IOWA STORM WATER MANAGEMENT MANUAL

9.08 STORMWATER WETLANDS

IOWA DEPARTMENT OF NATURAL RESOURCES

TABLE OF CONTENTS

Refer to the glossary for words in **bold black text**. Some items of emphasis are listed in **bold blue text**.

9.08-1 DESIGN

A. SUMMARY

Stormwater wetlands are a management practice designed and constructed to address the quality and quantity of stormwater runoff. **Stormwater rates** and **volumes** are decreased by **absorption, evapotranspiration** and **outlet restrictions**. Pollutant removal is accomplished by **settling, biochemical reactions** and **plant uptake**. They are most appropriate in locations where a continuous **base flow** or **high-water table** can assist in sustaining a **permanent pool** of water to support aquatic vegetation. **Microtopography** is created through fine grading to develop a series of shallow and deep water zones to extend the required length of flow through the practice.

Established stormwater wetland in Prairie Trail, Ankeny, Iowa

DESIGN PROCESS OVERVIEW

1. Investigate site feasibility
2. **BMP** selection early in site design process
3. Review permitting requirements
4. Perform preliminary sizing calculations
5. Determine required practice footprint
6. Verify sizing through more detailed calculations
7. Prepare design plans, specifications
8. Incorporate maintenance and establishment plans

KEY MAINTENANCE CONSIDERATIONS

Short-term (establishment period)

- Weed control, re-seeding and re-planting

Long-term (ongoing)

- Keep inlets and outlets clear of debris
- Removal of invasive species and less desirable vegetation
- Prescribed burns
- Forebay sediment removal
- Dam embankment, inlet and outlet inspections and maintenance

NOTE

It must be stressed that stormwater wetlands are constructed stormwater best management practices.

It is not appropriate to direct runoff to existing, federally regulated wetland features to address water quality and quantity management requirements for new infrastructure and urban development and retrofit sites.

FIGURE 9.08-1-1:
WETLAND PERSPECTIVE

FIGURE 9.08-1-2:
WETLAND SECTION

FIGURE 9.08-1-3:
WETLAND PLAN

B. APPLICATIONS

Stormwater **wetlands** are best applied in watersheds of 10 or more acres, which have been **urbanized** or where urban growth is planned. They are best suited to areas where soils have limited **infiltration** potential (**HSG** C or D) or where ground water is present relatively close to the surface. Groundwater **flow** or other steady sources of flow (such as sump pump discharges) may provide a continuous base flow to support aquatic vegetation.

UNIFIED SIZING CRITERIA

Stormwater wetlands can be designed to address management for both **stormwater quantity and quality**. The requirements of the Unified Sizing Criteria can be addressed through these best management practices.

1. *Water Quality Volume (WQv) ESSENTIAL*
   Stormwater wetlands include many mechanisms to improve water quality. They should be designed to extend flow paths and reduce flow velocity to maximize settlement by filtration through vegetation. Uptake by aquatic plants can reduce levels of nutrients and reduce runoff through evapotranspiration. Chemical and biological **degradation** and **volatilization** are also at work in these systems.
   Pollutant removal rates are expected to be greatest during the growing season and lowest during the winter months (Strecker, et al, 1990). For additional information and data on pollutant removal capabilities for stormwater wetlands, see the National Pollutant Removal Performance Database available at *www.cwp.org* and the National Stormwater Best Management Practices Database at *www.bmpdatabase.org*.
   The WQv requirement is most effectively addressed by providing a permanent pool volume equal to or exceeding the WQv. Another preferred approach is locating additional water quality BMPs upstream of the wetland (closer to the source of runoff) to address a portion of the WQv, reducing the volume treatment storage required to be provided by the wetland itself.
   In retrofit locations, where upstream, off-site areas have been fully urbanized, up to 50% of the WQv may be provided through **extended detention (ED)**. When extended detention is used to address the WQv, the ED portion of the volume will need to be slowly released over a period of no less than 24 hours. To reduce the potential for shoreline erosion and stress on desired vegetation, it is also recommended that the **high-water elevation** caused by the WQv event not exceed 1.5 feet above the permanent pool. Refer to the ISWMM Chapter 3, Section 6 for more information on calculation of **allowable flow rates** for extended detention.

2. *Channel Protection Volume (CPv) ESSENTIAL*
   The footprint area required to manage the WQv usually means that the CPv can be easily addressed by the stormwater wetland. This is accomplished by extended detention of the volume of runoff directed to the wetland during a 1-year, 24-hour storm (release over a period of no less than 24 hours). To maintain desired vegetation, recommended limits for the expected rise in water level above permanent pool are listed in Table 9.08-1-1.

3. *Overbank and Extreme Flood Protection (Qf, Qe) TARGET*
   The available volume for **temporary storage** above the permanent pool often makes it possible to provide flow attenuation of larger storm events. The goal of this sizing criteria is to reduce peak outflow rates from these types of events to **pre-development** levels (rates expected prior to pioneer settlement, represented by meadow in good condition considering local types and pre-settlement times of concentration). Some jurisdictions may have more restrictive standards for peak flow rate control.

Positive factors when screening sites for stormwater wetlands:

- Larger drainage areas
- Limited infiltration/percolation
- Hydric soils
- High groundwater table

Refer to Chapter 2 of the ISWMM for more detailed information about the Unified Sizing Criteria (USC).

For information on Small Storm Hydrology (WQv and CPv) refer to Chapter 3, Section 6.

NOTE
Refer to Section 3.01–7 for definitions of “Essential,” “Target” and “Advisory” guidelines.

Make sure to visit the Center for Watershed Protection website (www.cwp.org) to find the most current edition of the National Pollutant Removal Performance Database. Other websites sometimes feature out of date versions.

Even in retrofit situations, use of extended detention to address WQv requirements is discouraged and its use should be limited to cases where insufficient space is available to fully provide WQv treatment volume within the permanent pool.

To reduce risks for vegetation, public safety and erosion, it is recommended to avoid extreme ponding depths. Refer to the table below: *TARGET*

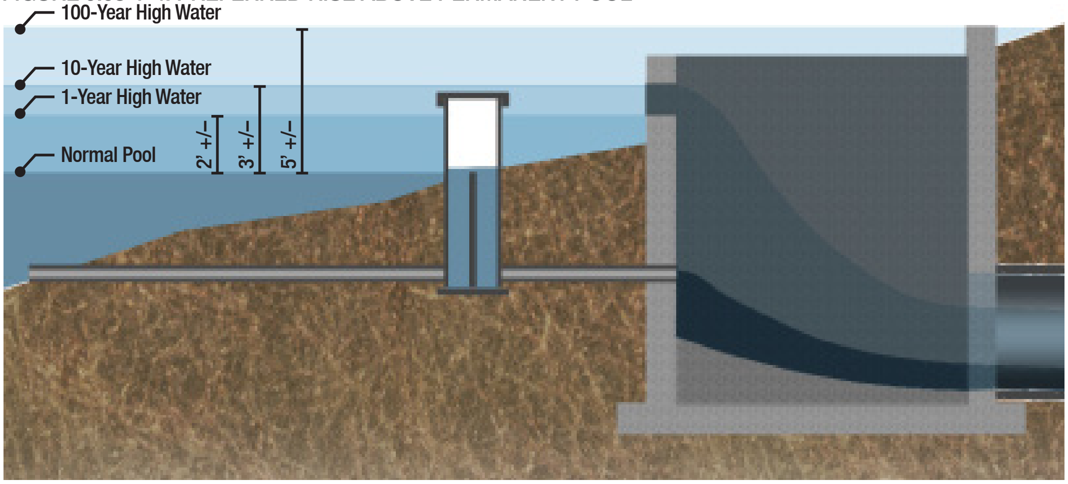
TABLE 9.08-1-1: EXAMPLE PROJECT TIME OF CONCENTRATION DATA

STORM EVENT (RECURRENCE INTERVAL)	PREFERRED HIGH-WATER DEPTH (ABOVE PERMANENT POOL)	ALLOWABLE HIGH-WATER DEPTH (ABOVE PERMANENT POOL)
WQv (1.25”)	Permanent pool volume > WQv	1.5 feet*
1-year, 24-hour (CPv)	2.0 feet	2.5 feet
10-year, 24-hour	3.0 feet	4.0 feet
100-year, 24-hour	5.0 feet	6.0 feet

Table 9.08-1-1: Design criteria for high-water elevation rise above permanent pool.

* WQv should only be treated through Extended Detention (ED) in special circumstances, see page 15.

FIGURE 9.08-1-4: PREFERRED RISE ABOVE PERMANENT POOL



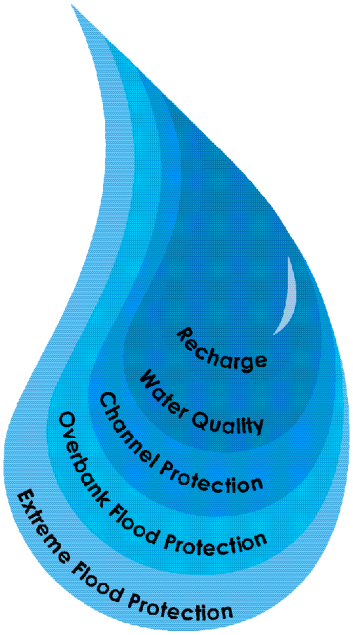


FIGURE 9.08-1-5:
UNIFIED SIZING CRITERIA

NOTE

If Overbank and/or Extreme Flood Protection is not to be provided at a given site, the primary and emergency overflow spillways will need to be designed to safely pass these flows. Expected overflow or outlet velocities should be kept less than 10 fps up to the 100–year, 24–hour storm event to reduce the potential for surface erosion. If overflow occurs frequently (storms of 10–year event scale or smaller), use a Turf Reinforcement Mat (TRM), articulated block or other form of surface protection to prevent erosion in the spillway area.

REFER TO CHECKLIST

A checklist is included at the end of this Chapter which was developed for projects which are receiving funding requiring review by the State's urban conservationists.

Stormwater wetlands can be created in areas with HSG A or B soils, but a liner may be needed to sustain a permanent pool of water.

A geotechnical study should:

- Classify site soil conditions
- Evaluate infiltration potential
- Recommend the type and thickness of liners
- Review the need for selective over–excavation and replacement of soil materials
- Provide recommendations on dam construction and seepage protection techniques

SITE FEASIBILITY CRITERIA

Search online for the NRCS Web Soil Survey.

- *Soils*
  Native soils of **hydrologic soil group** C or D should be adequate to maintain wetland conditions. Sites with HSG A soils and some B soils will often require a clay or **bentonite** liner. The presence of hydric soils within the expected wetland footprint is also desirable. County soil maps can be used for initial screening of soil properties. Final evaluation of soils should be based upon a geotechnical analysis and **permeability** tests of the soils at the expected surface and subsurface elevations. Consult a geotechnical engineer or soil scientist for case-by-case guidance.

- *Existing vegetation ADVISORY*
  Impacts to **prairie remnants**, established **native vegetation** or well-maintained **savanna** woodland areas should be avoided or limited to the maximum extent possible. Evaluating existing vegetation within the site and surrounding area may also indicate if a site is capable of supporting wetland vegetation.

- *Existing wetlands ADVISORY*
  Disturbing existing, functional wetlands to create a new stormwater wetland is strongly discouraged and may not be permitted. Initial screening may be completed by review of National Wetland Inventory maps for the site area. More detailed site ecological investigations to delineate the presence of wetlands at a given site and determine if any such identified wetlands are considered **"jurisdictional"** should be completed as part of the preliminary design process.

- *Tributary drainage area TARGET*
  The recommended minimum watershed size is 10 acres, although special considerations may be made in watersheds with high impervious cover (>65% impervious). Smaller areas may not generate sufficient runoff to sustain water balance. The maximum drainage area served primarily is limited by the available footprint area.

- *Space required*
  Size as needed to provide required storage. For initial site selection, approximately 3–5% of the tributary drainage area may be needed to address WQv. For management of the Extreme Flood event, 6–12% of tributary drainage area may be required. Both will vary based on impervious ratio of tributary area.

- *Site topography*
  Site grading costs may be elevated at sites with steeper **topography**. It also may be difficult to provide a permanent pool at a single elevation over a large area on steeper sites. Designers should consider if the wetland can be constructed by excavation into the existing surface, creation of a dam embankment or some combination of these grading methods.

- *Elevation change at outfall*
  There should be sufficient elevation change between the proposed permanent pool elevation and the discharge point (downstream surface elevation, storm sewer, swale or stream) to allow drawdown of the pool elevation by at least 3 feet for maintenance and to aid in establishment of desired vegetation. If possible, complete drawdown may aid in removal of sediment or maintenance of habitat structures.

- *Minimum depth to water table*
  No constraints at most sites. At locations with an underlying water supply aquifer or when receiving runoff from a hotspot site, a separation distance of 2 feet is recommended between the bottom of the wetland and the elevation of the seasonally high water table. In areas of Karst topography, a bentonite or clay liner or a synthetic impermeable liner should be provided.

C. MAJOR DESIGN ELEMENTS

Stormwater wetlands should include the following key features:

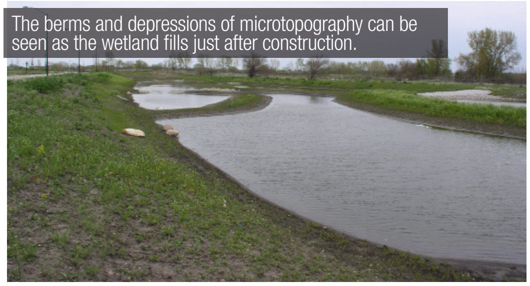
Stormwater wetlands can be designed to address both stormwater quantity and quality. The requirements of the Unified Sizing Criteria can be addressed through these best management practices.

Stormwater wetlands should include the following key features:

1. *A sediment **forebay** (or equivalent pre-treatment practice) should be located at all points of concentrated inflow, to capture heavier sediment particles from incoming runoff. ESSENTIAL*

Forebay, soon after construction within Precedence neighborhood in Prairie Trail, Ankeny, Iowa

2. *Microtopography is a series of small berms and depressions that maximize the length of flow required for water to pass through the wetland.* This can be thought of as a "stormwater maze," forcing water to weave slowly through the constructed wetland. The microtopography will provide areas of variable pool depth and saturated zones just above the permanent pool elevation. *ESSENTIAL*



The berms and depressions of microtopography can be seen as the wetland fills just after construction.

Wetland during construction, shaping of berms and depressions and installation of check dams.

3. *Areas of deeper water, with a minimum depth of 5 feet.* Deeper pool depths may support fish and increase biodiversity, reduce resuspension of sediments and address thermal pollution. *TARGET*

Shaping the wetland pool zones during construction.

Wetland pool zone after full establishment of permanent vegetation.

Pre–treatment measures such as forebays, vegetative buffer strips, grass swales, etc. are critically important for intercepting sediment, debris and litter before it can be washed into the marsh and pool zones within the wetland.

Without pre–treatment, deposition of sediment can lead to lost capacity and give rise to invasive species.

Refer to 8.1.D "Design Criteria" for more detailed information about these topics.

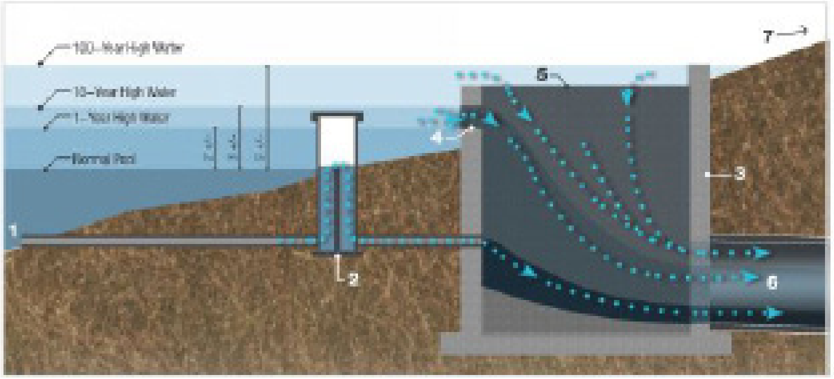
Most of the wetland floor will be comprised of the microtopography area. In this area, depths of water below the permanent pool will typically be less than 18 inches.

To maximize stormwater filtration and pollutant removal, it is important to have the correct balance of shallow and deeper water areas within the stormwater wetland. Refer to "Wetland Topography and Geometric Layout" starting on page 13 of this section.

Refer to 8.1.D “Design Criteria” for more detailed information about these topics.

4. *A* ***multi-stage outlet is essential for effectively managing both small and large storm events.*** *TARGET*

FIGURE 9.08-1-6: AN EXAMPLE OF A MULTI-STAGE OUTLET DESIGN ADAPTED FROM WALNUT CREEK WATERSHED MASTER PLAN



Staged Outlet

1. 1st Stage: Perforated riser, small pipe or orifice (below surface)
2. Water Level Control Structure (recommended to control permanent pool elevation)
3. Main Outlet Structure
4. 2nd Stage: Above 1-year high-water elevation
5. 3rd Stage: As needed to manage larger storms (set above 10-year)
6. Pipe Outlet (likely controls 50- to 100-year storms)
7. 4th Stage: Emergency Spillway (not shown; set at least 1.5 feet below dam crest—may need to be at or above 100-year storm level to meet local release rate criteria)

5. *A dam is created by excavation (cut) or embankment (fill) to contain the 100-year event with one foot of freeboard between the top of the dam and the expected high-water elevation. ESSENTIAL*

6. *An emergency overflow spillway,* is best located at one end of the dam and preferably not located in an area of fill. *ESSENTIAL*

7. *The outfall should be placed in a stable location,* with adequate protection from erosion. Some options are: *ESSENTIAL*

   - Pipe outfall to the surface, to a swale or to a **level spreader**
   - Connection to a local storm sewer system or to a culvert
   - An outfall to a waterway, such as a stream or river

When designing outfalls to waterways, pay careful attention to signs of bank erosion or **stream migration**. Avoid placement of outfalls on the outside bend of stream, where higher levels of shear stress frequently occur. Outfalls should be placed as close to the normal flow elevation of the stream as possible to reduce the potential for surface erosion or downcutting below the outlet. Reduce the potential for erosion below or around the pipe outlet by placing revetment stone materials or an equivalent level of protection.

FIGURE 9.08-1-7:
MAJOR DESIGN ELEMENTS OF
A STORMWATER WETLAND

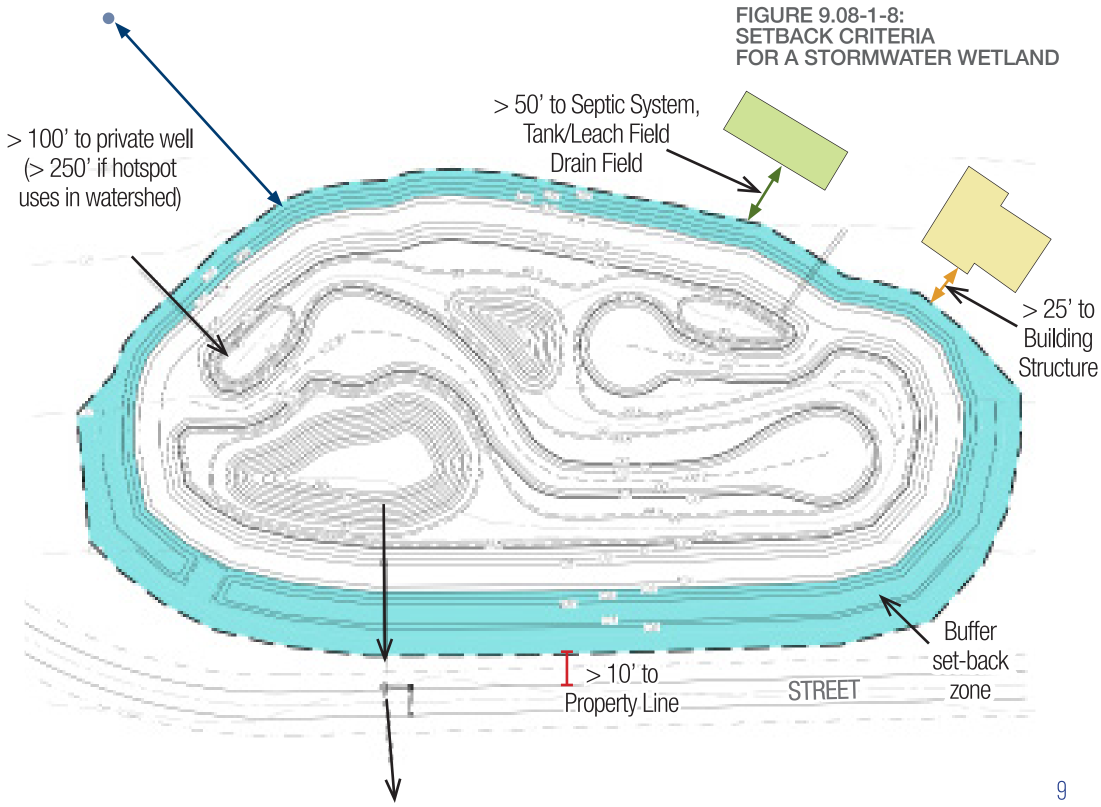


FIGURE 9.08-1-8:
SETBACK CRITERIA
FOR A STORMWATER WETLAND

Construction activities within floodplains and along streambanks likely will require state and federal permits. It is advisable to discuss potential impacts with the Iowa DNR and U.S. Army Corps of Engineers to determine permit requirements at a given site.

