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

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

Bart Davidson
University of Kentucky, bdavidson@uky.edu

Katie Russell
University of Kentucky

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

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Daniel I. Carey and Bart Davidson
Kentucky Geological Survey

Katie Russell
University of Kentucky

Acknowledgments

Geology adapted from Carey and Hettinger (2000), Hettinger (2000), Patton (2000), Sparks and Nuttall (2000), Zhang (2000a, b), and Crawford (2004a, b). Mapped sinkholes from Paylor and others (2004). Thanks to Paul Howell, U.S. Department of Agriculture, Natural Resources Conservation Service, for pond construction illustration. Thanks to Kim and Kent Anness, Kentucky Division of Geographic Information for base map data.

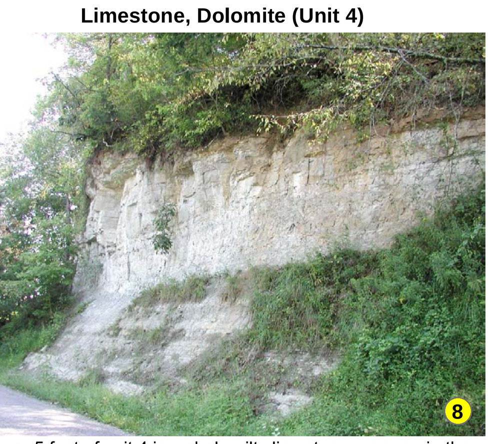
For Planning Use Only

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.

The Knobs

The Knobs are isolated, steep-sloping, often cone-shaped hills that dominate the horizon of southern Boyle County. They were originally continuous with the Mississippian Plateau, but were separated from the plateau by stream erosion. Many of the knobs are still capped by erosionally resistant limestones or sandstones. The sharp slopes of the Knobs are composed of shales of the 350-million-year-old Mississippian Borden Formation, which are more easily eroded than the overlying limestones and sandstones. The base of the Knobs contains Devonian black shales. Photo by Dan Carey, Kentucky Geological Survey.

Limestone, Dolomite (Unit 4)

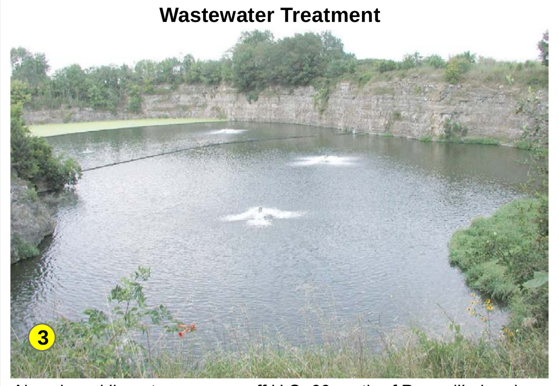


The lower 5 feet of unit 4 is a shaly, silty limestone, as seen in the lower section of this roadcut off Ky. 37. Photo by Dan Carey, Kentucky Geological Survey.

Boyle County Courthouse

Boyle County, an area of 182 square miles, lies in four physiographic provinces: northern Boyle in the Outer and Inner Bluegrass Region, and southern Boyle in the Mississippian Plateau and Knobs. The highest point in the county, 1,364 feet, is Parksville Knob. The lowest elevation, 740 feet, is where the North Rolling Fork leaves the county. The 2005 population was 27,990, 1 percent greater than in 2000. Photo by Bart Davidson, Kentucky Geological Survey.

Wastewater Treatment



Abandoned limestone quarry off U.S. 68 north of Perryville has been incorporated into the city's wastewater treatment system. Photo by Dan Carey, Kentucky Geological Survey.

Perryville

Seven thousand five hundred men were killed or wounded on October 8, 1862 in the fields north of Perryville. The Battle of Perryville was the largest Civil War battle in Kentucky. Photo by Dan Carey, Kentucky Geological Survey.

