IOWA STORM WATER MANAGEMENT MANUAL

9.09 TRADITIONAL DRY DETENTION

IOWA DEPARTMENT OF NATURAL RESOURCES

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

9.09-1 LAYOUT AND DESIGN

A. SUMMARY

Over the past few decades, the primary practice used for stormwater management has been dry detention basins. Storage volume in the detention area is created by excavation and/or construction of a dam. These basins are called "dry" because they do not retain a permanent pool of water between rainfall events; the entire basin surface is designed to drain out.

Traditionally, these types of basins were designed to provide flood control during moderate to **large storm events**. They were most often used to restrict outflow during a 100-year storm event to a required release rate. These practices typically do not include features that capture and clean runoff to improve **water quality**. They were usually designed without features to provide protection of downstream channels through **extended detention** of small storm events. For this reason, these "traditional" dry detention basins may provide flowrate reduction for larger storm events, but are not able to address the Water Quality or Channel Protection requirements of the Unified Sizing Criteria (USC) on their own.

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. Estimate required practice footprint
6. Verify sizing through more detailed calculations
7. Develop maintenance and establishment plans
8. Prepare final design, routing calculations and project specifications

KEY MAINTENANCE CONSIDERATIONS

Short-term (establishment period)

- Weed control, re-seeding, replanting
- Surface erosion repair

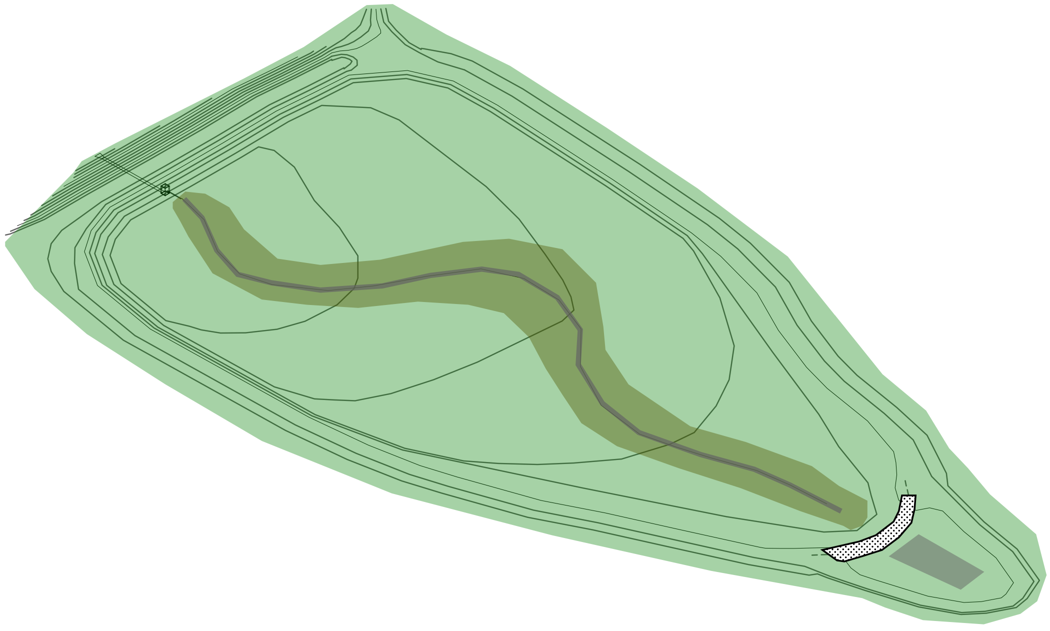
Long-term (ongoing)

- Keep inlets and outlets clear of debris
- Remove invasive species and less desirable vegetation
- Turf grass areas
  - Routine mowing
  - Weed control
  - Re-sodding, re-seeding and/or repairs
- Native planted areas
  - Annual mowing or prescribed burns
  - Weed/invasive species control
  - Re-planting, re-seeding and/or repairs
- Forebay sediment removal
- Surface erosion repair
- Inspections and maintenance
  - Dam embankment
  - Inlets and outlets

NOTE

See Section 9.09–4 for more detail on maintenance requirements.

Figure 9.09-1-1: Dry Detention Perspective Illustration



B. APPLICATION

Traditional dry detention may be applied in **watersheds** of any size. It is often used to mitigate stormwater flow rate increases that are expected in **urbanized** or developing watersheds when **impervious** cover is created and soil compaction occurs.

NOTE

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

ABILITY TO ADDRESS THE UNIFIED SIZING CRITERIA

Recharge Volume (Rev), Water Quality Volume (WQv) and Channel Protection Volume (CPv)

Traditional dry basins are not constructed with features that maximize capture, infiltration or treatment of stormwater. They are also not constructed with a method to provide extended detention of flows from the CPv event (1-year storm). **Therefore, traditional dry detention basins are not intended for use to meet these aspects of the USC. Dry detention areas will need to be paired with other BMPs to meet these USC requirements.** ADVISORY

Overbank Flood Protection (Qp) and Extreme Flood Protection (Qf)

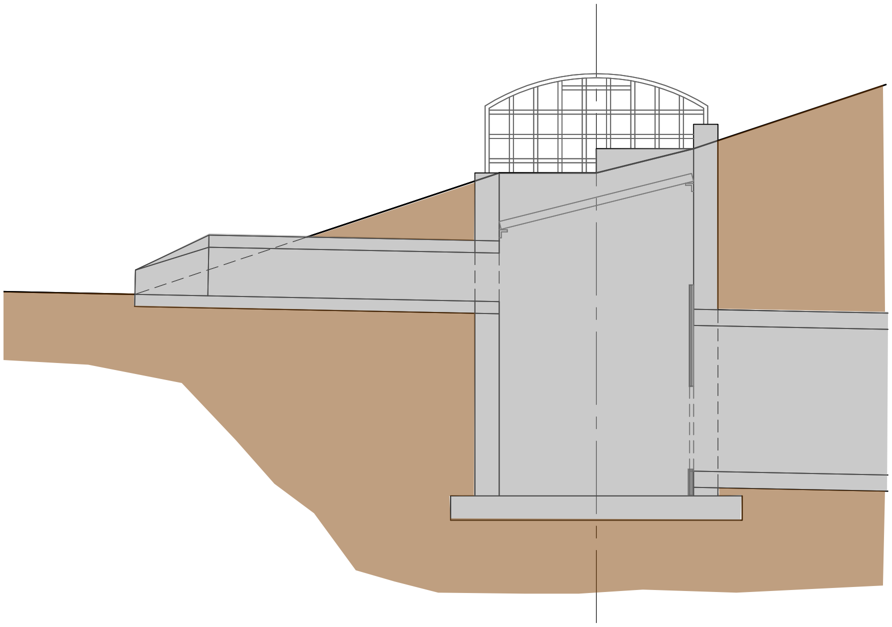
Traditional dry detention basins can be sized to meet these requirements, through **temporary storage** of runoff to limit outflow release rates to required levels. **The goal of this sizing criteria is to reduce peak outflow rates during these types of events to levels resembling natural levels (rates prior to pioneer settlement), unless a more restrictive standard has been established by a local jurisdiction.** ESSENTIAL

To reduce risks for vegetation, public safety and erosion, avoiding extreme ponding depths is recommended. Refer to the table on the next page: TARGET

TABLE 9.09-1.1: MAXIMUM TEMPORARY STORAGE DEPTHS FOR TRADITIONAL DRY DETENTION		
STORM RECURRENCE INTERVAL	PREFERRED HIGH-WATER DEPTH *	ALLOWABLE HIGH-WATER DEPTH *
10-year, 24-hour duration	3.0 feet	4.0 feet
100-year, 24-hour duration	5.0 feet	6.0 feet

* Measured above the surface inlet elevation of lowest stage of outfall structure

Figure 9.09-1-2: Multi-Stage Outlet Example



C. SITE FEASIBILITY

SOILS

There are no specific restrictions based on soil type or HSG classification. However, it may be difficult to maintain the dry basin surface in areas with steady sources of flow such as sump pump discharges or where seasonal groundwater levels are close to the surface in upstream areas. In some cases, a pilot channel may convey daily **base flows** through the footprint of the basin. (A concrete pilot channel should not be used; See Section 9.01.3-I.) Certain soil types may also influence the maximum surface slopes within the basin that can be maintained without erosion or slope failures. Consult a geotechnical engineer on a case-by-case basis for guidance.

MINIMUM DEPTH TO WATER TABLE

There are no constraints at most sites; however, as noted above, a dry bottom surface and stable side slopes may be difficult to maintain in areas where pre-project groundwater levels are close to or above the expected finished grades within the basin. This could result in growth of undesirable vegetation or side slope erosion.

