2006

Generalized Geologic Map for Land-Use Planning: Carroll County, Kentucky

Richard A. Smath
University of Kentucky, rsmath@uky.edu

Bart Davidson
University of Kentucky, bdavidson@uky.edu

Daniel I. Carey
University of Kentucky, daniel.carey@uky.edu

John D. Kiefer
University of Kentucky, john.kiefer@uky.edu

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

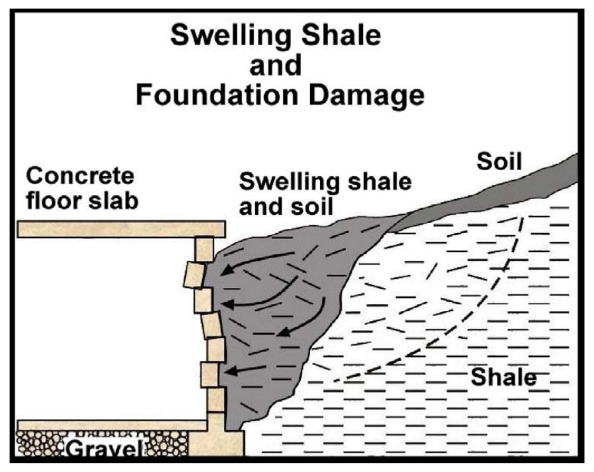
https://doi.org/10.13023/kgs.mc122.12
MAP AND CHART 122
Series XII, 2006

Generalized Geologic Map for Land-Use Planning: Carroll County, Kentucky

Richard A. Smath, Bart Davidson, Daniel I. Carey, and John D. Kiefer

Swelling and Shrinking Shales

A problem of considerable concern in this area is the swelling of some of the clay minerals in shale units 2 and 3. Expanding shale can cause backfill to swell, and concrete to crack and crumble. It can heave the foundation, the slab, and interior partitions resting on it, and damage upper floors and interior partitions. This phenomenon has been responsible for extensive damage to schools, homes, and businesses in Kentucky. During times of drought, these same shales may shrink, causing foundations to drop. Anyone planning construction on these shales should seek professional advice from a geologist or engineer familiar with the problem.



Some shales, and the soils derived from them, swell when exposed to water or air. These swelling shales and soils can have severe impacts on building foundations and other structures (e.g., bridges, dams, roads). Photo by John Kiefer, Kentucky Geological Survey.

Carroll County Courthouse

Carroll County, covering an area of 130 square miles in the Outer Bluegrass, was established in 1838. The population in 2000 was 10,155 people, about 78 per square mile. The elevation ranges from 420 feet at the Ohio River to 940 feet in the uplands. Photo by Dan Carey, Kentucky Geological Survey.

River Transportation

Coal barge on the Ohio River. Photo by Dan Carey, Kentucky Geological Survey.

Carrollton, Kentucky

City of Carrollton as seen from Butler State Park, looking down the Ohio River. The Kentucky River flows into the Ohio from the left. Photo by Dan Carey, Kentucky Geological Survey.

Acknowledgments

Geology adapted from Nelson (2002), Thompson (2002a, b), and Tyra (2002a-c). Sinkhole data from Paylor and others (2004). Thanks to Paul Howell, U.S. Department of Agriculture–Natural Resources Conservation Service, for pond construction illustrations.

