I-66 CORRIDOR STUDY
WESTERN KENTUCKY TO MISSOURI
BALLARD / MCCRACKEN COUNTY - ITEM # 1-23.00

APPENDIX 5 – GEOTECHNICAL OVERVIEW

Prepared for

Kentucky Transportation Cabinet (KYTC) – Division of Planning

Kentucky Transportation Cabinet (KYTC) – District 1

Missouri Department of Transportation (MoDOT)

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1. Project Description

The Kentucky Transportation Cabinet (KYTC) is evaluating potential roadway corridors for the construction of Interstate Route I-66 through portions of Marshall, Graves, Ballard, Carlisle, and McCracken Counties, Kentucky; Mississippi, Scott and Cape Girardeau Counties, Missouri; and Alexander, Pulaski, and Massac Counties in Illinois. Also under review are two potential Ohio River crossings and three Mississippi River crossings. These corridors were initially developed through public input and have been processed through three levels of evaluation designated Levels 1, 2 and 3, respectively. Maps presenting the various corridors studied during each level of evaluation are presented throughout the full project report. Level 1 Alternatives were the initial compilation of corridors suggested by the public, and included 22 potential roadway corridors crossing various portions of Missouri, Illinois, and Kentucky. The ensuing Level 2 Alternatives consisted of seven corridors primarily in Kentucky and Missouri with various bridge options, as well as one unspecified corridor in Illinois. The Level 3 Alternatives focused primarily on three corridors in Kentucky, a single corridor in Missouri and bridge options across the Mississippi River.

For the purpose of this geotechnical overview, three composite roadway corridors and three bridge crossing locations were selected by the Project Team for geotechnical review. A preliminary geotechnical overview was performed on combined corridor 11, 12, 13, 14, 15 and 21 as presented in the Level 2 Alternatives; Corridor 8 as presented in the Level 2 Alternatives; and Corridor 8B as presented in the Level 3 Alternatives.

The composite of roadway corridor 11, 12, 13, 14, 15 and 21 as presented in the Level 2 Alternatives begins on the west side of I –24 between the interchanges with US 68 and US 62 immediately southwest of the city of Paducah. The corridor roughly follows US 45 in a southwesterly direction to the intersection with KY Route 1322 (Lovelaceville Road). The corridor then follows KY 1322 west to the intersection with KY Route 726. Immediately north of this intersection, KY Route 286 is encountered which leads the corridor to the west near the city of Wickliffe. The corridor progresses over the Mississippi River at mile point 951, just south of the Fort Jefferson Historic Memorial and below the confluence of the Mississippi and Ohio Rivers. Upon crossing the Mississippi River, the corridor traverses the Birds Point-New Madrid Floodway, and continues west to a terminus at a common intersection with existing I-57 near the community of Charleston, in Mississippi County, Missouri.

Corridor 8 – Level 2 Alternatives begins near US 60 south of the community of Barlow and proceeds west-northwest through the Barlow Bottoms to the Ohio River. This corridor crosses the Ohio River at approximate River Mile point 975 near the mouth of the Cache River, and into Pulaski County, Illinois.

Corridor 8B – Level 3 Alternatives begins in Kentucky at the intersection of US 60 and I-24 and proceeds to the west along the existing US 60 alignment to a location just south of the community of Barlow, Kentucky. From the location south of Barlow, the alternate leaves US 60 and proceeds southwesterly until it crosses Mayfield Creek. The corridor then turns to the west and encounters the Mississippi River near Mississippi River mile point 948. Upon crossing of the Mississippi River, the corridor traverses the Birds Point-New Madrid Floodway, and continues west to a terminus at a common intersection with existing I-57 near the community of Charleston, in Mississippi County, Missouri.

2. Scope of Work

The scope of work for this study consists of performing a geotechnical overview for the proposed roadway corridors previously discussed based upon research of available published data; FMSM's experience with highway design and construction within the Mississippi Embayment physiographic region; and field reconnaissance of the preliminary corridors. General geotechnical/geologic characteristics of the study area have been identified with special attention given to the potential Mississippi and/or Ohio River crossings. A literature search was performed by FMSM personnel using a variety of sources. Tasks performed by FMSM included reviews of the following items:

- Available topographic and geologic mapping of the project area published by the United States Geological Survey (USGS) and the Kentucky Geological Survey (KGS);
- The Geologic Map of Missouri, published by the State of Missouri, the Department of Natural Resources, and the Missouri Geological Survey;
- KGS Oil and Gas Development Activity mapping;
- National Wetlands and Wildlife Management Areas as recognized by the U.S. Department of the Interior, Fish and Wildlife Service;
- KYTC data from geotechnical explorations for roadway bridges in the vicinity of Wickliffe, Kentucky;
- Letter from Memphis District, United States Army Corps of Engineers (USACE) to Kentucky Transportation Cabinet, dated July 3, 2003, regarding issues of proposed corridors crossing the Birds Point-New Madrid Floodway;
- Resource Agency Coordination Memo dated February 2004; and
- Websites of various bridge projects of Mississippi River crossings.

