DAM SAFETY
POLICY MEMORANDUM #21

TO: Dam Owners, Operators, and Engineers

FROM: Stormwater, Dam Safety, and Flood Management Program
Water and Science Administration

DATE: November 1, 2023

SUBJECT: Use of Anti-Seep Collars and Filter Diaphragms

Policy Statement

It is the policy of the Maryland Department of the Environment (the Department) that the design of dam embankments must consider potential failure modes and incorporate defensive design measures as appropriate. Embankment failures and accidents occur more often in the vicinity of conduits in the embankments than at other locations due to various opportunities for seepage to contribute to internal erosion processes. Accordingly, adequate seepage control is a required defensive design element. Filter diaphragms and, in some cases anti-seep collars are appropriate to control seepage along conduits.

This policy seeks to clarify the conditions when the use of filter diaphragms is required for small ponds and dams, and the limited cases where anti-seep collars remain acceptable. This policy supersedes the criteria in the USDA, Natural Resource Conservation Service (NRCS), Maryland Conservation Practice, Standard Pond Code 378, January 2000 (MD-378).

Background

For many years, anti-seep collars were the standard design approach used by most agencies to increase the length of the potential seepage flow path and thus decrease the hydraulic gradient at the interface of the conduit and the backfill surrounding the conduit in embankment dams. Based on knowledge gained during the period of intensive embankment construction by NRCS and other agencies in the 1960s through 1980s, the use of anti-seep collars was reconsidered. Filter diaphragms have been recognized as superior to anti-seep collars as a seepage control measure.

Selecting Appropriate Seepage Control

Filter diaphragms are always recommended, but are <u>required</u> when any of the following conditions are encountered:

- The hazard classification of the dam is High or Significant.

- The structure is not classified as a small pond in accordance with the Department's policies.
- The embankment height is 15 feet or greater (measured vertically from the lowest point on the top of the dam to the lowest point on the upstream toe of the dam).
- The dam can impound greater than 50 acre-feet of water at the crest elevation.
- Embankment soils have high piping potential such as Unified Classes GM, SM, and ML.
    - When embankment borrow soils are not identified during the design phase, soils must be assumed to have a high piping potential.
- When criteria for anti-seep collars is not met.

Anti-seep collars can be used where all of the following soil and site conditions apply:

- When the use of filter diaphragms is not required as indicated above.
- Embankment soils are documented to be non-dispersive by crumb testing or evidence that the site is located in geologic formations that are known to be non-dispersive.
- Soils tests show that embankment soils have a plasticity index (PI) equal to or greater than 15.
- The water content of the soils at the time of construction is such that a 1/8-inch diameter thread 1/2- inch long may be rolled out on a flat surface without breaking or falling apart.
- Natural or excavated ground slopes transverse to the embankment centerline in the vicinity of the conduit are no steeper than two (2) horizontal to one (1) vertical.
- Laboratory or field tests show that the foundation soils left in-place under the embankment and principal spillway are medium to very stiff in saturated consistency or medium dense to very dense depending on if these soils are cohesive or cohesionless, respectively.

Design Criteria for Filter Diaphragms

- Design the filter diaphragm according to the requirements of USDA, NRCS, 210-NEH, Part 628, Chapter 45, "Filter Diaphragms." (2007)
- Locate the filter diaphragm immediately downstream of the cutoff trench or downstream of the centerline of the dam if the foundation cutoff is upstream of the centerline or if there is no cutoff trench. It shall be located approximately parallel to the centerline of the dam but no further upstream than the centerline of the dam.
- Provide a drain outlet for the filter diaphragm at the downstream toe of the embankment. Protect the outlet from surface erosion and animal intrusion.
- Ensure that the filter diaphragm functions both as a filter for adjacent base soils and as a drain to intercept seepage. Materials for the filter diaphragm must meet the requirements of USDA, NRCS, 210-NEH, Part 633, Chapter 26, "Gradation Design of Sand and Gravel Filters" (2017).
    - Demonstration of the filter compatibility is required for dams. Filter compatibility calculations are not required for small ponds.

