M E M O R A N D U M

TO: **Stephen De Witte, PE**
Project Management Coordinator
Division of Planning

FROM: **Michael Carpenter, PE**
Director
Division of Structural Design

BY: **Sean House, PG**
Geotechnical Branch

DATE: **March 24, 2021**

SUBJECT: **Campbell County**
FD52 019 0009 017-018P
Improve Safety and Reduce Congestion at the I-275 Interchange
With KY-9 (AA HWY)
Item # 6-448.00
Mars # 1237501P
Geotechnical Overview Report

1.0 Project Description

The Kentucky Transportation Cabinet (KYTC) is conducting a study to identify and evaluate the I-275 interchange with KY-9 in Campbell County, stretching from approximate mile points 76.8 to 77.5 on I-275 and approximate mile points 16.5 to 18.2 on KY-9. The goal of this study is to improve safety and congestion along the I-275/KY-9 interchange corridor. This overview will be utilized to identify geotechnical considerations for the study area. The project location and corridor are presented on the drawing provided (Appendix A).

2.0 Scope of Work

The scope of work for this study consists of performing a geotechnical overview for the proposed study area base upon research of available published data and the Geotechnical Branch's experience with highway design and construction within the region. General geotechnical and geologic characteristics of the study area have been identified and are discussed in this report. The following sources were used to perform a literature search:

- USGS Professional Paper 1151-H: The Geology of Kentucky: Physiography;
- USGS Professional Paper 1151-H: The Geology of Kentucky: Ordovician System;
- USGS Professional Paper 1151-H: The Geology of Kentucky: Quaternary System;
- Geologic Map of Parts of Newport and Withamsville Quadrangles (GQ# 1072), by A.B. Gibbons, published by the USGS, 1973;
- Surficial Geologic Map of Parts of the Newport 7.5 Minute Quadrangle, Northern Kentucky, by Matthew A. Massey, Antonia E. Bottoms, and Maxwell Hammond III, published by the KGS, Contract Report 14 Series 13, 2018;
- USDA Web Soil Survey,

https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm;

- Available KYTC Arcmap Datasets and Layers
- KYTC Projects Nearby (KYTC Geotechnical Report Number):
  - Roadway Soils Investigation Project I-275-9 (3) 13, SP-19-781-1L, Circle Freeway, Campbell County, KY, L.E. Gregg & Assoc., March 1970 **(R-004-1970**)
  - Final Stability Report on Embankment Construction in the Licking River Valley, I-275-9 (3) 13, SP-19-781-1L, Circle Freeway, Campbell County, KY, Watkins & Assoc., September 15, 1966
  - Geotechnical Engineering Report, AA Highway-Section C, Campbell County, KY, FMSM Civil Engineers, Inc., October 1987 **(R-041-1987)**
  - Embankment Landslide, Campbell County, KY, I-275-9 (25) 20, SP-19-781-3Cl, Relocated KY-9, Stations 34+00 to 39+00, Division of Materials, April 15, 1974 **(L-002-1974)**
  - Landslide on Carlton Garman Property, 236 Licking Pike, Division of Materials, May 3, 1976 **(L-006-1976)**
  - Supplemental KY Route 9 Global Stability Analyses Proposed Commercial Development KY-9 at I-275, Wilder, KY, H.C. Nutting Company, March 8, 2006.
  - Proposed Landslide Correction, KY-9, Stations 139+50 to 145+00, Geotechnical Branch, June 6, 1993 **(L-015-1993)**

2.1 Topography and Drainage

The project study area is located within the Outer Bluegrass Physiographic Region. The topography throughout most of the project site is characterized by broad ridge tops and relatively narrow valleys. Typical vertical relief is in the magnitude of 300 feet. The Licking River runs approximately parallel to the North-South trending KY-9. The width of the valley floor is in the order of 1,800 feet, while relief from the bottom of the valley to the east ridge tops exceeds 400 feet.

Surface drainage is directed towards the Licking River and follows a dendritic pattern, believed to be the result of bedrock with fairly uniform resistance to erosion. In general, groundwater above the river valley is insignificant but hillside seeps and springs are common as groundwater can travel between rock strata and joints.

The 1966 investigation (R-041-1987) indicates that the uplands east of the adjacent river valley contribute most or all of the ground water recharge to the Licking Valley. The normal pool elevation of the Licking River is at 455 feet above sea level. Borings perpendicular to the Licking River towards the eastern ridges displayed higher water level readings closer to the ridges.