FMSM also participated in a conference call on June 25, 2003 between the project team, the U.S. Army Corps of Engineers, the U.S. Coast Guard, and the Kentucky Transportation Cabinet. Some issues discussed during that conference are addressed within this report.

A field reconnaissance of the proposed roadway corridors was performed by FMSM personnel on July 3, 2003. Based upon the results of the field reconnaissance and reviews of the noted information, the general site physiology has been summarized, and corridor features of geotechnical significance that may influence alignment and grade selection have been identified. The following sections present the results of this overview.

3. Physiographic and Stratigraphic Setting

3.1. Topography and Drainage

Figure 1. Mississippi River and Adjacent Flood Plains

The proposed roadway corridors are primarily located in Western Kentucky and Southeastern Missouri, and lie within the Mississippi Embayment physiographic region which is part of the Coastal Plain physiographic province. In Kentucky, these corridors are situated on portions of seven USGS 7.5-minute topographic quadrangle maps. They are the Barlow (1977), Wickliffe (1983), La Center (1975), Blandville (1977), Heath (1978), Lovelaceville (1978), and Paducah West (1982) Quadrangles. In Missouri, the corridors are situated on the Wyatt (1979) and Charleston (1979) Quadrangles. The surface topography varies within the project corridors from well dissected uplands in the northern and eastern portions of the areas in Kentucky, to large areas of nearly level flood plain in the vicinity of the Ohio and Mississippi Rivers in both Kentucky and Missouri. Figure 1 is a typical view of the topography of the flood plains adjacent to the Ohio and Mississippi Rivers. The upland areas are composed of rolling hills, locally flat-topped ridges, and broad valleys. Bottom lands adjacent to the Ohio and Mississippi Rivers are relatively flat, and marked by north-south oriented lakes, ponds, sloughs, chutes, and swamps, all former routes of these rivers in normal or flood-flow conditions. Additionally, loessal silt bluffs rise as much as 150 feet above the Mississippi River flood plain near Wickliffe, Kentucky. The bedrock surface is deep within both Kentucky and Missouri in this study area (generally in excess of two hundred feet). Therefore fluvio-lacustrine soil deposits dominate the area physiology.

Surface drainage within these area of Kentucky and Missouri is directed towards numerous swales, ditches, creeks and streams, and ultimately to the Ohio and Mississippi Rivers. Backwater sloughs are present within the project vicinity at lower elevations and retain water depending on the elevation stage of the adjacent river.

3.2. Stratigraphy

Corresponding USGS geologic quadrangles are available for Barlow (1971), Wickliffe (1974), La Center (1978), Blandville (1971), Heath (1966), Lovelaceville (1968), and Paducah West (1966). The 1979 Geologic Map of Missouri, published by the State of Missouri, the Department of Natural Resources, and the Missouri Geological Survey was used to describe geologic conditions relevant to the Missouri portion of the corridors and Mississippi River crossings. Based on the various geologic mapping and literature reviewed, the proposed corridors are primarily underlain by deeply buried Paleozoic era bedrock. Thick Tertiary sediments lie under a mostly complete covering of Ice Age deposits of sand. Alluvial deposits of gravel, silt, clay, and loess from the meltwater swollen Ice Age Mississippi River and its tributaries are also present.

Specifically, the eastern (Kentucky) portions of the corridors will cross over well dissected, Quartenary age Peoria Loess silt as well as Tertiary and Quartenary Continental deposits comprised of sandy chert gravel and gravelly sand. Within creek bottoms the surface materials are Quaternary age alluvial silt, sand, and clay deposits. In the study areas of Kentucky and Missouri adjacent to the Mississippi and Ohio river bottoms, surface materials are composed of Quaternary age fluvio-lacustrine silt, sand, and clay deposits. Throughout the project corridors, these deposits are underlain by Tertiary age silts, sands, and clays of the Clairborne and Wilcox Formations. Underlying these deposits is the Lower Tertiary Porters Creek Clay. This Paleocene formation of the Midway Group is comprised of over-consolidated, montmorillinitic clay with interlensed fine sand. Below these deposits are Upper Cretaceous and Tertiary clays and sands of the McNairy and Clayton Formation. The Paleozoic age bedrock (including Mississippian limestone and sandstone) is indicated to be at depths in excess of several hundred feet below the ground surface throughout the study limits.

