MEMORANDUM

Cc:

TO: John Moore P.E.
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BY: Bart Asher, P.E., P.L.S.
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DATE: January 13, 2017

SUBJECT: **Lincoln County**
US-27 Corridor improvements from Somerset to Lexington
Halls Gap
Mile Point 11.169-15.881
Item # 8-167.00
Mars # 9011101D
Preliminary Geotechnical Assessment

The Division of Planning is conducting a planning study for the subject project. This project is located in Lincoln County, KY along US 27 between KY 1247 and Education Way. Notably, this includes the cut through Halls Gap. This abbreviated review will discuss some general geotechnical concerns with the area.

The approximate coordinates for the site are:

Beginning: 37.439161 degrees North and -84.638564 degrees West
End: 37.519158 degrees North and -84.659028 degrees West.

The site is located in the Stanford, Halls Gap and Crab Orchard Quadrangles as depicted on the attached map. The site is at the edge of the Outer Bluegrass and the Knobs Regions. Elevation relief in the area of the existing alignment ranges from approximately 915 feet to 1420 feet. Bedrock formations in the subject area are depicted on the attached map. Descriptions of the dominate bedrock types in the area are as follows:

Salem Formation – Calcareous Siltstone, shale and limestone – cut slopes are typically ½:1 slopes.

Nancy Member of Borden Formation – Interbedded siltstone and shale. The siltstone quantity usually increases and shale decreases at higher elevations in the Borden Formation – cut slopes are typically ½:1 slopes.

New Providence Shale Member of Borden Formation – Clay shale which often has a deep Rock Disintegration Zone (RDZ). Typically 2:1 cut slopes (0-25 SDI, 0 RQD). Can be used for encapsulating the New Albany Shale Formation (Acid Producing).

New Albany Shale Formation – Silty, Pyritic Shale that can produce acidic runoff. Requires special construction techniques. Typically over-excavated on a 2:1 slope, serrated and then encapsulated with an impermeable material (usually clay). This shale placed in excess material sites or used in embankments must be encapsulated. Structures in contact with the shale may require special design considerations.

Brassfield Formation – Dolomitic bedrock. Relatively thin formation (up to 10' thick). Very

good for road construction where it can be separated.

Preachersville Member of the Drakes Formation – Shale (mudstone), can be calcareous, and dolomitic – cut slopes are typically ½:1 slopes.

Rowland Member of the Drakes Formation – Shale (mudstone), can be calcareous and dolomitic – cut slopes are typically ½:1 slopes.

Limestone and dolomite in this area, where they can be separated from the shale, are suitable for embankment foundation construction and rock roadbed. Visually, it appeared that there will be minimal amounts of durable rock for use in these select construction activities. Quantities of available bedrock will require an investigation that takes the proposed grades into account. The cut slopes composed of the material described above as having a typical cut slope of ½:1 will have an approximate 1:1 footprint including slopes and benches where required. This footprint does not include any required rock fall area (ditch) widths.

Of special interest, the cut in Hall's Gap has long been scavenged by rock collectors seeking specimen grade geodes containing the mineral millerite. Apparently, it is one of the few places in the world where such high quality specimens can be readily found. Prospectors in the past have opened up dangerous hand dug works into the hillside that have had to be sealed off. Measures may need to be considered to deter this for any new cuts.

Some potential karst activity was noted in the field but it appears to be fairly minimal. Karst in this area is likely to be associated with the Drakes Formation. There are numerous faults indicated in the mapping throughout the area, especially on the northern section of the corridor. These faults are not known to be geologically active. If faulting is exposed in a rock face, additional design considerations may be required to compensate for potential dipping bedrock conditions.

Soils in this area generally are clays (CH and CL) materials. It is not uncommon to also encounter silts, silty sands, and silty clay materials (ML, SM, CL-ML). Most soils in the area are residual in nature, being derived from the area bedrock. Although the mapping does not indicate it, artificial fill is located throughout the corridor in the roadway fill areas. Alluvial soil deposits (soils that are generally unconsolidated and can sometimes cause issues with road construction) may be located in low lying drain areas. Soils in the area are generally suitable for embankment construction. Generally embankments built from the native soils and bedrock can be constructed to a height of 60 feet or more with 2H:1V side slopes if the foundation is suitable and proper compaction methods are used. Embankments constructed primarily of non-durable shale may only reach 30 feet in height before flatter slopes may be necessary. The use of area shales in the construction of embankment can require special construction techniques to ensure adequate long term stability. Soil cuts over approximately 10 feet often require analyses to design proper side slopes. In no case should soil cuts be steeper than 2H:1V.