Microtopography creates small berms to lengthen flow paths through the wetland and variations in depth in the shallow depth zones (low and high marsh).

The pool is divided into shallow and deep pool zones.

See "wetland topography and geometric layout" within this chapter for more information.

NOTE

Setbacks shown are measured from the perimeter of the buffer setback zone.

Refer to Figures 9.08–1–15 and 16 on page 19 for illustrations of cross–section elements

D. DESIGN CRITERIA

GENERAL BACKGROUND

These setbacks *must* be measured from the perimeter of the 25–foot minimum buffer setback described above.

1. There should be a minimum 25-foot buffer **setback** perimeter measured from the expected high-water elevation expected during a 100-year, 24-hour storm event and from the toe of the dam embankment. Other minimum setback requirements for stormwater wetland facilities should be measured beyond this buffer (when not specified by local ordinance or criteria): *ESSENTIAL*

10 FT from a property line *(if no right of entry or easement has been granted by owner)*	**25 FT** from a building structure	*All utilities must be located* **OUTSIDE** *of the wetland site, or provision of access to said utility must be included in the design*
100 FT from a private well *(increase to 250 feet if wetland receives runoff from a hotspot land use)*	**50 FT** From a septic system tank/leach field drain field	

2. When evaluating potential wetland sites, consider features such as natural depressions, buffers and undisturbed natural areas; attempt to make the wetland fit aesthetically into the surrounding landscape.

Disturbing existing wetlands may not be allowed by permitting agencies.

3. *Disturbing existing and functional wetlands to create a new stormwater wetland is strongly discouraged.* Initial investigations should determine potential impacts to existing wetlands, stream corridors, floodplains and endangered species. Impacts to these types of resources may require a Joint Permit application to the U.S. Army Corps of Engineers and the Iowa Department of Natural Resources. Depending on the level of impact, other studies may be required to satisfy permit requirements. It is advisable to contact these regulatory agencies early in the evaluation process if there is evidence that a permit may be required. *ADVISORY*

   - In some cases, the potential to provide an **ecological lift** of existing wetlands or stream corridors may be a reason to construct a stormwater wetland in an area where a poor-quality wetland or impacted stream exists. Use wetland mitigation calculation methods or the Iowa Stream Mitigation Method to evaluate the potential for ecological lift or the need to provide mitigation for wetland or stream features that may be impacted by the proposed stormwater wetland.

Cattails have overrun this stormwater wetland, leading to a lack of biological diversity.

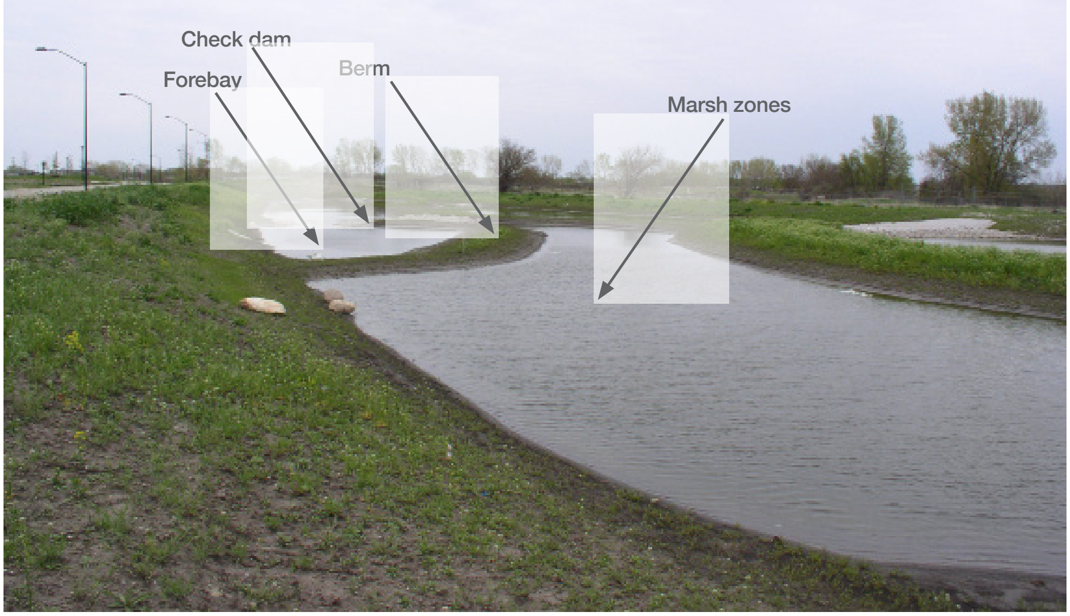
PRE-TREATMENT PRACTICES

It is critical to minimize the **sediment loading** into stormwater wetlands. Deposition in shallow pools and flowpaths of a constructed wetland system can reduce capacity and deteriorate habitat. Flow paths may be blocked, leading to flow redirection and erosion of berms. Heavy sediment deposits can reduce establishment of desired vegetation, giving opportunity for accelerated growth of **invasive species**.

The wetland facility should have a sediment forebay or equivalent upstream pre-treatment practice for every inflow point to the practice. *ESSENTIAL*

Ideally, constructed wetlands should be constructed after upstream areas have been fully stabilized. However, if **active construction** is expected upstream of the stormwater wetland, additional sediment forebays should be constructed upstream of the proposed wetland, providing at least 3,600 cubic feet per **disturbed acre** drained.

- A forebay (or equivalent practice) should be sized to contain 10% of the WQv (approximately 0.1 inches per **impervious area** drained). Volume allocated to the pre-treatment practice may be deducted from the WQv volume to be treated by the stormwater wetland. *ESSENTIAL*
- If forebays are used for pre-treatment:
  - To increase sediment capture by slowing water entry into the wetland, a forebay should be physically separated from the wetland in some fashion, such as a berm, reinforced low-head crossing, check dam or pipe. *ESSENTIAL*
  - Paths for maintenance access should be provided to and from the forebay from adjacent streets or other points of public access. *ESSENTIAL*
  - The forebay should create a permanent pool of water which is no more than 4 feet deep. *ESSENTIAL*
  - A fixed vertical sediment depth marker or hard-armored bottom is recommended to be placed in the bottom of the forebay to monitor the depth of sediment to be removed. *ESSENTIAL*
  - Inflow and outflow conditions at the forebay should be checked to make sure that erosive conditions are not expected. *ESSENTIAL*
  - Consider methods of **dewatering** the forebay for sediment removal (gated or valved maintenance drawdown pipe, wet well for a temporary pump system, etc.) *TARGET*



Forebay located at middle left side of wetland. Berms and check dams separate the forebay from the marsh zones to the right

The separation between the forebay and wetland is intended to slow flow and increase settlement and deposition within the forebay. The separation may be low enough that temporary detention storage for large storm events is provided by the area above both the wetland and the forebay areas.

NOTE

Although recommended at all inflow locations, pre–treatment is not required where drainage sub–areas entering the wetland are less than 0.25 acres in size, are already fully stabilized with permanent vegetation and no further land disturbing activities are expected.

Even in such cases, it is **strongly recommended** to use available space outside of the buffer setback to establish a vegetative buffer strip.

Refer to Figures 9.08–1–15 and 16 on page 19 for illustrations of cross–section elements

- Other options for pre-treatment measures are grass swales, vegetative filter strips, mechanical separators, etc. Vegetative filter strips are most effective in areas where stormwater will approach the filter strip as sheet flow, so that water spreads fairly evenly across the entire width of the buffer, and the terrain within the buffer strip allows such sheet flow to be maintained (flow doesn't funnel into concentrated flow paths). Swales, separators and other practices are often used as pre-treatment measures for concentrated flow paths. When planning and designing these pre-treatment measures, refer to the relevant section of the ISWMM for information on proper location and sizing.

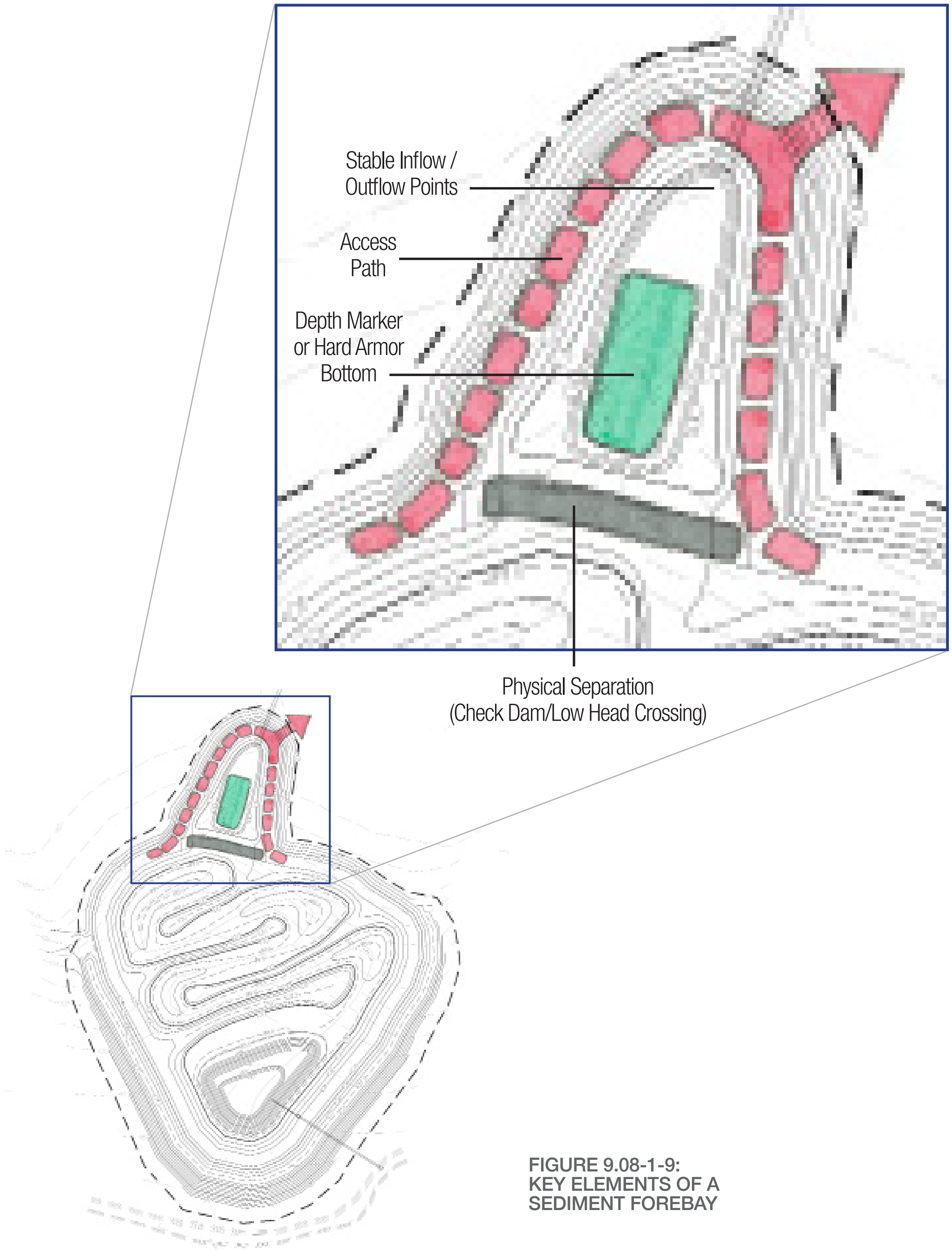


FIGURE 9.08-1-9: KEY ELEMENTS OF A SEDIMENT FOREBAY

WETLAND TOPOGRAPHY AND GEOMETRIC LAYOUT *ESSENTIAL*

1 *Microtopography in stormwater wetlands creates distinct depth zones. These zones are unique from one another in their purpose and the habitat they provide. The types and variety of vegetation expected to survive in each will also vary.*

VEGETATION ZONES—KEY:

DEPTH | EMERGENT | UPLANDS

BELOW PERMANENT POOL

DEEP POOL ZONE

Water depth 36 inches or greater below permanent pool. Usually a deeper water area is provided near the outlet structure, but other pools and channels can be provided throughout. If deep enough, these zones may provide protection for fish population during winter months and provide an area of open water free of vegetation.

SHALLOW POOL ZONE

Water depth of between 18 and 36 inches below permanent pool. This zone supports little **emergent wetland vegetation**, but may support **submerged** or **floating vegetation**.

LOW MARSH ZONE

Water depth of 6 to 18 inches below the permanent pool. This zone is suitable for the growth of several emergent wetland plant species.

HIGH MARSH ZONE

Water depth of less than 6 inches below the pool to the normal pool elevation. This zone will support a greater density and diversity of wetland species than the low marsh zone.

ABOVE PERMANENT POOL

SEMI-WET (EXTENDED DETENTION) ZONE

Areas above the permanent pool, but below the high-water elevation of the channel protection volume. These areas are more frequently inundated. Vegetation selected for this zone should consist of species that can survive frequent or sporadic flooding. These areas may remain inundated 24 to 48 hours following storm events.

DETENTION ZONE

Areas above the high-water elevation of the channel protection volume, but below the high-water elevation caused by the 100-year, 24-hour storm event. A wider palette of native vegetation may be established in this zone. This area may be submerged less frequently for shorter periods of time.

PERIMETER BUFFER

BUFFER ZONE

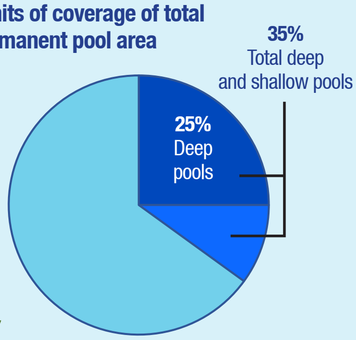
A minimum perimeter buffer of 25 feet must be provided outside of the high-water elevation of the 100-year, 24-hour event and along the exterior footprint of dam embankment grading.

The permanent pool is a constant water depth expected to be supported within a wetland or pond during normal moisture conditions. This pool is often established by the level of a pipe or inlet opening, or other spillway control.

To maximize nitrate removal, it is recommended that deep pool zones comprise no more than 25% of the surface area of the permanent pool of the wetland.

No more than 35% of the surface area covered by the permanent pool should be assigned to the total of the shallow and deep pool zones.

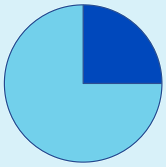
Limits of coverage of total permanent pool area



To maximize filtration and plant uptake and to provide for greater habitat diversity, it is recommended that the area allocated to each of the marsh zones be balanced (difference in area should be no greater than 20% of the area covered by the permanent pool.

$$\frac{[\text{High–marsh area}] - [\text{Low–marsh area}]}{(+/-)\ 20\%\ \text{of total permanent pool area}}$$

The volume of water stored in the marsh zones should be at least 25% of the permanent pool of the wetland.



Marsh zone water volume *must* equal or exceed

25%

of the permanent pool

NOTE

These are the zones based on the topography of this example.

If the separation berms are not being used for equipment access, they may be set below the CPv high water elevation, which would place them in the Semi–wet (ED) zone.

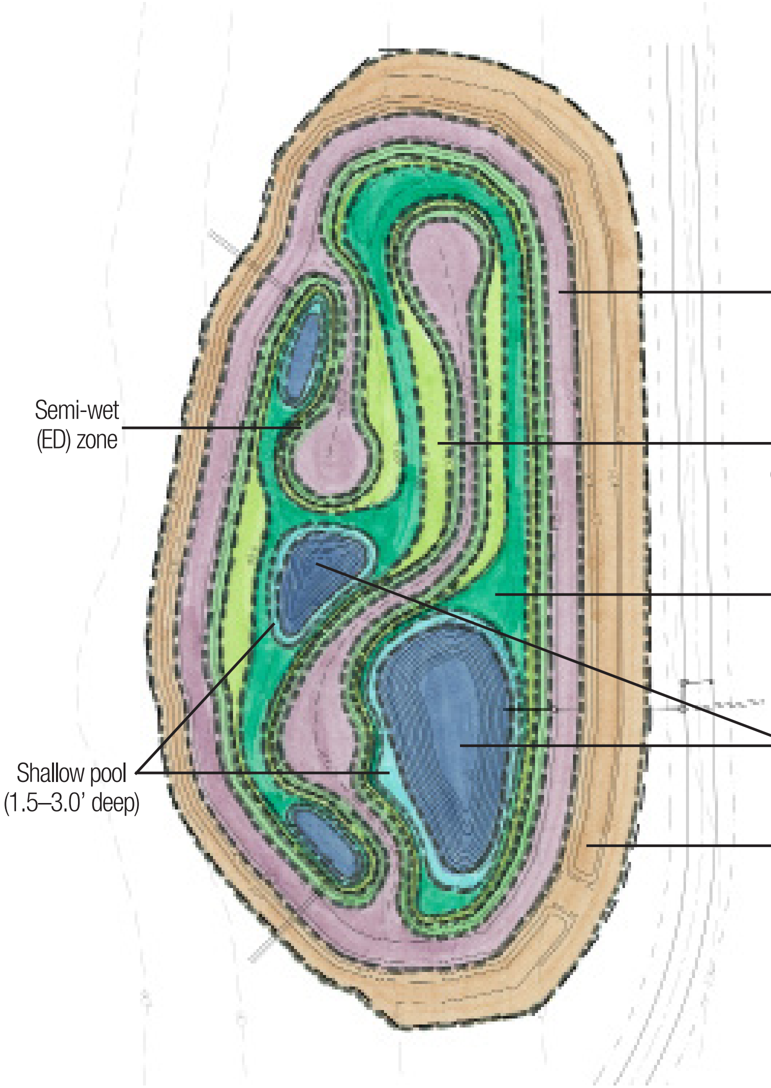
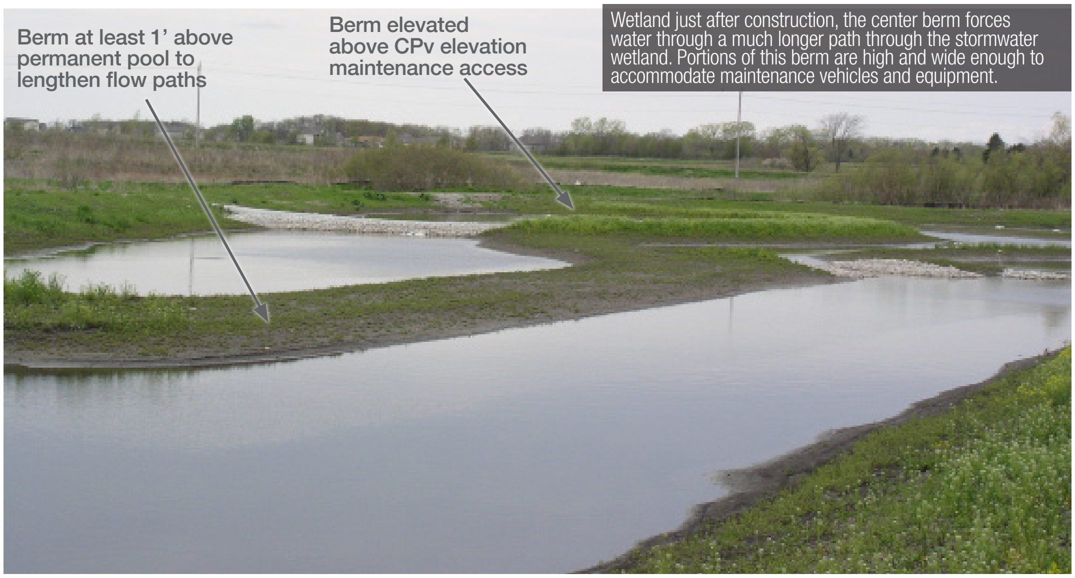


FIGURE 9.08-1-10: TOPOGRAPHIC ZONES WITHIN A STORMWATER WETLAND



Wetland just after construction, the center berm forces water through a much longer path through the stormwater wetland. Portions of this berm are high and wide enough to accommodate maintenance vehicles and equipment.