3.3. Soils and Unconsolidated Materials

A thin mantle of wind blown silt material (loess) covers a large portion of the study area. Loess thicknesses are shown on the referenced geologic mapping to be up to 30 feet along the Mississippi River bluffs near Wickliffe, Kentucky. This material is described as yellowish-brown to medium-gray silt, unstratified, and containing minor amounts of clay and sand. Loess deposits are generally highly erodible and flatter cut slopes should be anticipated in these areas. Wetlands, such as marshes, natural ponds, and floodplains are common in low lying areas in both Kentucky and Missouri. These situations often contain organic material and soft, unconsolidated soils that may require stabilization prior to constructing roadway improvements.

Alluvial materials comprised of sands, silts and gravels cover the floodplains of the Mississippi and Ohio Rivers, as well as major tributaries in the study area. The referenced mapping indicates the alluvium has been encountered in thicknesses up to 73 feet beneath the Mississippi River floodplain. These alluvial deposits overlay the fluvio-lacustrine silts, clay and sand deposits noted in Section 3.2.

3.4. Groundwater

The project corridors addressed in this overview lie within relatively flat areas of Western Kentucky and Southeastern Missouri in proximity to the Tennessee, Ohio, and Mississippi Rivers watersheds. Because of the permeable nature of the subsurface stratum, the groundwater table is close to the ground surface in floodplain or backwater areas. During design of the project roadways and associated structures, the effects of groundwater on soil strengths and stability will need to be taken into account.

3.5. Regional Seismicity

Review of available geologic mapping indicates that the roadway corridors and potential bridge sites are within the New Madrid Seismic Zone (NMSZ). The NMSZ lies within the central Mississippi Valley, extending from northeast Arkansas, through southeast Missouri, western Tennessee, western Kentucky to southern Illinois. The NMSZ is a series of faults associated with the Reelfoot Rift, and is the most seismically active region in the United States east of the Rocky Mountains. Historically, this area has been the site of some of the largest earthquakes in North America. Between 1811 and 1812, four catastrophic earthquakes, with magnitudes estimated to be greater than 8.0 on the Richter Scale, occurred during a 3-month period. Hundreds of aftershocks followed over a period of several years. The largest earthquakes to have occurred since then were on January 4, 1843 and October 31, 1895. Instruments were installed in and around this area in 1974 to closely monitor seismic activity. Since then, more than 4000 earthquakes have been detected, most of which are too small to be felt by human senses. On average one earthquake per year will be large enough to be felt by communities in the area.

On the basis of the large area of damage (230,000 square miles), the widespread area of perceptibility (1,930,000 square miles), and the complex physiographic changes that occurred, the Mississippi River valley earthquakes of 1811-1812 rank as some of the largest in the United States since its settlement by Europeans. The area of strong shaking associated with these shocks is two to three times larger than that of the 1964 Alaska earthquake and 10 times larger than that of the 1906 San Francisco earthquake.

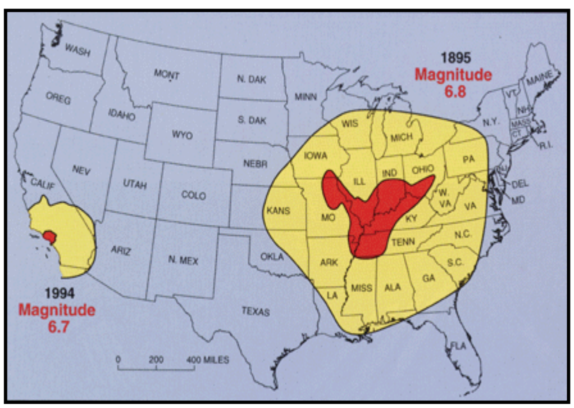

Figure 2. Relative Size of Affected Areas

Although earthquakes in the central and eastern United States are less frequent than in the western United States, they affect much larger areas. Figure 2 (Source: http://quake.wr.usgs.gov/) shows two areas affected by earthquakes of similar magnitude-the 1895 Charleston, Missouri, earthquake in the New Madrid seismic zone and the 1994 Northridge, California, earthquake. Red indicates minor to major damage to buildings and their contents. Yellow indicates shaking felt, but little or no damage to objects.

Earthquake epicenters and magnitudes for the Central and Eastern United States are presented in Figure 3. This figure indicates all of the corridors within this study are in areas of significant seismic potential.

