KENTUCKY GEOLOGICAL SURVEY
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UNIVERSITY OF KENTUCKY, LEXINGTON

MAP AND CHART 185
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Geologic Hazards in Kentucky

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Geologic hazards

Damage from geologic hazards usually does not make the news—cracking walls and foundations, local flooding, subsidence beneath a home—but the cost to Kentuckians adds up to millions of dollars each year. The level and type of geologic hazards—landslides, flooding, subsidence from mining, shrinking and swelling shales, sinkhole collapse—vary across the state, depending on the geology, topography, and hydrology.

Fifty-five percent of the state sits atop carbonate rocks that are prone to developing karst. Karst hazards include sinkhole flooding, sudden cover collapse, and leakage around dams. Annual damages related to karst hazards are estimated to cost $23 million each year. Wolf Creek Dam, which impounds Lake Cumberland, has been a constant problem because it is built on karst. Current repairs will cost over $300 million.

Kentucky has experienced hundreds, if not thousands of earthquakes in the past. A magnitude-5.1 earthquake occurred in 1980 near Sharpsburg in Bath County and caused $3 million in damage. Damages from a magnitude 6 or higher earthquake—which scientists estimate has a 25 to 40 percent chance of occurrence within the next 50 years—could be hundreds of million dollars.

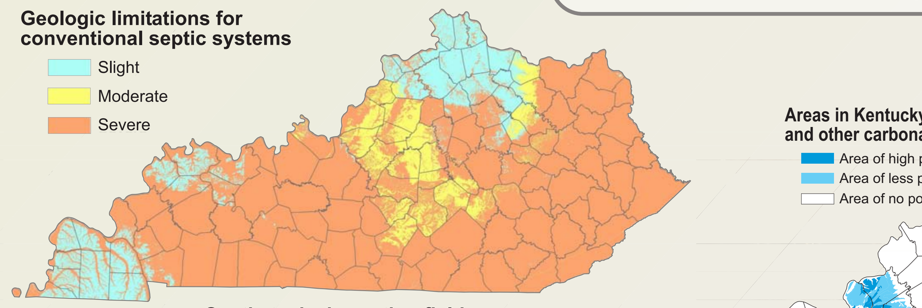
A large landslide in Hickman in western Kentucky destroyed many houses, and more than $10 million has been spent to try to fix it. About $1 million has been spent to repair damage caused by landslides on the Audubon Parkway between Owensboro and Henderson.

Millions of dollars are spent to repair damages that shrinking and swelling shales cause to structures and foundations.

As our existing infrastructure begins to age, the expanding economy and population are forcing new development and construction in more undesirable locations, which are more prone to geologic hazards. KGS is striving to provide better information on geologic hazards in Kentucky through technical research and assistance, as well as public education and awareness.

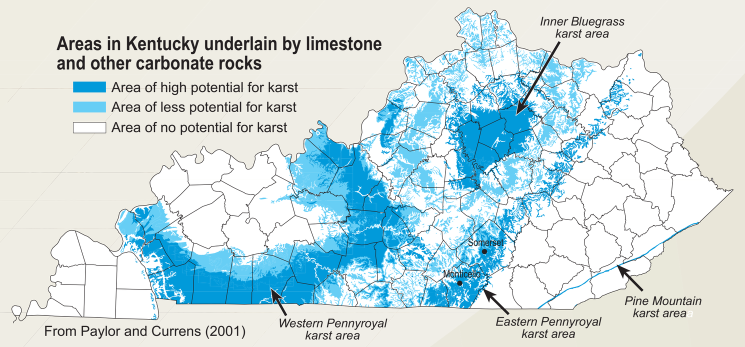
Explanation for primary map in center of map sheet

- Possible flooding
- Possible landslides
- Karst geology
- Possible landslides, unstable shales, mined areas, flooding
- Possible landslides, slope stability, expansive shales
- Sinkholes
- Faults
- State capital
- County seat
- Incorporated city
- Parkway or interstate highway
- U.S. highway
- State primary highway
- County boundary
- State boundary



