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

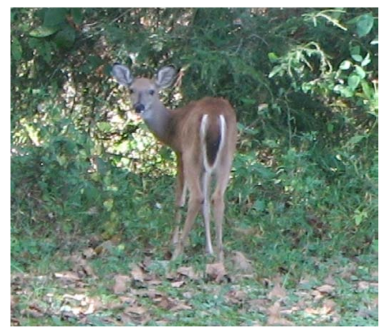
Generalized Geologic Map for Land-Use Planning: Letcher County, Kentucky

Daniel I. Carey, Steven E. Webb, Bart Davidson

KGS
MAP AND CHART 183
Series XII, 2007

Letcher County Courthouse in Whitesburg

Letcher County, 339 square miles in the Eastern Kentucky Coal Field, was formed in 1842. The highest elevation, 3,739 feet, is a peak on Black Mountain at the headwaters of Roberts Branch in the southeastern corner of the county. The lowest elevation, 940 feet, is where the North Fork of the Kentucky River leaves the county. The 2006 human population of 24,420 was 3.4 percent smaller than that of 2000. There are also many deer. Photos by Dan Carey, Kentucky Geological Survey.



Acknowledgments

Geology adapted from Sparks (2003a-c), Conley (2004), Johnson (2004), Mullins (2004), Murphy (2004), Petersen (2004a-d), and Morris and others (2005a, b). Thanks to Paul Howell, U.S. Department of Agriculture, Natural Resources Conservation Service, for photos. Thanks to Kim and Kent Anness, Kentucky Division of Geographic Information, for base-map data. Thanks to Meg Smath, Kentucky Geological Survey, for editorial improvements.

Earth History

From the 355-million-year-old shale at the bottom to the 315-million-year-old sandstone at the top, nearly 40 million years of the earth's history can be seen in the tilted bands of rocks in Pine Mountain along U.S. 23 at Pound Gap. Photo by Dan Carey, Kentucky Geological Survey.

Reclamation Development

Raven Rock Development is a 680-acre commercial and residential development located in Jenkins. Built primarily on reclaimed mine land, the development consists of an 18-hole public golf course, residential property strategically located near the course, and commercial development properties located along U.S. 23. Photo by Dan Carey, Kentucky Geological Survey.

Sandstone, Siltstone, Shale, Coal (Unit 6)

Water percolates through cracks and crevices in sandstone, siltstone, and coal until it hits impermeable shale. Sulfate in the water precipitates out with a distinctive yellow color. Photo by Dan Carey, Kentucky Geological Survey.

Construction on Shale

Additional support is commonly needed to prevent pavement failure for highways constructed on shale. Photo by Dan Carey, Kentucky Geological Survey.

Landslides

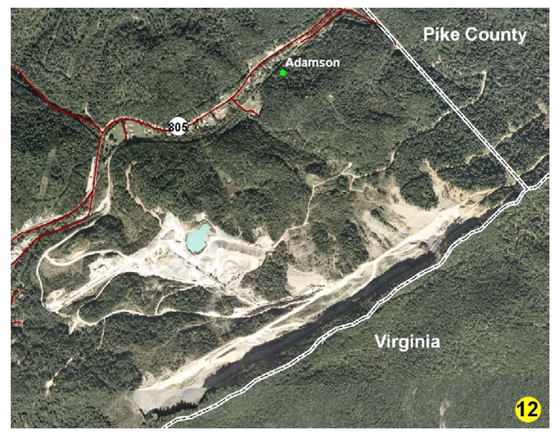
Hillside construction can cause earth movements if not properly planned. Photos by Paul Howell, U.S. Department of Agriculture, Natural Resources Conservation Service.

Bad Branch State Nature Preserve

The severe drought of 2007 reduced Bad Branch Falls to a 60-foot trickle down the sandstone cliff. Bad Branch is a Kentucky Wild River inside the 2,639-acre state nature preserve. Photo by Dan Carey, Kentucky Geological Survey.

Mineral and Energy Resources

From 1980 to 2005, Letcher County produced 3.5 million barrels of oil and 74 billion cubic feet of natural gas. The Jenkins quarry (below) produces aggregate from the 340-million-year-old Newman Limestone. Line Fork Compressor Station photo (above) by Dan Carey, Kentucky Geological Survey. Aerial photo by the U.S. Department of Agriculture, Farm Services Administration, National Agricultural Imagery Program.