Refer to Figures 9.08–1–15 and 16 on page 19 for illustrations of cross–section elements

2 *Microtopography should be used to maximize flow length. The length of flow along a normal low flow path through the wetland should be at least three times as long as the shortest distance across the practice (measured at permanent pool elevation. ESSENTIAL*

3:1
preferred ratio

To find this ratio:

(A) Measure length along the meandering flow path

(B) Measure the length from the inflow point(s) to the outlet

Ratio = (A) / (B)

- All berms should extend at least one foot above proposed permanent pool elevations.
- Avoid dead ends and dead zones. Try not to create stagnant areas. Maximize the portion of the pool that water must meander through.
- Berms and depressions should be designed with irregular shapes to simulate natural topographic features.
- Side slopes on berms below the high-water elevation for the CPv event should be no steeper than 4:1.
- Areas along the perimeter of the wetland that are between the permanent pool elevation and the CPv high-water should be no steeper than 6:1.
- Check dams made up of open graded materials (free of fine sands, silts and gravels) can be used to divide the wetland into multiple cells, slow velocities and increase residence time. The crest of these dams should be set within 0.25 feet of the permanent pool elevation and they should be keyed into the center of the adjacent berms.
- If access for maintenance vehicles or equipment is desired into the interior of the wetland, some berms may need to be raised above the CPv elevation and be wide enough to accommodate the desired equipment. A turnaround point, bridge, boardwalk or other crossing is advisable to provide for personnel and/or equipment access in and out of the access area. In some cases, this access could be designed as a path or trail.
- Near points of entry, check dams and points where flow paths narrow, it is advisable to ensure that berms are tall and wide enough to not be frequently overtopped which could lead to erosion of the berm and "short-circuiting" of the desired flow path.

NOTE

Designers should check flow velocity for the CPv event, using the continuity equation or some other method to ensure that velocities between berms will not be erosive (< 5 fps)

NOTE

In locations where a liner is required, topsoil respread or soil quality restoration will need to be carefully installed in a layer on top of the liner in areas outside of the deep pool zone.

3 *The volume of water stored in the permanent pool should be equal or greater to the WQv to be treated. ESSENTIAL*

- This volume may be reduced by up to 10% when properly sized pre-treatment measures are provided.
- In special circumstances, where stormwater wetlands are being used in retrofit situations or developed areas, where off-site upstream areas have been fully urbanized, up to 50% of the WQv may be addressed through extended detention. However, providing WQv treatment within the permanent pool remains the preferred option, and ED should only be used to address WQv when there is insufficient space available to fully address WQv.

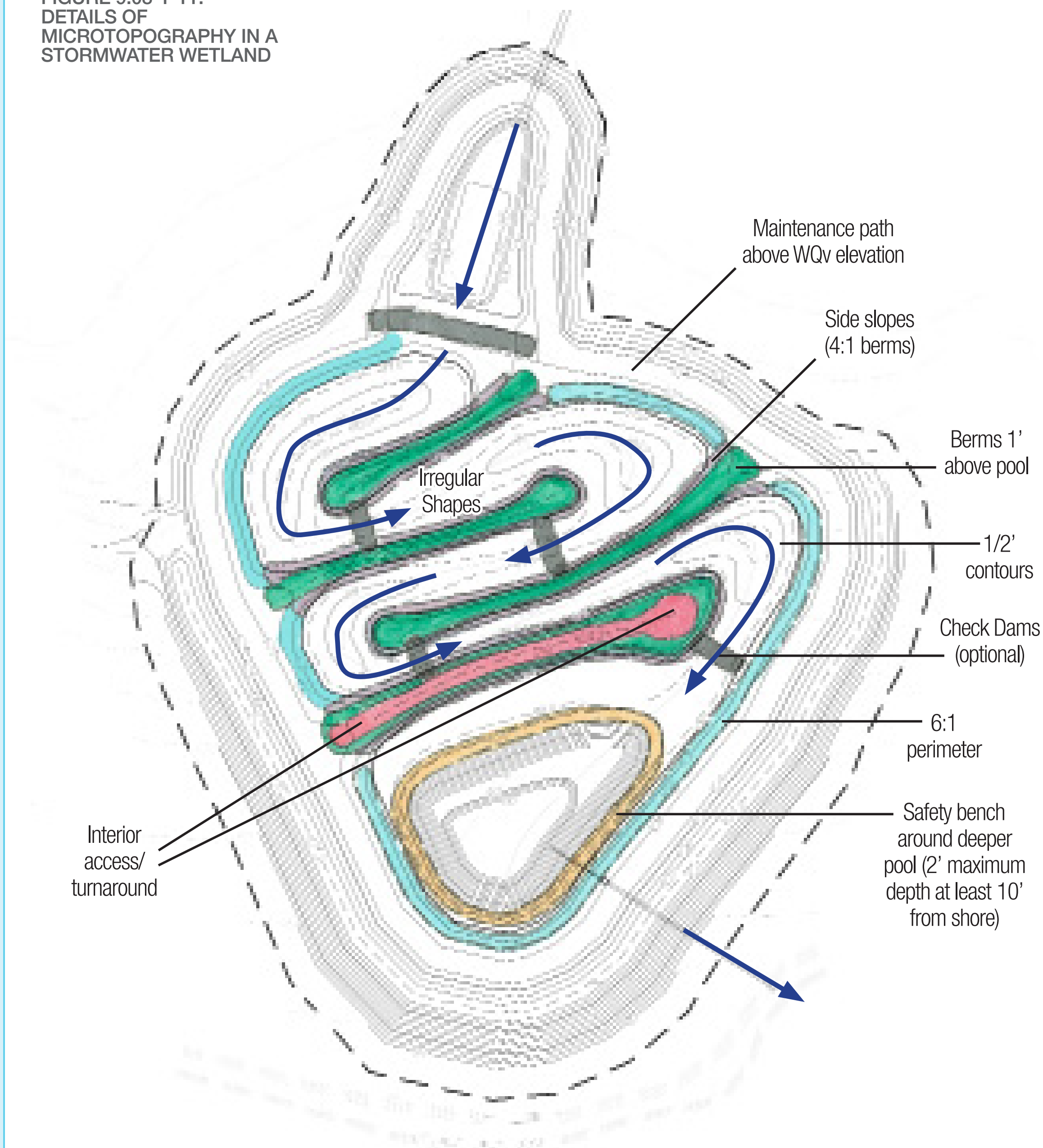
Keying a check dam is burying the ends of the stone material of the dam into the adjacent berms or the perimeter of the wetland. This helps reduce the potential for erosion of soil materials around either end of the check dam.

4 *Around the perimeter of the deeper pool a safety zone with a depth of 0 to 2 feet should be provided for a width of no less than 10 feet. TARGET*

- [x] To clarify the intent of grading design plans, contours should be shown in 0.5-foot intervals to better define desired microtopographic features.

- [x] To prevent overcompaction and provide quality soil materials to promote growth of desired vegetation, it is recommended that low-ground-pressure construction equipment (tracked equipment preferred over tires) be used to complete construction of microtopography. Surface roughening, soil quality restoration and seedbed preparation are also recommended in areas outside of the deep pool zone.

FIGURE 9.08-1-11:
DETAILS OF MICROTOPOGRAPHY IN A STORMWATER WETLAND



Refer to Figures 9.08–1–15 and 16 on page 19 for illustrations of cross–section elements

OUTLET STRUCTURE DESIGN

1. *The multi-stage outlet* should be designed to provide the following:
   - *Drawdown of the permanent pool elevation* by at least 3 feet during initial establishment and when maintenance is required. Use a knife valve or an in-line water level control structure to control flow through the drawdown pipes. A gate valve is not recommended, as its operation may be most impacted by the presence of debris. *TARGET*
   - *Withdrawal of water from below the surface* during most flow conditions. The expected peak discharge rate for the WQv event (1.25" rainfall within 24-hour period) should pass through this outlet stage. (Pool drawdown and subsurface withdrawal can be accommodated by inclusion of an In-line Water Level Control structure in the design.) *ESSENTIAL*

     An in-line water level control structure can be used as both a maintenance drawdown and for controlled release of the WQv. It includes stop logs which can be used to raise and lower water elevations during initial vegetation establishment or maintenance. It also allows for subsurface withdrawal of water from the permanent pool.

   - *A perforated riser or orifice control* that provides extended detention for the CPv by restricting flow to outflow rates to provide a minimum 24-hour drawdown. *ESSENTIAL*
   - *Higher outflow stages* which will likely include some combination of orifices, pipes, weirs and spillways as needed to limit outflow rates from larger events to those similar to pre-development conditions (or other standard based on local jurisdictional requirements). These higher stages should be set above the expected high-water level of the CPv event. Flows from these events should be passed without erosion near inlets and overflow spillways. *TARGET*
   - *Tops of larger intakes and pipe openings may need to be protected* with a grate below Permanent Pool for debris collection and to restrict access. Minimum opening sizes of 3 inches should be used to intercept debris while reducing the potential for clogging from leaves or other floating vegetation. *TARGET*

OUTLET PIPE AND OUTFALL PROTECTION

1. Revetment materials or other erosion protection measures should be placed at pipe outlets. Check expected velocities at outfalls and overflow spillways during a 100-year storm event. If necessary, consider increasing the size of the discharge pipe to lower expected velocity at outlet. (In such a case, verify that the multi-stage outlet still meets the release rate requirements for all storm events being managed. *ESSENTIAL*
2. Water seepage can easily occur along pipe conduits through dams. This can result in a failure to maintain the desired water level within the wetland (or pond). In extreme cases, this water movement can lead to erosion along the outside of the pipe, potentially leading to a breach of the dam itself. Pipe conduits through spillways must include seepage control measures to prevent these issues. In the past, seepage collars were often used to address this issue; however, these have been shown to be ineffective in many situations. *ESSENTIAL*

   Some of the options listed within the FEMA Technical Manual to control seepage and erosion through dams are:

   - Concrete cradles may be cast below circular pipe spillways to avoid problems with soil compaction along the undersides of the pipe.
   - Use of waterstop materials at pipe joints.
   - Construct chimney filters to control internal seepage or erosion within the dam structure.

A water level control structure is a device that uses stop logs to control the elevation of the permanent pool.

In many cases, the subsurface outlet may be used to provide the extended detention control for both the WQv and CPv events.

REMINDER

Construction activities to install outfalls within floodplains and along streambanks may require state and federal permits. It is advisable to discuss potential impacts with the Iowa DNR and U.S. Army Corps of Engineers to determine permit requirements at a given site.

Refer to the following standards for the design of dams and outlet conduit spillways:

FEMA Technical Manual: Conduits Through Embankment Dams (September 2005)*

DNR Technical Bulletin No. 16: Design Criteria and Guidelines for Iowa Dams (December 1990)

**most recent guidance on the design of outlet conduit spillways*

NOTE

If a stormwater wetland is not required to provide management of the 100–year event, stage–storage routings of that event should still be performed to ensure that the high–water level within the wetland is not expected to reach within 1 foot of the top crest of the dam (not including the auxiliary spillway.

This analysis should demonstrate wetland operation for this event, either through bypass of most of these larger flows (off–line system) or flow cresting over an auxiliary spillway.

However, we should emphasize that even when not required, the footprint area that will be required to manage WQv and other smaller storms often provides great opportunities to manage larger events when employing multi–stage outlets. It is highly encouraged that such opportunities be used as often as possible for overall watershed benefits.

Flows may crest over the auxiliary spillway, but longer weirs provide less flow control. It may be difficult to meet local requirements to reduce peak flow rates for storm events where flows crest over the auxiliary spillway.

NOTE

Depending on the volume of water stored in the wetland facility, design and construction of the dam may require permitting through the Iowa Department of Natural Resources (see Chapter 7). Refer to DNR Technical Bulletin 16 and DNR Form 542–1014.

FIGURE 9.08-1-12:
KNIFE VALVE

Courtesy: A-C Valve, Inc.

FIGURE 9.08-1-13:
IN-LINE WATER LEVEL CONTROL STRUCTURE

Courtesy: agridrain.com

DAM CONSTRUCTION AND AUXILIARY SPILLWAY *ESSENTIAL*

1. When constructed by placement of embankment materials, the dam must be created with less permeable clay fill material or through placement of key trench (dam core) materials through excavation areas to prevent seepage through or underneath.
2. Unless constructed as an off-line facility, the dam should be high enough to contain the 100-year event with 1 foot of freeboard between the top of the dam and the expected high-water elevation.
3. It is recommended that the crest of the dam be at least 10 feet in width at all locations and side slopes should be no steeper than 3:1 (4:1 recommended).
4. An emergency overflow spillway should be located at one end of the dam and preferably not located in an area of fill.

The auxiliary spillway should be set at least 1.5 feet below the crest of the dam.	The spillway may be set below the 100-year high-water elevation within the wetland, if flow over the spillway is accounted for in calculations and total discharge from the wetland (through both pipe and spillway outfalls) does not exceed the maximum allowable outflow rates.	The spillway should be protected from surface erosion, based on the expected velocities and frequency of overtopping.	The spillway should be directed to a location where downstream properties, buildings or infrastructure are not expected to be negatively impacted.	Surface water flowage easements may be required to allow flows to be conveyed across off-site areas downstream.

FIGURE 9.08-1-14: AUXILIARY SPILLWAY DETAILS

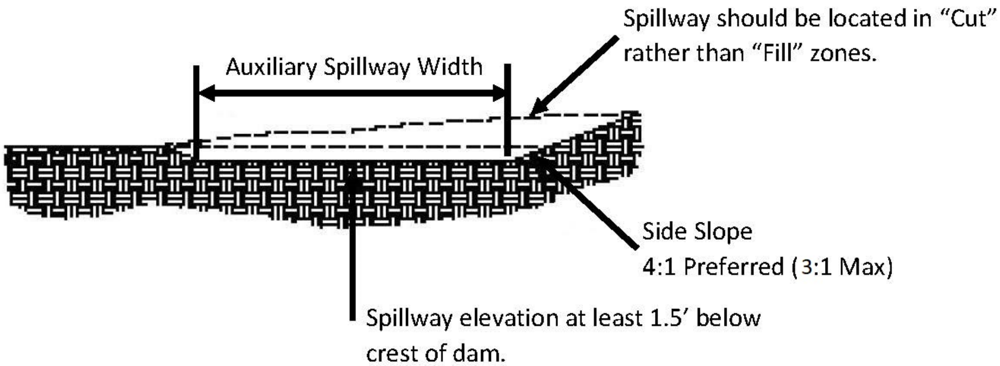


FIGURE 9.08-1-15: SAMPLE WETLAND CROSS-SECTION

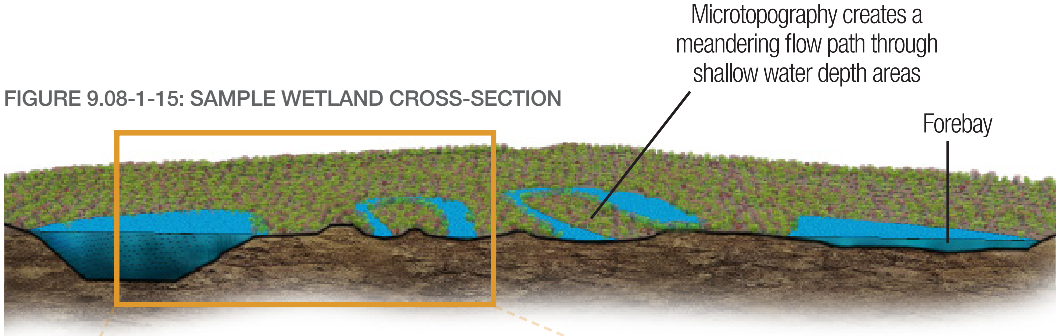
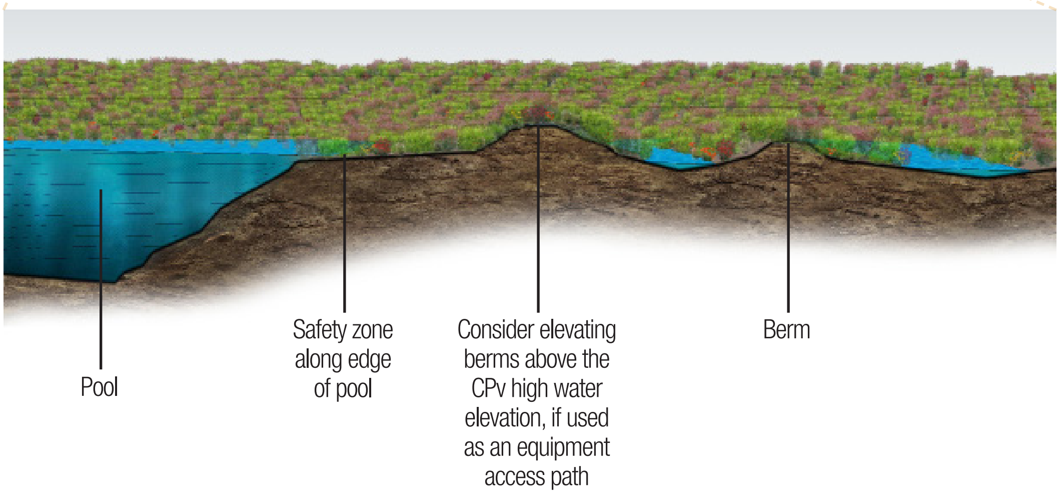


FIGURE 9.08-1-16: INSET OF WETLAND CROSS-SECTION



NOTE

Illustrations shown have an exaggerated vertical scale to make it easier to identify typical changes in topography.

DESIGNING FOR MAINTENANCE ACCESS *ESSENTIAL*

A maintenance path should be provided around the perimeter of the facility, with paths of access to forebays, pre-treatment devices, safety benches, spillways, outlet structures and pipe outfalls.

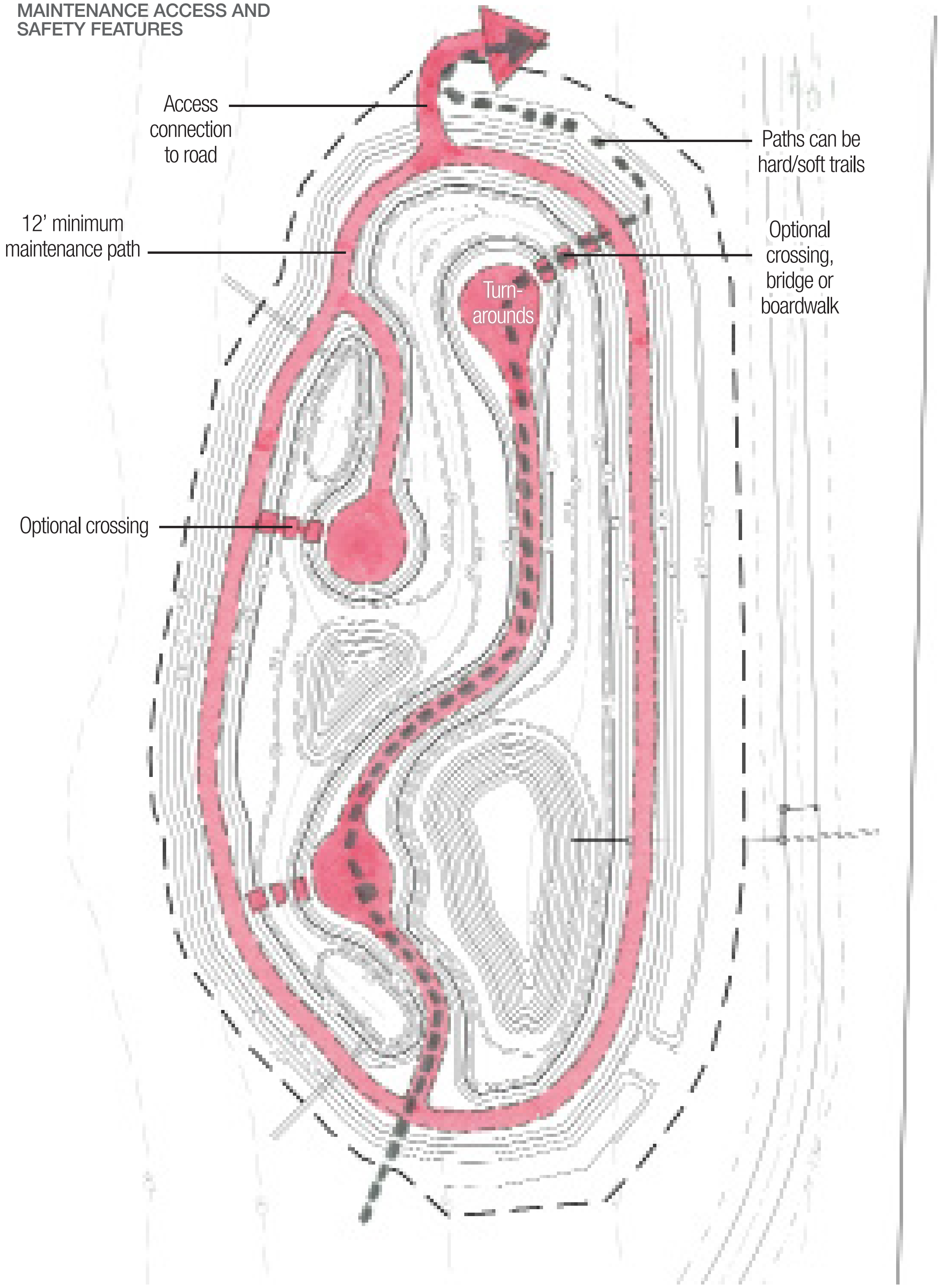
- The path of access should be **at least 12 feet wide** with a maximum cross-slope of 8% (5% preferred).
- The path should be kept **clear of trees** or other woody vegetation. (This mowed or paved access may also serve as a fire break, if fire is planned for vegetation maintenance.)
- It should be constructed to **withstand maintenance vehicles** and equipment. (While not required, shared-use paths and multi-use trails can be constructed to serve a dual purpose for maintenance access.)
- The path should have **access to a public or private road** for a point of entry, and should be completely within the property owned by the party responsible for maintenance, or within an easement recorded to grant such access.
- In some cases, **turn-around areas, low head crossings, culverts or bridges** may be needed for ingress and egress of equipment to certain areas.

