USDA
NATURAL RESOURCES
CONSERVATION SERVICE
MARYLAND

CONSERVATION PRACTICE
STANDARD

POND

CODE 378
(Reported in No.)

DEFINITION

A water impoundment made by constructing a dam or an embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at the principal spillway storm design high water elevation is 3 feet or more (See Table 1).

This 3 feet shall be measured from the low point on the upstream toe of the embankment to the design high water.

PURPOSE

To provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and other related uses, and to maintain or improve water quality. This standard also applies to stormwater management ponds.

CONDITIONS WHERE PRACTICE APPLIES

General - This practice applies where it is determined that stormwater management, water supply, or temporary storage is justified and it is feasible and practicable to build a pond which will meet local and state law requirements.

This standard establishes the minimum acceptable quality for the design and construction of ponds if:

1. Failure of the dam will not result in loss of life; in damage to homes, commercial or industrial buildings, main highways, or railroads; or interruption of the use or service of public utilities.

2. The product of the storage times the effective height of the dam is less than 3,000. Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the emergency spillway.

   The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point on a profile taken along the centerline of the dam, excluding the cutoff trench. If there is no emergency spillway, the top of the dam becomes the upper limit for determining the storage and the effective height.

3. For dams in rural areas, the effective height of the dam (as defined above) is 35 feet or less and the dam is hazard class ”a”. For dams in urban areas, the effective height of the dam is 20 feet or less and the dam is hazard class ”a”.

Ponds exceeding any of the above conditions shall be designed and constructed according to the requirements of Technical Release 60.

Exemptions - Soil Conservation District small pond approval is not required for small class “a” structures where the following exists:

1. Ponds or other structures have less than four (4) feet of embankment, or

2. The storage at emergency spillway design

high water elevation according to Table 1 does not exceed 40,000 cubic feet, and the height of the embankment is 6 feet or less.

The height of the embankment shall be measured from the top of the dam to the lowest point of excavation, excluding the cutoff trench, along the centerline of the dam.

In addition, an embankment pond that meets the criteria below shall be considered an excavated pond and is also exempt from small pond approval.

1. The calculation of 10H+20=L, where H=height from the pond bottom to the top of the dam, is provided, and

2. The projection of L horizontally downstream from the pond bottom is below the existing or proposed ground, and

3. The existing or proposed downstream ground slope within the projection of L is less than 10% at any point.

The review and design of such class "a" structures shall be based on sound engineering judgment assuring a stable outfall for the ten (10) year, 24-hour storm event.

Site Conditions - Site Conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed emergency spillway, (2) a combination of a principal spillway and an emergency spillway, or (3) a principal spillway.

Drainage Area - The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure.

For ponds whose primary purpose is to trap sediment for water quality, adequate storage should be provided to trap the projected sediment delivery from the drainage area for the life of the pond.

If the intent is to maintain a permanent pool, the drainage area should be at least 4 acres for each acre-foot of permanent storage. These recommendations may be reduced if a dependable source of ground water or diverted surface water contributes to the pond. The water quality shall be suitable for its intended use.

Soils Investigation - A soils investigation is required on all ponds. As a minimum it shall include information along the centerline of the proposed dam, in the emergency spillway location, and the planned borrow area. The type of equipment used and the extent of the investigation will vary from site to site. All investigations shall be logged using the Unified Soil Classification System.

Road Embankments - Where road embankments are being designed to impound a specific volume of water, either as a permanent pool or temporary stormwater storage, special design and evaluation criteria may be required as determined by Appendix B.

CONSIDERATIONS

Water Quantity - The following items should be considered for water quantity:

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

2. Variability of effects caused by seasonal or climatic changes.

3. Effects on the downstream flows or aquifers that could affect other water uses or users.

4. Potential for multiple use.

5. Effects on the volume of downstream flow to prohibit undesirable environmental, social or economic effects.

Water Quality - The following items should be considered for water quality:

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment attached substances that are carried by runoff.

2. Effects on the visual quality of on-site and downstream water resources.

3. Short-term and construction-related effects of this practice on the quality of downstream water courses.

4. Effects of water level control on the temperatures of downstream waters to prevent undesired effects on aquatic and wildlife communities.

5. Effects on wetlands and water-related wildlife habitats.

6. Effects of water levels on soil nutrient processes such as plant nitrogen use or denitrification.

7. Effects of soil water level control on the soil chemistry, soil water, or downstream water.

8. Potential for earth moving to uncover or redistribute sulfidic bearing soils.

CRITERIA

Embankment Ponds

Structure Hazard Classification - Documentation of the classification of dams is required. Documentation is to include but is not limited to location and description of dam, configuration of the valley, description of existing development (houses, utilities, highways, railroads, farm or commercial buildings, and other pertinent improvements), potential for future development, and recommended classification. It is also to include results obtained from breach routings, if breach routings are used as part of the classification process. The class ("a", "b", and "c") as contained in this document is related to the potential hazard to life and property that might result from a sudden major breach of the earth embankment. Structure classification and land use for runoff determination must take into consideration the anticipated changes in land use throughout the expected life of the structure. The classification of a dam is the responsibility of the designer, and subject to review and concurrence of the approving authority.

The classification of a dam is determined only by the potential hazard from failure, not by the criteria. Classification factors in the National Engineering Manual, as supplemented, are given below:

Class "a" - Structures located in rural, agricultural or urban areas dedicated to remain in flood tolerant usage where failure may damage non-inhabited buildings, agricultural land, floodplains or county roads.

Class "b" - Structures located in rural, agricultural, or urban areas where failure may damage isolated homes, main highways or minor railroads or cause interruption of use or service of relatively important public utilities.

Class "c" - Structures located where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads.

"Rural areas" is defined as those areas in which residents live on farms, in unincorporated settlements, or in incorporated villages or small towns. It is where agriculture, including woodland activities, and extractive industries, including seafood harvesting, provides the primary employment base for residents and where such enterprises are dependent on local residents for labor.

Non-rural areas shall be classified as urban.

Peak Breach Discharge Criteria - Breach routings are used to help delineate the area potentially impacted by inundation should a dam fail and can be used to aid dam classification. The breach hydrograph is the outflow hydrograph attributed to the sudden release of water in reservoir storage. This is due to a dam breach during non-storm conditions.

Stream routings made of the breach hydrograph are to be based upon topographic data and hydraulic methodologies mutually consistent in their accuracy and commensurate with the risk being evaluated.

The minimum peak discharge of the breach hydrograph, regardless of the techniques used

to analyze the downstream inundation area, is as follows:

$Q_{max} = 3.2\ H_w^{2.5}$ where,

Q_{max} = the peak breach discharge, cfs.

H_w = depth of water at the dam at the time of failure, feet. This is measured to the crest of the emergency spillway or to design high water, if no emergency spillway exists. Use "non-storm" conditions downstream of the dam.

Where breach analysis has indicated that only overtopping of downstream roads will occur, the following guidelines will be used:

Class	**Depth of Flow (d) ft.**
"a"	$d \leq 1.5$
"b" & "c"	$d > 1.5$

Use and importance of the roadway shall be considered when making a classification.