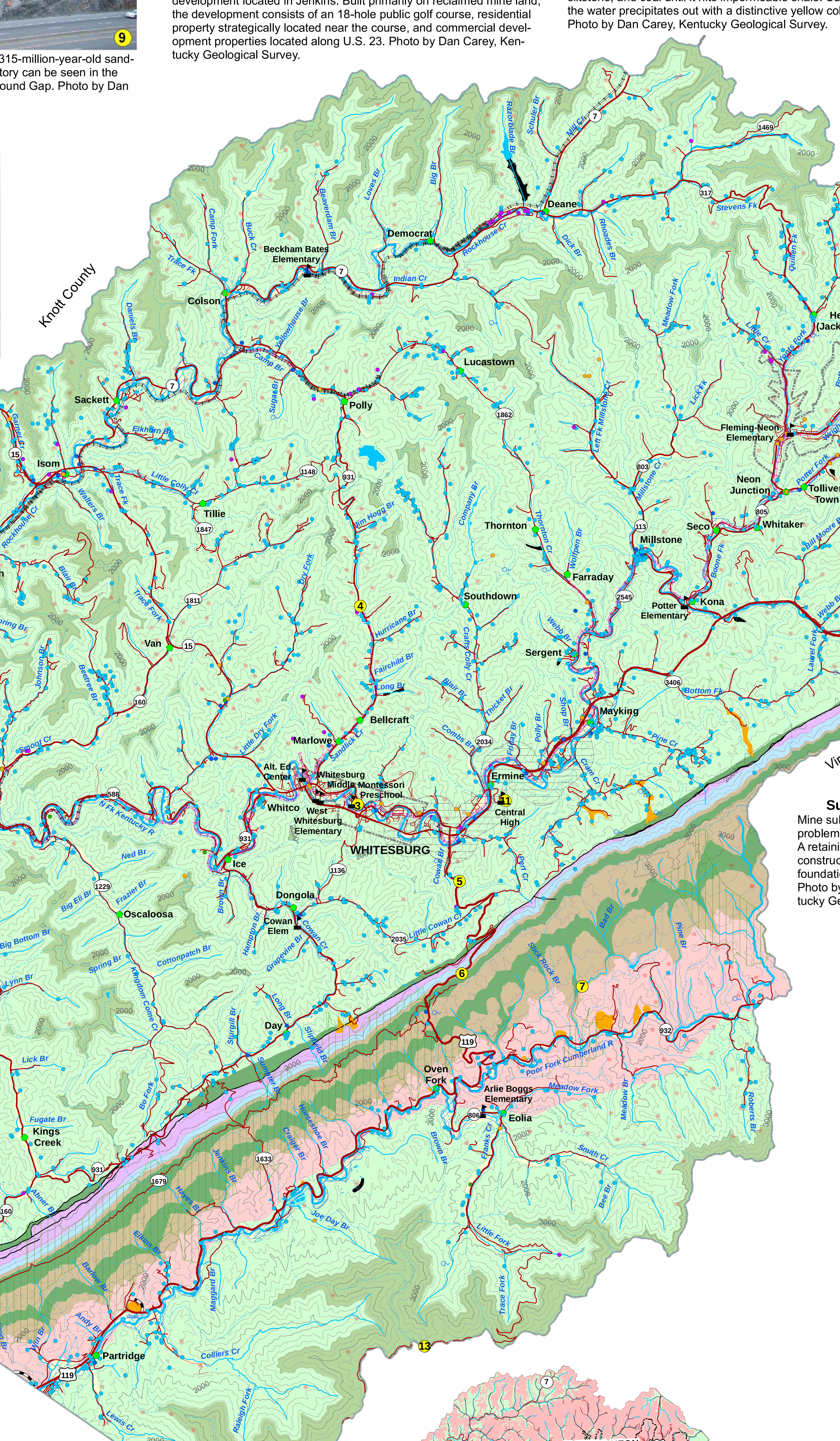
Terrain

The terrain of the county is generally rugged, with communities—like Whitesburg seen here from Pine Mountain—nestled in valleys. Photo by Dan Carey, Kentucky Geological Survey.