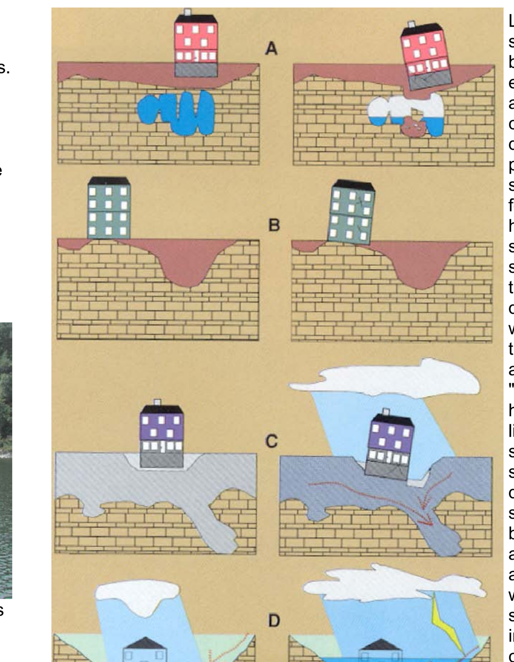
Karst Geology

Karst areas in Boyle County are indicated by sinkholes. 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.

Herrington Lake

Herrington Lake, seen here from the Coffey Cove Marina, provides fishing and boating recreation, and is the county's primary water source. Nearly everyone in the county has access to public water. Limestones of unit 3 line the banks. Photo by Dan Carey, Kentucky Geological Survey.

Karst Subsidence

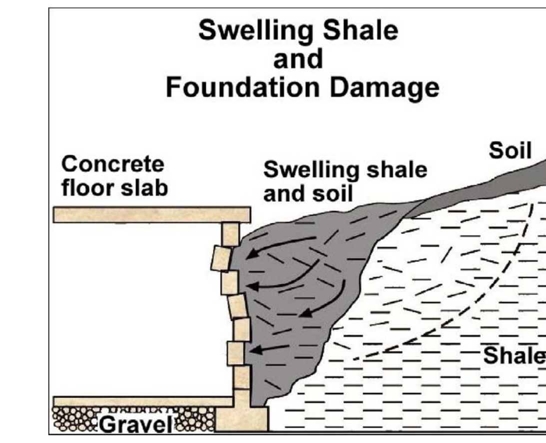


Limestone terrain can be subject to subsidence hazards, which usually can be overcome by prior planning and site evaluation. "A" shows construction above an open cavern, which later collapses. This is one of the most difficult situations to detect, and the possibility of this situation beneath a structure warrants insurance protection for homes built on karst terrain. In "B," a heavy structure presumed to lie above solid bedrock actually is partially supported on soft, residual clay soils that subside gradually, resulting in damage to the structure. This occurs where inadequate site evaluation can be traced to lack of geophysical studies and inadequate core sampling. "C" and "D" show the close relationship between hydrology and subsidence hazards in limestone terrain. In "C," the house is situated on porous fill (light shading) at a site where surface- and groundwater drainage move supporting soil (darker shading) into voids in limestone (blocks) below. The natural process is then accelerated by infiltration through fill around the home. "D" shows a karst site where normal rainfall is absorbed by subsurface conduits, but water from infrequent heavy storms cannot be carried away quickly enough to prevent flooding of low-lying areas. Adapted from AIPG (1993).

Swelling and Shrinking Shales

A problem of some concern in Boyle County is the swelling of some of the clay minerals in shale units 8 and 9. The process is exacerbated when the shale contains the mineral pyrite (fool's gold). Pyrite is a common mineral and can be found distributed throughout the black shale, although it is not always present and may be discontinuous both laterally and horizontally. In the presence of moisture and oxygen, pyrite oxidizes and produces sulfuric acid. The acid reacts with calcium carbonates found in water, the rock itself, crushed limestone, and concrete. This chemical reaction produces sulfate and can form the mineral gypsum, whose crystallization can cause layers of shale to expand and burst, 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.

