Kentucky Geological Survey

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UNIVERSITY OF KENTUCKY

MAP AND CHART 52

Series XII, 2003

Generalized Geologic Map for Land-Use Planning: Berea 7.5-Minute Quadrangle, Kentucky

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For Planning Use Only

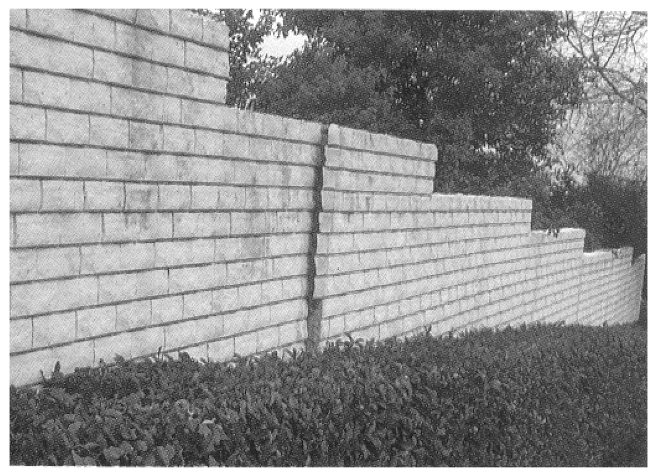
This map is not intended to be used for selecting individual sites. Its purpose is to inform land-use planners, government officials, and the public in a general way about geologic conditions that affect the selection of sites for various purposes. Site-specific investigations should be made by a professional geologist.

Bedrock mapping adapted from Nelson (2000).

Typical Problems

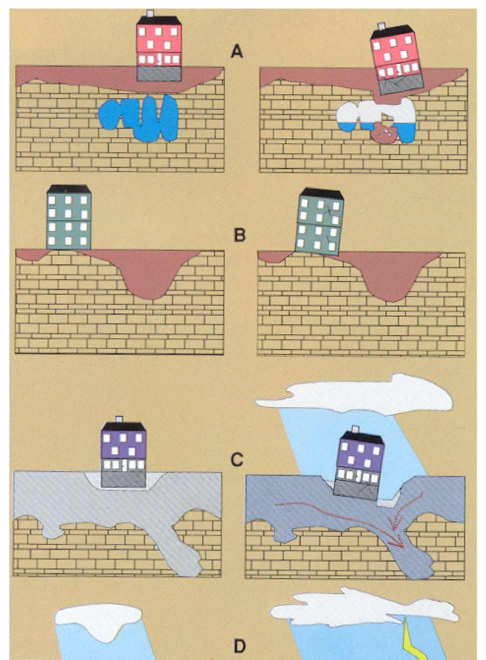
An uplifting experience that will not be appreciated! Left: All is well in this newly built home until water from percolation, drains, lawn sprinklers, leaking sewers, or water mains soaks swelling soil beneath the foundation. Right: With time, expanding soils exert several tons per square foot of pressure on the foundation and shallow pilings. Without remedial measures, the house will actually become deformed and shatter masonry and windows. Remedies vary from mere maintenance that keeps drainage away from the house to expensive reconstruction of foundations. Prior site planning that takes geology into account is always preferable to dealing with problems after a structure is built. From AIPG (1993).

Seepage at the boundary between overlying permeable and underlying impermeable rocks. Often not evident during dry weather construction, it can produce a variety of problems, including foundation disturbance, flooding, soil movement, wet basements, and failure of onsite wastewater treatment systems. (photo by Paul Howell)



Stresses exerted by swelling soils have caused this block wall surrounding a condominium complex to tilt and break. From AIPG (1993). (photo by Edward Nuhfer)

