Part 650.1304 (c) Design of Structural Components

All restored wetlands shall be designed according to MN standard Wetland Restoration (657). Standards Wetland Creation (658) and Wetland Enhancement (659) are closely related.

Hydrologic Analysis

A hydrologic analysis is required for each wetland restoration design. Its purpose is to aid in determining the following:

- The availability of an annual or sustainable water supply or water budget to keep the wetland wet.
- The variation in wetland water levels and hydrologic conditions that can be expected throughout the year.
- The extent and duration of flooding from single storm events.
- The extent of wetland storage available or needed to accommodate expected inflows.
- The minimum required design capacities of planned wetland outlets.

Principal Spillways

Principal spillways are designed in combination with emergency spillways to safely control flows from the design storm. Principal spillways are used to accomplish any of the following:

- Regulate wetland water levels.
- Manage wetland discharges.
- Safely convey wetland discharges into a downstream system (i.e. ditch or tile).
- Protect and/or minimize flooding problems for downstream areas.
- Provide water quality treatment benefits.
- Allow for management of wetland water levels (drawdown/flooding).
- Provide a physical barrier preventing undesired or nuisance wetland species from entering the wetland system being restored or created

Principal spillways may consist of pipes, weirs, drop structures, armored spillways, and drain tile systems. Vegetated spillways may also be used as principal spillways where the rate and duration of flow can safely be handled. Principal spillways must be durable and long lasting with the use of concrete, plastic, metal, rock, or other materials; natural durable materials are preferred. Principal spillway inlets are to be designed to prevent plugging by debris or sediment.

Vegetated Spillways

Vegetated spillways are intended to safely convey wetland runoff to a downstream area. Vegetated spillways can be designed to function as: The primary wetland outlet when the rate and duration of flows through it can safely be handled; or as an emergency spillway to convey runoff from large events when used in combination with a principal spillway.

Vegetated spillways are open channels, trapezoidal in shape, and usually consist of an inlet channel, a control section, and an exit channel. The inlet channel may be curved to fit existing topography. The shape of the level section is designed to have the same dimensions (side slope and bottom width) as the outlet section. The outlet section is to be as straight as possible throughout its length. The side slopes are chosen to be stable for the material in which they are constructed. Vegetated spillways provide for passing the design flow at a safe velocity to a point downstream where an embankment, if constructed, will not be endangered. The designer is responsible for determining that the flow through a vegetated spillway is designed to be stable in as-built and aged conditions.

The use of vegetated spillways in natural low areas without shaping is desirable since existing soils and established vegetation are not disturbed. A minimum 10 foot bottom width is required for all vegetated spillways.

Foundation

A foundation investigation should be made in sufficient detail to determine if the site is suitable for construction of an embankment or dike. If the foundation materials are found to be unsuitable for the required design conditions, at a minimum, a core trench is required.

Tile Blocks

For *depressional wetlands*, the location or upstream end of the tile block should begin no closer to the wetland than at the outside edge of the saturated zone of the wetland (see Figure B). When this location criteria can be met, the minimum length of drain tile that should be removed or rendered inoperable at each tile block should be the lesser of 100 feet or the calculated lateral effect distance of the remaining, functioning downstream tile (see Figure A). The end effect of the downstream functioning tile is 1/3 to 1/2 of the lateral effect on the longitudinal side of the tile (see Figure C). When ownership or other site constraints exist and the location criteria cannot be met, the suggested minimum length of tile to be removed is 100 feet.

Additional tile blocks within the extents of a drained depressional wetland may be warranted to improve the restoration of hydrology or to restore wetland microtopography. In these situations the minimum length of tile to be removed is 50 feet.

For *non-depressional wetlands*, multiple tile blocks may need to be considered as one block may not effectively restore wetland hydrology. For wetlands on a slope, multiple blocks need to be considered along each string of tile with blocks located no further apart than every 4 to 5 feet in elevation change of the tile. For wetlands on flats or in floodplains, appropriate design methods need to be used to locate the blocks within the flat or floodplain. The suggested minimum removal length for blocks within these wetlands is 40 feet with the block at the bottom or lowest elevation being 100 feet in length.