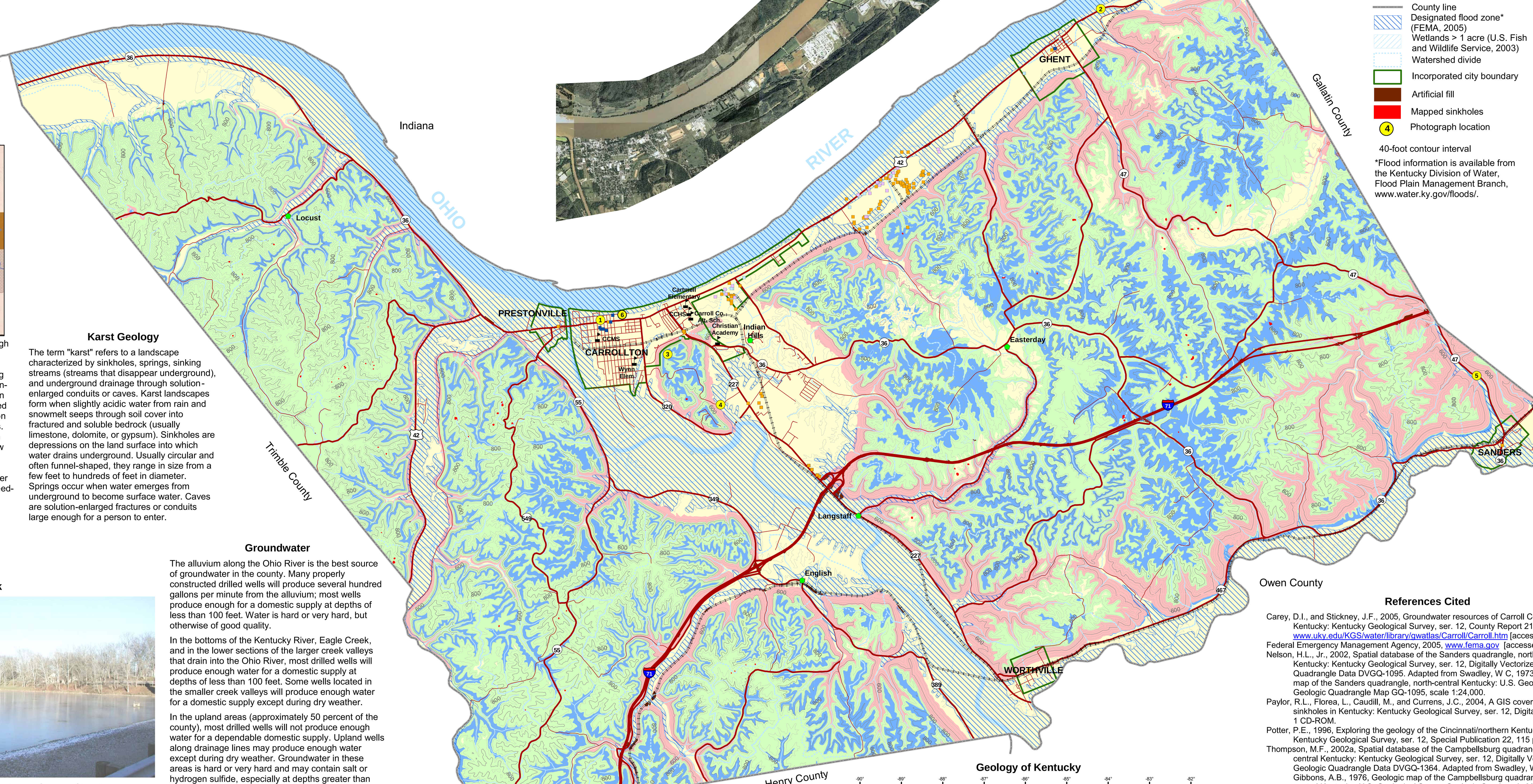
Ghent Power Plant

Kentucky Utilities' coal-fired Ghent power plant has a net generating capacity of 2,000 megawatts. Each of Ghent's four generating units can produce enough electricity to light 5 million 100-watt lightbulbs. The station consumes an average of 14,000 tons of coal daily. Photo by Dan Carey, Kentucky Geological Survey.

Gypsum from Ghent plant scrubbers is processed and shipped to nearby BPB plant and used for manufacturing wallboard. Photo by Dan Carey, Kentucky Geological Survey.

Industrial Corridor

Inexpensive electrical power, ample water, and access to river, road, rail, and air transportation makes the Carroll County Ohio River corridor an attractive location for industry. This aerial photography was taken in 2004 by the U.S. Department of Agriculture, Farm Services Administration, National Agricultural Imagery Program.