EXISTING VEGETATION

Impacts to prairie remnants, established native vegetation or well-maintained savanna woodland areas should be avoided. TARGET

EXISTING WETLANDS

Disturbing existing, functional wetlands to create new stormwater management areas is strongly discouraged and may not be permitted by regulatory agencies. Initial screening may be completed by review of National Wetland Inventory maps of the site areas. **As part of the preliminary design process, more detailed ecological investigations should be completed to delineate the presence of wetlands and determine if any such identified wetlands are considered jurisdictional.** ESSENTIAL

TRIBUTARY DRAINAGE AREA

There are no set minimums or maximums, although sources of steady flow are more likely, as watersheds grow in size. It also may be difficult to meet the maximum high-water depth and minimum surface slope criteria for practices with larger tributary areas.

SPACE REQUIRED

Practices will vary in size based on watershed size, shape and land cover. They need to have sufficient space to provide temporary storage to reduce outflow rates to required levels. For management of the Extreme Flood Event, 6–12% of the tributary drainage area may be required. ***This value is only an estimate to be used very early in the design process. Section 9.09–2 details methods to determine the actual space a practice may require.***

SITE TOPOGRAPHY

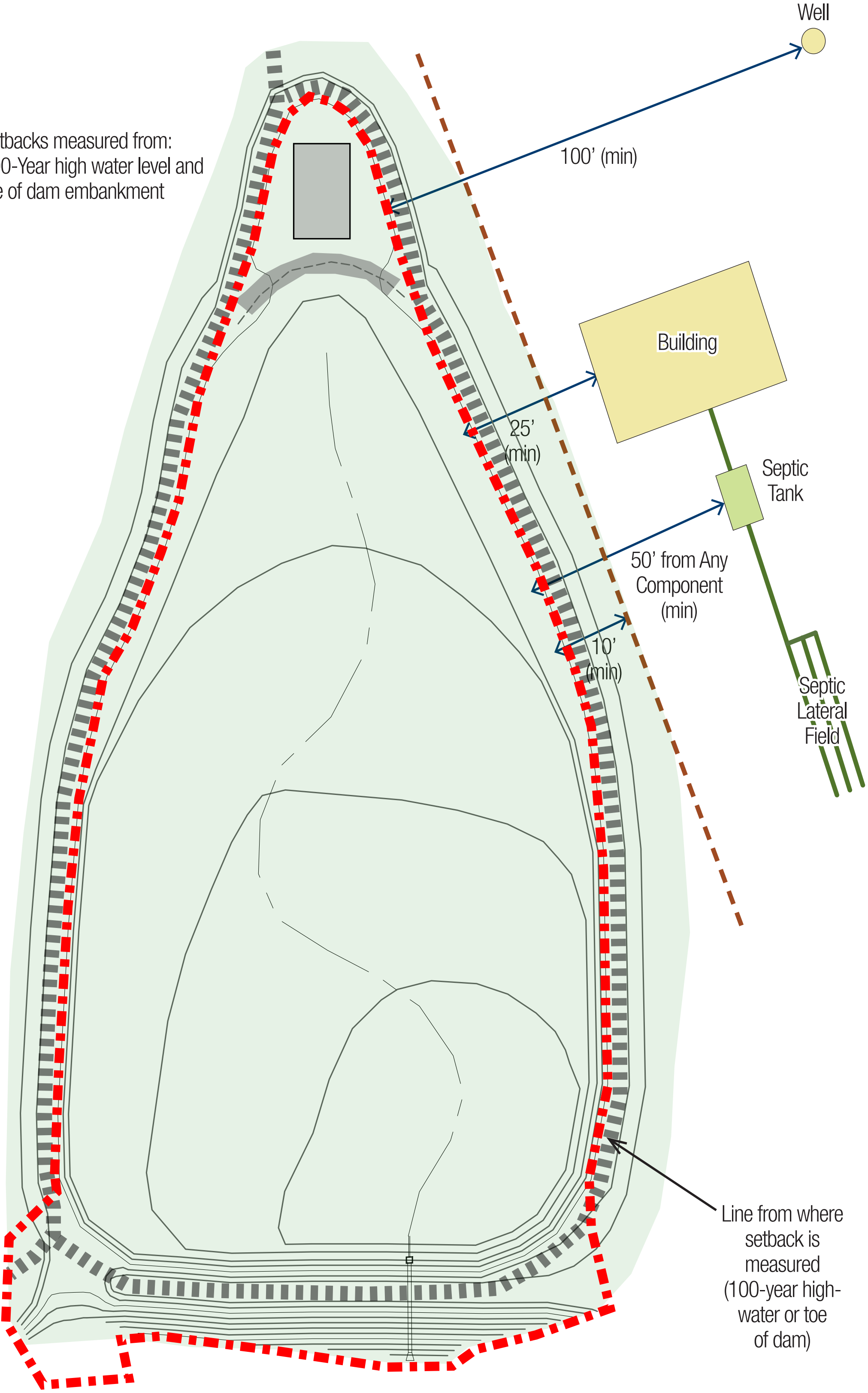
Site grading costs may be elevated at sites with steeper **topography**. Designers should consider whether the basin can be constructed by excavation into the existing surface, creation of a dam embankment or some combination of these grading methods.

D. SETBACKS

The following setbacks should be provided, measured horizontally from the perimeter of the detention area (defined as the area inundated within the basin during the 100–year storm event) and the upstream side of any dam and the toe of the embankment on the downstream side of the basin: ESSENTIAL

Perimeter building setback envelopes	25 feet
Property line (unless common ownership, easement or other right of access granted)	10 feet
Septic system tank or leach field drain	50 feet
Separation from wells	100 feet

Figure 9.09-1-3: Illustration of Setback Requirements

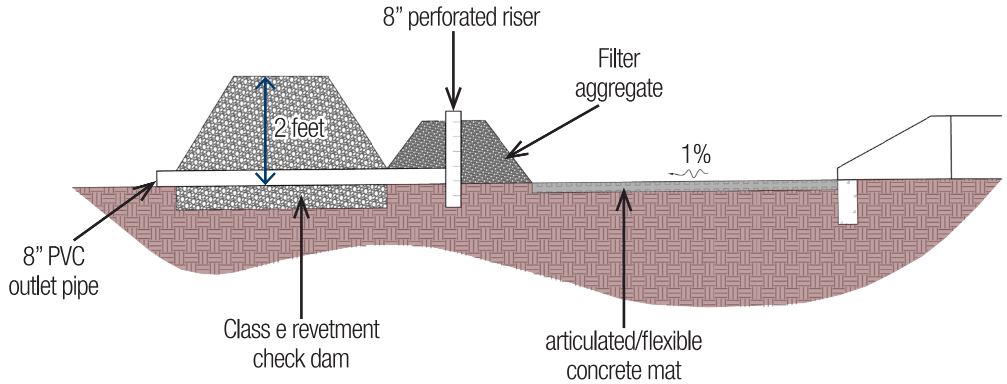


E. DESIGN ELEMENTS AND PARAMETERS

PRE-TREATMENT

Sediment forebays (or other equivalent pre–treatment practices) should be located at all points of concentrated inflow to capture heavier sediment particles from incoming runoff. Without pretreatment, sediment deposition across the basin will reduce storage over time. Desired vegetation may be lost and **invasive species** may establish in deposition areas. **Forebays** provide a place where sediment can be captured and more efficiently removed.

Figure 9.09-1-4: Illustration of Dry Forebay Option



Pretreatment practices should be sized to contain 10% of the WQv. Pretreatment at the detention site may be omitted for those portions of its watershed that have passed through an adequately sized pretreatment or water quality practice upstream. ESSENTIAL

When forebays are used:

- To increase sediment capture by slowing water entry into the detention basin, each forebay should be physically separated from the detention basin in some fashion, such as a berm, reinforced low-head crossing, check dam or pipe. This separation is simply intended to slow flow and increase deposition within the forebay. ESSENTIAL
- Paths for maintenance access should be provided to and from the forebay from adjacent streets or other points of access. ESSENTIAL
- The forebay should create a temporary or permanent pool of water that is no more than four feet deep. TARGET
- 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. TARGET
- Inflow and outflow velocities should be checked during the design process to make sure that erosive conditions are not expected. ESSENTIAL
- A method of **dewatering** the forebay for sediment removal (such as gated or valved maintenance drawdown pipe, wet well for temporary pump system, etc.) should be provided. TARGET

Other options for pre-treatment include grass swales, vegetative filter strips, mechanical separators, etc. Vegetative filter strips are most effective where stormwater is approaching as **sheet flow**, so that water spreads evenly through the filter strip. Swales and mechanical separators are often used along paths of concentrated flow.

Refer to Section 5.01 for additional design information related to pretreatment practices.

NOTE

Forebays designed to contain 10% of WQv are not sized to intercept sediment–laden runoff from active construction sites. Additional sediment basins or an enlarged forebay should be installed above any detention area where **active construction** (involving grading or other land–disturbing activities) is expected to start or continue after the detention basin is completed. Such temporary sediment controls should provide 3,600 **cubic feet** of storage per **disturbed acre** drained.

NOTE

Pre–treatment may be omitted in cases where a drainage area entering the detention facility is less than 0.50 acres in size and is already fully stabilized with permanent vegetation, and no further land–disturbing activities are expected.

