Appendix

Geotechnical Red Flag Summary and Overview

REPORT OF
GEOTECHNICAL RED FLAG SUMMARY AND OVERVIEW

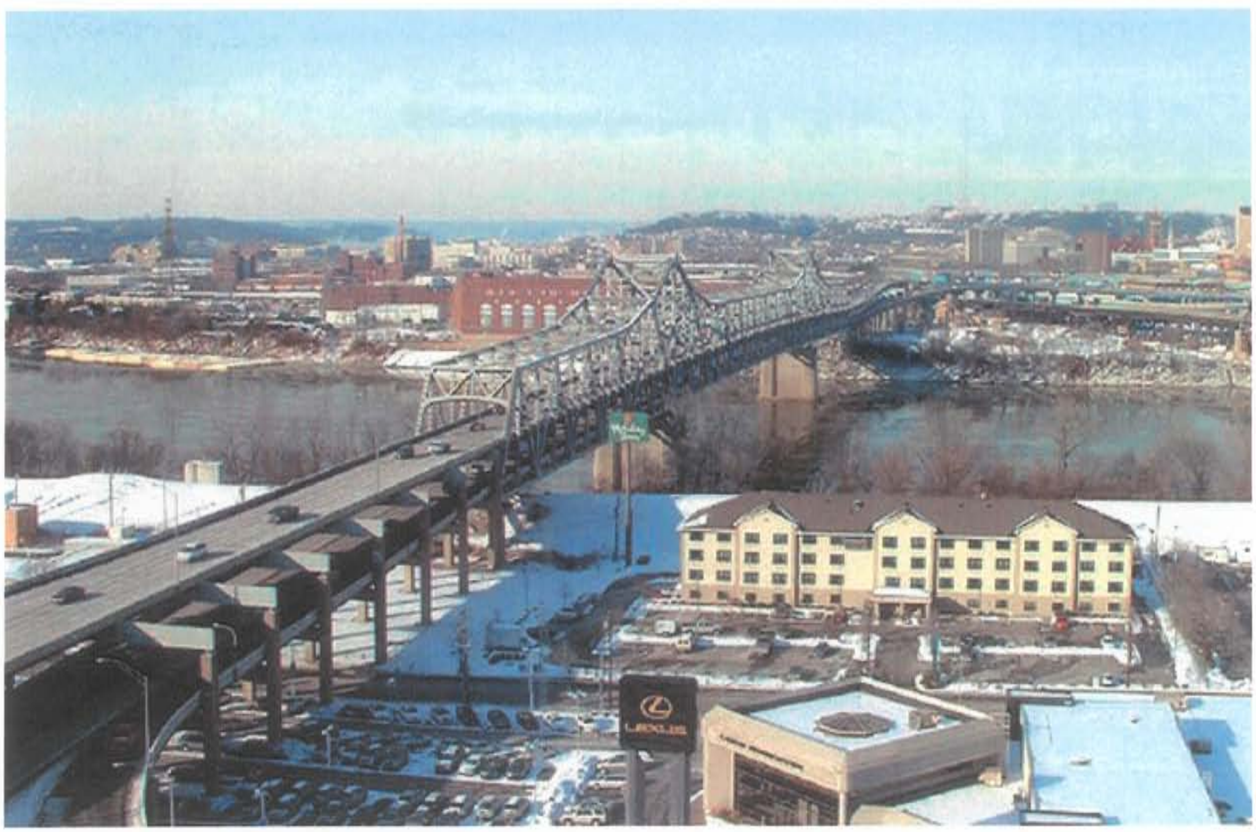
PROPOSED ROADWAY IMPROVEMENTS AND BRIDGE (BRENT SPENCE) REPLACEMENT CARRYING I-71/I-75 OVER THE OHIO RIVER COVINGTON, KENTON COUNTY, KENTUCKY TO CINCINNATI, HAMILTON COUNTY, OHIO

OHIO DEPARTMENT OF TRANSPORTATION
HAM-71-0.00 (BRENT SPENCE BRIDGE) PID NO. 75119

PREPARED FOR

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.
CINCINNATI, OHIO

SEPTEMBER 2005



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EMPLOYEE OWNED

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September 30, 2005

W.O. # 10974.049

Mr. Alfred B. Craig, Jr.
Parsons Brinckerhoff Quade & Douglas, Inc.
312 Elm Street, Suite 2500
Cincinnati, Ohio 45202

Re: Report of Geotechnical Red Flag Summary and Overview
Proposed Roadway Improvements and
Bridge (Brent Spence) Replacement
Carrying I-71/I-75 Over the Ohio River
ODOT Project HAM-71-0.00, PID No. 75119
Covington, Kenton County, Kentucky to
Cincinnati, Hamilton County, Ohio

Dear Mr. Craig:

The H.C. Nutting Company (HCN) is pleased to present our report of geotechnical overview for the proposed roadway improvements and bridge (Brent Spence) replacement project carrying I-71/I-75 over the Ohio River. The proposed project generally extends from the intersection of Kyles Lane and I-71/I-75 in Covington, Kenton County, Kentucky to the intersection of Western Hills Viaduct and I-75 in Cincinnati, Hamilton County, Ohio (south to north). The overview is based on our field reconnaissance performed on August 3, 2005, review of both Ohio and Kentucky geologic publications, review of numerous subsurface investigations performed along the proposed construction corridor (in Kentucky and Ohio), available Ohio Department of Transportation (ODOT) data, and various pertinent sources.