EXPLANATION

- School
- Water wells
  - Domestic
  - Industrial
  - Monitoring
  - Public
- Gas well
- Railroad
- County line
- Designated flood zone* (FEMA, 2005)
- Wetlands > 1 acre (U.S. Fish and Wildlife Service, 2003)
- Watershed divide
- Incorporated city boundary
- Artificial fill
- Mapped sinkholes
- Photograph location

40-foot contour interval

*Flood information is available from the Kentucky Division of Water, Flood Plain Management Branch, www.water.ky.gov/floods/.

Slope Failure

Mass movements or landslides of surficial materials are by far the most frequent and most costly geologic hazards in the northern Kentucky area. Northern Kentucky has the greatest monetary loss per capita caused by landslides in the country. The failure of the slope may be rapid, but more commonly is a slow, almost imperceptible movement, called creep, of a few inches per year. Whether rapid or slow, the end results and damage are similar and costly: broken plumbing, cracked walls and foundations, cracked streets and sidewalks, and commonly total loss of the structures.

Virtually all of the mass movements in northern Kentucky occur in colluvium—the weathered soil and rock materials that crumble from the bedrock as it weathers. The lower slopes of unit 2 are commonly thickly mantled with colluvium.

Shales of unit 2 and adjacent unit 3 will break down and weather rapidly when exposed to air and water. These shaly units tend to swell considerably when exposed to water. For this reason, plumbing trenches under walls and foundations should be prevented from accumulating water. Units 2 and 3 may share a translational landslide.

Gravity is the main driving force, but water nearly always plays a critical role by adding weight and lubricating the particles in the colluvium. Cutting into or overloading a slope with structures and fill can also be major contributing factors.

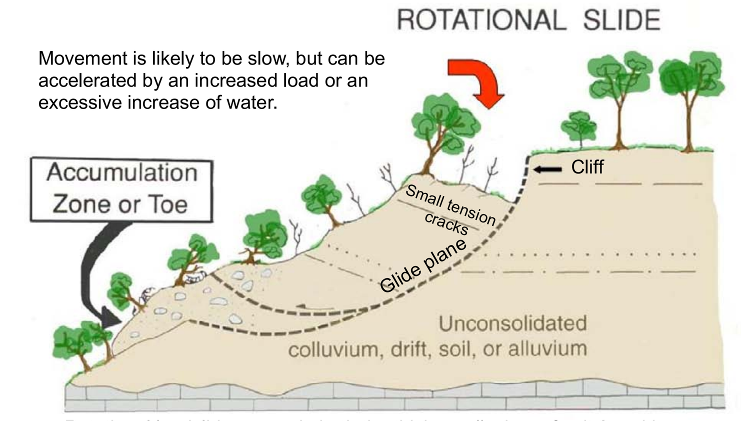
Precautions include taking care of all surface-water runoff by making certain that all runoff from roofs, gutters, patios, sidewalks, and driveways is carried well away from and not toward the house; diverting drainage from areas sloping toward the house; cutting into natural slopes as little as possible and avoiding the use of fill; and trying to place the foundation of the structure on undisturbed bedrock.

When in doubt, consult an engineering geologist or a geotechnical engineer. Old relict landslides can also be easily reactivated. Look for unusual bulges or cracks in the slope, tilted or curved trees, springs coming out onto the hillside, and tilted and cracked sidewalks, streets, and retaining walls.

For more information, see Potter (1996).