BASIN SHAPE AND SIZE

The detention area should be designed to work with site topography, to minimize grading as much as possible and to create shapes and finished grades that appear more natural. As feasible, a basin should be longer than it is wide, to promote greater flow length through the pond and reduce flow path shortcutting. **A minimum length–to–width ratio of 2:1 is desired.** TARGET

PILOT CHANNELS

Pilot channels are recommended in applications where more constant surface flow is anticipated to direct such flows through the footprint of the basin. Pilot channels may be less needed where constant flow is not expected, such as basins managing parking lot runoff. There are many options for pilot channels, which are shown in Figure 9.09-1-5. Articulated or flexible concrete mats may also be used to stabilize the channel lining, provided that the selected material features an open cell design that allows vegetation to be established between or within the concrete elements. The pilot channel should follow a meandering path to maximize flow length through the basin.

Pilot channels should have a minimum slope of 0.5% (infiltration trenches with subdrains may be flatter), with side slopes as noted on details. Channels will typically be only as deep as needed to convey daily baseflows, allowing flow to quickly spread across the bottom of the basin during storm events. TARGET

Figure 9.09-1-5: Pilot Channel Alternatives

Infiltration Trench

Wet Swale

Articulated/Flexible
Concrete Mats

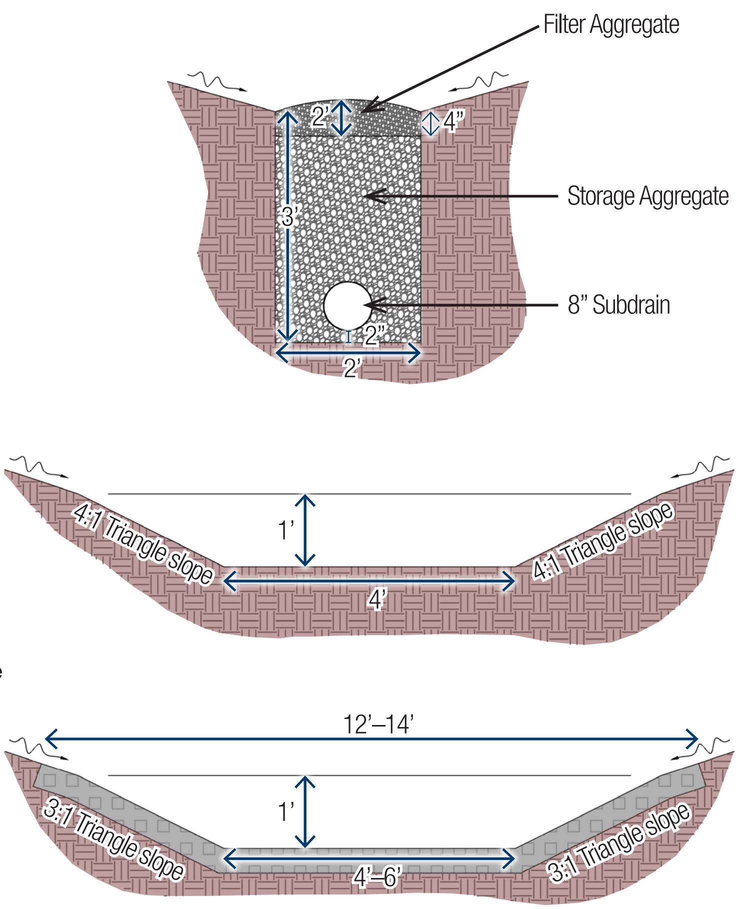
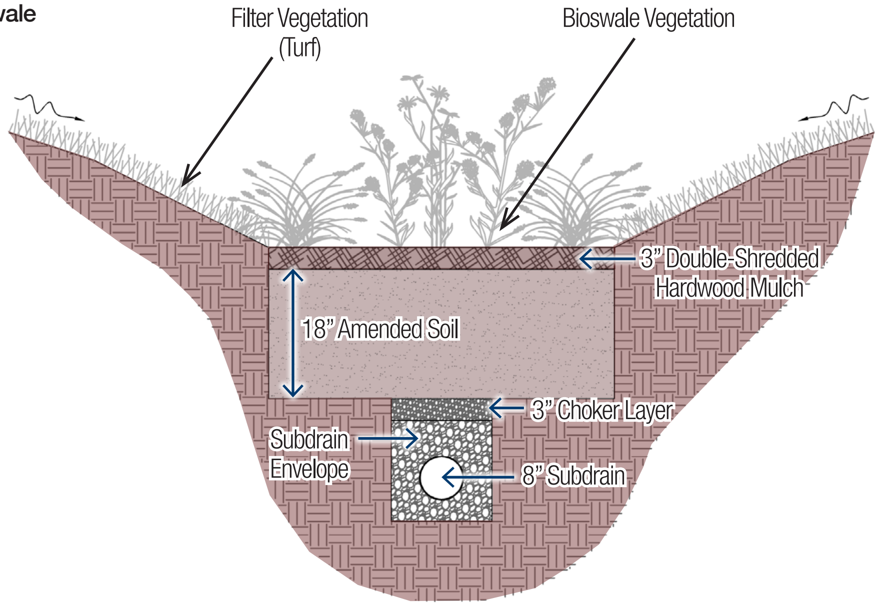
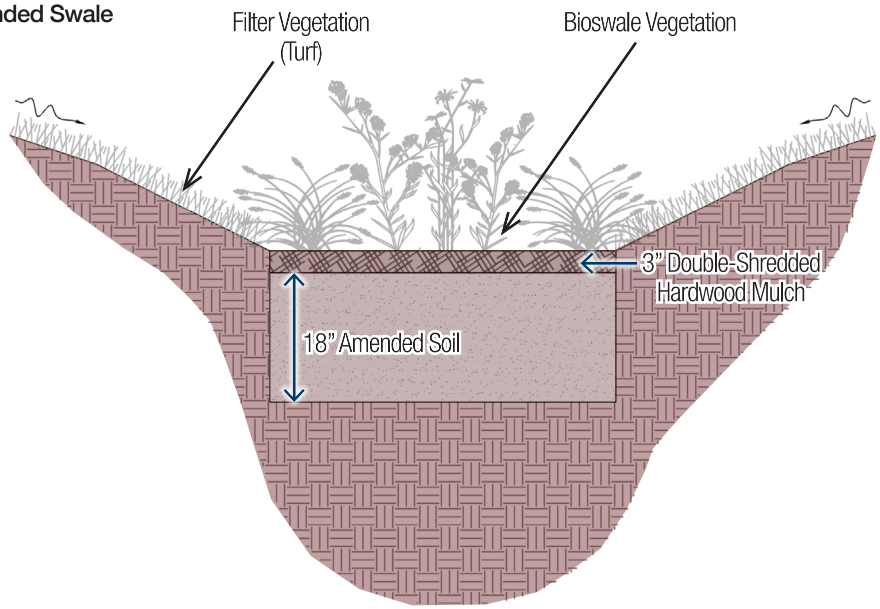


Figure 9.09-1-5: Pilot Channel Alternatives (continued)

Bioswale



Amended Swale



BASIN FLOOR

The basin floor should be graded with a minimum slope of 1.5% on finished surfaces to be maintained as turf grass. For areas to be maintained as **native vegetation**, the minimum slope may be reduced to 0.5%. TARGET

