2.8 Extended Detention Constructed Wetland

Description

An extended detention constructed wetland is an engineered basin designed to treat and control urban stormwater runoff in shallow pools of variable depth that support hydrophytic vegetation, both emergent and riparian. It is among the most effective stormwater quality management practices due to its numerous pollutant removal mechanisms including uptake by vegetation and algae; filtering; sedimentation; chemical and biological decomposition; sorption; and volatilization, as well as its use of vegetation to stabilize captured sediment and provide shade for thermal moderation within the pools.

An extended detention constructed wetland is an artificial wetland ecosystem. It does not provide the degree of wildlife habitat and biodiversity associated with natural wetlands. Many natural wetlands are low-energy environments that detain runoff from wet seasons well into dry seasons to provide extensive hydrologic benefit. In contrast, a wetland constructed for stormwater treatment has a manipulated hydroperiod influenced by rapid urban runoff and short-term (daily, hourly) extended detention. Do not use this chapter to restore natural wetlands or create wetlands for functions other than urban stormwater runoff treatment.

Credits

Table 2.8.1 Credits for an Extended Detention Constructed Wetland Meeting the Criteria in this Chapter

Objective	Credit
Runoff Reduction Volume (RRv)	None.

Planning and Feasibility

An extended detention constructed wetland is well suited for sites with a high ground water table, where impediments limit permanent pool depth, where the contributing drainage area may be insufficient to sustain the permanent pool of a wet basin, or where prolonged wetness within a dry extended detention basin is a concern.

Do not design an extended detention constructed wetland to directly receive streamflow (often referred to as in-line or side-saddle). These configurations interfere with the natural transport of sediment and channel bed load which can cause excessive sediment accumulation, limiting the functional life of the practice.

Suitable soil must be available for constructing a stable embankment and ensuring sufficient impermeability. Prior to final design, a qualified professional should conduct an on-site soil evaluation to characterize the adequacy of the soil stratum of the proposed pool, embankment, and borrow areas. Do not rely solely on web soil survey data to characterize the engineering properties of soils for design purposes.

Dams are regulated under the Ohio Revised Code (ORC) 1501:21 Dam Safety Administrative Rules. A dam is exempt from the state's authority (ORC Section 1521.062) if it is six feet or less in height regardless of total storage; less than 10 feet in height with not more than 50 acre-feet of storage, or not more than 15 acre-feet of total storage regardless of height. Check with the Ohio Department of Natural Resources for the most current requirements.

Jurisdictional wetlands may not serve as an extended detention constructed wetland.

Design Criteria

The design of an extended detention constructed wetland requires careful planning from both a hydrologic and an ecological perspective to ensure long-term success. If possible, consult with a wetland ecologist or other knowledgeable professional to develop the right proportions of water depths and plant species. To meet post-construction stormwater management objectives and maximize the functional life of the practice, design an extended detention constructed wetland according to the following criteria.

Water Quality Volume Storage

Provide a temporary or detention storage volume equal to the water quality volume (WQv) above the water surface elevation (WSE) of the permanent wetland pool and below the invert of a local peak discharge control outlet or the auxiliary spillway (see Figure 2.8.1). Calculate the WQv for the drainage area to the wetland as described in Chapter 2.16 and as required by Ohio EPA's NPDES general permit for construction activities.

Outlet Structure and Drawdown

Design an outlet structure to drain or draw down the WQv storage over a minimum 24-hour period with less than 50 percent of the WQv storage emptying within the first eight hours. Targeting a 24-hour drawdown period extends detention of the WQv long enough to provide treatment but short enough to provide storage for subsequent rainfall events. Extending the detention time also lessens erosion in receiving channels by reducing the flow rate of discharging runoff.

Extended detention of the WQv can require a small orifice or weir outlet that must be designed to minimize clogging and be accessible for maintenance activity. A reverse slope pipe outlet draws water mid-depth in a micropool to minimize clogging of a water quality orifice by floating debris and vegetation while also preventing the outlet from drawing nutrient-rich bottom sediment. Size the micropool to hold at least 10 percent of the water quality volume with an average depth of at least three feet. A V-notch, T-shape, or trapezoidal broad-crested weir and micropool may be a better alternative for low head wetlands. See Chapter 2.6 for further discussion on outlet configurations.

