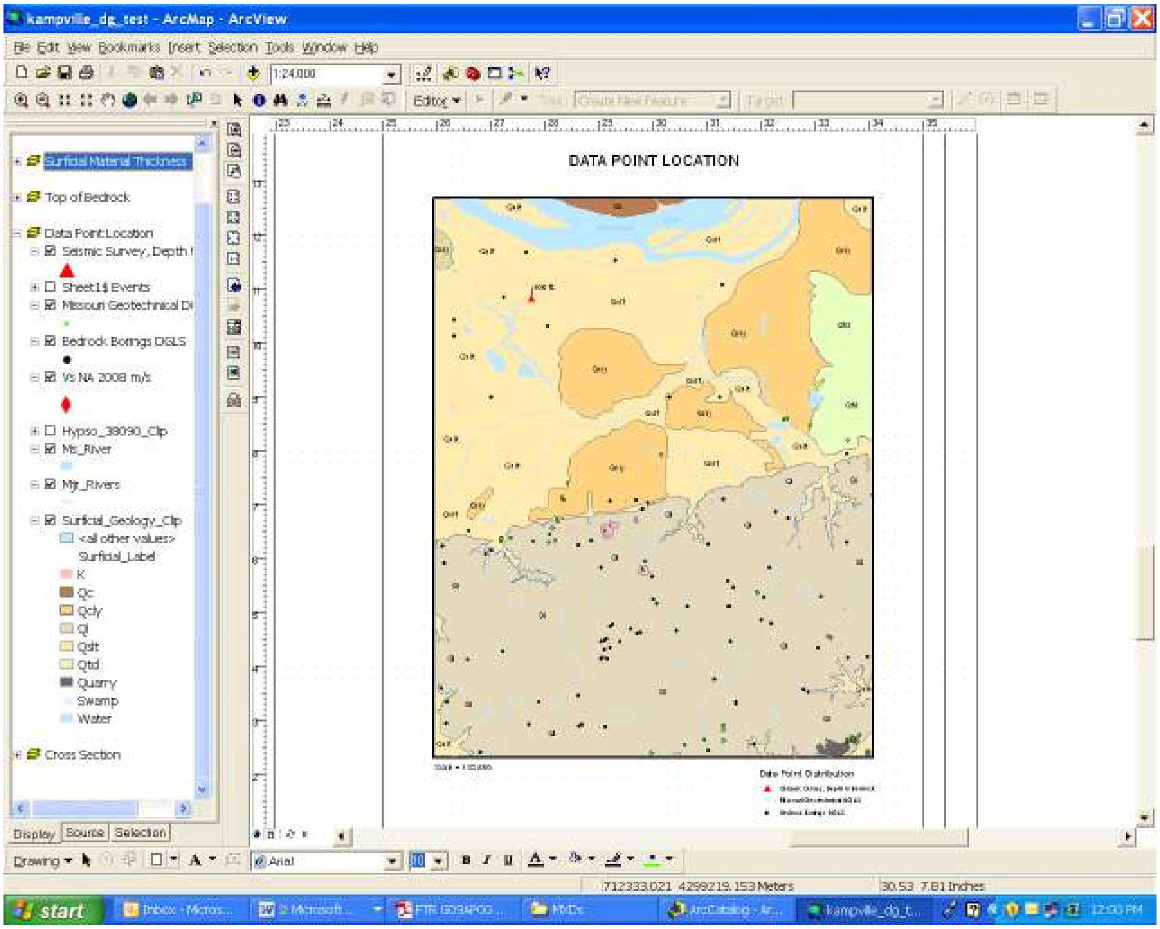

Figure 9. DATA POINT LOCATION. The 1:52,800 scale data point location inset map displays the spatial distribution and type of data points.

The data point location inset maps were constructed at a 1:52,800 scale and use a surficial geology layer as the base layer. These maps display the type of data points such as geotechnical boring, bedrock boring or seismic survey methods.