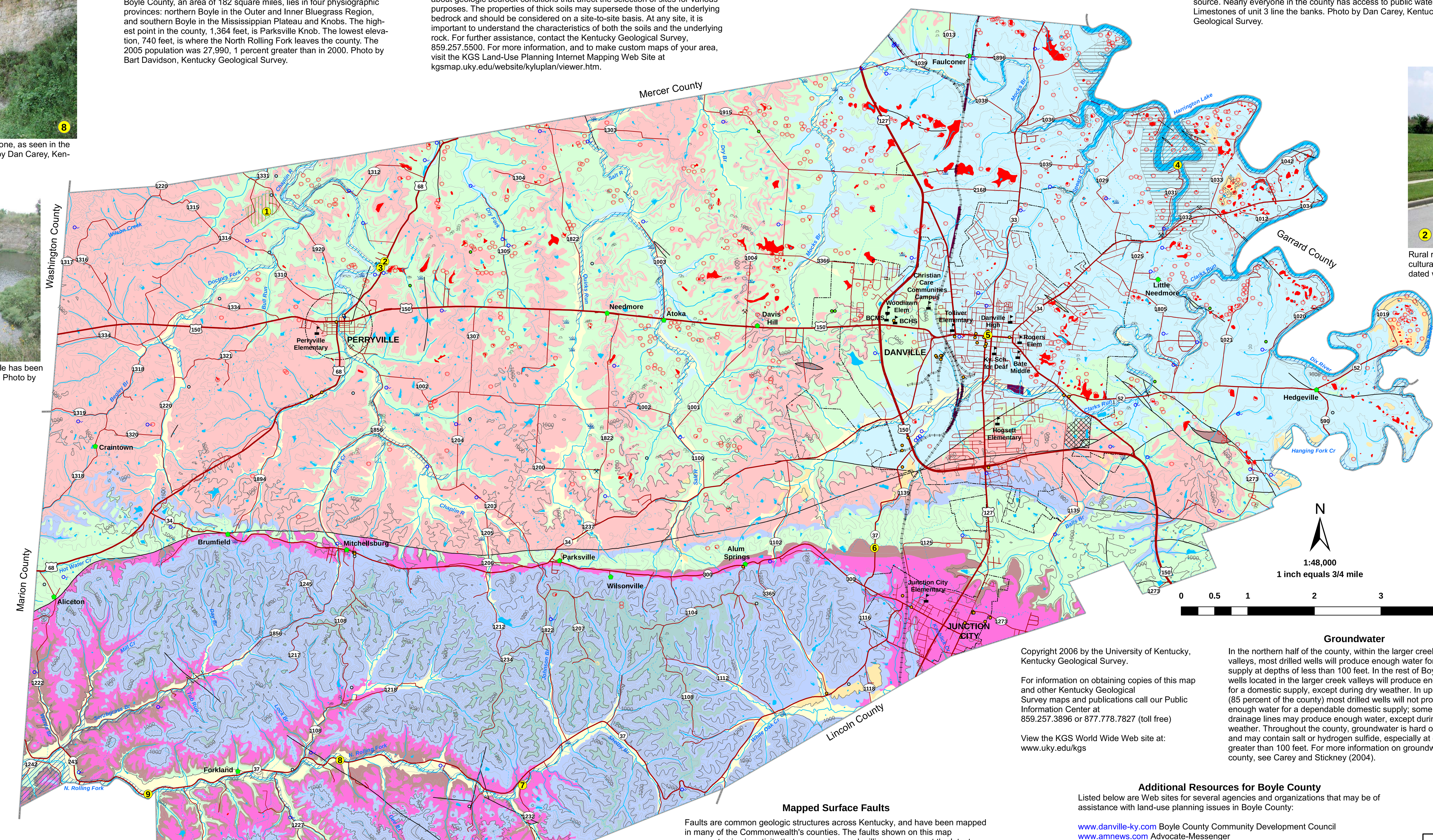
Anyone planning construction on these shales should seek professional advice from a geologist or engineer familiar with the problem.



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.

Rural Residential Development

Rural residential development off U.S. 68 north of Perryville. Limestones of unit 6 provide soils for an agricultural economy and attractive sites for development. Conflicting land-use interests can often be accomodated with thoughtful planning. Photo by Dan Carey, Kentucky Geological Survey.



EXPLANATION

- School
- Geologic fault
- Concealed geologic fault
- Railroad
- County line
- Incorporated city boundary
- Watershed boundary
- Public lands
- Designated flood zone (FEMA, 2004)
- Wetlands > 1 acre (U.S. Fish and Wildlife Service, 2003)
- Source-water protection area, zone 1
- Quarry
- Mapped sinkholes
- Artificial fill

Water wells

- Domestic
- Monitoring
- Public
- Agricultural

- Severely eroded area
- Rock outcrop
- Sinkhole
- Wet area
- Mine or quarry
- Spring