The outlet may also include flashboard risers so the wetland can be drained for maintenance purposes or temporarily manipulated for plant health. If installed, flashboard risers must be secured so that only intended personnel can manipulate the water level. The design outlet elevation(s) must be permanently marked in the riser to ensure the design conditions are properly returned to after any temporarily lowering occurs.

In addition to the sizing and configuration of the water quality control outlet, design the outlet spillway to be structurally sound and specify:

- durable pipe and other materials that will resist degradation under ultraviolet light, oxidation, and other forms of corrosion; and
- proper grouting or sealing of any pipe joints and penetrations to prevent unintentional bypass of the controlled outlet.

An outfall to a stream or ditch must be stable for the maximum (pipe-full) design discharge. Use outlet protection consistent with state or local guidance to prevent erosion of the receiving channel bed or banks. Minimize any necessary modifications to a receiving stream channel.

The constructed wetland shall have an auxiliary outlet to pass storm events that exceed the WQv.

Local Peak Discharge Control

Where local regulations require additional peak discharge control for moderate to large storm events (often with the critical storm method described in Appendix 2.A.3), design a multi-stage outlet (see Figure 2.14.1) with additional storage volume. It is not necessary to stack the storage volume needed for peak discharge control above WQv except where required by local regulation, however the WQv storage must be developed prior to activation of an upper peak discharge control outlet.

