REPORT OF GEOTECHNICAL OVERVIEW

KY 163 GEOTECHNICAL OVERVIEW STUDY SOUTH OF TOMPKINSVILLE TO CLAY COUNTY, TENNESSEE

MONROE COUNTY, KENTUCKY

PREPARED BY:

AMERICAN ENGINEERS, INC.
FIELD SERVICES CENTER
GLASGOW, KENTUCKY

April, 2007

AEI
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April 25, 2007

Mr. Tom Springer
QK4
815 West Market Street
Suite 300
Louisville, KY 40202-2654

RE: Geotechnical Overview
KY 163 South of Tompkinsville to Clay County, Tennessee
Monroe County, Kentucky
Item No. 3-9310.00
AEI Project No. 207-068

Dear Mr. Springer:

American Engineers, Inc. Field Services Center is pleased to submit this geotechnical overview which details the results of our research and observations performed in support of the above mentioned project.

The attached report describes the site, geology, topography, and geotechnical considerations. The Appendix to the report contains a drawing with identified oil and water well locations, state and county karst maps, and a general block diagram of karst terrain in western Kentucky.

We appreciate the opportunity to be of service to you on this project and hope to provide further support on this and other projects in the future. Please contact us if you have any questions regarding this report.

Respectfully,
AMERICAN ENGINEERS, INC.

Brad High, P.G.
Project Geologist

Greg Meredith, P.E.
Vice President

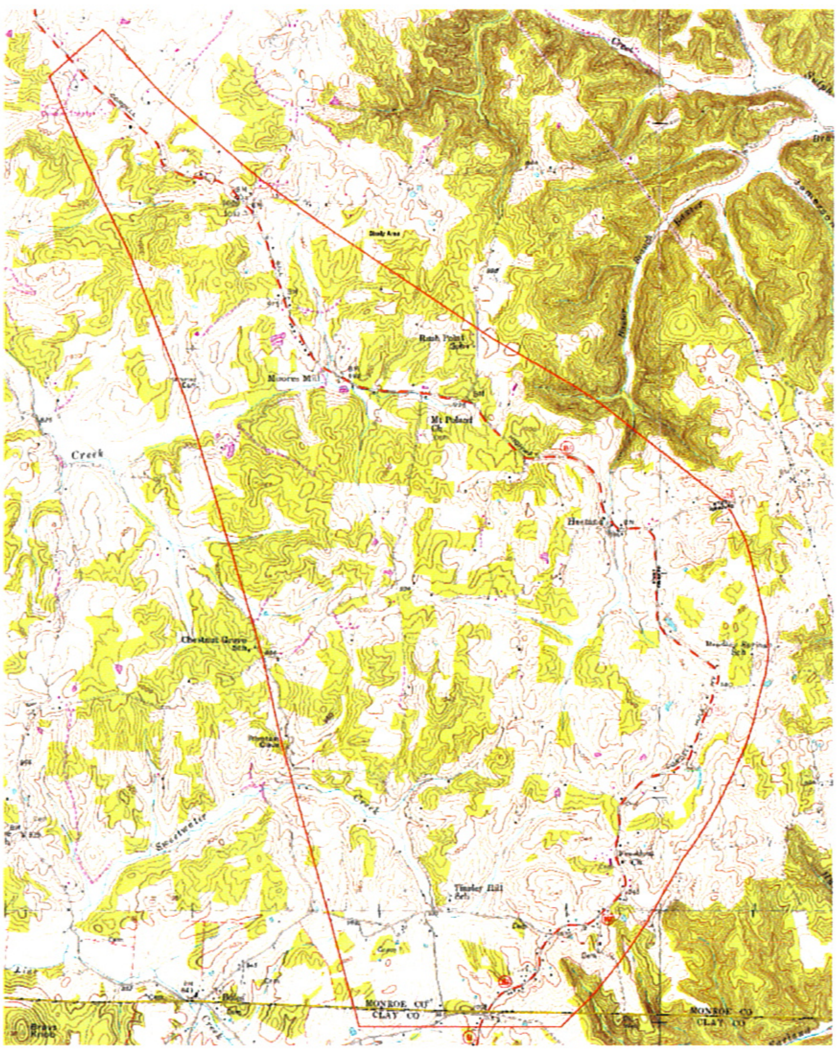
Geotechnical Overview

KY 163 Planning Study

South of Tompkinsville to Clay County, Tennessee

<u>Appendix</u>

- **Monroe County Karst Areas Map**
- **Block Diagram of Western Kentucky Karst**
- **Kentucky Karst Occurrence Map**
- **Oil and Water Well Location Map**