2.2 Stratigraphy

The study corridor is located in the southwestern corner of the Newport and Withamsville Quadrangles (GQ # 1072). Geologic mapping indicates the project area to be underlain by Upper Ordovician aged bedrock. In descending order, they are the Bull Fork Formation, Bellevue Tongue of Grant Lake Limestone, Fairview Formation, and Kope Formation.

The Bull Fork Formation is the upper most rock formation in the study corridor and would only be encountered at the top of the ridges. The formation consists of interbedded limestone and shale. Limestone composes slightly more than 50% of the formation and is irregularly to evenly bedded in mostly thin beds, but locally more than six (6) inches thick. The shale is commonly silty and calcareous.

Beneath the Bull Fork Formation lies the rubbly limestone of the Bellevue Tongue of Grant Lake Limestone. The limestone is fossil fragmental, in an argillaceous and calcareous matrix, in irregular and lenticular thin to very thin beds.

The Fairview Formation consists of interbedded limestone, 40 % near the base increasing upward to about 65% near the top, and shale. The predominant limestone is a coarse crystalline variety which exhibits bedding thicknesses ranging from eight (8) inches to greater than three (3) feet. The shale is silty and calcareous and susceptible to weathering.

The Kope Formation, the predominant strata within the project limits, consists of interbedded shale and limestone. Shale comprises 70-80% of the formation. It is laminated, silty, calcareous, and typically exhibits a very low resistance to weathering. While fresh, the unweathered shales appear to be competent materials, but upon exposure to the elements they will usually degrade into highly plastic clays and silts with low shear strength. The limestone strata consists of two types: (1) finely to coarsely crystalline, fossil fragmental, regular to irregular beds as much as 12 inches thick, and (2) fine grained, argillaceous and silty, regularly bedded up to eight (8) inches thick.

Figure 1: Kope Formation I-275 Eastbound east of KY-9 Interchange.

2.3 Soils and Unconsolidated Materials

The ridgetops consists of residual soils. Residual soils are derived in-place from a weathering process of the parent bedrock material. Drilling in the project area indicates that the soils are brown silts and clays that are typically five (5) feet or less in depth. Geologic mapping notes that soil depths can reach up to 13 feet in depth.

The hillsides consists of colluvium. Colluvium is a locally derived residuum that has accumulated and/or migrated downslope due to gravity. Hillside soils depths can range approximately from five (5) to ten (10) feet. Drilling and sampling has indicated that these soils consists of brown clays with gravel and boulders.

Located at the base of the hillsides, wedge shaped deposits with a hummocky topography have accumulated. These deposits are an accumulation of the gravity driven residuum that were located on the hillsides. They consist of poorly sorted clay, silty, gravel and boulders (limestone and shale) and soil horizons are not distinguishable. Soil depths in these deposits have been observed to reach up to 40 feet in depth during the 1974 KY-9 landslide investigation.

The Licking River Valley lies west of the previously discussed ridges. The rock surface slopes downward sharply toward the existing channel of the river where it bottoms out and lies relatively flat and wide 40-50 feet below the existing river channel. Lacustrine and alluvium terrace deposits cover the valley floor and increase significantly in thickness approaching the Licking River. Thicknesses have been found to range from 15 feet in depth to 110 feet in depth. A detailed profile view of the valley subsurface can be found in the Final Stability Report on Embankment Construction in the Licking River Valley report.

The Quaternary aged terrace deposits were deposited during three (3) separate time periods. They were deposited in alluvial and lacustrine environments. In general they comprise of varved, firm to stiff silty clays with silt and sand seams. The varved structure of the soils consists of intercalated laminations of clays, silts, and fine sands. The lamination thicknesses range from a fraction of an inch to several inches. The changes of the soil type are distinct and occur in a random sequence. Secondary structures consisting of desiccation cracks and slickensides were noted.

Alluvium deposits are found along the Licking River. They comprise of clays, sands, and gravels that consists of pebbles and small cobbles of chert, quartz, and quartzite.

2.4 Geologic Structures and Hazards

According to geologic mapping (GQ#1072) structural contours, drawn on the base of the Fairview Formation, plunge to the southwest at approximately 30 feet per mile. No faults or other significant structural features are noted in the study area.

Karst features are known to be in the Outer Bluegrass Physiographic Region however the site location (Appendix C) is not in a karst risk location. Springs are common between the limestone and shale beds and can be observed in the field during heavy rain falls.