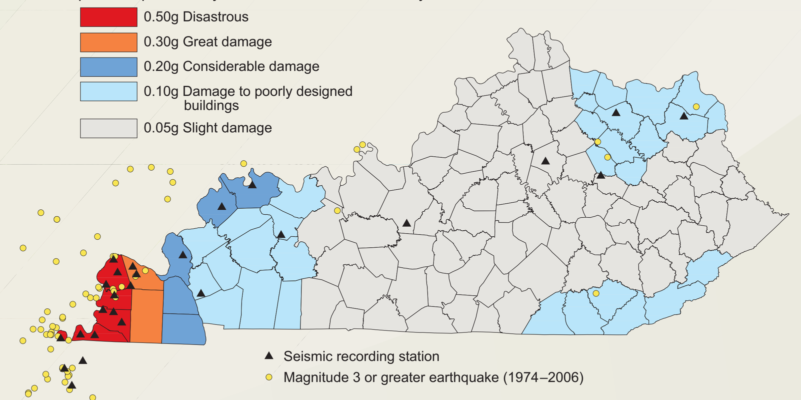
Septic tank absorption fields

If the soils in a septic tank absorption field cannot perform adequately, the underlying rock in most of Kentucky will not serve to prevent pollution of water wells and streams. Soils in karst areas, particularly, must be carefully evaluated to ensure performance.



From Paylor and Currens (2001)

Earthquake Hazard Information



Although we do not know exactly when and where the next major earthquake will occur, we do know that earthquakes will occur and could cause damage. The severity depends on many factors, such as magnitude, distance from the epicenter, and local geology. Seismic recording stations operated by the Kentucky Geological Survey monitor earthquake activity in Kentucky. Information on earthquake effects is obtained by monitoring earthquakes and performing research. Such information is vital for earthquake hazard mitigation and risk reduction.

The most important information for seismic-hazard mitigation and risk reduction is ground-motion hazard. One way of measuring ground-motion hazard is by determining the peak ground acceleration (PGA) that may occur in a particular timeframe. The map above shows the PGA at the top of bedrock that will likely occur within the next 500 years or longer in Kentucky (Wang and others, 2008). It shows, as expected, that PGA would be greatest in far western Kentucky near the New Madrid Seismic Zone. Ground-motion hazard maps for the central United States and other areas are also available from the U.S. Geological Survey. These maps are used to set general policies on earthquake hazard mitigation. For example, maps produced by the USGS were used for seismic design in building codes. For additional information about earthquake hazards, visit the Kentucky Geological Survey Web site at www.uky.edu/KGS/geologichazards/geologic-hazards.html.

For building code information see the Kentucky Office of Housing, Buildings, and Construction Web site at www.ohbc.ky.gov/bce/.

Mapped surface faults

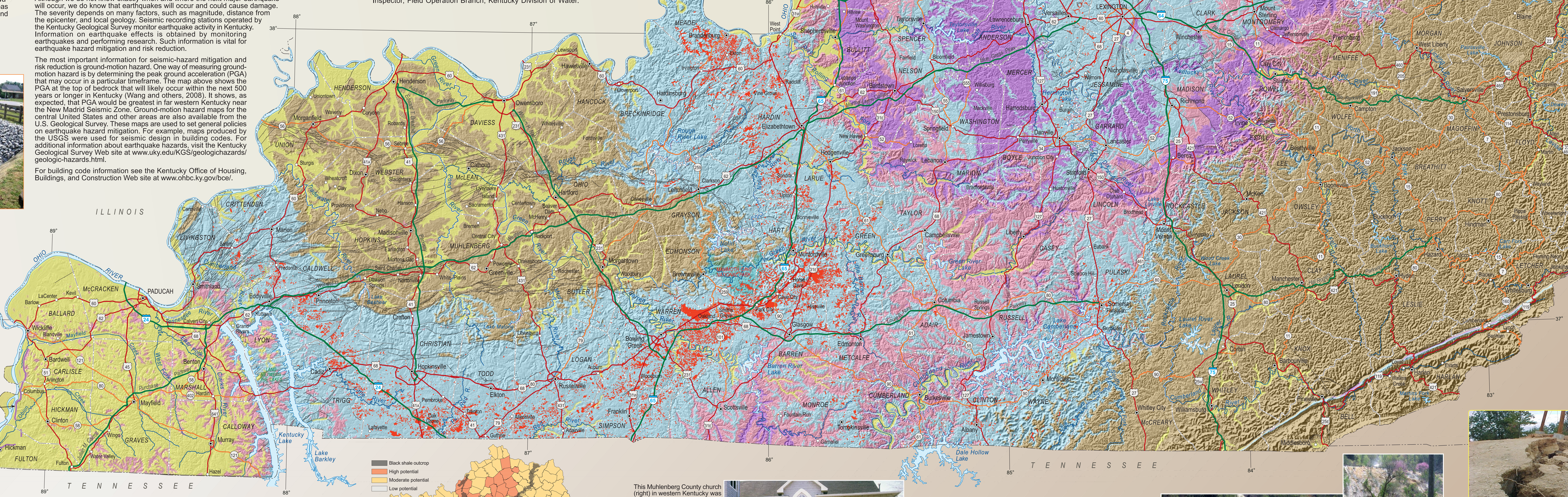
Faults are common geologic structures across Kentucky, and some, but by no means all, have been mapped in many of the commonwealth's counties. In the Jackson Purchase Region, many faults occur but few are shown on this map because they are buried beneath more recent sediments. The faults shown on this 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 and, in karst regions, faulted areas are often marked by extensive solution and sinkhole development.