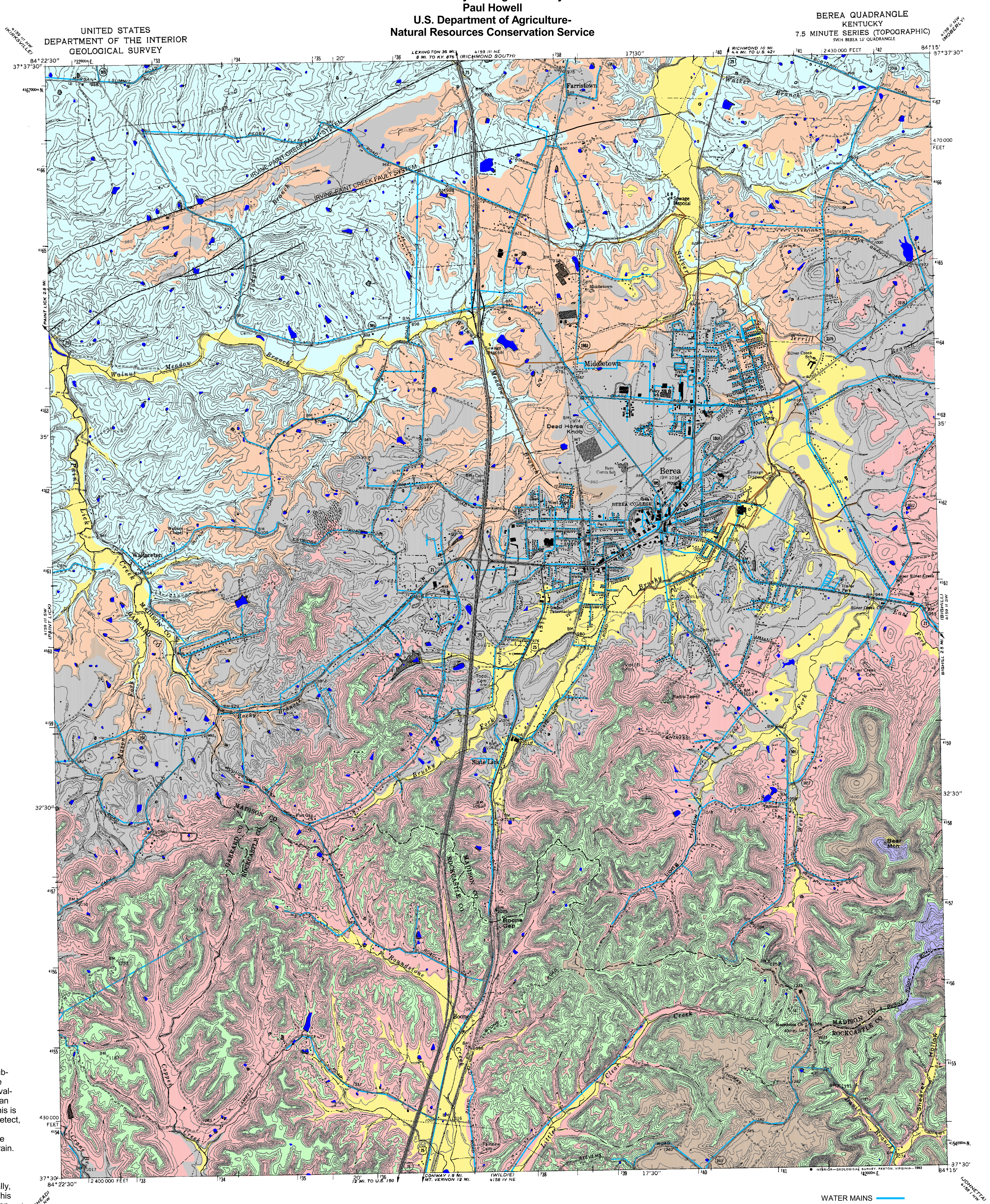
Paved roads constructed without precautions on swelling soils exhibit heaving, undulation, and extensive cracking. From AIPG (1993). (photo by Edward Nuhfer)



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. From AIPG (1993).

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 area immediately adjacent to the fault. This fracturing may influence slope stability and groundwater flow in these limited areas.