Hydrology - Principal and emergency spillways will be designed within the limitations shown on TABLE 1. The storm duration used shall be 24 hours except where TR-60 is specified. The pond shall be designed to safely pass the base flow along with volume and peak rates of runoff from design storms, specified in Table 1. All storm water management ponds shall be designed using urban criteria. This can be done by using principal and emergency spillways. The following shall be used to determine runoff rates and volumes:

1. NRCS "Engineering Field Handbook, Part 650" or;
2. NRCS, NEH, Section 4, Hydrology" or;
3. NRCS, TR-55, "Urban Hydrology for Small Watersheds" or;
4. NRCS, TR-20, "Computer Program for Project Formulation" or,
5. Computer programs using NRCS hydrology methods with identifiable inputs and outputs as approved by the reviewing agency.

Earth Embankment

Top Width - The minimum top width of the dam is shown in Table 2. When the embankment top is to be used as a public road, the minimum width is to be 16 feet for one-way and 26 feet for two-way traffic. If the embankment is to be used for infrequent vehicle crossings, the minimum top width shall be 10 feet. Guardrails or other safety measures are to be used where necessary and are to meet the requirements of the responsible road authority.

Side Slopes - The combined upstream and downstream side slopes of the settled embankment shall not be less than five horizontal to one vertical (5:1) with neither slope steeper than 2:1. If the dam is used as a road crossing with a top width greater than 26 feet, then the combined side slopes of the settled embankment shall not be less than 4 horizontal to one vertical (4:1) with neither slope steeper than 2:1. Slopes must be designed to be stable in all cases, even if flatter side slopes are required.

Earth Cuts - If cuts in an existing fill or in natural ground are required for the rehabilitation of an existing pond spillway or the construction of a new pond, the slope of the bonding surfaces between the existing material in place and the fill to be placed shall not be steeper than a ratio of two horizontal to one vertical (2:1).

Foundation Cutoff - A cutoff trench of relatively impervious material shall be provided under the entire length of the dam and shall be located at or upstream from the centerline of the dam. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill and compaction operations, with the minimum width being 4 feet, and shall have side slopes no steeper than one horizontal to one vertical. Minimum depth shall be 4 feet.

Impervious Core - Any impervious core within the embankment shall be located at or upstream from the centerline of the dam, and shall extend up the abutments to the 10-year water surface elevation. The impervious core shall extend vertically from the cutoff trench up to the 10-year water surface elevation throughout the embankment.

Seepage Control - Seepage control is to be included: (1) if pervious layers are not intercepted by the cutoff; (2) if seepage from the abutments may create a wet embankment; (3) if the phreatic line intersects the downstream slope; or (4) if special conditions require drainage to insure a stable dam. The phreatic line shall be drawn on a 4:1 slope starting on the inside slope at the normal pool elevation. For stormwater management ponds, normal pool shall be considered as the 10-year water surface elevation.

Seepage may be controlled by (1) foundation abutment or embankment drains; (2) reservoir blanketing; or (3) a combination of these measures. Foundation drains may control seepage encountered in the cutoff trench during construction. These drains must be located downstream of the dam centerline and outside the limits of the proposed cutoff trench. All drains must be designed according to the section Principal Spillway, *Conduit Piping and Seepage Control*.

Wave Erosion Protection - Where needed to protect the face of the dam, special wave protection measures such as a bench, rock riprap, sand-gravel, soil cement or special vegetation shall be provided. (Reference NRCS Technical Releases 56 & 69)

Freeboard - The top elevation of the settled embankment shall be determined in accordance with minimum criteria established in Table 1

Allowance for Settlement - The design height of the dam shall be increased by the amount needed to insure that the design top of fill elevation will be maintained after all settlement has taken place. This increase shall not be less than 5 percent, except where detailed soil testing and lab analyses indicate a lesser amount is adequate.

Principal Spillway

Capacity - A conduit, with needed appurtenances, shall be placed under or through the dam, except where a weir type structure is used. The minimum capacity of the principal spillway shall be that required in Table 1.

Crest Elevation of Inlet - The crest elevation of the principal spillway shall be no less than 1.0 foot below the crest of the emergency spillway. The crest elevation is the invert elevation of the lowest opening 6 inches or larger in any direction.

The inlet or riser size for the pipe drops shall be such that the flow through the structure goes from weir-flow control to pipe-flow control without going into orifice-flow control in the riser. The inlets and outlets shall be designed and analyzed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The riser shall be analyzed for flotation assuming all orifices and pipes are plugged. The factor of safety against flotation shall be 1.2 or greater.

Pipe Conduits - Pipe conduits under or through the dam shall meet the following requirements:

1. All pipes shall be circular in cross section except for cast-in-place reinforced concrete box culverts.

2. Pipe shall be capable of withstanding the external loading without yielding, buckling, or cracking.

3. Pipe strength shall be not less than those shown on Tables 3, 4 and 5 for corrugated steel, aluminum, and plastic pipes and applicable ASTM's for other materials.

4. Where inlet or outlet flared sections are used, they shall be made from materials compatible with the pipe.

5. All pipe joints shall be made watertight by the use of flanges with gaskets, coupling bands with gaskets, bell and spigot ends

with gaskets, or by welding. See Construction Specifications for details.

6. The joints between sections of pipe shall be designed to remain watertight after joint rotation and elongation caused by foundation consolidation.

The capacity of the pipe conduit shall be adequate to discharge long duration, continuous or frequent flows without flow through the emergency spillway. The diameter of the pipe shall be not less than 6 inches.

For dams 20 feet or less in effective height, the following pipe materials are acceptable: cast-iron, ductile iron, steel, corrugated steel or aluminum, concrete with rubber gaskets, plastic, and cast-in-place reinforced concrete box culverts. Plastic pipe that will be exposed to direct sunlight should be made of ultraviolet resistant materials and protected by coating or shielding. Connections of pipe to less flexible pipe or structures must be designed to avoid stress concentrations that could rupture the pipe.

For dams over 20 feet in effective height, conduits are to be reinforced concrete pipe, cast-in-place reinforced concrete box culverts, corrugated steel, ductile iron, welded steel or aluminum pipe. The maximum height of fill over any principal spillway steel, aluminum, or plastic pipe must not exceed 25 feet.

Concrete pipe shall have a concrete cradle extending up the sides of the pipe at least 50% of its outside diameter with minimum thickness of 6 inches. Where a concrete cradle is not needed for structural reasons, flowable fill may be used as described in the CONSTRUCTION SPECIFICATIONS section of this standard. Gravel bedding is not permitted. Cantilever outlet sections, if used, shall be designed to withstand the cantilever load. Pipe supports shall be provided when needed. Other suitable devices such as plunge basin, stilling basin, impact basin, or rock riprap spreader should be used to provide a safe outlet. Cathodic protection is to be provided for welded steel and corrugated steel pipe where the need and importance of the structure warrant. Cathodic protection should normally be provided for corrugated steel pipe where the saturated soil resistivity is less than 4,000 ohms-cm or the pH is lower than 5. The National Handbook of Conservation Practices, Irrigation Water Conveyance, Steel Pipeline Standard (430-FF), provides criteria for cathodic protection of welded steel pipes.

