NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

POND

(Each)

CODE 378

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 the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at spillway elevation is 3 ft or more.

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.

CONDITIONS WHERE PRACTICE APPLIES

Site conditions. Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed auxiliary spillway, (2) a combination of a principal spillway and an auxiliary 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. The drainage area shall be large enough so that surface runoff and groundwater flow will maintain an adequate supply of water in the pond. The quality shall be suitable for the water's intended use.

Reservoir Area. The topography and soils of the site shall permit storage of water at a depth and volume that 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.

Foundation Area. The area on which a dam is to be placed shall consist of material that has sufficient bearing strength to support the dam without excessive consolidation. The foundation must consist of or be underlain by relatively impervious material, which will prevent excess passage of water.

State Laws. All state and local laws, rules and regulations governing pond construction will be strictly adhered to. The landowner or operator is responsible for obtaining all necessary permits from the Vermont Agency of Natural Resources and Army Corps of Engineers.

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

Storage. 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 auxiliary spillway. 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 top of the dam is the upper limit.

Dam Height. The effective height of the dam shall be 35 ft or less, and the dam shall be hazard class (a) or lower.

DESIGN CRITERIA FOR ALL PONDS

Vegetative Protection. A protective cover of vegetation shall be established on all disturbed areas including embankments, spillways, borrow areas and spoil banks in accordance to standard 342 - Critical Area Planting. The embankment and spillway shall be fenced where necessary to protect the vegetation.

Fencing. All stockwater ponds shall be fenced to exclude cattle from the pond area. Where the pond cannot supply a stockwater trough by gravity flow, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than 3 horizontal to 1 vertical

Recommended Pond Size. A stockwater pond shall provide 20 to 30 gallons per cow per day, or 20 cubic yards of water per cow per year with no in flow, or 1500 gallons per day (enough for 72 cows). A fire protection pond shall provide a minimum of 150,000 gallons of storage or a minimum of 75,000 gallons between two feet below full elevation and two feet above bottom elevation. Check local fire departments and insurance regulations. Refer to the appropriate standard in the Vermont Field Office Technical Guide for Wildlife pond size.

DESIGN CRITERIA FOR EMBANKMENT PONDS

Site Investigation. The foundation of dams shall be investigated to the depth of an unyielding and slowly permeable foundation, or to the height of the embankment, which ever is less. The depth of investigation shall be increased when seepage losses may be significant and a relatively impermeable base strata is not encountered within the depth limitations described.

The borrow area shall be investigated to determine that the construction materials available are adequate in quantity and quality to serve the purpose intended. Soil materials testing will be performed on soil samples when deemed necessary.

The reservoir area shall be investigated in sufficient detail to determine that the pond can be constructed to design depth and that excessive seepage will not result in the pond failing to hold water or the failure of natural earth embankments.

Auxiliary spillway area shall be investigated to determine whether soils can withstand design velocities without serious erosion. Loose sands and other erodible soils should be avoided. Soils should be able to support good vegetative cover; dormant and/or droughty seasons should be considered.

Foundation Cutoff. A cutoff of relatively impervious material shall be provided under the dam if necessary. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up the abutments as required and shall be deep enough to extend into a relatively impervious layer or provide for a stable dam 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 (1) pervious layers are not intercepted by the cutoff, (2) seepage creates swamping downstream, (3) such control is needed to insure a stable embankment, or (4) special problems require drainage for a stable dam. Seepage may be controlled by (1) foundation, abutment, or embankment drains; (2) reservoir blanketing; or (3) a combination of these measures.

Earth Embankment. The minimum top width for a dam is shown in table 1. If the embankment top is to be used as a public road, the minimum width shall be 16 ft for one-way traffic and 26 ft for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority.

Table 1.- Minimum top width for dams

Total height of embankment	Top width
ft	*ft*
10 or less	6
10 - 15	8
15 - 20	10
20 - 25	12
25 - 35	14
35 or more	15

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 must be designed to be stable, even if flatter side slopes are required.

If needed to protect the slopes of the dam, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (Technical Releases 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").

