M E M O R A N D U M **P-008-2022**

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Division of Planning

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DATE: September 13, 2022

SUBJECT: Hardin County
KY 222
M.P. 0.0 – 6.5
SP0020030
Mars # 1343807P
Preliminary Geotechnical Assessment for Route Improvement

1.0 General Overview

This planning study focuses on the southcentral portion of Hardin County, Kentucky, along KY 222 – west of I-65 – through Glendale. The western extent of the project area begins at the intersection of KY 222 and US 62 (Leitchfield Rd.), approximately 7.7 miles southwest of Elizabethtown, and continues east by southeast across KY 9001 (Western Kentucky Parkway), KY 1904, and KY 1136, before intersecting I-65.

The purpose of the study is to identify any geological or geotechnical hazards or concerns in the provided project area that could be problematic for the improvement of KY 222.

1.1 Scope of Work

The scope of work for this study consists of performing a geotechnical overview for the proposed study area based 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:

- Arms, Fred S., Mitchell, Michael J., Watts, Frank C., Wilson, Byron J. "Soil Survey of Hardin and Larue Counties, Kentucky." United States Department of Agriculture: Soil Conservation Service. Natural Resource Conservation Service. 1974.

- Kepferle, Roy C. "Geology of the Cecilia Quadrangle, Kentucky." Kentucky Geological Survey: USGS. GQ 263. 1963. <https://kgs.uky.edu/kgsweb/download/24k/gq/CECILIA.pdf>
- Kepferle, Roy C. "Geology of the Elizabethtown Quadrangle, Hardin and Larue Counties, Kentucky." Kentucky Geological Survey: USGS. GQ 559. 1966. <https://kgs.uky.edu/kgsweb/download/24k/gq/ELIZABETHTOWN.pdf>
- Moore, Frank B. "Geologic Map of the Sonora Quadrangle, Hardin and Larue Counties, Kentucky." Kentucky Geological Survey: USGS. GQ 492. 1965. <https://kgs.uky.edu/kgsweb/download/24k/gq/SONORA.pdf>
- Moore, Frank B. "Geologic Map of the Tonieville Quadrangle, Larue and Hardin Counties, Kentucky." Kentucky Geological Survey: USGS. GQ 560. 1966. <https://kgs.uky.edu/kgsweb/download/24k/gq/TONIEVILLE.pdf>
- USGS Professional Paper 1151-H: The Geology of Kentucky: Physiography
- The Kentucky Speleological Society
- Available KYTC ArcMap Datasets and Layers
- KYTC Projects Nearby (see Section 6.0 – Past [Relevant] Geotechnical Reports)

2.0 Physiography and Topography

While majority of Hardin County is contained within the Western Pennyroyal physiographic region, the northeastern edge of the county lies in the Knobs physiographic region. The Knobs consists of hundreds of independent, steep-sloping, often conoidal hills lying at the outer edge of the Bluegrass Region. The Knobs are associated with the outcrop belt of Silurian and Devonian black and clay shales. The extent of this planning study is contained within the Western Pennyroyal region. The Western Pennyroyal region is characterized as an upland area primarily consisting of high-karst potential limestones and karstic features. The limestones are highly susceptible to solution weathering; thus, sinkholes are frequent in the region (see Karst Potential Map).

Topography within Hardin County is variable, ranging from gently rolling plains with springs, sinking creeks, and abundant sinkholes to steeper slopes associated with the Knobs in the northern part of the county. Relief in the project area is generally less than 200 feet, with the steepest terrain along the eastern extent of the area – along I-65.

Figure 1: Typical [karst] topography with visible sinkholes and rolling hills.

Within Hardin County, elevation varies from approximately 380 feet above mean sea level (MSL) south/southwest of Lebanon, just west of KY 208 to over 1,200 feet above MSL near the southeastern edge of the county. Site specifically, the elevation ranges from approximately 380 to 1000 feet above MSL, based on the United States Geological Survey (USGS) 7.5-minute series maps of the Cecilia (GQ 293), Elizabethtown (GQ 559), Sonora (GQ 492), and Tonieville (GQ 560), Kentucky quadrangles.

Surface drainage in the study area trends South toward Nolin River via Valley Creek. Tributaries flowing into Valley Creek include Rose Run, East Rhudes Creek, and West Rhudes Creek.

Subsurface contours mapped along the base of the New Albany Shale indicate bedrock in the study area dips westward near Glendale, creating a shallow syncline/basin with an axis primarily paralleling the Nolin River, trending west.

3.0 Geology & Stratigraphy

3.1 Bedrock

Available mapping by the Kentucky Geologic Survey (KGS) Geologic Map Service (2022) indicates the study area is primarily underlain (in descending order) by bedrock belonging to the Mississippian Ste. Genevieve Limestone and St. Louis Limestone.

The Ste. Genevieve Limestone is characterized as having highly oolitic zones, numerous crinoid fossils, and as being argillaceous, thick bedded, and locally dolomitic. Chert appears in the Ste. Genevieve as banded beds and nodules. Within the study area, the Ste. Genevieve Limestone ranges from approximately 100 feet thick to 160 feet thick. The Ste. Genevieve weathers to dark-red cherty soil, forming low hills and flats with numerous sinkholes.

The St. Louis Limestone contains abundant chert that is highly fossiliferous to fossil-fragmental, appearing in 6” to 12” beds. The top of the St. Louis is identifiable by its reddish-brown, weathered chert residuum that has formed atop the unit. Similar to the Ste. Genevieve in the area, the St. Louis Limestone ranges from approximately 100 feet thick to more than 200 feet thick. The St. Louis weathers to dark-red cherty clay soil and forms low hills and broad flats with abundant sinkholes.