Acknowledgments
Thanks to Paul Howell, U.S. Department of Agriculture, Natural Resources Conservation Service, for photos and diagrams. Thanks to Bart Davidson for constructive comments.

Geologic data were derived from the Kentucky Geological Survey-U.S. Geological Survey areal geologic mapping project. Nearly 190 geologists mapped the geology of Kentucky from 1960 to 1978. KGS geologists converted the resulting 707 geologic quadrangle maps into digital format as part of the STATEMAP component of the National Cooperative Geologic Mapping Program of the United States Geological Survey.

Western Kentucky landslides

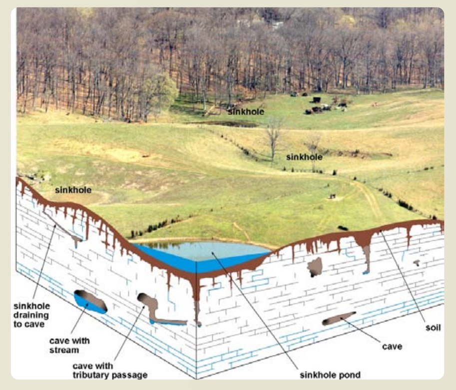

Bluffs of the Mississippi and Ohio Rivers can be unstable, and careful geotechnical site evaluations before construction can save dollars and peace of mind. A slide site in Hickman County (below) was rebuilt (right) by the U.S. Army Corps of Engineers at a cost of millions of dollars. Photo by Mike Lynch, Kentucky Geological Survey.



For a land-use planning map of your county, go to kgsweb.uky.edu/download/geology/landuse/lumaps.htm.

Karst geology

Over half of Kentucky is karst. 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 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.

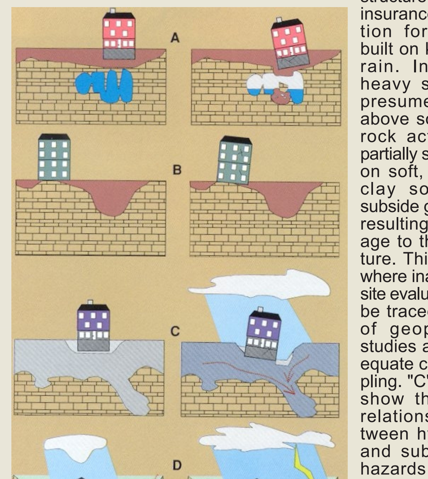


- Never use sinkholes as dumps. All waste, but especially pesticides, paints, household chemicals, automobile batteries, and used motor oil, should be taken to an appropriate recycling center or landfill.
- Make sure runoff from parking lots, streets, and other urban areas is routed through a detention 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)

Construction on karst

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).