Radon

Radon levels can be high in the black shales. Homes in these areas should be tested for radon, but the homeowner should keep in mind that the threat to health results from relatively high levels of exposure over long periods of time, and the remedy may simply be additional ventilation of the home.

COMPARATIVE RISK CHART for RADON LEVELS

Radon Level pCi/L	Estimated Fatal Lung Cancers/1000	Comparable Exposure Levels	Comparable Risk Estimate
200	440 - 770	1,000 times average outdoor level	More than 60 times non-smoker risk
100	270 - 630	100 times average indoor level	Four pack/day smoker or 20,000 chest X-rays/yr
40	120 - 380	100 times average outdoor level	Two pack/day smoker
20	60 - 210		
10	30 - 120	10 times average indoor level	One pack/day smoker
4	13 - 50	10 times average outdoor level	Five times non-smoker risk
2	7 - 30		
1	3 - 13	Average indoor level	Non-smoker risk of fatal lung cancer
0.2	1 - 3	Average outdoor level	20 chest X-rays/yr

EPA recommends action be taken if indoor radon levels exceed 4 pCi/L, which is 10 times the average outdoor level. Some EPA representatives believe the action level should be lowered to 2 pCi/L; other scientists dissent and claim the risks estimated in this chart are already much too high for low levels of radon. The action level in European countries is set at 10 pCi/L. Note that this chart is only one estimate; it is not based upon any scientific result derived from a study of a large population meeting the listed radiation criteria. (from U.S. Environmental Protection Agency)

Landslides

Hillside construction can cause earth movements if not properly planned.

(Photos by Paul Howell)

Planning Units

Limestone/Dolomite

Foundation and Excavation
These rocks are generally very hard, requiring blasting or heavy equipment for excavation. Where sound, limestones and dolomites generally provide an excellent foundation. They will support heavy loads, except where sinkholes may be present. However, the surface of these rocks may be highly irregular, with pinnacles and solution cavities. Topography cannot always be relied upon as a predictor of soil thickness above the limestone bedrock.

Landfills
This unit's use for landfills is severely limited. Groundwater flowing through fractures and solution openings is easily contaminated by leachate from landfills.

Groundwater
These rocks yield 100 to 500 gal/day to drilled wells in the few places where they occur below stream level. They yield almost no water to wells on narrow ridgetops or hillsides, but do yield water to small springs on hillsides, particularly at the heads of streams. Springs have large winter and small summer flows. Water is hard to very hard.

Pond Construction
There is a high risk of severe pond leakage, because of the presence of both large and small openings in the bedrock. Sinkholes and karst basins are often present. Soil thickness ranges from absent to several feet. Much of the soil is clayey, but the soil structure is very permeable, and allows pond water to leak into the underlying limestone. Successful ponds have been constructed, however, by lining the pond basins with compacted, clayey soil (Note 1). Even when treated in this manner, the presence of cavities deeper in the subsurface creates the potential for collapse, and rapid drainage of the pond. Synthetic lining materials may be substituted for the compacted clay (Note 2).

Sandstone/Siltstone

Foundation and Excavation
These rocks are generally very hard, requiring blasting or heavy equipment for excavation. They can be highly variable in thickness over short distances. They provide an excellent foundation, which will support heavy loads except where excavated to the lowermost few feet of the unit.

Landfills
This unit's use for landfills is severely limited. Water flowing through openings between grains and along widely spaced cracks could be easily contaminated by leachate from landfills.

Groundwater
Sandstones yield 100 to 500 gal/day to drilled wells on broad ridges, but almost no water to wells on narrow ridges or hilltops. They do yield water to small springs. Water from sandsone is soft; from siltstone, hard.

Pond Construction
Ponds in this area are at risk of leaking because of openings in the underlying sandstones and siltstones. Soil cover is commonly thin to absent, and consists mostly of sandy silt with little or no clay. An artificial liner may be required to prevent leakage, except where a shale layer is present below the pond; most shales create favorable subsurface conditions for pond construction.