Slumped deposits (see Sonora Quadrangle – GQ-492) of sandstone and shale have been mapped within the project area between the intersection of I-65 and KY 222 and the west end of Glendale along and south of KY 222. These deposits are the result of (now eroded) sandstone and shale formations formerly overlying the Ste. Genevieve Limestone weathering into sinkholes and cavities within the Ste. Genevieve and St. Louis Limestones.

Slumped sandstone deposits are generally fine grained, poorly consolidated or disintegrated into sand, and locally crosscut by thin, red or gray clay dikes. Slumped shale deposits are gray or greenish gray, predominately weathered to clay, and largely devoid of chert. Per the KGS, the slumped sandstone and shale deposits may be up to 110-feet thick.

3.2 Soils and Unconsolidated Material

The [current] Web Soil Survey (WSS) report obtained from the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) indicates [in the project area] the surficial soil deposits within approximately 40 inches of the ground surface consist primarily of silt loam, with some clay loam, silty clay loam, sandy clay loam, variant fine sandy loam, and bedrock. Low-plasticity fat clays (CH) are typical in the project area. These soils are primarily derived from their parent material – fine-silty, noncalcareous loess over clayey residuum weathered from limestone (USDA NRCS, 2022).

Alluvium is commonly found along the floodplains of streams. Alluvium in the project area consists of sand, silt, and clay, with chert pebbles and lenses of chert pebbles. Locally, the alluvium ranges from zero to 20-feet deep; in many locations only extending a few feet below grade.

In the project area, deep soils are to be expected. As previously mentioned, slump deposits in the area can range from a few feet to more than 110-feet deep – depending on presence of karst features in the underlying limestones. Previous structure projects in the area (Hardin S-111- through 114-2011) identify soils along KY 222 as ranging from a few feet to approximately 50-feet deep.

4.0 Geologic Hazards and Considerations

4.1 Karst

Because the bedrock underlying the study area has a high karst potential, well developed underground drainage systems including caves, sinkholes, and/or springs can be expected. Sinkholes that form in the Ste. Genevieve Formation are generally deep with steep sides.

The extent of the study area is underlain by karstic limestone and has, therefore, intense karst potential. Multiple sinkholes, varying in size from a few feet in length to a few thousand feet in length are shown on the attached Karst Potential Map. Available mapping indicates no known caves are present in the project area.

The abundance of karstic limestone facilitates subsurface flow and promotes ponding. Extreme or prolonged precipitation events can result in extremely wet soils, ponding, flooding of low-lying areas, and sinkhole formation and/or growth.

4.2 Faults

Two faults (shown on attached Geologic Map) are in proximity to – but do not intersect – the project area. One fault is located northeast of the project area, while the other is southwest of the project area. Both faults are associated with the Rough Creek fault system and create a graben around the project area.

The fault southwest of the project area trends west to east. The bedrock to the south of the fault is the uplifted section. The fault northeast of the project are trends northwest-to-southeast. The bedrock to the north of this fault is the uplifted section. There are no geotechnical concerns associated with either fault.

4.3 Mining/Quarry Activity

Vulcan Materials Company operates the Vulcan Materials aggregate quarry in the northwest corner of the study area, along US 62. This active quarry extracts limestone within the Ste. Genevieve and St. Louis Limestone units for the purposes of crushed aggregate.

4.4 Landslides

As previously mentioned, soils in the project area typically consist of low-plasticity fat clays, and soil depths in the project area can exceed 50-feet deep. As such, the area is prone to landslide in soil cuts that are at least ten-feet tall. Therefore, where depth to bedrock exceeds ten-feet, there will be an increased risk for landslide.

5.0 Design Expectations and Expected Foundation Considerations

5.1 Embankments

Generally, embankments built from the native soils and bedrock can be constructed to a height of 20 feet with 2H:1V side-slopes – if the foundation is suitable and proper compaction methods are used. Any embankment built 20 feet or taller will require a stability analysis, which could necessitate a flatter slope be used.

5.2 Cut Slopes

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 or 1H:4V 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 a range of 2H:1V to 3H:1V slopes or flatter based on the height of the slopes and content of the material. A detailed cut stability analysis will most likely be necessary in the project area.

5.3 Structures

Past geotechnical projects along or over KY 222 around I-65 indicate shallow to moderately deep (0 to 20-feet deep) soils around structure foundations, though soil depths can be greater when sinkholes are encountered. Bridges in the study area are generally rock bearing (spread footings). Smaller structures such as retaining walls and box culverts may be constructed on soil or bedrock.

Figure 2: Bridge 047B00091N on KY 1904, looking south toward KY 222.

Figure 3: Underneath 047B00091N on KY 1904, looking south toward KY 222. Note the lack of bedrock in the south embankment.

Figure 4: Looking east along KY 222, beneath 047B00046N. Note the sandy embankment (foreground), the lack of bedrock in the east embankment, and the fallen tree with roots intact against the north side of the central pier.

Figure 5: New culvert construction adjacent existing culvert under KY 222, both built on soil (slumped material).

5.4 Saturated, Soft, or Unstable Soils

California Bearing Ratio (CBR) values in the area are generally low (in the range of 1-3). If rock roadbed is not available other methods of improving 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.

Low and high plasticity clays can be very moisture sensitive. Working platforms may be necessary for cut and/or fill situations where soft and/or saturated soil is encountered. In these areas a working platform consisting of Kentucky Coarse Aggregate #2's, 3's, or 23's or limestone from roadway excavation wrapped with Geotextile Fabric may be required.

5.5 Sinkholes

Figure 6: Repaired sinkhole along Bacon Creek Road, south of KY 222, in the project area.