California Bearing Ratio (CBR) values used in pavement design for soils subgrades in the area range from 2-4. The use of rock roadbed is common in the area. Chemical modification of the subgrade has also been used successfully in the area

Low lying areas may be wet and saturated, creating problems during construction. Ponds may be encountered and require remediation efforts. Ponds were noted in multiple areas along the alignment. Springs will likely be present in the corridor and will need to be addressed properly in

design and construction pending an investigation.

There are numerous water wells, monitoring wells and oil wells in the vicinity of the project. The locations of the known wells can be retrieved from the Kentucky Geologic Survey web site.

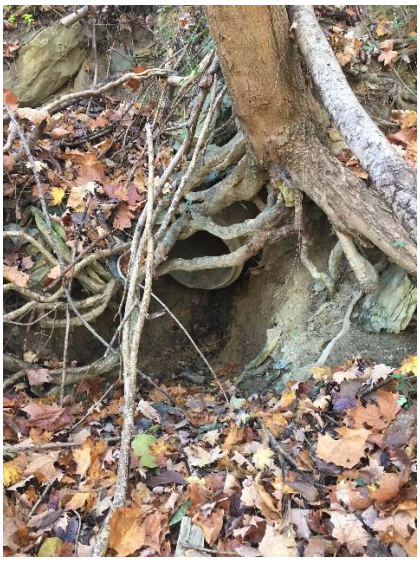
Previous embankment failures have been previously addressed in the study area. It would appear that most of these were caused by the original construction of over-steepened embankments or by undermining existing embankments. Other hillsides in the area showed a few signs of instabilities, such as pop out failures.

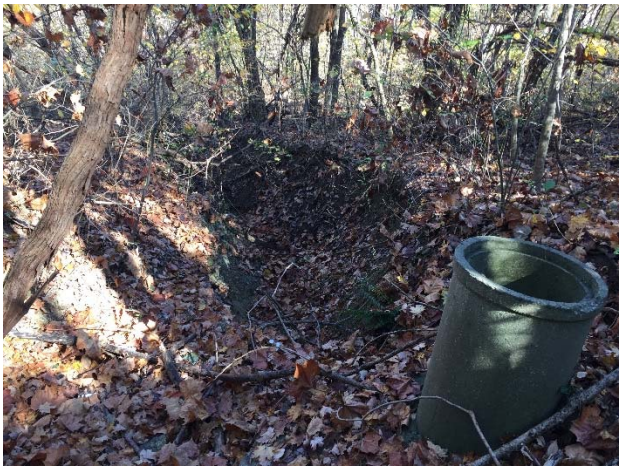
Areas of consideration encountered in the site visit include (MP = Mile Point):

MP 11.8-12.3 - Bedrock in existing rock slopes (right and left of centerline) can likely be designed with ½:1 slopes with a 14 foot fall catchment area (ditch) at the base of the cut (an overall 1:1 footprint from the base of the cut can be assumed) . The maximum lift height would likely be 30 feet before an intermediate bench would be required.

MP 12.3-12.8 - Bedrock in existing rock slopes (left of centerline) would likely be designed for a 2:1 cut slope.

MP 12.3-13 – Existing embankments on the right side have been historically unstable. Current signs of stability problems are still present. Existing embankment slopes in this area are too steep. A more thorough investigation for a chosen alternate would be required but it is likely that it will be necessary to excavate the material in the over steepened areas to bedrock from the vicinity of the existing northbound driving lane down on a 1:1 slope and reconstruct with properly compacted embankment on a 2H:1V slope. A drainage blanket and embankment benching would be required. Any installed retaining structures (H-piles or railroad rails) would be removed as part of the reconstruction. It should be noted that two of the concrete pipes that were investigated at the toe of the slope in this area show signs of extreme erosion. Portions of these pipes have separated and dropped, including the headwalls. It is likely that these concrete pipe joints have separated in the fill and are causing water to directly enter the embankment. This causes further issues with slope stability. It is recommended that a camera is used to evaluate these pipes for further mitigation.

