Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

KARST SINKHOLE TREATMENT

Code 527

(No.)

DEFINITION

The treatment of sinkholes in karst areas to reduce contamination of groundwater resources, and to improve farm safety.

PURPOSE

The practice supports one or more of the following purposes:

- Improve ground and surface water quality
- Conserve soil and surface water resources
- Improve farm safety

CONDITIONS WHERE PRACTICE APPLIES

This practice may be applied as part of a conservation management system in karst topography which is an area underlain by carbonate or sulfate bedrock (e.g., limestone, dolomite, gypsum) which may form solution depressions (e.g., sinkholes), caverns, or solution subsidence (e.g., areas of non-soluble rocks that may collapse into underlying solution cavities). Minnesota does have known areas of extensive sinkhole development in sandstone bedrock. These areas can be particularly difficult to properly treat because the rock is eroded much quicker than the chemical dissolution of carbonate rock such as limestone or dolostone. This practice applies to all the areas defined in the DNR publication titled: "Minnesota regions prone to surface karst feature development" (see reference below for link to the map).

This practice does not apply to erosional or collapse features caused by failure or leakage of underground pipes or constructed surface drainage features (e.g., canals), piping of unstable soil materials, or poorly compacted or constructed features.

This practice does not apply to karst sinkholes that may appear in or beneath structures or in flowing streams. Treatment of sinkholes in these areas are outside the scope of this standard.

CRITERIA

General Criteria Applicable to All Purposes

The installation and operation of karst sinkhole treatment(s) shall comply with all applicable Federal, State, and local laws, rules, and regulations.

Conduct a geologic investigation of the potential impact of the treatment on groundwater, surface water influent, and the karst features under the supervision of a qualified geologist as defined in the NRCS National Engineering Manual, Part 531, Geology. The geologic investigation may include information obtained from local experts, such as other Federal agencies, State agencies, and academic institutions. If conditions are complex and uncertain, use additional expertise to conduct onsite evaluation and to provide professional recommendations regarding the suitability of the site for treatment.

Develop nutrient and pest management plans for the portion of the drainage area surrounding the sinkhole feature which is controlled by the landowner. However, the preparation of these plans shall not result in a delay of treatment of an immediate safety concern.

Remove refuse and all other unsuitable material from the sinkhole and the established buffer area and dispose of it in an environmentally sound manner.

Vegetative Treatment. The minimum treatment of a sinkhole must include a fenced vegetated buffer (e.g., filter strips, field borders, riparian forest buffers) that meets the intent of the selected NRCS conservation practice standard(s). The buffer will be sized and designed based on the filter strip (393) conservation practice standard. The buffer will serve as a means to exclude people, animals, and equipment. The buffer will also serve to increase the overland flow path for surface water leading to the karst topography in an effort to minimize the potential for direct contamination into the sinkhole.

The buffer will be a minimum of 25-feet wide as measured from the farthest estimated point of collapse. (Note: This may represent an interior portion of the feature, rather than measured from the surface rim of the sinkhole). Extend the buffer area as needed to prevent concentrated flow channels from occurring and entering the sinkhole. The width of the vegetated buffer will be established and maintained in accordance with the type of buffer chosen.

Use appropriate erosion and sediment control measures to reduce the amount of sediment entering sinkhole openings during the establishment of the vegetative buffer. Do not apply nutrients, herbicides, pesticides, and animal waste within the established buffer area. Use only mechanical treatments for weed control.

Surface Water Control. Changes to the volume of surface water that enters a sinkhole may disturb the underground hydrology. To the extent possible, the surface water flow should be maintained at historic (or predevelopment) volumes. Minimal alterations should be made while stabilizing pre-existing concentrated flow channels. Disperse concentrated flow caused by construction activities with suitable spreading or diversion techniques.

Sinkhole Treatment/Closing. Adequate protection of most sinkhole and sinkhole areas can be achieved by the use of vegetative buffers and livestock exclusion. However, if an open sinkhole presents a safety hazard, it may be treated with an inverted filter, geosynthetics, gabions, or other appropriate methods. To enable a suitable design when a sinkhole will be closed by an inverted filter or plug, the area of concern will be characterized by a qualified geologist in consultation with the engineer.

Excavate the sinkhole area to competent, stable bedrock, if possible. All rock, aggregates, and soil used to treat the sinkhole shall be filter-compatible in the direction of flow, per the NRCS National Engineering Handbook, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters

Initial backfill material shall be placed directly on material that does not have the ability to migrate into the identified bedrock void. Non-woven Class I Geotextile may be used as a filter layer where applicable. Initial backfill shall be of such material that it also will not have the ability to migrate into the void. Concrete (as defined in ASTM D 5299) can also be used by itself or in conjunction with rocks to bridge the void. Initial backfill shall be free draining filter compatible into the void and not intended to seal the void.