ROTATIONAL SLIDE

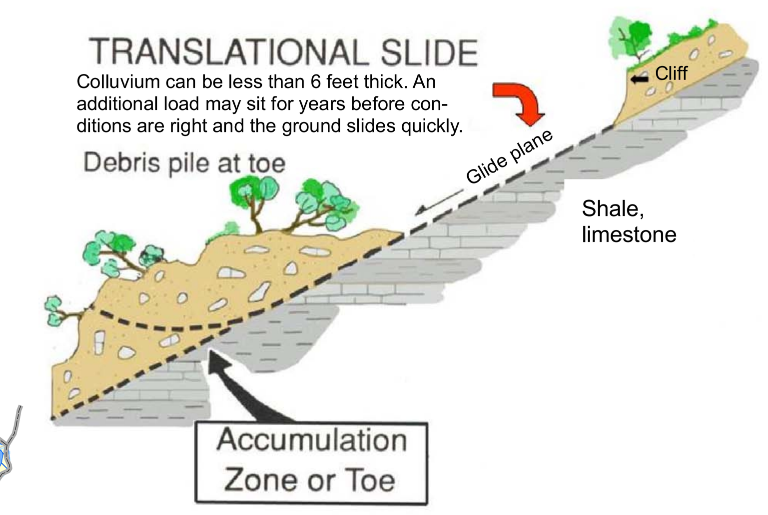
Movement is likely to be slow, but can be accelerated by an increased load or an excessive increase of water.



Rotational landslides occur in both the thicker colluvium of unit 2 and in glacial deposits. The head or top area has tension cracks or small cliffs; the toe or bottom has transverse ridges or bulges. A principal glide plane connects the top to the bottom. Small tension cracks in the top become large scarps or cliffs as material moves downslope and small bulges in the bottom become larger ones. After Potter (1996).

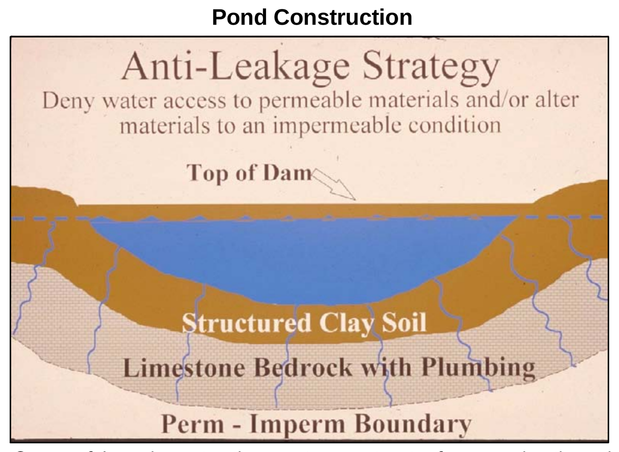
TRANSLATIONAL SLIDE

Colluvium can be less than 6 feet thick. An additional load may sit for years before conditions are right and the ground slides quickly.



A transitional landslide is a relatively thin sheet of colluvium that separates from the underlying bedrock and slides catastrophically downslope more or less as a coherent sheet until it abruptly stops and becomes a crumbled, disorganized pile of debris. Such failures are common on steeper slopes of shale-dominated units (units 2, 3) when both colluvium and the weathered, more permeable bedrock below become fully saturated with water. After Potter (1996).

Pond Construction



Successful pond construction must prevent water from seeping through structured soils into limestone solution channels below. A compacted clay liner or artificial liner may prevent pond failure. Getting the basin filled with water as soon as possible after construction prevents drying and cracking, and possible leakage, of the clayey soil liner. Ponds constructed in dry weather are more apt to leak than ponds constructed in wet weather. A geotechnical engineer or geologist should be consulted regarding the requirements of a specific site. Other leakage prevention measures include synthetic liners, bentonite, and asphaltic emulsions. The U.S. Department of Agriculture–Natural Resources Conservation Service can provide guidance on the application of these liners to new construction, and for treatment of existing leaking ponds.

Dams should be constructed of compacted clayey soils at slopes flatter than 3 units horizontal to 1 unit vertical. Ponds with dam heights exceeding 25 feet, or pond volumes exceeding 50 acre-feet, require permits. Contact the Kentucky Division of Water, 14 Reilly Rd., Frankfort, KY 40601, telephone: 502.564.3410. Illustration by Paul Howell, U.S. Department of Agriculture–Natural Resources Conservation Service.