When breaking a tile line to restore a wetland, the point at which to start measuring the 100 foot (or other distance) setback must be on the edge or just outside the wetland boundary. The wetland may include both a ponded area and a saturated area (See Figure A).

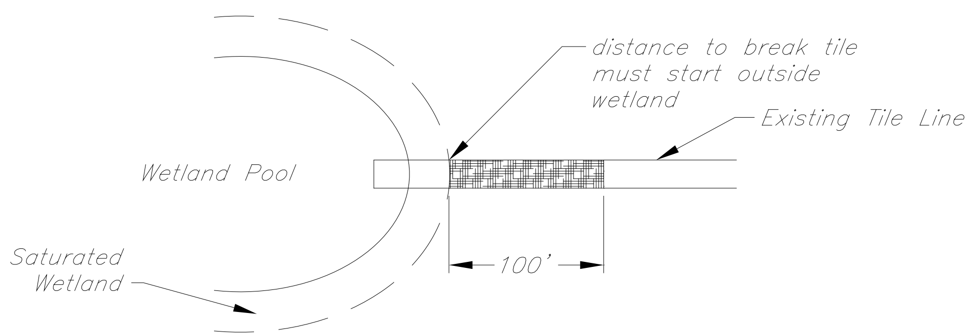

Figure A. Tile break distance begins outside the wetland boundary.

When a drainage feature will be near a wetland, the drainage feature must be outside the lateral effect zone of the tile or ditch. The lateral effect zone is measured from the outside boundary of the wetland, which may be a saturated wetland beyond the area with standing water (See Figure B).

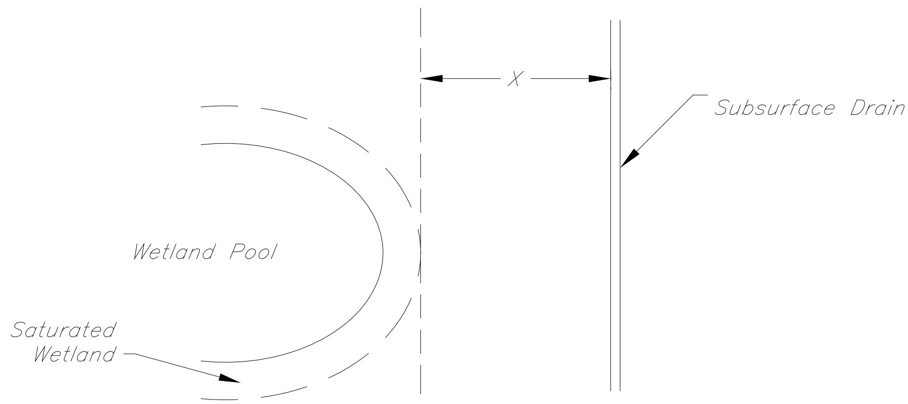

Figure B. Subsurface drain must stay a lateral effect distance away from the wetland to avoid impacting the hydrology of the wetland.

The end point of a drainage feature has a lateral effect on a wetland, but usually 1/3 to ½ of the lateral effect perpendicular to the drainage feature. This needs to be considered when considering the location for a tile break or ditch plug for a wetland restoration (See Figure C).

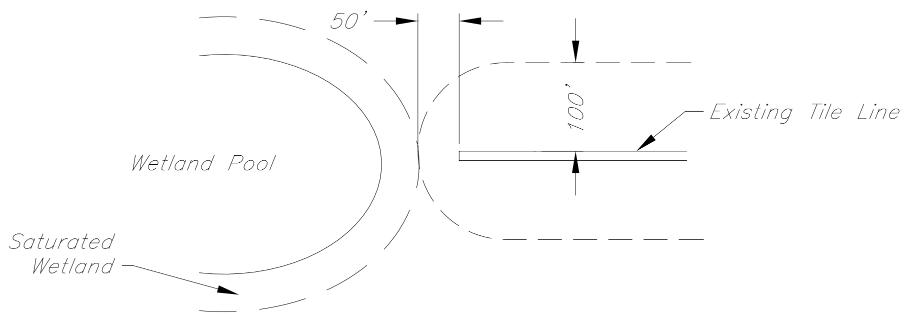

Figure C. The lateral effect distance for the end of a subsurface drain must be measured outside the wetland boundary.

