Pond (No.) 378

DEFINITION

A water impoundment made by constructing 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 the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at the auxiliary spillway elevation is 3 feet or more.

PURPOSES

To provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard irrigation, and other related uses, and to maintain or improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

This standard establishes the minimum acceptable quality for the design and construction of low hazard ponds where:

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

2. The effective height of the dam is 35 feet (10.7m) or less. The effective height of the dam is the difference in elevation, in feet, between the auxiliary spillway crest and the lowest point in the cross-section taken along the centerline of the dam. If there is no auxiliary spillway, the design top of the dam is the upper limit.

3. The product of the storage times the effective height of the dam is less than 3,000 (1,130,000). Storage is the volume, in acre-feet (m^3), in the reservoir below the elevation of the crest of the auxiliary spillway.

GENERAL CRITERIA APPLICABLE TO ALL PONDS

Ponds shall be planned, designed, and constructed to comply with all federal, state, tribal, and local laws and regulations.

Vegetation

A protective cover of vegetation shall be established on all exposed areas of embankments, spillways, and borrow areas as climatic conditions allow according to the guidelines in NRCS-Michigan Standard Critical Area Planting (342).

Site Conditions

Site conditions shall be such that runoff from the design storm can be safely passed through:

- A vegetated spillway.
- A lined spillway.
- A pipe conduit spillway.
- A combination of any of the above spillways.

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. The drainage area shall be large enough so that surface runoff and groundwater will provide an adequate supply of water for the intended purpose unless an alternate water source exists to serve this purpose. The quality shall be suitable for the water's intended use.

Reservoir Area

The topography and geology of the site shall permit storage of water at a depth and volume that will ensure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

Water shall not be impounded on land that is not owned by the landowner without written permission from the affected landowner.

If livestock will water directly from the pond, a watering ramp of ample width and stable surface shall be provided. The ramp shall extend to the anticipated

low water elevation at a slope no steeper than five horizontal to one vertical.

Excavated side slopes of the reservoir shoreline shall be stable and shall not be steeper than two horizontal to one vertical.

DESIGN CRITERIA FOR EMBANKMENT PONDS

Geologic Investigation

A subsurface investigation is required for all embankment ponds. Subsurface investigations shall be conducted by individuals trained in soil science, engineering, geology, or a related field. The number and depth of test holes, pits, or borings will vary depending on the planned embankment height and length and the conditions encountered during the investigation such as the complexity of the soils, the depth to groundwater, and the presence or absence of seeps. At a minimum, there shall be one test hole, pit, or boring for each 200 feet (60m) of planned embankment, plus at least one test hole, pit, or boring for the auxiliary spillway, if applicable. The log for each test hole, pit, or boring shall indicate the following:

- Existing ground surface elevation.
- A description of the soil material encountered using the Unified Classification System.
- Depth to changes in the soil material encountered.
- Depth to any seeps encountered.
- Depth to high water table (note method of determination: mottling, free water encountered, etc.).
- Depth to bottom of test hole, pit, or boring.

The location and log information for all test holes, pits, and/or borings in or near the structure shall be shown on the construction drawings.

Foundation Cutoff

A cutoff of relatively impervious material shall be provided under the embankment, if necessary, to reduce seepage through the foundation. The cutoff shall be located at or upstream from the centerline of the embankment. It shall extend up the abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable embankment when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall not be steeper than one horizontal to one vertical.

Seepage Control

Seepage control is to be included if:

- Pervious layers are not intercepted by the cutoff,
- Seepage could create swamping downstream,
- Such control is needed to ensure a stable embankment, or
- Special problems require drainage for a stable embankment.

Seepage may be controlled by:

- Foundation, abutment, or embankment drains,
- Reservoir blanketing, or
- A combination of these measures.

Embankment

Unsuitable foundation material such as organic matter, grasses, weeds, sod, debris, soft soils, and stones larger than 12 inches (30cm) in diameter shall be removed from the foundation before earth fill is placed.

Top Width. The minimum top width for an embankment is shown in Table 1. If the embankment top is to be used as a public road, the minimum width shall be 16 feet (5m) for one-way traffic and 26 feet (8m) for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority. If the embankment is to be used for maintenance or farm roads, a minimum top width of 12 feet (3.7m) shall be used.