The minimum elevation of the top of the settled embankment shall be 1 ft 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 dam shall be 2 ft for all dams having more than a 20-acre drainage area or more than 20 ft in effective height.

The design height of the dam shall be increased by the amount needed to insure that after settlement the height of the dam equals or exceeds the design height. This increase shall not be less than 5 percent, except where detailed soil testing and laboratory analyses show that a lesser amount is adequate.

The minimum elevation of the top of the settled embankment shall be 1.5 feet above the auxiliary spillway design flow for those dams requiring state agency approval.

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

The crest elevation shall be no less than 0.5 ft below the crest of the auxiliary spillway for dams having a drainage area of 20 acres or less, and no less than 1 ft for those having a drainage area of more than 20 acres.

When design discharge of the principal spillway is considered in calculating peak outflow through the auxiliary spillway, the crest elevation of the inlet shall be such that the full flow will be generated in the conduit before there is discharge through the auxiliary spillway. The inlets and outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The capacity of the pipe conduit shall be adequate to discharge long-duration, continuous, or frequent flows without flow through the auxiliary spillways. The diameter of the pipe shall not be less than 4 in. If the pipe conduit diameter is 10 in or greater, its design discharge may be considered when calculating the peak outflow rate through the auxiliary spillway.

Pipe conduits under or through the dam shall meet the following requirements. The pipe shall be capable of withstanding external loading without yielding, buckling, or cracking. Flexible pipe strength shall not be less than that necessary to support the design load with a maximum of 5 percent deflection. The inlets and outlets shall be structurally sound and made of materials compatible with those of the pipe. All pipe joints shall be made watertight by the use of couplings, gaskets, caulking, or by welding.

For dams 20 ft or less in effective height, acceptable pipe materials are cast-iron, steel, corrugated steel or aluminum, asbestos-cement, concrete, plastic, vitrified clay with rubber gaskets, and cast-in-place reinforced concrete. Asbestos-cement, concrete, and vitrified clay pipe shall be laid in a concrete bedding. 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.

For dams more than 20 ft in effective height, conduits shall be plastic, reinforced concrete, cast-in-place reinforced concrete, corrugated

steel or aluminum, or welded steel pipe. The maximum height of fill over any principal spillway steel or aluminum pipe must not exceed 25 ft. Pipe shall be watertight. The joints between sections of pipe shall be designed to remain watertight after joint elongation caused by foundation consolidation. Concrete pipe shall have concrete bedding or a concrete cradle, if required. 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 a Saint Anthony Falls stilling basin or an impact basin may be used to provide a safe outlet. Protective coatings of asbestos-bonded, asphalt coated, or vinyl coating on galvanized corrugated metal pipe, or coal tar enamel on welded steel pipe should be provided in areas that have a history of pipe corrosion, or where the saturated soil resistivity is less than 4,000 ohms-cm, or where soil pH is lower than 5.

Specifications in tables 2 and 3 are to be followed for polyvinyl chloride (PVC), steel, and aluminum pipe.

Cathodic protection is to be provided for coated welded steel and 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.

Practice standard 430-FF provides criteria for cathodic protection of welded steel pipe.

Seepage control along a pipe conduit spillway shall be provided if any of the following conditions exist:

1. The effective height of dam is greater than 15 feet.

2. The conduit is of smooth pipe larger than 8 in. in diameter.

3. The conduit is of corrugated pipe larger than 12 in. in diameter.

Table 2.- Acceptable PVC pipe for use in earth dams[1]

Nominal pipe size	Schedule for standard dimension ratio (SDR)	Maximum depth of fill over pipe
in		*ft*
4 or less	Schedule 40	15
	Schedule 80	20
	SDR 26	10
6,8,10,12	Schedule 40	10
	Schedule 80	15
	SDR 26	10

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

Table 3.- Minimum gage for corrugated metal pipe [2-2/3-in x ½-in corrugations][1]

Fill height (ft)	Minimum gauge for steel pipe with diameter (in) of ___					
	21 and less	24	30	36	42	48
1 - 15	16	16	16	14	12	10
15 - 20	16	16	16	14	12	10
20 - 25	16	16	14	12	10	10

Fill height (ft)	Minimum thickness (in) of aluminum pipe[2] with diameter (in) of ___			
	21 and less	24	30	36
1 - 15	0.06	0.06	0.075	0.075
15 - 20	0.06	0.075	0.105	0.105
20 - 25	0.06	0.105	0.105	----[3]

[1] Pipe with 6-, 8-, and 10-in diameters has 1-1/2 in x ¼-in corrugations.