The entirety of the project area is notorious for cut and fill slope stability failures. The driving force behind these instabilities can be attributed to groundwater movement, poor rock mass quality, deep colluvium accumulations, primary and secondary structures of the river valley deposits, and the proximity to the Licking River and potential high water levels.

Figure 2: Landslide and scarp southwest embankment of I-275 west of KY-9 interchange.

In 1973, a landslide occurred along the downhill slope of relocated KY-9 on the south side of the I-275 Interchange. Based on the Soil Engineering and Geologic Report (L-002-1974) prepared by the Division of Materials, plans were developed to perform corrective construction which included the excavation of the slide material along the toe of the hillside to the top of rock, placement of an underdrain system at the bottom of the excavation, and back filling the excavation using free draining granular material. Exercise caution when evaluating this area. Any work in this area should avoid disturbing the granular material or underdrain system placed during the landslide remedial construction.

Pictured above (Figure 2) is a landslide and scarp located at the toe of the embankment on the south side of I-275 eastbound before the KY-9 exit. In the immediate vicinity to the scarp is a large power line structure that sits atop fill material. It is not known if the foundation for the power line structure was built as part of I-275 or after. Extreme caution should be used when evaluating this area. Removal of the toe could result in further deterioration of the slope and potentially harm the power line structure.

3.0 Geotechnical Considerations

Based on the available resources significant geotechnical concerns should be considered when evaluating the project area. This includes any large scale alignment changes or small scale spot improvements that involve disturbing the current earthwork. A site investigation was performed on March 12, 2021 to help identify any current geotechnical deficiencies with the current alignment.

3.1 Cut Slope Considerations

Cut slope configurations in rock are generally controlled by bedrock lithology, bedrock quality, results of Slake Durability Index (SDI) tests in shales and siltstones, and by the presence of any fractures and/or joints. Slope configurations for rock cuts in durable bedrock can generally be 1H:2V presplit slopes on approximate 30-foot intervals of vertical height with 18 to 20-feet intermediate benches or 15-foot overburden benches. Slope configurations for non-durable bedrock or soils are generally constructed on 2H:1V slopes or flatter.

The Kope Formation is the dominant rock formation in the project corridor. Highway projects that intersect the Kope Formation have typically experienced slope stability and maintenance issues associated with the deep Rock Disintegration Zones (RDZ) and the rapid slaking of the newly exposed bedrock. The disintegration mainly occurs in the shale component (60-80%) of the formation. Slope configurations of 2H:1V or flatter should be anticipated. As the shale in the Kope Formation erodes large blocks of limestone beds can slide and potentially reach the road. To limit falling rock hazards roadside ditch benches of 14 (non-interstate) or 18 (interstate) feet are often recommended.

Figure 3: Falling rock debris in I-275 eastbound ditches.

Cut slopes on ridge flanks where deep deposits of colluvium have accrued should be avoided. These areas have been subjected to groundwater seepage, erosion, creep displacement, and expansion/contraction of the shales and residual soils. The removal of toe support can accelerate the rate of creep or cause outright slope failures.

3.2 Embankment Considerations

The project area is notorious for unstable fill slopes. As mentioned above a host of factors contribute to the instability of fill slopes: ground water movement, poor fill construction material, weak poorly sorted colluvium material, compressible and relatively weak terrace deposits, secondary structures consisting of desiccation cracks and slickensides, and proximity to the Licking River and its flooding hazard.

To help combat groundwater conditions adequate sub drainage facilities are often used. A system of longitudinal underdrains and lateral outlets increase stability factors both during and following construction.

Material excavated from the project would most likely consist of non-durable shales. Embankments principally of non-durable shale (SDI less than 95 according to KM 64-513) should be constructed using special shale compaction methods. If this construction method is not followed the shale can break down in a few years causing settlement and potential failures. Previous stability analyses also dictate that side slopes should be no steeper than 3H:1V.

The areas at the base of the ridges should be avoided where colluvium has accrued. Failures have already occurred in these zones on the south side of the I-275 Interchange and across the Licking River at a railroad embankment in the DeCoursey Railroad yards. To fix these, foundation materials were excavated and shear keys with drainage were installed. Based off of stability analyses shear keys can be implemented during construction and are a common practice in unstable areas. Please note that due to the non-uniform structure of the colluvium deposits that soil parameters are difficult to assign. A detailed exploration and analysis would be required for embankments in this material.