Working in areas effected by karst can prove to be unpredictable. Due to the abundance of karst features, rockline depths/elevations can vary greatly in a relatively short distance. Karst terrain will likely be the [most] critical factor to any new construction in the project area.

All open sinkholes and/or solution cavities within the limits of construction, whether shown on the plans or not, will require an investigation as outlined under Section 215, Treatment of Open Sinkholes, of the standard specifications for road and bridge construction (see attached Standard Drawing No. BGX-018).

Any sinkhole to be used for drainage purposes shall incorporate sufficient measures to minimize water infiltration into the subgrade and erosion control measures to minimize siltation of exposed sinkholes – as outlined in section "Drainage to Significant Resources" in the current edition of the Drainage Manual. Such measures may include the use of vegetated channels, grass-lined swales, interceptor ditches, containment basins, etc. as designated in the Manual.

5.6 Ponds

Figure 7: Pond at the intersection of KY 222 and Bacon Creek Road.

Multiple ponds have been identified within the project corridor. Should these ponds be impacted by roadway construction due to alignment, they will require treatment – such as removal of soft and/or unstable material and stabilization of the area by use of Kentucky Corse Aggregate #2's, #3's or 23's and underlain by geotechnical fabric (typical treatment).

6.0 Past [Relevant] Geotechnical Reports

The following is a list of geotechnical reports that have been previously issued near the project area:

Roadway	Planning	Structures	Structures (cont.)
RA-004-2015	P-005-2015	S-111-2011	S-118-2011
RA-005-2015		S-112-2011	S-126-2011
		S-113-2011	S-138-2014
		S-114-2011	S-140-2014
		S-115-2011	SA-014-2021
		S-116-2011	SA-021-2012
		S-117-2011	

7.0 Conclusion

This is a general overview of the geotechnical considerations that need to be taken in to account during alignment selection and construction. This includes the bedrock, soil, and geotechnical hazards that are expected to be encountered in the project corridor. These features may have adverse impacts on the project.

A complete Geotechnical investigation including drilling, sampling, and testing of materials will be needed to anticipate and plan for any special treatment of issues encountered during that phase. This may include the taking of pavement cores were directed by the project team. Analysis of rock core and soil sample testing will be compiled and presented in a Geotechnical Engineering Roadway Report and a Structure Report if needed.

Attachments:

- Site Map
- Geologic Map
- Springs and Wells Map
- Karst Potential Map
- Standard Drawing No. BGX-018

