

Appendix

D.2

**Geotechnical Methods for Karst Feasibility
Testing**

The following information on BMP design and SWM geotechnical testing in Karst areas has been adapted from the *Carroll County Water Resource Management Manual and Ordinance* (CCWRM) dated July 2, 1996. For a complete discussion of these items, please refer to the Carroll County document.

Section 1: Stormwater Management in Karst Areas

In general, stormwater runoff should not be concentrated and should be conveyed through vegetated areas; in addition, the facilities should be designed in accordance with the following standards:

- (1) Detention/retention ponds should be designed and constructed with a synthetic or clay liner approved by the local plan approval authority.
- (2) Discharges from SWM facilities or directly from impervious surfaces should not be routed within 1000 feet of the edge of any existing unremediated sinkhole. The flow should then be directed to an area not underlain by carbonate rock. Alternatively, these discharges may be routed to a stable watercourse via a pipe or lined channel.
- (3) Sinkholes occurring within stormwater management structures should be repaired within 72 hours of first observation of occurrence.
- (4) Liners: Where natural soil permeabilities are greater than 10^{-6} cm/sec or 1.4×10^{-3} inches per hour for the two-foot interval below the depth of the proposed facility, a stable, low permeability liner shall be installed as follows:
 - (a) One foot of clay with a permeability less than 10^{-7} cm/sec, or;
 - (b) Two feet of clay with a permeability less than 10^{-6} cm/sec, or;
 - (c) Two feet of compacted soil with a permeability less than 10^{-5} cm/sec with a 30 mil thick artificial liner with a permeability less than 10^{-7} cm/sec, or;
 - (d) A very low permeability base constructed of concrete.

Section 2: Soils Investigation for Karst Areas

The purpose of a karst investigation is to identify subsurface voids, cavities, fractures, or other discontinuities which could pose an environmental concern or a construction hazard to an

existing or proposed SWM facility. By definition, karst investigations are required only in areas suspected of containing carbonate rocks. The requirements outlined below should not be interpreted as all-inclusive. The design of any subsurface investigation should reflect the size and complexity of the proposed project.

The investigation should determine the nature and thickness of subsurface materials, including depth to bedrock and to the water table. Subsurface data may be acquired by backhoe excavation and/or soil boring. These field data should be supplemented by geophysical investigation techniques, deemed appropriate by a qualified professional. The data listed herein should be acquired under the direct supervision of a qualified geologist, geotechnical engineer, or soil scientist who is experienced in conducting such studies. Pertinent site information shall be collected which should include the following:

1. Bedrock characteristics (type, geologic contacts, faults, geologic structure, rock surface configuration).
2. Soil characteristics (type, thickness, mapped unit).
3. Photogeologic fracture traces.
4. Bedrock outcrop areas.
5. Sinkholes and/or other closed depressions.
6. Perennial and/or intermittent streams.

Section 3: Location of Borings

Borings should be located to provide representative area coverage of the proposed facilities. The exact location of borings will be based on the following conditions or features:

1. In each geologic unit present, as mapped by the Maryland and U.S. Geological Surveys (USGS) and local county records.
2. Placed near on-site geologic or geomorphic indications of the presence of carbonate rock.
3. On photogeologic fracture traces.

4. Next to bedrock outcrop areas (i.e., ten feet from).
5. As near to identified sinkholes and/or closed depressions as possible.
6. Near the edges and center of the proposed facility, and spaced at equal distances from one another.
7. Near any areas identified as anomalies from any geophysical studies.

Section 4: Number of Borings

The density shall be dependent upon the type and size of the proposed facility such that a representative sampling is obtained, as follows:

1. Ponds/wetlands - a minimum of three per facility, or three per acre, whichever is greater with at least one along the centerline of the proposed embankment and the remainder within the proposed impoundment area.
2. Infiltration trenches - a minimum of 2 per facility.
3. Additional borings - to define lateral extent of limiting horizons, or site specific conditions, where applicable.

Section 5: Depth of Borings

Borings shall be extended to depths dependent upon bedrock type as follows:

1. Non-carbonate rocks - a minimum depth of 5 feet below the lowest proposed grade, within the facility unless auger/backhoe refusal is encountered.
2. Carbonate rocks - a minimum of 20 feet below ground surface or proposed grade; where refusal is encountered the boring may either be extended by rock coring or moving to an adjacent location within 10 linear feet of the original site, in order that the 20-foot minimum depth be reached.

Section 6: Identification of Material

All material penetrated by the boring shall be identified, as follows:

1. Description, logging, and sampling for the entire depth of the boring.
2. Any stains, odors, or other indications of environmental degradation.
3. A minimum laboratory analysis of two soil samples, representative of the material penetrated including potential limiting horizons, with the results compared to the field descriptions.
4. Identified characteristics shall include, as a minimum: color; mineral composition; grain size, shape, and sorting; and saturation.
5. Any indications of water saturation shall be carefully logged, to include both perched and groundwater table levels, and descriptions of soils that are mottled or gleyed should be provided. Water levels in all borings shall be taken at the time of completion and again 24 hours after completion. The boring must remain fully open to total depth of these measurements.
6. When conducting a standard penetration test (SPT), estimation of soil engineering characteristics, including “N” or estimated unconfined compressive strength.

Section 7: Geophysical Investigation

An electromagnetic terrain conductivity survey may be conducted over the entire area of the facility and extending outward to 200 feet beyond the boundaries of the proposed facility. This survey may be performed to provide a qualitative evaluation of the area to be utilized. The survey results may be used to identify “suspect areas” which will be further evaluated using borings. The use of this technique may reduce the total number of borings for a site by better defining “suspect areas.” This survey shall include appropriate techniques such that representative data are collected from a minimum depth of 20 feet below ground surface or the final proposed grade, whichever is deeper. These data shall then be correlated with boring data in the site area.

Section 8: Evaluation

At least one subsurface cross section shall be provided. It should extend through a central portion of the proposed facility, using the actual or projected boring data and the geophysical data. In addition, an iso-conductivity map should be constructed. Finally, a bedrock contour map should be developed to include all of the geophysical and boring data. A sketch map or formal construction plan indicating the location and dimension of the proposed facility and line of cross section should be included for reference, or as a base map for presentation of subsurface data.

Section 9: Sinkhole Remediation

Proper sinkhole remediation involves investigation, stabilization and final grading. For more information, please see the CCWRM, Section 4.2.

Section 10: Sinkhole Stabilization

Sinkholes should be repaired by (1) reverse-graded backfilling, (2) concrete plugging, or (3) an engineered subsurface structure. For more information on these methodologies, see the CCWRM, Section 4.2.2.

Section 11: Monitoring of BMPs in Karst Regions

A water quality monitoring system installed, operated and maintained by the owner/operator may be required in a karst region. For areas requiring monitoring, at least one monitoring well shall be placed at a point hydraulically up gradient from the BMP and two (2) down gradient monitoring wells shall be provided within 200' of the facility. The wells shall be fitted with locking caps. Bi-annual sampling should take place, and an annual report should be filed with the plan approval authority.