

USDA  
NATURAL RESOURCES  
CONSERVATION SERVICE  
MARYLAND CONSERVATION  
PRACTICE STANDARD  
**SINKHOLE AND SINKHOLE  
AREA TREATMENT**  
CODE 527  
(Reported by No.)

**DEFINITION**

The treatment of sinkholes and/or sinkhole areas to reduce contamination of groundwater resources, and/or improve farm safety.

**PURPOSE**

This practice may be applied as part of a conservation management system to support one or more of the following purposes:

1. Improve water quality.
2. Improve farm safety.

**CONDITIONS WHERE PRACTICE  
APPLIES**

On any land surface or existing practice where the soils and geologic conditions have led to the development of sinkholes.

**CONSIDERATIONS**

The practice should work in conjunction with conservation cropping systems, pest and nutrient management, and practices that control sheet, rill and gully erosion.

Current and planned land use should be considered. In particular, structures, septic fields, wells, feedlots, ponds, and animal waste storage systems should not be located over a sinkhole

site or within the impact area.

For a sinkhole receiving contaminated overland flow, every effort should be made to first treat the source of the contamination. Although it is important to maintain the hydrology of the karst system, it may be more beneficial to the ground water quality to divert the 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 a 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 site that is difficult to protect by any other method.

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

Treatment of one sinkhole may have an effect on other sinkholes or solution features in the vicinity.

The use of a Conservation Easement for the buffer and sinkhole should be considered.

**CRITERIA**

**General Criteria Applicable to all Purposes**

The installation and operation of sinkhole treatment(s) will comply with all federal, state, and local laws, rules, and regulations.

A geologic investigation of the potential impact of the treatment on ground water, surface water, and the karst features will be conducted by a qualified geologist.

Remove trash and other material from the sinkhole and disposed of in an environmentally sound manner.

Divert excess surface water caused by construction activities from the sinkhole area.

Develop nutrient and pest management plans for the drainage area of the sinkhole controlled by the landowner.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the [Natural Resources Conservation Service - Maryland](#) or visit the [electronic Field Office Technical Guide \(eFOTG\)](#).

**Vegetative Treatment** - On disturbed areas and/or sinkholes (as applicable), determine the appropriate vegetation to be established based on site conditions and planned land use. Follow the Maryland conservation practice standards for Critical Area Planting (Code 342), Conservation Cover (Code 327), or Pasture and Hay Planting (Code 512), as appropriate.

Do not use plants listed on the Maryland noxious weed list. Schedule construction so that completion occurs during periods suitable for the establishment of vegetation.

Provide a vegetative buffer around all treated sinkholes. The minimum width of the buffer is 25 feet measured from the rim of the sinkhole. The buffer area may be extended to control concentrated flow channels entering the sinkhole. The width of the vegetated buffer will be established and maintained in accordance with the type of buffer chosen.

Provide fencing around treated sinkholes and their buffer area. Exclude livestock except as needed for maintenance purposes.

Nutrients, herbicides, pesticides, and animal waste will not be applied within an established buffer. Use only mechanical treatments for weed control.

Appropriate erosion and sediment control measures will be used to reduce the amount of sediment entering sinkhole openings during the establishment of the vegetative buffer.

**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.

Stabilize pre-existing concentrated flow channels but should not otherwise be altered. If a plug or inverted filter is used, the area to be protected will be characterized by a qualified geologist. Concentrated flow caused by the construction activities will be dispersed with a suitable spreading structure.

**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 is a safety hazard, it may be treated with a rock filter, gabions, or other methods approved by the State Conservation Engineer.

Do not fill sinkholes that open into caves under any circumstances. Gated openings may be used for safety reasons.

Select the type of treatment based on the size of the sinkhole drainage area and include both direct sinkhole treatment along with surface water control measures and filter strips. The sinkhole treatment shall not result in surface water ponding or high soil moisture conditions over an extended period of time. However, because percolation rates vary among different soils, ponding and soil moisture conditions may also vary.

The design for this treatment applies to sinkholes with excavated depths between 5 and 25 feet and with drainage areas up to 15 acres. (For most sinkholes, excavation up to 5 feet is sufficient to allow for filter installation.) For sinkholes requiring excavated depths greater than 25 feet or uncontrolled drainage areas greater than 15 acres, adjustments to the inverted filter and/or surface water control measure(s) may be required. In these cases, geologic and engineering assistance must be requested and a site specific design prepared.