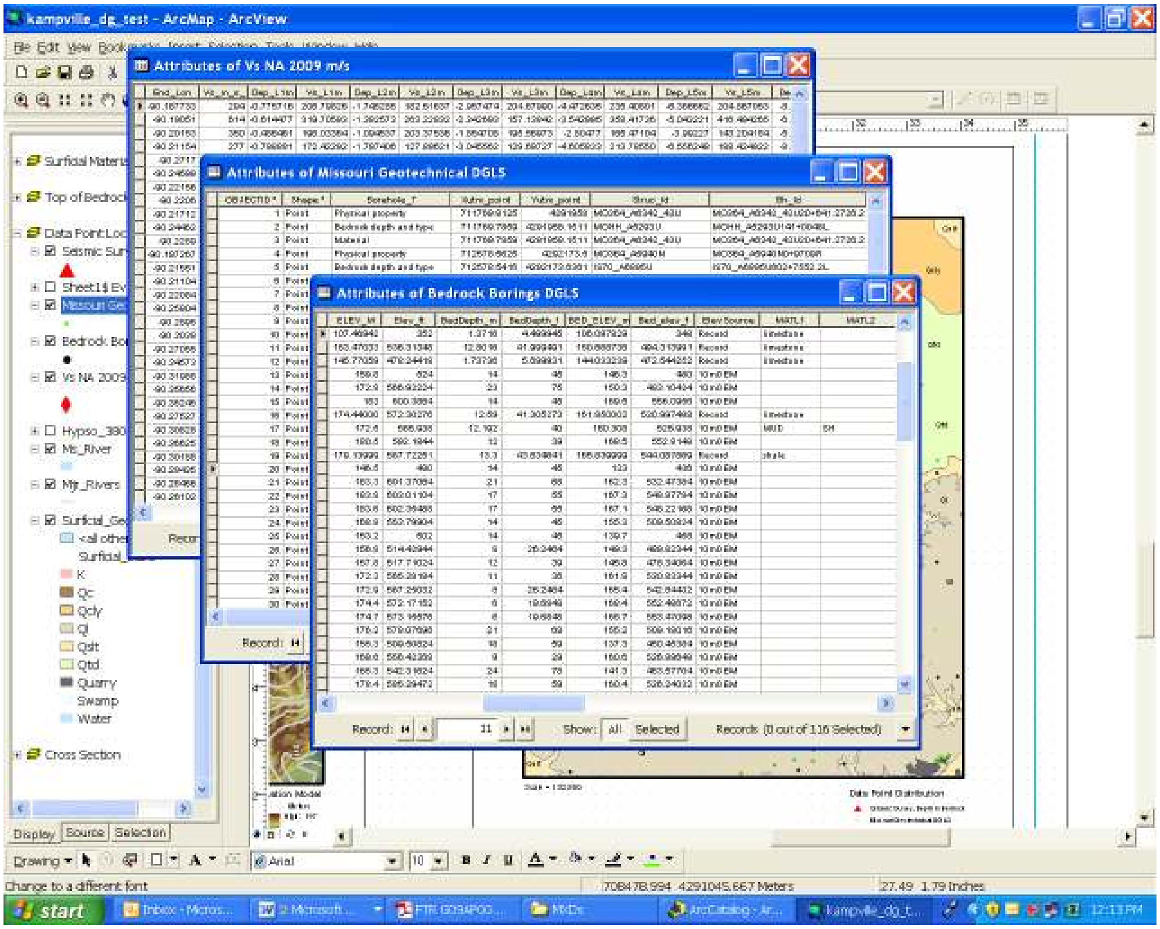

Figure 10. DATA POINT ATTRIBUTES. The screen shot displays the attribute tables of three of the five feature classes within the data point location feature data set. The attributes displayed are from the shear wave (v/s), geotechnical borings and the bedrock borings.

Each of the feature classes in each feature data set contains the information pertinent to that particular class. The "bed depth" feature class contains 12,189 lines of information. Each line is a data point within the project area. The attribute table lists the information in a table format and operates similar to other database tables. The desired fields are then added and populated. The attributes for the feature classes bed depth, geotechnical borings, shear wave velocity (Vs) and surficial geology contain the data for the entire project area while others only contain information for the particular quadrangle. When a feature class is being edited, the changes are also applied to all other feature classes within the feature data set. This allows greater continuity within the maps attribute tables and increased productivity.