The terrace and alluvium deposits of the Licking River Valley are considered weak and compressible. Embankments constructed in the valley would most likely require a staged construction method. This method would help control groundwater conditions, restrict buildup of excess pore water pressure, provide slopes long-term stability, and confirm or amend predicted time versus settlement relationships. Settlement platforms and piezometers would be installed to monitor excess water pore pressures and ground movement from settlement due to new embankments at bridge end bents. Proximity to the Licking River should be avoided as the existing river bank is unstable following rapid draw down.

3.3 Saturated, Soft, or Unstable Soils in Subgrade

Based on review it appears durable rock will not be sufficient to construct a roadbed for the entire project. Therefore, other methods of improving the subgrade can be considered. Chemical stabilization is the preferred method of subgrade improvement. In areas where lanes are being added or chemical stabilization is not feasible (such as cross-overs, tie-ins, etc.) the subgrade can be constructed with Kentucky Coarse Aggregate No. 2, No. 3, or No. 23 sized stone with geotextile fabric.

Natural streams or drains may be encountered within the project limits along with possible springs. Any saturated or unstable areas encountered within embankment foundation limits may need to be stabilized and the stream channel may need to be redirected or have pipes installed.

3.4 Water Wells and Springs

As previously noted, the uplands area contribute most or all of the ground water recharge to the Licking River Valley. An adequate subsurface drainage system may be required to help control artesian conditions and increase stability factors both during and following construction.

Springs may be present within the proposed study area. These locations should be inventoried to verify their locations. Spring boxes and/or granular material may be required in the vicinity of springs. All water wells and/or cisterns within the limits of construction, whether shown on the plans or not, shall be plugged in accordance with Section 708 of the current Standard Specifications for Road and Bridge Construction.

3.5 Gas and Oil Well

Based on the available mapping, there are no oil and gas wells in the vicinity of the project study area. Any gas wells within the proposed right-of-way limits, shall be treated in accordance with Mines and Mineral Specifications.

3.6 Karst Conditions

Geologic mapping and field observations does not indicate the presence of sinkholes (Appendix C). Any open sinkhole and/or solution cavities within the limits of construction, whether shown on the plans or not, that are not used for drainage purposes, shall be filled and/or capped in accordance with the current edition of Section 215 of the Standard Specifications for Road and Bridge Construction.

Any sinkholes utilized for drainage purposed for new roadway construction should incorporate adequate measures to minimize water infiltration into the subgrade and erosion control measures to minimize situation of open sinkholes.

Adequate drainage will be of primary concern with any new design or new construction in the area to minimize environmental impacts by surface runoff into the underlying karst network. Proper management of surface water will also lesson the occurrence of sinkhole dropouts during construction. Mitigation of surface runoff should be performed by silt checks, silt traps, sediment basins and lined ditches where appropriate. Situation sinkholes should be avoided, especially those to remain open after construction.

3.7 Structures

At this time, it is unknown as to whether the proposed roadway would require new and/or widened substructure elements. A detailed geotechnical investigation will be required to determine the foundation support systems.