This report includes an overview of our understanding of the proposed project, a summary of the work performed during this study, and a discussion of our findings, observations, and conclusions. Following this report is an Appendix containing a general project site location plan, various figures, and an ODOT Red Flag Summary.

The H.C. Nutting Company appreciates the opportunity of providing our professional and technical geotechnical engineering services for this project. HCN is available to answer any questions that may arise following review of this report. If you would like to meet to discuss our findings and/or conclusions, please do not hesitate to contact us at (513) 321-5816.

Thank you for your consideration.

Respectfully submitted,

H. C. NUTTING COMPANY

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1.0 INTRODUCTION

The H.C. Nutting Company (HCN) was retained by Parsons Brinckerhoff Quade & Douglas, Inc. (PB) to perform a project overview and red flag summary for the proposed roadway improvement and bridge (Brent Spence) replacement project carrying I-71/I-75 over the Ohio River. The proposed project generally extends along I-71/I-71 from Kyles Lane in Covington, Kenton County, Kentucky to Western Hills Viaduct in Cincinnati, Hamilton County, Ohio. The general site location is shown on Figure 1, Regional Site Vicinity Map in the Appendix.

1.1 Purpose

The purpose of this "Red Flag Summary - Geotechnical Overview" was to review available geologic information, and conceptually characterize the subsurface conditions and summarize the geotechnical considerations within the proposed study corridor (about 1,000 feet east to 1,000 feet west of the existing I-71/I-75 roadway). This report summarizes our findings and provides an overview of the general geotechnical aspects with respect to the proposed roadway improvements and bridge replacement project.

1.2 Scope of Study and Report Format

This study included attendance at a project bus tour by the design team, site reconnaissance, and discussions with design team personnel, review of available published and experience-based geologic information, and preparation of this report. The report includes a brief history and our understanding of the proposed roadway improvement and bridge replacement project, a summary of the anticipated geotechnical conditions in the project area based on review of available data, a geotechnical overview of the anticipated subsurface conditions and geotechnical expectations along the corridor and bridge replacement study area, and any geotechnical aspects that may be considered "red flags" during the design phase of the proposed development. In addition to the geotechnical overview, the pertinent sections of ODOT's "Red Flag Summary" have been completed and are included in the Appendix of this report.

Following the text of this report is an Appendix, which contains a general site vicinity map and numerous supplemental figures. The figures include geotechnical subsurface cross-sections, general geologic information, approximate locations of previous selected geotechnical studies in the vicinity of the project area, known areas of geotechnical concerns (i.e. landslides, deep fills, surface mines), and other pertinent geotechnical overview information. The pertinent portions of the ODOT Red Flag Summary are also included in the Appendix.

2.0 PROJECT OVERVIEW

2.1 Project Background

The existing Brent Spence Bridge carrying I-71/I-75 over the Ohio River from northern Kentucky to Cincinnati opened in November of 1963. The roadway was developed to complete the I-75 link between Lexington, Kentucky and Dayton, Ohio. Not until 1970 was I-71 traffic routed over the bridge. The existing bridge is located at the approximate Ohio River mile point 471, connecting Covington, Kentucky to the south with Cincinnati, Ohio to the north.

The truss design bridge was originally constructed as a three-span, double-deck bridge, with three (3) traffic lanes per level. Northbound traffic is carried on the lower deck, while southbound traffic is carried on the upper deck. The main bridge span is about 830 feet long, with approach spans each measuring about 453 feet. The original design was based on a traffic volume of about 85,000 vehicles per day. In 1985, the decks were reconfigured, with the removal of the emergency pull-off lanes. The reconfiguration resulted in four (4) lanes in each direction and an increased capacity to about 130,000 vehicles per day. However, the reconfiguration provides safety concerns with only minimal shoulder widths and congested areas for merging on/off ramp traffic.

The construction of the bridge related directly to increased development in the Northern Kentucky area, thus resulting in a substantial increase in commuter and local traffic. Recent studies (2003) indicate current traffic loads between about 150,000 to 160,000 vehicles per day. The current traffic load includes nearly 30,000 trucks. Projected traffic loadings suggest approximately 200,000 vehicles per day in 20 years. A 1996 study suggested a fatigue life of less than about 12 years. However, a 2003 study completed jointly by the Ohio Department of Transportation (ODOT) and Federal Highway Administration (FHWA) concluded that the primary truss members have an infinite fatigue life.

In addition to the structural fatigue concerns surrounding the bridge, traffic safety is also an issue. The current lane widths do not meet desired standards and there is no space for disabled vehicles to pull off. Based on FHWA criteria for the National Bridge Inventory, the existing Brent Spence Bridge is classified as functionally obsolete.

2.2 Project Description

Numerous conceptual alternatives have been developed, including various reconstruction alternatives at the current location and at new locations. Currently, this report of geotechnical overview is being performed as part of the project development process (PDP) in consideration of feasible alternatives for the possible replacement of the Brent Spence Bridge. Based on the feasible conceptual alternatives developed, a corridor study area for this geotechnical overview was selected. The corridor geotechnical overview area generally extends 1,000 feet to the west and 1,000 feet to the east of the existing I-71/I-75 mainline roadway (2,000 feet total width). The overview study area is generally bounded by Kyles Lane in Covington, Kenton County, Kentucky to the south and Western Hills Viaduct in Cincinnati, Hamilton County, Ohio to the north, a total length of about 5½ miles. The corridor study area is shown on Figure 2, Corridor Study Area in the Appendix of this report.