Karst Geology

The term "karst" refers to a landscape characterized by sinkholes, springs, sinking streams (streams that disappear underground), and underground drainage through solution-enlarged conduits or caves. Karst landscapes form when slightly acidic water from rain and snowmelt seeps through soil cover into fractured and soluble bedrock (usually limestone, dolomite, or gypsum). Sinkholes are depressions on the land surface into which water drains underground. Usually circular and often funnel-shaped, they range in size from a few feet to hundreds of feet in diameter. Springs occur when water emerges from underground to become surface water. Caves are solution-enlarged fractures or conduits large enough for a person to enter.

Groundwater

The alluvium along the Ohio River is the best source of groundwater in the county. Many properly constructed drilled wells will produce several hundred gallons per minute from the alluvium; most wells produce enough for a domestic supply at depths of less than 100 feet. Water is hard or very hard, but otherwise of good quality.

In the bottoms of the Kentucky River, Eagle Creek, and in the lower sections of the larger creek valleys that drain into the Ohio River, most drilled wells will produce enough water for a domestic supply at depths of less than 100 feet. Some wells located in the smaller creek valleys will produce enough water for a domestic supply except during dry weather.

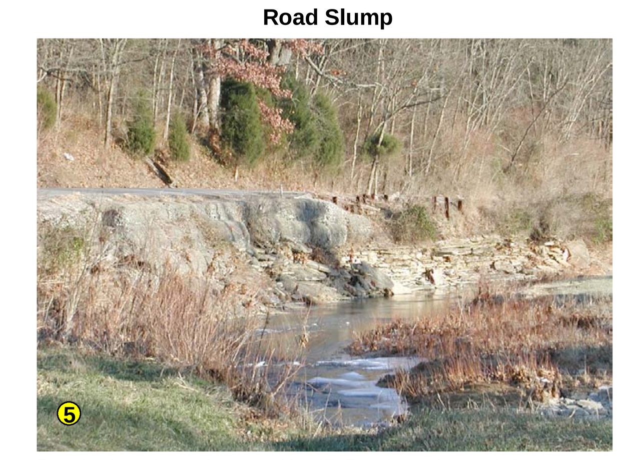
In the upland areas (approximately 50 percent of the county), most drilled wells will not produce enough water for a dependable domestic supply. Upland wells along drainage lines may produce enough water except during dry weather. Groundwater in these areas is hard or very hard and may contain salt or hydrogen sulfide, especially at depths greater than 100 feet.

For more information on groundwater in the county, see Carey and Stickney (2005)

General Butler State Park

General Butler State Park is a hilltop resort overlooking Carrollton and the confluence of the Kentucky and Ohio Rivers. It has a spacious conference center, and also provides golfing, hiking, swimming, and tennis. Photo by Dan Carey, Kentucky Geological Survey.

Road Slump



Repaired roadway slump on Ky. 47. Roads cut into unit 2 often present difficulties with drainage management to prevent such slumping. Photo by Dan Carey, Kentucky Geological Survey.

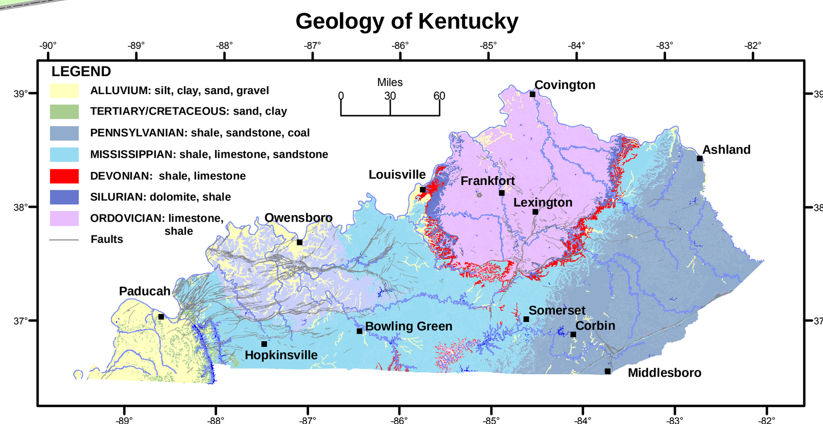
Earthquake Hazard

Ground shaking (peak particle accelerations) caused by an earthquake in or near the county is minimal for structures situated on or tied into the bedrock foundation. In areas underlain by poorly consolidated soils, site-specific investigations should be conducted to assure that the building codes will conform to any ground deformation such as liquefication, landslides, or surface fault ruptures. See www.uky.edu/KGS/geologichazards/eqhazards.htm for more information.