Backfill when preventing inflow of surface runoff. Backfill above the initial backfill shall be in layers of suitably graded material so as not to migrate into the previous layer. Geomembranes may be used to separate layers. The installation of geomembranes shall follow the manufactures recommendations. A minimum of 4 feet of backfill shall be placed over the top geomembrane. All sealing layers shall be crowned 2 feet in the center and graded outward in all directions. Compaction of backfill shall be by tamping rollers or loaded rubber tired earthmoving equipment. When the sinkhole is backfilled to field elevations, a 1 to 2 feet or more crown of the backfill shall be provided to allow for settlement and provide positive surface water drainage. It may be necessary to construct conservation practices to control this surface water to an adequate outlet.

A sinkhole that opens into a cave shall not be filled under any circumstances. A cave is defined as a naturally formed subterranean open area or chamber or series of chambers that is a direct conduit into rock devoid of sediment infilling. Gated openings may be used for safety reasons. Design gates so that they do not impede movement or negatively impact wildlife species such as bats.

Karst areas may provide habitat for a diversity of highly specialized and sensitive fish and wildlife species such as bats, amphibians, fish, insects, and crustaceans including federally listed threatened or endangered species. NRCS shall follow all policies associated with the Endangered Species Act.

CONSIDERATIONS

Current and planned land use should be considered. Document the location of the sinkhole on a plan map so that structures, septic drain fields, wells, feedlots, ponds, animal waste storage, and other systems will not be located over a sinkhole site or within the impact area. Establishing a conservation easement for the buffer and sinkhole area should be considered.

For a sinkhole receiving contaminated overland flow, every effort should be made to first treat the source of the contamination. If completely plugging a sinkhole or diverting surface water is not feasible or the preferred treatment method, and water quality is a resource concern, the designer shall consider installing a buffer, meeting the requirements above, in addition to any treatment which still allows water to enter the sinkhole.

Although it is important to maintain the hydrology of the karst system, it may be more beneficial to the groundwater quality to divert contaminated water away from the sinkhole. In some cases, it may be necessary to completely plug a sinkhole with sealing materials rather than treat it with an inverted filter. Acceptable sealing materials are provided in ASTM D 5299, part 6.4. (An example of this would be a sinkhole in a feedlot or a pond site that is difficult to protect by any other method.) For those sites requiring a sealing by the methods mentioned in ASTM D 5299. An additional sealing layer of backfill shall extend a minimum of 3 feet on all sides of the sinkhole opening. Consideration should be given to sealing a wider area when soil will be saturated above the sinkhole. The sealing layer shall be a minimum of 2 ft. thick. The backfill immediately beneath the sealing layer shall be graded to prevent the migration of the sealing layer material into underlying material. The sealing layer should comprise of compacted plastic soils with PI's greater than 5. When plastic soils are not available, geomembranes may be used. The installation of geomembranes shall follow the manufactures recommendations. A minimum of 4 feet of backfill shall be placed over the top geomembrane. All sealing layers shall be crowned 2 feet in the center and graded outward in all directions.

The sinkhole treatment should not result in excessive surface water ponding or high soil-moisture conditions over an extended period of time.

When filling a sinkhole, mounding of the fill materials may be required to compensate for future settlement potential due to consolidation or migration of the fill material into subsurface voids. Additional fill may be required as treatment ages.

The treatment of one sinkhole may have an impact on other sinkholes or solutional features within the vicinity as hydraulic equilibrium is reestablished.

PLANS AND SPECIFICATIONS

Provide plans and specifications that describe the requirements for applying the practice to achieve its intended purpose.

Plans and specifications shall include, but not limited to—

- Plan view delineating the sinkhole and sinkhole area, including topographic information and photographs.
- A geologic investigation that includes a study of potential impacts on the karst resource.
- Depth to stable, competent bedrock, if applicable.
- Details of planned treatment measures.
- The drainage area of sinkhole delineated on a topographic map.
- Availability of safe outlet for surface water, if applicable.
- Special safety requirements, as appropriate.
- Additional site-specific considerations.

OPERATION AND MAINTENANCE

Provide an operation and maintenance (O&M) plan that describes specific instructions for maintaining the sinkhole and sinkhole area treatment, including—

- Reference to monitoring and periodic inspections.
- Nutrient and pest management.
- Prompt repair and/or replacement of damaged components.

REFERENCES

ASTM Standard D 5299. Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities. ASTM International, West Conshohocken, PA. – Latest Edition.

National Engineering Manual, Part 531 Geology, [M_210_NEH_531] – Latest Edition.

National Engineering Handbook, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters [H_210_633] – Latest Edition.

Adams, R., Barry, J., Green, J., 2016, Minnesota regions prone to surface karst feature development: St. Paul, Minnesota Department of Natural Resources, Ecological and Water Resources Division, Series GW-01, http://files. dnr.state.mn.us/waters/groundwater_section/mapping/ gw/gw01_report.pdf.