SAFETY FEATURES

- All embankments and spillways must be designed to **State of Iowa guidelines for dam safety** (see Chapter 7). *ESSENTIAL*
- **Fencing of wetlands is not generally desirable**, but may be required by the local review authority. *TARGET*
- The **safety bench** around the perimeter of deep pool areas eliminates rapid drop-offs into deep water, reducing the potential for accidental drowning. *ESSENTIAL*
- A **grate or trash rack on larger openings** of the multi-stage outlet structure should deter access by small children. *ESSENTIAL*
- **Pipe outfalls of greater than 48 inches** in height may require a fence or railing to reduce fall risks. *ESSENTIAL*

Wetland during construction. This check dam was constructed out of open graded larger stones below (free of fine materials) to allow water filtration through the dam. Smaller diameter stone was used above to allow the dam to act as a crossing for maintenance vehicles and equipment. Articulated mats and blocks could also be used on the surface of such a feature.

FIGURE 9.08-1-17:
MAINTENANCE ACCESS AND
SAFETY FEATURES



Access paths should be kept clear of trees, brush and other obstacles for equipment. They may simply be mowed paths, but could also be soft or hard trails.

Low–head crossings may be incorporated into check dam designs.

Bridges and boardwalks are other methods to provide for equipment or personnel access across marsh or pool zones.

LANDSCAPING

Establishing and maintaining desired vegetation is one of the most critical elements in ensuring proper long-term function of a wetland. It is strongly recommended that bidding of projects be structured in such a fashion to encourage qualified, experienced contractors to be responsible for the installation and establishment of desired native vegetation within the limits of the project.

- A landscaping plan should be provided that indicates the methods used to **establish and maintain wetland coverage.** Minimum elements of a plan include: delineation of landscaping zones, selection of corresponding plant species, planting plan, sequence for preparing wetland bed (including soil amendments, if needed), and sources of plant material.
- **Landscaping zones** include low marsh, high marsh, semi-wet, detention and buffer zones.
- The landscaping plan should include **habitat features** that promote greater wildlife and waterfowl use within the wetland and buffers.
- **Woody vegetation** must not be planted on the dam embankment or allowed to grow within 25 feet of the toe of the embankment, and the principal and emergency spillway structures, to prevent damage from root growth.
- When possible, existing healthy, native **tree species should be preserved** in the buffer area during construction. It is desirable to locate forest or savanna conservation areas adjacent to wetlands.
- To discourage resident geese populations, the buffer should primarily include **taller vegetation** including trees, shrubs, and native vegetation.
- Overcompaction of site soils may require **excavation of pits,** to be backfilled with less compacted topsoil materials in tree and shrub planting areas.

Detailed plant material recommendation lists are included in the specification section of the ISWMM manual.

FIGURE 9.08-1-18: A DIVERSE MIX OF PLANT SPECIES HAS BEEN ESTABLISHED IN THE VARIOUS ZONES OF THIS WETLAND, THROUGH SEEDING, PLANTING AND EFFECTIVE MAINTENANCE.

The landscaping plan should clearly identify the limits of the area for each seed mix application and the location of plant materials. Refer to the specification sections of the ISWMM related to Stormwater Wetlands for suggested seed and plant lists.

To simplify maintenance, it is recommended that plugs should be placed within the high marsh zones of the permanent pool. (This keeps mowing operations away from planted plugs.)

Be aware that **time is required for nurseries to grow the proper quantities of native plants.** Consider this when preparing construction and establishment schedules.

One advantage of using an in–line water level control structure for outlet control is that water levels may be slowly raised during seed establishment or lowered during planting.

Installing plugs one season after permanent seeding may help hide them from feeding animals.

When preparing a seeding plan, consider the need for firebreaks along adjacent private properties or larger native landscaped areas. Cool season seed mixes, alfalfa, mowed turf and paved trails may act as firebreaks (alfalfa may need to be replanted after a few years).

Construction activities may occur outside desired seeding periods for permanent vegetation. Temporary seed and mulch should be used to reduce the potential for surface erosion until permanent seeding and planting can occur.

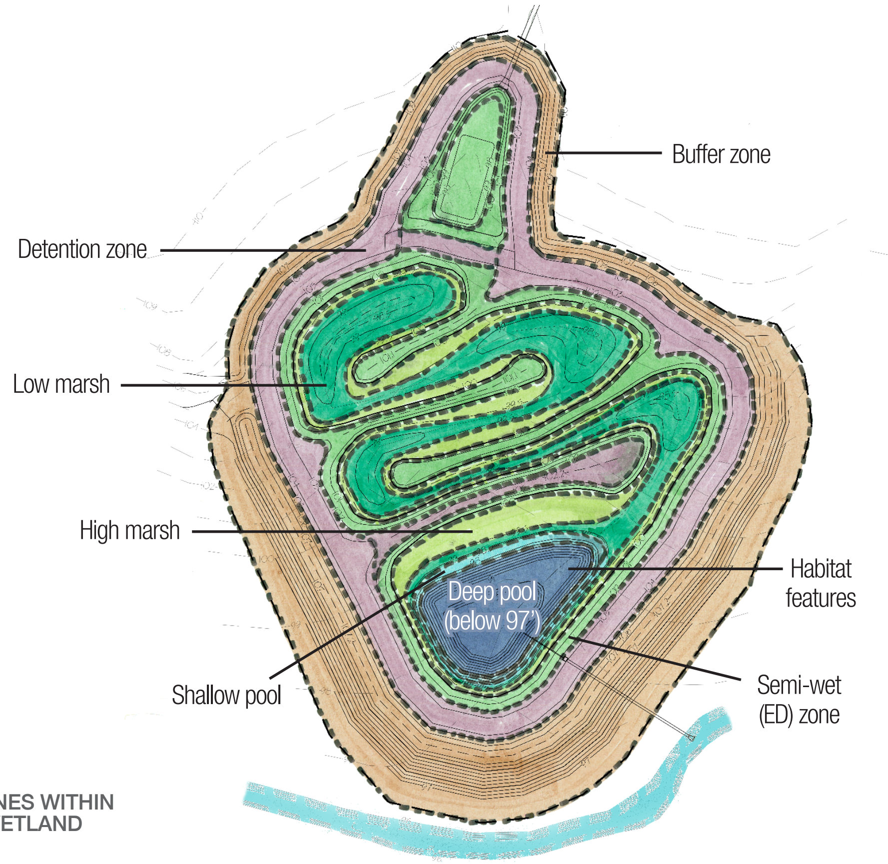


FIGURE 9.08-1-19: LANDSCAPING ZONES WITHIN A STORMWATER WETLAND

E. SPECIAL CASE ADAPTATIONS

FLOOD PLAINS

Areas subject to flooding often feature gentle slopes and hydric soils which may create favorable sites for constructed wetlands.

Siting these practices within areas subject to flooding should be done with caution. During site screening, look for evidence of sediment deposition, debris or surface erosion.

Locating constructed wetlands in areas where deposition is common or debris is found may cause the wetland to lose storage depth over time. This may limit the water quality benefits of the wetland, negatively impact habitat improvements and desired vegetation and could promote establishment of invasive species.

Wetlands located in areas which may see higher-velocity flows during flood events could erode microtopographic features, leading to short-circuiting of low-flow paths through the wetland. Higher flows may also have a negative impact on desired trees, shrubs, control structures and outlet stability.

STREAM MORPHOLOGY *ESSENTIAL*

Constructed wetlands should be located with adequate buffer space from adjacent streams. The designer should review historic photographs or use other information to understand local stream movement. If a stream is demonstrating active bank erosion or has shown lateral migration over a period of time, the wetland and associated embankments and outlet structures should be located so that such movement will not be expected to impact these features. Alternatively, stream stabilization techniques may be employed to reduce the potential for local stream migration.

The buffer setback around the wetland should be located outside of a projected line from the toe of the adjacent streambank at a 4:1 slope to the finished surface. The buffer setback near streams should be increased in areas where lateral stream migration is anticipated, or areas where lowering of the stream (incision) is being observed or is expected.

Incision is a process where stream channels become lower and wider. Increases in stream flow are often the cause, due to altered hydrology from channelization or land use changes.

Generally, the stream is creating a wider, flatter cross–section which ultimately will be able to pass these flows at a lower velocity with less shear stress. It often can take decades for some type of equilibrium to be reached after significant changes in land use. So care should be taken in locating outfalls or wetlands near streams with incision.

9.08-2 SIZING CALCULATIONS

A. CALCULATION PROCEDURE

Step 1. Determine if the development site and conditions are appropriate for the use of a stormwater wetland. Consider the Application and Feasibility criteria in this section.

Step 2. Confirm any state, federal and local jurisdiction design criteria and applicability standards.

A. Review need for state and federal permits (NPDES, Joint Permit application)

B. Consider any special site-specific design conditions/criteria listed in this section.

C. Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply. (State Dam Safety requirements will be checked in Step 8).

Step 3. Compute runoff control volumes from the stormwater Unified Sizing Criteria.

A. Water Quality Volume

- Calculate the WQv requiring treatment.
- Use TR-55 software to generate inflow runoff hydrographs for developed conditions
  - Use modified Curve Numbers (CNs) for this smaller storm event
  - The peak rate of flow (in cfs) and runoff volume (in cubic feet) will be needed
- If Extended Detention is used to address WQv, calculate the allowable release rate for a 24-hour drawdown

B. Channel Protection Volume

- Use TR-55 software to generate inflow hydrographs for the CPv and larger events to be studied
  - Prepare these for pre-developed, existing and proposed conditions
  - The peak rate of flow and runoff volume for each event will be needed
- Use the procedure in Chapter 3, Section 6 to estimate the required CPv volume and calculate the allowable release rate for extended detention of CPv

C. Overbank/Extreme Flood Protection

- Assemble the data generated by the TR-55 models in Step 3b.
- The peak runoff rates for pre-development and existing conditions will be used to determine allowable release rates.
- Estimate the required storage volume necessary to meet outflow release rate requirements.

NOTE

This procedure assumes that evapotranspiration from the pond is not being counted toward meeting the Recharge Volume (Rev) criteria. If the pond is being used to meet that criteria, refer to Section 9.05 for Water Balance calculations.

The procedure assumes that the pond is providing extended detention of the CPv event. If that is the case, no separate control structure for the WQv event is needed. (ED of the CPv event is assumed to also effectively control outflow during the WQv event.)

If a pond is not proposed to meet the CPv extended detention criteria, a separate calculation would be needed to design an outlet to limit outflow rates for the WQv event. Outflow rates would be set to provide 24–hour extended detention of that event.

A process similar to the CPv procedure can be used, except that the TR–55 model used to calculate flow rates and volumes for the 1.25” event would need to use adjusted CNs, as per Section 3.02.

Details on the unified stormwater sizing criteria are found in Chapter 2.

Refer to Chapter 3, Section 6 of the ISWMM for more details on calculating runoff for “Small Storm Events” (WQv and CPv).

Refer to Chapter 3, Section 5 of the ISWMM for other applications of the NRCS TR–55 method.

NRCS TR–55 calculations may be completed using the Win–TR55 software available through the NRCS. However, third party software packages which run the same calculation methods may also be used. Such software often is more user friendly and offers a wider array of graphical output than Win–TR55.

Step 4. Determine pre-treatment measures.

- The pre-treatment volume should be 10% of WQv.
- A sediment forebay (or equivalent practice) is to be provided at each inlet.
  - The forebay should be no more than 4 feet deep. Determine the proposed storage volume at each concentrated inflow point.
  - The forebay storage volume may be counted toward the total WQv requirement and therefore may be subtracted from the WQv for subsequent calculations.
  - Vegetative buffer strips or other alternative pretreatment methods may be used as described earlier in this Chapter. Size according to related sections of the ISWMM as applicable.

Pre–treatment may be omitted in cases where a drainage area entering the wetland is less than 0.25 acres in size and is already fully stabilized with permanent vegetation, and no further land disturbing activities are expected.

Step 5. Develop a preliminary stage-storage relationship to provide the estimated storage volume required as calculated in Step 3c. Refer to Table 9.08-1-1 for maximum storage depth requirements for key storm events.

1. Select a preliminary elevation for the permanent pool.
2. Calculate the area required to provide the estimated CPv calculated in Step 3b at the recommended depth of 2 feet, then work inward at a 6:1 slope to establish an initial value for the surface area of the permanent pool.
3. Set higher stage-storage relationships based on a slope no steeper than 4:1 projected upwards from the estimated CPv depth.

When developing initial estimates of space needed for permanent pool storage, remember that space for the permanent pool will be lost to create the microtopographic berms needed to lengthen flowpaths through the wetland.

Step 6. Enter the preliminary stage-storage relationships and outlet configurations into a TR-55 software program to route inflow hydrographs through the preliminary wetland design. Perform iterations, adjusting staged outlet controls within the software program as needed to meet required release rate restrictions. Comply with maximum storage depths listed in Table 9.08-1-1.

- "Work from the bottom up."
  - A. Calculate the approximate size of the primary spillway outfall pipe to be used to control the 100-year storm event, based on an approximate elevation of the outfall pipe and the recommended high-water surface elevation.
  - B. Compute the approximate size of the perforated riser or outfall pipe needed to provide extended detention of the CPv (or WQv if applicable).
    - When estimating the size of the outlet, remember that head conditions to calculate orifice flow through submerged openings are measured differently than unsubmerged openings.
    - Use the software program to iterate the design as needed to refine the design to meet the maximum release rate and water surface elevation.
  - C. Set a second stage for larger storms above the expected high-water elevation of the CPv event.
  - D. Adjust the type or size of the second control stage to meet the maximum release rate and water surface elevation for the 10-year storm event.
  - E. Select a preliminary type, size and elevation of upper stages above the expected high-

NOTE

For submerged orifices (orifice upstream of a stoplog or other control which establishes the permanent pool elevation), head condition "h" would be measured from the permanent pool elevation and not the center of the orifice located below the water surface.

In most other cases, "h" for orifices is to be measured to the elevation of the centroid of the area of the orifice.

NOTE

If needed, alter the stage–storage relationship to provide additional storage to meet these requirements.

Item D gives PRELIMINARY sizing of upper stages. It is suggested to start with a preliminary design then adjust openings or weirs to control the 10–year event first. Then, change the size or elevation of the outflow spillway pipe (called "Culvert A" by many software programs) to control the 100–year flow. Finally, adjust higher openings and weirs as needed to meet requirements for events between the 10– and 100–year events.

(Sometimes after Items D and E, release rates may be too high for the 25– or 50–year event, so this final adjustment in Item F to upper–stage design is needed to address those events).

Refer back to design information on microtopography, beginning on page 13 of this chapter.

water elevation of the 10-year event to control larger storms.

F. Adjust the size of the outflow spillway pipe (or emergency overflow spillway) as needed to control runoff from the 100-year event, meeting the maximum release rate and water surface elevation requirements.

G. Go back and adjust the type, size and elevation of upper stages (set in item D above) as needed to meet release rate requirements for all storm events to be reviewed.

Total outflow during these events must not exceed design values computed in Step 3.

Step 7. Determine wetland location and preliminary grading plan, including distribution of wetland depth zones.

- Develop an initial outline of the permanent pool area, based on the surface area developed in Step 5 (and revised in Step 6, if applicable).
    - It will be necessary to enlarge this area slightly, to account for the area of the pool that will be lost to the small berms, check dams or other features.
- Within the footprint of the permanent pool, establish the boundary of the pool zones. Usually these will be located close to the multi-stage outlet structure, but they can be distributed throughout the wetland. Remember to provide a safety bench (2 feet deep or less) at least 10 feet wide around any deep pool zone.

The deep pool zone should not cover more than	The total pool zone area should not exceed	Overall, volume of water stored within the marsh zones should be at least
25%	**35%**	**25%**
of the surface area covered by the permanent pool	of the surface area covered by the permanent pool	of the total stored below the permanent pool elevation

- Outside of the pool zones, develop a grading plan that creates a series of small berms to direct water through a meandering path. The permanent pool that remains between the berms will be the marsh zones (0 to 18 inches in depth).
    - Modify the grading to balance the area between the low and high marsh zones (the difference in area should be no greater than 20% of the area covered by the marsh zones).
- Complete the stage-storage table in the design checklist (provided at the end of this chapter) to verify that the required WQv volume has been provided and that the criteria listed above have been attained. Adjust design as necessary to achieve these results.
- Expand the grading plan around the perimeter of the permanent pool and incorporate forebay locations.

Step 8. Investigate potential pond/wetland hazard classification. The design and construction of stormwater management ponds and wetlands are required to follow the current version of the Iowa DNR Technical Bulletin 16 related to embankment dam safety rules.

- **The height of the dam and the stage-storage relationships (both above and below the permanent pool elevation) are necessary to complete this step.**

Refer to DNR Form 542–1014 for specific guidance on when a permit is required for construction of an earth embankment dam. (Check DNR website for most recent updated version.)

Step 9. Revise the stage-storage information entered in the TR-55 software model (Step 6) to reflect the preliminary grading plan. Perform a stage-storage-discharge routing.

- **Verify that the peak release rate and maximum high-water elevation requirements are still being met.**
- **Adjust storage and/or outfall design as needed until all design criteria are met.**

Step 10. Check outflow velocities at pipe outfalls and spillways. Adjust sizing, geometry or add erosion protection features as needed for the 100-year, 24-hour event.

- **From the continuity equation, determine pipe velocity based on flow rate (Q) and area (A) [V = Q/A]**
- **Using the same equation, check for velocity across the crest of the emergency spillway (if any overflow occurs during the 100-year storm event).**

Step 11. Complete design checklists at the end of this section to verify that sizing design criteria have been satisfied

Proceed to development of detailed plans and specifications. After completion of final design, verify information in Steps 9–11 is accurate. Make any adjustments as needed so that final plan information matches finished calculation report.

Projects with certain types of grant funding require review at key benchmark points in the design process. It may be necessary to provide grant administration agencies with preliminary plan information at these stages during the design process.

The information at right is given for this design example. A stormwater wetland is proposed to manage runoff from an 80 acre watershed in a community in **South Central Iowa.**

Soil Quality Restoration (SQR) is critical to reducing soil compaction, decreasing direct surface runoff and establishing and maintaining desired permanent vegetation.

Refer to the ISWMM Chapter 5, Section 8 for more information.

Providing less than 8" of soil quality restoration is not encouraged. This example includes "< 4–in" and "4–in SQR" scenarios only to demonstrate how to perform calculations in such circumstances.

NOTE

If any of these were present, a Joint Permit application to DNR and the Corps of Engineers would likely be required. Avoid impacts to jurisdictional wetlands, if possible. Presence of habitat for threatened and endangered species may require project restrictions, such as seasonal limitations on tree removal. Flood plain impacts may require modeling in certain circumstances to demonstrate that the project would not have a negative impact on expected flood high–water elevations.

Some communities require WQv to be managed with infiltration based practices, which might prohibit the use of a stormwater wetland to manage WQv.

B. DESIGN EXAMPLE

PROJECT WATERSHED DATA

TABLE 9.08-2-1: EXAMPLE PROJECT WATERSHED DATA

SITE LOCATION: IOWA REGION ZONE 8 (SOUTH CENTRAL)

PROPOSED LAND USE	AREA	HYDROLOGIC SOIL GROUP	% IMPERVIOUS	SQR DEPTH
Commercial	20 acres	B	73%	4"
Multi-family	15 acres	B	65%	< 4"
Single Family*	45 acres	B	43%	8"
Total	**80 acres**			

* Wetland footprint included in this area

Existing conditions: Row crop, contoured with crop residue (C + CR) in good condition, HSG B (CN=74).

Step 1. Determine if the development site and conditions are appropriate for the use of a stormwater wetland. Consider the Application and Feasibility criteria in this section.

For this example, assume that the site feasibility criteria have been reviewed and the site is suitable for a stormwater wetland.

Step 2. Confirm any state, federal and/or local jurisdiction design criteria and applicability standards.

A. Review the need for state and federal permits (NPDES, Joint Permit application)

For this example, assume that no jurisdictional wetlands, habitat for endangered or threatened species or regulated flood risk areas are present.

B. Consider any special site-specific design conditions/criteria listed in this section.

This example is not adjacent to a stream, but if it were, the wetland should be setback from the edge of the stream to account for anticipated bank erosion, stream migration or stabilization methods.

Refer to Section 8.1.E. For this example, the wetland is proposed to be outside of areas of known flood risk. It may still be wise to look for evidence of significant sediment deposition under existing conditions within the site area (assumed this was done and no such indications were observed).

C. Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply (State Dam Safety requirements will be checked in Step 8).

For this example, assume that the local jurisdiction has adopted the use of the ISWMM and requires the following related to application of the Unified Sizing Criteria.