Groundwater

About 18,500 Letcher Countians depend on private domestic water supplies: about 17,000 use wells and 1,500 use other sources. The Sandlick area has had problems with a lack of water in private wells. Most other areas of the county have high levels of iron or sulfur. Iron in water flowing from underground (photo below) precipitates out with the characteristic iron oxide red color. More than three-quarters of the wells drilled in valley bottoms and on mountain sides are adequate for a domestic supply. Some wells on ridges and mountaintops are adequate for domestic supply. Drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. North of Pine Mountain, groundwater from most drilled wells is moderately hard and contains noticeable amounts of iron. Salty water in drilled wells probably will not be found less than 200 feet below the principal valley bottoms. Along and south of Pine Mountain the water quality is slightly better, and few wells less than 300 feet below the principal valley bottoms will yield salty water. The groundwater is soft but contains noticeable amounts of iron. This area also contains limestone beds that, when faulted and below drainage, may yield several hundred gallons per minute. Springs in this area will yield 50 gallons per minute, but generally yield less than 10 gallons per minute.

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



EXPLANATION

- School
- Water wells
  - Domestic
  - Monitoring
  - Public
  - Mining, industrial, commercial
  - Agriculture
- Spring
- Wet area
- Gas well
- Oil well
- Railroad
- Abandoned railroad
- County line
- Watershed boundary
- Geologic fault
- Concealed geologic fault
- Scarp
- Landslide deposits—boulders, gravel, sand
- Dump or mine spoil
- Designated flood zone* (FEMA, 2005)
- Source-water protection area, zone 1
- Wetlands > 1 acre (U.S. Fish and Wildlife Service, 2003)
- Incorporated city boundaries
- Quarry
- Public lands

200-foot contour interval

Photo location

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.

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

Scale 1: 63,360

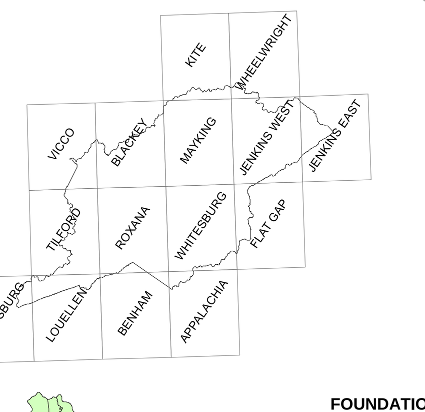
1 inch = 1 mile

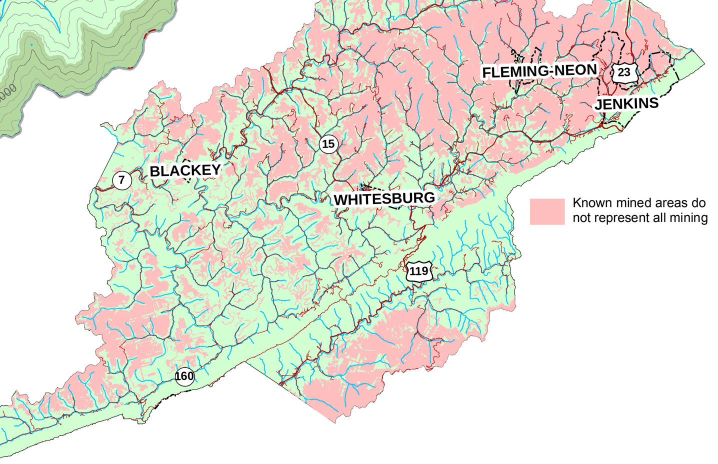
0 1 2 4 Miles

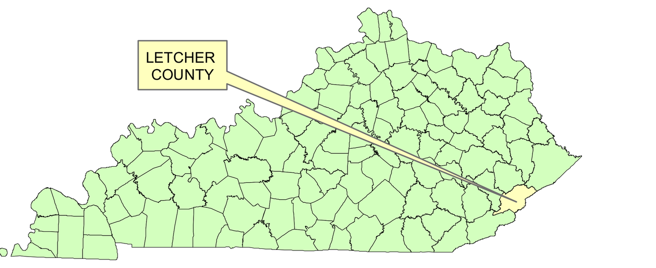
Mapped Surface Faults

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.