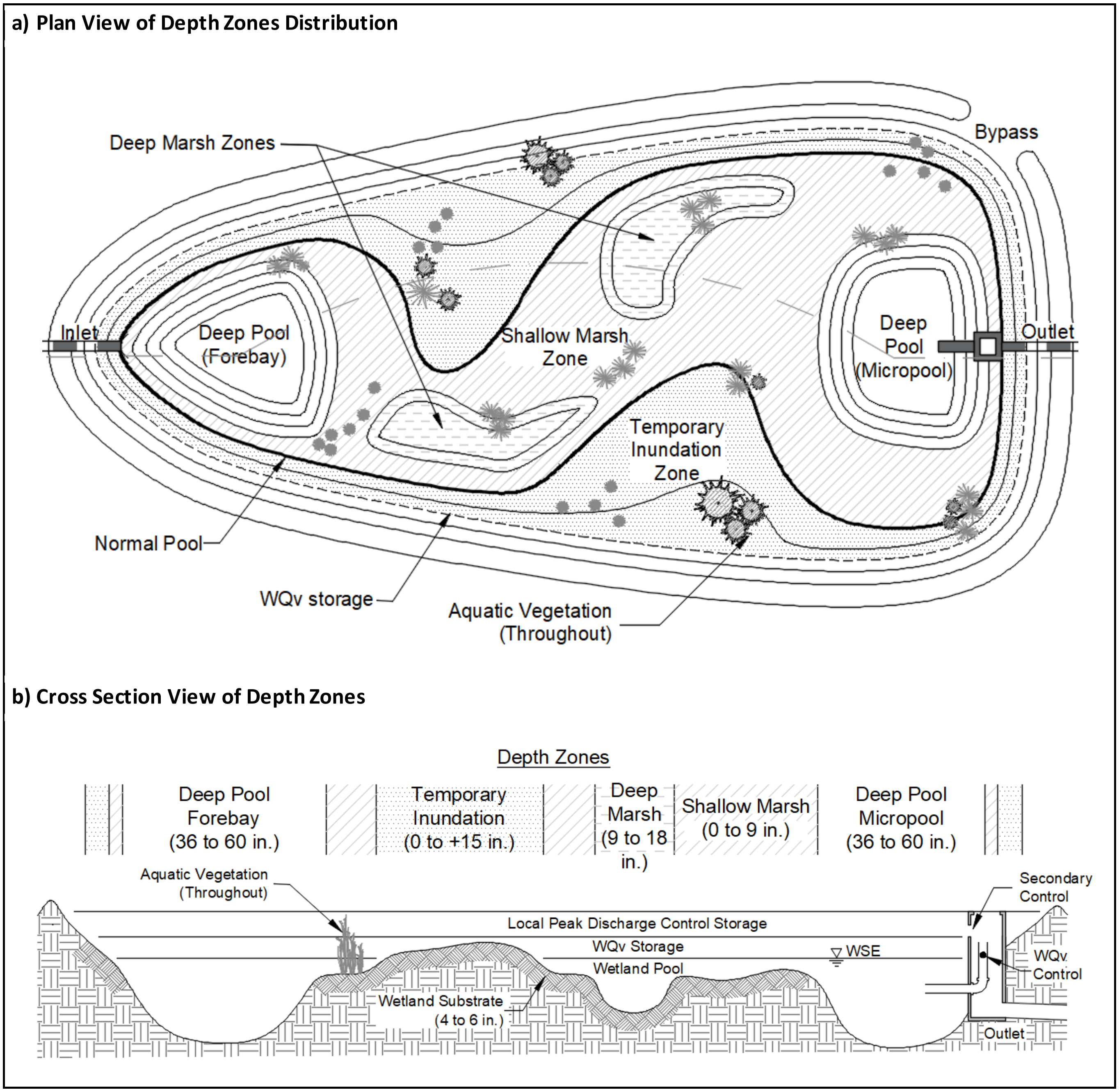

Figure 2.8.1 Conceptual illustration of an extended detention constructed wetland (not to scale).

Permanent Wetland Pool

Design a wetland permanent pool with complex micro and macro topography that develops a long, serpentine flow path through the pool and/or use submerged embankments to spread flow through multiple cells that segment the pool. The objective is to create diverse and balanced ecological settings that support multiple treatment mechanisms as well as maximize the water residence time within the wetland. In all cases, prevent short-circuiting within the pool by separating the outlet and inlet to develop a flow length to width ratio of 1:1. Avoid layouts that may develop a channelized flow path through erosion or narrow gaps in vegetation.

The permanent wetland pool volume should be based on a detailed ecological assessment and water budget to determine the sustainable pool volume and appropriate hydroperiod. The water budget should include water entering the pool from direct precipitation, surface runoff, and ground water and exiting by evaporation, plant transpiration, stormwater discharge, and seepage. Consult *Engineering Field Manual, Chapter 13*[1] for guidance on developing a water budget for a constructed wetland.

If it is not practical to conduct a detailed ecological assessment and water budget, provide a permanent wetland pool meeting the criteria given in Table 2.8.2 and illustrated in Figure 2.8.1. A detailed grading plan reflecting these criteria must be provided by the designer.

Table 2.8.2 Permanent Wetland Pool Criteria

Zone	Surface Area (Percent of Total)	Depth Range (Inches)	Min. Volume (Percent of WQv)	Notes
Deep Pool	20 to 25	36 to 60	20	• Permanently flooded. • Includes forebay(s) and micropool. • May support submerged or floating vegetation.
Deep Marsh	5 to 15	9 to 18	10	• Flooded long-term. • Supports emergent plants.
Shallow Marsh	30 to 45	0 to 9	10	• Flooded long-term. • Supports hydrophytic plants that can tolerate both wet and dry conditions.
Temporary Inundation Zone	30 to 45	0 to +15 (Above the WSE)	n/a	• Long-term saturation. • Inundated on an irregular basis following rain events. • Provides detention storage only. • Supports hydrophytic or riparian plants that can tolerate extended dry periods.

Forebay(s)

A forebay is a small basin located at the inlet to a practice, separate from the main pool, and readily accessible for maintenance. It serves multiple functions: sedimentation, energy dissipation, and inflow dispersion. A separate forebay pool absorbs the energy of incoming concentrated runoff before distributing it throughout the wetland as slow, uniform flow over the berm. This improves the mean water residence time and promotes the gravitational settling of fine particles within the main pool. A forebay also facilitates maintenance by capturing initial (coarse grain) sediment deposition in a confined, accessible area.