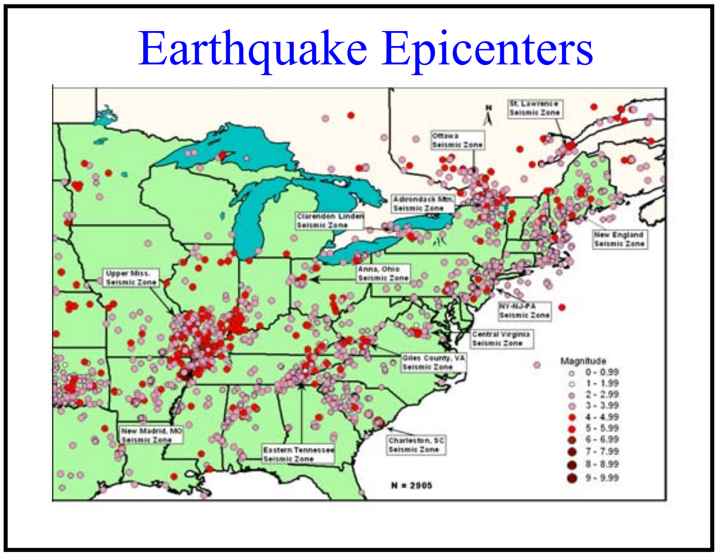

Figure 3. Earthquake Epicenters and Magnitudes in the Central and Eastern United States

4. Existing Corridor Features

4.1. General

The primary land uses within the project corridors are farmland cultivated for crops; undeveloped forest, grasslands and wetlands; single family dwellings; and commercial entities commonly associated with small towns. The area is extensively farmed both within and outside the flood plains of the Ohio and Mississippi Rivers. Levee systems, both privately and publicly owned, are located adjacent to the Ohio and Mississippi Rivers and function as flood control structures during high water events. Additionally, sand and gravel has been quarried and timber logging has occurred throughout the region.

4.2. Domestic and Public Areas

McCracken, Ballard, and Carlisle counties Kentucky are within a predominantly rural farm community setting. Likewise, Mississippi County Missouri is also heavily agricultural in land use. Small towns are usually situated at the intersection of county and state routes or historic railroad depots. Numerous schools and churches are located within the proposed corridors presented herein. Gas stations, stores, small commercial businesses and residences are common within these communities. Many of the stores sell gas and diesel fuel. Existing gas stations and stores that handle petroleum products and chemicals often have numerous storage tanks for their products. Small businesses such as auto body and repair shops, farm equipment and supply stores, construction companies and equipment rental companies have tanks and other environmentally sensitive concerns that need to be considered when evaluating a corridor.

Locations of former gas stations, stores and other businesses may have abandoned storage tanks, unstable refuse storage areas, or debris dump sites.

The rural areas generally have various homestead and farm situations that exist within subwatersheds off a primary watershed. These properties are often owned by families that have been in the area for many decades. Lumber yards, farm equipment stores, and community groceries are commonplace in rural areas. Family and community cemeteries are common throughout the region. The field reconnaissance of July 3, 2003 noted that the corridor which follows US 60 to be the more heavily populated of the corridors. Also, US 60 is the primary arterial road between the major communities in this area, and is therefore much more heavily traveled than the roads associated within other corridors.

4.3. Other Features

The Peal and Swan Lake Wildlife Management Areas (WMA's) are located approximately two miles west of the community of Barlow, Kentucky and could be impacted by corridor 8- Level 2 Alternatives. The Winford WMA is located nearly 2.5 miles southeast of Wickliffe, KY, and could be impacted by the approach to bridge crossing Corridor 8B – Level 3 Alternatives over the Mississippi River in the vicinity of Mayfield Creek.

Corridor 8 – Level 2 Alternatives will likely have to traverse approximately three miles of wetlands, lakes and streams in the Barlow Bottoms area on the Ohio River floodplain. This area consists primarily of north-south oriented ancient river channels of the Ohio River which were abandoned during channel migration and have been filled in over time by alluvial sediments. Geotechnically, each trough may present its own individual subsurface profile and strength characteristics. Also, these wetlands typically present high water tables as well as soft and/or unconsolidated soils which present issues regarding foundation stability, settlement and sensitivity to seismic events.

Corridor 8B – Level 3 Alternatives and the approach to the Mississippi River crossing will traverse Mayfield Creek and approximately 1.0 – 1.5 miles of wetlands and streams associated with the corresponding floodplain. Mayfield Creek is a low gradient stream which is prone to flooding by backwaters of the Mississippi River. A bridge will be required to cross this stream, and the substructure elements will be required to resist alternating flow directions and forces from debris/drift.