Outside of the existing I-71/I-75 roadway and associated on/off ramps, the corridor study area is primarily developed with numerous commercial and residential structures, in both the public and private sectors. Some undeveloped areas occur primarily in Kentucky due to limitations caused by the existing hilly terrain. The existing topography south of the Ohio River in Kentucky is generally characterized by a severely to moderately undulating terrain. Heading north near the Ohio River and north of the Ohio River in Ohio, the terrain is generally characterized by a more gentle topography.

2.3 Project Scope

The scope of work for this project generally consists of compiling existing geologic data into a geotechnical overview within the corridor study area for the proposed bridge replacement and roadway improvement project. Our evaluation was based on review of published geologic data, review of projects and information from the Ohio Department of Transportation (ODOT) and Kentucky Transportation Cabinet (KTC), and H.C. Nutting's geotechnical experience in both the Ohio and Kentucky regions. Our scope of work also included attendance at various project meetings, site reconnaissance, and preparation of this report. Our geotechnical overview was based on information compiled from review of numerous documents, including:

- Various topographic and geologic maps within the project area published by the United States Geological Survey (USGS), the Geological Survey of Ohio, and the Kentucky Geological Survey, including website reviews of the same organizations.
- Soil Conservation Service Soil Surveys of Kenton County, Kentucky and Hamilton County, Ohio published by the United States Department of Transportation.
- Numerous geotechnical subsurface soils boring data in both Kentucky and Ohio in the project corridor study area.
- Results of ODOT's Geotechnical Records Request in the applicable areas of Hamilton County, Ohio within the project corridor.
- History of notable landslides within the project corridor study area.
- Existing Brent Spence Bridge rehabilitation/reconstruction studies and feasibility studies performed by FHWA and others.
- Information obtained from our site reconnaissance.
- Historical topographic maps including 1912 maps and Hamilton County, Ohio CAGIS maps.

The geotechnical overview presented in this report is based on the available project information, the limits of the corridor study area, and review of the available geological/geotechnical data listed above. Based on the review of the above data sources, this report generally summarizes the typical site geology in the corridor study area. The following sections provide a geological/geotechnical overview of the study area and address aspects that may influence the proposed project or raise a "red flag". In the event of changes in location or concept of the project, the overview should be reviewed and applicable changes, if required, should be made.

Following the text of the geotechnical overview is an Appendix, which contains figures and subsurface cross-section data along the alignment. The completed applicable portions of the Red Flag Summary are also attached in the Appendix of this report. A listing of the figures contained in the Appendix is shown on the front page of the Appendix.

3.0 SITE CONDITIONS

3.1 Site Description

The corridor study area generally passes through urban areas of Covington, Kentucky and Cincinnati, Ohio. Beyond the area currently occupied by the I-71/I-75 roadway alignment and associated interchanges/ramps, the corridor area is predominantly occupied by residential communities; however, portions remain undeveloped generally due to geographic limitations caused by the sloping topography. As the alignment approaches the Ohio River, the study area currently consists of residential developments along with an increasing number of commercial businesses, such as shopping centers, office parks, light industry, restaurants, hotels, and car dealerships.

Immediately north of the Ohio River in Cincinnati, Ohio, a sand/gravel quarry and a major Cinergy power distribution facility lie within the existing corridor study area. A local historic site, the B&O Warehouse structure, also falls within the corridor. Continuing northward, the Fort Washington Way interchange, along with the split of I-75/I-71 and several downtown Cincinnati exits occupy the majority of the study area. North of the Fort Washington Way interchange, the majority of the corridor study area generally consists of business developments. Near the northern limits of the project area (Western Hills Viaduct), the area is currently developed with a combination of commercial businesses and residential housing.

3.2 Site Topography

Beginning at Kyles Lane, existing site grades along the proposed roadway corridor generally range between about 850 and 900 feet. Continuing northward along the corridor, the existing topography generally slopes downward to about elevation 450 to 500 feet at the Ohio River. From the interchange at Kyles Lane (Interchange 189) to Interchange 190, the topography within the corridor area is relatively level along the existing I-75/I-71 roadway, with moderately to steeply sloping hillsides and ridges outside the roadway footprint. From Interchange 190 to the Ohio River, the west side of the corridor area exhibits similar moderately to steeply sloping hillsides. The eastern side of the corridor is relatively level in comparison to the existing terrain along the western side of the corridor.

The existing grades from the Ohio River, northward to Western Hills Viaduct gradually slope upward from about elevation 450 to 500 adjacent to the Ohio River, to about elevation 550 feet near Western Hills Viaduct. The corridor area is relatively flat beyond the existing roadway footprint.

The Ohio River, forming the border between Ohio and Kentucky, is about 1,300 feet wide at the existing Brent Spence Bridge location. The normal pool elevation of the Ohio River in the area of the bridge is about 455 feet. On the Kentucky side of the Ohio River, the nearest body of water is the Licking River, which is located about 1 mile to the east of the existing I-71/I-75 roadway. In Ohio, the nearest body of water is the Mill

Creek, which is located about ½ to ¾ of a mile to the west of the existing roadway. The USGS map indicates several smaller water features, including lakes, ponds, and manmade ponds/reservoirs.