Multiple Conduits - Where multiple conduits are used, there shall be sufficient space between the conduits and the installed anti-seep collars to allow for backfill material to be placed between the conduits by the earth moving equipment and for easy access by hand operated compaction equipment. This distance between conduits shall be equal to or greater than half the pipe diameter but not less than 2 feet.

Conduit Piping and Seepage Control - Seepage along pipe conduit spillways extending through the embankment shall be controlled by use of (1) anti-seep collars, or (2) filter and drainage diaphragm. Seepage control will not be required on pipes 6 inches in diameter or less.

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

1. 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.

2. The assumed normal saturation zone shall be determined by projecting a line at a slope (4) horizontal to (1) vertical from the point where the normal water 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, the phreatic line starting elevation shall be the 10-year water elevation.

3. Maximum collar spacing shall be 14 times the required projection above the pipe. The minimum collar spacing shall be 5 times the required minimum projection.

4. Anti-seep collars should be placed within the saturated zone. In cases where the spacing limit will not allow this, at least one collar will be in the saturated zone.

5. All anti-seep collars and their connections to the conduit shall be watertight and made of material compatible with the conduit.

6. Collar dimensions shall extend a minimum of 2 feet in all directions around the pipe.

7. Anti-seep collars shall be placed a minimum of two feet from pipe joints except where flanged joints are used.

8. For pipes with concrete cradles, the projection shall be measured from the cradle.

Filter and drainage diaphragms are always recommended, but are required when the following conditions are encountered:

1. The pond requires design according to TR-60.

2. Embankment soils with high piping potential such as Unified Classes GM, SM, and ML.

Filter and drainage diaphragms shall be designed in accordance with procedures from NRCS TR-60, Earth Dams and Reservoirs, Section 6, Principal Spillways, as described below.

The drainage diaphragm shall usually consist of sand, meeting the fine concrete aggregate requirements (ASTM C-33). A design analysis shall be made using Part 633 of the National Engineering Manual, Chapter 26, Gradation Design of Sand and Gravel Filters.

The drainage diaphragm shall be a minimum of 3 ft thick and extend vertically upward and horizontally at least three times the conduit outside diameter or the width of the cradle, whichever is greater except that:

1. The vertical extension need be no higher than the maximum potential reservoir water level, and

2. The horizontal extension need be no further than 5 feet beyond the sides and slopes of any excavation made to install the conduit.

3. The minimum soil cover over any portion of the filter-drainage diaphragm measured normal to the nearest embankment surface shall be at least 2 feet.

It shall extend vertically downward at least 2 ft beneath the conduit outside diameter or bottom of the cradle, whichever is greater. The drainage diaphragm shall be located immediately downstream of the cutoff trench, approximately parallel to the centerline of the dam but no further upstream than the centerline of the dam.

The drainage 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 will be 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 in resisting 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 NEH Part 633, Chapter 26 and Soil Mechanics Note 3. 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)

Anti-vortex Devices - Drop inlet spillways are to have adequate anti-vortex devices. Splitter type anti-vortex devices shall be placed in line with the barrel. An anti-vortex device is not required if weir control is maintained in the riser through all flow stages.

Trash Racks - All pipe and inlet structures shall have a trash rack. Openings for trash racks shall be no larger than 1/2 of the barrel conduit diameter, but in no case less than 6 inches.

Flush grates for trash racks are not acceptable. Inlet structures that have flow over the top shall have a non-clogging trash rack such as a hood-type inlet extending a minimum of 8 inches below the weir openings, which allows passage of water from underneath the trash rack into the riser.

For inlet structures with solid covered tops, the bottom of the cover slab must be set at an elevation to prevent orifice flow control before pipe flow control governs.

Low stage releases, where the opening is larger than 6 inches, shall have a non-clogging trash rack with openings no larger than half the low flow dimension.

For all low stage releases 6 inches or smaller in any direction, the emergency spillway design storm shall be routed assuming the release has failed, using storage and discharge only above the elevation of the next opening larger than 6 inches in all directions. This design storm routing shall not overtop the dam.

Drain Pipe - A pipe with a suitable valve shall be provided to drain the pool area, where needed for proper pond management. The principal spillway conduit may serve as a pond drain, when so located, to accomplish this function.

Water Supply Pipes or Utilities - All pipes through the dam shall have an inside diameter of not less than 1 1/4 inches. Pipes / utilities not parallel to the axis of the dam shall meet all principal spillway requirements (i.e. filter diaphragm, embankment soils, etc.). Pipes / utilities parallel to the axis of the dam shall be constructed with no granular bedding.

Earth Emergency Spillways

Emergency spillways are provided to convey large flood flows safely past earth embankments. An emergency spillway must be provided for each dam, unless the principal spillway is large enough to pass the routed design hydrograph peak discharge and any trash without overtopping the dam. The only design that may be utilized without an emergency spillway is: a principal spillway with a cross-sectional area of 3 square feet or more and an inlet that will not clog, such as a hood-type inlet which allows passage of water from underneath the trash rack into the riser.

Capacity - The minimum capacity of emergency spillways shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 1 less any reduction creditable to conduit discharge and detention storage.

The emergency spillway shall (1) safely pass the storm design peak or (2) the storm runoff shall be routed through the reservoir. The routing shall start with the water surface at the elevation of the crest of the principal spillway, or at the water surface after 10 days drawdown, whichever is higher. The 10-day drawdown shall be computed from the crest of the emergency spillway or from the elevation that would be attained had the entire design storm been impounded, whichever is lower. Emergency spillways are to provide for passage of the design flow at a non-erosive velocity to a point downstream where the dam will not be endangered.

Component Parts - Earth spillways are open channels and usually consist of an inlet channel, level section, and an exit channel. The minimum difference in elevation between the crest of the emergency spillway and the settled top of dam shall be 2.0 feet.

Cross-Section - Earth spillways shall be trapezoidal and shall be located in undisturbed earth. The side slopes shall be stable for the material in which the spillway is to be constructed, but not steeper than 2:1. The emergency spillway shall have a bottom width of not less than 8 feet.

The inlet channel may be curved to fit existing topography; however, it should be flared to allow unrestricted flow to the level section. The level section should be located as near the centerline of dam as possible. The level section shall be 25 feet in length, and shall be rectangular or square.

Exit channel centerline shall be perpendicular to the level section downstream edge and must be straight for a distance beyond the downstream toe, so that discharges will not reach the earth embankment. The grade of the exit channel shall fall within the range established by discharge requirement and permissible velocities.

The crest of any "token" spillway will be located at or above the 100-year storm elevation in undisturbed earth and have a minimum depth of one foot and bottom width of 8 feet.

Permissible Velocities - Earth spillways shall be designed for non-erosive velocities through the control section and to a point downstream where the dam will not be endangered. The maximum permissible velocity for the grass and grass mixture to be used shall be selected from Table 6. Velocities exceeding these values will require use of linings other than vegetation.