KY 222 Glendale Corridor Study

Hardin County

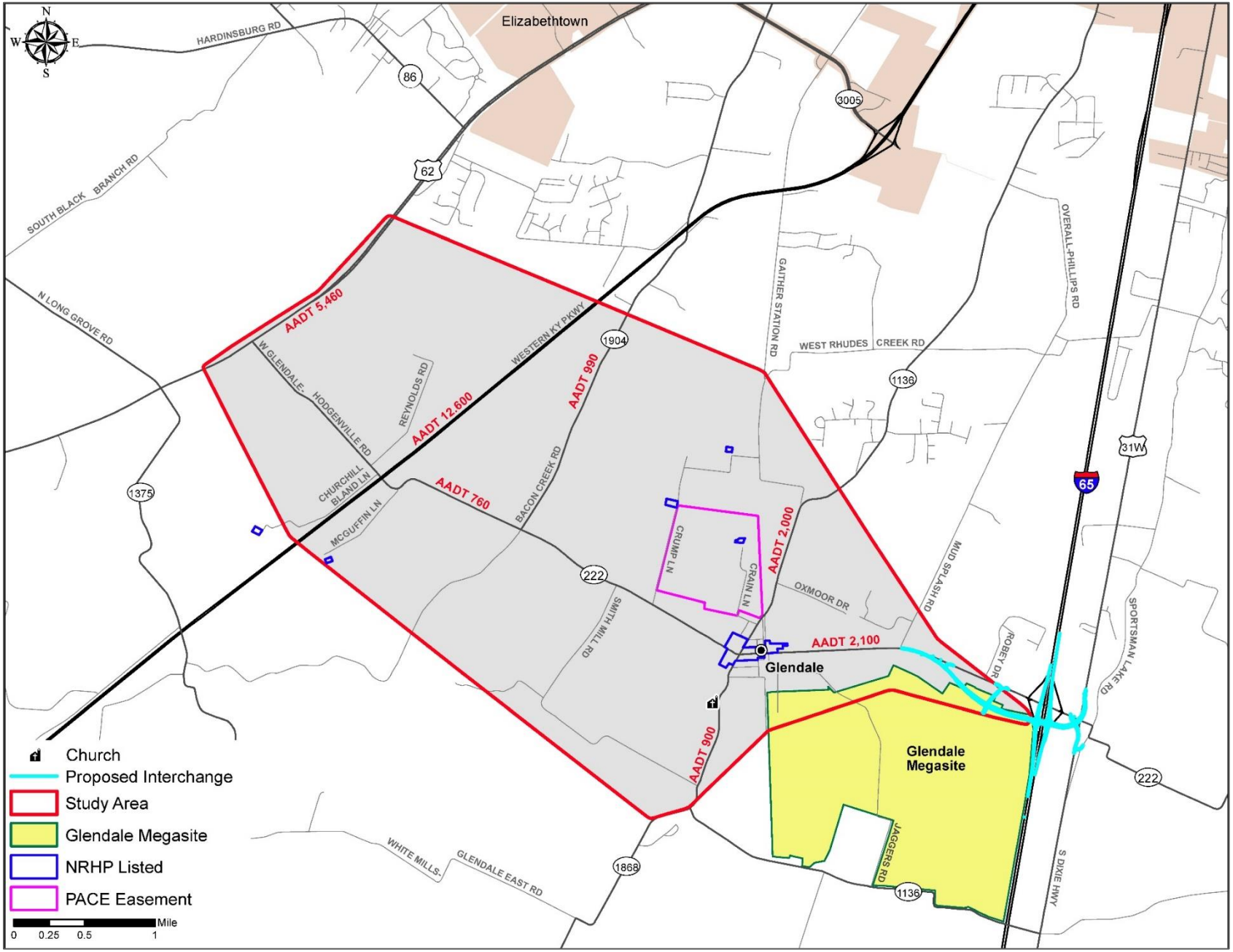


Figure 1: KY 222 - Glendale Corridor Study Area

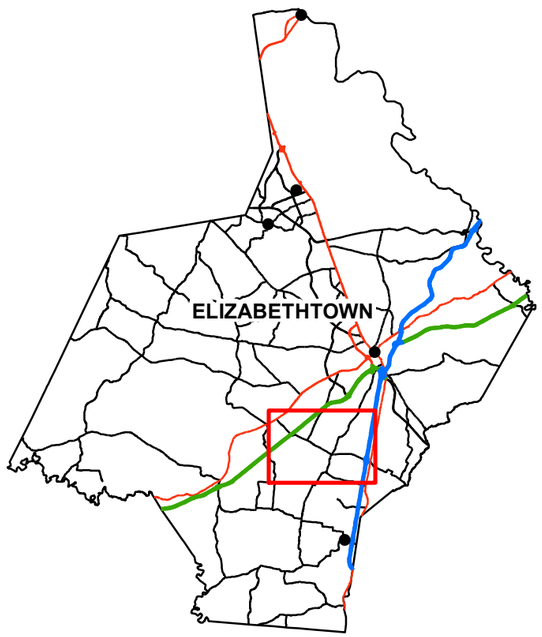
Hardin P-008-2022 Geologic Map

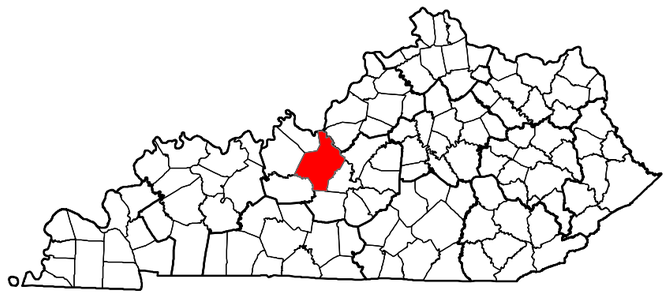
Legend

- State Bridges
- County Bridges
- City Points
- Streams
- Rivers
- Lakes
- Quarries
- Faults
- I-65
- KY 9001 - Western KY Parkway
- US Highways
- State Routes
- Local Roads
- Project Area
- Area with Underlying Slump Material

Formations

- Qal — Alluvium
- Mbp — Beaver Bend LS, Mooretown FM, and Paoli LS
- Msa — Sample Sandstone
- Msl — St. Louis Limestone
- Msg — Ste. Genevieve Limestone