Water drainage in the corridor study area is generally achieved by diverting water towards the Ohio River and/or adjacent connecting streams. Due to the relatively large watershed that the Ohio River covers upstream to the north and east, periodic flooding is generally common in low-lying areas along the Ohio River in the Cincinnati/Covington area. The following flood information was obtained from the Louisville District U.S. Army Corp of Engineers near the corridor study area:

Normal pool – Elevation 455 feet

Ordinary High Water Mark – Elevation 468.5 feet

100 Year Flood – Elevation 498.5 feet

500 Year Flood – Elevation 512 feet

3.3 Geologic Site Conditions

Northern Kentucky has been affected by major glaciations occurring during the Pleistocene Epoch. These glacial advances caused profound drainage changes and were responsible for the deposition of a variety of soils lying beneath the Covington/Cincinnati area and the project site. To understand the depositional sequence at the site, we have generally described the Pleistocene history of the Covington area and Cincinnati area in the following paragraphs.

3.3.1 General Northern Kentucky/Southwest Ohio Geology

A highly estimated, two million years before present time, the first major ice sheet arrived in Southwest Ohio and Northern Kentucky. At the time, the northwesterly-flowing Teays River flowed across West Virginia and entered Ohio near Portsmouth.

This ancestral river occurred along with several tributaries, including the Licking River. The valleys at that time were only about 150 feet deep, compared with 400 feet deep today.

Between an estimated 1.2 and 2 million years ago, the Kansan and Nebraskan glaciers advanced into Cincinnati and the Northern Kentucky area. At that time, the north-flowing Teays Age Licking River was dammed by the snout of the glacial ice, resulting in deposition of lake clays within the valleys. The basal elevation of the lake-filled valley was about elevation 650 feet.

In time, the lake waters rose and eventually overflowed a divide near Madison, Indiana. The glacial meltwaters caused elevated water flow through the new drainage system westward, near Hamilton, Ohio and southwesterly toward Ross and Harrison, Ohio, Lawrenceburg, Indiana, and on to Louisville, Kentucky. The water flow eroded a deep and wide channel, termed the Deep Stage Ohio. The valley bottom was deepened well below today's Ohio, Little Miami, and Great Miami Rivers to about elevation 380 feet.

The Teays Age Licking River abandoned its former course and shifted somewhat westerly, cutting its Deep Stage valley where the present day Licking River occurs. However, in Deep Stage time, the Licking River did not terminate at its present day mouth location. Instead, it continued northerly across the basin of present day downtown Cincinnati, west of Great American Ball Park and northward to what is now called the Mill Creek Valley to join the Deep Stage Ohio River near Norwood, Ohio.

The Illinoian Age glacier then advanced into southwest Ohio about 400,000 years ago. This glacier did not reach Northern Kentucky. The ice dammed the north flowing Deep Stage Ohio River, forming a lake, which extended towards Portsmouth and well into the Deep Stage Licking valley to the south. The resulting deposition above the valley bottom consisted of Deep Stage gravels topped by Illinoian lakebed silts and clays. The lake filled and eventually spilled over directly west from Cincinnati. A new valley was now cut through Anderson Ferry, Saylor Park, and on to North Bend, Ohio. This process created the present day course of the Ohio River. Also occurring at this time, the Illinoian glacier continued to creep southwesterly and deposited till on top of the lake clays.

Over the next 300,000 years, well after the Illinoian glacier retreated, extensive weathering and erosion took place. New valleys were carved by streams, within the partially filled former valleys.

The last glacial advance began about 70,000 years ago. This glacier, called the Wisconsin glacier, retreated slightly and then readvanced into Northern Hamilton County, Ohio about 18,000 years ago. This glacier left till and then granular outwash from its meltwaters. Subsequent stream erosion has cut terraces into this outwash along many of the valleys.

3.3.2 Kentucky Corridor Area Geology

Near the Covington, Kentucky corridor area, the sediments begin at the base of the Deep Stage Licking Valley, which was eroded prior to the Illinoian glacial advance. Soils consist of a gravelly zone topped by granular outwash deposits. Near-surface soils contain alluvial sediments, deposited by the floodwaters of both the Ohio and Licking Rivers. Man has also affected soil conditions at the site by placement of fill, construction of buildings, construction of marina and housing developments, demolition of structures, roadway grading, etc.

Heading southward from the existing Brent Spence Bridge into Covington, Kentucky, the first mile or so of the corridor area experiences valley basin sediments (already discussed), together with valley wall deposits on the western perimeter consisting of glacial and residual clays underlain by limestone and shale, remnants of the extremely ancient Ordovician Sea. Elevations on the basin of this trend are on the order of about elevation 510 to 540 feet, moving north to south, while the west valley wall will ascend from an approximate elevation of 510 feet upslope to an approximate elevation of 800 feet (±).

The remaining mile and a half (±) of the corridor study area ascends into an upland environment to Kyles Lane. Within the upland, Illinoian age glacial soils, sometimes capped with windblown loessian silts, overlying residual clays provide a soil mantle of varying thickness atop native bedrock.

The Ordovician bedrock in the corridor area that ascends from the basin to the upland is composed of two major rock units. The Kope Formation is typically found from approximate elevations 510 to 690 feet (±) being principally shale with relatively thin (4-inch to 8-inch) thick and well-spaced limestone interbeds. The overlying Maysville Formation, from approximate elevations 690 to 800 feet (±), is composed of limestone and shale, at times of equal proportions, but with limestone often predominating, with thicker (8-inch to 22-inch) and more closely packed beds.

The rock beds are highly fossiliferous and calcareous. The limestone distribution within the Maysville often provides a formidable resistance to excavation efforts due to hardness, thickness of layers, and close packing of layers at some elevations.

There are no mapped coal mines within the corridor area. In this region, solutioned limestone, or karst, sometimes develops in upland areas where limestone is the predominant bedrock formation. The Northern Kentucky region is within an area with limited to moderate potential for karst. Based on local experience, the development of karst in the project corridor area may occur in isolated areas, but is not anticipated to be a significant concern.

