Appendix C

Stormwater Management Design in Karst Areas

Figure C.1. Classic karst terrain north of Lewisburg, WV. *Courtesy William K. Jones.*

The effect of land development on karst terrain is an inexact science. Karst geology is very complex and difficult to analyze due to the highly variable subsurface conditions. Even a professional analysis may not identify the potential influence of manipulating the hydrology and surface runoff patterns in areas of karst topography. However, there is increasing pressure to develop land in these sensitive areas. Therefore, in an effort to provide the most up to date guidance on evaluating and protecting this sensitive and valuable resource, the Chesapeake Stormwater Network (CSN) Technical Bulletin No. 1: *Stormwater Design Guidelines for Karst Terrain in the Chesapeake Bay Watershed*, latest version, is adopted by reference.

The Technical Bulletin is intended to be a dynamic document that can be updated over time to reflect new research, experience, and project implementation. It is important to note that the potential for geological hazards, damage to infrastructure, and groundwater contamination is an ongoing concern when developing in these areas. And that best approach is to craft stronger comprehensive land use plans that direct new growth away from karst areas to more appropriate locations. It is also recognized that

there may be situations where an entire community is underlain by karst. It is therefore critical to implement rigorous geotechnical investigation requirements aimed at minimizing the impacts of land development on the natural drainage patterns.

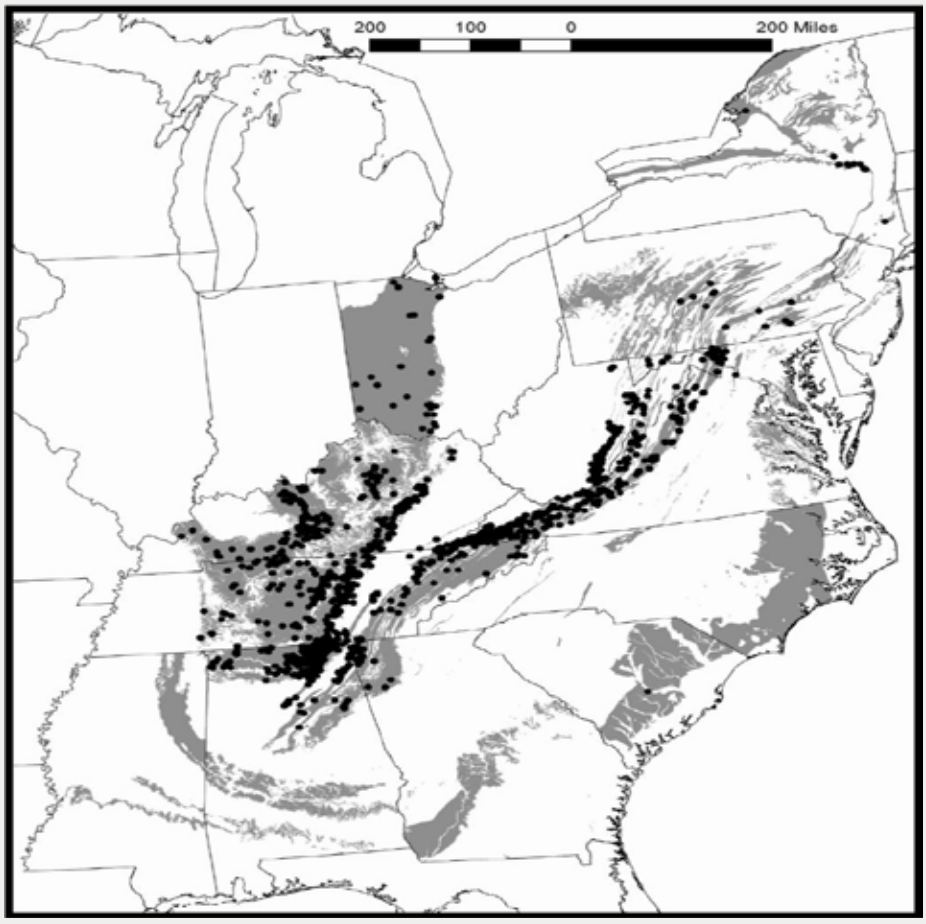

Figure C.2 Karst Terrain Distribution: grey = karst, black = caves
(Source: CSN Technical Bulletin; Weary, 2005)