- Stormwater wetlands are eligible to be used to address WQv treatment requirements.
- Extended detention must be provided to release runoff from the CPv event over a period of not less than 24 hours.
- Release rates for larger events (up to the 100-year, 24-hour storm event) will be limited to the lesser of the following:
    - Peak flow rates similar to pre-settlement conditions (meadow in good condition, based on local soil types and historic times of concentration) for similar storm events (i.e. post-project peak flow from 2-, 5-, 10-, etc., year events must be equal to or less than pre-settlement conditions for the same rainfall event).
    - Peak flow rates similar to existing conditions for a 5-year, 24-hour storm event.

Step 3. Compute runoff control volumes from the stormwater Unified Sizing Criteria.

Calculate time of concentration for pre-settlement, existing and developed conditions.

Pre-development conditions: Use NRCS Lag Equation [Eqs. C3-S3-5 & 6]

Watershed length (L) = 3,675 feet
Average watershed land slope (Y) = 3%, CN = 58 (meadow in good condition, HSG B)

Tc = 94.8 minutes

For existing and developed conditions, use the **NRCS TR-55 method.**

TABLE 9.08-2-2: EXAMPLE PROJECT TIME OF CONCENTRATION DATA

	SHEET		SHALLOW CONCENTRATED		PIPE	CHANNEL	
	LENGTH	SLOPE	LENGTH	SLOPE	5 FPS*	3 FPS*	TC
Existing	100 ft	1%	500 ft	2%	0 ft	3,075 ft	37.9 min
Developed	50 ft	4%	250 ft	2%	1,450 ft	1,730 ft	22.1 min

* Assumed since exact pipe size, length and slope are not known

NOTE

This example assumes that evapotranspiration from the pond is not being counted toward meeting the Recharge Volume (Rev) criteria. If the pond is being used to meet those criteria, refer to Section 9.05 for Water Balance calculations.

Stormwater management and release rate criteria may vary between municipalities. Verify local design requirements prior to proceeding further with design.

Refer to the ISWMM Chapter 3, Section 3 for guidance on calculating time of concentration.

It is recommended that the NRCS Lag equation be used for pre–settlement conditions.

NOTE

The procedure in this example assumes that the pond is providing extended detention of the CPv event. If that is the case, no separate control structure for the WQv event is needed.

If that would not be the case, a separate calculation would be needed to design an outlet to limit outflow rates for the WQv event. Outflow rates would be set to provide 24–hour extended detention of that event.

A process similar to the CPv procedure can be used, except that the TR–55 model used to calculate flow rates and volumes for the 1.25" event would need to use adjusted CNs, as per Section 3.02.

A Water Quality Volume

- Calculate the WQv volume required to be treated

TABLE 9.08-2-3: CALCULATION OF EFFECTIVE IMPERVIOUS AREA

LAND USE	AREA (ACRES)	% IMPERVIOUS	% OPEN SPACE WITH <4" SQR	ADJUSTED % IMPERVIOUS	EFFECTIVE IMPERVIOUS AREA
Commercial	20	73%	0%	73.0%	14.600 acres
Multi-Family	15	65%	35%	82.5%	12.375 acres
Single-Family	45	43%	0%	43.0%	19.350 acres
Total	**80**				**46.325 acres**
		Impervious % to use in Calculating WQv			**57.9%**

From Chapter 3, Section 6 --- Calculate Rv (runoff coefficient), Qa (WQv runoff volume in inches), WQv (in cubic feet)

Rv = 0.05 + 0.009 (57.9) = **0.571** [Eq. C3-S6-1]

Qa = Rv x 1.25"= 0.571 x 1.25" = **0.714 watershed-inches** [Eq. C3-S6-2]

WQv = Qa x (1 ft / 12 inches) x A (acres) x (43,560 SF / 1 acre) = 0.714 x (1/12) x 80 x (43,560 / 1) = **207,330 CF**

- Use TR-55 software to generate inflow runoff hydrographs for developed conditions
    - Use modified CNs for this smaller storm event

$$CN = \frac{1000}{[10 + 5P + 10Q_a] - 10(Q_a{}^2 + 1.25Q_aP)^{\frac{1}{2}}}$$ [Eq. C3-S6-3]

Adjusted CN = 1000 / {[10 + 5 (1.25) + 10 (0.714)] – 10 [(0.714)^2 + 1.25 (0.714)(1.25)]$^{1/2}$} = 93.98 ≈ **94**

- The peak rate of flow (in cfs) and runoff volume (in cubic feet) will be needed

Storm event	Peak runoff rate	Runoff volume
WQv (1.25")	60.7 cfs (From TR-55 model output)	205,912 CF

- If Extended Detention (ED) is used to address WQv, calculate the allowable release rate for a 24-hour drawdown

The WQv runoff rates and volumes calculated above are not used in this example, since ED is not being used in this example to address the WQ event, and since the peak runoff rate is not being used to size a pre-treatment practice (such as a grass swale) or a diversion structure (for off-line systems). However, the calculations have been included to provide guidance for such cases. If ED is being used to slowly release runoff from the WQv event, then use a similar procedure as for ED of the Channel Protection Volume (see following steps).

NOTE

* Open–space areas without at least 4" of SQR applied or preserved are counted as 50% impervious for the purpose of calculating WQv. For previously developed areas, refer to local requirements that were in place at the time of construction. If not known, assume less than 4" of SQR was performed.

Refer to the ISWMM Chapter 3, Section 6 for information on Small Storm Hydrology calculations for WQv, CPv

NOTE

The adjusted CN is ONLY used in modeling runoff from the WQv event storm.

NOTE

The runoff volume here (205,912 CF) should be approximately equal to the WQv volume solved for previously (207,330 CF); values are within 1% for this example.

B *Channel Protection Volume*

- Use TR-55 software to generate inflow hydrographs for the CPv and larger events to be studied
  - Prepare these for pre-developed, existing and proposed conditions
  - The peak rate of flow and runoff volume for each event will be needed

TABLE 9.08-2-4: EXAMPLE PROJECT “STANDARD” CN CALCULATIONS

FULLY DEVELOPED WATERSHED CN CALCULATION

		IMPERVIOUS	OPEN SPACE			
			POOR < 4” SQR	FAIR >/= 4” SQR	GOOD >/= 8” SQR	
	CN	98	79	69	61	
LAND USE	AREA	% OF LAND USE AREA				WEIGHTED CN
Commercial	20 acres	73%	0%	27%	0%	90.17
Multi-Family	15 acres	65%	35%	0%	0%	91.35
Single-Family	45 acres	43%	0%	0%	57%	76.91
Total	**80 acres**			**Total Weighted CN**		**83**

TABLE 9.08-2-5: TR-55 RUNOFF MODEL DIRECT RUNOFF TO WETLAND SITE

TR-55 MODEL INPUT/OUTPUT

		PRE-SETTLEMENT		EXISTING		POST-DEVELOPMENT	
		CN = 58	TC = 94.8 M	CN = 74	TC = 37.9 M	CN = 83	TC = 22.1 M
EVENT	RAINFALL*	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)
WQv	1.25”					61	205,900
CPv (1-year)	2.77”	3.1	59,100	42	221,000	106	364,000
2-year	3.20”	6.3	98,900	59	300,000	136	463,000
5-year	3.99”	15.1	191,000	95	459,000	193	655,000
10-year	4.74”	26.4	298,000	131	623,000	249	846,000
25-year	5.90”	48.1	491,000	191	896,000	336	1,150,000
50-year	6.90”	69.9	678,000	243	1,140,000	412	1,420,000
100-year	7.98”	95.4	898,000	303	1,420,000	494	1,710,000

* Rainfall depths are for Iowa Region 8 (South Central Iowa)

- Use the procedure in Chapter 3, Section 6 to estimate the required CPv volume and calculate the allowable release rate for extended detention of CPv

NOTE

Providing less than 8” of soil quality restoration is not encouraged. This example includes “< 4–in” and “4–in SQR” scenarios only to demonstrate how to perform the calculations in such circumstances.

Open space Curve Numbers (CNs) in this table are based on HSG B soils, as given for this project example.

Curve Numbers are always rounded to the nearest whole number.

Steps 1 and 2

of the storage estimation procedure listed in Part C of Chapter 3, Section 6 have been completed as part of the preceding tables.

Pick up with

Step 3

For CPv, the total runoff volume (Qa) from Table 9.08-2-5. Convert this value to watershed-inches:

Qa = 364,000 CF x (1 acre / 43,560 SF) x (1 watershed / 80 acres) x (12 inches / 1 foot) = 1.25 watershed – inches

The unit peak discharge is calculated by:

qu = (peak runoff rate in cfs) x [(640 ac/mi2) / (watershed area in acres)] x [1 / (Qa in watershed inches)]

qu = 106 cfs x [(640 ac/mi^2) / 80 acres] x [1 / 1.25 watershed-inches] = 678 cfs / mi^2-inch (csm/in)

Step 4

Using Figure C3-S6-1, with qu = 678 csm/in…

The ratio of allowable outflow to inflow (qo / qi) = 0.03. (see figure below, from C3-S6-1)

Step 5

Therefore, the maximum allowable outflow from the wetland to achieve the 24-hour extended detention is:

Step 6

qo = (qo / qi) x qi = 0.03 x 106 = 3.2 cfs

The estimated storage required can be calculated using Equation C3-S6-4.

Equation C3-S6- 4

$$\frac{Vs}{Vr} = 0.683 - 1.43\left(\frac{qo}{qi}\right) + 1.64\left(\frac{qo}{qi}\right)^2 - 0.804\left(\frac{qo}{qi}\right)^3$$

For the CPv event, Vr = Volume of runoff = 364,000 CF and (qo / qi) = 0.03.

NOTE

Designers may use other software to calculate PRELIMINARY ESTIMATES of storage volume to be used in initial site design; however, the maximum outflow rate from the final basin design should not exceed the values calculated by Steps 4 and 5 as shown here, in order to ensure that Extended Detention of the CPv event with a 24–hour minimum drawdown has been provided.

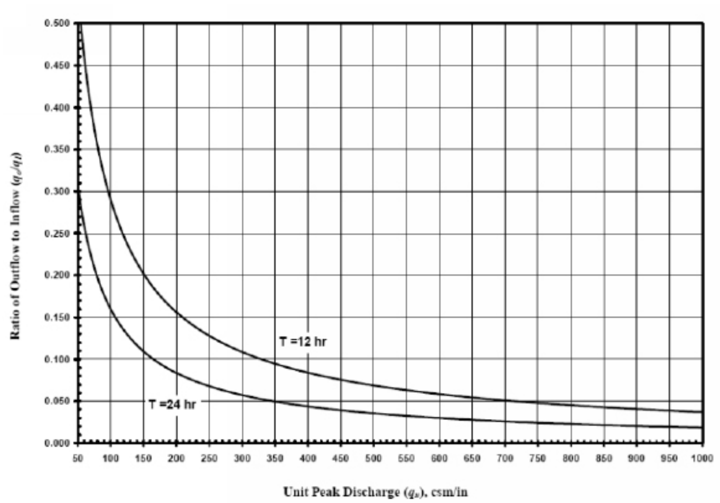


Figure C3-S6- 1: Detention time vs. discharge ratios (qo/qi)

Step 7

Estimate of CPv storage required to provide 24–hour drawdown of extended detention volume

Vs / Vr = 0.683 – 1.43 (0.03) + 1.64 (0.03)^2 – 0.804 (0.03)^3 = 0.6416

Vs = (Vs / Vr) x Vr = 0.6416 x 364,000 CF = 233,500 CF

C

Overbank/Extreme Flood Protection

- Assemble the data generated by the TR-55 models in Step 3b.
- The peak runoff rates for pre-development and existing conditions will be used to determine allowable release rates.
- Estimate the required storage volume necessary to meet outflow release rate requirements.

Following a similar procedure to the one used to estimate the required CPv storage volume, we can estimate the required storage to manage runoff from larger storm events. To do this, we need to determine the allowable release rate for each event. Remember, in Step 2 of the stormwater wetland design procedure, we learned that for this site the local jurisdiction has the following requirements.

Release rates for larger events (up to the 100-year, 24-hour storm event will be limited to the lesser of the following:

- Peak flow rates similar to pre-settlement conditions (meadow in good condition, based on local soil types and historic times of concentration) for similar storm events (i.e., post-project peak flow from a 2-, 5-, 10-, etc., year events) must be equal to or less than pre-settlement conditions for the same rainfall event).
- Peak flow rates similar to existing conditions for a 5-year, 24-hour storm event.

TABLE 9.08-2-6: TR-55 RUNOFF MODEL DIRECT RUNOFF TO WETLAND SITE

TR-55 MODEL OUTPUT

		PRE-SETTLEMENT		EXISTING	
EVENT	RAINFALL	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)
2-year	3.20”	6.3	98,900	59.4	300,000
5-year	3.99”	15.1	191,000	**94.8**	459,000
10-year	4.74”	26.4	298,000	131	623,000
25-year	5.90”	48.1	491,000	191	896,000
50-year	6.90”	69.9	678,000	243	1,140,000
100-year	7.98”	**95.4**	898,000	303	1,420,000

From the table above, we can see that for the 2 through 50-year events, the pre-settlement peak rate of flow is less than the existing peak flow rate for the 5-year event (94.8 cfs). *For these events, the pre-settlement peak rate of flow is the more restrictive standard.* For the 100-year event, the pre-settlement rate is higher than the peak rate for the 5-year event under existing conditions. *So, for this event, the more restrictive measure (94.8 cfs) will be used.*

Now that we know the allowable release rate from the wetland for each of these events, we can estimate the required storage volume required, once again using the following equation.

Equation C3-S6- 4

$$\frac{Vs}{Vr} = 0.683 - 1.43\left(\frac{qo}{qi}\right) + 1.64\left(\frac{qo}{qi}\right)^2 - 0.804\left(\frac{qo}{qi}\right)^3$$

For the designer, it is often easiest to integrate this equation into a spreadsheet, to solve it for the multiple storm events.

TABLE 9.08-2-7: CALCULATION OF ESTIMATED REQUIRED STORAGE VOLUMES

STORM EVENT	QO (CFS)	QI (CFS)	QO/QI	VS/VR	VR (CF)	VS (CF)	VS *1.15 (CF)
1-year (CPv)	3.2	106	0.03	0.6413	364,000	233,526	268,600
2-year	6.3	136	0.05	0.6203	463,000	287,195	330,300
5-year	15.1	193	0.08	0.5808	655,000	380,406	437,500
10-year	26.4	249	0.11	0.5489	846,000	464,338	534,000
25-year	48.1	336	0.14	0.5095	1,150,000	585,970	673,900
50-year	69.9	412	0.17	0.4837	1,420,000	686,806	789,800
100-year	94.8	494	0.19	0.4633	1,710,000	792,231	911,100

In later steps, we will use these values to develop a preliminary stage-storage-discharge model of the stormwater wetland and develop preliminary grading and outlet designs.

Step 4. Determine pre-treatment measures.

- The pre-treatment volume should be 10% of WQv.
- A sediment forebay (or equivalent practice) is to be provided at each inlet.

Pre-Treatment Measure #1—Vegetative Filter Strip

For this example, it is assumed that 1 acre of the single-family development area will drain through a vegetative filter strip before entering the wetland area. In this case, flow from this part of the single-family area would need to be spread fairly evenly across the filter strip for it to be effective (not one concentrated point of flow across the strip). If we have a mix of pervious and impervious areas, we will use the maximum inflow approach length of 75 feet. The required effective width of the strip can be determined by:

Required width (feet) = Area (square feet) / Inflow approach length (feet) = 43,560 SF / 75 feet = **581 feet**

NOTE

A factor of safety of 15% has been applied in this table to the calculated PRELIMINARY storage volumes calculated by this method.

Other project examples have shown that the formula alone may provide preliminary volumes which are slightly smaller than what will ultimately be required for the final design.

Adding this correction factor here will reduce the potential need to significantly redesign a grading plan to increase storage during the final design process.

Pre–treatment may be omitted in cases where a drainage sub–area entering the wetland is less than 0.25 acres in size and is already fully stabilized with permanent vegetation, and no further land disturbing activities are expected.

Chapter 9, Section 4 of the ISWMM – guidance is available on using filter strips for pre–treatment.

As per table C9-S4-1, assuming a slope of greater than 2%, a filter strip length of 25 feet is required for pre-treatment. Therefore, the filter strip for pre-treatment would need to be at least 581 feet wide, with at least 25 feet of flow length across the strip.

We then need to calculate the WQv volume which can be managed by the strip. This amount cannot exceed 10% of the WQv for the area it serves.

Rv = 0.05 + 0.009 (43.0) = **0.437** [Eq. C3-S6-1]

Qa = Rv x 1.25"= **0.437** x 1.25" = **0.546 watershed-inches** [Eq. C3-S6-2]

WQv = Qa x (1 ft / 12 inches) x A (acres) x (43,560 SF / 1 acre) = **0.546** x (1/12) x 1 x (43,560 / 1) = **1,983 CF**

10% of WQv = **1,983 CF** x 10% = **198 CF**

Pre-Treatment Measure #2 – Sediment Forebays

For this design, it is assumed that the remainder of the watershed area enters the wetlands through two outfall pipes. The forebay volume can then be calculated as:

207,346 CF	(total watershed WQv)
x 10%	
= 20,735 CF	*(total pre-treatment volume required)*
– 198 CF	(provided by vegetative buffer strip)
= 20,537 CF	***(required to be provided in forebays)***

- The forebay should be no more than 4 feet deep. Determine the proposed storage volume at each concentrated inflow point.

For this example, if flow is equally split to each outfall, each forebay will need to have at least 10,269 CF of storage (20,537 CF / 2).

- The forebay storage volume may be counted toward the total WQv requirement and therefore may be subtracted from the WQv for subsequent calculations.

The remaining WQv to be addressed by the wetland will be:

207,346 CF	(total watershed WQv)
– 198 CF	(vegetative buffer strip)
– 20,537 CF	(forebay pre-treatment)
= 186,611 CF	***(WQv to be addressed by the wetland)***

NOTE

For simplicity of this example we are assuming that flow is equally distributed to each of these pipes. However, in most cases it will be necessary to determine the WQv directed to each pipe separately, then multiply that volume by 10% to determine the size of each forebay.

Step 5. Develop a preliminary stage-storage relationship to provide the estimated storage volume required as calculated in Step 3c.

The permanent pool elevation at this site has been selected as elevation 100 for a fictional site topography.

For a real project, the designer will need to consider many factors including site topography, as well as inflow and outflow conditions to determine the best elevation for the permanent pool.

- To start, select a preliminary elevation for the permanent pool.

For this example, we are using elevation 100 as the expected permanent pool elevation.

- Next, figure the area required to provide the estimated CPv calculated in Step 3b at the recommended depth of 2 feet, then work inward at a 6:1 slope to establish an initial value for the surface area of the permanent pool.

Develop a preliminary stage-storage relationship that yields greater storage than the estimates of required storage at the desired temporary ponding depths. For this example, we will try the following relationships.

TABLE 9.08-2-8: ESTIMATED CONTOUR AREA/STORAGE BELOW CPV TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
0	100	125,000	0	0
1	101	145,000	135,000	135,000
2	102	165,000	155,000	290 000

- Then, set higher stage-storage relationships based on a slope of no steeper than 4:1 projected upwards from the estimated CPv depth.

TABLE 9.08-2-9: ESTIMATED CONTOUR AREA/STORAGE ABOVE CPV TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
3	103	185,000	175,000	465,000
4	104	210,000	197,500	662,500
5	105	230,000	220,000	882,500
6	106	255,000	242,500	1,125,000
7	107	280,000	267,500	1,392,500

For this example, our target high-water elevations above permanent pool are 2 feet (CPv), 3 feet (10-year) and 5 feet (100-year). Check to make sure we are close to providing the required storage at these elevations.

TABLE 9.08-2-10: COMPARISON OF ESTIMATED REQUIRED / PRELIMINARY DESIGN STORAGE VOLUMES

STORM EVENT	VS (CF)	VS X 1.15 (CF)	VOLUME PROVIDED (CF)
1-year (CPv)	233,526	268,600	290,000
10-year	464,338	534,000	465,000
100-year	792,231	911,100	882,500

Using these preliminary values, it appears that there is excess volume to address CPv, but we are close to target for the 10-year event and are within the safety factor zone for the 100-year event. It is worth proceeding to the next step with these values.

Step 6. Enter the preliminary stage-storage relationships and outlet configurations into a TR-55 software program to route inflow hydrographs through the preliminary wetland design. Perform iterations, adjusting staged outlet controls within the software program as needed to meet required release rate restrictions. Comply with maximum storage depths listed in Table 9.08-1-1.

"Work from the bottom up."