A SCPT was performed at 2 locations in the St. Charles quadrangle under a cooperative agreement with the Missouri Department of Transportation (MoDOT). The SCPT sampling locations were based on accessibility and spatial gaps in shear wave velocity information, as well as the need to evaluate materials beneath transportation infrastructure. Subsurface data and stratigraphic profiles were reviewed and compared with published small scale surficial material maps and other previously developed genetic and lithostratigraphic surficial material models to facilitate mapping. These data points were used to verify surficial material types and thicknesses, not to generate top of bedrock elevation contours. This analysis is necessary to assess seismic wave amplification and liquefaction potential of unconsolidated material. In addition, the accuracy and precision of earthquake hazard maps being produced by the SLAEHMP TWG will be improved through the application of this information.

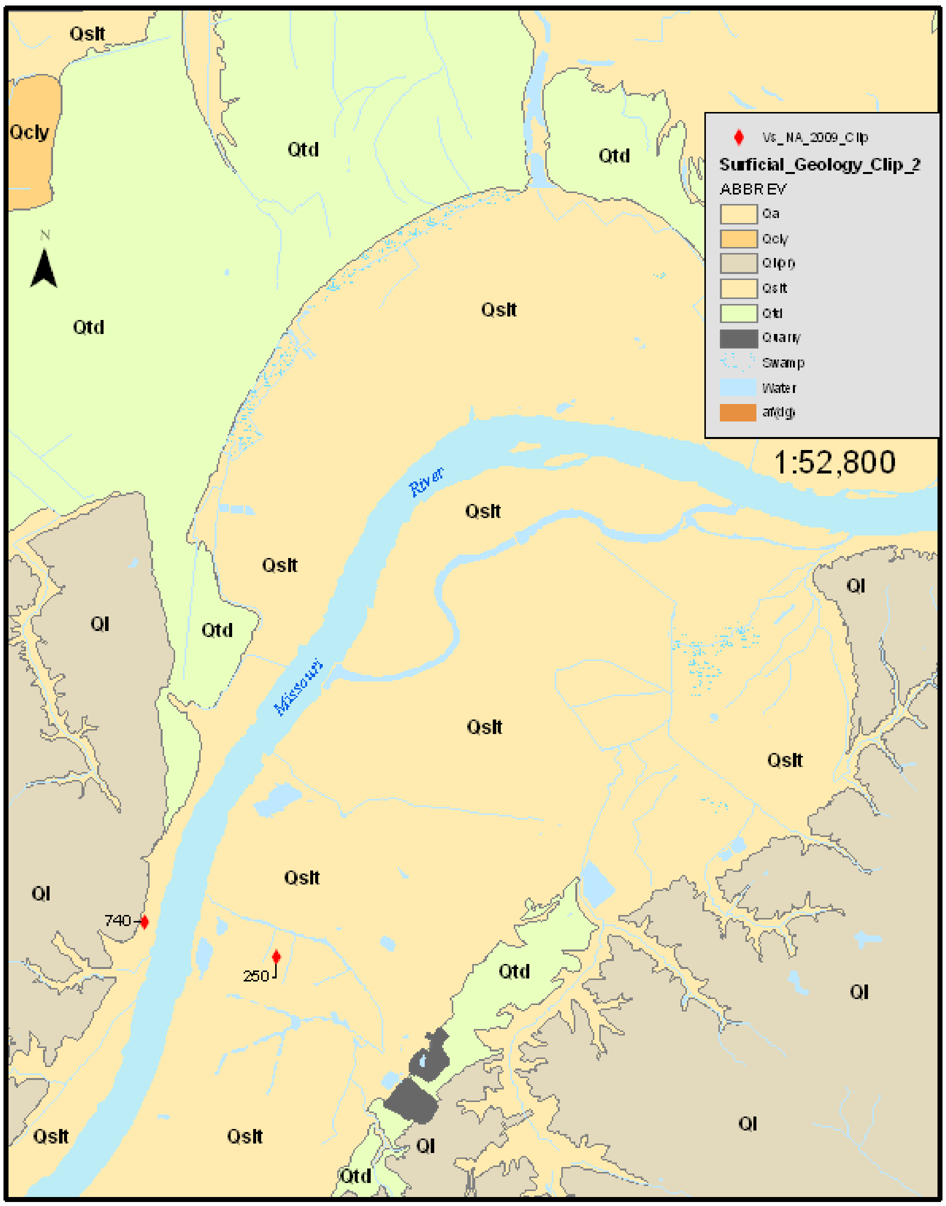

Figure 11. SCPT LOCATIONS. The SCPT test sites displayed above contain 2 test sites conducted in 2009 by the DGLS and the Missouri Department of Transportation.