The Birds Point – New Madrid Floodway is located on the Mississippi River Floodplain in Southeastern Missouri, south of the confluence of the Mississippi and Ohio Rivers. Corridors 8B – Level 3 Alternatives and 11, 12, 13, 14, 15 and 21 – Level 2 Alternatives will traverse the levee and associated floodway. The central purpose of the floodway is to provide additional flood water storage in this part of the river to prevent the Project Design Flood from exceeding its design elevation at and above Cairo, Illinois. Therefore, it is anticipated that any roadway crossing the floodway will be elevated in the form of a bridge to reduce the impact upon the floodway capacity. Substructure elements of these bridges should be designed to resist extreme flow conditions and scour events resulting from levee breaches and inundation during the operation of the flood way. In order to cross the floodway at the proposed locations, bridge lengths must be on the order of 2.8 and 4.2 miles, respectively. Such bridge crossings would necessitate the construction of large numbers of deep foundations.

It should be noted that in a July 3, 2003 letter to the KYTC, the Memphis District – USACE expressed strong opposition to any proposed corridor that crosses the Birds Point – New Madrid Floodway. The letter expressed operational, engineering, real estate, and regulatory concerns regarding construction across the floodway. The 1965 Flood Control Act provides for operation of the floodway in the event floods reach a height of 58 feet, and are projected to exceed 60 feet on the Cairo, Illinois gauge. The current operation plans entail artificially crevassing sections of the levee at the upper and lower "fuse plugs" using explosives having a cratering effect 1.5 times greater than TNT. The Upper Fuse Plug section is approximately 11.3 miles long and includes an area to be breached (the inflow crevasse) approximately 11,000 feet in length. Figures presented in the USACE letter indicate that only crossing 11, 12, 13, 14, 15 and 21 will be within the inflow crevasse area. A safety zone for liquefaction potential, airblast, and ground motion has been established to be one half mile from any of the detonation sites. Additionally, a one-half mile strip along the length of the Upper Fuse Plug was purchased by the USACE and quit claimed to the local levee district. The quit-claim deed(s) reportedly contain a clause stipulating that no permanent structures may be built on this property because of anticipated damage from blueholing (deep scour) and sanding (sandbar deposition) resulting from floodway operations. The USACE operation of the floodway would require that all roadways entering the area be closed until recession of floodwaters and safety inspections of the floodway area have been performed.

Flood control levees were noted to border other portions of the flood plains of the Ohio and Mississippi Rivers, as well as smaller tributaries. These earthen levees were placed to protect both developed and agricultural areas during high water events. Also, structures comprised of large cyclopean stone dikes were noted along the banks of the Mississippi and Ohio Rivers jutting into the river channels in the study area. These structures are typically under the jurisdiction of local levee districts or the United States Army Corps of Engineers and are used to control or channel flow within the river. Close interaction with these entities will be required because these levees and dikes will have to be accounted for in evaluation of any corridors to reduce the potential of the I-66 roadway jeopardizing their effectiveness.

5. Geotechnical Concerns

5.1. Roadway

Existing roadways within the proposed corridors typically follow existing topography with little excavation or fill placement. In areas of Kentucky and Missouri crossing significant floodplains and streams, planned roadways are often elevated atop existing earthen levees or in the form of bridges. As previously noted, local soils are primarily loessal in nature, and are highly erodible. Soil embankments should be designed with as flat an outslope as practical (maximum of 3 horizontal to 1 vertical) to reduce erosion and promote revegetation. Embankments crossing areas subject to inundation by flooding may require the application of slope protection, and/or require construction using freely draining materials up to the high water elevation, in order to reduce the loss of embankment material and improve stability during floodwater recession.

Soil cuts may occur in upland loess soils, and should also be designed with as flat an outslope as possible to reduce erosion and promote revegetation. Additionally, intercept ditching may be required above the daylight points of soil cuts to direct surface runoff away from soil cut faces.

In addition to being highly erodible, the referenced loessal soils are extremely moisture sensitive, and this characteristic should be considered in all aspects of design. Dry loess deposits subjected to moisture intrusion may lose interparticle bonds and therefore experience a loss of strength and an increase in compressibility. Also, the saturation of a loess soil and the subsequent loading/unloading can fluctuate pore water pressures within the soil and create quick (free flowing) conditions. Because these loess soils are highly moisture sensitive, the KYTC typically avoids the use of these soils as roadway subgrade.