Locate a forebay at concentrated flow inlets that convey runoff from 10 percent or more of the wetland's total drainage area or any inlet expected to contribute an excessive sediment load. Proportion the area and volume among multiple forebays if the wetland has multiple inlets. Where possible, design the forebay to receive multiple inlets.

The forebay average depth should be at least three feet to dissipate turbulent inflow without scouring and resuspending previously deposited sediment.

Design the forebay for ease of construction and cleanout. Equip the forebay with a metered rod for monitoring sediment accumulation. The bottom of the forebay may be hardened to make sediment removal easier. To accommodate frequent

[1] This document is publicly available from the U.S. Department of Agriculture, Natural Resource Conservation Service on their website.

sediment cleanout, provide unobstructed equipment access to the forebay.

Wetland Substrate

The importance of the substrate in constructed wetlands cannot be over-emphasized. Many constructed wetlands are excavated into sub-soil that lacks the structure, nutrients, and organic matter needed to support the vigorous growth of wetland plants. Rhizomes and roots may penetrate well into loamy soil, but dense or clayey subsoil will inhibit root growth. Further, the low nutrient content of subsoil limits growth and development.

Design a substrate or planting medium conducive to wetland plant growth and retention of contaminants. Stockpiling the original topsoil excavated from the wetland area for later use as a soil amendment is strongly recommended. If available, wetland mulch is preferable due to its maturity and seed or propagule bank. Donor soils for wetland mulch shall not be removed from natural wetlands without proper permits.

Plow, disk, or rip the substrate to a depth of four to six inches and, if necessary, incorporate an organic amendment of wetland mulch, original topsoil, very mature compost, leaf litter, and/or other stable organic material. Target the properties listed in Table 2.8.3 when selecting or specifying substrate soil.

Table 2.8.3 Recommended Extended Detention Constructed Wetland Substrate Properties (adapted from Davis, 1995)

pH	6.5 to 8.5
Cation Exchange Capacity (CEC)	15 meq / 100 g
Electrical Conductivity (EC)	< 4 mmho/cm
Texture	Loam, Silt Loam, or Sandy Loam
Organic Matter Content	>3 percent by weight

Wetland Vegetation Plan

The design of an extended detention constructed wetland must include a plan for establishing hydrophytic vegetation. Vegetation may be established by either planting nursery stock (plants or rhizomes), seeding, mulching with soil from an existing wetland, or a combination. Volunteer establishment is not acceptable as it often leads to monocultural stands of invasive or undesirable species. A wetland vegetation or landscaping plan must address each of the following items.

1. **Plant Species Selection** – A variety of wetland plant species, typically six or more, with tolerance to various water levels and water chemistry should be specified. Species that have worked well in constructed urban wetlands include common three square, arrowhead, soft stem bulrush, wild rice, pickerelweed, sweetflag, smartweeds, spike rush, soft rush, and a number of other sedges. Many of these species are aggressive colonizers that accelerate establishment. When selecting plant species, give priority to native wetland plants collected or grown from material within the ecological region of the constructed wetland location. Do not specify noxious or invasive species that could spread and become a nuisance to surrounding wetlands.
2. **Location and Rates for Seeding, Sprigging, or Containerized Plants** – Initial planting should cover at least 30 percent of the total wetland area, concentrated in several areas, and have densities of four to five plants per square yard. Planting clusters of single species will improve the quality and diversity of plantings. An appropriate plant palette should be planned for each depth zone.
3. **Handling of Seed or Plant Materials** – Nursery stock must be correctly handled prior to planting. For growing plants, this consists of keeping the roots moist at all times and the potted plants out of direct sunlight as much as possible. Vegetation should be planted as soon as possible to avoid damage during on-site storage. Dormant plant material should be stored under conditions similar to those under which the material was stored at the nursery.
4. **Seeding or Planting Dates and Methods** – Ensure that plant materials have an acceptable rate of germination and/or survival. Certain seeds may require special treatment (for example, high or low temperatures) or require considerable time to germinate. Dormant seed only when recommended for the species. The transplanting window typically extends from early April to mid-June. This ensures the wetland plants have a full growing season to build the root reserves prior to winter. When planting container plants dig holes about one-third bigger to allow root systems an un-compacted area in which to develop.