Results

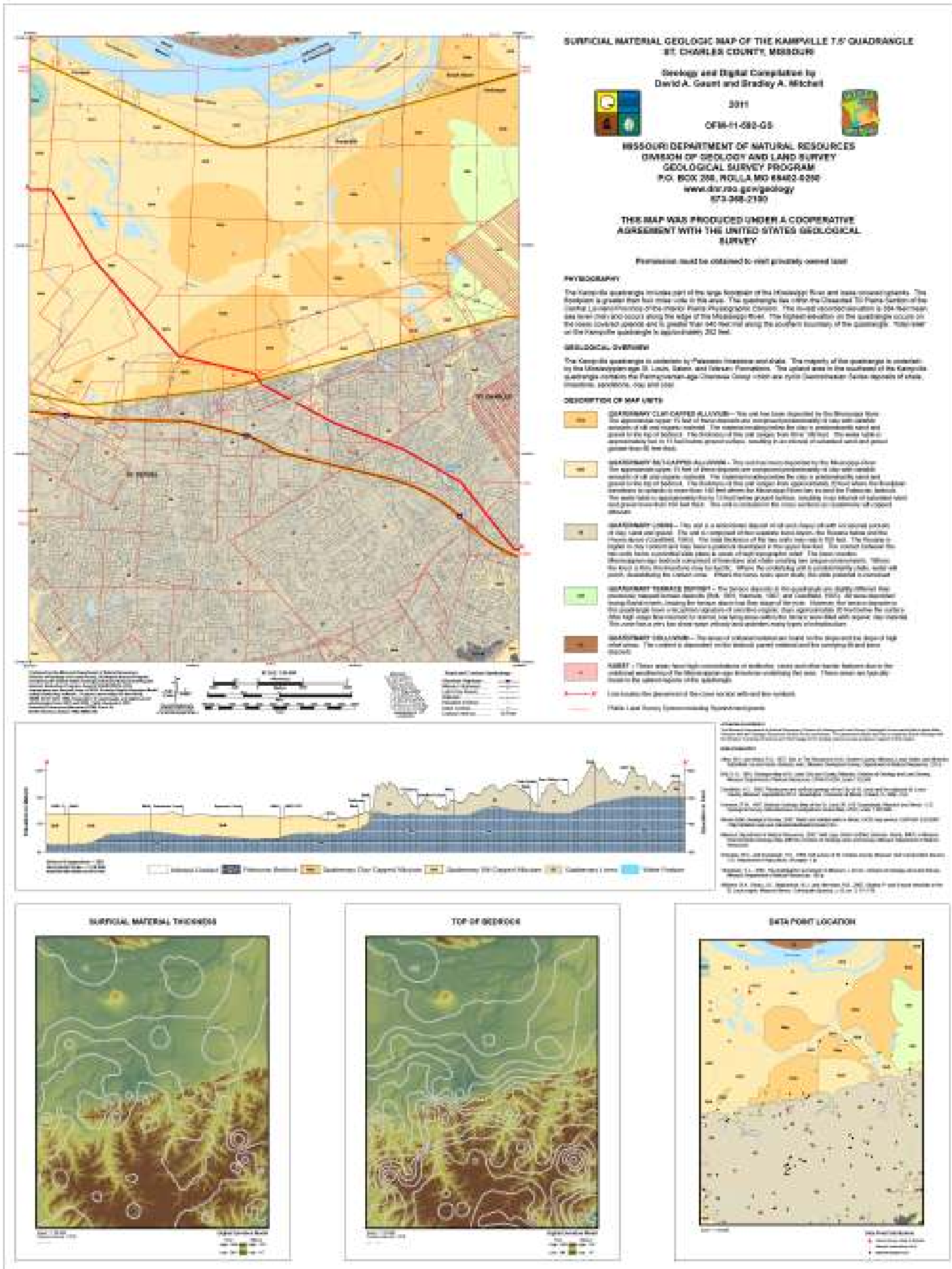

Figure 12. SURFICIAL MATERIAL GEOLOGICAL MAP OF THE KAMPVILLE QUADRANGLE. The Kampville quadrangle contains various surficial materials and displays the complex nature of the study area.