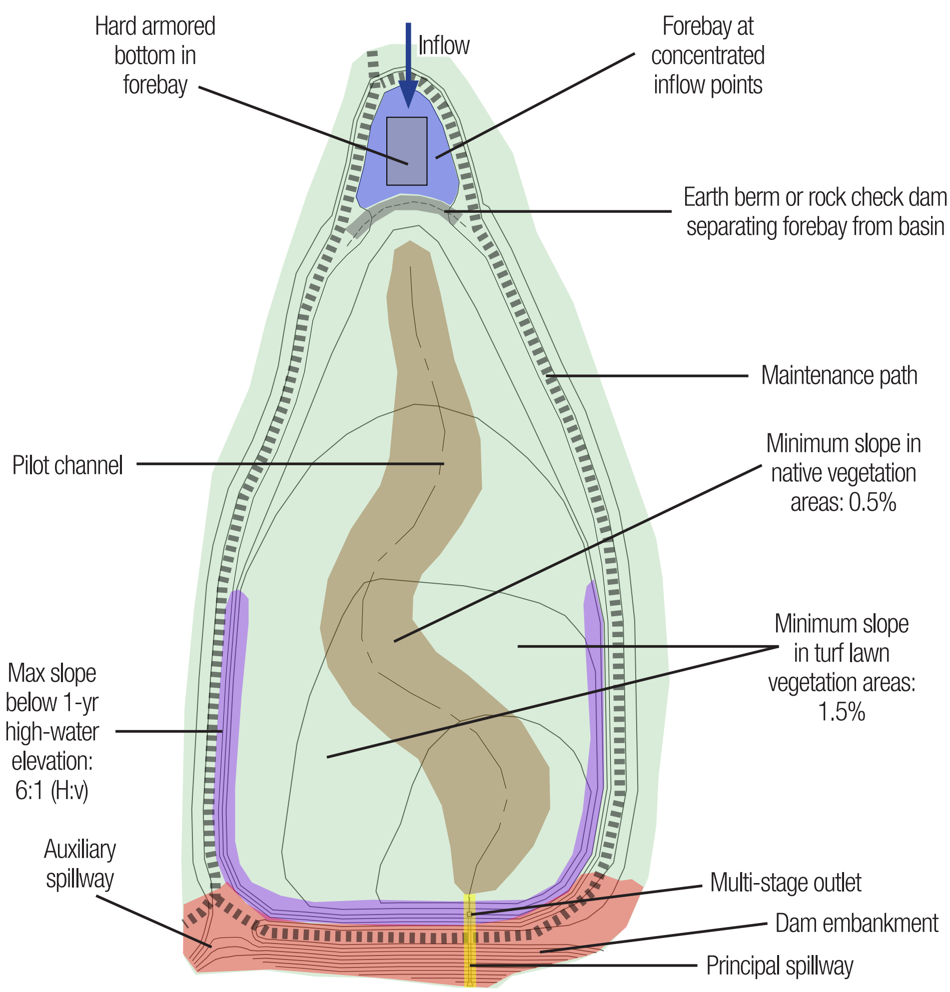
PERIMETER SLOPES

Perimeter areas of the basin should be graded with slopes that are stable and mowable. Slopes of 6:1 or flatter are recommended on side slope areas located below the expected high-water elevation caused by the CPv event (1-year, 24-hour storm).

- It is recommended that slopes should be 4:1 or flatter. TARGET
- However slopes may be as steep as 3:1 in select areas. ESSENTIAL
- Flatter slopes may be required based on site-specific soil conditions.

Use of walls or earth–retaining structures within and around the perimeter of the detention area should be limited to the greatest extent possible. Such features restrict access for maintenance, may be negatively impacted by rapidly changing water levels and can be detrimental to the aesthetics around the basin. TARGET

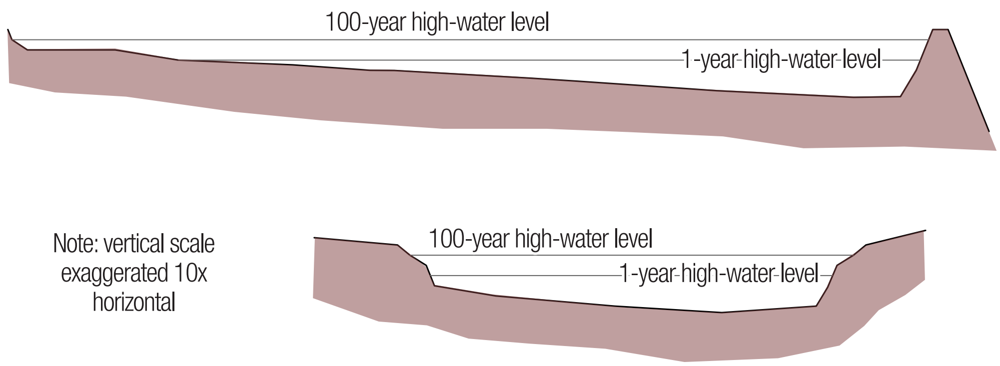
Figure 9.09-1-6: Typical Features of a Dry Detention Basin



NOTE

Flatter bottoms may require careful plant selections.

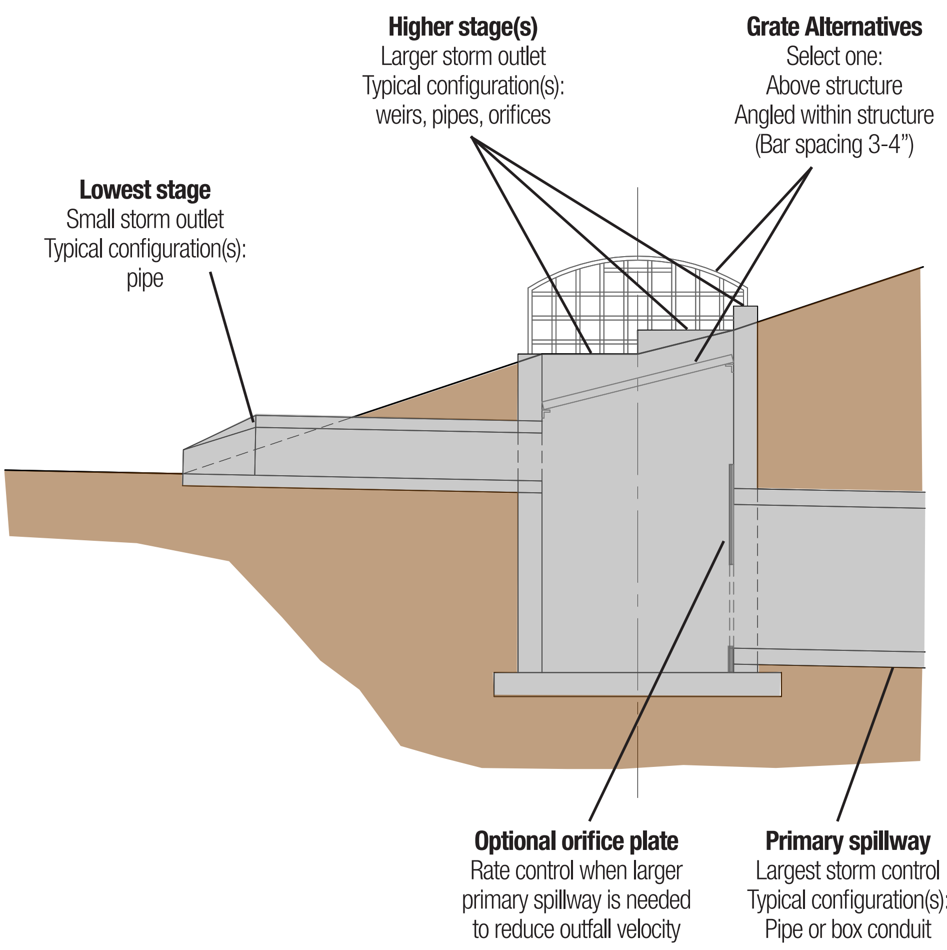
Figure 9.09-1-7: Cross-Section View Graphic of Detention Features



OUTLET STRUCTURES

Multi-stage outlets may be needed to meet release rate reduction targets for various storm events. TARGET

Figure 9.09-1-8: Multi-Stage Outlet Elements



TEMPORARY STORAGE VOLUME

Storage volume for stormwater detention is created through excavation (cut) or creation of a dam embankment (fill) to store water as needed to limit release rates.

DAM CONSTRUCTION AND AUXILIARY SPILLWAY

The dam should be constructed of suitable embankment materials, typically less permeable clay materials. The crest of the dam should be at least 10 feet in width, with a 0.1' rise in elevation from the center to the exterior of the crest. For smaller detention areas—where the entire basin can be reached from an adjacent paved surface—the crest of the dam width may be reduced to 6 feet, with the same rise in elevation provided. Side slopes of the dam below the crest should be no steeper than 3:1 (4:1 recommended).

An emergency overflow spillway is best located at one end of the dam (on the downstream side of the basin) and preferably not located in an area of fill. ESSENTIAL

- The crest of the auxiliary spillway should be level as it runs along the centerline of the dam to maximize the weir length. ESSENTIAL
- The spillway should be protected from surface erosion, based on the expected velocities and frequency of overtopping. ESSENTIAL
- The spillway should be directed to a location where downstream properties, buildings or infrastructure will not be negatively impacted. ESSENTIAL
- Surface water flowage easements may be required to prevent construction of buildings, fences and other obstructions that would prevent flows from being safely conveyed across off-site areas downstream. ESSENTIAL

The crest of the dam should be set to include at least one foot of **freeboard** between the top of the dam and the expected high-water elevation during the 100-year, 24-hour storm event. The dam crest should also be set at least 1.5 feet above the crest of the auxiliary spillway. ESSENTIAL

NOTE

Check with local jurisdictions and Iowa DNR (as applicable) about freeboard requirements, which may be more restrictive.