Geotechnical Overview
KY 163 Planning Study
South of Tompkinsville to Clay County, Tennessee

1. Project Description

The project corridor begins approximately ½ mile south of the city of Tompkinsville, Kentucky and ends to the south near the Tennessee state line, covering a length of about 5 miles. The project corridor ranges from about ½ mile wide near the beginning and end of the project, to about 2 ½ to 3 miles wide in the vicinity of Hestand, Kentucky. The existing alignment of Kentucky 163, also known as the Cordell Hull Highway, is currently part of the Kentucky Scenic Byway System. The highway within the study area is a 2-lane, AAA weight-class, undivided highway with Average Daily Traffic (ADT) computer estimated at 1,570. Heavy truck traffic comprises about fifteen percent of traffic estimates. Average right-of-way width is on the order of 60 feet from M.P. 0 to M.P. 3.6. Right-of-way width from M.P. 3.6 to M.P. 4.3 is 100 feet. The study area lies within the Mississippian Plateaus region of the Pennyrile physiographic province.

The existing KY 163 alignment is currently in the project planning phase in an effort to determine the most feasible means of addressing concerns with the existing roadway. Safety is a primary concern with the existing alignment. Conversations with people who live within the study area indicate that the number of traffic accidents and fatalities are disproportionate to similar roadways. Sight distance is very low along much of the roadway in the study area, and there are few opportunities to safely pass slower traffic. Also, the volume of heavy truck traffic is rather high for a rural highway. Ultimately, the new roadway will serve as part of a regional north-south connection between Interstate 40 in Tennessee and the Louie Nunn Parkway.

The planning study was conducted in relative accordance with Scope of Work for Geotechnical Overviews for Planning Studies provided to QK4 by KYTC Planning Division, as well as Section 801 of the Kentucky Transportation Cabinet Geotechnical

Manual. The study was conducted from February through April, 2007, and included field reconnaissance and geologic research of available geologic and topographic quadrangle maps, soil survey of Monroe County, Kentucky, as well as online resources available from the Kentucky Geological Survey and the United States Geological Survey. Past reports from geotechnical investigation of KY 163 performed by the Geotechnical Branch north of Tompkinsville were also reviewed in preparation of the overview.

2. *Site Geology*

The corridor lies within portions of two USGS 7.5-minute geologic quadrangle maps, *Tompkinsville* and part of the *Union Hill Quadrangle*, (Irving J. Witkind, 1971), and the *Vernon* and part of the *Celina Quadrangle*, (Richard Q. Lewis, Sr., 1972). The available mapping indicates that the site is underlain by portions of the St. Louis Limestone, Salem and Warsaw Limestones, and the Fort Payne Formations. Portions of the site are also underlain by alluvial and brecciated sandstone deposits. The majority of the existing alignment lies within lower portions of the St. Louis Limestone, and upper portions of the Salem and Warsaw Limestones. These formations are well known for karst landscapes, particularly the St. Louis Limestone and the upper portion of the Salem and Warsaw Limestones. Sinkholes, springs, disappearing streams, and caves are typical. *See Appendix- Monroe County Karst Areas Map and Kentucky Karst Occurrence Map.* The soil overburden generally consists of thick reddish brown residual clay soils containing abundant chert fragments. As with most karst landscapes, overburden thickness varies greatly, due to variant rates of chemical weathering and patterns of surface drainage. The weathering of limestone bedrock in such formations commonly results in knife-like ridges surrounding the surface depressions, where depth to competent bedrock is much less than in the base of the depressions, where weathering is more continuous, resulting in the distinctive "bowl shaped topography". *See Appendix- Block Diagram of Western Kentucky Karst.* As previously described, the site lies within a karst landscape containing several large diameter and deep sinkholes

Figure 1 *Sinkholes located within project area.*

(figure 1). The term "sinkhole" is used to refer to any closed surface depression within karst areas. The sinkholes in this area are typically broad, bowl-shaped depressions. Surface runoff drains into these bowl-shaped depressions and funnels into underground streams and caves below. The smaller holes that often develop near the bottoms of larger sinkholes are referred to as "sinkhole collapses". The process that leads to the formation of these collapses usually begins at the soil/bedrock contact. The soil is eroded from below by groundwater surging upward from joints or fissures in the bedrock or from underground streams. The surging action occurs during wet periods when the conveyance ability of the underground drainage system is exceeded and the groundwater is surcharged. The groundwater rises above the bedrock level and forces itself into the soil surrounding the bedrock joint or fissure. When the groundwater pressure returns to normal, soil particles are flushed into the bedrock and a void within the soil is created. With continued time and hydraulic action, the void increases in size and eventually leads to collapse of the soil arch to form a "sinkhole collapse" at the ground surface. Sinkhole collapses can also occur when concentrated surface runoff increases the downward movement of water resulting in the piping of saturated soil from above into joints or fissures in the bedrock below.