Unconsolidated (Nonlithified) Deposits

Foundation and Excavation
Alluvium and unconsolidated deposits generally provide fair to good foundation. Problems with differential settling are possible. They are easily excavated, but subject to flooding.

Landfills
This unit's use for landfills is severely limited.

Groundwater
The alluvium is too thin and fine grained to yield much water. Water is hard. High-level terrace deposits yield 100 to 500 gal/day to wells where the deposits are thick; otherwise, they are too thin and scattered to be important as an aquifer. They do yield water to small springs and dug wells. Water from terrace deposits is soft.

Pond Construction
Successful ponds can generally be constructed in alluvium if the pond basins are lined with compacted clayey soil (Note 1). Alluvial deposits consist of clayey silt and fine sand. These deposits may be up to 2 ft thick in major stream valley bottoms, but are generally much thinner. Sand and gravel layers may be encountered, and should be covered with about 2 ft of compacted clayey soil to prevent leakage. Synthetic lining materials may be substituted for the compacted clay (Note 2). In some valley bottoms, so-called "water table ponds" may be constructed by excavating into the shallow groundwater. The water level in these ponds will vary seasonally with the groundwater level.

Black Shales

Foundation and Excavation
These shales are moderately difficult to excavate. They generally make good foundation material, although unweathered shale containing iron sulfide (pyrite) swells when saturated, which can cause cracking of walls and foundations. Fresh exposures of fractured shale are hard and require heavy machinery for excavation. Springs and seepage zones characteristically occur near the base of the black shale where it overlies the Crab Orchard Formation. Shale at the top of the Crab Orchard Formation is perpetually moist and plastic; construction along this interface requires special design to control drainage or conduct water away from the Crab Orchard. Radon levels can be high in this unit; therefore buildings should be well ventilated.

Landfills
This unit's use for landfills is moderately limited. Shales contain joints that transport water into the ground, which could lead to contamination by leachate.

Groundwater
The black shale yields 100 to 500 gal/day to drilled wells in valley bottoms and on uplands, usually at depths of less than 50 ft; water from greater depths is highly mineralized. The shale yields water to small springs. Water may be soft or highly mineralized. Salt, hydrogen sulfide, and iron are the usual objectionable constituents.

Pond Construction
Most ponds constructed in the black shale are successful. Soils associated with the black shale usually are 40 in. thick or less; the lower half of the subsoil is often clayey. This clayey soil may be used as a liner to prevent the pond water from seeping into fractures in the underlying shale (Note 1). Synthetic lining materials may be substituted for the compacted clay (Note 2).

Expansive Clay Shales

Foundation and Excavation
They make a poor foundation material, but are easily excavated. Because these clay shales are expansive, landslides and slumps are common where valley slopes are steep or excavated cuts are oversteepened. Permeability is low to very low. The lower part of this unit is a dolomitic layer generally 10 ft thick. In areas of broad, flat topography, this layer may be significant. The behavior of this dolomite is similar to the limestone/dolomite unit.

Landfills
Their use for landfills is only slightly limited. These shales are easily excavated and restrict groundwater movement. The high clay content can produce slippage and workability problems. Siltstone beds near the base of landfills can result in leakage through joints.

Groundwater
The shale yields almost no water to wells or springs, but may yield small amounts of water to wells in valley bottoms. The water is highly mineralized. Dolomite beds yield hard water to small springs.

Pond Construction
Most ponds are successful. Associated soils are clays with high shrink-swell potential. Ponds can be built in dry weather, because of the impervious nature of the clay shales. Any hard rocks encountered should be covered with about 2 ft of compacted clayey soil to prevent leakage.

Clay Shales

Foundation and Excavation
Because these clay shales are expansive, landslides and slumps are common where valley slopes are steep or excavated cuts are oversteepened. Permeability is low to very low. They make a poor foundation material, but are easily excavated.