Figures 3A to 3D, in the Appendix of this report, include physiographic, geologic, and karst maps for the Kentucky region.

3.3.3 Ohio Corridor Area Geology

Heading northward from the Ohio River, the local geology generally consists predominantly of a combination of alluvium and outwash soils, with minor amount of lacustrine (lakebed) and glacial till deposits. Based on review of the published Quaternary Geology Map of Ohio (dated 1999), the western portion of the corridor area from the Ohio River to Western Hills Viaduct consists of recent alluvium and alluvial terraces deposited in present and former floodplains. The alluvial deposits ranged from silty clays, sands, gravels, and silty sands. The alluvium soils typically are encountered between about elevation 460 and 530 feet.

Along the eastern side of the corridor, the predominant geology consists of Late Wisconsinian Age outwash soils from the Ohio River to about 1½ miles (±) north of the Ohio River. The outwash materials were deposited by meltwater in front of glacial ice in valley terraces or low plains. The outwash soils are generally granular, consisting predominantly of sands or sands and gravels. The approximate elevation of the outwash deposits range from about elevation 400 to 460

It should be noted that this area of downtown has been heavily worked by man. Thus, cisterns, dry wells, privies, etc., should be expected. Silt pipes and anomalous loose granular zones have also been noted. Remnant foundation walls of buildings, which formerly occupied the site, can also be anticipated.

A zone of lacustrine (lakebed) deposits is generally positioned along the eastern side of the corridor from about 1½ miles (±) north of the Ohio River to Western Hills Viaduct. The water-deposited Illinoian Age soils are lake-bottom sediments consisting of clays and silts, and are often distinguished by their laminar depositional appearance. Occasionally, the lakebed deposits contain organics.

At approximately 1½ miles (±) north of the Ohio River, minor amounts of Illinoian glacial till deposits border the eastern boundary of the corridor area. Till soils are typically comprised of an unsorted, unstratified conglomeration of silts, clays, sands, and gravels. The till profile often contains intermediate sand/silt seams and/or layers. The outwash and till deposits are often covered by a relatively thin loess layer.

The overburden soils are generally underlain by Ordovician Age interlayered shale and limestone bedrock of the Eden Formation. Bedrock is generally encountered at elevations ranging from about 400 to 420 feet, and as high as about elevation 460 feet at Western Hills Viaduct. Based on review of published and existing subsurface information, the bedrock surface is highly variable, with relatively drastic changes in depth over relatively short distances.

Figures 4A to 4D, in the Appendix of this report, include physiographic, geologic, and karst maps for the Ohio region.

3.3.4 USDA Soil Survey Review

Based on review of the USDA Soil Survey for Hamilton County, Ohio, the soils within the study area on the Ohio side of the bridge generally belong to the Pate-Urban land (PhD) and urban land series of the Huntington (Uh), Elkinsville (UgB), Stonelick (Ux), and Martinsville (UmB) complexes. Other soil types within the vicinity of the project limits consist of urban land series of the Rossomoyne (RtB, RtC) complex. Based on review of the USDA Soil Survey for Boone, Campbell, and Kenton County, Kentucky, the soil types on the Kentucky side of the project belonged to urban land (Ur) along the east side of the corridor, and Eden (EdE2), Faywood (FcD), and Rossmoyne (RsB) series on the west side of the corridor.

The Pate soil and Urban land (Phd) are intricately mixed and are located on the colluvial positions on the lower part of the hillsides in Ohio. The Pate soil has very slow permeability and moderate organic content. It has a high shrink-swell potential and is also considered highly corrosive to untreated steel. The Pate soils often make up parks, open space, lawns, and gardens, and are generally unsuited to use as a site for buildings and is subject to slippage.

The Urban land series soils in Ohio, are generally dark brown silty loams with moderate permeability and make up parks, open space, lawns, and gardens. The Elkinsville (UgB) and Martinsville (UmB) series soils have low strength and high frost action susceptibility, and are considered suitable for buildings and recreation areas. However, the Huntington (Uh), and Stonelick (Ux), soils are not generally suited for buildings. Closer to the Ohio River, the Huntington soils have a high water table and frost susceptibility. The Rossomoyne series (Rtb, Rtc) soils are silt to clay loams and are covered by streets, parking lots, buildings and other structures with moderate permeability above the fragipan. These soils are moderately well suited to use as a site for buildings and have high frost action susceptibility. Moreover, these soils are highly corrosive to uncoated steel and concrete.

The urban land (Ur) on the Kentucky side of the project limits is disturbed by cuts and fills and is underlain by alluvium and outwash deposits. The Eden (EdE2), Faywood (FcD) series soils are formed of residual material weathered from calcareous shale and limestone and are generally silty clays with slow to moderately slow permeability. The Rossomoyne (RsB) series soils are silty loam and silty clays formed in loess and in glacial till. The permeability is slow in the fragipan. The shrink/swell potential of these soils varies from moderate to high with increasing depths.

The applicable USDA Soil Survey Maps have been reproduced as Figures 5 (Kentucky) and 6 (Ohio), and are included in the Appendix of this report.