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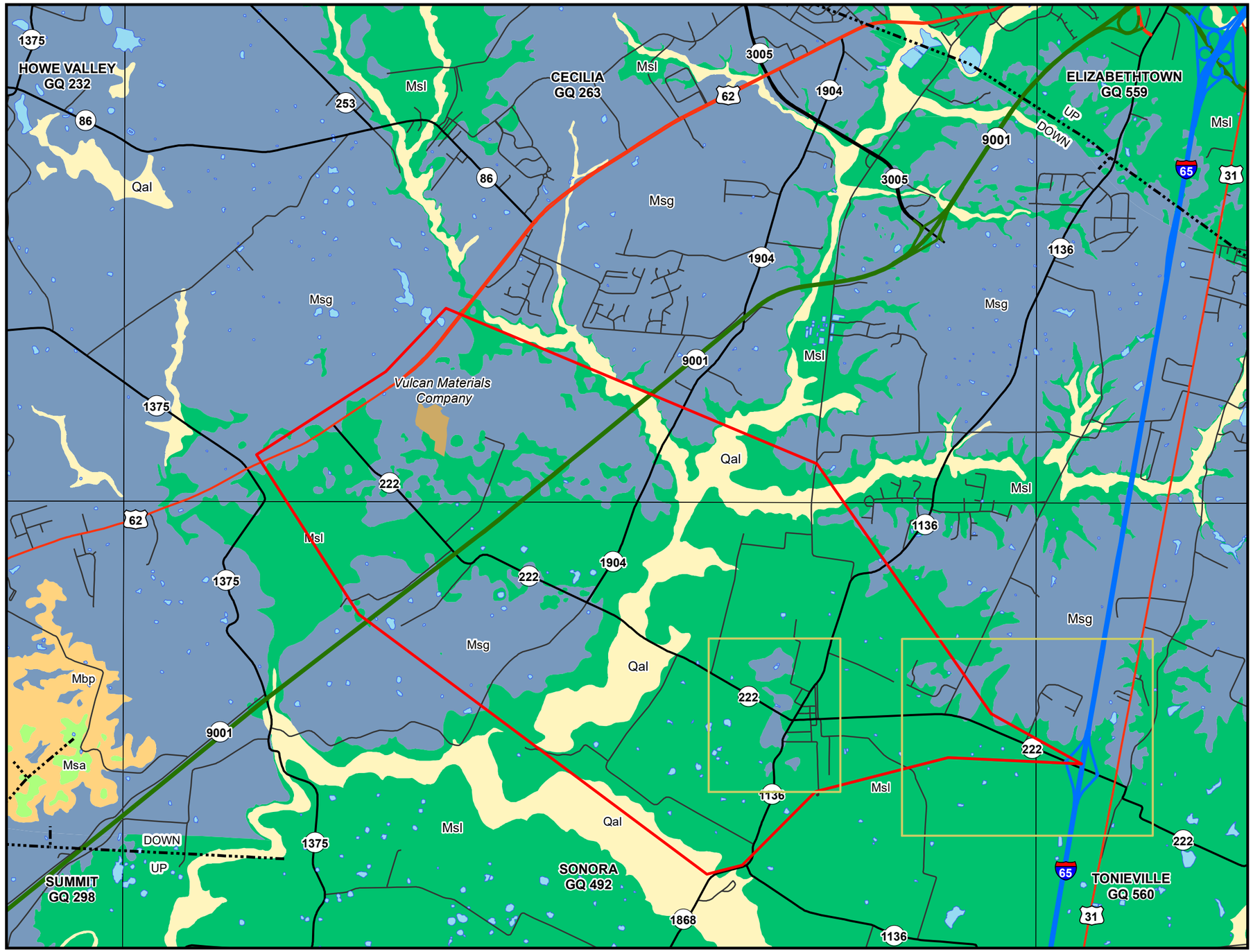
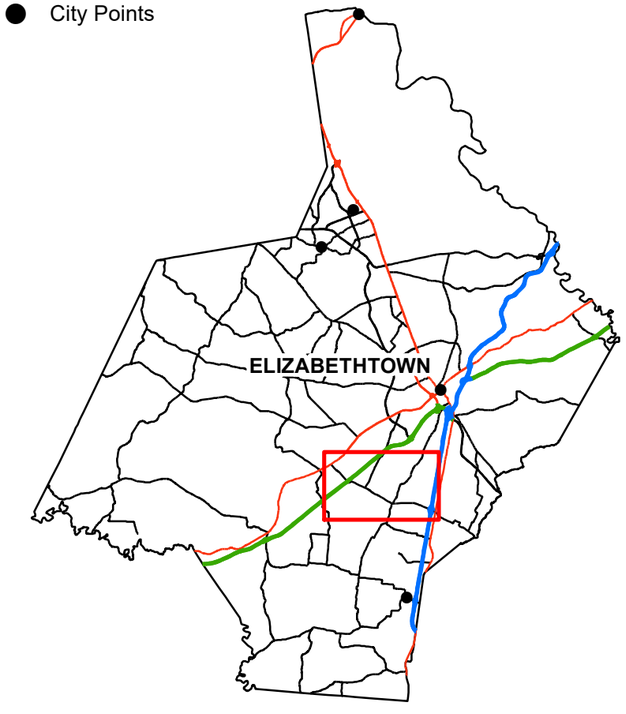


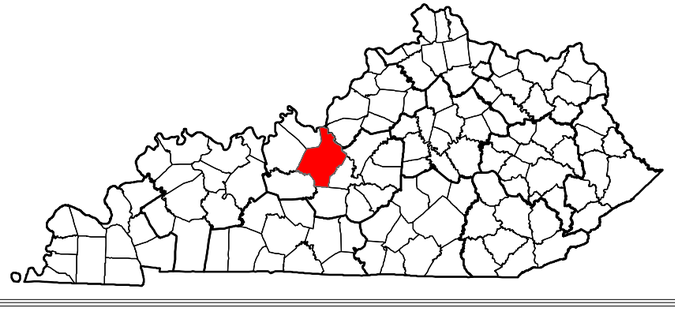
0 0.5 1 2 Miles

Hardin P-008-2022 Springs and Wells Map

Legend

- Monitoring Wells (Monitoring)
- Monitoring Wells (Plugged)
- DOW Groundwater - Springs
- Water Wells (Agriculture)
- Water Wells (Domestic)
- Water Wells (Other)
- Water Wells (PWS)
- Water Wells (Plugged)
- Dry and Abandoned Well
- Gas Well
- Stratographic Core, Public
- Project Area
- City Points
- I-65
- KY-9001 - Western KY Parkway
- US Highways
- State Routes
- Local Roads
- Elev. Contours (20-ft Intervals)
- Lakes
- Nolin River
- Streams





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CECILIA GQ 263

Vulcan Materials Company

ELIZABETHTOWN GQ 559

Glendale

SONORA GQ 492

TONIEVILLE GQ 560

East Rhudes Creek

Valley Creek

Rose Run

Nolin River

62 222 9001 1904 1136 1375 65 31

0 0.5 1 2 Miles

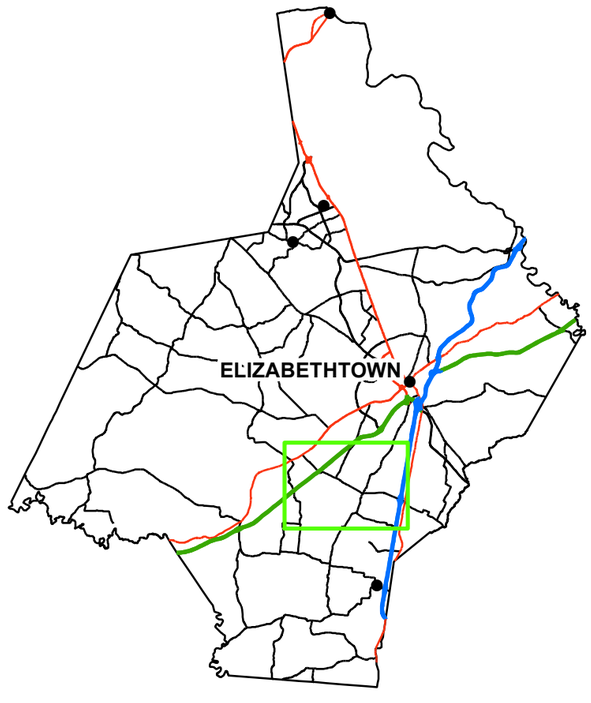
Hardin P-008-2022 Sinkholes and Karst Potential Map