A. **Calculate the approximate size of the primary spillway outfall pipe to be used to control the 100-year storm event, based on an approximate elevation of the outfall pipe and the recommended high-water surface elevation.**

For this example, the flowline of the outfall pipe as it leaves the main outfall structure will be set at elevation 93.0' (7 feet below permanent pool. Using the orifice equation, we will start with an assumption of a 36" outfall pipe. Our goal is to limit outflow from the 100-year event to 94.8 cfs (from Step 3c). Re-arranging the formula for flow through an orifice restriction:

$$A = \frac{Q}{C\sqrt{2gh}}$$

Where: Q = flow (cfs)
C = orifice coefficient (0.60)
g = 32.2 ft/s^2
h = head measured from high-water to center of opening (feet)

h (feet) =	*105.0*	*(100-year target high-water)*
	– 93.0	*(flowline of pipe)*
	– 1.5	*(assumed radius of pipe)*
	= 10.5	**feet**

A = *94.8 cfs / [0.6 x (2 x 32.2 x 10.5)$^{1/2}$]* = **6.1 SF**

Area of 36" pipe = $\pi r^2 = \pi(1.5 \text{ feet})^2$ = 7.07 SF (good for initial estimate)

B. **Compute the approximate size of the perforated riser or outfall pipe needed to provide extended detention of the CPv (or WQv if extended detention is being used to manage part of the WQv).**

For a stormwater wetland, it is preferred that normal flow is withdrawn below the surface of the permanent pool. A structure with an internal weir wall or stop logs can be used to set the permanent pool elevation. In this example, an in-line water level control structure is planned, with stop logs used to set the permanent pool elevation. Our goal is to limit outflow from the CPv (1-year, 24-hour) event to 3.2 cfs (from Step 3b).

NOTE

Setting the outfall several feet below the permanent pool allows the primary spillway pipe to be used to draw down the water surface for future maintenance activities.

REMEMBER

The 100–year allowable release rate in this example is the lesser of the peak rate from the 100–year event under pre–settlement conditions and the 5–year event under existing conditions.

NOTE

For a submerged orifice, the head condition is the difference in water surface elevations measured on either side of the orifice.

NOTE

For culvert "B," the elevation has been set one pipe radius length below the proposed permanent pool, to force the program to measure head across that orifice as the difference between high–water and permanent pool.

NOTE

Commercial software packages use these "Multi–stage" and "Active" designations. They must be selected properly in order for the software to model outflow correctly.

$$A = \frac{Q}{C\sqrt{2gh}}$$

Where: Q = flow (cfs)
C = orifice coefficient (0.60)
g = 32.2 ft/s^2
h = head measured from high-water to center of opening (feet)

h (feet) = *102.0* *(CPv target high-water)*
– 100.0 *(permanent pool)*
= 2.0 **feet**

A = *3.2 cfs / [0.6 x (2 x 32.2 x 2.0)$^{1/2}$] =* **0.469 SF**

r = *(A / π)$^{1/2}$ = (0.469 SF / π)$^{1/2}$ =* **0.386 feet**

d = *2r = 0.773 feet* **= 9.3 inches** *(use 9" as initial trial)*

- Use the software program to iterate the design as needed to refine the design to meet the maximum release rate and water surface elevation.

For this example, inputting the 36" outfall pipe (Culvert A) and the 9" CPv orifice (Culvert B) into a third-party software program running the TR-55 model (Hydraflow Hydrographs was used) and performing a stage-storage-discharge routing yields an expected outflow rate of 2.8 cfs during the CPv event (< 3.2 cfs, **OK)**

TABLE 9.08-2-11:
INITIAL DATA FOR CULVERT A AND B FOR DESIGN EXAMPLE

CULVERT/ORIFICE	A	B
Rise	36"	9"
Span	36"	9"
No. Barrels	1	1
Invert Elevation	93'	99.625'
Length	100'	40'
Slope	0.5%	0.0%
N-Value	0.013	0.013
Orifice Coefficient	0.6	0.6
Multi-Stage	NA	Yes
Active	Yes	Yes

C. Set a second stage for larger storms above the expected high-water elevation of the CPv event.

Try setting a second stage at elevation 102.00—a 6'-long rectangular weir (could be the front face of a 6' x 6' inlet structure).

TABLE 9.08-2-12:
INITIAL DATA FOR WEIR A FOR DESIGN EXAMPLE

WEIR	A
Weir Type	Rectangular
Crest Elevation	102.00'
Crest Length	6.00'
Weir Coefficient	3.33
Multi-Stage	Yes
Active	Yes

D. Adjust the type or size of the second control stage to meet the maximum release rate and water surface elevation for the 10-year storm event.

Entering the 6' weir (Weir A) into the software program yields an outflow rate of 25.6 cfs during the 10-year event (< 26.4 cfs from Step 3c, **OK)**

E. Select a preliminary type, size and elevation of upper stages above the expected high-water elevation of the 10-year event to control larger storms.

TABLE 9.08-2-13: DATA ON WEIRS A, B AND C FOR DESIGN EXAMPLE

WEIR	A	B	C
Weir Type	Rectangular	Rectangular	Broad-Crested
Crest Elevation	102.00’	104.00’	105.50’
Crest Length	6.00’	18.00’	30.00’
Weir Coefficient	3.33	3.33	2.60
Multi-Stage	Yes	Yes	No
Active	Yes	Yes	Yes

Try setting a third stage at elevation 104.00—an 18’ long rectangular weir (remaining three sides of the 6’ x 6’ inlet structure). For this example, we will set the emergency spillway above the desired high-water elevation for the 100-year event.

Entering the 18’ weir (Weir B) and emergency spillway (Weir C) into the software program yields an outflow rate of 108.19 cfs during the 10-year event (**> 94.8 cfs** from Step 3c, **NOT OK**)

F. Adjust the size of the outflow spillway pipe (or emergency overflow spillway) as needed to control runoff from the 100-year event, meeting the maximum release rate and water surface elevation requirements.

Adjust outfall pipe (Culvert A) to 33” and re-try… Modeled 100-year release rate = 92.6 cfs (< 94.8 cfs, **OK)**

G. Go back and adjust the type, size and elevation of upper stages (set in item #4 above) as needed to meet release rate requirements for all storm events to be reviewed.

TABLE 9.08-2-14: SUMMARY OF OUTFALL DESIGN ITERATIONS 2-4 AND RESULTS

		RESULTS OF DESIGN ITERATIONS			
ITERATION		2	3	4	
Culvert A	Diameter >	33”	33”	33”	Elev = 93.0
Culvert B	Diameter >	9”	9”	9”	Elev = 99.625 (modeled CL at 100.00)
Weir A	Length >	6’	4’	4’	Elev = 102.00
Weir B	Length >	18’	20’	8’	Elev = 104.00
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (ITERATION #4)
1-year (CPv)	3.2	2.8	2.8	2.8	101.76
2-year	6.3	4.4	4.1	4.1	102.18
5-year	15.1	12.6	10.7	10.7	102.66
10-year	26.4	25.6	20.1	20.1	103.15
25-year	48.1	52.3	39.6	39.6	103.92
50-year	69.9	83.8	78.0	67.8	104.52
100-year	94.8	92.6	92.5	89.5	105.18

NOTE

Boxes highlighted in red in Table 9.08–2–14 exceed the allowable release rate for the given storm event.

Iterate until all allowable release rate requirements are met and high–water levels are within requirements of Table 9.08–1–1.

- If needed, alter the stage-storage relationship to provide additional storage to meet these requirements.

For this preliminary design, it appears that required outflow conditions are met at the high-water stages for the CPv, 10-year and 100-year and are reasonably close to the target depths of 2, 3 and 5 feet respectively. This design information can be used to advance a more detailed grading plan.

Step 7. Determine wetland location and preliminary grading plan, including distribution of wetland depth zones.

- Develop an initial outline of the permanent pool area, based on the surface area developed in Step 5 (and revised in Step 6, if applicable).
  - It will be necessary to enlarge this area slightly, to account for the area of the pool that will be lost to the small berms, check dams or other features.

An initial outline of the permanent pool of the wetland was drawn (with no microtopography). This outline was made 20–30% larger than the estimated footprint created in Step 5. Contours 101 and 102 around the perimeter of the wetland were set at a 6:1 slope above the permanent pool elevation. At this point, the areas inscribed by these contours were checked to verify that they were close to the areas listed in Step 5.

Within the outline of the permanent pool, forebay zones were located and checked to ensure they had adequate storage to meet the pre-treatment volume required. Forebays were located near maintenance paths to provide easier access.

Once the forebay areas were designated, microtopography berms were laid out to lengthen flow through the wetland. Where interior equipment access was desired, berms were designed to be taller (above CPv elevation) and wider. Turnaround locations were planned near forebays or near the ends of the berms.

Once the forebays and berms were established, the area covered by the pool zone was rechecked (it should remain close to the value estimated in Step 5). Some adjustments were necessary to maintain the desired pool footprint area.

TABLE 9.08-2-15: FOREBAY VOLUME CALCULATIONS

FOREBAY #1 STORAGE

ELEVATION (FEET)	CONTOUR AREA (SF)	INC. VOLUME (CF)	CUMULATIVE VOLUME (CF)
100	5,100		
99	3,700	4,400	4,400
98	2,900	3,300	7,700
97	2,300	2,600	10,300

FOREBAY #2 STORAGE

ELEVATION (FEET)	CONTOUR AREA (SF)	INC. VOLUME (CF)	CUMULATIVE VOLUME (CF)
100	5,400		
99	3,700	4,550	4,550
98	2,900	3,300	7,850
97	2,200	2,550	10,400

- Within the updated footprint of the permanent pool, establish the boundary of the deep and shallow pool zones. Usually these will be located close to the multi-stage outlet structure, but they can be distributed throughout the wetland. Remember to provide a safety bench (2 feet deep or less) at least 10 feet wide around any deep pool zone.

NOTE

Forebays may be completely separated from the rest of the wetland by a roadway or culvert crossing.

Longer, narrower forebays are easier to maintain. Equipment can reach across the forebay from either side.

Bridges, culverts or low–head crossings may be used in lieu of turnaround areas. These are most useful if the access route is also used as a paved or soft trail through the wetland.

Within the permanent pool area, the boundary of the shallow pool zone (1.5 feet or more below permanent pool) was drawn so that the total of all areas located within the shallow pool zone(s) would not exceed 35% of the total surface area covered by the permanent pool.

Within the contour line boundary for the shallow pool zone, the boundary of the deep pool zone (3.0 feet below permanent pool or more) was drawn so that the total of all areas located within the deep pool zone(s) would not exceed 25% of the total surface area covered by the permanent pool. From the shoreline to the edge of the deep pool, a maximum slope of 6:1 was used to make sure the required safety bench was provided. Within the deep pool, a maximum slope of 4:1 was used for this example.

- Outside of the pool zones, refine the grading plan for the marsh zones.

The volume within the marsh zones was checked to verify there was a volume of at least 25% of the WQv volume. The boundary between the high and low marsh zones (contour line 0.5 feet below permanent pool) was moved until the desired balance between these zones was achieved.

- Complete the stage-storage table in the design checklist (provided at the end of this chapter) to verify that the required WQv volume has been provided and that the criteria listed above have been attained. Adjust design as necessary to achieve these results.

TABLE 9.08-2-16: WETLAND SUMMARY STATISTICS

WETLAND SUMMARY STATISTICS			
Forebay Capacity	101.8%	of Req.	OK
Marsh Volume	31.9%	of WQv	OK
Low Marsh Area	41.8%	of pool	
High Marsh Area	24.2%	of pool	
Difference in Marsh Areas	17.6%	< 20%	OK
Deep Pool Surface Area	24.6%	< 25%	OK
Total Pool Surface Area	34.1%	< 35%	OK
WQv Pool/Marsh Storage	297,900 CF		
Required WQv Volume within wetland	186,600 CF		
Total WQv Pool/Marsh Storage	159.7%		OK

NOTE

The difference in area between the high and low marsh zones should be no greater than 20% of the total area covered by the permanent pool.

Note that a slightly different method of calculating pond storage is used, so that the areas above the pool zones are not being counted into the volume of the marsh zones.

This is done to verify that the volume allocated to the various pool and marsh zones is in compliance with the recommendations within this chapter.

TABLE 9.08-2-17: WETLAND PERMANENT POOL STORAGE

WETLAND PERMANENT POOL STORAGE

ELEVATION (FEET)	CONTOUR AREA (SF)	DIFFERENCE (SF)	AVERAGE DEPTH (FEET)	INC. VOLUME (CF)	CUMULATIVE VOLUME (CF)
100.0	115,400				
99.5	87,500	27,900	0.25	6,975	6,975
99.0	85,400	2,100	0.75	1,575	8,550
98.5	39,300	46,100	1.25	57,625	66,175
98.0	36,300	3,000	1.75	5,250	71,425
97.0	28,400	7,900	2.50	19,750	91,175
96.0	26,000	2,400	3.50	8,400	99,575
95.0	22,500	3,500	4.50	15,750	115,325
94.0	19,400	3,100	5.50	17,050	132,375
93.0	16,400	3,000	6.50	19,500	151,875
92.0	13,600	2,800	7.50	21,000	172,875
91.0	11,200	2,400	8.50	20,400	193,275
90.0	8,900	2,300	9.50	21,850	215,125
89.0	7,100	1,800	10.50	18,900	234,025
88.0	5,600	1,500	11.50	17,250	251,275
87.0	0	5,600	12.50	46,667	297,942

- Expand the grading plan around the perimeter of the permanent pool, the extent of any grading for the dam, and incorporate forebay locations (if any are completely separated from the wetland).

For this example, maximum slope of 6:1 was used above the CPv elevations. A flatter shelf was provided above elevation 103.00 to allow for maintenance access around the perimeter of the wetland. (In a real application, flatter grades would also need to be provided above elevation 103.00 to provide access from the maintenance path to the adjacent roadway.)

An emergency spillway has been shown at elevation 105.50 (needs to be located at least 1.5 feet below the crest of the dam). The dam crest was set at 107.20.

Step 8. Investigate potential pond/wetland hazard classification. The design and construction of stormwater management ponds and wetlands are required to follow the current version of Iowa DNR Technical Bulletin 16 related to embankment dam safety rules.

From the information given for this example it is understood that:

- The site is located outside of any regulated flood plain.
- No jurisdictional wetlands have been located within the site area.

- No habitat for endangered or threatened species has been observed at this site.

Reviewing criteria within DNR Form 542-1014:

- The dam has an emergency spillway, and has a total of 1,828,000* CF of temporary and permanent storage (42.0 acre-feet). For this grading plan, the dam has a height of less than 5 feet (wetland primarily created through excavation). Neither of these parameters related to item (a) of that form reach the levels that would require a permit (50 acre-feet, 5 feet dam height).
- The wetland has 319,000 CF* of permanent storage (7.3 acre-feet). The dam height is less than 5 feet, so again neither of these parameters related to item (b) of that form is to the level where a permit is required (18 acre-feet and 5 feet dam height).
- The watershed area is 80 acres, which is much less than 10 square miles as per item (c), so again no permit is required. (also, item (c) does not apply to urban areas)
- Item (d) is related to facilities planned within 1 mile of an incorporated municipality. Let us assume for this example, that this wetland is within an incorporated area. The total storage is 42.0 acre-feet and is situated so that discharge from the dam will flow through the incorporated area. Both of these parameters would require a permit (threshold is 10 acre-feet), however in this case the dam height is less than 10 feet, so again not all three parameters are met, so no permit is required.
- The facility would not be considered a low-head dam, modification to an existing dam or be related to maintenance of pre-existing dams, so none of these criteria would apply in this situation.

It appears no permit for dam embankment construction would be required from DNR in this case. However, it should be noted that for a wetland of this size, a taller dam height and/or an increase in overall storage volume could result in all the parameters for items (a) or (d) to be met.

For this example, using all the criteria above, it appears that a Joint Permit application would not be required for this project. However, it is often worthwhile to review such issue with permit agency staff to validate that a permit is not required under the given site conditions.

Iowa Department of Natural Resources
Flood Plain Management Program

Do I need a Flood Plain Permit? – Earth Embankment Dams

This form has been developed to help you determine if a flood plain permit will be required from the Iowa DNR. You must also obtain approval from the Iowa DNR Sovereign Lands Program (515) 725-8464, the US Army Corps of Engineers (309) 794-5371, and your local flood plain manager (if applicable) before beginning construction. You are legally responsible if you proceed with a project without obtaining all required permits.

When is a DNR Flood Plain Permit Required?
The thresholds for when a Flood Plain Permit from this department is required are outlined in Iowa Administrative Code 567-71.3 and are listed below. The thresholds are primarily based on both dam height and water storage volumes. The height of a dam is defined as the vertical distance from the top of the dam to the lowest elevation at the downstream toe of the dam, typically the streambed.

* Volumes of forebay storage added to wetland volumes from Tables 9.08–2–17 and 18.

Step 9. Revise the stage-storage information entered in the TR-55 software model (Step 6) to reflect the preliminary grading plan. Perform a stage-storage-discharge routing.

- Verify that the peak release rate and maximum high-water elevation requirements are still met.
- Adjust storage and/or outfall design as needed until all design criteria are met.

The stage-storage information from the designed grading plan was entered into the software program as follows:

TABLE 9.08-2-18: TEMPORARY DETENTION STORAGE

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
0	100	125,900	0	0
1	101	144,500	135,200	135,200
2	102	163,500	154,000	289,200
3	103	210,600	187,050	476,250
4	104	249,300	229,950	706,200
5	105	261,400	255,350	961,550
6	106	273,700	267,550	1,229,100
7	107	286,300	280,000	1,509,100

The additional storage provided at upper stages (due to the reduced slope across the access drive) resulted in a reduction in outflow rates for the 50- and 100-year events. This allowed for a final adjustment to the weir length which may make the outlet structure more aesthetically pleasing and easier to construct (two stages, no need to elevate the back wall above 100-year high-water to restrict flow).

TABLE 9.08-2-19: FINAL DESIGN ITERATIONS

ITERATION		4	5	FINAL	
Culvert A	Diameter >	33”	33”	33”	Elev = 93.0
Culvert B	Diameter >	9”	9”	9”	Elev = 99.625 (modeled CL at 100.00)
Weir A	Length >	4’	4’	4’	Elev = 102.00
Weir B	Length >	8’	8’	16’	Elev = 104.00
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (FINAL)
1-year (CPv)	3.2	2.8	2.8	2.8	101.76
2-year	6.3	4.1	4.1	4.1	102.17
5-year	15.1	10.7	10.3	10.3	102.64
10-year	26.4	20.1	19.0	19.0	103.10
25-year	48.1	39.6	35.7	35.7	103.78
50-year	69.9	67.8	57.3	61.3	104.32
100-year	94.8	89.5	84.8	89.2	104.88

TABLE 9.08-2-20: REVISED STORMWATER WETLAND PERFORMANCE TABLE

STORM EVENT	ALLOWED (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (FEET)	MAX. TEMP. STORAGE ABOVE POOL (CF)	MAX. TEMP. STORAGE ABOVE POOL (WATERSHED INCHES)
1-year (CPv)	3.2	2.8	101.76	252,800	0.87
2-year	6.3	4.1	102.17	321,200	1.11
5-year	15.1	10.3	102.64	408,600	1.41
10-year	26.4	19.0	103.10	498,200	1.72
25-year	48.1	35.7	103.78	655,100	2.26
50-year	69.9	61.3	104.32	788,200	2.72
100-year	94.8	89.2	104.88	931,100	3.21

The above table shows that for this example, all of the release rate requirements have been met, and expected temporary storage depth is in agreement with project goals (CPv: 2.0 feet; 10-year: 3.0 feet; 100-year: 5.0 feet).

Step 10. Check outflow velocities at pipe outfalls and spillways. Adjust sizing, geometry or add erosion protection features as needed for the 100-year, 24-hour event.

- From the continuity equation, determine pipe velocity based on flow rate (Q) and area (A) [V = Q/A]

During a 100-year storm event, peak flow through the 33" outlet pipe will be 89.2 cfs. The pipe cross-sectional area is 5.93 sq ft.

$V = Q / A = 89.2 \text{ cfs} / 5.93 \text{ ft}^2 = 15.0 \text{ fps}$

In this example, flow is connecting to a storm sewer system, so this velocity is acceptable. However, if this pipe were directed to the ground surface, it may need to be enlarged so that the expected flow velocity would not exceed 10 fps. This could be accomplished using an orifice plate or other flow restriction over the enlarged outlet at the outfall structure, or by placing a manhole or other structure downstream where the change in pipe size would occur. If such a change is made, adjust the modeling in previous steps to reflect this revised design.

Where the storm system is directed to the surface, requirements for additional erosion protection would need to be checked. Refer to resources such as HEC-14 "Hydraulic Design of Energy Dissipators for Culverts and Channels" or Iowa SUDAS Chapter 7E-10 "Rip Rap" to properly select the size, length, width and depth of outfall protection materials.

- Using the same equation, check for velocity across the crest of the emergency spillway (if any overflow occurs during the 100-year storm event).

In this example, the emergency spillway has been set above the expected high-water elevation caused by a 100-year, 24-hour storm event. No overflow is expected, so no velocity check is necessary.

NOTE

Maximum temporary storage depths set forth in this section are:
CPv: 2.5 feet
10–year: 4.0 feet
100–year: 6.0 feet

NOTE

While it is allowable to overtop the emergency spillway during the 100–year event, it may be difficult to meet local Unified Sizing Criteria requirements if the spillway is overtopped. The exception might be in cases where there are limited or no requirements to provide management for this larger event.