For Planning Use Only

This map is not intended to be used for selecting individual sites. Its purpose is to inform land-use planners, government officials, and the public in a general way about geologic bedrock conditions that affect the selection of sites for various purposes. The properties of thick soils may supersede those of the underlying bedrock and should be considered on a site-to-site basis. At any site, it is important to understand the characteristics of both the soils and the underlying rock. For further assistance, contact the Kentucky Geological Survey, 859.257.5500. For more information, and to make custom maps of your area, visit the KGS Land-Use Planning Internet Mapping Web Site at kgsmap.uky.edu/website/kyluplan/viewer.htm.

Geology of Kentucky



Learn more about Kentucky geology at www.uky.edu/KGS/geoky/

LAND-USE PLANNING TABLE DEFINITIONS

FOUNDATION AND EXCAVATION

The terms "earth" and "rock" excavation are used in the engineering sense; earth can be excavated by hand tools, whereas rock requires heavy equipment or blasting to remove.

LIMITATIONS

Slight—A slight limitation is one that commonly requires some corrective measure but can be overcome without a great deal of difficulty or expense.

Moderate—A moderate limitation is one that can normally be overcome but the difficulty and expense are great enough that completing the project is commonly a question of feasibility.

Severe—A severe limitation is one that is difficult to overcome and commonly is not feasible because of the expense involved.

LAND USES

Septic tank disposal system—A septic tank disposal system consists of a septic tank and a filter field. The filter field is a subsurface tile system laid in such a way that effluent from the septic tank is distributed with reasonable uniformity into the soil.

Residences—Ratings are made for residences with basements because the degree of limitation is dependent upon ease and required depth of excavation. For example, excavation in limestone has greater limitation than excavation in shale for a house with a basement.

Highways and streets—Refers to paved roads in which cuts and fills are made in hilly topography, and considerable work is done preparing subgrades and bases before the surface is applied.

Access roads—These are low-cost roads, driveways, etc., usually surfaced with crushed stone or a thin layer of blacktop. A minimum of cuts and fills are made, little work is done preparing a subgrade, and generally only a thin base is used. The degree of limitation is based on year-around use and would be less severe if not used during the winter and early spring. Some types of recreation areas would not be used during these seasons.

Light industry and malls—Ratings are based on developments having structures or equivalent load limit requirements of three stories or less, and large paved areas for parking lots. Structures with greater load limit requirements would normally need footings in solid rock, and the rock would need to be core drilled to determine the presence of caverns, cracks, etc.

Intensive recreation—Athletic fields, stadiums, etc.

Extensive recreation—Camp sites, picnic areas, parks, etc.

Reservoir areas—The floor of the area where the water is impounded. Ratings are based on the permeability of the rock.

Reservoir embankments—The rocks are rated on limitations for embankment material.

Underground utilities—Included in this group are sanitary sewers, storm sewers, water mains, and other pipes that require fairly deep trenches.