3. *Topography*

Topography of the study area is typically described as gently rolling to steep (figure 2). Topographic relief throughout the corridor ranges from a low of about 700 feet near Baxter Branch along the eastern section of the corridor, with a high elevation of about 1,046 feet near the Freedom Church located at the southeastern section of the corridor. The karst associated with the geologic formations of the area typically dictates the topography of the terrain. Steep slopes, with pronounced relief, are common in mature karst such as that found in most areas of the corridor study area. Based upon field observations and geologic mapping review, drainage in the area is influenced by weather-resistant portions of the Salem and Warsaw Formations, where the bedrock is more resistant to weathering

Figure 2 *Typical study area topography.*

and the further development of karst features. The bedrock in the lower elevations of the study area are less soluble than the overlying strata. As a result, more of a dendritic drainage pattern is observed than is common with younger karst areas. The preferred realignment will likely follow ridge tops, and avoid crossing surface depressions or valleys whenever possible to minimize the amount of cut and fill to achieve the desired subgrade elevation, and also to reduce the risk of subsidence due to karst activity.

Figure 3 *Stream located within study area.*

The study area is highly dissected by small streams and creeks (figure 3). Two streams, Mill Creek and Sweetwater Creek, were identified on available topographic mapping. Surface runoff in the study area typically drains in a dendritic pattern, and ultimately drains to either the Cumberland or Barren River. Some surface runoff is directed into the underlying karst network as well, as observed during site visits in the vicinity of Rhoton Cave along the western portion of the study area (figure 4).

Figure 4 *Karst drainage in study area*

4. Geotechnical Considerations

- Since the planning study area lies within a significant karst area, karst features such as sinkholes will have some bearing on any corridor chosen.

The ideal corridor chosen will minimize the impact of karst on the construction of the new roadway. Sinkholes are often identified after construction begins. Sinkholes or dropouts identified either prior to or during construction should be repaired per KDOH current specifications.

- Subgrade soils are expected to have a CBR value typically less than 6. Residual clays encountered may also have a moderate to high potential to shrink or swell when subjected to significant decreases or increases in moisture content for prolonged periods. Chemical treatment, such as lime application, may be desired to effectively stabilize road subgrades. In areas where rock is encountered during roadway excavations, it should be utilized as a more affordable yet effective alternative.

- Several small streams and creeks were identified in the study area, especially in the central and western portions of the study area. Any corridor chosen will require structures to cross these streams. Typically, the streams or creeks encountered will require only a single or double reinforced concrete box culvert to accommodate the new roadway construction. Foundations for any structure will most likely consist of shallow spread footings, which will bear on competent bedrock as identified from previous geotechnical exploration. Rock will normally be encountered near stream-crossing locations at depths of less than fifteen to twenty feet below the finished roadway grade.

- Roadway embankments and cut slopes will be required for construction of the new roadway in order to balance cut and fill for the selected finished road grade. Based upon our prior experience with residual soils and rock types from the St. Louis Limestone and Salem and Warsaw Formations, embankments of 2H:1V will likely provide an acceptable factor of safety for construction in the area. Cuts exceeding 10 feet may require slopes from 2.5 H:1V to 3H:1V.

- At least two (2) oil wells were noted either during site visits or from a search of Kentucky Geological Survey oil and gas well records database. One is located near the eastern limits of the study area along KY 216 near Hestand, Kentucky. The second is west of Moore's Mill near the western edge of the study area. No gas wells were apparent from the study area visits or from KGS well records database search. Any oil or gas wells encountered during construction will need to be sealed per KYTC Standard Specifications. *See Appendix- Oil and Water Well Location Map*

- Water wells encountered within the construction limits of any corridor chosen will need to be sealed per KYTC Standard Specifications. At least 4 were identified from a water well records search at www.kgs.gov, and several more are likely to exist within the study area. *See Appendix- Oil and Water Well Location Map* .