Other Maryland conservation practice standards that may need to be implemented in conjunction with this practice include: Fence (Code 382), Diversion (Code 362), Filter Strip (Code 393), Grassed Waterway (Code 412), Lined Waterway or Outlet (Code 468), and Terrace (Code 600).

**Treatment for Sinkholes with Drainage Areas Less than 5 Acres**

Treat the sinkhole using the Inverted Filter 1 specification in this standard.

The existing (or planned) land use or practice may exist over the treated sinkhole as long as the treatment is maintained.

**Treatment for Sinkholes with Drainage Areas of 5 Acres or More, and a Safe Outlet**

The following additional criteria apply to sinkholes with drainage areas of 5 acres or more, where a safe outlet can be provided for surface water that is diverted away from the sinkhole. A safe outlet is one that does not erode, divert surface water to another sinkhole, or cause flood damage to crops, property or buildings.

**Inverted Filter** - Treat the sinkhole using the Inverted Filter 1 specification in this standard.

Inspection of the treatment shall be made after periods of heavy precipitation, because some material may run further into sinkhole voids causing a surface depression. In this case, maintenance will include adding soil material at the surface.

The existing (or planned) land use or practice may exist over the treated sinkhole as long as the treatment is maintained.

**Treatment for Sinkholes with Drainage Areas from 5 to 15 Acres, and No Safe Outlet**

The following additional criteria apply to sinkholes with drainage areas from 5 to 15 acres, where a safe outlet for surface water is not feasible.

**Inverted Filter** - Treat sinkhole using the Inverted Filter 2 specification in this standard.

Inspection of the treatment shall be made after periods of heavy precipitation, because some material may run further into sinkhole voids causing a surface depression. In this case, maintenance will include adding filter material at the surface.

The treated sinkhole will remain as unused land.

**Materials**

**Geotextile** – Geotextile must be non-woven with minimum burst strength of 100 psi. It must meet the requirements of Maryland Department of Transportation, State Highway Administration, Standard Specifications for Construction and Materials, Section 921.09, Class SE.

**Aggregates** - Fine aggregates, gravel, and rock riprap must meet the requirements of Maryland Department of Transportation, State Highway Administration, Standard Specifications for Construction and Materials, Sections 901.01 and 901.02 respectively, or the American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Construction Materials, as specified.

**PLANS AND SPECIFICATIONS**

Plans and specifications for Sinkhole and Sinkhole Area Treatment will be in keeping with this standard and will describe the requirements for applying the practice to achieve its intended purpose.

**Inverted Filter 1**

Use the following procedure for installing an inverted filter to treat sinkholes with drainage areas of less than 5 acres:

1. Remove and properly dispose of materials dumped in and around the sinkhole;
2. Excavate loose material from the sinkhole and try to expose the solution void(s) in the bottom. Enlarge the sinkhole, as necessary, to allow for installation of the filter materials;
3. Select a field stone(s) that is about 1.5 times larger than the solution void(s). Place the stone(s) into the void(s) forming a secure "bridge";
4. Place a layer of filter material over the "bridge" at a minimum thickness of 18 inches. About 30 percent of the material should be larger than the opening between the bridge and the void(s). (A well placed "bridge" should not have large openings around it.) In most cases, this material can be MSHA gabion stone;
5. Place a layer of smaller size filter material over the previous layer at a minimum thickness of 9 inches. The size should be 1/4 to 1/2 the size of the previous layer. In most cases, this material can be No. 57 stone;