Infiltration / Water Quality Basins – Ponds, either excavated or embankment, that are designed solely for infiltration or as water quality basins will have an emergency spillway. The capacity of the spillway will be determined by the following procedure:

Pass the routed 100-Year Storm with 1 foot of freeboard to the top of dam elevation. Routing will begin at the emergency spillway crest.

Structural Emergency Spillways

Chutes or drops, when used for principal spillways or principal-emergency or emergency spillways, shall be designed in accordance with the principals set forth in the National Engineering Handbook, Section 5 "Hydraulics"; Section 11 "Drop Spillways"; and Section 14 "Chute Spillways". The minimum capacity of a structural spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 1 less any reduction creditable to conduit discharge and detention storage.

Visual Resource Design

The visual design of ponds shall be carefully considered in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their functions.

The embankment may be shaped to blend with the natural topography. The edge of the pond should be shaped so that it is generally curvilinear rather than rectangular. Excavated material shall be shaped so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, islands may be added for visual interest and to attract wildlife.

Trees and Shrubs

Non-Roadway Embankments - Trees and/or shrubs will not be allowed on any embankment, will not be allowed within the buffer zone (15 feet from the toe of the dam), and will not be allowed within a 25-foot radius around the inlet structure.

Roadway Embankments - Trees and/or shrubs will not be allowed on any embankment, except for dry stormwater management

structures that will be utilized as a roadway under all the following conditions:

1. Plantings may only be on top of the dam along the roadway and/or sidewalks.

2. The top of the dam shall have a minimum of 50-foot top width.

3. Plantings will not be allowed on the side slopes of the embankment.

4. Plantings will not be allowed within the buffer zone (15 feet from the toe of the dam).

5. Plantings will only be shallow rooted (roots less than 3' deep) trees or shrubs.

6. The pond is a "dry" structure (normal pool not exceeding 18 inches).

7. A landscape plan showing type and location of planting must be prepared by a Landscape Architect certifying shallow rooted plants (roots less than 3' deep) under mature conditions.

8. A minimum of 3 feet freeboard above the 100-year water surface elevation must be maintained.

9. The structure is a low hazard (Class "a") pond.

Safety

Special considerations should be made for safety and access during the design of a pond. Measures to be considered may include fencing, slope benching, access roads, flattened side slopes, etc. When fencing a structure, the fence will be located so it will not interfere with the operation of the emergency spillway.

Excavated Ponds

General - Excavated ponds that create a failure potential through a constructed or created embankment will be designed as embankment ponds. Excavated ponds that include a pipe or weir outlet control system for urban stormwater management shall be designed using the principal and emergency spillway hydrologic criteria for Embankment Ponds, Table 1.

Side Slopes - Side slopes of excavated ponds shall be such that they will be stable and shall not be steeper than 1 horizontal to 1 vertical. Flatter slopes are to be utilized where safety for children, livestock watering, etc. is a design factor.

Perimeter Form - Where the structures are used for recreation or are located in high public view, the perimeter or edge should be shaped to a curvilinear form.

Inlet Protection - When the excavated pond is a bypass type and water is being diverted from a stream, the minimum size inlet line shall be a 4-inch diameter pipe. All state laws concerning water use and downstream rights shall be strictly adhered to.

Where surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

Outlet Protection – An excavated pond with a low embankment (combination excavation / embankment pond) shall be designed to ensure a stable outfall for the 10-year, 24-hour frequency storm.

Placement of Excavated Material - The material excavated from the pond shall be placed in one of the following ways so that its weight will not endanger the stability of the pond side slopes and where it will not be washed back into the pond by rainfall:

1. Uniformly spread to a height not exceeding 3 feet with the top graded to a continuous slope away from the pond;

2. Uniformly placed or shaped reasonably well with side slopes no steeper than 2 to 1. The excavated material will be placed at a distance equal to the depth of the pond, but not less than 12 feet from the edge of the pond;

3. Shaped to a designed form that blends visually with the landscape;

4. Used for low embankment and leveling; or

5. Hauled away.

Reservoir Area for Wet Ponds

For most ponds, the topography of the site shall permit storage of water at a depth and volume that ensures a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. Soils in the reservoir shall be impervious enough to minimize seepage losses or shall be of a type that sealing is practical.

Excavation and shaping required to permit the reservoir area to suitably serve the planned purpose shall be included in the construction plans.

Reservoirs designed specifically for fish production or wildlife management shall follow design criteria in the standards and specifications for Fish Pond Management (MD-399) and Wildlife Wetland Habitat Management (MD-644), as appropriate.

TABLE 1

HYDROLOGIC CRITERIA FOR PONDS

Structure Class	Storage Height Product[1]	Watershed Area (Acres)	Height To Emergency Spwy Crest (Feet)	Normal Surface Area (Acres)	Spillway Capacity[5]				Freeboard[6]
					Principal[2]		Emergency[3, 4]		
					Rural	Urban	Rural	Urban	Rural & Urban
"c" & "b"	Any	Any	Any	Any	TR 60	TR 60	TR 60	TR 60	TR 60
"a"	3,000 or more	Any	Any	Any	TR 60	TR 60	TR 60	TR 60	TR 60
"a"	Less than 3,000	320 and Larger	>20 - 35	≥12	25 YR	TR 60	100 YR	100 YR	2.0' above E.S. Design Storm
			≤20	≥12	10 YR	25 YR	100 YR	100 YR	
			<15	<12	5 YR	10 YR	50 YR	100 YR	
		100 to 320	>20 - 35	≥12	10 YR	TR 60	100 YR	100 YR	2.0' above E.S. Design Storm
			≤20	≥12	5 YR	10 YR	50 YR	100 YR	1.0' above E.S. Design Storm
			<15	<12	2 YR	5 YR	25 YR	100 YR	1.0' above E.S. Design Storm
		Less Than 100	>20 - 35	≥12	5 YR	TR 60	50 YR	100 YR	1.0' above E.S. Design Storm
			≤20	≥12	2 YR	5 YR	25 YR	100 YR	
			<15	<12	10% of 25 YR Peak	5 YR	25 YR	100 YR	

NOTES

1) The storage is defined as the original capacity of the reservoir in acre-feet at the elevation of the crest of the emergency spillway. The effective height is the difference in elevation in feet between the emergency spillway crest and the lowest point on a profile taken along the centerline of the dam, excluding the cutoff trench. If there is no emergency spillway, this height shall be to the top of the dam.

2) Principal - minimum storm to be contained below the crest of the emergency spillway including any combination of temporary storage and principal spillway discharge.

3) Emergency - minimum storm used to proportion the emergency spillway to meet the limitations for shape, size, velocity and exit channel. This storm can be handled by any combination of principal spillway discharge, emergency spillway discharge and storage.

4) For ponds without a separate emergency spillway, the principal spillway functions as the emergency spillway. In this situation, the principal spillway must comply with the emergency spillway hydrologic criteria.

5) All ponds, which are being designed to meet local stormwater requirements, will be required to use the urban criteria. Storm duration used shall be 24 hours except where TR-60 is specified.