Landfills
Their use for landfills is only slightly limited. These shales are easily excavated and restrict groundwater movement. The high clay content can produce slippage and workability problems. Siltstone beds near the base of landfills can result in leakage through joints.

Groundwater
The shales yield almost no water to wells or springs, but may yield small amounts of water to wells in valley bottoms. The water is highly mineralized.

Pond Construction
Most ponds are successful. Associated clayey soils are relatively impervious. Ponds can be built in dry weather, because of the impervious nature of the clay shales. Any hard rocks encountered should be covered with about 2 ft of compacted clayey soil to prevent leakage.

Mudstones and Limestones

Foundation and Excavation
These rocks make good to excellent foundation material, but are moderately difficult to difficult to excavate. A foundation in these rocks will support heavy loads, except where sinkholes may be present. Removal requires blasting and heavy power equipment. Permeability is low, with internal drainage along joints and fractures. Artificial cuts and oversteepened banks are subject to slippage.

Landfills
There are slight to moderate limitations for landfills. Groundwater movement is generally restricted.

Groundwater
These rocks yield 100 to 500 gal/day to drilled wells in broad valleys and along streams in upland areas, but almost no water to drilled wells on hillsides or ridgetops. They do yield water to small springs. Water is hard, and in valley bottoms may contain salt or hydrogen sulfide. Shale, where present, limits the amount of water that has access to thick limestone beds, and therefore restricts the number of openings in these beds that may be enlarged by solution. As a result, the limestone beds below the shale yield little water. However, where thick limestone beds with little shale occur below stream level in valley bottoms or on uplands, they may have undergone solutional enlargement of fractures and bedding-plane openings. Wells drilled into these limestone beds may produce more than 500 gal/day. These thick beds also yield water to some large springs.

Pond Construction
Ponds located in these areas have some risk of leakage from natural openings in the underlying bedrock. Successful ponds can be constructed, however, if the basins are lined with compacted clayey soils (Note 1). Any bedrock exposed in the pool area should be covered with 1 to 2 ft of compacted clayey soil. Clayey subsoils are sometimes thin; flat hilltops are often good sources of additional liner or dam material. The bedrock may be permeable to a depth of 4 to 5 ft, but is generally unweathered and hydraulically tight below. It may be necessary to excavate down to this boundary and fill the core of the dam with impermeable, material (keyway) to prevent seepage below the dam. Site-specific evaluations should be made by a professional geologist.

Interbedded Shales and Sandstones/Siltstones

Foundation and Excavation
These rocks make generally good foundation material, but are moderately difficult to excavate.

Landfills
Areas underlain by shale present slight limitations, whereas areas underlain by sandstone/siltstone present severe limitations for use as landfills.

Groundwater
These rocks yield almost no water to wells on narrow ridges or hilltops. They do yield water to small springs. Water is soft.

Pond Construction
When underlain by thicker shale layers, these rocks are generally favorable for pond construction. When this unit is underlain by sandstones and siltstones, there is some risk of subsurface leakage, so the basin should be sealed with compacted clayey soil. Clayey soils are found in areas underlain by shale. At the time of preparation of this map, no ponds were identified in this area, and, in general, the mostly wooded, rugged topography is not conducive to pond siting.

Notes:
1. The soil is placed in loose, moist layers 9 in. thick and compacted in six passes with a sheepsfoot roller. The rule of thumb is 1 ft of compacted clay for each 8 ft of water depth.
2. 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.

General considerations:
* Ponds constructed in dry weather are more apt to leak than ponds constructed in wet weather.
* 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 below springs and seeps should be constructed so that the springs or seeps will always be above the level of the pond surface.
* 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 ft, or pond volumes exceeding 50 acre-feet, require permits.

Contact the Kentucky Division of Water, 14 Reilly Road, Frankfort, KY 40601, 502-564-3410.

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