Planning Guidance by Rock Unit Type

Rock Unit	Karst Potential Rating	Foundation and Excavation	Septic System	Residence with Basement	Highways and Streets	Access Roads	Light Industry and Malls	Intensive Recreation	Extensive Recreation	Reservoir Areas	Reservoir Embankments	Underground Utilities
1. Clay, silt, sand, and gravel	None, but on-site karst investigation recommended where less than 25 feet thick over soluble rock.	Fair foundation material; easy to excavate.	Severe limitations. Failed septic systems can contaminate groundwater. Refer to soil report (Weisenberger and Richardson, 1972).	Water in alluvium may be in direct contact with basements. Refer to soil report (Weisenberger and Richardson, 1972).	Slight limitations. Refer to soil report (Weisenberger and Richardson, 1972).	Slight to moderate limitations. Refer to soil report (Weisenberger and Richardson, 1972).	Slight to moderate limitations. Avoid construction in floodplain. Refer to soil report (Weisenberger and Richardson, 1972).	Refer to soil report (Weisenberger and Richardson, 1972).	Refer to soil report (Weisenberger and Richardson, 1972).	Refer to soil report (Weisenberger and Richardson, 1972).	Not recommended. Refer to soil report (Weisenberger and Richardson, 1972).	Not recommended. Refer to soil report (Weisenberger and Richardson, 1972).
2. Shale*, limestone	Medium to low.	Fair to good foundation material; difficult excavation. Slumps when wet. Avoid steep slopes.	Slight to severe limitations, depending on amount of soil cover and depth to impermeable rock.	Severe to moderate limitations. Rock excavation may be required. Slumps when wet. Avoid steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate limitations. Rock excavation likely. Local drainage problems, especially on shale. Sinks common.	Slight to severe limitations, depending on topography. Rock excavation. Sinks common. Local drainage problems. Groundwater contamination possible.	Slight to moderate limitations, depending on activity and topography. Possible steep wooded slopes.	Slight limitations, depending on activity and topography. Possible steep wooded slopes. Slight limitations for forest or nature preserve.	Moderate to slight limitations. Reservoir may leak where rocks are fractured. Sinks possible.	Moderate to severe limitations. Reservoir may leak where rocks are fractured. Sinks possible.	Moderate to severe limitations. Possible rock excavation. Susceptible to landslides.
3. Limestone, shale*	High to medium.	Good to excellent foundation material; difficult to excavate.	Slight to severe limitations, depending on amount of soil cover and depth to impermeable rock.	Severe to moderate limitations. Rock excavation may be required.	Moderate limitations. Rock excavation possible. Local drainage problems, especially on shale. Sinks common and caves possible.	Moderate limitations. Rock excavation possible. Possible steep slopes. Slight limitations with suitable topography.	Slight to severe limitations, depending on topography. Rock excavation. Sinks common. Local drainage problems. Groundwater contamination possible.	Slight to moderate limitations. Rock excavation may be required.	Slight limitations, depending on activity and topography. Possible steep wooded slopes. No limitations for nature or forest preserve.	Moderate to slight limitations. Reservoir may leak where rocks are fractured. Sinks possible.	Moderate to severe limitations. Reservoir may leak where rocks are fractured. Sinks possible.	Severe to moderate limitations. Possible rock excavation.
4. Limestone	High.	Excellent foundation material; difficult to excavate.	Severe limitations. Impermeable rock. Locally fast drainage through fractures and sinks. Danger of groundwater contamination.	Severe to moderate limitations. Rock excavation may be required.	Severe limitations. Rock excavation. Possible steep slopes.	Severe to moderate limitations. Possible rock excavation. Possible steep slopes and narrow ravines.	Slight to moderate limitations, depending on topography. Rock excavation possible. Sinks common. Local drainage problems.	Moderate to slight limitations, depending on activity and topography. Possible wooded slopes.	Severe to slight limitations, depending on activity and topography. Possible wooded slopes. Slight limitations for nature preserve.	Slight to severe limitations. Reservoir may leak where rocks are fractured. Sinks possible.	Slight to severe limitations. Reservoir may leak where rocks are fractured. Sinks possible.	Severe to moderate limitations. Possible rock excavation.

*Some of these shales can shrink during dry periods and swell during wet periods, and cause cracking of foundations. On hillsides, especially where springs are present, they can also be susceptible to landslides.

References Cited

Carey, D.I., and Stickney, J.F., 2005, Groundwater resources of Carroll County, Kentucky: Kentucky Geological Survey, ser. 12, County Report 21, www.uky.edu/KGS/water/library/gwatlas/Carroll/Carroll.htm [accessed 12/12/05].

Federal Emergency Management Agency, 2005, www.fema.gov [accessed 10/21/05].

Nelson, H.L., Jr., 2002, Spatial database of the Sanders quadrangle, north-central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1095. Adapted from Swadley, W C, 1973, Geologic map of the Sanders quadrangle, north-central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1095, scale 1:24,000.