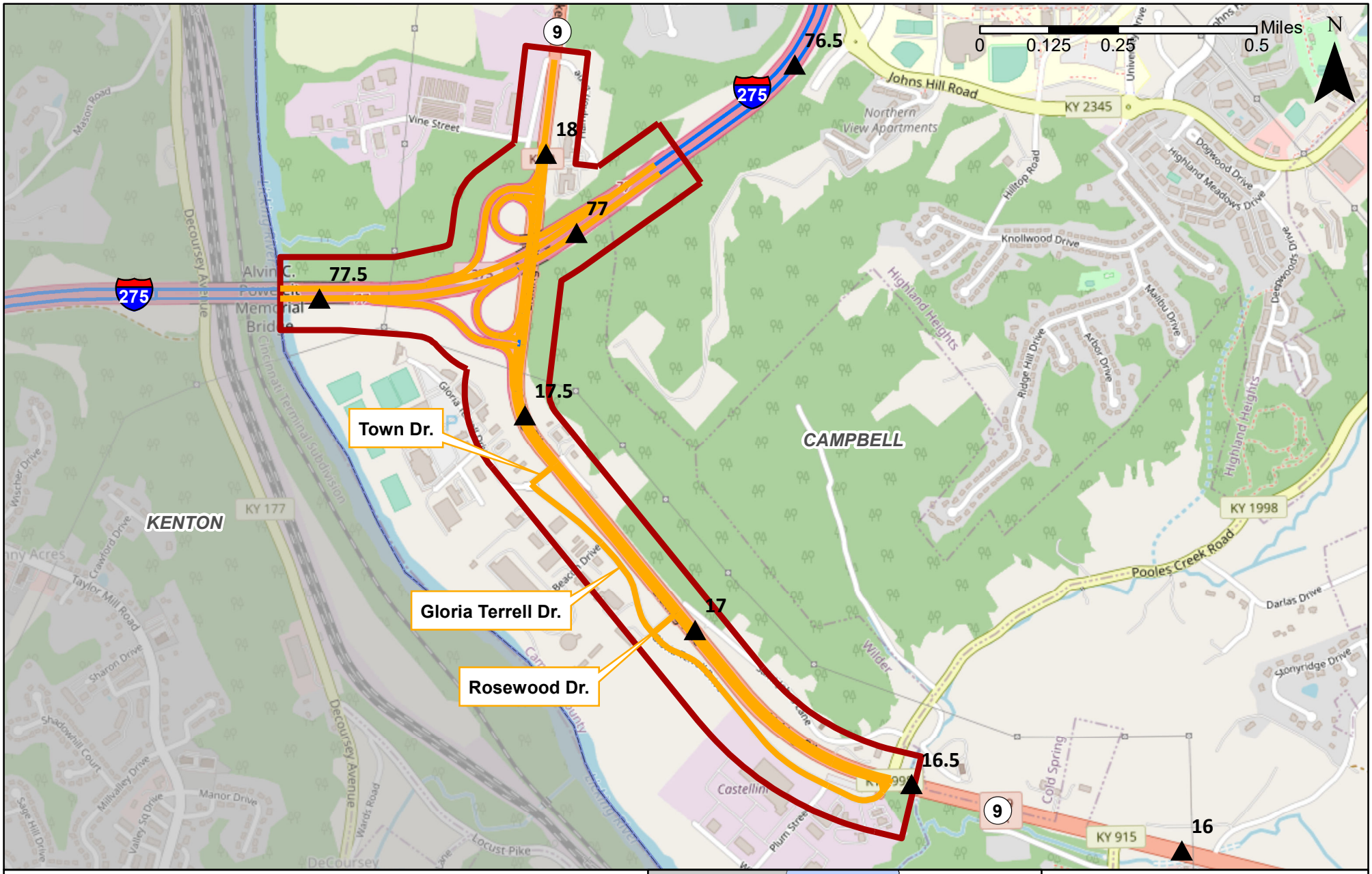
4.0 Conclusions

The purpose of this overview was to provide a general summary of the bedrock, soil, and geomorphic features likely to be encountered within the proposed alignment; and to identify geotechnical features that may have an adverse impact on the project.

Geotechnical drilling will be needed for roadway cut/fills and structures. If a portion of this project will be a widening project, information on existing pavement structure should be obtained to assist the team in pavement design. Due to the high volume of traffic chemical modification may not be feasible so a granular subgrade could be utilized. Sampling of foundation soils should be performed for embankment situations.

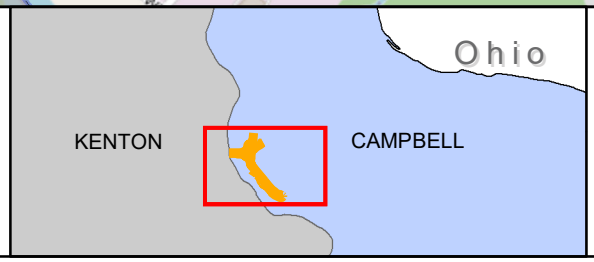
The information presented in this overview should be reviewed in the general nature in which it was intended. A thorough geotechnical exploration of the proposed alignment and grade will be required to properly anticipate and plan for special requirements necessary for the design and construction of the proposed alignment.