ITEMS OF NOTE

During the CPv event, the peak outflow rate will occur 6.7 hours (401 minutes) after the peak inflow rate occurs.

Peak outflow during the CPv is expected to be reduced 97.4% from the peak inflow rate.

Significant reductions in peak flow rate are also expected for the larger storm events.

The final storage volumes are fairly close to the initial storage volume estimates.

Step 11. Complete design checklists at the end of this section to verify that sizing design criteria have been satisfied.

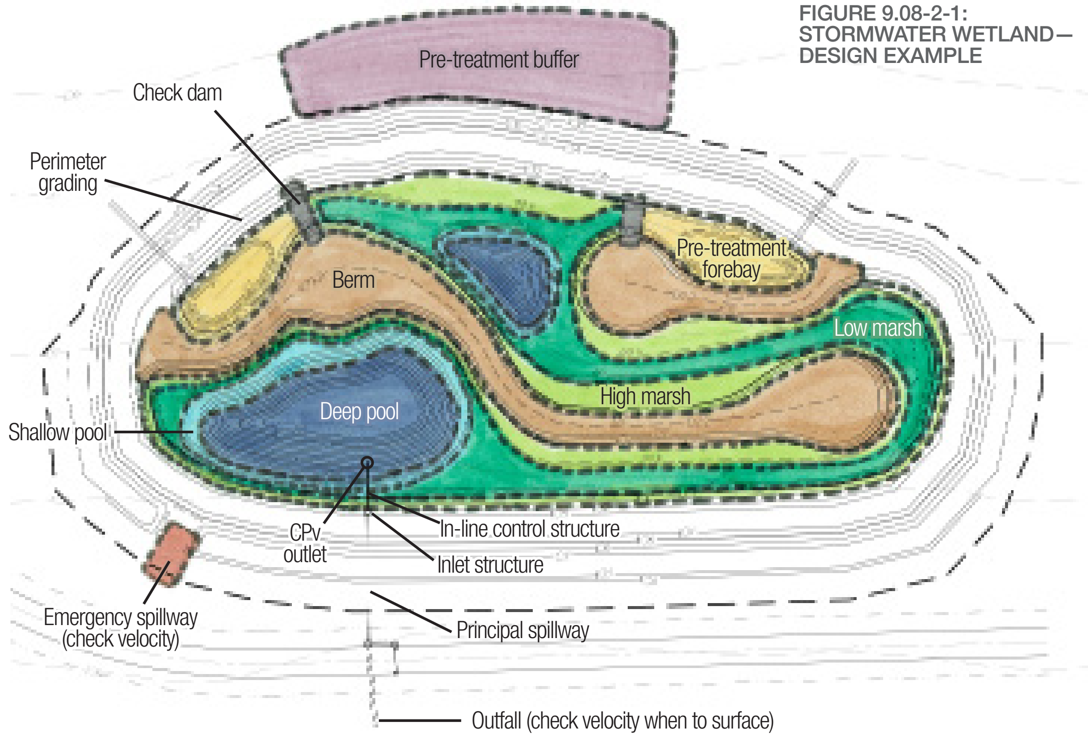
Proceed to development of detailed plans and specifications. After completion of final design, verify information in Steps 9–11 is accurate. Make any adjustments as needed so that final plan information matches finished calculation report.

TABLE 9.08-2-21: STORMWATER WETLAND PERFORMANCE - OTHER INTERESTING METRICS

EVENT	RAINFALL * (INCHES)	MAX TEMP. STORED VOLUME (INCHES)	MAX. RAINFALL VOLUME STORED (%)	PEAK DELAY IN VS. OUT (MINUTES)	PEAK FLOW REDUCTION IN VS. OUT (%)	INITIAL STORAGE ESTIMATE* (CF)	FINAL ROUTING RESULT (CF)
CPv (1-year)	2.77”	0.87”	31.4%	401	97.4%	268,600	252,800
2-year	3.20”	1.11”	34.7%	318	97.0%	330,300	321,200
5-year	3.99”	1.41”	35.3%	124	94.6%	437,500	408,600
10-year	4.74”	1.72”	36.3%	75	92.4%	534,000	498,200
25-year	5.90”	2.26”	38.3%	45	89.4%	673,900	655,100
50-year	6.90”	2.72”	39.4%	30	85.1%	789,800	788,200
100-year	7.98”	3.21”	40.2%	25	81.9%	911,100	931,100

* Includes 15% safety factor adjustment

FIGURE 9.08-2-1: STORMWATER WETLAND—DESIGN EXAMPLE



Design Review Checklist for Storm Water Wetlands
(Page 1 -- Site Screening / Initial Planning)

Project: Project Name
Applicant: Applicant name **Date:** 1/6/2022
Submitted by: Designer name **Location:** South Central Iowa

Provide project information above and in colored blank fields below

Site Evaluation Criteria

Soils Information — Source: ____ County Soils Map / Site Specific Geotechnical Report
____ Copy of Geotech Report Provided? (Y or N)

HSG of Soils at Wetland Site: (mark all that apply with X) A ____ B ____ C ____ D ____

Other available soils information (permeability, soil properties, etc.): ____

Existing vegetation: (mark all that apply with X) prairie remnants ____ savanna ____ native vegetation ____ other ____
Describe "other": ____

Tributary area: 1 acres

Approximate slope across site (pre-construction): ____ %

Depth to groundwater table: ____ feet (below pre-construction surface)

Hotspot uses expected in watershed: ____ (Y or N)

Existing wetlands within site area: ____ (Y or N)
If yes: jurisdictional determination made? ____ (Y or N)
Is site located within a regulated floodplain? ____ (Y or N)
Habitat for endangered / threatened species found? ____ (Y or N)

Initial Planning - Storm Water Wetland Elements

Pretreatment (mark all that apply with X): ____ forebay ____ vegetative buffer ____ grass swale ____ other ____

(mark with X below)
Pond liner ____ type ____
Microtopography ____
Pool zones ____ max depth ____ feet
Multi-stage outlet ____
Dam ____
Emergency spillway ____
Stable outfall ____

Local review jurisdiction ____
Describe local stormwater management requirements ____

Setbacks
Perimeter ____ (25' min - Y or N?)
Property line ____ (10' min)
Private well ____ (100' min / 250' for hotspot)
Building structure ____ (25' min)
Septic / leach field ____ (50' feet)
Utilities ____ (Outside perimeter or access provision - Y or N?)

Design Review Checklist for Storm Water Wetlands
(Page 2 -- Design Summary)

Project: Project Name

Applicant: Applicant name **Date:** 1/6/2022

Provide information in colored blank fields below (other information populates from data entry sheets)

Unified Sizing Criteria

WQv	Required:	2,269 CF	Provided:	0 CF*	!
Pretreatment Volume	Required:	227 CF	Provided:	0 CF	!

** Includes pre-treatment required volume (if requirements met)*

Is Extended Detention (ED) being used to meet WQv requirements? ______ (Y or N)

	CPv (1-yr)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Allowed Release	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Criteria Met?	!	!	!	!	!	!	!

	CPv (1-yr)	10-yr	100-yr		
Predicted high water elev above normal pool (ft)	0.00	0.00	0.00	Normal pool elevation	0.00
	OK	OK	OK		

Wetland Metrics

Wetland to Watershed Ratio**	0.0%	of watershed area		
***based on permanent pool footprint area*				
Permanent Pool Storage	0.0%	of WQv	!	> 100%
Marsh Volume	#VALUE!	of WQv	#VALUE!	> 25%
Low Marsh Area	#VALUE!			
High Marsh Area	#VALUE!			
Difference in Marsh Areas	#VALUE!	of perm. pool	#VALUE!	< 20%
Deep Pool Surface Area	#DIV/0!	of perm. pool	#DIV/0!	< 25%
Total Pool Surface Area	#DIV/0!	of perm. pool	#DIV/0!	< 35%
Permanent Pool Storage	0.0	acre-feet		
Temporary Storage	0.0	acre-feet		
Total Storage	0.0	acre-feet		

Wetland Topography

Average straight line distance from inlet(s) to outlet		feet		
Average flow path through wetland from inlet(s) to outlet		feet	Ratio	NA
Max side slope interior berms		H:V slope		
Max side slope perimeter below CPv elevation		H:V slope		
Safety bench of 10' to any water depth of 2' or more		(Y or N)	!	
Height of dam		feet		

Other Information

Required for review	**Provided? (Y or N)**			
Inlet / outlet details		Outfall protection calcs		(Y or N)
Design calculations following ISWMM procedure				
Plans and specifications				
Landscaping plan (temporary and permanent stabilization)				
Establishment and maintenance plan				
Is a Joint Permit Application to IDNR / USCOE required?		Has it been obtained?		(Y or N)
Completed IDNR Form 542-1014		Dam review required?		(Y or N)

9.08-3 CONSTRUCTION

A. NECESSARY EROSION AND SEDIMENT CONTROL MEASURES

STORMWATER POLLUTION PREVENTION PLAN AND NPDES PERMIT REQUIREMENTS

If total site disturbed area

> 1 ACRE

(including all parts of a common plan of development), a SWPPP must be prepared

Prior to construction, coverage under the State of Iowa's NPDES General Permit No. 2 must be obtained (or individual permit coverage, if required).

EXTERIOR PROTECTION

All perimeter and site exit controls should be installed prior to any land disturbing activities.

Such controls may include (but not be limited to) site construction exits, perimeter sediment controls, construction limit fencing, waste collection, sanitary facilities and concrete washout containment systems.

INTERIOR PROTECTION

As construction activities commence, internal controls will be added to prevent erosion and sediment loss from the site area.

Erosion controls prevent detachment of soil particles from the surface (mulches, rolled erosion control products, turf reinforcement mats, etc.). Sediment controls capture sediments after they have become suspended in runoff (wattles, filter socks, silt fences, sediment basins, etc.). Installation of controls may need to be staged to be implemented immediately after construction operations have ceased or are paused in a certain area.

NOTE

The SWPPP document will meet state and local regulatory requirements and will detail the structural and non–structural pollution prevention best management practices (BMPs) that are to be employed at the site.

NOTE

After the utility installation construction stage, a skimmer or perforated riser might be connected to the outlet works to reduce the potential for suspended sediments from being washed downstream during grading operations until the permanent pool is filled.

B. CONSTRUCTION SEQUENCING

Major construction operations to create constructed wetlands will usually be staged in this manner:

1—DEMOLITION AND CLEARING

In some cases, trees, shrubs, fences, structures, etc. may need to be removed prior to construction. Tree removals may need to be limited to certain periods of time, due to restrictions related to habitat for endangered species.

NOTE

Comply with any permit requirements related to staging of tree removals.

2—TOPSOIL STRIPPING AND STOCKPILING

One of the initial site-disturbing activities is often the removal of topsoil materials from the area to be graded and stockpiling them for use. In some cases, this step can be skipped, if grading operations are expected to be subtle enough to not extend below existing topsoil depths. In these circumstances, earthwork will only involve the moving and shaping of the topsoil materials.

3—ROUGH GRADING (MAJOR EARTHWORK OPERATIONS)

The primary movement of earth materials to adjust graded surfaces to approximate elevations (within 6 inches) as needed to allow for installation of the liner (when necessary), performance of microtopography and placement of topsoil materials.

4—STORM STRUCTURE AND PIPE INSTALLATION

Installation of the outlet structures and pipes which will control water levels within the wetland area.

Installing these structures allows for control of the water level, providing for drier soil conditions during construction of the clay liner, microtopography and other wetland features.

If possible, installation of storm pipes and structures to divert runoff to the basin should be staged as late as possible in the construction process.

5—LINER INSTALLATION

Placement of impermeable materials to support storage of a permanent pool of water to the desired elevation and coverage area. Omit this step in cases where a liner is not required.

The contract documents need to define the type of liner to be used (if necessary) and the methods and details of its installation.

6—FINISH GRADING (MICROTOPOGRAPHY)

Fine grading, usually accomplished with smaller equipment, which creates the small berms and depressions used to make subtle changes in grade within and around the wetland which are necessary to define the low-flow path through the wetland and establish subtle variations of the finished surface.

Care needs to be taken to not disturb the liner during finish grading operations.

7—CHECK DAM/HABITAT FEATURES

These structures are often used to create a **physical barrier between forebay pre-treatment areas and the other parts of the wetland**. They can be used to divide the wetland into separate zones and increase filtration of low flows through an open graded rock media.

Subsurface fish habitat structures, anchored logs or other habitat features may be installed at this stage.

8—SOIL QUALITY RESTORATION (SQR)

If an adequate supply of topsoil is available, **SQR can be accomplished by re-spreading the materials** that were stockpiled in earlier phases of construction. Topsoil materials should be free of rocks, debris and rubble and should generally be loosely placed across the finished surfaces for areas outside of the deep pool zone to a minimum depth of 8 inches. Do not move, grade or place wet topsoil materials.

NOTE

If topsoil resources are insufficient, compost materials may be used to enhance organic matter to build the depth of healthy soil required.

9—SURFACE ROUGHENING

Use of equipment to create horizontal grooves (on contour) and other methods to loosen the surface of topsoil materials after placement. These **grooves limit the potential for sheet and rill erosion** across slopes and prepare the soil for seedbed preparation.

Construction activities may occur outside desired seeding periods for permanent vegetation. Temporary seed and mulch should be used to reduce the potential for surface erosion until permanent seeding and planting can occur.

10—LANDSCAPING

Completion of seedbed preparation and installation of temporary and permanent seeding, plugs, shrubs and trees as specified within the construction documents.

11—STAGED FILLING

To promote better establishment of desired vegetation, it is recommended to **utilize outlet controls** that allow the water surface to be adjusted. This will allow the wetland area to be filled in stages.

It can be more difficult to establish vegetation (either by seeding or plugs) in areas of ponding water. Staged filling allows vegetation in these zones to get started before they are permanently inundated. As vegetation in the lower marsh zones begins to establish, the water level can be raised in increments.

NOTE

It is recommended to wait at least 2 weeks after initial establishment of vegetation within the high marsh zone, to raise water levels to the final design permanent pool elevation.

12—ESTABLISHMENT AND MAINTENANCE PERIOD

This period follows the end of major construction operations. **Weed removal, re-seeding and invasive species control are needed during this period** to foster establishment of a diverse system of desired native vegetation.

NOTE

A separate contract for establishment of permanent vegetation and maintenance service for a period of 3 years following the end of construction operations is recommended.

C. CONSTRUCTION OBSERVATION

A designated representative of the owner should observe construction operations on a frequent basis to confirm the following:

- **Topsoil stripping, stockpiling and respread** activities have been completed as specified.
- **Rough grading generally conforms to plan elevations** and test results have been provided that demonstrate that compaction requirements have been met. (Compaction tests are often performed by a geotechnical engineer and provided for owner review.)
- **Storm sewer and pipe structures** are installed to the dimension, location and elevations specified on the plans and proper installation techniques and trench compaction techniques have been followed. (Compaction tests are often performed by a geotechnical engineer and provided for owner review.)
    - Any **seepage protection devices or features** should be directly observed during construction.
    - **Proper compaction** around all storm structures should be verified.
    - **Storm facilities should be kept free of sediment and debris during construction** and inspected again at a final site walk through.
- Verification that the **liner (if required) has been constructed per construction documents.** Collect any test results as needed to document its proper construction. (Such tests are often performed by a geotechnical engineer.)
- Observe that finished grading has created the desired **microtopographic features.**
- Observe that **check dams and habitat features** have been constructed properly. Verify that the gradation of stone or other materials to construct check dams is in compliance with the contract documents.
- Verify that the required methods of **soil quality restoration** are completed and that surface roughening and seedbed preparation are completed prior to seeding.
- Confirm that **seed, plug and other landscape materials** (trees, shrubs, etc.) delivered to the site are in accordance with the contract documents.
- Observe that the **rate of temporary and permanent seed and mulch materials** are in compliance with the contract documents, and that activities are completed within the specified seeding dates.
- Inspect **outlet control structures** to make sure that stop logs, valves or other control structures are operated to allow for staged filling of the permanent pool.
- Verify that the **final elevation of the permanent pool** matches the proposed design.
- Complete a walk-through with the designer and contractor to **identify any items which are not in compliance** with project requirements. Document issues in a punch list and confirm when all items are installed or repaired.
- As needed by the local jurisdiction, author a **letter of acceptance** noting either conformance with construction documents, or any allowed deviation thereof.
- **Be present during establishment and maintenance** operations to verify that required duties are completed.

NOTE

If the project is required to be permitted under the State of Iowa's NPDES General Permit No. 2, qualified personnel must be employed to complete the following until final establishment:

- Maintain and update the SWPPP document and retain records.
- Conduct site inspections as required by the general permit.
- Throughout construction, work with the erosion and sediment control contractor to coordinate proper installation of all BMPs.
- Verify that exterior sediment and erosion BMPs are in place prior to initiation of site–disturbing activities.
- Observe that interior BMPs are implemented as site work progresses.
- Complete site inspection reports; make recommendations for additional BMPs as necessary.
- Upon final establishment of permanent vegetation (as defined by the permit), recommend to the owner that the site Notice of Discontinuation is required to be submitted to the DNR.

D. AS-BUILT REQUIREMENTS

During construction, records should be kept by the contractor (and site observer) that will allow record drawings of as-built improvements to be provided to the owner. To demonstrate that the project has complied with contract documents, these records should include, but not be limited to, the following:

- All rim and flow-line elevation of storm structures and pipes, or any other utilities included as part of the project
- The final permanent pool elevation established by the installation of stop logs or other control devices
- A topographic survey to verify that required storage volumes have been achieved and microtopography has been established in a manner similar to plan elevations
- Footprint of check dams or grade control features and their crest width and top-over elevation
- The top elevation and width of the dam crest and the auxiliary spillway
- Confirmation that required trees and shrubs have been installed

Record drawings can be prepared by using survey equipment to verify that proposed site improvements have been completed and that their vertical and horizontal position is similar to those described within the contract documents.

Fully established wetland. Arrowhead and other desirable wetland plants can be seen less than two years after construction. A short-term maintenance program was used to kick-start this wetland, to foster establishment of planned vegetation and control growth of invasive species.

9.08-4 MAINTENANCE

A. ESTABLISHMENT PERIOD (SHORT-TERM MAINTENANCE)

A more intense maintenance program is required for a period of at least 3 years, to support full establishment of desired vegetation and prevent growth of invasive species (especially cattails and volunteer woody growth). It is recommended that these activities should be completed by personnel with experience (3 years or more preferred) in performing maintenance of native vegetation.

These short-term activities can be included into a separate contract for "Establishment and Maintenance Activities." In such a case, that contract would include the initial installation of permanent vegetation (by seeding, plugging or planting) and a set of routine maintenance trips (quarterly trips recommended after initial installation, for a period of 3 years).

YEAR ONE – MAINTENANCE ACTIVITIES

Maintenance activities to be performed during each maintenance trip should include:

- **Weed suppression** by cutting native seeding areas with mowers (if accessible) or string-type trimmers to prevent weeds from developing seeds. No cutting or trimming should be closer than 8 inches to ground surface. Mow native seeding areas (at least three times a year).
- **Removal of cuttings** longer than 8 inches that fall within 20 feet of the edge of water or cover areas larger than 20 square feet to off-site location.
- **Systemic herbicide treatment** of areas larger than 20 square feet where weeds are the dominant plant material.
- **Hand wipe systemic herbicide on invasive weeds and woody species** where native plants are the dominant plant material, taking care not to damage nearby native plants.
- **Remove the above-ground portion of previously treated dead or dying weeds and woody species** from planting areas.
- **Add topsoil and raking to restore grade** in areas where poor germination, erosion or weed removal have left rills deeper than 3 inches and longer than 10 feet or areas in excess of 20 square feet depressed or below finished grade.
- **Re-seed** areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- **Apply mulch** to areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- **Prune dead or dying material** from trees or shrubs.
- **Remove weeds** from the mulched areas around trees and shrubs.
- **Apply appropriate insecticides and fungicides,** as necessary, to trees and shrubs only to maintain plants free of insects and disease.

NOTE

The contract documents should detail the expected maintenance schedule, including the month and year the required activities are to occur.

Goose fences may be used to protect native plantings.

Make sure that plugs are planted according to plan locations. It is advised to plant plugs in shallow waters to avoid damage from mowing activities.

If the designer chooses to use plugs in zones above the permanent pool, mowing should be restricted around areas with plugs to avoid damage (use trimming equipment, rather than mowers). Plugs should be marked with flags or other durable markers. Make sure the party responsible for maintenance understands and is able to carry out this requirement.

NOTE

Follow manufacturer's instructions on any herbicide application.

