Policy 12

SINKHOLE DEVELOPMENT

Introduction and Overview -

A sinkhole is a naturally occurring surface depression which occurs primarily in limestone regions and is usually denoted with hachured lines on a contour map, or is otherwise part of a closed watershed system. A sinkhole typically receives surface stormwater runoff, and may be directly or indirectly linked to an underground cavern system or groundwater table. For the purposes of regulating site development, a sinkhole is a minimum of 2' deep when measured from the lowest part of the depression to the overflow lip.

Sinkholes are a common feature in Knoxville and throughout east Tennessee. The predominant geology in Knoxville is a system of parallel ridges and valleys that run in a southwest-northeast direction. The ridges typically are a combination of folded shales, sandstones and limestones. The valleys contain soft shales, limestones and clay soils.

It is not possible to determine the condition of a sinkhole by visual inspection. Even if a sinkhole appears to be well-drained based on repeated observations and measurements, it may still close tomorrow for no apparent reason. It is suspected that many sinkholes become nonfunctioning due to construction activities. Construction heavy equipment and/or dynamite may have changed drainage characteristics for many sinkholes along I-40 and I-640 in previous decades. Excess silt and sediment can also clog sinkholes and make them nonfunctioning.

Historically in decades past, some sinkholes have been used to dump trash, liquid wastes, etc. This is particularly harmful to the environment due to the direct connection to groundwater tables and subsurface drainage. Trash, debris and sediment will clog the sinkhole throat and eventually reduce the drainage capability of the sinkhole. Most water entering a sinkhole will eventually reappear in a nearby creek or stream.

Sinkholes are typically not reliable as a primary drainage system. Every sinkhole behaves differently under changing conditions. Saturated ground conditions and high groundwater tables will cause a sinkhole to drain very poorly. It is even possible for groundwater to flow upwards and fill a sinkhole. Sinkholes are prone to settlement and generally do not have suitable soil foundations.

Sinkhole Requirements -

1. *(For site development on a property that contains a sinkhole or partially contains a sinkhole)* -- Engineering Department will require a copy of a Class V Injection Well Permit and/or an Aquatic Resource Alteration Permit (ARAP) prior to approving a site development permit. These permits are issued by the Tennessee Department of Environment and Conservation (TDEC) to protect Waters of the State. After reviewing the TDEC permit, the Engineering Department may require additional information relating to the structural integrity and flood protection. When existing or documented flooding problems are present, the Engineering Director may require additional measures such as detention, conveyance facilities, or other stormwater management solutions to reduce adverse impacts to the subject development or to other properties.

Requirements #2 through #6 apply to site development projects that must provide stormwater detention for the 1-year, 2-year, 5-year, 10-year, 25-year and 100-year NRCS storms as required by Section 22.5-23 of the Stormwater and Street Ordinance:

A. *Road construction containing one-half acre or more of impervious surface.*

B. *Commercial, industrial, educational, institutional, or recreational developments containing one acre or more of disturbed area.*

C. *Single-family or duplex residential development containing at least five acres of disturbed area or at least five lots.*

D. *Any development containing one-half acre or more of additional impervious area.*

E. *Any redevelopment that causes the improvement of 50% of the assessed value of the lot, building, or lot use.*

Requirements #2 through #6 must include calculations to demonstrate that the requirement is met. Volume computations must be performed using regular intervals, preferably using the conic volume formula shown on page ST-11-13 of the Knoxville BMP Manual. All hydrologic and hydraulic computations must be prepared by a registered engineer proficient in the field of hydrology and hydraulics, and licensed to practice engineering in the State of Tennessee. Detention and routing computations shall meet the general requirements contained in ST-10, ST-11 and ST-12 of the Knoxville BMP Manual.

---

2. *(For site development on a property that contains a sinkhole, partially contains a sinkhole or ultimately drains to a sinkhole)* -- Provide calculations that show that the 100-year, 24-hour NRCS design storm will not flood any structures assuming plugged conditions for the sinkhole (0 cfs outflow). These calculations must include the entire contributing watershed area for the sinkhole. A sinkhole easement, similar to a detention easement as defined in Policy 05, must be dedicated at least 5' horizontally outside the highest closed contour defined by the sinkhole lip.

3. *(For site development on a property that partially contains a sinkhole)* -- Provide calculations that show no rise in water surface elevations between the predeveloped and postdeveloped 100-year, 24-hour NRCS design storm, assuming plugged conditions for the sinkhole (0 cfs outflow). These calculations must include the entire contributing watershed area for the sinkhole. A sinkhole easement, similar to a detention easement as defined in Policy 05, must be dedicated on the property being developed at least 5' horizontally outside the highest closed contour defined by the sinkhole lip. In some cases, a rise in the 100-year water surface elevation is allowable if all parties with ownership of the sinkhole agree to allow the rise with written documentation.

4. *(For site development on a property within a Critical Sinkhole Watershed)* -- Provide calculations that show total retention of the difference between the predeveloped and postdeveloped 100-year, 24-hour NRCS design storms. These calculations must include the entire contributing watershed area for all designed retention basins and sinkholes.

5. *(For site development on a property within a Critical Sinkhole Watershed)* -- Provide calculations that show that the postdeveloped 100-year, 24-hour NRCS peak flow rate does not exceed the predeveloped 100-year, 24-hour NRCS peak flow rate. In basins or subbasins with a documented historical drawdown time, it may be acceptable to assume drawdown if the documented value is at least 1.5 times larger than the drawdown time for the region. In general, advanced subsurface testing must be performed and certified by a professional engineer registered in the state of Tennessee with a demonstrated expertise in hydrogeology. Subsurface testing shall reasonably determine the range of outflows under a variety of design conditions.