TABLE 1
Minimum Top Width for Embankments

Total Height of Embankment *Feet (m)*	Top Width *Feet (m)*
Less than 10 (3)	6 (1.8)
10–14.9 (3-4.5)	8 (2.4)
15-19.9 (4.5-6)	10 (3)
20-24.9 (6-7.5)	12 (3.6)
25-34.9 (7.5-10.7)	14 (4.2)

Top widths for wetland restorations shall be as required by this standard or NRCS-Michigan Standard Wetland Restoration (657), whichever requires wider top widths.

Side Slopes. The combined upstream and downstream side slopes of the settled embankments shall not be less than five horizontal to one vertical, and neither slope shall be steeper than two horizontal to one vertical. All slopes shall be designed to be stable. Flatter side slopes and/or berms may be used to achieve stable slopes.

Side slopes for wetland restorations shall be as required by this standard or NRCS-Michigan Standard Wetland Restoration (657), whichever requires flatter slopes.

Slope Protection. If needed to protect the slopes of the embankment from erosion, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (Technical Release 56, "A Guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments" and Technical Release 69, "Riprap for Slope Protection Against Wave Action" contain design guidance).

Freeboard. The minimum elevation of the top of the settled embankment shall be 1 foot (0.3m) above the water surface in the reservoir, with the auxiliary spillway flowing at design depth. The minimum difference in elevation between the crest of the auxiliary spillway and the settled top of the embankment shall be 2 feet (0.6m) for all dams having more than a 20 acre (8ha) drainage area or more than 20 feet (6m) in effective height.

Settlement. The design height of the embankment shall be increased by the amount needed to ensure that after settlement the height of the embankment equals or exceeds the design height. This increase shall not be less than 5 percent for mineral foundation soil and 33 percent for organic foundation soil to allow for settlement, except where detailed soil testing and laboratory analysis shows a lesser amount is adequate.

Compaction. Compaction of the earthfill materials shall be appropriate for the requirements of the site (NCS-Michigan Construction Specification MI-154, Earthfill, contains construction guidance).

Spillways

A pipe conduit principal spillway, with needed appurtenances, shall be placed under or through the embankment, except where rock, concrete, or other types of lined spillways are used, or where the rate and duration of flow can be safely handled by a vegetated or earth spillway.

The principal spillway, auxiliary spillway, or a combination of auxiliary spillway and principal spillway, as allowed, shall safely pass the total design storm shown in Table 2 less any reduction creditable to detention storage. If a principal spillway pipe conduit diameter is 10 inches (25cm) or greater, its design discharge may be considered when calculating the peak outflow rate through the auxiliary spillway. When design discharge of a principal spillway pipe is considered in calculating peak outflow through the auxiliary spillway, the crest elevation of the inlet shall be such that the design discharge will be generated in the pipe before there is discharge through the auxiliary spillway.

TABLE 2
Minimum Spillway Capacities

Drainage Area	Effective Height of Dam [1]	Storage [1]	Minimum Frequency of Design - 24-Hour Duration Storm [2]	
			Principal Spillway Capacity	Total Capacity
Acre (ha)	*Feet (m)*	*Acre-feet (ha-m)*	*Years*	*Years*
20 or less (8 or less)	20 or less (6 or less)	< 50 (< 6)	none	10
20 or less (8 or less)	> 20 (> 6)	< 50 (< 6)	5	25
> 20 (> 8)		< 50 (< 6)	5	25
All others			10	50

1 As defined under "Conditions Where Practice Applies."
2 Select rain distribution based on climatological region.

An auxiliary spillway must be provided for each dam, unless the principal spillway is large enough to pass the peak discharge from the routed design hydrograph and the trash that comes to it without overtopping the dam. The following are minimum criteria for acceptable use of a closed conduit principal spillway without an auxiliary spillway:

- Conduit with a cross-sectional area of 3 square feet ($0.25m^2$) or more.
- An inlet that will not clog.
- An elbow designed to facilitate the passage of trash.