[2] Riveted or helical fabrication.

[3] Not permitted.

Seepage along pipes extending through the embankment shall be controlled by use of a filter and drainage diaphragm, unless it is determined that anti-seep collars will adequately serve the purpose.

The drain is to consist of sand, meeting fine concrete aggregate requirements (at least 15% passing the No. 40 sieve but no more than 10% passing the No. 100 sieve). If unusual soil conditions exist, a special design analysis shall be made.

The drain shall be a minimum of 2 ft thick and extend vertically upward and horizontally at least three times the pipe diameter, and vertically downward at least 18 in. beneath the conduit invert. The drain diaphragm shall be located immediately downstream of the cutoff trench, approximately parallel to the centerline of the dam.

The drain shall be outletted 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.

When anti-seep collars are used in lieu of a drainage diaphragm, they shall have a watertight connection to the pipe. Maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe. Collar material shall be compatible with pipe materials. The anti-seep collar(s) shall increase by 15% the seepage path along the pipe.

Closed conduit spillways designed for pressure flow must have adequate antivortex devices.

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

A pipe with a suitable valve shall be provided to drain the pool area if needed for proper pond management or if required by State law. The principal spillway conduit may be used as a pond drain if it is located where it can perform this function.

Supply pipes through the dam to watering troughs and other appurtenances shall have an inside diameter of not less than 1-1/4 in.

The crest of the principle spillway shall not be less than one foot below the auxiliary spillway crest regardless of drainage area and size.

The class (a) structure to which this standard applies are further subdivided into job classes for the purpose of proportioning principle spillways. These job classes conform to those found in the National Engineering Manual, Part 501, Engineering Approval Authority. The following table contains minimum design criteria for proportioning principle spillways according to job class.

Vermont Table 3a - Design Criteria

Job Class	I	II	III	IV	V
Watershed Area(Ac.)	50	100	320	640	>640
Dam Height(Ft.) 1/	10	15	20	25	35
Principle Spillway 24-Hr. Design Storm Frequency (Yrs.) 2/	2	2	5	10	25

1/ Height is the difference in elevation between the crest of the auxiliary spillway and the lowest point on the centerline profile.

2/ The principle spillway design storm may be flood routed using procedures outlined in the Engineering Field Handbook, Chapter 11 or other approved methods.

Quick return flow (QRF) is the rate of discharge that persist for some period beyond that for which design discharge is derived. It includes base flow, drainage from marshes and potholes, and delayed drainage from snowmelt. Quick return flow can be a factor in sites where the QRF is significant when compared to the capacity of the principle spillway. When applicable QRF should be added to the design discharge prior to selecting the pipe size. QRF is 0.015 cfs/acre in Vermont.

In lieu of the above design criteria and procedures, the following table may be used to determine principle spillway size for Class I structures.

Vermont Table 3b - Recommended CMP Principle Spillway Size (Class I Jobs Only)

Watershed (Acres)	**Barrel Diameter (Inches)**	**Riser Diameter (Inches)**
0 - 5	4 or none	6
6 - 10	6	8
11 - 20	8	10
21 - 30	10	12
31 - 50	12	15

When anti-seep collars are used in lieu of a drainage diaphragm, they shall be have watertight connections to the pipe and shall be designed in accordance with the following criteria:

1. Conduits less than two inches in diameter shall have at least one anti-seep collar.

2. Conduits with diameters ranging from two inches to eight inches shall have at least two anti-seep collars. The collars shall be centered about the dam centerline and spaced approximately 15 feet apart.