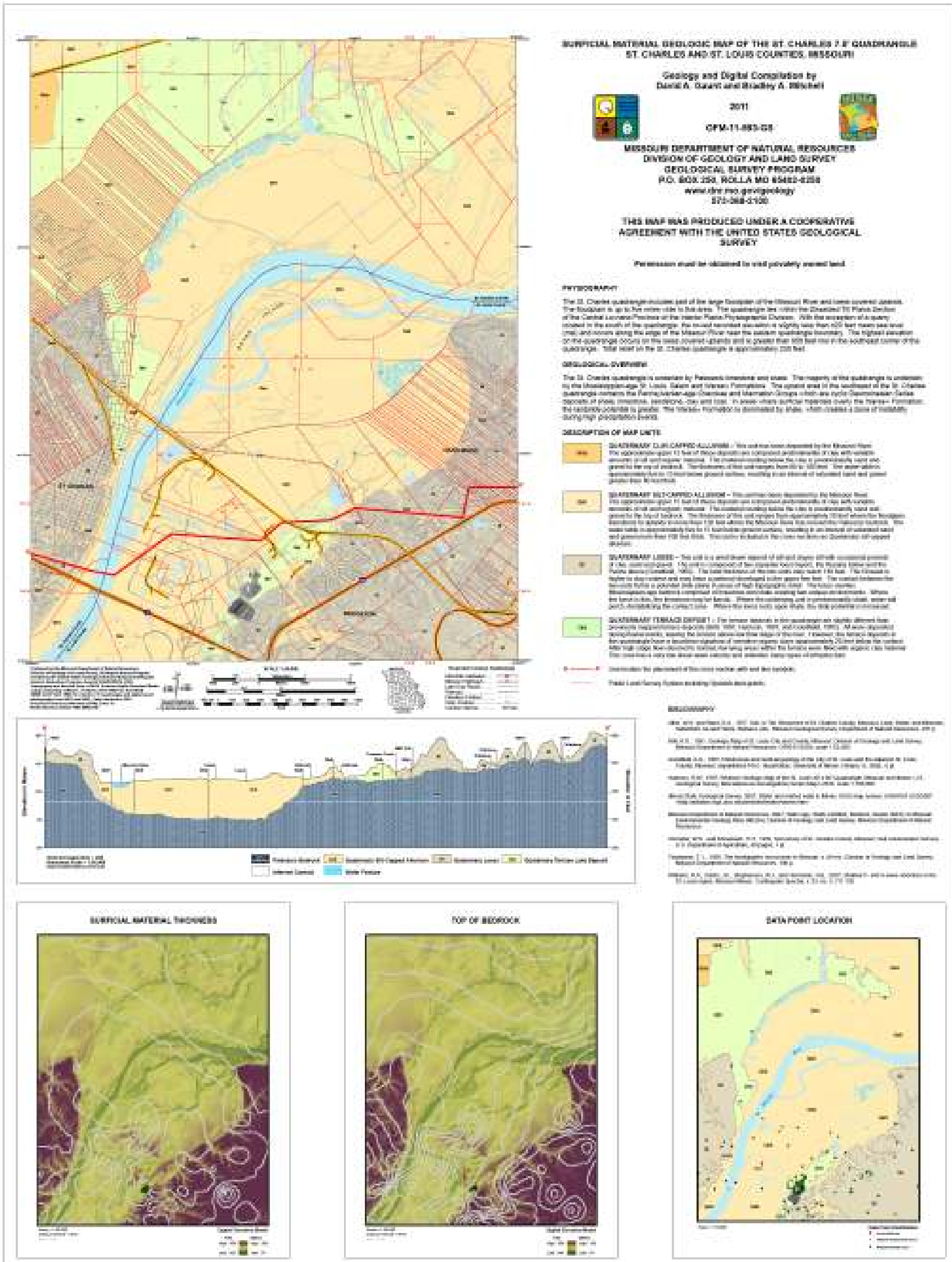

Figure 13. SURFICIAL MATERIAL GEOLOGICAL MAP OF THE ST. CHARLES QUADRANGLE. The St. Charles quadrangle contains various surficial materials and displays the complex nature of the study area.

The area represented by the Kampville quadrangle is covered by between 10 feet and greater than 100 feet thick deposits of loess on the upland areas and alluvium greater than 140 feet thick in the floodplain. The bedrock surface in the upland area of the Kampville quadrangle can reach elevations of 580 feet mean sea level (msl) but is more commonly between 460 feet msl and 560 feet msl. At the mouth of the tributaries the bedrock surface is consistently around 400 feet msl while the bedrock surface at the head of the tributaries varies between 440 feet msl and 460 feet msl. The floodplain bedrock surface elevation ranges from 400 feet msl at the upland edge, to 300 feet msl toward the interior of the floodplain.

The area represented by the St. Charles quadrangle is covered by between 20 feet and greater than 100 feet thick deposits of loess on the upland areas and alluvium greater than 120 feet thick in the floodplain. The floodplain is lined with thick terrace lake deposits that are occasionally overlain from resulting weathering and transportation of the loess to the toe of slopes. The bedrock surface in the St. Charles quadrangle upland areas is highly variable. Bedrock surface ranges from approximately 440 feet msl to 540 feet msl excluding an area of aggregate mining which creates a bedrock surface as low as 243 feet msl. Floodplain areas of the quadrangle have bedrock elevations that range from 300 feet msl to 440 feet msl. However, consistent measurements of 340 feet msl to 400 feet msl are the most common.

Conclusion

The surficial material geologic maps for the Kampville and St. Charles 7.5’ quadrangles have been completed as deliverables in fulfillment of award number G10AP00074. These maps were compiled using new and existing data derived from the St. Louis Surficial Material Database (formerly compiled by DGLS), St. Louis Database, shallow seismic surveys, SCPT and from various sources listed in the bibliography.