Karst collapse

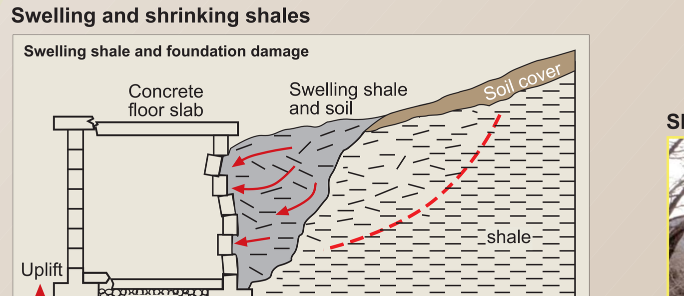
A rather extreme example of karst collapse occurred beneath a Warren County highway. When buildings or roads are constructed in areas of known subsurface cavities, great care must be taken in managing the surface drainage. Photo courtesy of Richard McGehee, Inspector, Field Operation Branch, Kentucky Division of Water.

Construction on shale

Areas underlain by shale are prone to landslides and slope failure (as above in Johnson County). Photo by Paul Howell, U.S. Department of Agriculture, Natural Resources Conservation Service.

Additional support and drainage management are often required to prevent pavement failure of roads built on slopes underlain by shale (as above in Martin County). Photo by Dan Carey, Kentucky Geological Survey.

Swelling and shrinking shales



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. Good drainage is critical.

Swelling shales in Irvine buckled the floor of the new Estill County Middle School gymnasium (Anderson, 2008). The floors were removed, loose shales were excavated, and the remaining shales were isolated from moisture and further oxidation by using an innovative process of covering them with resin. The remediation project cost millions of dollars. Photo by John F. Stickney, Kentucky Rural Water Association.

Slope failure

This landslide in Johnson County was caused by a septic drain field. Photo by Paul Howell, U.S. Department of Agriculture, Natural Resources Conservation Service.

Additional support for foundation stability is often required for construction on slopes (Johnson County). Photo by Dan Carey, Kentucky Geological Survey.

Landslides

Mass movements or landslides of surficial materials are frequent and costly geologic hazards throughout the state, but particularly in eastern and northern Kentucky. The failure of the slope may be rapid, but more commonly is a slow, almost imperceptible movement of a few inches per year called creep. Whether rapid or slow, the end results are often costly: broken plumbing, cracked walls and foundations, doors and windows that won't open or close, cracked streets and sidewalks, and often total loss of the structures.

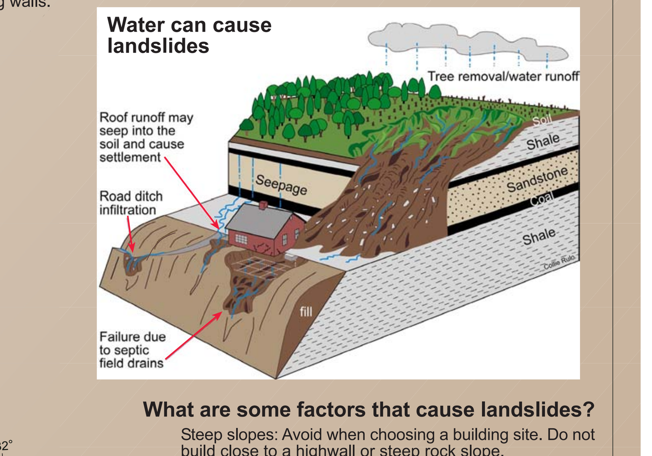
Virtually all units containing shale on slopes are susceptible to landslides.

Clay shales become plastic when saturated and present particularly difficult swelling problems for excavations and foundations. An engineering geologist or a geotechnical engineer should be consulted when clay shales are present.

Gravity is the main driving force for landslides, but water nearly always plays a critical role by adding weight and lubricating the particles in the weathered shale. Once the saturated clay particles begin to move in a slide they also tend to orient parallel to one another, making sliding easier and often more rapid. Cutting into or overloading a slope with structures and fill can also be major contributing factors.

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

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



What are some factors that cause landslides?

Steep slopes: Avoid when choosing a building site. Do not build close to a highwall or steep rock slope.

Water: Slope stability decreases as water moves into the soil. Springs, seeps, roof runoff, gutter downspouts, septic systems, and site grading that causes ponding or runoff that drains toward the building are sources of water that often contribute to landslides.

Changing the natural slope by creating a level area where none previously existed can unintentionally set up conditions for a landslide above or below the house. Again, seek the advice of a knowledgeable professional.

Poor site selection for roads and driveways. Fill on slopes provides a poor foundation for driveways.

Improper placement of fill material.

Removal of trees and other vegetation: Site construction often results in the elimination of trees and other vegetation. Plants, especially trees, help remove water and stabilize the soil with their extensive root systems.