50-foot contour interval

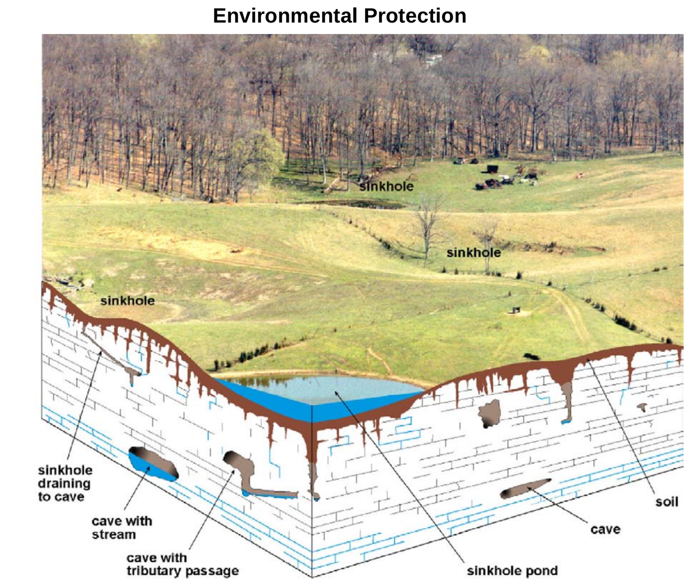
4 Photo location

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

Source-Water Protection Areas

Source-water protection areas are those in which activities are likely to affect the quality of the drinking-water source. For more information, see kgsweb.uky.edu/download/water/swapp/swapp.htm.

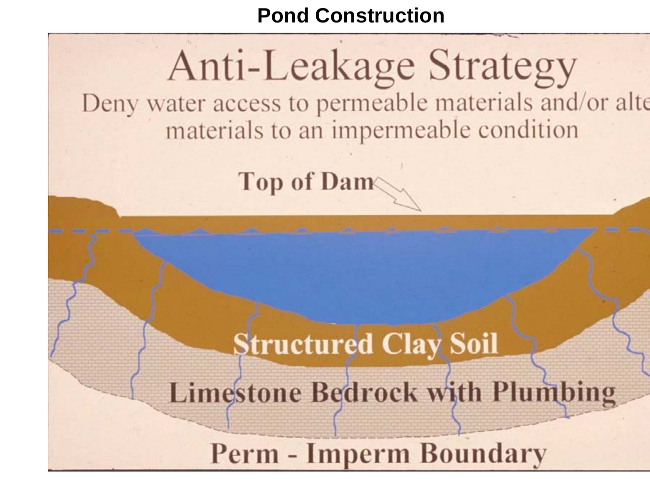
Environmental Protection



- Never use sinkholes as dumps. All waste, but especially pesticides, paints, household chemicals, automobile batteries, and used motor oil, should be taken to an appropriate recycling center or landfill.
- Make sure runoff from parking lots, streets, and other urban areas is routed through a detention basin and sediment trap to filter it before it flows into a sinkhole.
- Make sure your home septic system is working properly and that it's not discharging sewage into a crevice or sinkhole.
- Keep cattle and other livestock out of sinkholes and sinking streams. There are other methods of providing water to livestock.
- See to it that sinkholes near or in crop fields are bordered with trees, shrubs, or grass buffer strips. This will filter runoff flowing into sinkholes and also keep tilled areas away from sinkholes.
- Construct waste-holding lagoons in karst areas carefully, to prevent the bottom of the lagoon from collapsing, which would result in a catastrophic emptying of waste into the groundwater.
- If required, develop a groundwater protection plan (410KAR5:037) or an agricultural water-quality plan (KRS224.71) for your land use.

(From Currens, 2001)

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 three units horizontal to one 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.

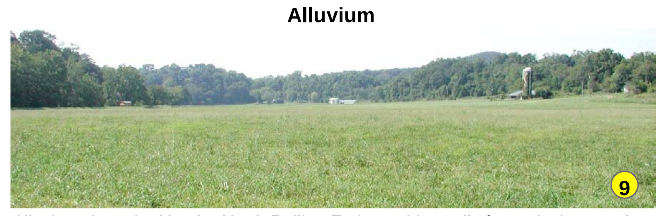
For information on obtaining copies of this map and other Kentucky Geological Survey maps and publications call our Public Information Center at 859.257.3896 or 877.778.7827 (toll free)