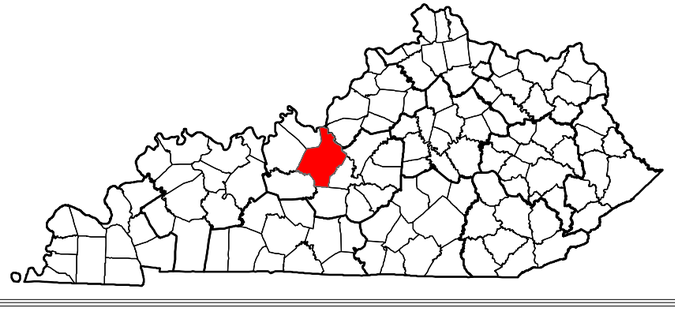
Legend

Karst Potential
- Non-Karst
- Prone
- Intense

- Sinkholes
- Streams
- Nolin River

- I-65
- KY-9001 - Western KY Parkway
- US Highways
- State Routes
- Local Roads
- Project Area





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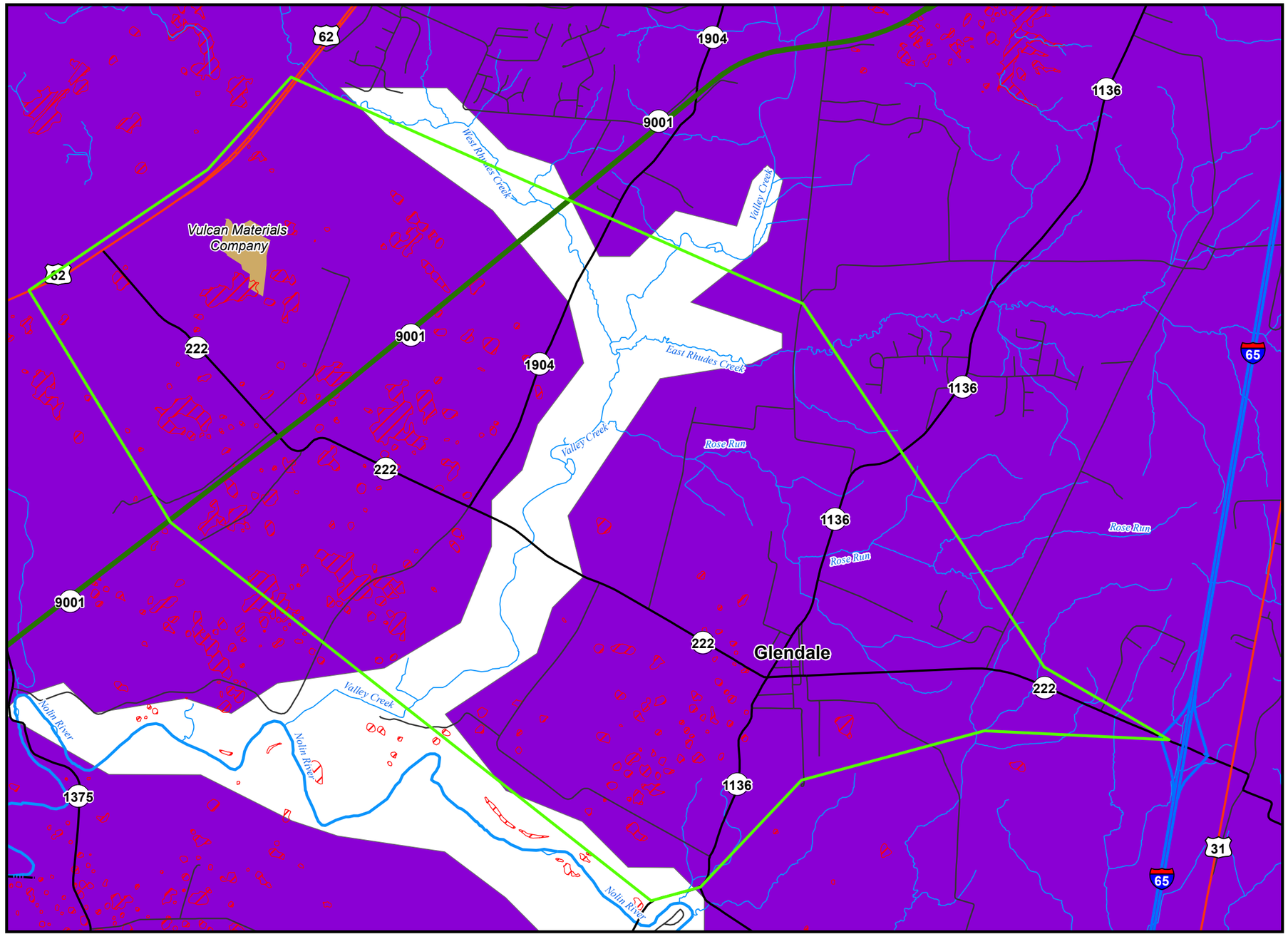
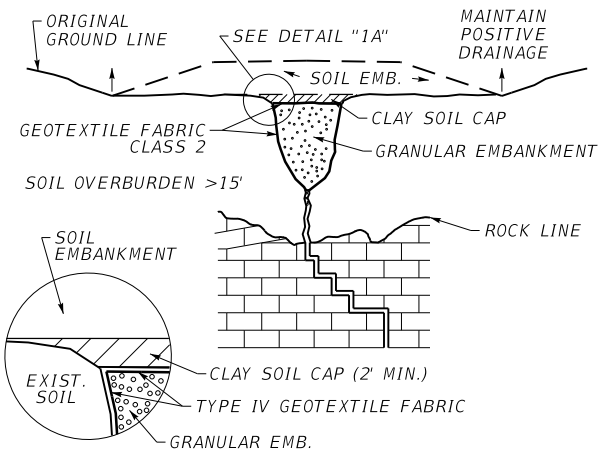