When routing for detention, the starting water elevation shall be either at the elevation of the crest of the principal spillway or at the 10 days' drawdown of the routed principal spillway design storm, whichever is higher. The 10-day drawdown shall be computed from the crest of the auxiliary spillway or from the elevation that would be attained if the entire principal spillway design storm were impounded, whichever is lower. Auxiliary spillways shall provide for passing the design flow at a safe velocity to a point downstream where the dam will not be endangered.

Lined Spillways

If lined chutes or drops are used for principal spillways and/or auxiliary spillways, they shall be designed according to the principles set forth in the National Engineering Handbook, Part 650, Engineering Field Handbook, and the National Engineering Handbook, Section 5, Hydraulics; Section 11, Drop Spillways; and Section 14, Chute Spillways.

Where rock riprap lined spillways are used, the rock shall be stable for the total capacity design storm.

The minimum capacity of a lined spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2, less any reduction creditable to conduit discharge and detention storage.

Vegetated Spillways

Constructed vegetated spillways are open channels that usually consist of an inlet channel, a control section, and an exit channel. They shall be trapezoidal and shall be located in undisturbed or compacted earth. The side slopes shall be stable for the material in which the spillway is to be constructed. For dams having an effective height exceeding 20 feet (6m), the vegetated spillway shall have a bottom width of not less than 10 feet (3m).

Upstream from the control section, the inlet channel shall be level for the distance needed to protect and maintain the crest elevation of the spillway. The inlet channel may be curved to fit existing topography. The grade of the exit channel of a constructed auxiliary spillway shall fall within the range established by discharge requirements and permissible velocities. The exit channel shall have a straight alignment where supercritical flow is possible.

Pipe Conduit Spillways

Elevation. For dams with a drainage area of 20 acres (8ha) or less, the principal spillway pipe conduit crest elevation shall not be less than 0.5 feet (15cm) below the auxiliary spillway crest elevation. For dams with a drainage area over 20 acres (8ha), this difference shall not be less than 1.0 foot (30cm).

Pressure Flow. Pipe conduits designed for pressure flow must have adequate anti-vortex devices. The inlets and outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

Size. The diameter of the principal spillway pipe shall not be less than 4 inches (10cm). Pipe conduits used solely as a supply pipe through the embankment for watering troughs and other appurtenances shall not be less than 1-1/4 inches (3.2cm) in diameter.

Pipe Structural Design. Pipe conduits shall be designed and installed to withstand all external and internal loads without yielding, buckling, or cracking. Rigid pipe shall be designed for a positive projecting condition. Flexible pipe shall be designed for a maximum deflection of 5 percent. The modulus of elasticity for polyvinyl chloride (PVC) pipe shall be assumed as one-third of the amount designated by the compound cell classification to account for long-term reduction in modulus of elasticity. Different reductions in modulus may be appropriate for other plastic pipe materials.

The inlets and outlets shall be structurally sound and made of materials compatible with those of the pipe. All pipe conduits shall be designed and installed to be watertight by means of couplings, gaskets, caulking, waterstops, or welding. Joints shall be designed to remain watertight under all internal and external loading including pipe elongation due to foundation settlement.

Cantilever outlet sections shall be designed to withstand the cantilever load. Pipe supports shall be provided when needed.

Materials. Pipe conduits shall be ductile iron, corrugated steel, corrugated aluminum, reinforced concrete (pre-cast or site-cast), or plastic. Pipe conduits through dams of less than 20 feet (6.1m) total height may also be cast iron or unreinforced concrete.

Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet-resistant materials and protected by coating or shielding, or provisions for replacement should be made as necessary. Connections of plastic pipe to less flexible pipe or structures must be designed to avoid stress concentrations that could rupture the plastic.

Flexible Pipe. The minimum thickness of flexible pipe shall be SDR 26, Schedule 40, Class 100, or 16 gage as appropriate for the particular pipe material. Connections of flexible pipe to rigid pipe or other structures shall be designed to accommodate differential movements and stress concentrations.

Specifications in Tables 3 and 4 are to be followed for (PVC) and Polyethylene (PE) pipe.