<u>3.3.5 Review of Soil Test Borings</u>

Test borings performed along the riverbanks for the existing Brent Spence Bridge in 1958 indicated up to about 45 feet, or to about elevation 450 feet, of sandy and clayey fill. The existing fill was underlain by medium stiff silty clay to a depth of about 66 feet below existing grade, or about elevation 430 feet. The cohesive alluvium was typically underlain by medium dense to very dense sandy outwash deposits with varying amounts of gravel to about 115 feet below existing grade, or about elevation 380 feet. Although no rock coring was performed, the casing refusal was encountered during drilling below the outwash at about elevation 380 feet, which was considered the top of bedrock.

Test borings performed within the Ohio River at the bridge location encountered granular soils, with varying consistency and gravel content to the top of the bedrock surface, which was encountered at about 70 to 75 feet below the existing water surface, or at about elevation 370 feet. Rock coring was performed below the depth of auger refusal at the test boring locations. The bedrock consisted of interbedded gray shale and limestone, with the limestone occurring in 1 to 9-inch thick layers. Limestone made up about 15 to 70 percent of the bedrock profile. Rock cores were generally extended about 10 to 30 feet below the auger refusal depths.

Various cross-sections along the I-71/I-75 mainline and perpendicular to the mainline have been developed based on test boring information. Figure 7, Selected Subsurface Investigations, identifies several projects in the corridor study area that were reviewed in preparation of this report. Figures 8 and 8A through 8E, show subsurface cross-section data in the corridor study area within Ohio. Likewise, Figures 9A to 9E show the generalized subsurface profile along the I-71/I-75 roadway along the corridor area. Figures 10A to 10E show subsurface cross-sections (perpendicular to the I-71/I-75 roadway) at various locations along the existing alignment.

4.0 GEOTECHNICAL DESIGN AND CONSTRUCTION CONSIDERATIONS

This section focuses on the geotechnical aspects that will likely impact the design and construction of the new bridge and roadway improvements within the corridor study area. The section is divided into three (3) main categories, including 1)

Geological/Geotechnical Considerations, 2) Preliminary Seismic Hazard Analysis, and 3) Landslide Issues.

4.1 Geological/Geotechnical Considerations

4.1.1 Bridge Structure Foundations

We anticipate that the bridge structure will need to be supported on deep foundations since bedrock was generally encountered at depths in excess of 100 feet in the area of the existing bridge. Deep foundations bearing on/in the existing bedrock may include driven steel piles or large diameter drilled shafts. Axial loads, seismic loads, and lateral loads, and constructability need to be considered in determining if pile groups or large diameter shafts socketed into the underlying shale and limestone bedrock would be the foundation of choice. The deep foundations would need to be designed to provide not only adequate axial support, but also resistance to uplift and lateral forces. Deep foundations would also provide protection from vessel impact loads and scour associated with erodible soils along the Ohio River riverbed.

Support of a new bridge with a deep foundation system will be required regardless of the location that the bridge crosses the Ohio River. End bent support on both the Kentucky and Ohio sides will also likely be supported on deep foundations. Since the general subsurface profile (type of overburden and depth to bedrock) will be similar along the riverbank, construction of the new bridge to optimize geotechnical support capabilities will not play a major role in bridge location selection. A very detailed exploration of overburden soils and bedrock characteristics is expected to determine the appropriate foundation type and its optimal performance.

4.1.2 Roadway Considerations

At-grade roadways can generally be constructed on suitable natural soils or new structural fill. We anticipate that minimal cut/fill will be required if the I-71/I-75 roadway generally follows the current alignment. If the mainline is shifted significantly to the west in Kentucky, deeper cuts, including rock excavation should be anticipated. It has been our experience that the Ordovician Age shale and limestone bedrock in the greater Cincinnati region can generally be excavated with heavy-duty equipment. Blasting, though not commonly used, may be needed in areas of deep rock cuts.

Due to the corridor area generally being developed, the use of typical embankment fills for roadway construction will likely be limited. Mechanically Stabilized Earth (MSE) walls and/or cut walls may be considered to reduce the roadway impact area. In urban areas, due to space limitations, use of soil nail walls, cantilevered, and tieback walls may also be needed. We would anticipate several opportunities to use innovative geotechnical technologies to meet project schedules and budgets. Raised roadway sections or “flyovers” may also be considered. Due to relatively large lateral loads associated with raised roadways, deep foundations are often required to provide adequate resistance to axial, lateral, and uplift forces.

In Kentucky, the biggest impact to realignment of the existing roadway is the amount of cut (soil and rock) and fill that would be required if the alignment is shifted significantly to the west of its' current location. Significant rock cuts should be anticipated if the alignment crosses through the hilly terrain to the west. Near the Ohio River in Kentucky, and on the Cincinnati side of the river, significant realignment of the I-71/I-75 mainline is limited due to existing interchange/tie-ins. Slight modifications to the alignment to either the west or the east will likely not have a significant impact on roadway construction. The presence of random fill, old structures, and moderately compressible overburden soils in some portions of the project area may warrant the need for ground modification. Various techniques for ground modification and/or improvement can be used and are anticipated.

4.1.3 Excavations

Excavations into soil and bedrock should be performed in accordance with applicable OSHA requirements. Permanent slopes in soil should be 3H:1V or flatter. Steeper slopes can generally be attained in rock formations; however, the local rock formations are highly degradable and prone to erosion and/or raveling of surficial material. Vegetation should be established on soil slopes as soon as possible and rock faces should be protected where required. As a minimum, permanent slopes would need to be evaluated periodically to monitor the integrity of the slope face and look for any destabilizing aspects caused by erosion or movement.