0 0.5 1 2 Miles

CONDITION NO. 1: SOIL EMBANKMENT OVER DEEP OVERBURDEN WITH OPEN SINKHOLES

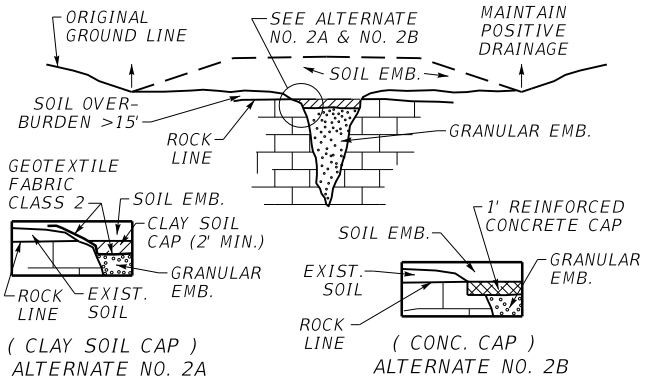


DETAIL "1A"

PROCEDURE:

a. REMOVE DEBRIS. DO NOT EXCAVATE SOIL OVERBURDEN.
b. LINE OPENING WITH TYPE IV GEOTEXTILE FABRIC.
c. REFILL WITH GRANULAR EMBANKMENT.
d. PLACE GEOTEXTILE FABRIC CLASS 2 ON TOP OF GRANULAR EMBANKMENT.
e. REFILL WITH (2' MINIMUM) CLAY SOIL CAP.

CONDITION NO. 2: SOIL EMBANKMENT OVER SHALLOW OVERBURDEN WITH SINKHOLE OPENING IN ROCK



(CLAY SOIL CAP)
ALTERNATE NO. 2A

(CONC. CAP)
ALTERNATE NO. 2B

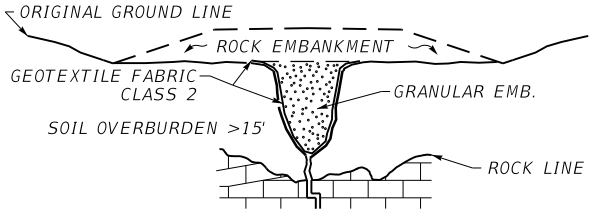
PROCEDURE FOR ALTERNATE NO. 2A

a. REMOVE DEBRIS AND SOIL OVERBURDEN.
b. REFILL OPENING WITH GRANULAR EMBANKMENT TO 2' MIN. BELOW ROCK LINE.
c. PLACE GEOTEXTILE FABRIC CLASS 2 ON TOP OF GRANULAR EMB. OVERLAPPING ORIGINAL GROUND LINE.
d. REFILL WITH (2' MIN.) CLAY SOIL CAP.

PROCEDURE FOR ALTERNATE NO. 2B

a. REMOVE DEBRIS AND SOIL OVERBURDEN.
b. REFILL OPENING WITH GRANULAR EMBANKMENT TO 1' MIN. BELOW ROCK LINE.
c. CONSTRUCT 1' REINFORCED CONCRETE CAP. CAP SHOULD BE INTERLOCKED WITH ROCK FOR SUPPORT.

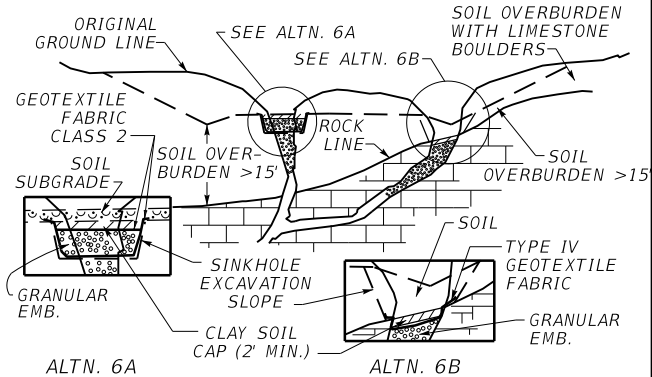
CONDITION NO.3: ROCK EMBANKMENT OVER DEEP OVERBURDEN WITH OPEN SINKHOLES



PROCEDURE:

a. REMOVE DEBRIS. DO NOT EXCAVATE SOIL OVERBURDEN.
b. LINE OPENING WITH GEOTEXTILE FABRIC CLASS 2.
c. REFILL OPENING WITH GRANULAR EMBANKMENT TO TOP OF DEPRESSION.

