

Dangers of Land Development in Limestone Areas

Engineers need to serve as educators

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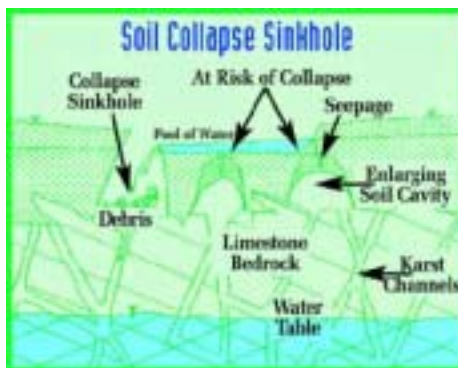
Introduction excerpted from the PADCNR

According to the Pennsylvania Department of Natural Resources and Conservation approximately seven percent of Pennsylvania is underlain by carbonate bedrock in the form of limestone and dolomite. Most carbonate bedrock occurs in the valleys and lowlands of south-central and southeastern Pennsylvania, where over 2 million people live.

Carbonate rocks are unique in that they weather more readily than other types of rocks. Dissolution of the carbonate bedrock by water over long periods of time results in a landscape called *karst topography*. It is characterized by features such as sinkholes, surface depressions, and caves. Dissolution of carbonate rock also develops the subsurface drainage network for water along widened cracks or fractures within bedrock layers. The majority of water in karst areas does not occur as surface streams but is primarily in the subsurface as groundwater.

Sinkholes and surface depressions are subsidence features. The surface expression of these features is a result of water transporting residual material and soil through subsurface pathways established by the dissolution process. Both features are typically circular in shape and can vary in size. Sinkholes exhibit an actual break or hole on the land surface; whereas surface depressions are generally bowl-shaped hollows that do not show this land-surface break. Caves are formed as fractures widen by dissolution, creating large openings in the rocks.

Karst features often impact public safety and health. Subsidence and water-quality problems have been associated with karst topography for many years. Gradual subsidence or the sudden collapse of the land surface can cause serious damage to urban structures, utilities, and roadways. In addition, karst features serve as direct recharge zones to local and regional aquifers, making these areas highly vulnerable to groundwater contamination.



Limestone sinkhole schematic

How Sinkhole Areas Form

Karst landscapes are a type of topography that consist of any terrain based on a layer of soluble bedrock, usually, though not always, of carbonate rocks.

Karst topography forms when rainwater picks up carbon dioxide from the air and decaying debris in the soil, and then percolates through cracks dissolving the rock.

Groundwater tends to flow into these bedrock openings and sometimes carries with it some of the overlying soil.

Gradually, a void forms over the surface opening into the bedrock. A sinkhole collapse of the soil covering the hole may be sudden or gradual.

Although the formation of sinkholes is a natural on-going process, in karst areas, human induced modifications to the hydrology of these areas commonly results in the acceleration of this natural process. For example, the pumping and removal of groundwater in karst areas can accelerate the formation of sinkholes. The loss of water, which affords a more stable foundation frequently results in collapse

The Need to be Proactive

When considering sinkhole management alternatives consider a systems approach, such as, treating both the sinkhole and its contributing drainage area.

Prior to implementing any sinkhole management alternative, a geotechnical investigation should be conducted. The depth and type of soil above the bedrock must be determined. Efforts should be made to determine the lateral extent of sinkhole prone areas.

Depending on the size of the tributary drainage area, the runoff water quality, and the difficulty of establishing an alternate outlet, sinkholes may need to continue accepting some or as much water as in the past. A filtering system design is necessary to prevent lateral erosion while allowing water to pass.

In other cases, the crevice or sinkhole should be sealed completely.

Planning a sinkhole management program in both rural and urban/suburban communities should give consideration to the following:

- Existing and planned land use and management.
- The sinkhole contributing drainage area.
- Dimensions of the sinkhole opening.
- Provision for a safe outlet for diverted surface water.
- Provision of an environmentally safe disposal site for sinkhole “clean out” material.
- Provision for safety of equipment operators and laborers during practice installation.

Site Investigative Approaches

- Geologic map
- Aerial photography
- Site visits for field truthing
- Test pits
- Test probes
- Geophysical methods.

Suggested Management Goals for Land Managers in Sinkhole Areas

- Encourage tree planting and preservation of existing trees in karst areas.
- Land managers should identify the total watershed area and be sensitive to the potential impact of any land development activities.
- Landscape companies should be aware of the use of fertilizers and pesticides in karst areas and their relative leaching potentials.
- Apply fertilizers, pesticides and manures on landscapes only at rates that plants can utilize them. Application rates should be based on soil and plant tissue samples.
- In agricultural areas promote proper grazing and cropland management.
- Establish vegetative filters and/or buffers around sinkholes in the vicinity of potential pollutants.
- In both agricultural and urban/suburban communities, sinkholes should not be used as dump sites. They may look like a convenient place to

dump trash, animal carcasses, engine oil, and empty agricultural containers, but disposing of these materials in sinkholes will pollute the groundwater. Clean out existing dumpsites in accordance with state and local codes.

- Educate landowners on proper sinkhole management practices.
- In agricultural areas, land managers should identify sinkhole locations on their conservation plan map with the assistance from the United States Department of Agriculture, Natural Resources Conservation Service.

Considerations for Land Developers, Designers and Contractors

- Follow design and construction techniques recommended for use in karst terrain for roadways, pipelines, foundations, underground storage tanks, and other structures that have the potential to contaminate groundwater if its integrity is compromised.
- Work with a qualified geologist and/or structural engineer to assist with a geotechnical study. ■

The following photos of sinkholes appear on the DCNR web page:



For additional data on sinkholes

- www.dcnr.state.pa.us/topogeo/maps/map15.pdf
- www.dcnr.state.pa.us/topogeo/map68/mapbook.aspx
- www.internationalchimney.com/kingofprussia.htm
- www.personal.psu.edu/faculty/j/e/jea4/geoglec10.html
- DCNR Sinkhole Inventory and Online Database at www.dcnr.state.pa.us/topogeo/hazards/sinkhole/default.asp
- Open-file reports have been developed by Survey geologist William E. Kochanov for specific counties in Pennsylvania. See the DCNR on-line listing of open-file reports for details like cost and how to order these reports.
- *Map 68 - Density of Mapped Karst Features in South-Central and Southeastern Pennsylvania* is a new publication that interprets the density of karst features.