Figure 9.09-1-9: Dam Crest Parameters

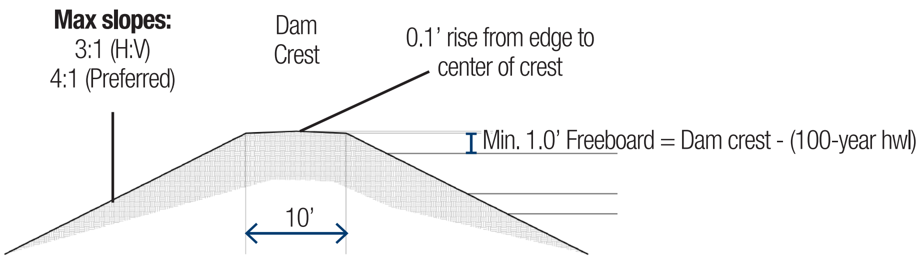
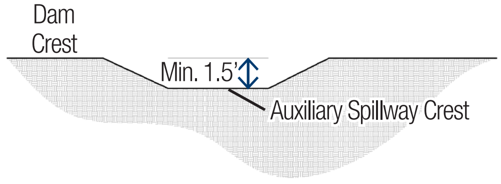


Figure 9.09-1-10: Auxiliary Spillway Parameters



NOTE

Some 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 pipe materials at pipe joints.
- Construct chimney filters to control internal seepage or erosion within the dam structure

OUTFALLS

Outfalls from the basin should be placed in stable locations, with adequate protection from erosion. ESSENTIAL Some options are:

- 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

Figure 9.09-1-11: Unstable outfall

Revetment materials or other erosion protection measures should be placed at pipe outlets. Check expected velocities at outfalls during a 100-year storm event. **If necessary, consider increasing the diameter of the outfall pipe to lower expected velocities (outlet structure would need to be designed so that allowable release rates are still not exceeded).** Alternatively, a stilling basin could be constructed to dissipate energy below the outfall. ESSENTIAL

Water seepage can easily occur along pipe conduits through dams. In extreme cases, water movement can lead to erosion along the outside of the pipe, potentially breaching the dam itself. **Pipe conduits through spillways must include seepage control measures to prevent these issues.** In the past, seepage collars were used to address this issue; however, these have proven ineffective in many situations. ESSENTIAL

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

- FEMA Technical Manual: Conduits Through Embankment Dams (September 2005)
- IDNR Technical Bulletin No. 16: Design Criteria and Guidelines for Iowa Dams (December 1990)
- Any updated versions of these standards which may be issued after the date of publication of this document

Level spreader outlet structure at Heritage Park in Minneapolis, MN.
(photo courtesy - Mississippi Watershed Management Organization mwmo.org)

Concrete level spread with grass basin on upstream side. Flow enters from pipe that runs parallel to the spreader and leaves by filling the basin and flowing across the level concrete strip.
(photo coutesy - NC State University "Urban Waterways - Level Spreader Update")

E. MAINTENANCE, ACCESS AND SAFETY

PLANNING FOR MAINTENACE ACCESS

A maintenance path shall be provided around the perimeter of the facility, with paths of access to forebays, pre–treatment devices, spillways, outlet structures and pipe outfalls. ESSENTIAL The path of access shall be at least 12 feet wide with a maximum cross-slope of 8% (5% preferred). For smaller detention areas where the entire basin can be reached from an adjacent paved surface, a perimeter path is optional, provided that all areas of the basin can be accessed within 40 feet (measured horizontally) from a point where maintenance equipment can be staged.

- **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.** This could be as simple as a mowed path or as formal as a paved trail or drive. (While not required, shared-use paths and multi-use trails can serve a dual purpose for maintenance access.)
- **The path should have access to a road as a point of entry.** The path should be completely within the property owned by the party responsible for maintenance, or within an easement recorded to grant such access.

Figure 9.09-1-13: Maintenance Path Needs

The maintenance path should extend around the perimeter of the basin and be aligned to provide access to the:

- Forebay(s)
- Auxiliary spillway
- Multi-stage outlet
- Dam embankment
- Outfall

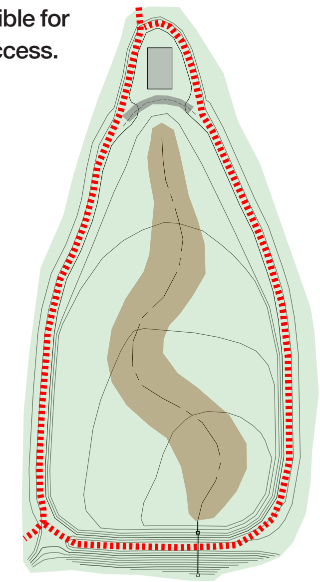
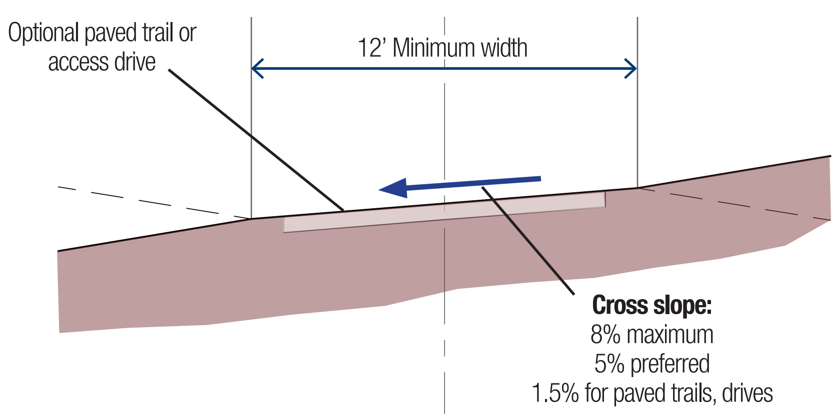


Figure 9.09-1-14: Cross-section of maintenance path



SAFETY FEATURES

A. All embankments and spillways shall be designed to State of Iowa guidelines for dam safety, as applicable. ESSENTIAL

B. Fencing of stormwater detention areas is not generally desirable, but may be required by the local review authority. TARGET

C. A grate or trash rack on larger openings of the multi-stage outlet structure should deter access by small children. ESSENTIAL

D. Pipe outfalls of greater than 48 inches in height may require a fence or railing to reduce fall risks. ESSENTIAL

F. LANDSCAPING

A landscaping plan should be provided that indicates the methods used to establish and maintain desired permanent vegetation. Minimum elements of a plan include: delineation of landscaping zones, selection of corresponding plant species, planting plan, sequence for preparing planting bed (including soil amendments, if needed) and sources of plant material. The designer should consider the frequency and duration of inundation for various zones within the basin when selecting plant materials.

- Separate landscaping zones may be considered for areas expected to be inundated more frequently (e.g., below the **high water** of the CPv event).
- Woody vegetation may not be planted on the dam embankment or allowed to grow within 25 feet of the toe of the embankment or 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.
- Over-compaction of site soils may require excavation of pits, to be backfilled with less compacted topsoil materials in tree and shrub planting areas.

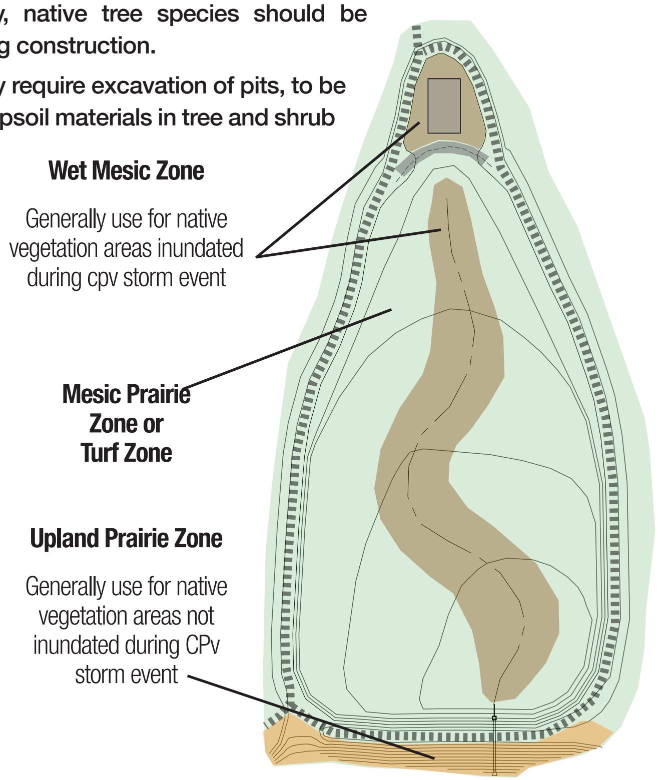


Figure 9.09-1-15: Landscaping Zones

NOTE

Locating dry detention basins within flood prone areas is discouraged.

Exceptions:

- Retrofits of existing BMPs
- On–line BMP: stream routed through basin
- BMP is constructed by excavation: no dam or berm that creates barrier to the floodplain

G. DESIGN ALTERNATIVES

None are detailed in this section.

H. SPECIAL CASE ADAPTATIONS

FLOOD PLAINS

It is preferred that dry detention basins be located outside of the extent of the mapped 1% chance **annual recurrence** (AR) flood event (100-year flood). Exceptions can be made for retrofits or existing sites that are already located within a flood plain or if the basin is located "on-line," so that the stream with the mapped flood zone will be routed through the basin for the purpose of reducing downstream flowrates. Exceptions are also allowed if the storage for the basin is to be constructed by excavating within the floodplain, without creation of a dam or berm that would effectively remove the basin from the floodplain. Any earth-moving activities to construct dams or create excavated areas will need to comply with local, state and federal floodplain regulations. Changes in surface elevation that result in increased high-water elevations across the floodplain should be avoided.