CONDITION NO. 6: CUT SECTIONS WITH SINKHOLE OPENINGS IN SOIL



ALTN. 6A ALTN. 6B

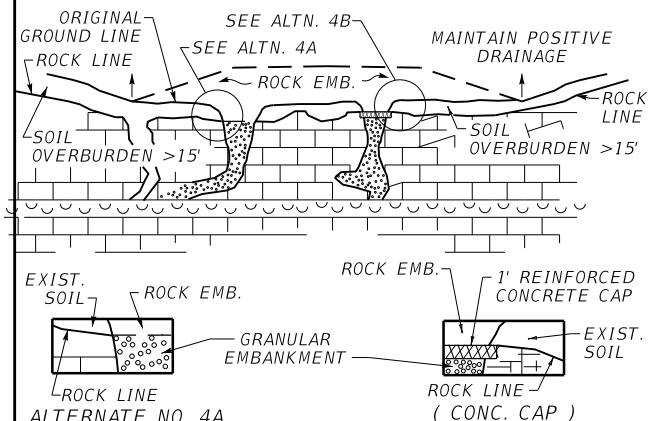
ALTERNATE NO. 6A SOIL OVERBURDEN GREATER THAN 15'

a. REMOVE DEBRIS. DO NOT EXCAVATE SOIL OVERBURDEN.
b. LINE OPENING WITH GEOTEXTILE FABRIC CLASS 2.
c. REFILL WITH GRANULAR EMBANKMENT.
d. PLACE GEOTEXTILE FABRIC CLASS 2 OVER GRANULAR EMBANKMENT OVERLAPPING ORIG. GROUND LINE.
e. REFILL WITH (2' MIN.) CLAY SOIL CAP. IF ROCK SUBGRADE IS USED OMIT SOIL CAP AND FABRIC UNDER-LYING SOIL CAP.

ALTERNATE NO. 6B SOIL OVERBURDEN LESS THAN 15'

a. REMOVE DEBRIS AND SOIL OVERBURDEN.
b. REFILL OPENING WITH GRANULAR EMBANKMENT TO 2' MIN. BELOW ROCK LINE.
c. PLACE GEOTEXTILE FABRIC CLASS 2 OVER GRANULAR EMBANKMENT OVERLAPPING ORIG. GROUND LINE.
d. REFILL WITH (2' MIN.) CLAY SOIL CAP. IF CONCRETE CAP IS USED THE FABRIC SHALL BE OMITTED AND CAP SHALL BE INTERLOCKED WITH THE BEDROCK FOR SUPPORT AS DETAILED IN COND. NO. 2 ALTERNATE NO. 2B.

CONDITION NO. 4: ROCK EMBANKMENT OVER SHALLOW OVERBURDEN WITH SINKHOLE OPENINGS IN ROCK



ALTERNATE NO. 4A

(CONC. CAP)
ALTERNATE NO. 4B

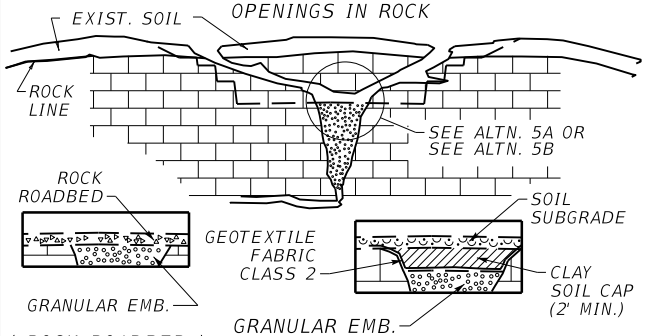
PROCEDURE FOR ALTERNATE NO. 4A

a. REMOVE DEBRIS AND SOIL OVERBURDEN.
b. REFILL OPENING TO ROCK LINE WITH GRANULAR EMBANKMENT.

PROCEDURE FOR ALTERNATE NO. 4B

a. REMOVE DEBRIS AND SOIL OVERBURDEN.
b. REFILL OPENING WITH GRANULAR EMBANKMENT TO 1' MIN. BELOW ROCK LINE.
c. CONST. 1' REINFORCED CONC. CAP. CAP SHOULD BE INTERLOCKED WITH ROCK FOR SUPPORT.

CONDITION NO. 5: CUT SECTIONS WITH SINKHOLE OPENINGS IN ROCK



(ROCK ROADBED)
ALTERNATE NO. 5A

(SOIL SUBGRADE)
ALTERNATE NO. 5B

PROCEDURE FOR ALTERNATE NO. 5A

a. REFILL OPENING WITH GRANULAR EMBANKMENT. IF CONCRETE CAP IS USED IT SHALL BE INTERLOCKED WITH THE BEDROCK FOR SUPPORT AS DETAILED IN CONDITION NO. 2 ALTERNATE NO. 2B.

PROCEDURE FOR ALTERNATE NO. 5B

a. REFILL OPENING WITH GRANULAR EMBANKMENT. TO 2' MINIMUM BELOW SOIL SUBGRADE.
b. PLACE GEOTEXTILE FABRIC CLASS 2 OVER GRANULAR EMBANKMENT.
c. REFILL WITH (2' MIN.) CLAY SOIL CAP. IF CONCRETE CAP IS USED THE FABRIC SHALL BE OMITTED AND CAP SHALL BE INTERLOCKED WITH THE BEDROCK FOR SUPPORT AS DETAILED IN COND. NO. 2 ALTERNATE NO. 2B.

THE CONCRETE CAP SHALL BE CLASS "B" CONC. AND CONTAIN NO. 8 REINFORCING BARS PLACED AT 12" CTRS. IN BOTH DIRECTIONS AND LOCATED 3" FROM THE BOTTOM SURFACE OF THE CAP.

KENTUCKY
DEPARTMENT OF HIGHWAYS

TREATMENT OF OPEN SINKHOLES

STANDARD DRAWING NO. BGX-018

SUBMITTED _____ 02-26-20
DIRECTOR DIVISION OF STRUCTURAL DESIGN — DATE

APPROVED _____ 02-26-20
STATE HIGHWAY ENGINEER — DATE