Stability of excavated slopes will be an important consideration. Portions of the corridor may have colluvial soils (especially in the upland areas), which are prone to movement. The presence of groundwater and its impact on cut excavations and overall long-term stability of slopes is also an important consideration. The Ohio Riverbank has a history of shallow sloughing and flood events have an impact on their overall short-term and long-term stability. Rapid drawdown and its impact, especially on the riverbanks and where loess is exposed, is an important stability issue needing detailed investigation and analyses.

Excavation through the underlying unweathered gray shale and limestone bedrock, will involve additional effort. The presence of limestone layers, its thickness, and its distribution will impact the level of difficulty. Proper equipment (heavy-duty) to deal with rock breaking and removal will likely be required. Rock excavation methods may include the use of a large hydraulic trackhoe or dozer with a ripper tooth, hydraulic rock hammers or rock splitters, and/or pneumatic rock drills (air drills) or percussion machines. If deep rock cuts are necessary and/or thick limestone layers are encountered in the bedrock, rock removal by blasting techniques may be required.

4.2 Seismic Considerations

4.2.1 General Seismic Characteristics of the Corridor Area

Hamilton County (Ohio) and Kenton County (Kentucky) is located within a relatively "quiet" seismic area with regard to local seismic activity. Figure 11, in the Appendix, shows the locations and intensities of notable earthquakes in Southwestern Ohio and

Northern Kentucky. As discussed in greater detail in the following section, the seismicity of the area is strongly controlled by the New Madrid fault zone in southeastern Missouri. The Ohio Geological Survey has prepared a map of basement structures in Ohio, indicating fault lines and tectonic zones. The map is reproduced as Figure 12 in the Appendix. There are no mapped faults in the project corridor area.

Recent maps published by the USGS (October 2002) for recommended peak acceleration values for 2 percent and 10 percent probability of exceedance in 50 years for the eastern United States are shown as Figures 13A and 13B, respectively, in the Appendix. A preliminary seismic hazard analysis is presented in the following section.

4.2.2 Preliminary Seismic Hazard Analysis

A preliminary seismic hazard analysis was performed for the proposed bridge corridor. The steps for the analysis generally include the identification of the seismic sources capable of strong motions at the project site, evaluation of the seismic potential for each capable source and evaluation of the intensity of the design ground motions at the project site.

Plate tectonic theories do not adequately explain the mechanisms associated with intra-plate earthquakes such as those which occur in this area. To our knowledge, there are no mapped faults within the project site area. Further, there are no mapped faults which have experienced surface displacement due to seismic activity during the Holocene Epoch (past 11,000 years) within 100 miles of the project site. The closest mapped fault with such movement is the New Madrid Seismic Zone, which is about 200 miles southwest of the site.

For this preliminary analysis, the evaluation of the intensity of ground motions was accomplished using U.S. Geological Survey (USGS) published information regarding the seismic hazard for the Central and Eastern United States. This information for the project site is strongly influenced by the New Madrid Seismic Zone in southeastern

Missouri. To a lesser degree, historical local seismicity of Ohio, Kentucky and Indiana contribute to the seismic hazard as well. The USGS Internet website seismic hazard mapping tools were used to estimate the potential ground motions for the project site corridor. For the purposes of this analysis, the design event evaluated was an earthquake whose ground motions have a 2 percent probability of exceedance in 50 yrs (equivalent to a 10 probability in 250 years, or a recurrence interval of 2475 years).

The USGS mapping evaluation uses a database that considers the contribution of all recorded earthquakes that may influence the project site area. The coordinates at three locations along the center of the project corridor (north end, Ohio River south bank, and south end) were entered to obtain peak ground accelerations and spectral accelerations. Maps which depict the relative contribution of historical earthquakes, their distance from the project site and the earthquake magnitude were produced. Figures 14A to 14H in the Appendix show these maps for the Ohio River south bank location. The following tables summarize the information obtained for each of the three locations for the design event:

Table A: Preliminary Seismic Hazard Data – North End of Project Corridor

		Site-Source Mean Event		Site-Source Modal Event		Relative Contribution		CEUS Source Mean Event	
Criteria	Accel. (g)	M	D (km)	M	D (km)	NMSZ (%)	CEUS (%)	M	D (km)
PGA	0.079	6.20	152	7.7	456	14	86	5.95	101
0.2 sec SA	0.178	6.42	185	7.7	456	18	82	6.13	126
0.3 sec SA	0.155	6.73	239	7.7	456	29	71	6.37	151
1.0 sec SA	0.076	7.25	358	7.7	456	51	47	6.73	241

Notes: Accel.=acceleration value, M=earthquake magnitude, D=distance, NMSZ= New Madrid Seismic Zone, CEUS=Central and Eastern US Seismic Zone, PGA = peak ground accelerations, SA = spectral accelerations

Table B: Preliminary Seismic Hazard Data – Ohio River South Bank

		Site-Source Mean Event		Site-Source Modal Event		Relative Contribution		CEUS Source Mean Event	
Criteria	Accel. (g)	M	D (km)	M	D (km)	NMSZ (%)	CEUS (%)	M	D (km)
PGA	0.080	6.21	150	7.7	455	14	86	5.94	100
0.2 sec SA	0.179	6.42	183	7.7	455	18	82	6.13	125
0.3 sec SA	0.156	6.73	237	7.7	455	28	72	6.33	150
1.0 sec SA	0.076	7.25	357	7.7	455	51	48	6.74	240

Notes: Accel.=acceleration value, M=earthquake magnitude, D=distance, NMSZ= New Madrid Seismic Zone, CEUS=Central and Eastern US Seismic Zone, PGA = peak ground accelerations, SA = spectral accelerations