Specifications in Table 5 are to be followed for corrugated metal pipe.

TABLE 3
Acceptable PVC Pipe for Use in Earth Dams [1]

Nominal Pipe Size *Inch (cm)*	Schedule or Standard Dimension Ratio (SDR)	Maximum Depth of Fill Over Pipe *Feet (m)*
4 (10) or less	Schedule 40	15 (4.5)
	Schedule 80	20 (6)
	SDR 26	10 (3)
6-12 (15-30)	Schedule 40	10 (3)
	Schedule 80	15 (4.5)
	SDR 26	10 (3)

1 Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ATSM-D-1785 or ATSM-D-2241.

TABLE 4
Acceptable PE Pipe for Use in Earth Dams [1]

Nominal Pipe Size *Inch (cm)*	Material and Schedule or Wall Type	Maximum Depth of Fill Over Pipe *Feet (m)*
8-24 (20-60)	PE single	20 (6)
8-60 (20-155)	PE double	20 (6)

1 Polyethylene (PE) pipe will conform to one or more of the following standards: ASTM F 405, ASTM F 667, AASHTO M 252, or AASHTO M 294.

TABLE 5
Minimum Gage for Corrugated Metal Pipe
[2-2/3-inch x 1/2-inch
(70mm x 13mm) corrugations] [1]

Fill Height in Feet (m)	Minimum gauge for steel pipe with diameter of inches(cm) of:					
	21 (55) and less	24 (60)	30 (75)	36 (90)	42 (110)	48 (120)
1–20 (0.3-6)	16	16	16	14	12	10
20–25 (6-7.5)	16	16	14	12	10	10

Fill Height in Feet (m)	Minimum thickness in inches(mm) for aluminum pipe [2] with diameter of inches(cm) of:			
	21 (55) and less	24 (60)	30 (75)	36 (90)
1-15 (0.3-4.5)	0.06 (1.5)	0.06 (1.5)	0.075 (1.9)	0.075 (1.9)
15-20 (4.5-6)	0.06 (1.5)	0.075 (1.9)	0.105 (2.7)	0.105 (2.7)
20-25 (6-7.5)	0.06 (1.5)	0.105 (2.7)	0.105 (2.7)	-- [3]

1 Pipe with 6, 8, and 10-inch (15, 20, and 25cm) diameters has 1-1/2-inch x 1/4-inch (38mm x 6mm) corrugations.
2 Riveted or helical fabrication.
3 Not permitted.

Coatings and Cathodic Protection for Steel Pipe. All steel pipe and couplings shall have protective coatings in areas that have traditionally experienced pipe corrosion, or in embankments with saturated soil resistivity less than 4,000 ohms-cm or soil pH less than 5. Protective coatings shall be asphalt, polymer over galvanizing, aluminized coating, or coal tar enamel as appropriate for the pipe type.

Cathodic protection is to be provided for galvanized corrugated metal pipe where soil and resistivity studies indicate that the pipe needs a protective coating, and where the need and importance of the structure warrant additional protection and longevity. If cathodic protection is not provided for in the original design and installation, electrical continuity in the form of joint-bridging straps should be considered on pipes that have protective coatings. Cathodic protection should be added later if monitoring indicates the need.

Seepage Control/Drainage Diaphragm. Seepage control along a pipe conduit spillway shall be provided by use of a drainage diaphragm if any of the following conditions exist:

1. The effective height of dam is greater than 15 feet (4.5m).
2. The conduit is of smooth pipe larger than 8 inches (20cm) in diameter.
3. The conduit is of corrugated pipe larger than 12 inches (30cm) in diameter.

The drainage diaphragm shall function both as a filter for adjacent base soils and a drain for seepage that it intercepts. The drainage diaphragm shall consist of sand meeting the requirements of ASTM C-33, for fine aggregate, or Michigan DOT 2NS. If unusual soil conditions exist such that this material may not meet the required filter or capacity requirements, a special design analysis shall be made.