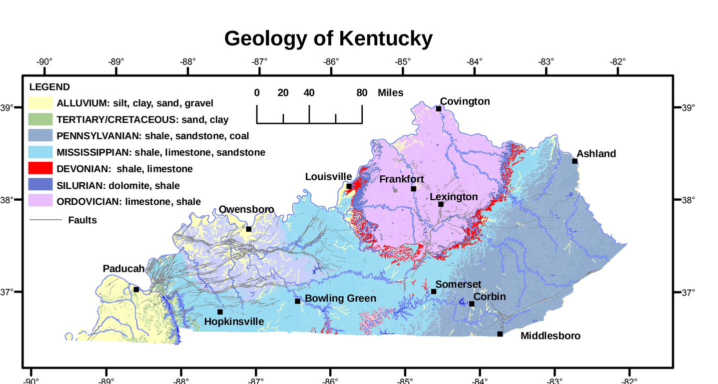
7.5-Minute Quadrangle Map Index







Geology of Kentucky



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

Subsidence

Mine subsidence can be a problem in some areas. A retaining wall (right) was constructed to stabilize the foundation of this home. Photo by Dan Carey, Kentucky Geological Survey.

Coal

Mining near the Virginia line south of Eolia seen from the air. Surface mines produced 3.8 million tons and underground mines produced 4.8 million tons in 2004. About 80 percent of the 547 million tons produced from 1912 to 2004 came from underground mines. Photo by the U.S. Department of Agriculture, Farm Services Administration, National Agricultural Imagery Program (2004).

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).

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

Landslides

Virtually all units containing shale on slopes are subject to landslides. Shales will break down and weather rapidly when exposed to air and water. Gravity is the main driving force, but water nearly always plays a critical role by adding weight and lubricating the shale. Cutting into or overloading a slope with structures and fill can also be major contributing factors. 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.

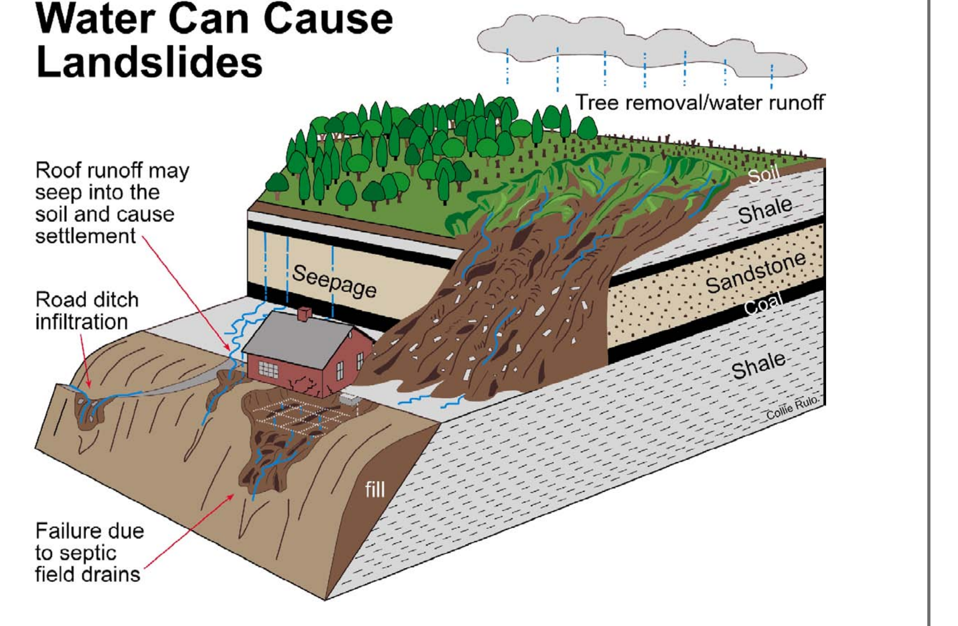
Precautions include taking care of all surface-water runoff by making certain that all runoff from roofs, gutters, patios, sidewalks, and driveways is carried well away from and not toward the house; diverting drainage from areas sloping toward the house; cutting into natural slopes as little as possible 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.

What Are the Factors That Cause Landslides?