6) For ponds without a functioning open channel emergency spillway, minimum freeboard will be 2 feet.

TABLE 2

Total Height Of Embankment (Feet)	Minimum Top Width (Feet)
10 or less	6
11 - 14	8
15 - 19	10
20 - 24	12
25 - 34	14
35 or more	15

TABLE 3[1,2]

MINIMUM GAGES

CORRUGATED STEEL PIPE
2 - 2/3 inches x 1/2 inch Corrugations

Fill Height Over Pipe (Feet)	Pipe Diameter in Inches				
	24 & Less	30	36	42	48
1 - 15	16	16	14	10	10
15 - 20	16	12	10	*	*
20 - 25	16	10	*	*	*

CORRUGATED STEEL PIPE
3 inches x 1 inch or 5 inch x 1 inch Corrugations

Fill Height Over Pipe (Feet)	Pipe Diameter (Inches) Flowable Fill						
	36	42	48	54[3]	60[3]	66[3]	72[3]
1 - 15	16	16	16	14	14	14	14
15 - 20	16	16	12	14	14	14	14
20 - 25	14	14	10	14	14	14	14

* Not Permitted.

TABLE 4[1,2]

MINIMUM GAGES

CORRUGATED ALUMINUM PIPE
2 - 2/3 inches x 1/2 inch Corrugations

Fill Height Over Pipe (Feet)	Pipe Diameter in Inches		
	21 & Less	24	30
1 - 15	16	14	10
15 - 20	12	10	*
20 - 25	10	*	*

CORRUGATED ALUMINUM PIPE
3 inches x 1 inch Corrugations

Fill Height Over Pipe (Feet)	Pipe Diameter in Inches				
	30	36	42	48	54[3]
1 - 15	16	16	14	10	14
15 - 20	16	12	*	*	*
20 - 25	12	*	*	*	*

* Not Permitted.

[1] Coatings for corrugated metal shall be as specified by the MD-378 Construction Specifications.
[2] Tables 3 and 4 were developed using the modified Spangler equation. Sizes other than those shown above are not permitted.
[3] Must use flowable backfill as specified by the MD-378 Construction Specifications and the pipe must be bituminous coated.

TABLE 5

ACCEPTABLE PLASTIC PIPE FOR USE IN EARTH DAM[1, 2]

Nominal Pipe Size (inches)	Schedule or Standard Dimension Ratio (SDR)	Maximum Depth of Fill Over [3]
6 - 24	PVC Schedule 40	10
6 - 24	PVC Schedule 80	15
6 – 24	PVC SDR 26	10
6 - 24	Corrugated HDPE	10

[1] See Specifications, Plastic Pipe

[2] All designs based on Technical Release 77, Reference 20. Other diameters and / or fill heights may be used that meet all the requirements of TR-77.

[3] larger fill heights may be permitted when using flowable fill.

TABLE 6

Permissible Velocities (Ft/Sec)
For Emergency Spillways Lined with Vegetation

Type of Cover	Slope Of Exit Channel 0 - 5%	Slope Of Exit Channel 5 - 10%
Bermudagrass	6	5
Reed Canarygrass	5	4
Tall Fescue	5	4
Kentucky Bluegrass	5	4
Grass-legume mixture	4	3

CONSTRUCTION SPECIFICATIONS

These specifications are appropriate to all ponds within the scope of the Standard for practice MD-378. All references to ASTM and AASHTO specifications apply to the most recent version.

Site Preparation

Areas designated for borrow areas, embankment, and structural works shall be cleared, grubbed and stripped of topsoil. All trees, vegetation, roots and other objectionable material shall be removed. Channel banks and sharp breaks shall be sloped to no steeper than 1:1. All trees shall be cleared and grubbed within 15 feet of the toe of the embankment.

Areas to be covered by the reservoir will be cleared of all trees, brush, logs, fences, rubbish and other objectionable material unless otherwise designated on the plans. Trees, brush, and stumps shall be cut approximately level with the ground surface. For dry stormwater management ponds, a minimum of a 25-foot radius around the inlet structure shall be cleared.

All cleared and grubbed material shall be disposed of outside and below the limits of the dam and reservoir as directed by the owner or his representative. When specified, a sufficient quantity of topsoil will be stockpiled in a suitable location for use on the embankment and other designated areas.

Earth Fill

Material - The fill material shall be taken from approved designated borrow areas. It shall be free of roots, stumps, wood, rubbish, stones greater than 6", frozen or other objectionable materials. Fill material for the center of the embankment, and cut off trench shall conform to Unified Soil Classification GC, SC, CH, or CL and must have at least 30% passing the #200 sieve. Consideration may be given to the use of other materials in the embankment if designed by a geotechnical engineer. Such special designs must have construction supervised by a geotechnical engineer.

Materials used in the outer shell of the embankment must have the capability to support vegetation of the quality required to prevent erosion of the embankment.

Placement - Areas on which fill is to be placed shall be scarified prior to placement of fill. Fill materials shall be placed in maximum 8 inch thick (before compaction) layers which are to be continuous over the entire length of the fill. The most permeable borrow material shall be placed in the downstream portions of the embankment. The principal spillway must be installed concurrently with fill placement and not excavated into the embankment.

Compaction - The movement of the hauling and spreading equipment over the fill shall be controlled so that the entire surface of each lift shall be traversed by not less than one tread track of heavy equipment or compaction shall be achieved by a minimum of four complete passes of a sheepsfoot, rubber tired or vibratory roller. Fill material shall contain sufficient moisture such that the required degree of compaction will be obtained with the equipment used. The fill material shall contain sufficient moisture so that if formed into a ball it will not crumble, yet not be so wet that water can be squeezed out.

When required by the reviewing agency the minimum required density shall not be less than 95% of maximum dry density with a moisture content within ± 2% of the optimum. Each layer of fill shall be compacted as necessary to obtain that density, and is to be certified by the Engineer at the time of construction. All compaction is to be determined by AASHTO Method T-99 (Standard Proctor).

Cut Off Trench - The cutoff trench shall be excavated into impervious material along or parallel to the centerline of the embankment as shown on the plans. The bottom width of the trench shall be governed by the equipment used for excavation, with the minimum width being four feet. The depth shall be at least four feet below existing grade or as shown on the plans. The side slopes of the trench shall be 1 to 1 or flatter. The backfill shall be compacted with construction equipment, rollers, or hand tampers to assure maximum density and minimum permeability.

Embankment Core - The core shall be parallel to the centerline of the embankment as shown on the plans. The top width of the core shall be a minimum of four feet. The height shall extend up to at least the 10 year water elevation or as shown on the plans. The side slopes shall be 1 to 1 or flatter. The core shall be compacted with construction equipment, rollers, or hand tampers to assure maximum density and minimum permeability. In addition, the core shall be placed concurrently with the outer shell of the embankment.

Structure Backfill

Backfill adjacent to pipes or structures shall be of the type and quality conforming to that specified for the adjoining fill material. The fill shall be placed in horizontal layers not to exceed four inches in thickness and compacted by hand tampers or other manually directed compaction equipment. The material needs to fill completely all spaces under and adjacent to the pipe. At no time during the backfilling operation shall driven equipment be allowed to operate closer than four feet, measured horizontally, to any part of a structure. Under no circumstances shall equipment be driven over any part of a concrete structure or pipe, unless there is a compacted fill of 24" or greater over the structure or pipe.