Paylor, R.L., Florea, L., Caudill, M., and Currens, J.C., 2004, A GIS coverage of karst sinkholes in Kentucky: Kentucky Geological Survey, ser. 12, Digital Publication 5, 1 CD-ROM.

Potter, P.E., 1996, Exploring the geology of the Cincinnati/northern Kentucky region: Kentucky Geological Survey, ser. 12, Special Publication 22, 115 p.

Thompson, M.F., 2002a, Spatial database of the Campbellsburg quadrangle, north-central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1364. Adapted from Swadley, W C, and Gibbons, A.B., 1976, Geologic map of the Campbellsburg quadrangle, north-central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1364, scale 1:24,000.

Thompson, M.F., 2002b, Spatial database of the Carrollton quadrangle, Carroll and Trimble Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1281. Adapted from Swadley, W C, 1976, Geologic map of the Carrollton quadrangle, Carroll and Trimble Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1281, scale 1:24,000.

Tyra, M.A., 2002a, Spatial database of the Madison East quadrangle, Trimble and Carroll Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1471. Adapted from Gibbons, A.B., 1978, Geologic map of the Madison East quadrangle, Trimble and Carroll Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1471, scale 1:24,000.

Tyra, M.A., 2002b, Spatial database of the Vevay South and Vevay North quadrangles, north-central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1123. Adapted from Swadley, W C, 1973, Geologic map of the Vevay South and Vevay North quadrangles, north-central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1123, scale 1:24,000.

Tyra, M.A., 2002c, Spatial database of the Worthville quadrangle, north-central Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1265. Adapted from Gibbons, A.B., 1975, Geologic map of the Worthville quadrangle, north-central Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1265, scale 1:24,000.

U.S. Fish and Wildlife Service, 2003, National Wetlands Inventory, www.nwi.fws.gov [accessed 10/21/05].

Weisenberger, B.C., and Richardson, A.J., 1972, Soil survey of Carroll, Gallatin, and Owen counties, Kentucky: U.S. Department of Agriculture–Soil Conservation Service, 62 p.

Additional Planning Resources

Listed below are Web sites for several agencies and organizations that may be of assistance with land-use planning issues in Carroll County:

www.carrollcountyky.com/ Carroll County Web page
ces.ca.uky.edu/Carroll/ University of Kentucky Cooperative Extension Service
www.nkadd.org/ Northern Kentucky Area Development District
www.thinkkentucky.com/edis/cmnty/cw065 Economic Development Information System
www.uky.edu/KentuckyAtlas/21041.html Kentucky Atlas and Gazetteer
quickfacts.census.gov/qfd/states/21/21041.html U.S. census data
kgsweb.uky.edu/download/kgsplanning.htm Planning information from the Kentucky Geological Survey

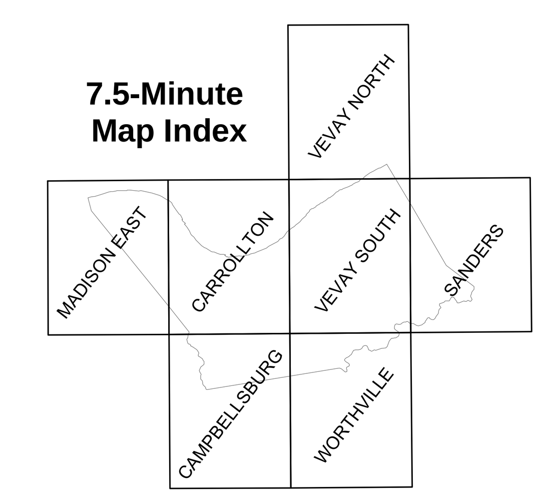
N

Scale 1:48,000

1 inch = 3/4 mile

0 0.5 1 2 3 4 Miles

7.5-Minute Map Index



For information on obtaining copies of this map and other Kentucky Geological Survey maps and publications call our Public Information Center at 859.257.3896 or 877.778.7827 (toll free).

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