Stormwater Runoff in Karst

One of the most obvious characteristics of karst geology is the absence of surface runoff features. In an extreme example, a drainage area will appear to drain (sheet flow) to a low point with no apparent outlet. A less obvious example is a large area that drains to a small road or driveway culvert. Both examples illustrate the very common occurrence in areas of karst terrain where the pre-developed runoff for small storms (up to the 1- or 2-year storm event) is minimal. Anecdotal evidence will reveal that there is rarely any flooding or surface ponding even though the best hydrologic models, based on traditional soil types and rainfall patterns, indicate otherwise.

This is a very common design issue when developing a stormwater management strategy that is intended to mimic the pre-developed hydrology. The addition of impervious cover in the form of rooftops, driveways, roads, and possibly parking lots and other larger scale infrastructure generates a significant increase in runoff without the typically available surface conveyance features to move the runoff to an adequate receiving channel or stream. Inevitably, the design will include retention, detention, or other form of runoff attenuation which is generally not recommended in the vicinity of karst terrain: attenuating surface runoff will increase the rate of sinkhole formation and potential groundwater contamination.

> **NOTE**: *The pre-developed rates and volume of runoff are generally less than most hydrologic models predict. Designers should be very cautious when using pre-developed conditions as a baseline target for stormwater designs.*

Preliminary and Detailed Site Investigations

Appendix B provides a detailed discussion of the geotechnical investigation required when considering infiltration or infiltration sump runoff reduction BMPs. The typical geotechnical investigation for exploring potential karst terrain is more detailed and will require the direct involvement of an experienced professional knowledgeable in karst terrain.

In addition to the geotechnical exploration described in Appendix B, the following are outlined in CSN Technical Bulletin 1 as minimal elements of an evaluation of potential karst geology:

- Bedrock characteristics (e.g., type, geologic contacts, faults, geologic structure);
- Photo-geologic fracture trace map;
- Bedrock outcrop areas;
- Sinkholes, closed depressions, grikes and solution-enlarged voids;
- Cave openings;
- Springs;

There are many different techniques to reveal the nature of subsurface conditions in karst terrain, including:

- Electric resistivity tomography
- Seismic refraction
- Gravity surveys
- Electromagnetic (EM) inductance/conductivity surveys

Electric resistivity tomography has proven to be a particularly useful technique to identify subsurface anomalies at a scale that impacts stormwater design. These surveys provide a qualitative evaluation of the site area and may identify "suspect areas" to be further evaluated by borings. The use of these surveys may reduce the total number of soil borings by narrowing down the locations of suspect areas at the site.

Distributed Stormwater BMPs

The effectiveness of the runoff reduction design strategy is enhanced by the use of distributed small scale practices. This is consistent with one of the stormwater design principles for karst areas: Treat runoff as sheet flow in a series of small runoff reduction practices before it becomes concentrated. This includes small scale runoff reduction practices such as bioretention basins (or raingardens) with underdrains to minimize groundwater interaction. The use of large centralized stormwater practices (generally any practice that manages runoff from a contributing impervious area of greater than 20,000 ft^2) is discouraged (even when using a liner) as it will generally include larger collection and outfall system, thereby requiring a more extensive geotechnical investigation.

CSN Technical Bulletin 1 provides a full range of stormwater design principles for use in karst areas including:

- Site Design;
- BMP Selection
- BMP Design Adaptations
- Modeling
- Large Storm Conveyance

The CSN Technical Bulletin also provides Karst-Related Digital Geospatial Data Sources. The CSN Technical Bulleting can be found on DEP's website here:

Or to ensure the latest edition, please refer to the CSN website:

http://chesapeakestormwater.net/2012/03/technical-bulletin-no-1-stormwater-design-guidelines-for-karst-terrain/