Structure backfill may be flowable fill meeting the requirements of Maryland Department of Transportation, State Highway Administration Standard Specifications for Construction and Materials, Section 313 as modified. The mixture shall have a 100-200 psi; 28 day unconfined compressive strength. The flowable fill shall have a minimum pH of 4.0 and a minimum resistivity of 2,000 ohm-cm. Material shall be placed such that a minimum of 6" (measured perpendicular to the outside of the pipe) of flowable fill shall be under (bedding), over and, on the sides of the pipe. It only needs to extend up to the spring line for rigid conduits. Average slump of the fill shall be 7" to assure flowability of the material. Adequate measures shall be taken (sand bags, etc.) to prevent floating the pipe. When using flowable fill, all metal pipe shall be bituminous coated. Any adjoining soil fill shall be placed in horizontal layers not to exceed four inches in thickness and compacted by hand tampers or other manually directed compaction equipment. The material shall completely fill all voids adjacent to the flowable fill zone. At no time during the backfilling operation shall driven equipment be allowed to operate closer than four feet, measured horizontally, to any part of a structure. Under no circumstances shall equipment be driven over any part of a structure or pipe unless there is a compacted fill of 24" or greater over the structure or pipe. Backfill material outside the structural backfill (flowable fill) zone shall be of the type and quality conforming to that specified for the core of the embankment or other embankment materials.

Pipe Conduits

All pipes shall be circular in cross section.

Corrugated Metal Pipe - All of the following criteria shall apply for corrugated metal pipe:

1. Materials - (Polymer Coated steel pipe) - Steel pipes with polymeric coatings shall have a minimum coating thickness of 0.01 inch (10 mil) on both sides of the pipe. This pipe and its appurtenances shall conform to the requirements of AASHTO Specifications M-245 & M-246 with watertight coupling bands or flanges.

   Materials - (Aluminum Coated Steel Pipe) - This pipe and its appurtenances shall conform to the requirements of AASHTO Specification M-274 with watertight coupling bands or flanges. Aluminum Coated Steel Pipe, when used with flowable fill or when soil and/or water conditions warrant the need for increased durability, shall be fully bituminous coated per requirements of AASHTO Specification M-190 Type A. Any aluminum coating damaged or otherwise removed shall be replaced with cold applied bituminous coating compound. Aluminum surfaces that are to be in contact with concrete shall be painted with one coat of zinc chromate primer or two coats of asphalt.

   Materials - (Aluminum Pipe) - This pipe and its appurtenances shall conform to the requirements of AASHTO Specification M-196 or M-211 with watertight coupling

bands or flanges. Aluminum Pipe, when used with flowable fill or when soil and/or water conditions warrant for increased durability, shall be fully bituminous coated per requirements of AASHTO Specification M-190 Type A. Aluminum surfaces that are to be in contact with concrete shall be painted with one coat of zinc chromate primer or two coats of asphalt. Hot dip galvanized bolts may be used for connections. The pH of the surrounding soils shall be between 4 and 9.

2. Coupling bands, anti-seep collars, end sections, etc., must be composed of the same material and coatings as the pipe. Metals must be insulated from dissimilar materials with use of rubber or plastic insulating materials at least 24 mils in thickness.

3. Connections - All connections with pipes must be completely watertight. The drain pipe or barrel connection to the riser shall be welded all around when the pipe and riser are metal. Anti-seep collars shall be connected to the pipe in such a manner as to be completely watertight. Dimple bands are not considered to be watertight.

   All connections shall use a rubber or neoprene gasket when joining pipe sections. The end of each pipe shall be re-rolled an adequate number of corrugations to accommodate the bandwidth. The following type connections are acceptable for pipes less than 24 inches in diameter: flanges on both ends of the pipe with a circular 3/8 inch closed cell neoprene gasket, prepunched to the flange bolt circle, sandwiched between adjacent flanges; a 12-inch wide standard lap type band with 12-inch wide by 3/8-inch thick closed cell circular neoprene gasket; and a 12-inch wide hugger type band with o-ring gaskets having a minimum diameter of 1/2 inch greater than the corrugation depth. Pipes 24 inches in diameter and larger shall be connected by a 24 inch long annular corrugated band using a minimum of 4 (four) rods and lugs, 2 on each connecting pipe end. A 24-inch wide by 3/8-inch thick closed cell circular neoprene gasket will be installed with 12 inches on the end of each pipe. Flanged joints with 3/8 inch closed cell gaskets the full width of the flange is also acceptable.

   Helically corrugated pipe shall have either continuously welded seams or have lock seams with internal caulking or a neoprene bead.

4. Bedding - The pipe shall be firmly and uniformly bedded throughout its entire length. Where rock or soft, spongy or other unstable soil is encountered, all such material shall be removed and replaced with suitable earth compacted to provide adequate support.

5. Backfilling shall conform to "**Structure Backfill**".

6. Other details (anti-seep collars, valves, etc.) shall be as shown on the drawings.

Reinforced Concrete Pipe - All of the following criteria shall apply for reinforced concrete pipe:

1. Materials - Reinforced concrete pipe shall have bell and spigot joints with rubber gaskets and shall equal or exceed ASTM C-361.

2. Bedding - Reinforced concrete pipe conduits shall be laid in a concrete bedding / cradle for their entire length. This bedding / cradle shall consist of high slump concrete placed under the pipe and up the sides of the pipe at least 50% of its outside diameter with a minimum thickness of 6 inches. Where a concrete cradle is not needed for structural reasons, flowable fill may be used as described in the "Structure Backfill" section of this standard. Gravel bedding is not permitted.

3. Laying pipe - Bell and spigot pipe shall be placed with the bell end upstream. Joints shall be made in accordance with recommendations of the manufacturer of the material. After the joints are sealed for the entire line, the bedding shall be placed so that all spaces under the pipe are filled. Care shall be exercised to prevent any deviation from the original line and grade of

the pipe. The first joint must be located within 4 feet from the riser.

4. Backfilling shall conform to "**Structure Backfill**".

5. Other details (anti-seep collars, valves, etc.) shall be as shown on the drawings.

Plastic Pipe - The following criteria shall apply for plastic pipe:

1. Materials - PVC pipe shall be PVC-1120 or PVC-1220 conforming to ASTM D-1785 or ASTM D-2241. Corrugated High Density Polyethylene (HDPE) pipe, couplings and fittings shall conform to the following: 4" – 10" inch pipe shall meet the requirements of AASHTO M252 Type S, and 12" through 24" inch shall meet the requirements of AASHTO M294 Type S.

2. Joints and connections to anti-seep collars shall be completely watertight.

3. Bedding -The pipe shall be firmly and uniformly bedded throughout its entire length. Where rock or soft, spongy or other unstable soil is encountered, all such material shall be removed and replaced with suitable earth compacted to provide adequate support.