Figure 4. View of Illinois Approach, Cape Girardeau, IL

5.2. Structures

Bridges will be required in each of the corridors to carry the roadways over small streams, backwater sloughs, major rivers, and possibly over sensitive wetland areas. Crossing 8 – Level 2 Alternatives will require a bridge over the Ohio River into Illinois. At this location, the Ohio River is approximately 4,000 feet wide. Other corridors will require bridges over the Mississippi River into the state of Missouri. At these crossings, the Mississippi River is on the order of 4,000 to 5,000 feet wide. Currently, there are two major bridge projects under construction over the Mississippi River which are similar to this project. The first, as shown in Figure 4 (Source: http://www.modot.state.mo.us/) is a cable-stayed structure connecting Cape Girardeau, Missouri and East Cape Girardeau, Illinois. This structure has a main span length of approximately 1,150 feet. The second structure carries US Highway 82 between Greenville, Mississippi and Lake Village, Arkansas. The main span length of the Greenville bridge is to be approximately 1,370 feet and when completed, will have the longest cable-stayed span over the Mississippi River. Figure 5 (Source: http://www.greenvillebridge.com/), shows the construction of a dredged caisson main span pier for the Greenville Bridge.

Figure 5. Greenville Bridge Pier 37

Approach embankments to structures in upland areas away from major streams will likely be designed using traditional soil fill placement techniques. Structures over floodplains subject to frequent or severe flooding may require elevated approach spans. Existing bridges within the corridors over low or 'backwater' areas such as Mayfield Creek and Minor Slough were noted during the field reconnaissance to be comprised of multiple short spans with reduced intrusion of approach embankment construction within the floodway.

Because of the depth to bedrock in each of the corridors, it is probable that all foundation systems for the bridges will be soil-bearing deep foundations. Typical foundation types for bridges with similar subsurface conditions include: driven piles, drilled shafts, and dredged caissons. Conversations with Kentucky Transportation Cabinet (KYTC) personnel indicate that the most widely used foundation type for short span bridges in the area is driven piles. It is FMSM's understanding that the bridge crossings over the Ohio and Mississippi Rivers will require main span lengths on the order of 1500 feet to meet navigation requirements. With increasing span length, increased foundation capacity is required. Therefore, each type of foundation system should be evaluated to determine which is the most efficient and cost effective. Both driven piles and drilled shafts are considered slender foundations, and will develop axial capacity from the friction between the pile/shaft perimeter and the surrounding soils. Resistance to lateral movement of the slender deep foundations will be derived from the surrounding soils and is dependent upon the embedment lengths, diameters and material properties of the piles or shafts. Dredged caisson foundations follow a spread footing concept which derives bearing capacity at the bearing surface under the caisson. This type of foundation is typically massive, and can withstand significant lateral loads. Because of the significant regional seismicity described in Section 3.5, the ability of a particular foundation type to withstand seismically induced forces will likely govern foundation selection.

5.3. Seismic Concerns

Regardless of which roadway corridor and bridge crossing are selected for final design, seismic considerations will play a significant role in design and construction. As noted in Section 3.5, the proposed corridors lie within the New Madrid Seismic Zone. A seismic event could create several geotechnical problems. One of which could be a seismic event inducing liquefaction of foundation soils beneath embankments and substructure locations. Liquefaction induces a reduction of the load bearing capacity of the soils in the affected areas. This loss of strength could cause embankment settlement/failures, or the loss of frictional soil resistance to bridge substructure foundations. The loss of frictional strength could leave the foundations laterally unsupported, and in the case of friction piles or drilled shafts bearing in soil, axially unsupported. A second potential geotechnical concern could be a seismic event introducing lateral movements and therefore loads into the foundation systems of structures. Introducing lateral loads while there is a loss of soil strength would require the foundation system to carry all structural and induced loads internally. Additionally, the proposed bridge site should be characterized seismically in order to provide spectra response to the bridge design team.

It is recommended that seismic analyses be performed using data collected from sample borings along the proposed centerlines of any bridge structures. Analyses may include simplified seismic site response, equivalent one-dimensional site response, liquefaction and post-liquefaction settlement. In addition, static slope stability, pseudo-static slope stability, and permanent seismic deformation analyses should be performed for all approach embankment locations.

5.4. Scour Concerns

Because of the previously described loess, clay, sand, and gravel soil types present throughout the corridors, scour will be of concern in areas surrounding bridge foundations, and embankments adjacent to streams. Both local and contraction scour potential should be estimated for each potential corridor prior to selection. Contraction scour is initiated because of increased flow velocities through the bridge openings, changes in local base-level elevations, or flow around a bend. The most common cause of contraction scour is the contraction of flow by bridge approach embankments that encroach on the floodplain or the main channel, or both. Local scour is the removal of material around piers, abutments, spur dikes, and embankments caused by flow acceleration and turbulence near bridge sub-structure elements and embankments. Local scour can be increased as the result of accumulation of debris in a bridge opening. Figure 6 (Source: http://www.missouri.usgs.gov/) illustrates the potential of local scour on a typical bridge pier location.