Many factors contribute to landslides. The most common in eastern Kentucky are listed below:

1. Steep slopes: Avoid when choosing a building site.
2. Water: Slope stability decreases as water moves into the soil. Springs, seeps, roof runoff, gutter downspouts, septic systems, and site grading that cause ponding or runoff are sources of water that often contribute to landslides.
3. Changing the natural slope by creating a level area where none previously existed.
4. Poor site selection for roads and driveways.
5. Improper placement of fill material.
6. 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.

Water Can Cause Landslides



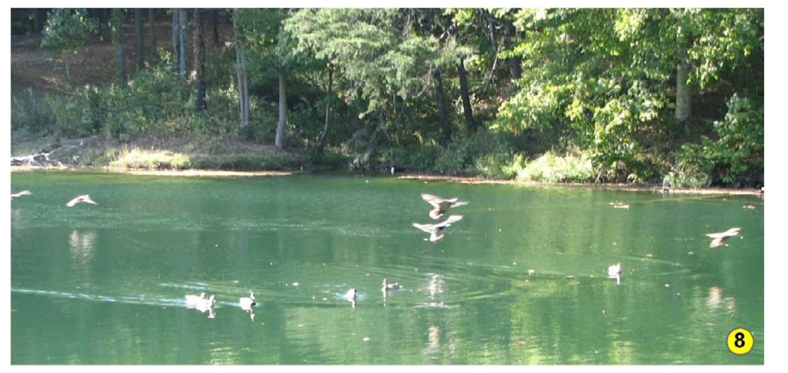
What Are Some Ways to Prevent Landslides?

1. Seek professional assistance prior to construction.
2. 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 soil movement that may lead to slope failure. Also be aware of geologically sensitive areas where landslides are more likely to occur.
3. 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 or add soil to the top of the slope. Landslides are less likely to occur on sites where disturbance has been minimized. Seek professional assistance before earth moving begins.
4. Remove as few trees and other vegetation as possible. Trees develop extensive root systems that are very useful in slope stabilization. Trees also remove large amounts of groundwater. Trees and other permanent vegetative covers should be established as rapidly as possible and maintained to reduce soil erosion and landslide potential.
5. Household water disposal system: Seek professional assistance in selecting the appropriate type and location of your septic system. Septic systems located in fill material can saturate soil and contribute to landslides.
6. Proper water disposal: Allowing surface waters to saturate the sloping soil is the most common cause of landslides in eastern Kentucky. 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)

Reclamation

Fish Pond Lake (right) was created as part of a strip-mining reclamation project. The lake provides for fishing, camping, and wildlife habitat. Photo by Dan Carey, Kentucky Geological Survey.



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, visit the KGS Community Development Planning Web Site at kgsweb.uky.edu/download/kgsplanning.htm.

Additional Resources

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

www.whitesburgkentucky.com The Kentuckian News
www.kyhometown.com/whitesburg/ Whitesburg/Letcher County
ces.ca.uky.edu/Harlan/ University of Kentucky Cooperative Extension Service
www.kradd.org/ Kentucky River Area Development District
www.thinkkentucky.com/EDIS/cmnty/index.aspx?cw=073 Kentucky Economic Development Information System
www.uky.edu/KentuckyAtlas/21133.html Kentucky Atlas and Gazetteer, Letcher County
quickfacts.census.gov/qfd/states/21/21133.html U.S. Census data
kgsweb.uky.edu/download/kgsplanning.htm Planning information from the Kentucky Geological Survey

References Cited

Carey, D.I., and Stickney, J.F., 2005, Groundwater resources of Letcher County, Kentucky: Kentucky Geological Survey, ser. 12, County Report 67, www.uky.edu/KGS/water/library/gwatlas/Letcher/Letcher.htm [accessed 7/7/07].

Conley, T.J., 2004, Spatial database of the Mayking quadrangle, Letcher and Knott Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1309. Adapted from Rice, C.L., 1976, Geologic map of the Mayking quadrangle, Letcher and Knott Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1309, scale 1:24,000.

Federal Emergency Management Agency, 2005: www.fema.gov [accessed 7/10/07].

Johnson, T.L., 2004, Spatial database of the Kite quadrangle, southeastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1317. Adapted from Hinrichs, E.N., and Rice, C.L., 1976, Geologic map of the Kite quadrangle, southeastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1317, scale 1:24,000.