What are some ways to prevent landslides?

Seek professional assistance prior to construction.

Proper site selection: Some sloping areas are naturally prone to landslides. Inspect the site for springs, seeps, and other wet areas that might indicate water problems. Take note of unusual cracks or bulges at the soil surface. These are typical signs of past soil movement that may lead to slope failure. Also be aware of geologically sensitive areas where landslides are more likely to occur. Look at the typical natural slopes around your building site. These tend to reflect the stability or instability of the natural slopes in the type of rock or soil in the area. Unusual changes in slope or in the type or color (light to dark green) of vegetation may indicate old landslide areas.

Alter the natural slope of the building site as little as possible during construction. Never remove soil from the toe or bottom of the slope. This takes away support for the material above. Don't add soil to the top of the slope. This adds additional weight to the natural slope and changes its stability. Landslides are less likely to occur on sites where disturbance has been minimized. Seek professional assistance before earth-moving begins.

Remove as few trees and other vegetation as possible. Trees develop extensive root systems that help stabilize the slope and remove excessive soil moisture. Trees and other permanent vegetative covers should be established as rapidly as possible and maintained to reduce soil erosion. Trees planted too close to the house can cause foundation problems, however. During droughts, trees can pull water from the soil and cause it to shrink and pull support away from the foundation. Water your large trees in a drought, especially hardwoods. When a large tree near your house dies, the holes should be backfilled to prevent rotting roots from providing conduits for water.

Household water disposal system: Seek professional assistance in selecting the appropriate type and location of your septic system. Septic systems can saturate soil and contribute to landslides.

Proper water disposal: Allowing surface waters to saturate the sloping soil is the most common cause of landslides in eastern Kentucky. Downspouts are a common source. The roof of a typical home can contribute more than 50,000 gallons of runoff water in a year of normal precipitation. Properly located diversion channels are helpful in redirecting runoff away from areas disturbed during construction. Runoff should be channeled and water from roofs and downspouts piped to stable areas at the bottom of the slope. (From U.S. Department of Agriculture, Natural Resources Conservation Service, no date)


A new water tower being built in Jackson County on a hilltop 200 feet above the roof of a limestone mine began to list (above). After construction began, several large mine roof collapses occurred, causing the surface beneath the tower to subside (left). Development in areas of mining must always be evaluated carefully before construction begins. Photos by Warren Anderson, Kentucky Geological Survey.

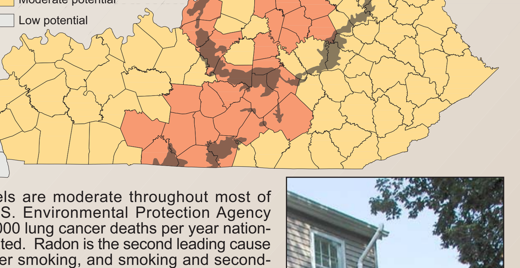
Flooding

Sinkhole plain in Warren County before (above left) and after a rain (above right). Photo courtesy of Western Kentucky University, Center for Cave and Karst Studies.

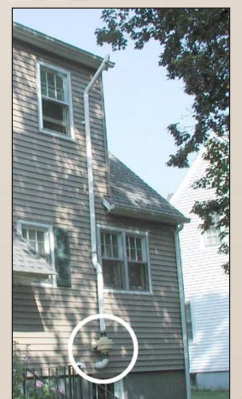
Flooding—whether on large streams in western Kentucky, creeks in the hills of eastern Kentucky, or in karst areas with no visible streams—can be a problem across Kentucky. This Marshall County photo by Glynn Beck, Kentucky Geological Survey.

Sinkhole flooding in the Inner Bluegrass (Fayette County). Photo by Jim Rebmann, Lexington-Fayette Urban County Government.