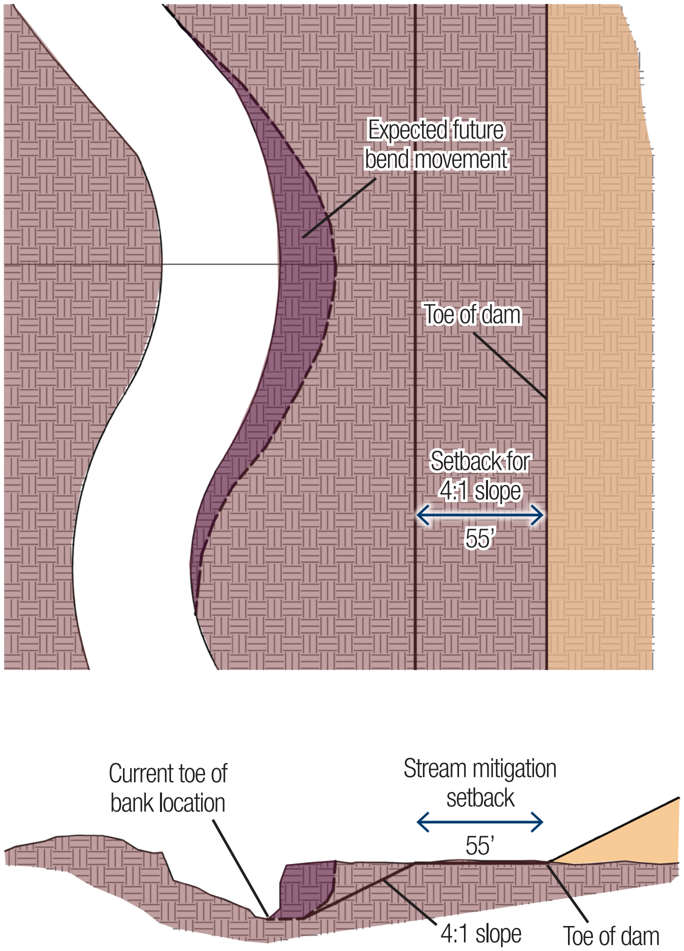
Basins located within flood-prone areas may require more frequent or extensive maintenance. When evaluating site locations within flood-prone areas, evidence of deposition or debris collection should be noted. **If a basin is constructed in an area expected to collect sediment or debris, available storage could be reduced over time and additional maintenance to remove trapped materials would be necessary.** ADVISORY

STREAM MORPHOLOGY

Stormwater detention areas should be located with adequate buffer space from adjacent streams. The designer should review historic photographs or use other information to understand past stream movement adjacent to a proposed basin. During site selection, it should be determined if a nearby stream is demonstrating active bank erosion, has shown lateral migration over a period of time or is actively incising. In such cases, the practice should be located so that such movement will not impact the basin, its related elements or points of access.

A **stream migration** buffer limit should be set beyond any projected future movement and beyond a line drawn from the toe of the closest adjacent streambank (either current or future location) at a 4:1 slope to the finished surface.

Figure 9.09-1-16: Stream Morphology Considerations



9.09-2 SIZING CALCULATIONS

A. CALCULATION PROCEDURE

Step 1. Determine if the development site and conditions are appropriate for the use of a stormwater detention basin. Consider the Application and Feasibility criteria in Section 9.09-1.

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

- Review need for state and federal permits (NPDES, Joint Permit application)
- Consider any special site-specific design conditions/criteria listed in this section.
- Check with local officials and other agencies to determine if there are additional restrictions and/or surface water or watershed requirements that may apply. (State Dam Safety requirements will be checked in Step 8).

Step 3. Develop a stormwater model (TR–55) for the watershed area for the practice. The model should determine peak flow rates and volumes for the natural, existing and proposed conditions. Refer to Section 9.02-2.A for the events to be studied and Section 9.03 for use of modeling software.

TR-55 MODEL INPUT/OUTPUT

TABLE 9.09.2-1: EVENTS TO BE STUDIED, DATA OUTPUT TO COLLECT

		NATURAL		EXISTING		POST-DEVELOPMENT	
		CN	TC	CN	TC	CN	TC
EVENT	RAINFALL	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)

Step 4. Estimate required storage volumes to meet the aspects of the Unified Sizing Criteria to be managed by the practice. For dry detention practices, this is typically the 2-year through 100-year storm events. Designers are strongly encouraged to use the procedure in Section 9.02-3 to estimate required storage very early in the planning process for any new development or stormwater facility. Estimated storage values can project the area that should be set aside for stormwater detention, allowing other development plans to be planned around that reserved open space.

NOTE

Refer also to IDNR Form 542–1014.

NOTE

Use perforated risers or other features with multiple small openings in lieu of single orifice openings that are less than 4 inches in diameter. Alternatively, provide guards or screens to protect the smaller opening from being plugged by debris or animal activity.

Step 5. Determine pretreatment measures.

- The pretreatment volume should be 10% of WQv. Pretreatment is required even for facilities that aren't managing the WQv. Pretreatment may be omitted in some areas (refer to Section 9.01-1.E).
- Determine the preliminary location, size and depth of forebays (where required).

Step 6. Review site topography and develop a preliminary grading plan to identify preliminary stage–storage relationships that provide the estimated storage volumes required as calculated in Step 4. Refer to Table 9.09-1.1 for maximum storage depth requirements for key storm events.

Step 7. Investigate potential pond/wetland hazard classification. The design and construction of stormwater management ponds are required to follow the current version of the Iowa 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.

Step 8. Enter the preliminary stage–storage relationships and outlet configurations into a TR–55 software program and route inflow hydrographs through the preliminary detention basin design. Identify the projected release rates for each event studied.

Step 9. Review projected release rates from Step 8 for the preliminary design. Verify that the projected rates are less than the allowable rates calculated as part of the estimation procedure referred to in Step 4. Iterate as needed, adjusting staged outlet controls or stage-storage relationships within the software program to meet required release rate restrictions. Maintain compliance with maximum storage depths listed in Table 9.09-1.1.

Step 10. Finalize practice location and refine the grading plan and outlet design. Alter the model that was developed and adjusted in Steps 8 and 9 to reflect the stage-storage and outlet conditions included in the final plan. Re-check that peak release rates are less than allowable levels and maximum storage depths are not exceeded.

Step 11. Check outflow velocities at pipe outfalls and spillways. Adjust sizing or 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 12. 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, make any adjustments as needed so that final plan information matches the finished calculation report.

B. DESIGN EXAMPLE

PROJECT WATERSHED DATA

TABLE 9.09-2.1: 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			

* Basin 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 basin. 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 dry detention basin.

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

A. Review 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.

Refer to Section 9.09-1H. For this example, the detention basin is assumed to be outside 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 (for the calculations, assume this was performed and no such indications were found).

C. Check with local officials and other agencies to determine if there are 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 ISWMM and requires the following related to application of Unified Sizing Criteria

» The requirements for Recharge Volume (Rev), Water Quality Volume (WQv) and Channel Protection Volume (CPv) are being achieved by upstream practices (as part of site development).

» Peak outflow rates from larger storm events will need to be limited to the lesser of the following:

- **Natural conditions** for the same rainfall event.
- Existing conditions for the 5-year, 24-hour rainfall event.

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.

NOTE

Local jurisdictions will define release rate parameters, often based on guidance from Section 3.01.`

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

It is recommended that the NRCS Lag equation be used for natural conditions.

Step 3. Develop a stormwater model (TR-55) for the watershed area for the practice. The model should determine peak flow rates and volumes for the natural, existing and proposed conditions. Refer to Section 9.02-2.A for the events to be studied and Section 9.03 for use of modeling software.

Calculate the WQv separately. Though detention basins do not treat the WQv, the pre-treatment is determined by the WQv.

This step may be omitted if sufficient pre-treatment is provided as a part of the upstream practices.

TABLE 9.09-2.2: 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**

Calculate time of concentration for natural, 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 9.09-2.3: 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

TABLE 9.09-2.4: 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 9.09-2.5: TR-55 MODEL INPUT/OUTPUT

		NATURAL		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)
2-year	3.20"	6.3	98,900	59	300,000	136	463,000
5-year	3.99"	15	191,000	95	459,000	193	655,000
10-year	4.74"	26	298,000	131	623,000	249	846,000
25-year	5.90"	48	491,000	191	896,000	336	1,150,000
50-year	6.90"	70	678,000	243	1,140,000	412	1,420,000
100-year	7.98"	95	898,000	303	1,420,000	494	1,710,000

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

Step 4. Estimate required storage volumes to meet the aspects of the Unified Sizing Criteria to be managed by the practice. For dry detention practices, this is typically the 2-year through 100-year storm events. Designers are strongly encouraged to use the procedure in Section 9.02-3 to estimate required storage very early in the planning process for any new development or stormwater facility. Estimated storage values can project the area that should be set aside for stormwater detention, allowing other development plans to be planned around that reserved open space.