McIntosh, J.D., 2004, Soil survey of Knott and Letcher Counties, Kentucky: U.S. Department of Agriculture, Natural Resources Conservation Service, 231 p.

Morris, L.G., Patton, J.A., Clark, L., Hesley, J., and Lambert, J.R., 2005a, Spatial database of the Tilford quadrangle, southeastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-451. Adapted from Puffett, W.P., 1965, Geologic map of the Tilford quadrangle, southeastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-451, scale 1:24,000.

Morris, L.G., Patton, J.A., Hesley, J., and Lambert, J.R., 2005b, Spatial database of the Vicco quadrangle, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-418. Adapted from Puffett, W.P., 1965, Geology of the Vicco quadrangle, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-418, scale 1:24,000.

Mullins, J.E., 2004, Spatial database of the Wheelwright quadrangle, southeastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1251. Adapted from Outerbridge, W.F., 1975, Geologic map of the Wheelwright quadrangle, southeastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1251, scale 1:24,000.

Murphy, M.L., 2004, Spatial database of the Blackey quadrangle, Letcher and Knott Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1322. Adapted from Waldrop, H.A., 1976, Geologic map of the Blackey quadrangle, Letcher and Knott Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1322, scale 1:24,000.

Petersen, C., 2004a, Spatial database of the Jenkins East quadrangle, Pike and Letcher Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1210. Adapted from Wolcott, D.E., 1974, Geologic map of the Jenkins East quadrangle, Pike and Letcher Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1210, scale 1:24,000.

Petersen, C., 2004b, Spatial database of the Jenkins West quadrangle, Kentucky-Virginia: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1126. Adapted from Rice, C.L., 1973, Geologic map of the Jenkins West quadrangle, Kentucky-Virginia: U.S. Geological Survey Geologic Quadrangle Map GQ-1126, scale 1:24,000.

Petersen, C., 2004c, Spatial database of the Roxana quadrangle, Letcher and Harlan Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1299. Adapted from Maughan, E.K., 1976, Geologic map of the Roxana quadrangle, Letcher and Harlan Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1299, scale 1:24,000.

Petersen, C., 2004d, Spatial database of the Whitesburg quadrangle, Kentucky-Virginia, and part of the Flat Gap quadrangle, Letcher County, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1119. Adapted from Rice, C.L., and Wolcott, D.E., 1973, Geologic map of the Whitesburg quadrangle, Kentucky-Virginia, and part of the Flat Gap quadrangle, Letcher County, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1119, scale 1:24,000.

Sparks, T.N., 2003a, Spatial database of the Benham and Appalachia quadrangles, Harlan and Letcher Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1059. Adapted from Froelich, A.J., and Stone, B.D., 1973, Geologic map of the Benham and Appalachia quadrangles, Harlan and Letcher Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1059, scale 1:24,000.

Sparks, T.N., 2003b, Spatial database of the Louellen quadrangle, southeastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1060. Adapted from Froelich, A.J., 1973, Geologic map of the Louellen quadrangle, southeastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1060, scale 1:24,000.

Sparks, T.N., 2003c, Spatial database of the Nolansburg quadrangle, southeastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-868. Adapted from Csejtey, B., Jr., 1970, Geologic map of the Nolansburg quadrangle, southeastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-868, scale 1:24,000.

U.S. Department of Agriculture, Natural Resources Conservation Service, no date, Landslide prevention in eastern Kentucky.

U.S. Fish and Wildlife Service, 2003, National Wetlands Inventory: www.nwi.fws.gov [accessed 7/10/07].

