Award Number 08HQAG0129

Proposal to Develop Detailed Surficial Geological Maps for the Alton, Elsah and Grafton 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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Abstract

The Missouri Department of Natural Resources' Division of Geology and Land Survey (MoDNR' DGLS) proposed and has produced geologic maps of surficial materials for the Missouri portion of the Alton, Elsah and Grafton 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. Shallow seismic surveys conducted by DGLS and Missouri University of Science and Technology (S&T) yielded P-wave velocities of 400 m/s, 1654 m/s, and 3609 m/s from the last depositional event through the alluvium column to the underlying limestone bedrock. Seismic cone penetration tests (SCPTs) performed by DGLS and the Missouri Department of Transportation (MoDOT) yielded shear wave velocities ranging from 117 m/s to 588 m/s to a depth from 11 to 20 meters. Most of the shear wave velocities are clustered between 170 m/s and 280 m/s. These data points were used to verify surficial material type and thickness and to generate top of bedrock elevation contours. This analysis is necessary to assess seismic wave amplification and liquefaction potential of unconsolidated material.

Introduction

The goal of the project for FY08 was to complete new detailed surficial geologic maps for the Alton, Elsah and Grafton 7.5' quadrangles in the SLAEHMP study area (Figure 1). The mapping was completed using available subsurface data and stratigraphic profiles developed for the St. Louis Surficial Materials Database, St. Louis Geodatabase 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 till, loess and alluvium, with wide ranges in grain sizes and small areas of artificial fill. The 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 Technical Work Group (TWG).

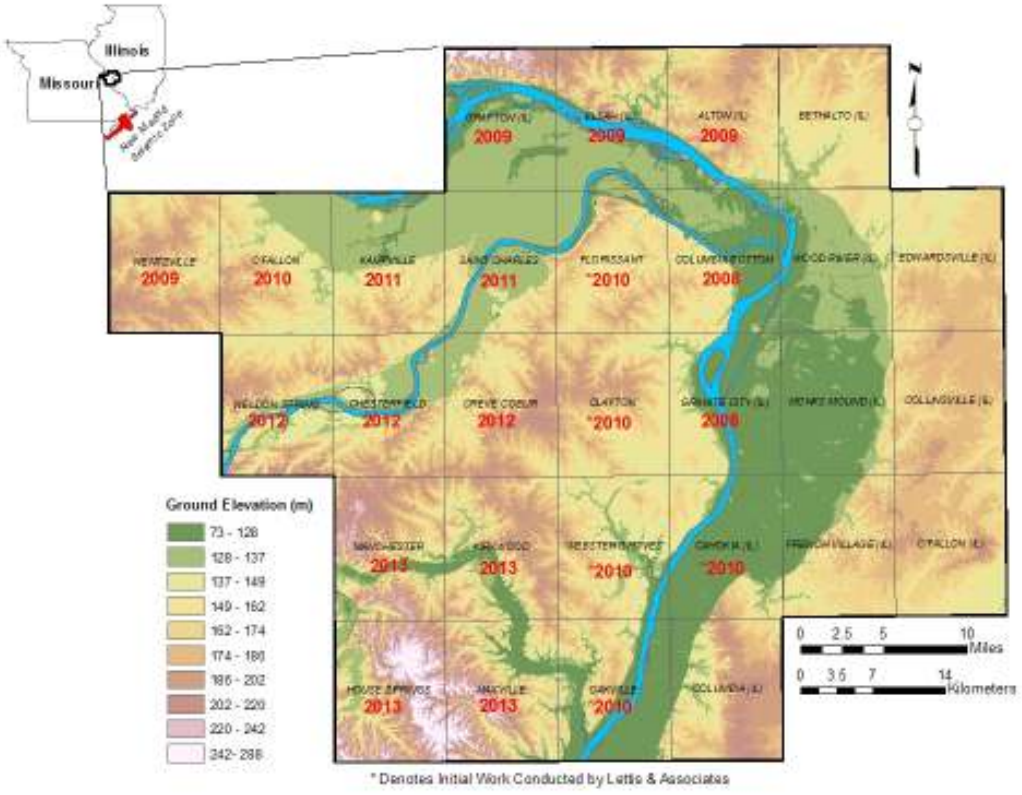

Figure 1. SLAEHMP AREA. The SLAEHMP study area and proposed mapping priorities for the SLAEHMP TWG. The years listed in red denote the year anticipated to be complete.

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 GeoDatabase 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 and depth to groundwater measurements.

A seismic refraction survey using a 24 channel Geometrics Geode Ultra-Light Exploration Seismograph was conducted by DGLS in cooperation with S&T to determine the seismic velocities of the subsurface layers, the nature of the lithology and the depth to bedrock in the floodplain confluence area of the Missouri and Mississippi Rivers. A 10 pound sledge hammer source, 5 meter (m) geophone interval, 120 m spread length and a 10 m offset were generally adopted throughout the survey. Forward and reverse surveys were taken in perpendicular directions to determine the depth and orientation of the bedrock. Travel-time graphs were plotted from the picks of the first arrivals of the primary P-wave and were used to determine the apparent and true velocities of the layers. Three layers were identified with an average velocity of 400 m/s, 1654 m/s, and 3609

m/s, respectively. The shallow seismic surveys will provide a better understanding of the amplification that will occur at the transition from the bedrock into the alluvium in the event of an earthquake.