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

Groundwater

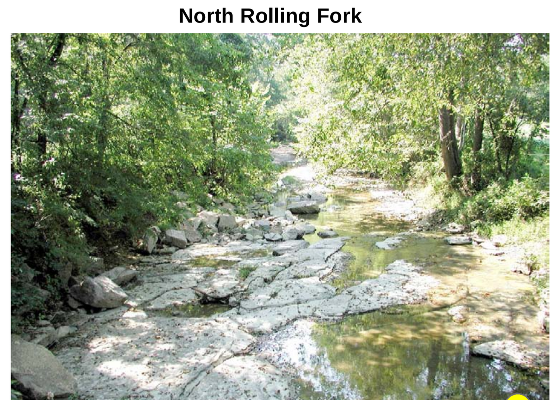
In the northern half of the county, within the larger creek and river valleys, most drilled wells will produce enough water for a domestic supply at depths of less than 100 feet. In the rest of Boyle County, wells located in the larger creek valleys will produce enough water for a domestic supply, except during dry weather. In upland areas (85 percent of the county) most drilled wells will not produce enough water for a dependable domestic supply; some wells along drainage lines may produce enough water, except during dry weather. Throughout the county, groundwater 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 (2004).

Alluvium



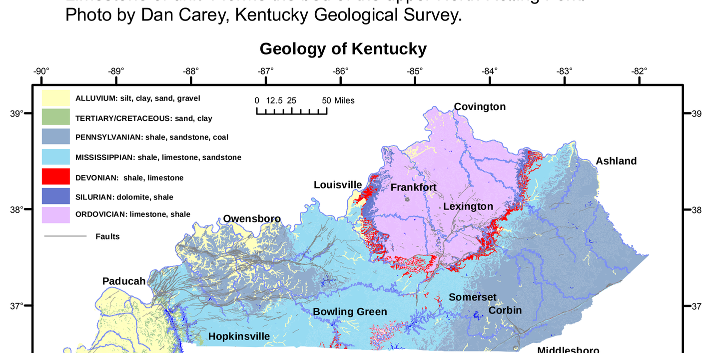
Alluvium deposited by the North Rolling Fork provides soils for agriculture and sites for peaceful rural living. Photo by Dan Carey, Kentucky Gelogical Survey.

North Rolling Fork



Limestone of unit 4 forms the bed of the upper North Rolling Fork. Photo by Dan Carey, Kentucky Geological Survey.

Geology of Kentucky



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

Radon

Radon gas can be a local problem, in some areas exceeding the U.S. Environmental Protection Agency's maximum recommended limit of 4 picocuries per liter. Radon from soil gas that enters the home from below through cracks and gaps is the main cause of radon problems. The shales of unit 9 and limestones of unit 3 may contain high levels of uranium or radium, parent materials for radon gas. Homes in these areas should be tested for radon. Testing is inexpensive and easy, taking only a few minutes. Radon reduction systems work and are not too costly. Even high levels can be reduced to acceptable levels. The EPA recommends action be taken if indoor levels exceed 4 picocuries per liter, which is 10 times the average outdoor level. (U.S. EPA, 2005).

Radon Risk If You've Never Smoked (U.S. Environmental Protection Agency, 2005)

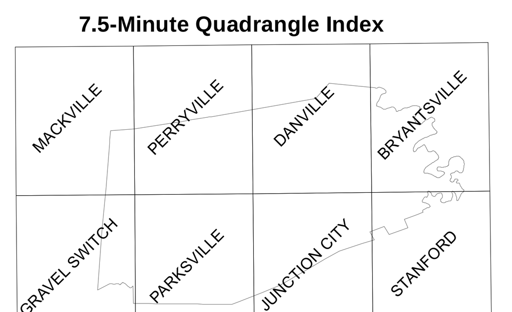
Radon Level	If 1,000 people who never smoked were exposed to this level over a lifetime*...	The risk of cancer from radon exposure compares to**...	WHAT TO DO:
20 pCi/L	About 36 people could get lung cancer	35 times the risk of drowning	Fix your home
10 pCi/L	About 18 people could get lung cancer	20 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 15 people could get lung cancer	4 times the risk of dying in a fall	Fix your home
4 pCi/L	About 7 people could get lung cancer	The risk of dying in a car crash	Fix your home
2 pCi/L	About 4 people could get lung cancer	The risk of dying from poison	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	About 2 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult.)
0.4 pCi/L		(Average outdoor radon level)	