4. Backfilling shall conform to "**Structure Backfill**".

5. Other details (anti-seep collars, valves, etc.) shall be as shown on the drawings.

Drainage Diaphragms - When a drainage diaphragm is used, a registered professional engineer will supervise the design and construction inspection.

Concrete

Concrete shall meet the requirements of Maryland Department of Transportation, State Highway Administration Standard Specifications for Construction and Materials, Section 414, Mix No. 3.

Rock Riprap

Rock riprap shall meet the requirements of Maryland Department of Transportation, State Highway Administration Standard Specifications for Construction and Materials, Section 311.

Geotextile shall be placed under all riprap and shall meet the requirements of Maryland Department of Transportation, State Highway Administration Standard Specifications for Construction and Materials, Section 921.09, Class C.

Care of Water during Construction

All work on permanent structures shall be carried out in areas free from water. The Contractor shall construct and maintain all temporary dikes, levees, cofferdams, drainage channels, and stream diversions necessary to protect the areas to be occupied by the permanent works. The contractor shall also furnish, install, operate, and maintain all necessary pumping and other equipment required for removal of water from various parts of the work and for maintaining the excavations, foundation, and other parts of the work free from water as required or directed by the engineer for constructing each part of the work. After having served their purpose, all temporary protective works shall be removed or leveled and graded to the extent required to prevent obstruction in any degree whatsoever of the flow of water to the spillway or outlet works and so as not to interfere in any way with the operation or maintenance of the structure. Stream diversions shall be maintained until the full flow can be passed through the permanent works. The removal of water from the required excavation and the foundation shall be accomplished in a manner and to the extent that will maintain stability of the excavated slopes and bottom required excavations and will allow satisfactory performance of all construction operations. During the placing and compacting of material in required excavations, the water level at the locations being refilled shall be maintained below the bottom of the excavation at such locations which may require draining the water sumps from which the water shall be pumped.

Stabilization

All borrow areas shall be graded to provide proper drainage and left in a sightly condition. All exposed surfaces of the embankment, spillway, spoil and borrow areas, and berms shall be stabilized by seeding, liming, fertilizing and mulching in accordance with the Natural Resources Conservation Service Standards and Specifications for Critical Area Planting (MD-342) or as shown on the accompanying drawings.

Erosion and Sediment Control

Construction operations will be carried out in such a manner that erosion will be controlled and water and air pollution minimized. State and local laws concerning pollution abatement will be followed. Construction plans shall detail erosion and sediment control measures.

OPERATION AND MAINTENANCE

An operation and maintenance plan in accordance with Local or State Regulations will be prepared for all ponds. As a minimum, the dam inspection checklist located in Appendix A shall be included as part of the operation and maintenance plan and performed at least annually. Written records of maintenance and major repairs needs to be retained in a file. The issuance of a Maintenance and Repair Permit for any repairs or maintenance that involves the modification of the dam or spillway from its original design and specifications is required. A permit is also required for any repairs or reconstruction that involve a substantial portion of the structure. All indicated repairs are to be made as soon as practical.

SUPPORTING DATA AND DOCUMENTATION

Field Data and Survey Notes

The following is a list of the minimum data needed:

1. Profile along centerline of structure.
2. Profile along centerline of principal spillway.
3. Profile along centerline of emergency spillway.
4. Survey of storage area to develop topography and storage volumes.
5. Soil investigation logs and notes.

Design Data

Record on appropriate engineering paper. The following is a list of the minimum required design data:

1. Determine pond class and list appropriate spillway design criteria, including map.
2. Determine peak runoff from the contributing area for the design storms selected, including topo map.
3. Develop a stage-storage/discharge curve for the site.
4. Determine the pipe spillway by storm routing using the procedure in the SWM Pond Design Manual; Chapter 11, EFH; Chapter 6, TR-55; or TR-20.
5. Design emergency spillway using EFH 11-61.
6. Drawings should show the following as a minimum: profile along centerline of dam; profile along centerline of emergency spillway; cross section through dam at principal spillway; cross section through emergency spillway; plan view; and construction details & notes and soil logs.
7. Compute earth fill (if needed).
8. Special design feature details; watering, fire hydrants, fish management, irrigation, outfall stabilization, etc.; structural details with design loadings, if applicable, should be shown on the drawings.
9. Complete data required on MD-ENG-14.
10. Record seeding plan on drawings or MD-CONS-10.
11. A written Operation and Maintenance Plan.

Construction Check Data/As-built

Record on survey note paper, SCS-ENG-28. Survey data for ponds will be plotted in red. All construction inspection visits shall be recorded on the CPA-6 or appropriate documentation paper. The documentation shall include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom. The following is a list of the minimum data needed for As-Builts:

1. A profile of the top of the dam.
2. A cross-section of the emergency spillway at the control section.
3. A profile along the centerline of the emergency spillway.
4. A profile along the centerline of the principal spillway extending at least 100 feet downstream of the fill.
5. The elevation of the principal spillway crest.
6. The elevation of the principal spillway conduit invert (inlet and outlet).
7. The diameter, length, thickness and type of material for the riser.
8. The diameter, length, and type of material for the conduit.
9. The size and type of anti-vortex and trash rack device and its elevations in relation to the principal spillway crest.

10. The number, size and location of the anti-seep collars.

11. The diameter and size of any low stage orifices or drain pipes.

12. Show the length, width, and depth of contours of the pool area so that design volume can be verified.

13. Notes and measurements to show that any special design features were met.

14. Statement on seeding and fencing.

15. Notes on site clean up and disposal.

16. Sign and date check notes to include statement that practice meets or exceeds plans and specifications.

REFERENCES

1. *AWWA Standards*, American Water Works Association, Denver, Colorado.

2. *ASTM Standards*, American Society for Testing and Materials, Philadelphia, Pennsylvania.

3. *Engineering Field Handbook, Part 650*, USDA, Soil Conservation Service.

4. *Handbook of PVC Pipe Design and Construction*, First Edition, Uni-Bell Plastic Pipe Association, Dallas, Texas, 1980.

5. *Handbook of Steel Drainage and Highway Construction Products*, Third Edition, American Iron and Steel Institute, Washington, D.C., 1983.

6. *Maryland Dam Safety Manual*, Maryland Department of Natural Resources, Water Resources Administration, Annapolis, Maryland, June 1993.

7. *Maryland Technical Guide, Section IV, Standards and Specifications*, USDA, Natural Resources Conservation Service.

8. *National Engineering Handbook, Section 4, Hydrology*, USDA, Natural Resources Conservation Service, March 1985.

9. *National Engineering Handbook, Section 5, Hydraulics*, USDA, Natural Resources Conservation Service, August 1956.

10. *National Engineering Handbook, Section 11, Drop Spillways*, USDA, Natural Resources Conservation Service, April 1968.

11. *National Engineering Handbook, Section 14, Chute Spillways*, USDA, Natural Resources Conservation Service, October 1977.

12. *National Handbook of Conservation Practices*, USDA, Natural Resources Conservation Service.