Appendix A
Study Area Corridor



Legend

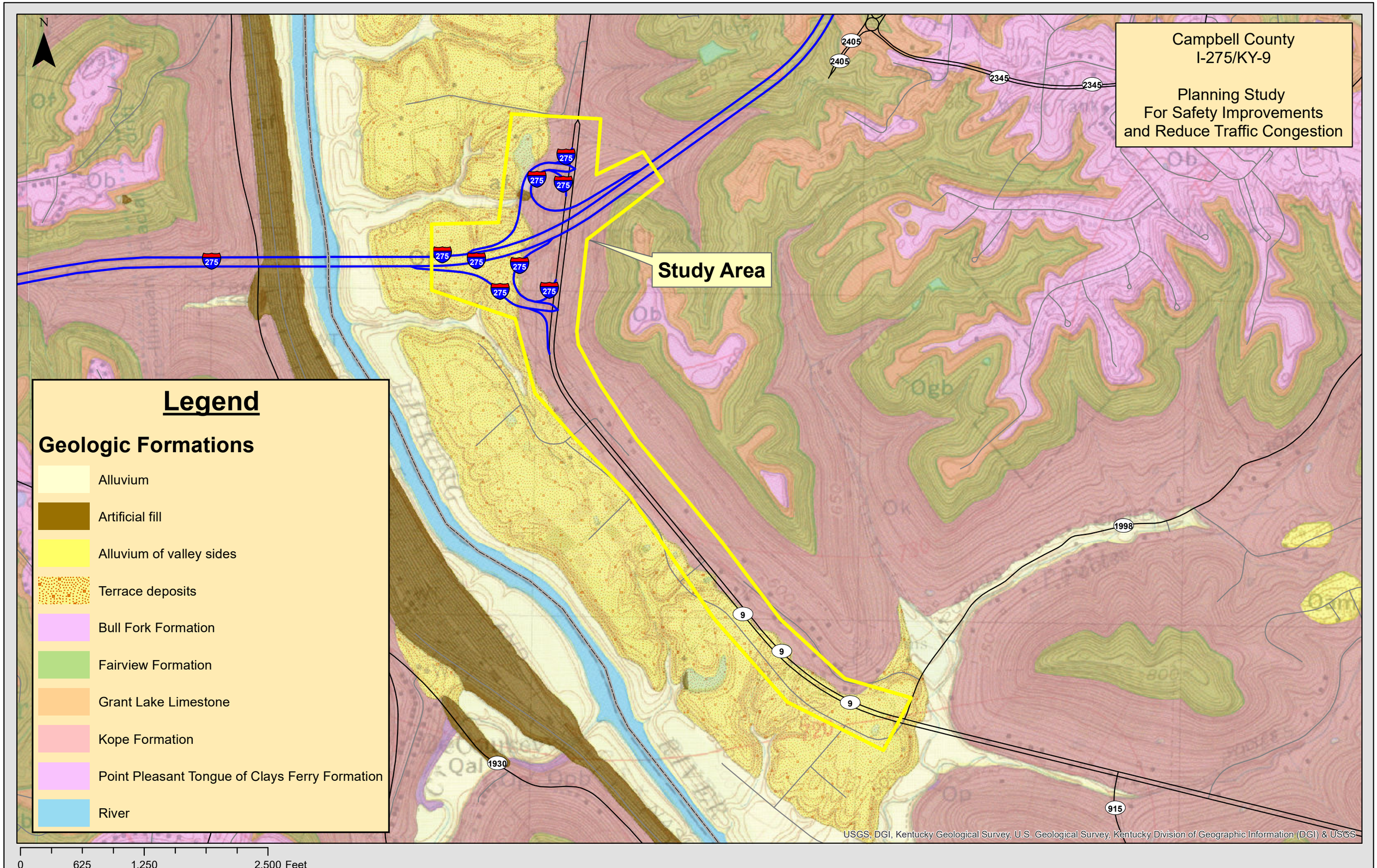
- Milepoint
- Interstate
- Study Area
- Study Area Boundary



I-275 / KY 9 Interchange Scoping Study

Study Area

Appendix B
Geologic Map


Campbell County
I-275/KY-9
Planning Study
For Safety Improvements
and Reduce Traffic Congestion
Study Area
N
Legend
Geologic Formations
Alluvium
Artificial fill
Alluvium of valley sides
Terrace deposits
Bull Fork Formation
Fairview Formation
Grant Lake Limestone
Kope Formation
Point Pleasant Tongue of Clays Ferry Formation
River
0
625
1,250
2,500 Feet
USGS, DGI, Kentucky Geological Survey, U.S. Geological Survey, Kentucky Division of Geographic Information (DGI) & USGS

Appendix C
Karst Potential Map

Campbell County
I-275/KY-9

Planning Study
For Safety Improvements
and Reduce Traffic Congestion

Study Area

INTERCHANGE

LICKING

RIVER

Lakeside Place Nursing Home

Latonia Ch

St Johns Ch

Pooles

DeCoursey Cr

CSX

Legend

- Interstates
- State Roads
- Local Roads
- County Lines

Karst

- INTENSE
- PRONE

USGS, DGI, Kentucky Division of Geographic Information (DGI) & USGS

0 625 1,250 2,500 Feet