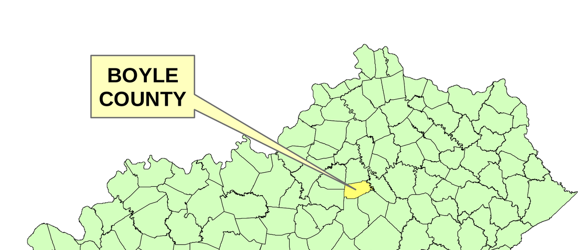
Note: If you are a former smoker, your risk may be higher.
* Lifetime risk of lung cancer deaths from EPA Assessment of Risks from Radon in Homes (EPA 402-R-03-003).
** Comparison data calculated using the Centers for Disease Control and Prevention's 1999-2001 National Center for Injury Prevention and Control Reports.

Radon Ventilation

Ventilation system removes radon from the basement area of this home on unit 9. Photo by Dan Carey, Kentucky Geological Survey.

7.5-Minute Quadrangle Index





Mapped Surface Faults

Faults are common geologic structures across Kentucky, and have been mapped in many of the Commonwealth's counties. The faults shown on this map represent seismic activity that occurred several million years ago at the latest. There has been no activity along these faults in recorded history. Seismic risk associated with these faults is very low. Faults may be associated with increased fracturing of bedrock in the immediately adjacent area. This fracturing may influence slope stability and groundwater flow in these limited areas.

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Additional Resources for Boyle County

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

www.danville-ky.com Boyle County Community Development Council
www.amnews.com Advocate-Messenger
ces.ca.uky.edu/boyle/ UK Cooperative Extension Service
www.kineticnet.net/kyrcd/kh.html Kentucky Heritage Resource Conservation and Development Council Inc.
www.bgadd.org/ Bluegrass Area Development District
www.thinkkentucky.com/edis/cmnty/cw114/ Kentucky Economic Development Information System
www.thinkkentucky.com/edis/cmnty/cw/cw114/ Detailed county statistics
www.uky.edu/KentuckyAtlas/21021.html Kentucky Atlas and Gazetteer, Boyle County
quickfacts.census.gov/qfd/states/21/21021.html U.S. Census data
www.bae.uky.edu/ext/Residential/Radon/QandA.htm Radon in the home
kgsweb.uky.edu/download/misc/landuse/mainkyluplan.htm Planning information from the Kentucky Geological Survey