13. *Standard Specifications for Materials and Methods of Sampling and Testing*, Nineteenth Edition, American Association of State Highway and Transportation Officials, Washington D.C., 1998.

14. *Standard Specifications for Construction and Materials*, Maryland Department of Transportation, State Highway Administration, Baltimore, Maryland, October 1993.

15. Technical Release No. 20, *Computer Programs for Project Formulation Hydrology*, USDA, Natural Resources Conservation Service, 1992.

16. Technical Release No. 55, *Urban Hydrology for Small Watersheds*, USDA, Natural Resources Conservation Service, 1986.

17. Technical Release No. 56, *A Guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments*, USDA, Natural Resources Conservation Service, 1974.

18. Technical Release No. 60, *Earth Dams and Reservoirs*, USDA, Natural Resources Conservation Service, 1985.

19. Technical Release 69, *Riprap for Slope Protection Against Wave Action*, USDA, Natural Resources Conservation Service, 1983.

20. Technical Release No. 77, *Design and Installation of Flexible Conduits*, USDA, Natural Resources Conservation Service, 1990.

21. *National Engineering Handbook, Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters*, USDA, Natural Resources Conservation Service, October 1994.

APPENDIX A

DAM INSPECTION CHECKLIST

To help the dam owner perform periodic safety inspections of the structure, a checklist is provided. Each item of the checklist should be completed. **Repair** is required when obvious problems are observed. **Monitoring** is recommended if there is potential for a problem to occur in the future. **Investigation** is necessary if the reason for the observed problem is not obvious.

A brief description should be made of any noted irregularities, needed maintenance, or problems. Abbreviations and short descriptions are recommended. Space at the bottom of the form should be used for any items not listed.

DAM _____ **DATE** _____ **OWNER** _____ **WEATHER** _____ **INSPECTED BY** _____ **POOL LEVEL** _____		Y/N	MONITOR	REPAIR	INVESTIGATE
Item	Comments				
1. CREST					
a. Visual settlement?					
b. Misalignment?					
c. Cracking?					
2. UPSTREAM SLOPE					
a. Erosion?					
b. Ground cover in good condition?					
c. Trees, shrubs, or other woody vegetation?					
d. Longitudinal/Vertical cracks?					
e. Adequate riprap protection?					
f. Stone deterioration?					
g. Settlements, depressions, or bulges?					
3. DOWNSTREAM SLOPE					
a. Erosion?					
b. Ground cover in good condition?					
c. Trees, shrubs, or other woody vegetation?					
d. Longitudinal/Vertical cracks?					
e. Riprap protection adequate?					
f. Settlements, depressions, or bulges?					
g. Soft spots or boggy areas?					
h. Movement at or beyond toe?					
i. Boils at toe?					
4. DRAINAGE-SEEPAGE CONTROL					
a. Internal drains flowing?	Est. Left _____ gpm Est. Right _____ gpm				
b. Seepage at toe?	Estimated _____ gpm				
c. Does seepage contain fines?					

INSPECTION CHECKLIST - PAGE 2

INSPECTED BY _____ **DATE** _____

Item	Comments	Y/N	MONITOR	REPAIR	INVESTIGATE
5. ABUTMENT CONTACTS					
a. Erosion?					
b. Differential movement?					
c. Cracks?					
d. Seepage?	Estimated _____ gpm				
e. Adequate erosion protection for ditches?					
6. INLET STRUCTURE	Concrete or Metal Pipe (circle one)				
a. Seepage into structure?					
b. Debris or obstructions?					
c. If concrete, do surfaces show:					
1. Spalling?					
2. Cracking?					
3. Erosion?					
4. Scaling?					
5. Exposed reinforcement?					
6. Other?					
d. If metal, do surfaces show:					
1. Corrosion?					
2. Protective Coating deficient?					
3. Misalignment or split seams?					
e. Do the joints show:					
1. Displacement or offset?					
2. Loss of joint material?					
3. Leakage?					
f. Are the trash racks:					
1. Broken or bent?					
2. Corroded or rusted?					
3. Obstructed?					
4. Operational?					
g. Sluice/Drain gates:					
1. Broken or bent?					
2. Corroded or rusted?					
3. Leaking?					
4. Not seated correctly?					
4. Periodically maintained?					
5. Operational?					

INSPECTION CHECKLIST - PAGE 3

INSPECTED BY _____ **DATE** _____

Item	Comments	Y/N	MONITOR	REPAIR	INVESTIGATE
7. PRINCIPAL SPILLWAY PIPE	Concrete or Metal Pipe (circle one)				
a. Seepage into conduit?					
b. Debris present?					
c. Do concrete surfaces show:					
1. Spalling?					
2. Cracking?					
3. Erosion?					
4. Scaling?					
5. Exposed reinforcement?					
6. Other?					
d. Do the joints show:					
1. Displacement or offset?					
2. Loss of joint material?					
3. Leakage?					
8. STILLING BASIN/POOL	Riprap or Concrete (circle one)				
a. If concrete, condition of surfaces?					
b. Deterioration or displacement of joints?					
c. Outlet channel obstructed?					
d. Is released water:					
1. Undercutting the outlet?					
2. Eroding the embankment?					
3. Displacing riprap?					
4. Scouring the plunge pool?					
e. Tailwater elevation and flow condition:					
9. EMERGENCY SPILLWAY					
a. Is the channel:					
1. Eroding or backcutting?					
2. Obstructed?					
b. Trees or shrubs in the channel?					
c. Seepage present?					
d. Soft spots or boggy areas?					
e. Channel slopes eroding or sloughing?					
10. RESERVOIR					
a. High water marks?					
b. Erosion/Slides into pool area?					
c. Sediment accumulation?					
d. Floating debris present?					
e. Adequate riprap protection for ditches?					

APPENDIX B

ROADWAY EMBANKMENT DESIGN CRITERIA

HW - TW > 10'* AND HW/D > 2, OR PERMANENT POOL > 3' OR PROPOSED RISER

No → **NO SPECIAL DESIGN**

Yes ↓

MEETS SMALL POND CRITERIA, AND CLASS "A"

No → **MDE DAM SAFETY REVIEW**

Yes ↓

8:1 PROJECTION LINE INTERSECTS DOWNSTREAM SLOPE OF THE EMBANKMENT

No → **SPECIAL EMBANKMENT DESIGN**

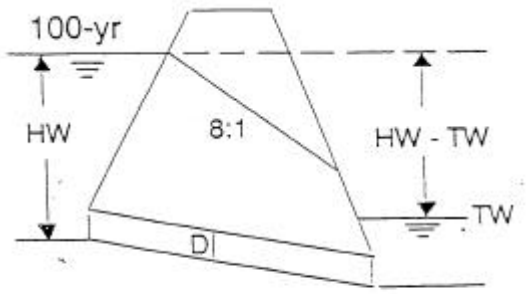
Yes ↓

MD 378 Design

Use any nonorganic soils for the embankment, elimination of the cut-off trench and core based on approval of geotechnical engineer and acceptable to local jurisdictions.

Filter diaphragm is required.

All other MD 378 criteria apply.



* Use HW when TW is below the inlet invert elevation.