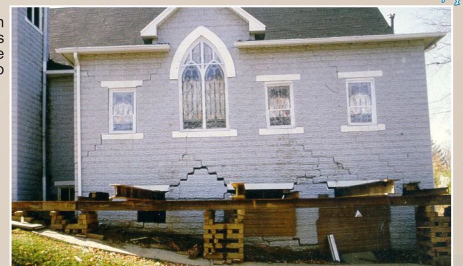
Radon



Indoor radon levels are moderate throughout most of Kentucky. The U.S. Environmental Protection Agency estimates that 20,000 lung cancer deaths per year nationwide are radon related. Radon is the second leading cause of lung cancer, after smoking, and smoking and secondhand smoke add to the risk. The radon risk for smokers is 10 times that for nonsmokers. Radon is a colorless, odorless gas. It is produced by the radioactive decay of naturally occurring uranium in soil and water. Kentucky has two geologic units that are often high radon emitters: the gas- and oil-producing Devonian-age black shale (see map) and a number of limestones of various ages, especially the limestones in the Bluegrass Region that were once mined for phosphate. Homes in these areas should definitely be tested. In the limestones, it is not the limestone itself that is the problem, but the thick clayey soils that develop from the limestone and concentrate small amounts of uranium in clays and phosphate minerals. The EPA recommends testing all homes and schools. Testing is inexpensive and easy. The average indoor radon level is 1.3 picocuries per liter. Homes with radon levels at 4 picocuries per liter or greater should be fixed. Often, simple ventilation can rid your house of radon. A commonly used method of radon reduction is a vent pipe system and a fan to pull radon from beneath the house (right) and vent it to the outside. If you conduct the 3-day test and it is above 4.0 picocuries, you should do a second, more reliable test of longer duration before performing any expensive repairs.



Mined areas



This Muhlenberg County church (right) in western Kentucky was damaged by subsidence above an old underground mine. Photo by John Kiefer, Kentucky Geological Survey.

More than 200 million gallons of slurry discharged from an impoundment in Martin County in October 2001. The slurry affected 75 miles of waterways downstream. Photo by Kentucky Department of Natural Resources.

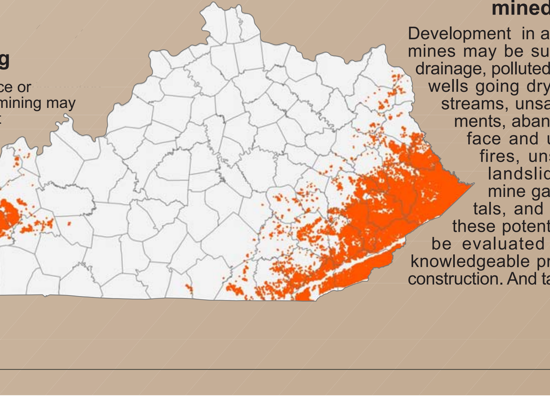
Landslides are a potential hazard in the steep-sided topography of eastern Kentucky. Prior to modern surface mining reclamation and regulations, old, unreclaimed mining areas (below) were especially prone to landslides. This Perry County photo by John Kiefer, Kentucky Geological Survey.

Abandoned mine blowout

The blowout at right occurred on the morning of April 18, 2005, near the Knott-Floyd County line, just west of the town of Garrett. Photographs of the blowout were taken just hours after the event was reported. The mine was the Consol James Fork Mine, operational during the late 1980's and early 1990's as an above-drainage room-and-pillar mine in the Hazard No. 4 seam. Water from the mine scoured trees and rock from the hillside, covering a part of the Hal Rogers Parkway before entering Rock Fork. Water was still flowing at a rate of 300 to 400 gallons per minute a week after the blowout. The subsurface area of the mine is over 800 acres, with a seam thickness near 5 feet. If the mine were fully flooded, a conservative estimate of the potential water volume would exceed 600 million gallons.

Blowouts occur when hydrostatic pressure within flooded, abandoned coal seams becomes too powerful for coal barriers to endure. This event happened in an unpopulated area, but other blowouts have caused injury and property damage, as hundreds of thousands of gallons of water have escaped the mine with great velocity. As abandoned deep mines continue to age, erosion of mine barriers will further enhance the probability that this type of geologic hazard will happen. (Photos courtesy of Kentucky Division of Abandoned Mine Lands.)

Mapped coal mining



Development hazards in mined areas

Development in areas of abandoned mines may be subject to acid mine drainage, polluted wells and streams, wells going dry, sedimentation of streams, unsafe water impoundments, abandoned dumps, surface and underground mine fires, unstable slopes and landslides, underground mine gases, unsealed portals, and subsidence. All of these potential hazards should be evaluated at the site by a knowledgeable professional prior to construction. And talk to the neighbors.

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