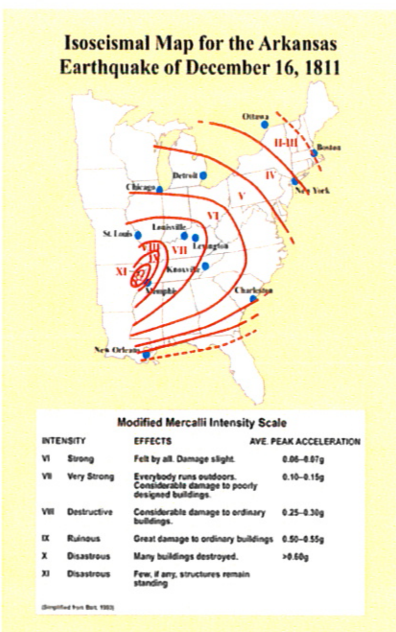


Figure 5- *Isoseismal Map of severe Arkansas Earthquake, December 16, 1811*

- As previously mentioned, topographic features within the study area will likely be the largest determining factor in selecting a corridor for the realignment. Topographic relief is rather pronounced throughout the study area. The area east of the existing alignment is very steep, and would be the least cost effective corridor for realignment, based solely on topography. The western section of the study area contains more drainage features (streams, springs, caves, etc.) than other portions of the study area and will likely require the placement of the greatest number of structures. Realignment of some portions of the existing roadway will also likely be considered to minimize cost of the project.

- The city of Tompkinsville, which lies just north of the study area, is located about 210 miles east of the city of New Madrid, Missouri, from which the New Madrid Fault derives its name. Figure-5 is an Isoseismal map of the Arkansas Earthquake of December 16, 1811, and is based on the Modified Mercalli Intensity Scale. Based upon that earthquake, the damage encountered within the study area would most likely fall within the Very Strong category, where damage was less considerable than closer to the epicenter, which was in Arkansas, a similar distance away from the study area as compared to the New Madrid area. Other available captions from www.earthquake.usgs.gov indicate that the study area would lie within an area for moderate potential for severe damage from an earthquake.

Figure 6- *Rhoton Cave*

- One cave, Rhoton Cave, was noted both in the field and on available topographic mapping (figure-6). Two separate entrances to the cave were noted, in addition to several springs along the western edge of the study area near Rhoton Cave Road. No springs were identified from a search of the Kentucky Geological Survey water well and spring database, however some were noted in the vicinity of Rhoton Cave along the western edge of the study area, and more are likely to exist within the study area.

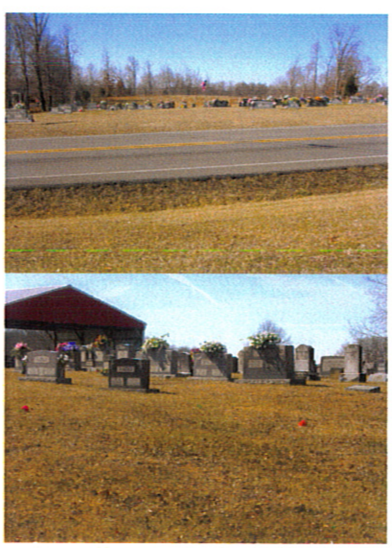


Figure 7 *Cemeteries located within study area.*

- At least eight (8) cemeteries were identified during site visits, and also from review of available county roadway mapping .Most of the cemeteries identified are concentrated in the south-central portion of the study area, along Beech Grove-Boles Road and KY 163 from M.P. 0 to M.P. 3. (figure 7)

Summary

Based upon field observations and geologic research, it appears that the largest determining factor in the selection of a corridor for the realignment of KY 163 will be the amount of topographic relief. Generally, increases in topographic relief result in larger variance in the amount of cut and fill required to achieve the desired finished road grade. Karst terrain, as well as the number of structures required for stream crossings, will also affect the corridor chosen. Social aspects, such as access to commercial facilities along the existing alignment, cemetery locations, and any environmental concerns discovered from further site assessments should also be considered.