TABLE 9.09-2.6: INITIAL ESTIMATES OF REQUIRED DETENTION

STORM EVENT	QO (CFS)	QI (CFS)	QO/QI	VS/VR	VR (CF, 000s)	VS (CF, 000s)	VS *1.15 (CF, 000s)
2	6.3	136	0.05	0.62	463	287	330
5	15	193	0.08	0.58	655	380	438
10	26	249	0.11	0.55	846	464	534
25	48	336	0.14	0.51	1,150	586	674
50	70	412	0.17	0.48	1,420	687	790
100	95	494	0.19	0.46	1,710	790	909

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.

For this calculation example, assume that sufficient space has been reserved to afford the preferred high-water depths from Table 9.09-1.1. The initial storage volume targets are the 10-year event in 3 feet of depth, and the 100-year in 5 feet of depth.

TABLE 9.09-2.7: INITIAL ESTIMATES OF REQUIRED FOOTPRINT

STORM EVENT	TARGET DEPTH (FEET)	EST. FOOTPRINT (SF)
10	3	178,000
100	5	181,780

Step 5. Determine pretreatment measures.

The pretreatment volume should be 10% of WQv. Pretreatment is required even for facilities that aren't managing the WQv. Pretreatment may be omitted in some areas (refer to Section 9.01-1.E).

Determine the preliminary location, size and depth of forebays (where required).

NOTE

WQv was determined in Step 3.

The pre-treatment volume (Ptv) is 10% of the WQv:

Ptv = 10% x WQv = 0.1 x 207,330 = 20,733 CF (use 20,735 CF)

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 basin 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**

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 basin through two outfall pipes. The forebay volume can then be calculated as:

207,330 CF	(total watershed WQv)
x 10%	
= 20,733 CF	*(total pre-treatment volume required)*
– 198 CF	(provided by **vegetative buffer** strip)
= 20,535 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).

Step 6. Review site topography and develop a preliminary grading plan to identify preliminary stage-storage relationships that provide the estimated storage volumes required as calculated in Step 4. Refer to Table 9.09-1.1 for maximum storage depth requirements for key storm events.

- To start, select a preliminary elevation for the outlet.

For this example, we are using elevation 100 as the outlet elevation.

- Next, figure the area required to provide the estimated storage for the 10- and 100-year events calculated in Step 4 at the recommended depths to establish initial values for area required to achieve such storage. For this example, assume that vegetation for the basin floor will be native Iowa plantings, so the minimum basin slope is 0.5%.

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 9.09-2.8: ESTIMATED CONTOUR AREA/STORAGE BELOW 2-YEAR EVENT TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
0	100	-	-	-
1	101	72,312	36,231	36,231
2	102	309,589	190,950	227,181
3	103	323,224	316,407	543,588
4	104	332,447	327,836	871,424
5	105	341,776	337,112	1,208,535

It appears from this analysis that we are close to providing the estimated storage at the desired depths of temporary ponding, so we can proceed with the next design steps. For this example, an auxiliary spillway is provided above stage (depth) 5 ft to pass event larger than the 100-year, 24-hour event.

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.

The lowest 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.

NOTE

A general shape of the basin was assumed with a 0.5% bottom slope and maximum 4:1 side slopes.

Estimates of storage from Step 4:

2–yr: 330,000 CF
10–yr: 534,000 CF
100–yr: 909,000 CF

Step 7. Investigate potential dam hazard classification. The design and construction of stormwater management ponds and wetlands are required to follow the current version of the Iowa 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.

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 IDNR Form 542-1014:

* Volumes of forebay storage added to the basin.

- The dam has an emergency spillway, and has a sum of 1,208,600* CF of temporary storage (27.75 **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 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 basin 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.

So, it appears that no permit for dam embankment construction would be required from IDNR in this case. However, it should be noted that for a basin 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.

Step 8. Enter the preliminary stage-storage relationships and outlet configurations into a TR-55 software program and route inflow hydrographs through the preliminary detention basin design. Identify the projected release rates for each event studied.

"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 the bottom of the basin). Using the orifice equation, we will start with an assumption of a 33" outfall pipe. Our goal is to limit outflow from the 100-year event to 95 cfs (from Step 4). 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/s²
h = head measured from high-water to center of opening (feet)

h (feet) =	*105.000*	*(100-year target high-water)*
	– 93.000	*(flowline of pipe)*
	– 1.375	*(assumed radius of pipe)*
	= 10.625	feet

A = *95 cfs / [0.6 x (2 x 32.2 x 10.625)*$^{1/2}$*]* = 6.1 SF

Area of 33" pipe = $\pi r^2 = \pi(1.375 \text{ feet})^2$ = 5.9 SF (good for initial estimate)

B. We will use a multi-stage outfall to address the release rates of the 2-year, 10-year, and 100-year events. Compute the approximate size of the orifice needed to discharge for the 2-year event.

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

Where: Q = flow (cfs)
C = orifice coefficient (0.60)
g = 32.2 ft/s²
h = head measured from high-water to center of opening (feet)

h (feet) =	*102.0*	*(2-year event target high-water)*
	– 100.5	*(assumed center of orifice)*
	= 1.5	feet

A = *6.3 cfs / [0.6 x (2 x 32.2 x 1.5)*$^{1/2}$*]* = 1.1 SF

r = *(A / π)*$^{1/2}$ *= (1.1 SF / π)*$^{1/2}$ = 0.583 feet

d = *2r = 1.17 feet (use 13" as initial trial)*

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 natural 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.

- 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 33” outfall pipe (Culvert A) and the 13” 2-year 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 5.56 cfs during the 2-year CPv event (<6.3 cfs, OK)

CULVERT/ORIFICE	A	B
Rise	33”	13”
Span	33”	13”
No. Barrels	1	1
Invert Elevation	93’	100’
Length	100’	40’
Slope	0.5%	0.5%
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 2-year event.

NOTE

Software packages like Hydraflow and HydroCAD use these “Multi–stage” and “Active” designations. They must be selected properly in order for the software to model outflow correctly.

Since we know the basin does not provide enough storage for the 2-year event at 102.00, set the weir slightly higher so that the 2-year water surface elevation is below the weir. Try setting a second stage elevation at 102.75’—a 4’ long rectangular weir (could be the front face of a 4’x4’ inlet structure).

WEIR	A
Weir Type	Rectangular
Crest Elevation	102.75’
Crest Length	5.5’
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.

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 9.09-2.9: SUMMARY OF OUTFALL DESIGN ITERATIONS 2-4 AND RESULTS

		RESULTS OF DESIGN ITERATIONS		
ITERATION		1	2	
Culvert A		33”	33”	Elevation = 93.0
Culvert B		13”	13”	Elevation = 99.45
Weir A			4’	Elevation = 102.75
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (ITERATION #2)
2-year	6.3	5.6	5.6	102.17
5-year	15	6	6	102.62
10-year	26	7	9	103.03
25-year	48	7	16	103.53
50-year	70	8	25	103.96
100-year	95	overtops	37	104.43

NOTE

Boxes highlighted in red in Table 9.09–2.9 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 C8–1.

- 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 2-year, 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.

DETAILED DESIGN OF FOREBAY

In the sediment basins, a perforated standpipe will be installed, allowing the basin to drain dry. The riser will be a 12" PVC pipe with ½" holes spaced along the pipe. The outfall pipe will be a 12" PVC pipe without perforations. The outlet invert of the 12" PVC pipe should be set equal to the pilot channel.

The sediment basins are sized to capture 10% of WQv before overtopping an earth berm, protected by an articulated concrete mat. Generally, forebays should be longer than they are wide to provide sufficient length for **settling** sediment. Specific guidance for pretreatment design can be found in Sections 5.01–5.07.

The earth berm can be approximated as a broad-crested weir. Use the weir equation to check the velocity over the berm during the 100-year peak flow to evaluate the potential for erosion.

The weir equation is
$Q = 1.6 \times L \times h^{3/2}$

Using the 100-year peak flow, 494 cfs, and the design weir length of 30 feet, solve for the depth of water over the weir. For this example, it assumed that the flow is split equally between the two sediment basins. In application, the expected inflows should be calculated for the two subcatchments separately. The treatment volume and velocity into the detention basin from each basin should be designed separately.

Q = C x L x H3/2

Where: Q = inflow (cfs)
C = 2.6 (coefficient for broad crested weir)
L = length (feet)
H = height of flow over weir (feet)

rearranged to solve for H:

$H = [Q / (C \times L)]^{2/3}$

$H = [247 \text{ cfs} / (2.6 \times 30 \text{ feet})]^{2/3}$

H = 2.1 feet

The flow area is then
30 feet x 2.1 feet = 62 square feet

Using the continuity equation, Q = A x V
247 cfs = 62 square feet x V
247 cfs / 62 square feet = V = **4.0 fps**

Step 9. Review projected release rates from Step 8 for the preliminary design. Verify that the projected rates are less than the allowable rates calculated as part of the estimation procedure referred to in Step 4. Iterate as needed, adjusting staged outlet controls or stage-storage relationships within the software program to meet required release rate restrictions. Maintain compliance with maximum storage depths listed in Table 9.09-1.1.