3. Dams having more than 15 feet in effective height or a conduit greater than eight inches in diameter shall have at least two anti-seep collars equally spaced throughout the saturated zone. The saturated zone is measured from the downstream face of the riser to the downstream toe of the dam or to the centerline of the embankment or foundation drain, if applicable. Anti-seep collars shall have sufficient size and number so that there is and increase in the length of the seepage path of at least 15 percent. The maximum spacing of the collars shall be 14 times the minimum projection of the collar measured perpendicular to the conduit.

4. Anti-seep collars for all ponds requiring state agency approval shall have sufficient size and number so that there is an increase in the length of the seepage path of at least 20 percent.

Auxiliary Spillways. Auxiliary spillways convey large flood flows safely past earth embankments.

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: a conduit with a cross-sectional area of 3 ft^2 or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash.

The minimum capacity of a natural or constructed auxiliary spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table 4, less any reduction creditable to conduit discharge and detention storage.

The auxiliary spillway shall safely pass the peak flow, or the storm runoff shall be routed through the reservoir. The routing shall start either 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 auxiliary spillway or from the elevation that would be attained if the entire 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.

Constructed auxiliary 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 ft, the auxiliary spillway shall have a bottom width of not less than 10 ft.

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.

Structural Auxiliary Spillways. If chutes or drops are used for principal spillways or principal auxiliary or auxiliary spillways, they shall be designed according to the principles set forth in the Engineering Field Manual for Conservation Practices and 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 4, 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 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.

DESIGN CRITERIA FOR EXCAVATED PONDS

Runoff. Provisions shall be made for a pipe and auxiliary spillway if necessary. Runoff flow patterns shall be considered when locating the pit and placing the spoil (see table 4).

Side Slopes. Side slopes of excavated ponds shall be stable and shall not be steeper than one horizontal to one vertical. If livestock will water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than three horizontal to one vertical.

Perimeter Form. If the structures are to be used for recreation or are highly visible to the public, the perimeter or edge should be curvilinear.

Inlet Protection. If surface water enters the pond in a natural or excavated channel, the side slope of the pond 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 disposed of in one of the following ways:

1. Uniformly spread to a height that does not exceed 3 ft, with the top graded to a continuous slope away from the pond.

2. Uniformly placed or shaped reasonably well, with side slopes assuming a natural angle of repose. The excavated material will be placed at a distance equal to the depth of the pond but not less than 12 ft 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.

5· Hauled away.

Table 4.-Minimum spillway capacity

			Minimum design storm[2]	
Drainage area	Effective ht. of dam[1]	Storage	Frequency	Minimum duration
acre	*ft*	*ac-ft*	*yr*	*hr*
20 or less	20 or less	< than 50	10	24
20 or less	> than 20	< than 50	25	24
> than 20		< than 50	25	24
All others			50	24

1. As defined under “Scope.”

2. Select rain distribution based on climatological region.

CONSIDERATIONS

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

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 onsite 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 water 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 salinity of soils, soil water, or downstream water.
8. Potential for earth moving to uncover or redistribute toxic materials such as saline soils.

OPERATION AND MAINTENANCE

A maintenance program shall be established to maintain the pond embankment, principle spillway, auxiliary spillway and other associated practices. Barren areas and vegetation damaged by livestock, machinery, herbicides, or erosion must be repaired promptly.

An operation and maintenance (O&M) plan shall be prepared for the Pond and any other associated conservation practices. Prior to construction, sufficient copies of the O&M plan shall be provided to the owner/operator, designer, and approving agencies. The owner shall sign the O&M plan to indicate an understanding of the requirements and a commitment to operate and maintain the area as specified.

The O&M plan shall include the periodic mowing of vegetation around the pond and removal of trees, brush and other woody vegetation from the embankment and auxiliary spillway. The O&M plan shall also include the inspection and repair of the pond as needed, including re-vegetating of barren and damaged areas. The grazing on embankments shall be prohibited and grazing immediately around the pond shall be kept to a minimum.

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.