The maps were constructed in a GIS geodatabase format for improved quality of the finished product. Each 7.5’ quadrangle in the project area is its own geodatabase to be easily seamed with the other quadrangles in the project area. This provides the base for the latest mapping techniques to be applied. Attribute tables are associated with each feature class in the geodatabase for ease of viewing the data. While increasing the quality of the product, the division was able to reduce the file size while also increasing storage capacity to facilitate the maps ease of transfer.

Specific age of mapped units was not determined or depicted, only their age in respect to other mapped units. Considerations were given to small scale maps in the region which were produced by former DGLS. Inset contour maps were developed using a 10 m DEM and data points across the 22 quadrangle SLAEHMP project site to generate contours based on the surficial material thickness and elevation of the top of bedrock. Contours were generated using a 20 foot contour interval and clipped to the specific quadrangle boundary. A surficial material vector map was utilized as the base map to display the spatial distribution of the point data. The inset maps were generated and added to the final map product.

The geologic surficial material mapping is the first product developed for seismic hazard analysis. The data gathered in the mapping process is critical base information in seismic hazard analysis. The depth to bedrock, depth to water table and type of surficial material is the fundamental basis for seismic assessment. Analysis of this data is used to assess how the alluvial column will respond to different magnitude earthquakes with respect to liquefaction potential and site amplification. This improves the accuracy and precision of earthquake hazard maps being prepared by the SLAEHMP TWG.

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