6. Place a layer of sand size filter material over the previous layer at a minimum thickness of 9 inches. The sand has to be compatible in size with the previous layer to prevent piping. In most cases, this material can be MSHA fine aggregate - underdrain;
  7. A non-woven geotextile with minimum burst strength of 100 psi can be substituted for the stone and sand filter materials discussed in 5 and 6;
  8. Stone used for the "bridge" and the filters should have a rock strength at least equal to moderately hard (i.e., resistant to abrasion or cutting by a knife blade but can be easily dented or broken by light blows with a hammer). Shale or similar soft and non-durable rock is not acceptable;
  9. Backfill over the last filter layer (or geotextile) with soil material to the surface. Overfill by about 5 percent to allow for settlement. The material should be mineral soil with at least 12 percent fines. The reuse of any soil material excavated from the sinkhole should be considered and any available topsoil should be placed on the surface;
  10. Establish vegetation on the treated sinkhole and other disturbed areas in accordance with the criteria provided in this standard for "Establishment of Vegetation."
4. Place a layer of the same size filter material at a thickness of about  $\frac{3}{4} D$  ( $D$  = total depth) above the sinkhole bottom;
  5. Place a layer of smaller size filter material over the previous layer at a thickness of about  $\frac{1}{4} D$ . Bring this layer to the surface. The size should be  $\frac{1}{4}$  to  $\frac{1}{2}$  the size of the previous layer. In most cases, this material can be No. 57 stone;
  6. Stone used for the filters should have a rock strength at least equal to moderately hard (i.e., resistant to abrasion or cutting by a knife blade but can be easily dented or broken by light blows with a hammer). Shale or similar soft and non-durable rock is not acceptable.
  7. Establish vegetation on disturbed areas in accordance with the criteria provided in this standard for "Establishment of Vegetation."

#### **OPERATION AND MAINTENANCE**

An operation and maintenance (O&M) plan will provide specific instructions for maintaining the sinkhole and sinkhole area treatment, including reference to periodic inspections and the prompt repair and/or replacement of damaged components.

At a minimum, the following items shall be included in the O&M plan, as applicable:

#### **Inverted Filter 2**

Use the following procedure for installing an inverted filter to treat sinkholes with drainage areas from 5 to 15 acres:

1. Remove and properly dispose of materials dumped in and around the sinkhole;
2. Excavate loose material from the sinkhole;
3. Place a layer of filter material into the sinkhole, allowing the stone to fill the void(s) below the bottom of excavated sinkhole. The size should be  $\frac{1}{4}$  to  $\frac{1}{2}$  the size of the void(s). In most cases, this material can be MSHA gabion stone;
1. Mow herbaceous plantings as necessary to promote vigorous growth;
2. Inspect practices at least once a year and after major storms. Fill in and reseed any damaged areas.

**SUPPORTING DATA AND DOCUMENTATION**

**Field Data and Survey Notes**

The following is a list of the minimum data needed:

1. Drainage area of sinkhole; Include topographic information and photographs;
2. Availability of safe outlet for surface water, if applicable;
3. Estimated depth and volume of sinkhole;
4. The geologic investigation will include a study of potential impacts on the Karst resource.

**Design Data**

Record on appropriate engineering paper. For guidance on the preparation of engineering plans, see Chapter 5 of the Engineering Field Handbook, Part 650. The following is a list of the minimum required design data:

1. Plan view showing sinkhole and, if applicable, any associated surface water control measures(s) and filter strip;
2. Drawing of inverted filter showing thickness of each filter material;
3. Determine the quantity of each filter material selected;
4. Identify any special safety requirements;
5. Environmental Assessment;
6. Planting plan. This must meet the criteria, specifications, and documentation requirements of the Maryland conservation practice standard for Critical Area Planting (Code 342). Show on plan.

**Construction Check Data/As-Built**

Record on survey notepaper, SCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted on plans in red. The following is a list of minimum data needed for As-builts:

1. Documentation of site visits on CPA-6. Include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom;
2. Check notes recorded during or after completion of construction showing width and depth;
3. Seeding performed;
4. Written operation and maintenance plan;
5. Final quantities and documentation for quantity changes, and materials certification;
6. Sign and date checknotes and plans by a person with the appropriate approval authority. Include a statement that the practice meets or exceeds NRCS practice standards.

**REFERENCES**

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3. National Crushed Stone Association, June 1978. *Graded Riprap Stone, Quarried Stone for Erosion and Sediment Control*.
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6. USDA, Natural Resources Conservation Service, 1978. *National Engineering Handbook*, Part 531, Section 8, *Engineering Geology, Chapter 1*.
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8. USDA, Natural Resources Conservation Service, June 1986. *Technical Release 55, Urban Hydrology for Small Watersheds*.
9. White, W.B. *Geomorphology and Hydrology of Karst Terrains*, Oxford University Press, Inc., New York, New York, 1988