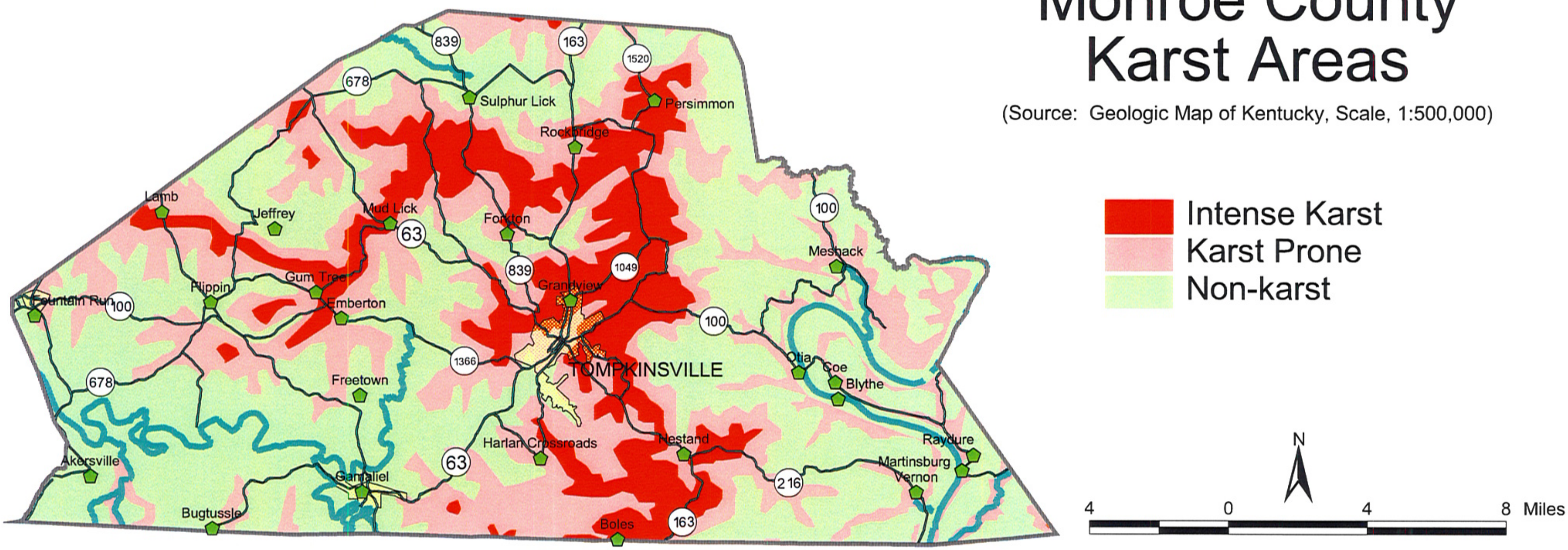
The area east of the existing alignment exhibits significant relief, and would most certainly require a large amount of cut and fill, and would most likely be the least cost effective. The preferred corridor for a new alignment will likely lie within the west-central portion of the study area. Realignment of at least some portions of the existing roadway may adequately address current safety issues and other concerns, and may ultimately prove to be the most cost effective solution, pending additional studies.

Appendix

Karst Maps and Block Diagram

Monroe County Karst Areas

(Source: Geologic Map of Kentucky, Scale, 1:500,000)



KENTUCKY GEOLOGICAL SURVEY
James C. Cobb, State Geologist and Director
UNIVERSITY OF KENTUCKY, LEXINGTON

MAP AND CHART 33
Series XII, 2001

KARST OCCURRENCE IN KENTUCKY

Randall L. Paylor and
James C. Currens

This map was compiled from a digital version of the 1:500,000-scale geologic map of Kentucky (Noger, M.C., comp., 1988, Geologic map of Kentucky: U.S. Geological Survey). The areas of potential karst development were delineated using stratigraphic units mapped on the geologic map. The classification of the potential for karst development was based on the field experience of the authors and other data. A number of isolated carbonate units that would not have otherwise been differentiated on the geologic map were newly digitized for this map.

This karst map should not be used for evaluating karst geologic hazards or hydrogeology at scales larger than 1:500,000. The base geologic map was digitized at 1:500,000 scale and is limited in precision to that scale. Because of the small scale of the original geologic map, lithostratigraphic units were consolidated into thicker chronostratigraphic units to create an area large enough to delineate on the geologic map. In some cases, the consolidation resulted in carbonates (limestone or dolomite) and noncarbonates (sandstone or shale, for example) being grouped; these rocks are not redivided on this map. Although the potential for karst development can be predicted from lithology, other factors such as relief and length of time the rock is exposed are also important and were not considered in the making of this map. Finally, areas where the near-surface bedrock is insoluble and closely underlain by soluble rock are common, particularly in the Eastern Pennyroyal. Conduits that pirate drainage commonly extend through ridges capped with insoluble rocks. Therefore, some areas mapped as having limited potential that are adjacent to areas of higher potential are actually karst, but cannot be differentiated on this map.