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	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. Silt, sand, and gravel	Fair foundation material; easy to excavate. Seasonal high water table. Subject to flooding.	Severe limitations. Seasonal high water table subject to flooding. Refer to soil report (Craddock, 1983).	Water in alluvium may be in direct contact with basements. Seasonal high water table subject to flooding. Refer to soil report (Craddock, 1983).	Slight limitations. Refer to soil report (Craddock, 1983).	Slight limitations. Refer to soil report (Craddock, 1983).	Moderate to slight limitations. Avoid construction in floodplain. Refer to soil report (Craddock, 1983).	No limitations. Possible flooding. Refer to soil report (Craddock, 1983).	No limitations. Possible flooding. Refer to soil report (Craddock, 1983).	Pervious material. Seasonal high water table. Subject to flooding. Refer to soil report (Craddock, 1983).	Fair stability. Fair compaction. Piping hazard. Refer to soil report (Craddock, 1983).	Slight limitations. Seasonal high water table. Refer to soil report (Craddock, 1983).
2. Silt, sand, and gravel (terrace deposits)	Good foundation material; easy to excavate.	Severe to moderate limitations. Possible groundwater contamination.	Slight limitations.	No limitations.	No limitations.	No limitations.	No limitations.	Moderate to slight limitations. Steep wooded slopes. Potential for forest reserve or natural history park.	Not applicable.	Not applicable.	Slight limitations.
3. Limestone	Excellent foundation material; difficult to excavate.	Severe limitations. Impermeable rock. Locally fast drainage through fractures; danger of groundwater contamination.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable. Sinks common; drainage required.	Slight to moderate limitations. Rock excavation; locally, upper few feet may be rippable. Sinks common; local drainage problems.	Moderate limitations. Rock excavation. Steep slopes; narrow ravines. Slight limitations where topographically suitable.	Slight to moderate limitations, depending on topography. Rock excavation; locally, upper few feet may be rippable. Sinks common; local drainage problems.	No limitations.	Moderate to slight limitations. Steep wooded slopes. Potential for forest reserve or natural history park.	Severe limitations. Leaky reservoir rock; locally, conditions may be favorable. Sinks common.	Severe limitations.	Severe limitations. Rock excavation.
4. Limestone, dolomite	Excellent foundation material; difficult to excavate.	Moderate to severe limitations. Impermeable rock. Locally fast drainage through fractures and sinks to water table, with possible contamination.	Severe limitations. Rock excavation.	Severe limitations. Rock excavation.	Severe to moderate limitations. Rock excavation.	Slight to moderate limitations, depending on topography. Rock excavation. Sinks possible. Local drainage problems.	Slight to moderate limitations, depending on activity and topography.	Slight to moderate limitations, depending on activity and topography.	Moderate limitations. Reservoir may leak where rocks are fractured. Sinks possible.	Moderate limitations. Reservoir may leak where rocks are fractured. Sinks possible.	Severe limitations. Rock excavation.
5. Limestone, sandstone, siltstone	Excellent foundation material; difficult to excavate.	Severe limitations. Thin soils and impermeable rock.	Moderate to severe limitations. Rock excavation may be required.	Severe limitations. Rock excavation. Possible steep slopes.	Severe to moderate limitations. Rock excavation may be required. Possible steep slopes.	Severe limitations. Rock excavation. Possible steep slopes.	Severe to moderate limitations. Rock excavation may be required.	Severe to slight limitations, depending on activity and topography.	Slight to moderate limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Rock excavation.
6. Limestone and shale	Good to excellent foundation material; difficult to excavate.	Severe to moderate limitations. Impermeable rock. Locally fast drainage through fractures and sinks to water table. Possible groundwater contamination.	Severe to moderate limitations. Rock excavation possible.	Moderate to severe limitations. Rock excavation possible. Local drainage problems, especially on shale. Sinks possible. Avoid steep slopes.	Slight to severe limitations, depending on topography. Rock excavation likely. Local drainage problems, especially on shale. Sinks possible.	Severe to slight limitations, depending on topography. Rock excavation. Sinks possible. 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.	Slight to moderate 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. Rock excavation likely.
7. Shale and limestone	Good to excellent foundation material; moderately difficult to difficult to excavate.	Severe limitations. Impermeable rock.	Slight to moderate limitations. Earth and rock excavation. Poor drainage.	Slight to moderate limitations. Rock excavation. Local seeps; subgrade requires drainage.	Slight limitations. Local seeps.	Slight limitations. Rock generally rippable in shallow cuts. Local seeps.	No limitations.	No limitations.	Slight limitations. Most favorable sites are in this unit; locally, impermeable rock and underlain by fissured limestone.	Slight limitations.	Moderate limitations. Highly variable amount of rock and earth excavation.
8. Siltstone and shale*	Siltstone, fair to good foundation material; difficult to excavate. See unit 9 for shale.	Severe limitations. Thin soils and low permeability.	Severe limitations. Rock excavation. Steep slopes. See unit 9 for shale.	Severe limitations. Rock excavation. Steep slopes. See unit 9 for shale.	Severe limitations. Rock excavation. Steep slopes. See unit 9 for shale.	Severe limitations. Rock excavation. Steep slopes. See unit 9 for shale.	Severe to moderate limitations, depending on activity and topography.	Severe to slight limitations, depending on activity and topography. Slight limitations for forest preserve.	Moderate to slight limitations. Reservoir may leak where rocks are fractured.	Moderate to slight limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Rock excavation. See unit 9 for shale.
9. Shale*	Fair to poor foundation material; easy to moderately difficult to excavate. Possible expansion of shales. Plastic clay is particularly poor foundation.	Severe limitations. Low permeability.	Severe limitations. Low strength, slumping, and seepage problems. Possible shrinking and swelling of shales.	Moderate to severe limitations, depending on slopes. Strength, slumping, and seepage problems.	Moderate to severe limitations, depending on slopes. Strength, slumping, and seepage problems.	Moderate to severe limitations, depending on slopes. Strength, slumping, and seepage problems.	Severe to slight limitations, depending on activity and topography. Strength, slumping, and seepage problems.	Moderate to slight limitations, depending on activity and topography.	Slight limitations. Reservoir may leak where rocks are fractured. Most ponds on shale are successful.	Severe limitations. Poor strength and stability.	Moderate limitations. Poor strength, wetness.

* See discussions of swelling shales and soils and slope stability