Table C Preliminary Seismic Hazard Data – South End of Project Corridor

		Site-Source Mean Event		Site-Source Modal Event		Relative Contribution		CEUS Source Mean Event	
Criteria	Accel. (g)	M	D (km)	M	D (km)	NMSZ (%)	CEUS (%)	M	D (km)
PGA	0.080	6.20	150	7.7	452	14	86	5.94	100
0.2 sec SA	0.179	6.42	185	7.7	449	18	82	6.13	125
0.3 sec SA	0.157	6.73	237	7.7	452	28	71	6.33	150
1.0 sec SA	0.076	7.25	355	7.7	452	51	48	6.74	240

Notes: Accel.=acceleration value, M=earthquake magnitude, D=distance, NMSZ= New Madrid Seismic Zone, CEUS=Central and Eastern US Seismic Zone, PGA = peak ground accelerations, SA = spectral accelerations

The primary conclusions that may be derived from the information presented above are:

1. The acceleration values predicted (for the soil-bedrock interface) do not vary significantly for peak ground acceleration and spectral accelerations at the selected periods across the range of the corridor. For conservatism, we recommend using the values observed at the south end of the corridor.
2. The relative contribution of the New Madrid Seismic Zone is limited except for the spectral accelerations predicted at a period of 1.0 second.
3. The relative contribution of the random seismicity of the Central and Eastern U.S. Seismic Zone (CEUS) appear to be higher for spectral accelerations at the other selected periods and for the peak ground acceleration.

These observations suggest that seismic site response analyses should be performed using a series of several time histories that represent the smaller magnitude earthquakes of the CEUS and at least one time history that represent the New Madrid Zone event.

4.3 Landslide Issues

Areas of the greater Cincinnati and Northern Kentucky region are prone to slope movements and landslides. On the Kentucky side of the Ohio River, within the corridor area and nearby, many landslides have been reported and documented. The landslides were typically observed to occur along the western side of the corridor area and near the southern limits. Due to the hilly terrain in these areas, slope instability was more common. Landslides typically occurred after heavy rain events or during extended periods of wet weather. The landslides generally occurred above the bedrock within the overburden soils, or along the soil/bedrock interface. The approximate locations of the landslides are shown on Figure 15 in the Appendix of this report.

Of particular interest, within a few years after the original construction of the I-71/I-75 in Kentucky (between Interchanges 189 and 190), the outside northbound lane started to show signs of settlement and cracking. The distress was initial evidence of a landslide. The lane was closed for some time and eventually a large buttress embankment was built to stabilize the slope in this area. In this case, the roadway embankment was constructed on a substantial depth of colluvium, which in turn overlaid a sloping bedrock surface. The approximate location of the landslide within the I-71/I-75 roadway is shown on Figure 15 in the Appendix.

Few, if any, landslides have been reported along the eastern side of the corridor (nearer the Ohio River) on the Kentucky side, and in the entire corridor area on the Ohio side of the river. In these relatively flat areas, the greatest potential for landslide or slope instability is adjacent to the Ohio River. Detailed slope stability analyses along the Ohio River should be performed once the bridge location has been selected.

Landslide concerns generally increase along the western side of the corridor area, and throughout the corridor from about Kyles Lane to about 1½ miles north of Kyles Lane in Kentucky. Therefore, shifting of the I-71/I-75 roadway west of its' current location increases the potential for landslides and slope instability.

5.0 RED FLAG SUMMARY

Per ODOT, the purpose of a Red Flag summary is to "identify concerns that could cause revisions to the anticipated design and construction scope of work, the purposed project development schedule, the estimated project budget, or the potential impacts of the project on the surrounding area". Based on the geotechnical overview described in this report, the Red Flag Summary is used to highlight geotechnical issues that are present and that should be considered during project development. The applicable geotechnical portions of the Red Flag Summary were completed and are attached to this report. The Red Flag Summary should not be reviewed independently of the information contained in this report. This geotechnical overview of the corridor study area should be used to supplement the Red Flag Summary.

6.0 CLOSING

The purpose of this report was to provide a geotechnical overview for the proposed Brent Spence Bridge replacement and I-71/I-75 roadway improvements from Kyles Lane in Covington, Kentucky to Western Hills Viaduct in Cincinnati, Ohio. The corridor study area extended 1,000 feet to the east and 1,000 feet to the west of the existing I-71/I-75 mainline. Based on review of available data, the overview includes general subsurface and geologic conditions in the project corridor area, and an overview of existing geotechnical features that have an impact on the final bridge/roadway location, and design and construction. The overview also included the completion of the applicable sections of ODOT's Red Flag Summary, which is attached to this report.

The information contained in this report is considered general in nature. No field exploration, laboratory testing, or analyses were performed for this overview. The information contained in this report is based on published data and previous experience across the corridor study area. A more detailed geotechnical study, including soil test borings, in-situ field testing, soils laboratory testing, and geotechnical engineering analyses should be performed once the bridge location/roadway alignment is more defined to identify areas of geotechnical concerns. The study should also be performed to assist the project team during design and construction of the Brent Spence Bridge and I-71/I-75 roadway improvement.

H.C. Nutting appreciates the opportunity of providing our geotechnical services for this overview. We would be pleased to assist the project team through attendance at future project meetings and/or by providing additional consultation as the need arises. Please do not hesitate to contact us if you have any questions and/or comments regarding this overview. We request the opportunity to provide future geotechnical engineering services for this premier project as it progresses into the design and construction phases.