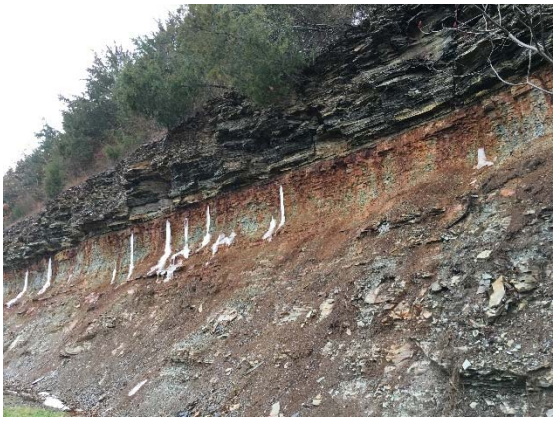




Failing concrete pipe

P-016-2016
Lincoln County
Hall's Gap

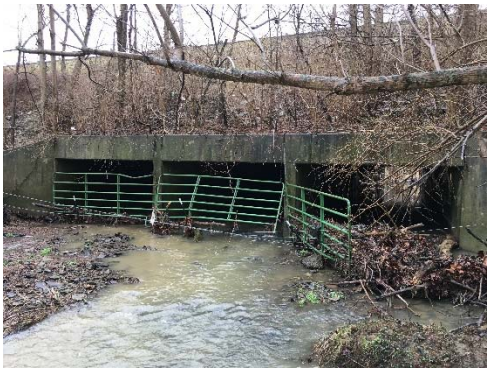
MP 13.9-14 – This existing cut contains the acid producing New Albany Shale Formation material (dark material at top of cut in picture). Cuts in this formation are typically over-excavated on a 2H:1V slope and capped with impervious control surface water from reacting with the pyrite in the shale.



New Albany Shale Formation

MP 15-15.3 – Preliminarily 2H:1V cuts would be recommended through this interval. This footprint could potentially be modified if needed. The New Albany Shale Formation may be located below grade.

MP 15.7 – There is an existing triple barrel culvert at this location. The embankment on the left side has a dip in the guardrail that could indicate some previous slope instability. The base of that slope shows indication of being wet year around.



Existing Culvert

Foundations for bridges in the study area are generally rock bearing (end bearing piles, drilled shafts or spread foundations). Smaller structures such as retaining walls and box culverts may be founded on soil or bedrock. Special considerations must be considered (such as the use of special concrete) where foundations encounter acid producing shales.

Six options were supplied for consideration as part of this overview. Those are (with comments specifically relating to Halls gap):

1. Widen Left (west side) – four lane with divided median.

With this option it may be possible to not touch the unstable slopes between MP 12.3-13 if the

road is pushed over far enough. This will require a thorough investigation. Otherwise, remediation to that area would still be recommended. Basic recommendations for cut slopes are as stated above. There is a road and dwellings on top of the cut in this area that could potentially be impacted.

2. Widen Right (East Side) – four lanes with divided median.
   With this option the unstable slopes will definitely need to be addressed. Rock cut slopes are as stated above. As with the first option there is a road and dwellings that could be affected.

3. Equal Widen – four lane with divided median.
   This option will have some of the same issues as the first two but may offer less impact to the roads and dwellings located above the cut.

4. Four lane with barrier wall median to reduce footprint through Hall's gap.
   This could be a less intrusive option, however the unstable slopes will still need to be fixed and there could still be R/W impacts to the roads and dwellings.

5. One new four lane with divided median "off alignment"
   This option would potentially have less impact to the traffic. Cut slopes through the material will depend on the formations encountered during the investigation based on the grade.

6. 2+1 Alternate
   This alternate could potentially leave Hall's Gap as is – the previously remediated slopes still appear to have some instability. Discussions can be undertaken as to how to handle the slopes short and long term with this alternate. The measures taken to date to remediate these slopes are considered to be long term temporary measures. District maintenance personnel should weigh in as to frequency of pavement patching and whether the existing rock cuts lose material into the driving lanes on a frequent basis.

A list of previously completed Geotechnical Investigations close to the study area is located below. The reports can be accessed through the KYTC Geotechnical Branch Database which can be accessed through the KYTC Division of Structural Designs home page (Click on Geotech and Search KYTC Completed Projects).

L-005-2002 – US 27 Landslide at MP 12.8 within study area
L-003-2002 – US 27 Landslide at MP 12.8 within study area
L-012-1986 - US 27 various landslides south of the project area
R-032-1993 – US 150
R-053-1999 – US 150B
R-064-2015 - US 27
R-077-2007 – KY 698
RA-002-2010 – KY 698

Site specific Geotechnical investigations are critical in this region.

Attachments:
GQ Site Maps

Lincoln County
US-27
Planning Study

N

Stanford

Lancaster

Study Area

Halls Gap

Crab Orchard

1247 1770 698 27 3249 643

Legend

- US Highways
- State Roads
- Local Roads
- Geologic Faults
- Qal Alluvium
- Dna New Albany Shale
- Sb Brassfield Dolomite
- Ms Salem Formation
- Ashlock Formation
- Oau Upper Member Reba & Terrill
- Oart Reba & Terrill Member
- Borden Formation
- Mbn Nancy Member
- Mbp New Providence Shale
- Drakes Formation
- Odp Preachersville Member
- Odr Rowland Member

USGS, DGI, Kentucky Geological Survey, U.S. Geological Survey

0 1,500 3,000 6,000 Feet