5. **Moisture Management** – Moisture and ponding in the wetland must be carefully controlled prior to and during plant establishment. Manage the water level within the wetland to 1) discourage the growth of upland species, 2) stimulate seed germination, 3) prevent young or newly germinated emergent plants from drying out, 4) avoid stressing young plants not ready to survive in anaerobic soils and standing water, and 5) ensure flooding does not float and wash away freshly sown seeds.

   It is recommended the wetland area be flooded for several weeks prior to draining and planting. After germination or planting, a cycle of shallow flooding for five to seven days followed by a draw down to saturated soil conditions for 15 to 20 days is recommended by Hoag (2007) up to eight weeks prior to gradually increasing the water level or until the vegetation shows vigorous growth. The process of filling the constructed wetland may take three to four months.

6. **Invasives and Geese Management** – Both invasive species proliferation and feeding geese can threaten vegetation establishment. An aggressive management plan may be necessary to prevent and remove invasive species during the initial establishment period. Follow-up inspections in late spring and early fall are good times to treat or remove invasives. Controls may be necessary discourage geese from eating the seed or young plants.

Design Considerations

In addition to the proceeding design criteria that address the stormwater management function, other design considerations are necessary to ensure a sound and successful practice. Consider the following items when designing a extended detention constructed wetland and address them as appropriate.

Structural Integrity

To ensure long-term operation and sustained performance, an extended detention constructed wetland must be designed to be structurally sound. Designers are encouraged to review both *Conservation Practice Standard Code 378 - Pond* and *Engineering Field Handbook, Chapter 11 - Ponds and Reservoirs* [2] for guidance the design of the spillway and embankment. In all cases:

- protect the embankment from overtopping by designing an emergency spillway in native soil to bypass flow exceeding the outlet structure capacity in a non-erosive manner;
- design the outlet structure to withstand flotation;
- incorporate an anti-vortex device and trash rack on the outlet structure as necessary; and
- utilize proper soil compaction methods, a core trench, and anti-seep measures to reduce the risk of embankment failure.

Safety

Public safety is an inherent concern with any open water, temporary or permanent. Appropriate measures such as fencing, warning signs, and personal flotation device stations are recommended. Outlet structures should be designed to prevent entry. Design the wetland pool to avoid situations where unsafe slopes or ledges approach open water.

Construction Considerations

A successful wetland requires the contractor adhere precisely to the design grading which can be quite different from typical excavations. Supervision by the designer is recommended during both grading and planting activities.

An extended detention constructed wetland may not serve as a sediment control basin during active construction. Schedule construction of the wetland after permanent stabilization of the contributing drainage area and to coincide with optimal plant growth conditions.

[2] These documents are publicly available from the U.S. Department of Agriculture, Natural Resource Conservation Service on their website.

Erosion control measures such as jute matting may be required within an extended detention constructed wetland immediately following construction to protect it from erosive flow until vegetation is fully established, which may require multiple growing seasons.

Maintenance Considerations

An extended detention constructed wetland must operate long-term with sustained performance. The designer must develop a detailed operation and maintenance plan for the owner that outlines the maintenance activities necessary and their expected schedule to ensure a consistent level of treatment occurs over the life of the practice.

While maintenance is inevitable, its frequency, level of effort, and cost can be minimized through good planning and design. The designer should consider the following measures to ease the maintenance burden.

- Provide a georeferenced survey of the constructed wetland elevations on an as-built drawing. This data establishes a baseline to determine sediment deposition rates and facilitate maintenance operations.
- Provide a maintenance easement if the practice is not readily accessible from the public right-of-way.

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