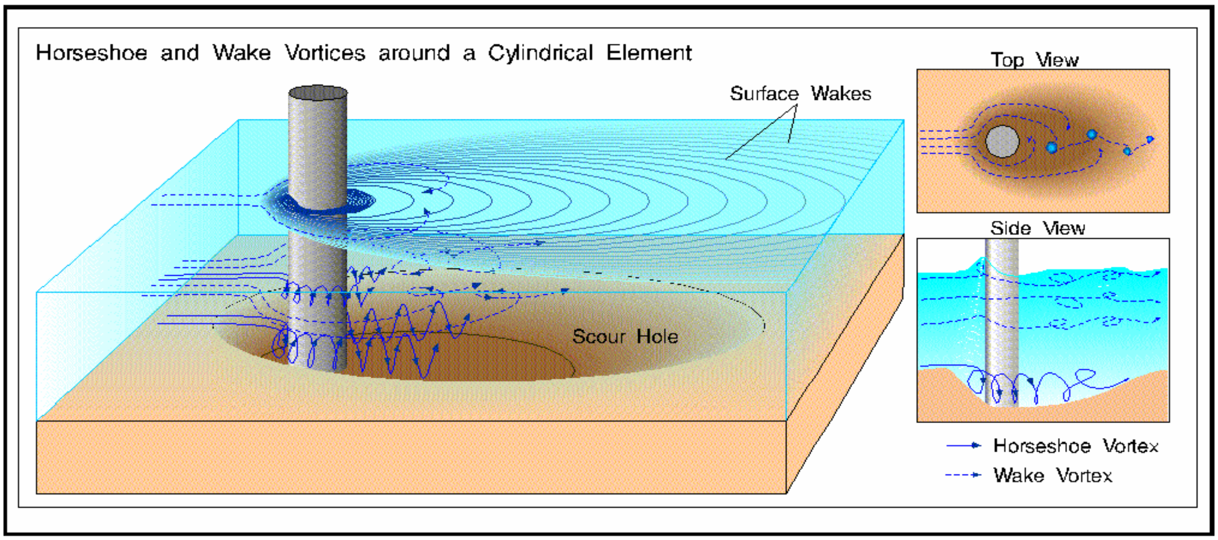

Figure 6. Local

A final scour study should be performed in conjunction with hydrological and hydraulic modeling during the design of the selected bridge structure. Major floods on the Mississippi and Ohio Rivers can create very high flow conditions. Local scour depths greater than 10 feet were reported, (on the above referenced website), after the 1993 Upper Mississippi/Missouri River floods. All bridge foundation designs in the study area will require that the results of detailed scour analyses be incorporated into establishing the embedment depth of individual substructure foundations. Typically, the KYTC requires that the tops of all spread footings and the bases of all shaft/pile caps be constructed below the anticipated maximum scour elevation.

6. Conclusions and Recommendations

6.1. General

6.1.1. The purpose of this overview was to provide a general summary of the soil and stratigraphic features likely to be encountered within the proposed roadway corridors, and to identify geotechnical features which could have adverse impacts on design and construction.

6.1.2. Based on this study, each of the proposed corridors are geotechnically feasible. All of the proposed corridors will encounter features associated with loessal deposits, deep soils and a major stream crossing. Moisture-sensitive loessal deposits present erosion problems as well as stability issues. Deep subsurface soils typically increase the foundation costs of bridges, and can be more sensitive to seismic events. Because of the substantial length of the main span and approaches as well as the seismic, scour, and deep foundation aspects of design, the Mississippi/Ohio River crossing will require the largest portion of the design effort for each of the study corridors.

6.1.3. It is recommended that a geotechnical exploration of the selected corridor be performed to determine the soil stratigraphy to establish foundation soil characteristics for evaluation of embankment slope stability and settlement, bridge foundation design, scour susceptibility, liquefaction potential and seismic response. Engineering analyses should be performed at each substructure location of each multi-span bridge in order to develop appropriate geotechnical information for design and identify potential areas of concern. Such analyses should include: slope stability at bridge abutment locations; bearing capacity of spread footings and dredged caissons; axial and lateral capacity of drilled shafts and/or pile groups; negative skin friction/uplift capacity of piles and/or shafts, and wave equation/drivability analyses for piles.

6.1.4. It is recommended that a seismic evaluation be performed at the bridge site selected for final design. Testing in the form of cross-hole logging, seismic reflection/refraction profiling, and seismic cone penetration testing should be evaluated for use in data acquisition. The purposes of a seismic evaluation would be to: identify soils along the proposed bridge alignment that may be susceptible to liquefaction, estimate the potential induced settlements, assess the stability of the approach embankments and quantify possible deformation under seismic loading, and develop representative foundation response spectra for use in structural design.