Protecting Upstream Drainage

Where the tile drains serve as outlets from upstream areas where drainage is still desired, appropriate measures to protect the upstream drainage benefits need to be included in the design. Design measures may include: 1) outletting the upstream tile drain into the restored wetland, or 2) re-routing the upstream tile drain around, away from, or through the restored wetland area. The planned tile grades and sizes should maintain the existing flow capacity for the upstream drainage system.

Design Tables

These tables are intended to be used for "quick" designs where a flood routing may not be necessary due to the site being relatively small and simple. These are referred to in the Minnesota 657 standard, Wetland Restoration.

These tables were developed using a 10-year frequency, 24-hour duration storm event. A runoff curve number (RCN) of 85 was used in the evaluations. The RCN is a composite representation of the entire drainage area, including the wetland. Sites having variables beyond the scope listed in the tables must be flood routed.

Table 2A Designs where DA:PA is less than 10

Drainage Area, Ac	Watershed Slope	Bottom Width, ft	HP ft	Min.Pipe Diam. Required	Pipe HW (feet)
≤40	Up to 5%	15	0.7	None	None
≤40	Up to 5%	10	0.4	10"	0.5
41-60	Up to 5%	25	0.7	None	None
41 - 100	Up to 5%	15	0.6	10"	0.5

Table 2B Designs where DA:PA is greater than 10

Drainage Area, Ac	Watershed Slope	Bottom Width, ft	HP ft	Min Pipe Diam. Required	Pipe HW (feet)
0 - 20	Up to 5%	15	0.7	None	None
20 - 40	Up to 5%	15	1.0	None	None
40 - 60	Up to 5%	30	1.0	10"	0.5
60 - 80	Up to 5%	40	1.0	10"	0.5
<100	Up to 5%	50	1.0	12"	0.5

Sites with a drainage area exceeding 100 acres must be flood routed. Sites having variables beyond the scope listed in the tables must be flood routed.

If effective skimmers or other trash restricting devices are used, an 8" diameter pipe may be used in place of a 10" diameter pipe when using the designs in Tables 2A and 2B.

The auxiliary spillway should not carry flow from a 10-year 24-hour frequency event for more than 24 hours to increase the likelihood that the auxiliary spillway will avoid damages during the storm event.

Table 2C Red River Valley Designs

Drainage Area, Ac	Watershed Slope	Bottom Width DA:PA ≤ 10	Bottom Width DA:PA > 10	HP ft	Min. Pipe Size Required
≤20	2% or less	10	20	0.5	None
21-40	2% or less	15	50	0.5	None
41-60	2% or less	25	80	0.5	None
61-80	2% or less	30	105	0.5	None
80-100	2% or less	40	125	0.5	None
Up to 150	2% or less	55	165	0.5	None

Table 2C was developed specifically for conditions that occur in the Red River Valley where the precipitation that occurs during a 10-year frequency, 24-hour duration rain event is 3.5 inches or less and the depth of flow in the vegetated spillway will be shallow. If the effective height of the structure will exceed two feet, or the maximum storage exceeds 25 acre-feet, or another parameter in the table is exceeded, a flood routing must be completed to verify the design.

Sites with a drainage area exceeding 150 acres must be flood routed. Sites having variables beyond the scope listed in the tables must be flood routed.

Definitions

DA:PA. Ratio of acres of drainage area to acres of pool area. The pool area is measured at the run-out elevation.

Drainage Area. Watershed area in acres that contributes water, surface and subsurface, to the wetland basin. This includes the wetland area.

Watershed Slope. Average watershed slope measured not including the wetland area.

Bottom Width. Minimum required bottom width of the vegetated spillway measured in feet.

HP. The calculated flow depth in feet of the design storm through the vegetated emergency spillway.

Pipe HW. The minimum pipe headwater measured in feet from the pipe inlet elevation to the vegetated spillway crest elevation.