YEARS TWO AND THREE – MAINTENANCE ACTIVITIES

Maintenance activities to be performed during each maintenance trip should include:

- **Suppress weeds** by cutting portions of native planting areas where weeds comprise more than 1/4 of the plants within an area. Use string-type trimmers to prevent weeds from developing seeds. No cutting or trimming should be closer than 12 inches to ground surface. Mow native seeding areas at least three times a year.
    - As allowed, add controlled burns by qualified personnel in appropriate areas on an annual or every-other-year basis to control weeds, starting in YEAR THREE.
- **Remove cuttings** longer than 8 inches that fall within 20 feet of the edge of water to an off-site location.
- **Systemic herbicide treatment** of areas larger than 20 square feet where weeds are the dominant plant material.
- **Hand-wipe systemic herbicide on invasive weeds and woody species** where native plants are the dominant plant material, taking care not to damage nearby native plants.
- **Remove above-ground portion of previously treated dead or dying weeds and woody species from planting areas.**
- Check that **firebreaks** have been established and are being maintained
- **Add topsoil and rake to restore grade** in areas where poor germination, erosion, or weed removal, have left rills deeper than 3 inches and longer than 10 feet or areas in excess of 20 square feet depressed or below finished grade.
- **Re-seed** and or **apply mulch** to areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- **Prune dead or dying material** in trees or shrubs.
- **Remove weeds** from the mulched areas around trees and shrubs.
- **Apply appropriate insecticides and fungicides** as necessary to trees and shrubs only to maintain plants free of insects and disease.
- On final inspection trip for maintenance – **remove staking wires** from trees but leave stakes in place.

NOTE

Follow manufacturer's instructions on any herbicide application.

Wetland after seasonal maintenance burning to control weeds and remove dead organic material.

B. ROUTINE OR LONGER-TERM MAINTENANCE ACTIVITIES

During the design process, the entity responsible for routine and long-term maintenance should be identified. These tasks are necessary to maintain the constructed wetlands' ability to function and support the desired diverse native vegetation. Invasive growth, storage loss, surface erosion and outlet control failures may occur if these tasks are not completed.

ACTIVITY	SCHEDULE
Look for signs of sediment accumulation, flow channelization, erosion damage, local streambank instability. Check the outfall for signs of surface erosion, seepage or tunneling along outfall pipe.	At least annually AND after rain events of 1.25" or larger
Inspect forebay and other pre-treatment areas.	At least twice annually.
Remove accumulated sediment from forebay.	When forebay is 1/2 full OR at least once every 5 years.
Inspect storm inlets and outlets. Clean and remove debris as necessary.	At least three times annually and after rain events of 1.25" or larger.
Monitor wetland vegetation and perform replacement planting as necessary.	Annually (after short-term establishment period)
• Examine stability of the original depth zones and micro-topographical features. • Inspect for invasive vegetation and remove where possible. • Inspect for damage to the embankment and inlet/outlet structures; repair as necessary. • Note any signs of oil build-up and remove accordingly.	Annual Inspection
Repair undercut or eroded areas.	When observed
Mow or use fire management on native vegetation areas.	Annually
Remove dead and/or dying vegetation.	Annually
Remove sediment when total pool and marsh volume has become reduced significantly (~25%), when plants are "choked" with sediment, or the wetland becomes eutrophic. (Estimated time: every 10–20 years)	As needed. When approximately 25% of the wetland total pool and marsh volume has been lost

- Sediments excavated from stormwater wetlands that do not receive runoff from contaminated areas are not considered toxic or hazardous material and can be safely disposed of by either land application or at a permitted landfill.
- Sediment testing may be required prior to sediment disposal when a contaminated areas are present.
- Sediment removed from stormwater wetlands during construction should be disposed of according to an approved SWPPP.

9.08-5 SIGNAGE RECOMMENDATIONS

Signage at constructed wetlands can be provided as an educational tool to detail the purpose and stormwater management function to the general public. Signage can also be used to advise maintenance staff against discouraged practices, such as frequent mowing and broad application of herbicides.

9.08-6 RESOURCES

Technical Manual: Conduits through Embankment Dams - Best Practices for Design, Construction, Problem Identification and Evaluation, Inspection, Maintenance, Renovation and Repair
Federal Emergency Management Agency, U.S. Department of Homeland Security. September 2005

Technical Bulletin No. 16 – Design Criteria and Guidelines for Iowa Dams
Iowa Department of Natural Resources. December 1990

Do I Need a Flood Plain Permit? – Earth Embankment Dams. DNR Form 542-1014
Iowa Department of Natural Resources. February 2017

Iowa Stormwater Management Manual. Iowa Department of Natural Resources
(Other related Chapters and Sections, current as of this date of publication and past version of Chapter 8 "Storm Water Wetlands" dated October 2009)

CREP Engineering Information Wetland and Site Design Guidelines
Iowa Department of Agriculture and Land Stewardship. Revised October 2013

Conservation Practice Standard – Wetland Creation, Code 658
U.S. Department of Agriculture, Natural Resource Conservation Service. September 2015

Conservation Practice Standard – Wetland Wildlife Habitat Management, Code 644
U.S. Department of Agriculture, Natural Resource Conservation Service. February 2008

National Pollutant Removal Performance Database – Version 3
Center for Watershed Protection. September 2007

Urban Subwatershed Restoration Manual Series: Urban Stormwater Retrofit Practices – Version 1.0
Center for Watershed Protection. August 2007

International Stormwater BMP Database
Website: bmpdatabase.org

Center for Watershed Protection
Website: cwp.org

Special thanks to Steve Jones, Ph.D (formerly of Iowa State University) and Wayne Petersen (formerly of the Iowa Department of Agriculture and Land Stewardship) for their contributions to this topic and other urban stormwater management practices across the State of Iowa.

APPENDIX DESIGN CHECKLIST/CALCULATION SHEETS

Design Review Checklist for Storm Water Wetlands

Purpose:
This spreadsheet file has been created to assist in the design and review of Storm Water Wetland Projects which are seeking or have obtained funding through the State of Iowa's water quality programs.

This document is intended to be completed by the designer to provide review agencies with project data assembled and presented for review in a consistent manner from project to project.

Using data entered by the designer (data to be entered within the provided blank shaded boxes on each tabulation sheet), this document will complete many of the basic sizing calculation steps following the methods described within the Iowa Storm Water Management Manual (ISWMM).

Contents:

Checklists (to be completed and provided as part of State of Iowa water quality project review):
CL_1: Screening
CL_2: Design Summary

Calculation worksheets (integrated into project design reports at required stage of review):
DE_1: Watershed Info
Step 3: Hydrology*
Step 4: Pre-treatment
Step 5-7: Final Storage Volumes
Step 9: Results
Note that Steps 3-9 refer to the calculation step listed within the ISWMM Design Manual.

**Step 3 tabulation sheet is available for use by the designer for preliminary estimation of required storage volumes. It may be omitted if software programs are used to complete similar calculations and if the same data is included by the designer with the design report for review.*

DISCLAIMER:
This document is intended only to be used for the purposes as described above. It is expected that designers which use this document are familiar with the Storm Water Wetlands chapter of ISWMM and understand the methods described within. The user of this document is ultimately responsible for the accurate entry of data into this document and to verify that all included and associated calculations performed are correct and consistent with the methods of design described within ISWMM as applicable to a given project.

By providing this document for use, the State of Iowa, the Iowa Department of Natural Resources, the Iowa Department of Agriculture and Land Stewardship, and any other entity involved in its creation assumes no responsibility for its use, associated calculations or for other project related tasks which are the responsibility of the design professional.

Design Review Checklist for Storm Water Wetlands
(Page 1 -- Site Screening / Initial Planning)

Project: Project Name

Applicant: Applicant name **Date:** 1/6/2022

Submitted by: Designer name **Location:** South Central Iowa

Provide project information above and in colored blank fields below

Site Evaluation Criteria

Soils Information Source: ____ County Soils Map / Site Specific Geotechnical Report

____ Copy of Geotech Report Provided? (Y or N)

HSG of Soils at Wetland Site: (mark all that apply with X) A ____ B ____ C ____ D ____

Other available soils information (permeability, soil properties, etc.): ____

Existing vegetation: (mark all that apply with X) prairie remnants ____ savanna ____ native vegetation ____ other ____

Describe "other": ____

Tributary area: 1 acres

Approximate slope across site (pre-construction): ____ %

Depth to groundwater table: ____ feet (below pre-construction surface)

Hotspot uses expected in watershed: ____ (Y or N)

Existing wetlands within site area: ____ (Y or N)
If yes: jurisdictional determination made? ____ (Y or N)

Is site located within a regulated floodplain? ____ (Y or N)
Habitat for endangered / threatened species found? ____ (Y or N)

Initial Planning - Storm Water Wetland Elements

Pretreatment (mark all that apply with X) ____ forebay ____ vegetative buffer ____ grass swale ____ other ____

(mark with X below)

Pond liner ____ type ____
Microtopography ____
Pool zones ____ max depth ____ feet
Multi-stage outlet ____
Dam ____
Emergency spillway ____
Stable outfall ____

Local review jurisdiction ____
Describe local stormwater management requirements ____

Setbacks

Perimeter		(25' min - Y or N?)
Property line		(10' min)
Private well		(100' min / 250' for hotspot)
Building structure		(25' min)
Septic / leach field		(50' feet)
Utilities		(Outside perimeter or access provision - Y or N?)

Design Review Checklist for Storm Water Wetlands
(Page 2 -- Design Summary)

Project: Project Name

Applicant: Applicant name **Date:** 1/6/2022

Provide information in colored blank fields below (other information populates from data entry sheets)

Unified Sizing Criteria

WQv	Required:	2,269 CF	Provided:	0 CF*	!
Pretreatment Volume	Required:	227 CF	Provided:	0 CF	!

** Includes pre-treatment required volume (if requirements met)*

Is Extended Detention (ED) being used to meet WQv requirements? ______ (Y or N)

	CPv (1-yr)	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Allowed Release	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Predicted Outflow	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Criteria Met?	!	!	!	!	!	!	!

	CPv (1-yr)	10-yr	100-yr		
Predicted high water elev above normal pool (ft)	0.00	0.00	0.00	Normal pool elevation	0.00
	OK	OK	OK		

Wetland Metrics

Wetland to Watershed Ratio**	0.0%	of watershed area		
***based on permanent pool footprint area*				
Permanent Pool Storage	0.0%	of WQv	!	> 100%
Marsh Volume	#VALUE!	of WQv	#VALUE!	> 25%
Low Marsh Area	#VALUE!			
High Marsh Area	#VALUE!			
Difference in Marsh Areas	#VALUE!	of perm. pool	#VALUE!	< 20%
Deep Pool Surface Area	#DIV/0!	of perm. pool	#DIV/0!	< 25%
Total Pool Surface Area	#DIV/0!	of perm. pool	#DIV/0!	< 35%
Permanent Pool Storage	0.0	acre-feet		
Temporary Storage	0.0	acre-feet		
Total Storage	0.0	acre-feet		

Wetland Topography

Average straight line distance from inlet(s) to outlet		feet		
Average flow path through wetland from inlet(s) to outlet		feet	Ratio	NA
Max side slope interior berms		H:V slope		
Max side slope perimeter below CPv elevation		H:V slope		
Safety bench of 10' to any water depth of 2' or more		(Y or N)	!	
Height of dam		feet		

Other Information

Required for review	Provided? (Y or N)			
Inlet / outlet details		Outfall protection calcs		(Y or N)
Design calculations following ISWMM procedure				
Plans and specifications				
Landscaping plan (temporary and permanent stabilization)				
Establishment and maintenance plan				
Is a Joint Permit Application to IDNR / USCOE required?		Has it been obtained?		(Y or N)
Completed IDNR Form 542-1014		Dam review required?		(Y or N)

Watershed Data Entry Sheet

Project: Project Name Date: 1/6/2022

Watershed Properties

Enter Data in Gray Fields

Red Text = Area in acres, Green Text = CN, Blue Text = Y or N

Pre-settlement Watershed Area (area in acres)	HSG A	HSG B	HSG C	HSG D
Meadow in Good Condition	0	1	0	0

Total Watershed Area:	1	acres
CN for most events:	58	

Existing Watershed Area (area in acres)	HSG A	HSG B	HSG C	HSG D	
Impervious*	0	0	0	0	
Open Space (w/8" SQR)	0	0	0	0	
Open Space (w/4" SQR)	0	0	0	0	
Open Space (<4" SQR)	0	0	0	0	
Row Crops (C+CR, good condition)	0	1	0	0	
Other Areas	0	0	0	0	
CN of Other Areas**	92	92	92	92	(permeable pavements, green roofs)
Other Areas Counted as Impervious for WQv calculation?			N	(Y/N)	

Total Watershed Area:	1	acres	Rv:	0.050		
Effective Impervious Area:	0.0%		WQv:	227	Qa:	0.063
CN for most events:		74				
Adjusted CN (for WQv modeling):		73				

Proposed Watershed Area (area in acres)	HSG A	HSG B	HSG C	HSG D	
Impervious*	0	0.5	0	0	
Open Space (w/>=8" SQR)	0	0.5	0	0	
Open Space (w/>=4" SQR, <8")	0	0	0	0	
Open Space (<4" SQR)	0	0	0	0	
Row Crops (C+CR, good condition)	0	0	0	0	
Other Areas	0	0	0	0	
CN of Other Areas**	92	92	92	92	(permeable pavements, green roofs)
Other Areas Counted as Impervious for WQv calculation?			N	(Y/N)	

Total Watershed Area:	1	acres	Rv:	0.500		
Effective Impervious Area:	50.0%		WQv:	2,269	Qa:	0.625
CN for most events:		80				
Adjusted CN (for WQv modeling):		93				

** Only include true impervious areas (buildings, standard pavement types, etc.)*

*** Provide calculations of weighted CNs for "Other Areas" if more than one land use type*

Hydrology Data Entry Sheet

Project: Project Name Date: 1/6/2022

Step 3. Compute runoff control volumes from the stormwater Unified Sizing Criteria

Water Quality Volume

Total Watershed Area:	1	acres	Rv:	0.500
Effective Impervious Area:	50.0%		WQv:	2,269 CF
CN for most events:		80	Qa:	0.625 watershed-inches
Adjusted CN (for WQv modeling):		93		

TR-55 Output (Flow to Wetland Location)

Enter values in colored cells from TR-55 data input / output

		Pre-settlement		Existing		Developed	
	Rainfall	**Peak rate**	**Volume**	**Peak rate**	**Volume**	**Peak rate**	**Volume**
Storm Event	inches	cfs	CF	cfs	CF	cfs	CF
WQv	1.25						
1							
2							
5							
10							
25							
50							
100							

Channel Protection Volume Metrics:

CPv Qa:	0.00	watershed-inches
CPv qu:	#DIV/0!	csm/in
qo/qi:		(From Figure C3-S6-1)
qo:	0.0	cfs

Initial Storage Estimation

Storm Event	**qo** cfs	**qi** cfs	**qo/qi**	**Vs/Vr**	**Vr** CF	**Vs** CF	**Vs *1.15** CF
1	0.0	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
2	0.0	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
5	0.0	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
10	0.0	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
25	0.0	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
50	0.0	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!
100	0.0	0	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!

Pretreatment Data Entry Sheet

Project: Project Name 1/6/2022 < Date

Step 4. Determine pre-treatment measures

Pretreatment Calculations

Enter values in blue

WQv Required	2,269	CF	
Pretreat Req.	227	CF	Describe other pre-treatment measures (below)
Pretreat by Other Practices		CF	
Forebay Required Volume	227	CF	

Storage Calculation Sheets

Forebay #1 Storage — **Forebay Pool Elevation=** 0.00

Depth Below Pool	Elevation	Contour Area	Inc. Volume	Cumulative Volume
feet	feet	SF	CF	CF
0.0	0.00			
1.0	-1.00		0	0
	0.00		0	0
	0.00		0	0
	0.00		0	0
	0.00		0	0

Forebay #2 Storage — **Forebay Pool Elevation=** 0.00

Depth Below Pool	Elevation	Contour Area	Inc. Volume	Cumulative Volume
feet	feet	SF	CF	CF
0.0	0.00			
1.0	-1.00		0	0
	0.00		0	0
	0.00		0	0
	0.00		0	0
	0.00		0	0

Forebay #3 Storage — **Forebay Pool Elevation=** 0.00

Depth Below Pool	Elevation	Contour Area	Inc. Volume	Cumulative Volume
feet	feet	SF	CF	CF
0.0	0.00			
1.0	-1.00		0	0
	0.00		0	0
	0.00		0	0
	0.00		0	0
	0.00		0	0

Total Forebay Storage	0	CF	
Forebay Capacity	0.0%	of Req.	!

Stage-Storage Data Entry Sheet

Project: Project Name Date: 1/6/2022

Steps 5-7. Preliminary stage-storage, refine, develop grading plan.

WQv Required	2,269	CF
Pretreatment	227	CF
WQv Remaining	2,042	CF

Normal Water Surface Elevation (W.S.) 0.00 feet

Storage Calculation Sheets Enter values in gray related to stage-storage information

Wetland Permanent Pool Storage

Below W.S. feet	Elevation feet	Contour Area* SF	Difference** SF	Average Depth feet	Inc. Volume CF	Cumulative Volume CF	
0.00	0.00						
0.50	-0.50		NA	NA	NA	NA	HI MARSH
1.00	-1.00		NA	NA	NA	NA	LO MARSH
1.50	-1.50		NA	NA	NA	NA	LO MARSH
2.00	-2.00		NA	NA	NA	NA	POOL
3.00	-3.00		NA	NA	NA	NA	POOL
4.00	-4.00		NA	NA	NA	NA	POOL
5.00	-5.00		NA	NA	NA	NA	POOL
6.00	-6.00		NA	NA	NA	NA	POOL
7.00	-7.00		NA	NA	NA	NA	POOL
8.00	-8.00		NA	NA	NA	NA	POOL
9.00	-9.00		NA	NA	NA	NA	POOL
10.00	-10.00		NA	NA	NA	NA	POOL
11.00	-11.00		NA	NA	NA	NA	POOL
12.00	-12.00		NA	NA	NA	NA	POOL
13.00	-13.00		NA	NA	NA	NA	POOL
14.00	-14.00		NA	NA	NA	NA	POOL
15.00	-15.00		NA	NA	NA	NA	POOL
16.00	-16.00		NA	NA	NA	NA	POOL

** Does not include areas within forebays*

*** Difference = Contour Area Above - Contour Area Below*

Temporary Storage (Above Permanent Pool)

Above W.S. feet	Elevation feet	Contour Area SF	Inc. Volume CF	Cumulative Volume CF
0.00	0.00			
1.00	1.00		NA	NA
2.00	2.00		NA	NA
3.00	3.00		NA	NA
4.00	4.00		NA	NA
5.00	5.00		NA	NA
6.00	6.00		NA	NA
7.00	7.00		NA	NA
8.00	8.00		NA	NA
9.00	9.00		NA	NA
10.00	10.00		NA	NA
11.00	11.00		NA	NA

Total Permanent Pool Storage	0.0	acre-feet***	0	CF
Total Temporary Storage	0.0	acre-feet***	0	CF
Total Storage	0.0	acre-feet***		

***Excludes forebays

Permanent Pool Storage	0.0%	of WQv (>100%)	!
Marsh Volume	#VALUE!	of WQv (>25%)	#VALUE!
Low Marsh Area	#VALUE!		
High Marsh Area	#VALUE!		
Difference in Marsh Areas	#VALUE!	of perm. pool (< 20%)	#VALUE!
Deep Pool Surface Area	#DIV/0!	of perm. pool (< 25%)	#DIV/0!
Total Pool Surface Area	#DIV/0!	of perm. pool (< 35%)	#DIV/0!

Routing Results Data Entry Sheet

Project: Project Name 1/6/2022 < Date

Step 9. Revise stage-storage relationships. Perform a stage-storage-discharge routing.

Water Quality Volume

Total Watershed Area: 1 acres

Enter values in grey from TR-55 routing output

Stormwater Wetland Performance Table

Storm Event	Allowed (cfs)	Out (cfs)	High Water Elevation (feet)	Max. Temp. Storage above Pool (CF)	Max. Temp. Storage above Pool (watershed-inches)
1-year (CPv)	0.0				0.00
2-year	0.0				0.00
5-year	0.0				0.00
10-year	0.0				0.00
25-year	0.0				0.00
50-year	0.0				0.00
100-year	0.0				0.00

Stormwater Wetland Metrics Table

Event	Max. Rainfall Volume Stored %	Peak Delay In vs. Out In vs. Out (min)	Peak Flow Reduction In vs. Out Reduction In vs. Out (%)	Initial Storage Estimate* (CF)	Final Storage Routing Result (CF)	Final / Estimate
CPv (1-year)	#DIV/0!		#DIV/0!	#DIV/0!	0	#DIV/0!
2-year	#DIV/0!		#DIV/0!	#DIV/0!	0	#DIV/0!
5-year	#DIV/0!		#DIV/0!	#DIV/0!	0	#DIV/0!
10-year	#DIV/0!		#DIV/0!	#DIV/0!	0	#DIV/0!
25-year	#DIV/0!		#DIV/0!	#DIV/0!	0	#DIV/0!
50-year	#DIV/0!		#DIV/0!	#DIV/0!	0	#DIV/0!
100-year	#DIV/0!		#DIV/0!	#DIV/0!	0	#DIV/0!

**Original "Vs" Storage Estimate Without Safety Factor*