6.1.5. It is recommended that a hydrographic survey and detailed scour analysis be performed for all stream crossings within the corridor selected for final design. The results of the analyses should be used to determine foundation embedment lengths, and span arrangements.

6.2. Roadway Corridors

6.2.1. Roadway aspects to be addressed as design continues are associated with use of flatter cut and embankment slopes to reduce soil erodibility, stabilization of soft/wet areas prior to embankment construction, and the construction of roadway embankments subject to floodwater inundation using free draining and/or scour resistant materials.

6.2.2. Geotechnically, the roadway corridors in this study present very similar characteristics. However, the corridor along existing US 60, 8 – Level 2 Alternatives, must cross approximately three miles of native wetlands, lakes and streams as the corridor leaves the community of Barlow, as well as the existing roadway, and traverses the Barlow Bottoms area for the approach to proposed crossing over the Ohio River. Corridor 8B – Level 3 Alternatives crosses substantially less wetlands, with only the Mayfield Creek area shown by the referenced mapping or noted during the field reconnaissance. However, if either Corridor 8B – Level 3 Alternatives or Corridors 11, 12, 13, 14, 15, and 21 – Level 2 Alternatives is selected, the approach to the bridge from the Missouri side will cross the Birds Point-New Madrid Floodway in the form of a bridge. The upper corridor will require approximately 2.8 miles of bridge to cross the floodway in Missouri, and crossing 8B will require approximately 4.2 miles of bridge.

6.2.3. A comparison of the roadway corridors during the field reconnaissance showed US 60 to be a densely populated and heavily traveled route. Therefore, impacts to the community would likely be more prevalent along the 8B corridor (US 60) than along the Corridor 11, 12, 13, 14, 15 and 21 (KY 286).

6.3. Major River Crossings

6.3.1. At the location of crossing 8, the Ohio River is roughly 4,000 feet wide. Approach spans in the Barlow Bottoms area of Kentucky, and in the areas of the Cache River and Cottonwood Slough in Illinois would greatly increase the length of the bridge. It is estimated that the cumulative length of the approach and main bridge spans for this crossing will be nearly four miles.

6.3.2. Crossing 11, 12, 13, 14, 15, and 21 will intersect the Mississippi River at mile point 951, just south of the confluence of the Mississippi and Ohio rivers. The river at this location is roughly 4,000 feet wide. In the conference call of June 25, 2003, the Unites States Coast Guard (USCG) stated that this location is unacceptable from a navigation standpoint, and that no bridge would be considered unless it is south (downriver) of mile point 949.5. The USACE also stated that a bridge crossing would not be acceptable north of mile point 949.5, and that this location at mile point 951 is further unacceptable from their viewpoint because the bridge may land in Missouri on a fuse plug of the Birds Point Levee which will be removed by explosives during extreme flood events.

6.3.3. Crossing 8B for the study would cross the Mississippi River at mile point 948. In this area, the river varies between 4,000 and 6,000 feet in width because of the presence of an island/sand bar called Island No. 1. In order to cross the river at this location, a bridge length on the order of 6,000 feet would likely be required. This bridge length would be greatly increased by approach spans on both the Kentucky and Missouri sides of the river. Rough estimates of lengths required to carry traffic over Mayfield Creek, the Mississippi River, and the Birds Point Floodway result in a cumulative length of over 6.5 miles of bridges. Based on USCG criteria, this crossing is enough south (below mile point 949.5) to be acceptable. However, USACE criteria pertaining to the operation of the floodway would have to be satisfied prior to alignment selection.

6.4. Closing

6.4.1. Based on the information obtained during research and the field reconnaissance, neither of the Ohio or Mississippi River crossings present any ‘fatal’ geotechnical flaws. Any crossings will require extensive amounts of bridging. Each corridor would involve the extensive use of deep foundations for the bridges, and will have to address roadway construction in loessal deposits. In this cursory overview it appears that crossing 8B may require as much as 2.5 miles more bridge length than crossing 8. The majority of the bridge length for the southern crossing will be associated with the Birds Point-New Madrid Floodway. Bridge substructure elements and foundations in this area would be required to meet much more stringent (USACE) criteria than traditional bridging over non-floodway lands in the area. These increased requirements within the floodway would likely require substantial supplemental geotechnical investigations and analyses.

6.4.2. The information presented in this report should be viewed in the general nature in which it was intended. A more detailed study, which was beyond the scope of this work, would be required to more specifically define potential problem areas within the proposed corridors. A thorough geotechnical exploration and seismic evaluation of the selected alignment and grade will be required to help the design team anticipate and plan for special requirements necessary for design and construction of a roadway and major river bridge.