A Seismic Cone Penetration Test (SCPT) was performed at six locations 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. Sampling depths ranged from 11 m to 20 m before reaching refusal while shear wave velocities ranged from 117 m/s to 588 m/s. Subsurface data and stratigraphic profiles were reviewed and compared with published small scale surficial material maps (Goodfield, 1965; Lutzen and Rockaway, 1971; Allen and Ward, 1977) and other previously developed genetic and lithostratigraphic surficial material models to facilitate mapping. These data points were used to verify surficial material type and thickness and 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 Technical Working Group (TWG) will be improved through the application of this information.

Seismic Data Collection Results

The majority of the shear wave velocities ranged from 170 m/s to 280 m/s (Figure 2) in the vertical column providing a detailed perspective on the response of the alluvial column to an earthquake.

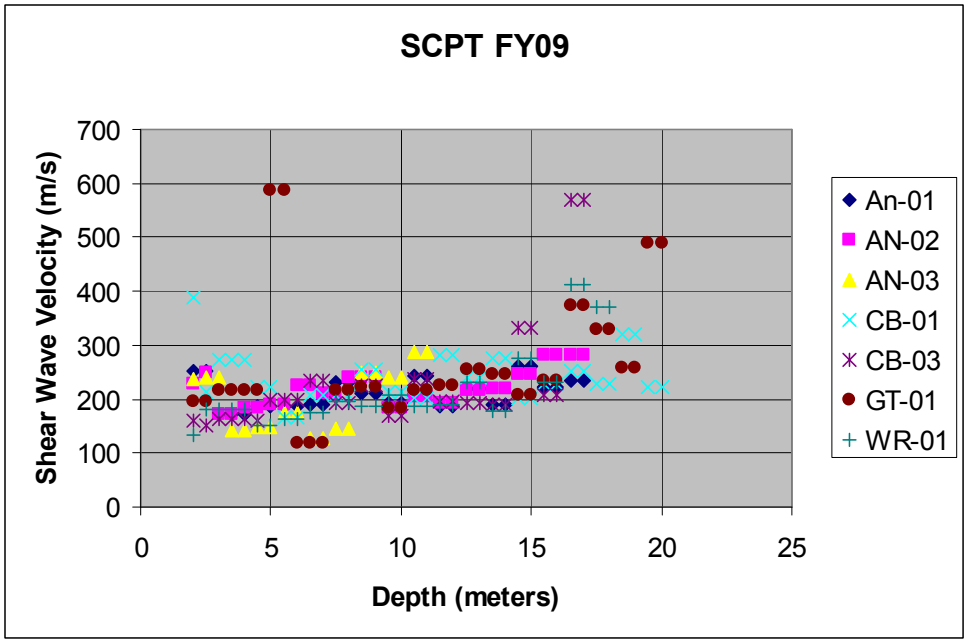

Figure 2. Results of the SCPT data show a clustering of shear wave velocities between 170 m/s and 280 m/s. Sampling began at two meters in depth.

The shallow seismic survey revealed a much thicker alluvial column in the Grafton quadrangle area of the confluence (Table 1) with an average depth ranging from 54 m to 60 m. This variability in the bedrock surface of the confluence area is expected but the bedrock surface of the confluence area of Elsah and Alton quadrangles becomes more uniform in the down stream direction with an average depth to bedrock of approximately 41 m.

Table 1. Shallow Seismic Survey Results. Showing the average P-wave velocities and depth to bedrock. Areas with numerous lines were averaged by location.

Location: Mars Conservation Southern Gate (W-E)				
	V1 (m/s)	V2 (m/s)	V3 (m/s)	Ave Depth of Bedrock (m)
L#2	328.04	1639.21	2232.91	54.41
L#3	341.44	1624.09	2362.42	54.07
L#1	303.03	1568.63	2720.59	56.01
Group Average	**324.17**	**1610.64**	**2438.64**	**54.83**
Location: Mars Conservation Southern Gate (S-N)				
	V1 (m/s)	V2 (m/s)	V3 (m/s)	Ave Depth of Bedrock (m)
L#4	**341.17**	**1704.99**	**2408.11**	**58.56**
Tilts to the South = 5 degrees				
Location: Mars Conservation Northern Gate (W-E)				
	V1 (m/s)	V2 (m/s)	V3 (m/s)	Ave Depth of Bedrock (m)
L#6A	297.95	1708.97	5353.83	59.11
L#6B	300.82	1711.43	6329.30	60.37
L#6C	329.00	1641.97	2859.14	61.32
Group Average	**309.26**	**1687.46**	**4847.42**	**60.26**
Location: West Alton at AH02 (S-N)				
	V1 (m/s)	V2 (m/s)	V3 (m/s)	Ave Depth of Bedrock (m)
L#AH02	**625.40**	**1614.08**	**4743.27**	**41.50**
Tilts to the North = 3 degrees				

Conclusion

The surficial material geologic maps for the Missouri portion of the Alton, Elsah and Grafton 7.5' quadrangles have been completed as deliverables in fulfillment of award number 08HQAG0129. These maps were compiled using new and existing data derived from the St. Louis Surficial Material Database (formerly compiled by DGLS), St. Louis Geodatabase, shallow seismic surveys, SCPTs and from various sources listed in the bibliography.

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 produced by former DGLS staff in addition to large scale map produced by the Illinois Geological Survey and Lettis and Associates, Inc. Inset contour maps were developed using a 10 m Digital Elevation Model (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 10 foot contour interval and clipped to the specific quadrangle boundary. A 10 m DEM was also 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 bases 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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