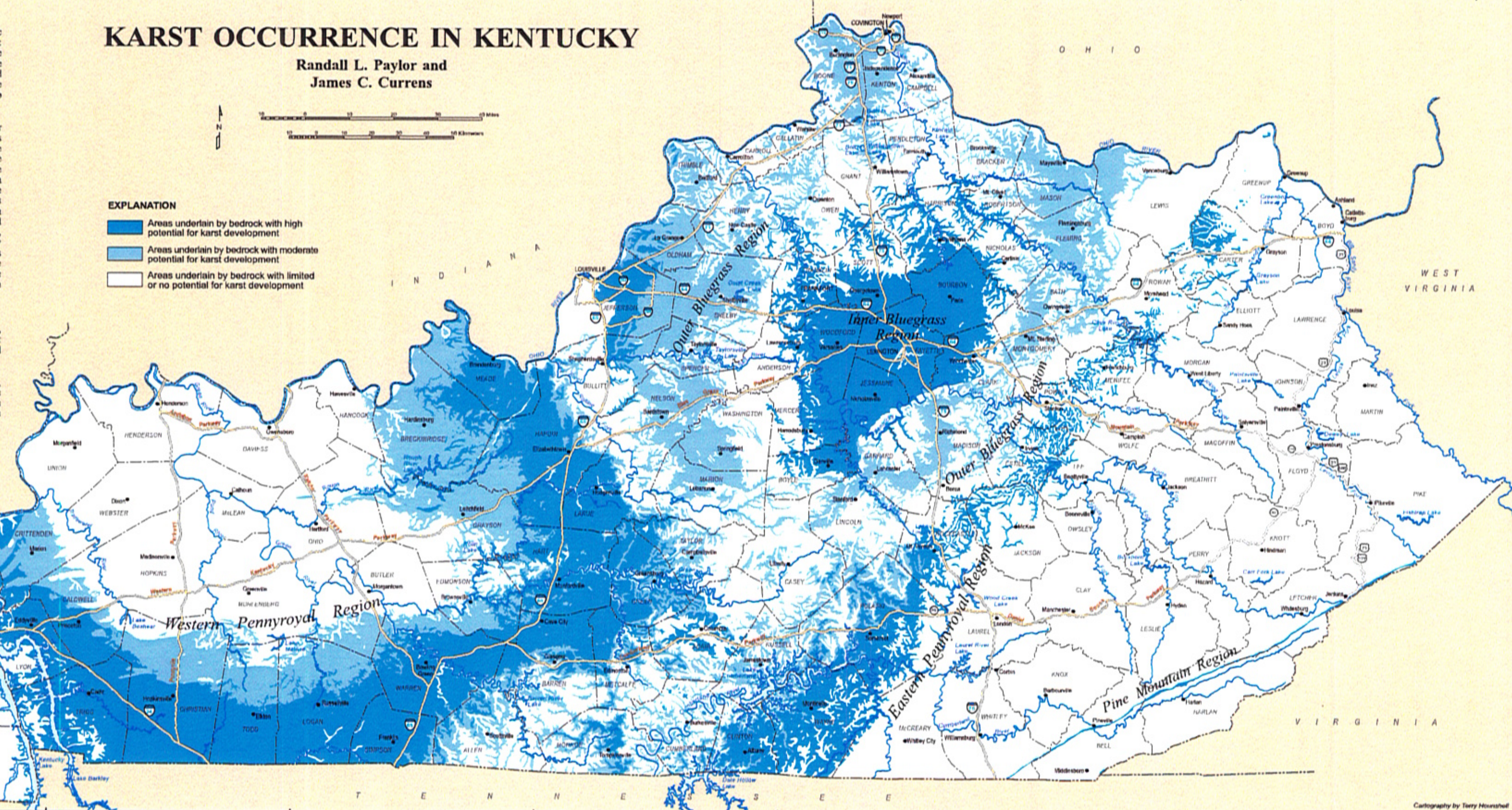
Karst is a terrane that is generally underlain by limestone or dolomite, where the topography is formed chiefly by the dissolving of rock. Karst landscapes are commonly characterized by sinkholes, sinking streams, closed depressions, subterranean drainage, large springs, and caves.

Karst regions are susceptible to unique problems such as sinkhole collapse, sinkhole flooding, and rapid groundwater pollution. Springs in karst areas are an important, productive source of groundwater. Rare biologic communities and endangered species can be found in the fragile underground environments developed in karst landscapes.