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. Clay, silt, sand, and gravel (alluvium)	Fair foundation material; easy to excavate. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2004).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2004).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2004).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2004).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2004).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2004).	Slight to severe limitations, depending on type of activity and topography. Subject to flooding. Refer to soil report (McIntosh, 2004).	Slight to severe limitations, depending on type of activity and topography. Subject to flooding. Refer to soil report (McIntosh, 2004).	Pervious material. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2004).	Fair stability. Fair compaction characteristics. Piping hazard. Refer to soil report (McIntosh, 2004).	Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2004).
2. Clay shale*, siltstone, and sandstone	Shale is poor foundation material; easy to moderately difficult to excavate. Low strength and stability. May contain plastic clays. See unit 8 for sandstone, siltstone.	Severe limitations. Thin soils and low permeability.	Severe to moderate limitations. Low strength, slumping, and seepage problems.	Severe to moderate limitations. Low strength, slumping, and seepage problems.	Severe to moderate limitations. Low strength, slumping, and seepage problems.	Not recommended.	Moderate to severe limitations, depending on activity and topography.	Severe to slight limitations, depending on activity and topography.	Slight limitations for small ponds.	Severe limitations. Poor strength and stability.	Moderate limitations. Poor strength. Wetness.
3. Limestone, shale, chert	Good to excellent foundation material; difficult to excavate.	Moderate to severe limitations. Thin soils and impermeable rock associated with shales.	Severe to moderate limitations. Rock excavation may be required. Steep slopes.	Severe limitations. Rock excavation. Steep slopes.	Severe limitations. Rock excavation. Steep slopes.	Severe limitations. Rock excavation. Steep slopes.	Severe limitations. Rock excavation. Steep slopes.	Slight to moderate limitations, depending on activity and topography. Slight limitations for forest or nature preserve.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Rock excavation. Thin soils.
4. Sandstone, siltstone, shale*, limestone, coal, underclay	Fair to good foundation material; difficult to excavate. Possible low strength associated with shales, coals, and underclays. Possibility of underground coal-mine voids.	Severe limitations. Thin soils and impermeable rock associated with shales.	Severe limitations. Rock excavation. Steep slopes.	Severe limitations. Rock excavation. Steep slopes.	Severe limitations. Rock excavation. Steep slopes.	Severe limitations. Rock excavation. Steep slopes.	Moderate to severe limitations. Rock excavation may be required. Steep slopes.	Moderate to severe limitations, depending on activity. Steep wooded slopes. Slight limitations for forest or nature preserve.	Slight limitations. Reservoir may leak where rocks, including coal, are jointed or fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe to moderate limitations. Thin soils. Rock excavation.
5. Shale*, siltstone, sandstone, minor coal	Fair to poor foundation material; difficult to excavate. Possible low strength associated with shales, sparse coals, and underclays.	Severe limitations. Thin soils and impermeable rock associated with shales.	Severe limitations. Rock excavation. Unstable slopes.	Severe limitations. Rock excavation. Unstable slopes.	Severe limitations. Rock excavation. Unstable slopes.	Severe limitations. Rock excavation. Unstable slopes.	Moderate to severe limitations, depending on activity and topography.	Slight limitations for forest or nature preserve.	Slight limitations. Reservoir may leak where rocks, including coal, are jointed or fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Rock excavation. Unstable slopes.
6. Sandstone, siltstone, shale, coal	Fair to good foundation material; difficult to excavate. Possible low strength associated with shales, coals, and underclays. Possibility of underground coal-mine voids.	Severe limitations. Thin soils and impermeable rock associated with shales.	Severe to moderate limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required.	Slight to severe limitations, depending on activity and topography. Possible steep wooded slopes. Slight limitations for forest or nature preserve.	Slight limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe to moderate limitations. Thin soils. Possible rock excavation.
7. Sandstone, siltstone, shale*, limestone	Fair to good foundation material; difficult to excavate. Possible low strength associated with shales.	Severe limitations. Thin soils and impermeable rock associated with shales.	Severe to moderate limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required.	Slight to severe limitations, depending on activity and topography. Possible steep wooded slopes. Slight limitations for forest or nature preserve.	Slight limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe to moderate limitations. Thin soils. Possible rock excavation.
8. Sandstone, siltstone, shale*, minor coal	Excellent foundation material; difficult to excavate. Low strength associated with shales.	Severe limitations. Thin soils.	Severe to moderate limitations. Rock excavation. Steep slopes.	Severe to moderate limitations. Rock excavation. Steep slopes.	Severe to moderate limitations. Rock excavation. Steep slopes.	Severe to moderate limitations. Rock excavation. Steep slopes.	Moderate to severe limitations, depending on activity and slope.	Slight to severe limitations, depending on activity. Slight limitations for forest or nature preserve.	Slight to moderate limitations. Reservoir may leak where rocks are fractured.	Slight to moderate limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Rock excavation.

*Shales and clays in these units may shrink during dry periods and swell during wet periods and cause cracking of foundations. On hillsides, especially where seeps and springs are present, they can also be susceptible to landslides.