- The filter diaphragm shall be a minimum of three (3) feet thick and extend upward and horizontally at least three (3) times the conduit outside diameter or the width of the cradle, whichever is greater except that:
    - The vertical extension need be no higher than the design high water level for the inflow design flood, and
    - The horizontal extension need be no further than five (5) feet beyond the sides and slopes of any excavation made to install the conduit.
    - The filter diaphragm shall extend vertically downward at least two (2) feet beneath the conduit outside diameter or bottom of the cradle, whichever is greater.
    - The minimum soil cover over any portion of the filter-drainage diaphragm measured normal to the nearest embankment surface shall be at least two (2) feet.
- The filter diaphragm shall outlet at the embankment downstream toe, preferably using a drain backfill envelope continuously along the pipe to where it exits the embankment. Protecting drain fill from surface erosion is necessary.
- It is required that the outlet for the filter diaphragm is sized to safely discharge the design flow. Where a drain backfill envelope is used as the outlet, it is recommended that it be designed so the hydraulic head does not exceed the depth of the drain outlet. The exposed area of the drain outlet must also be protected from external attack such as surface erosion and slope instability due to horizontal seepage pressures. A weighted toe cover such as riprap can be effective if protected with a properly designed filter between the sand drain material and the riprap cover.
- If pipe drain outlets are used, consideration must be given to the structural design of the conduit including its fittings in resisting internal and external loading and the design life of the pipe must be consistent with the design life of the dam and physical conditions of the site. Also, the pipe must be designed for capacity and size of perforations as outlined in USDA, NRCS, 210-NEH Part 633, Chapter 26 (2017) and USDA, SCS Soil Mechanics Note 3 (1971). If the pipe corrodes, is crushed by exterior loading, or is otherwise damaged, the outlet of the filter diaphragm is lost and a piping failure may occur.

The design quantity (Q) used to size the outlet can be calculated by Darcy's Law, $Q = kiA$ where:

k = permeability of the embankment or drain outlet material (ft/day)
i = hydraulic gradient where $i = h/l$
h = head differential (ft)
l = seepage path (ft)
A = area of flow (diaphragm or outlet) (ft^2)

Design Criteria for Anti Seep Collars

Anti-seep collars shall be installed around all conduits through earth fills according to the following criteria:

- Sufficient collars shall be placed to increase the seepage length along the conduit by a minimum of 15 percent of the pipe length located within the saturation zone.

- The assumed normal saturation zone shall be determined by projecting a line at a slope four (4) horizontal to one (1) vertical from the point where the normal pool elevation meets the upstream slope to a point where this line intersects the invert of the pipe conduit or bottom of the cradle, whichever is lower. For stormwater management ponds and sediment basins, the phreatic line starting elevation shall be the 10-year water surface elevation, not the normal pool elevation.
- Maximum collar spacing shall be 14 times the required projection above the pipe. The minimum collar spacing shall be five (5) times the required minimum projection.
- Anti-seep collars should be placed within the saturated zone. In cases where the spacing limit will not allow this, at least one (1) collar must be in the saturated zone.
- All anti-seep collars and their connections to the conduit shall be watertight and made of material compatible with the conduit.
- The total perpendicular projection length can be determined following the instruction sheet on page G-39 of the 2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control.
- Collar dimensions shall extend the computed total perpendicular projection length or the projection length when multiple collars are used, or a minimum of two (2) feet whichever is greater in all directions around the pipe.
- Anti-seep collars shall be placed a minimum of two (2) feet from pipe joints except where flanged joints are used.
- For pipes with concrete cradles, the projection shall be measured from the cradle.

Additional Information

Questions about this policy or other items relating to ponds and dams can be directed to the Chief of the Dam Safety Permits Division at 410-537-3552.