The drainage diaphragm shall be a minimum of 2 feet (60cm) thick. It shall extend vertically above the pipe at least three times the outside pipe diameter but no higher than 1 foot below the top of the embankment. It shall extend horizontally at least three times the outside pipe diameter on each side of the pipe. It shall extend vertically downward at least 18 inches (45cm) beneath the conduit invert. The drainage diaphragm shall be located immediately downstream of the cutoff trench, but downstream of the centerline of the embankment if the cutoff is upstream of the centerline.

The drainage diaphragm shall be outletted at the embankment downstream toe using a drain backfill envelope continuously along the pipe to where it exits the embankment. The drainfill shall be outletted through a riprap section. The drainfill shall be protected from piping through the riprap by placement of an 8 ounce or greater per square yard ($271 g/m^3$) nonwoven geotextile or properly graded gravel between the drainfill and riprap.

Trash Guard. To prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser.

Design Criteria For Excavated Ponds

Geologic Investigation

A subsurface investigation is required for all excavated ponds. Subsurface investigations shall be conducted by individuals trained in soil science, engineering, geology, or a related field. The number and depth of test holes, pits, or borings will vary depending on the planned pond size and length and the conditions encountered during the investigation such as the complexity of the soils, the depth to groundwater, and the presence or absence of seeps. At a minimum, there shall be one test hole, pit, or boring for each acre (0.4ha) of planned pond area, plus at least one test hole, pit, or boring for the auxiliary spillway, if applicable. The log for each test hole, pit, or boring shall indicate the following:

- Existing ground surface elevation.
- A description of the soil material encountered using the Unified Classification System.
- Depth to changes in the soil material encountered.
- Depth to high water table (note method of determination: mottling, free water encountered, etc.).
- Depth to bottom of test hole, pit, or boring.

The location and log information for all test holes, pits, and/or borings in or near the structure shall be shown on the construction drawings.

Runoff

Provisions shall be made for spillway capacity, if needed, that will meet the capacity requirements of Table 2. Runoff flow patterns shall be considered when locating the excavated pond and placing the spoil.

Inlet Protection

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

Excavated Material

The material excavated from the pond shall be placed so that its weight will not endanger the stability of the pond side slopes and so that it will not be washed back into the pond by rainfall. It shall be shaped to a form that blends with the landscape or hauled off site.

CONSIDERATIONS

Visual resource design

The visual design of ponds should be carefully considered in areas of high public visibility and those associated with recreation. Consider how the shape

and form of ponds, excavated material, and plantings relate visually to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so that it is generally curvilinear rather than rectangular. Excavated material can 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.

Consider building slopes to four horizontal to one vertical where mowing is anticipated.

Cultural Resources. Consider the potential effects of installation and operation of ponds on the cultural, archeological, historic, and economic resources.

Fish and Wildlife. Project location and construction should minimize the impacts to existing fish and wildlife habitat.

Consider retaining trees in the upper reaches of the pond, stumps in the pool area, and other structure to provide fish and wildlife habitat. Upper reaches of the pond can be shaped to provide shallow areas and wetland habitat.

If fish are to be stocked, consider criteria and guidance in NRCS-Michigan Standard Fishpond Management (399).

Vegetation. Stockpiling topsoil for placement on disturbed areas can facilitate revegetation.

Consider placement and selection of vegetation to improve fish and wildlife habitat and species diversity.

PLANS AND SPECIFICATIONS

Plans and specifications for installing ponds shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Support data documentation requirements are as follows:

- Inventory and evaluation records
  - Assistance notes or special report
- Survey notes, where applicable
  - Design survey
  - Construction layout survey
  - Construction check survey
- Design records
  - Physical data, functional requirements, and site constraints, where applicable
  - Soils/subsurface investigation report, where applicable
- Design and quantity calculations
- Construction drawings/specifications with:
  - Location map
  - "Designed by" and "Checked by" names or initials
  - Approval signature
  - Job class designation
  - Initials from preconstruction conference
  - As-built notes
- Construction inspection records
  - Assistance notes or separate inspection records
  - Construction approval signature
- Record of any variances approved, where applicable
- Record of approvals of in-field changes affecting function and/or job class, where applicable

OPERATION AND MAINTENANCE

An Operation and Maintenance (O&M) plan shall be developed for this practice. The O&M plan shall be consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for design.