For information on obtaining copies of this map and other Kentucky Geological Survey maps and publications call:

Publication Sales
859.257.3896

View the KGS World Wide Web site at
www.uky.edu/kgs

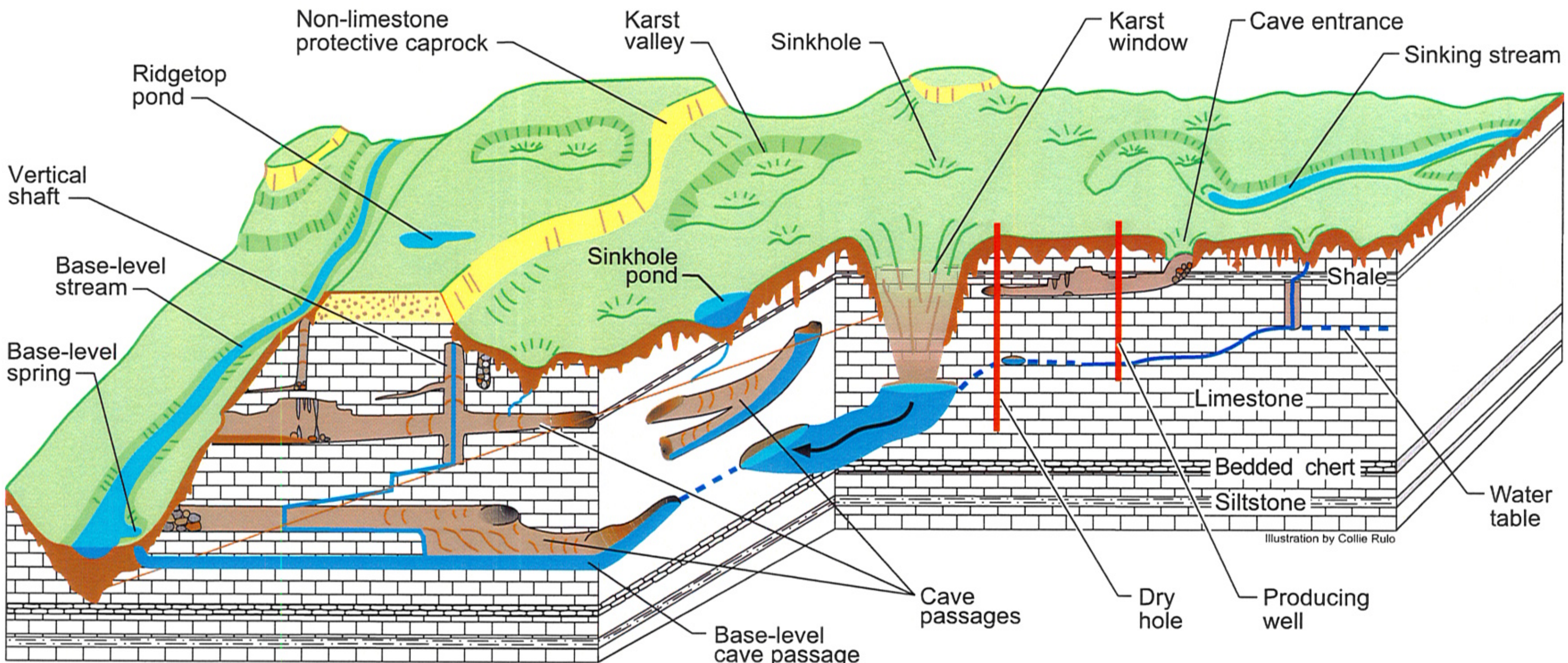


Kentucky Geological Survey
James C. Cobb, State Geologist and Director
UNIVERSITY OF KENTUCKY, LEXINGTON