6. *(For any site development that drains to any sinkhole or retention basin within a Critical Sinkhole Watershed)* -- Subsurface testing shall reasonably determine the range of outflows under a variety of design conditions. In general, advanced subsurface testing must be performed and certified by a professional engineer registered in the state of Tennessee with a demonstrated expertise in hydrogeology. If it is proven by geotechnical testing that the soil does not percolate, then a drawdown orifice may be used. This is evaluated by a case-by-case basis. The drawdown rate will be 0.05 cfs for drainage areas 2.5 acres and less, or 0.02 cfs per acre for larger drainage areas.

Critical Sinkhole Watersheds -

The following areas contain sinkholes and are labeled as critical watersheds. These areas can be viewed on maps at the Engineering Department, 4th Floor City County Building, during normal working hours.

(1) The entire watershed for Ten Mile Creek (since the entire creek drains into a huge sinkhole near the intersection of Ebenezer Road and Southern RR crossing)

(2) Sinking Creek

(3) Emily Avenue and Timothy Avenue

(4) Harrell Hills subdivision (near Cranberry Drive, Clairmont Drive, and Gaines Road) Prosser Road #1 (between Cherry Street and immediately north of the railroad crossing)

(5) Prosser Road #2 (approximately halfway between Knoxville Zoo Drive and Magnolia Avenue)

(6) Pamela Lane

(7) All areas draining to a sinkhole

(8) Any area of known flooding where deemed necessary by the Engineering Director

Definitions -

Baseflow The quantity of water in a stream or creek that is contributed by groundwater and is not directly associated with surface stormwater runoff.

Closed A sinkhole that no longer drains is said to be closed. An open sinkhole can become closed for any number of reasons: sediment and debris; nearby construction activity with heavy equipment or dynamite; changing subsurface conditions; underground collapse; high groundwater tables; etc.

Dolomite A soluble rock consisting mainly of magnesium carbonate and calcium carbonate. Classified as sedimentary rock; common throughout Knoxville.

Interflow Movement of groundwater from one location to another; often accounting for springs and stream baseflow.

Karst A region with porous limestone that may also contain other soluble rocks and minerals such as carbonates. A karst region may contain sinkholes, underground caves, springs, disappearing streams, subsurface cavities or voids, and natural streams with high baseflow characteristics.

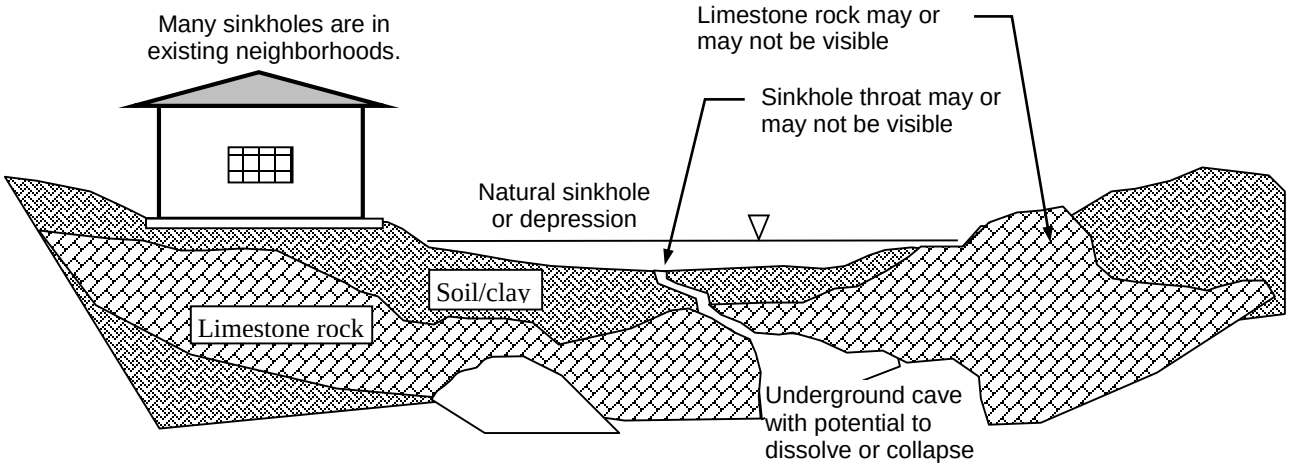
Limestone A soluble rock consisting mainly of calcium carbonate. Classified as sedimentary rock; common throughout Knoxville in both ridges and valleys.

Open A sinkhole that drains well is said to be open. It is possible for a closed sinkhole to become open for any number of reasons: dissolution of limestone or other soluble rock, underground collapse, settlement, etc.

Resurgence Groundwater that flows out of a sinkhole, due to high groundwater tables or perched springs. A sinkhole may or may not experience resurgence at different times for different storm events.

Sinkhole Lip The portion of the sinkhole perimeter where stormwater first begins to overflow. This elevation is likely to be flooded for large storms and high-intensity rainfalls.

Throat The area of a sinkhole where surface stormwater drains into the ground to become subsurface water. Normally located at the lowest part of the depression, but not necessarily.



Increasing stormwater runoff to a natural depression may increase sinkhole formation by further dissolving limestone. Even if the amount of stormwater runoff has not been increased, stormwater quality treatment is necessary to prevent pollutants from entering groundwater and to reduce potential pH changes and chemicals within stormwater runoff.

NOT TO SCALE

Figure 1 -- Typical Concerns of Sinkholes in Residential Areas