Generalized Block Diagram of the Western Pennyroyal Karst

MAP AND CHART 16
Series XII, 2001

James C. Currens



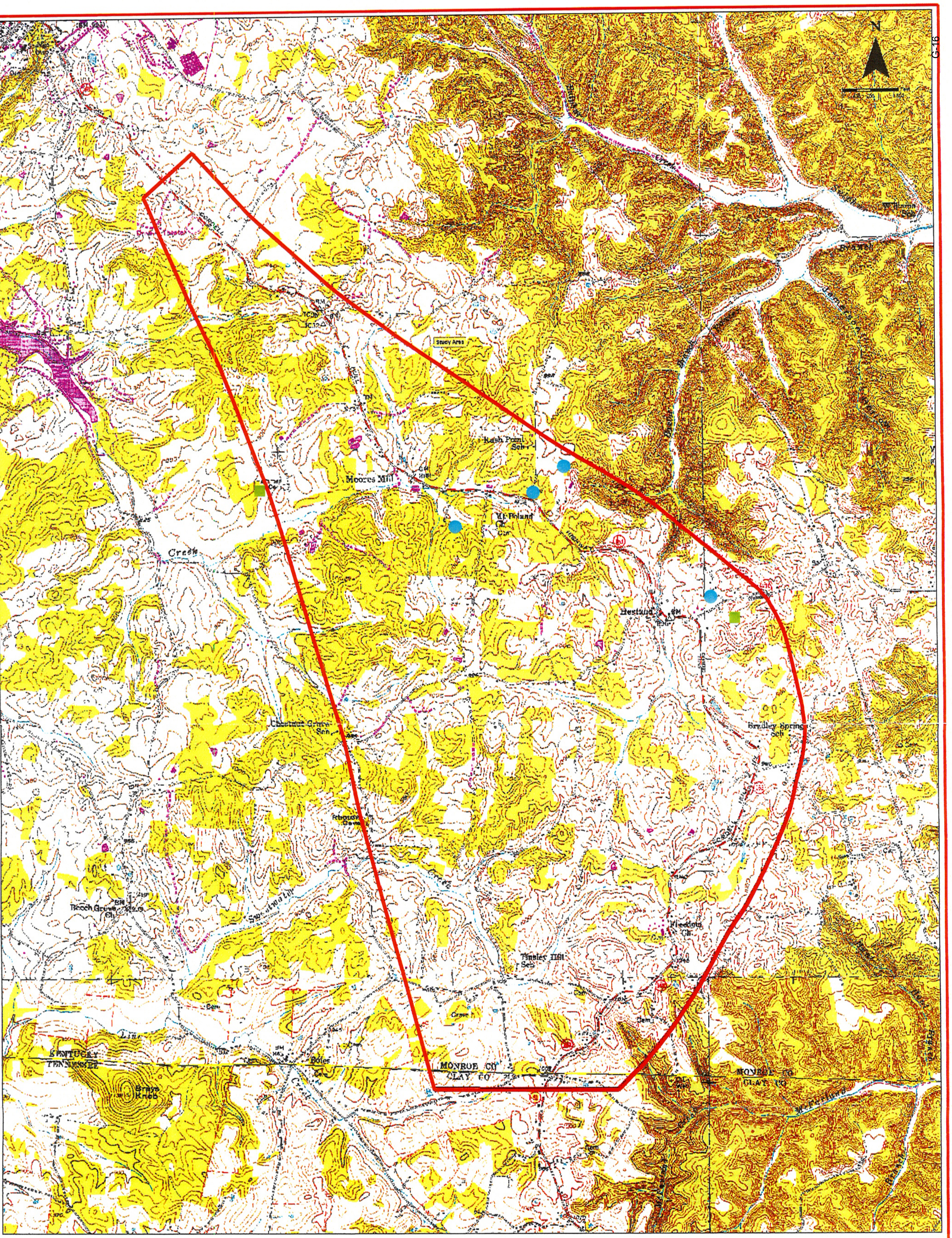
Western Pennyroyal karst:

Karst occurs where limestone or other soluble bedrock is near the earth's surface, and fractures in the rock become enlarged when the rock dissolves. Sinkholes and sinking streams are two surface features that indicate karst development. In karst areas most rainfall sinks underground, resulting in fewer streams flowing on the surface than in non-karst settings. Instead of flowing on the surface, the water flows underground through caves, sometimes reemerging at karst windows, then sinks again to eventually discharge at a base-level spring along a major stream or at the top of an impermeable strata. The development of karst features is influenced by the type of soluble rock and how it has been broken or folded by geologic forces. There are four major karst regions in Kentucky: the Inner Bluegrass, Western Pennyroyal, Eastern Pennyroyal, and Pine Mountain. This diagram depicts the Western Pennyroyal karst.

Many of the conditions needed for long cave systems occur in the Western Pennyroyal. These include a thick block of pure limestone, a high rainfall rate, higher elevation areas draining toward a major stream, rocks dipping toward the stream, and large areas of the limestone protected from erosion at the surface by overlying insoluble rocks. In the Mammoth Cave area, all of these conditions are found together, which resulted in Mammoth Cave, the longest known cave system in the world at 350 miles! As erosion on the surface continues over geologic time, the major stream draining a karst terrane cuts its channel deeper. In response, deeper conduits increase their flow to the major stream and new springs develop at lower elevations along the stream's banks. Older, higher flow routes are left as dry cave passages, some of which become sediment filled. To produce significant amounts of water, wells drilled into karst aquifers must intersect a set of enlarged fractures, a dissolution conduit, or a cave passage with an underground stream.

For information on obtaining copies of this chart and other Kentucky Geological Survey maps and publications call:
Publication Sales
(859) 257-3896
View the KGS World Wide Web site at:
www.uky.edu/kgs

KGS



LEGEND

- WATER WELLS
- OIL WELLS

OIL & WATER WELL LOCATION MAP
KY 163 SOUTH OF TOMPKINSVILLE, KY TO CLAY COUNTY, TN