Since the projected high water level calculated in Step 8 was less than our target (4.4' < 5'), the footprint of the proposed basin could be reduced. The grading plan developed for this practice could be used to determine final storage volumes.

TABLE 9.09-2.10: TEMPORARY DETENTION STORAGE

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
0	100	-	-	-
1	101	100,000	50,000	50,000
2	102	223,892	148,396	184,921
3	103	239,094	231,493	416,414
4	104	248,418	243,756	660,170
5	105	257,907	253,162	913,332

The 10-year storage is satisfied between the 3-ft and 4-ft depths, and the 100-year storage is provided at the 5-ft depth. Accept this preliminary grading and stage-storage relationship.

For this example, none of these changes are significant enough to change the permit status against requirements reviewed in Step 7.

Move on to iterating the outlet structure to provide the appropriate release rate. Begin with the outlet structure already developed. The iteration summary is provided in the following table.

Iteration 1: With the adjusted grading plan, it appears that the 13” orifice for Culvert B allows too much flow to pass. Change the diameter of Culvert B to 12”.

Iteration 2: The 12” culvert restricts the outflow to below the maximum allowed release rate, but the 50- and 100-year events overtop.

Iteration 3: Set a 4’ weir, Weir A, at 102.50. Flow will pass over this weir during the 5-year event, but that the 5-year outflow is less than the maximum allowed release rate. Flow from the 100-year event would still overtop the spillway, which would result in flows exceeding the allowed peak rates.

Iteration 4: Use the remaining 3 sides of the 4’ x 4’ structure for a 12’ weir set at elevation 104.00’. All event outflows are below the maximum allowable release rates and do not overtop the basin.

TABLE 9.09-2.11: FINAL DESIGN ITERATIONS

DETENTION POND 5						
ITERATION		1	2	3	4	
Culvert A		33”	33”	33”	33”	Elevation = 93.00
Culvert B		13”	12”	12”	12”	Elevation = 100.00
Weir A				4’	4’	Elevation = 102.50
Weir B					12’	Elevation = 104.00
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (ITERATION #4)
2-year	6.3	6.6	5.7	5.7	5.7	102.30
5-year	15	9.4	6.5	8.9	8.9	102.83
10-year	26	16	7.1	15	15	103.23
25-year	48	29	8.0	29	29	103.86
50-year	70	44	overtops	43	51	104.37
100-year	95	62	overtops	overtops	85	104.90

The routed storage volume reported by the software is summarized below:

STORM EVENT	VS [CF]	VS X 1.15 [CF]	ROUTED VOLUME PROVIDED [CF]
2-year	287,195	330,300	284,900
10-year	464,338	534,000	555,900
100-year	792,231	911,100	1,022,400

Step 10. Finalize practice location and refine the grading plan and outlet design. Alter the model that was developed and adjusted in Steps 8 and 9 to reflect the stage-storage and outlet conditions included in the final plan, re-check that peak release rates are less than allowable levels and maximum storage depths are not exceeded.

The grading plan was adjusted to meet the parameters developed in previous steps.

Step 11. Check outflow velocities at pipe outfalls and spillways. Adjust sizing or geometry, or add erosion protection features as needed for the 100-year, 24-hour event.

From the continuity equation, check the velocity of the outfall pipe based on the routed 100-year flow rate of 85 cfs and the design diameter 33 inches.

85 cfs = 5.9 square feet x V
85 cfs / 5.9 square feet = V = **14.33 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, go back and adjust 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. In the case of some energy dissipators, such as a stilling basin, an expected tailwater elevation (of the stream, for example) is necessary.

- Using the same equation, check for velocity across the crest of the auxiliary spillway (if any overfow 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 overfow is expected, so no velocity check is necessary.

Step 12. 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, make any adjustments as needed so that final plan information matches the finished calculation report.

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.

9.09-3 CONSTRUCTION

A. POLLUTION PREVENTION

STORMWATER POLLUTION PREVENTION PLAN AND NPDES PERMIT REQUIREMENTS

If the site's total disturbed area exceeds one acre (including all parts of a common plan of development) a stormwater pollution prevention plan (SWPPP) shall be prepared.

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

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.

Exterior Protection

All perimeter and site exit controls should be installed prior to any land-disturbing activities. Such controls may include (but are not 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 (mulches, rolled erosion control products, turf reinforcement mats, etc.) prevent detachment of soil particles from the surface. Sediment controls (wattles, filter socks, silt fences, sediment basins, etc.) capture sediments after they have become suspended in runoff. Installation of controls may need to be staged to be implemented immediately after construction operations have ceased or are paused in a certain area.

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 finished grades are stabilized with permanent vegetation.

Project phasing can also be used as a form of protection. This is accomplished by staging construction operations to limit the amount of surface area that is disturbed or left unprotected by erosion controls at any given time.

Figure 9.09-3-1-A: Construction Stage Features and Controls

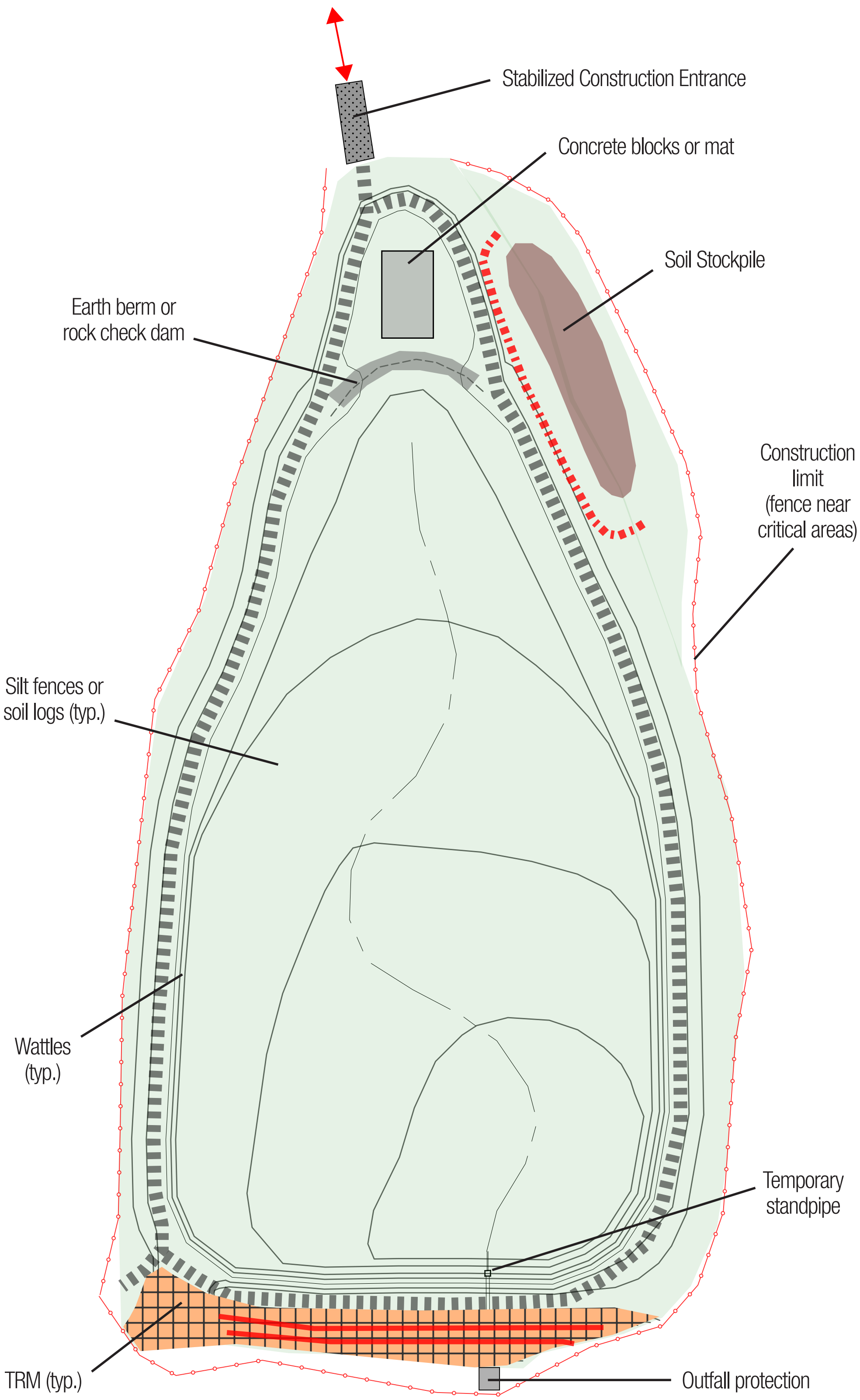
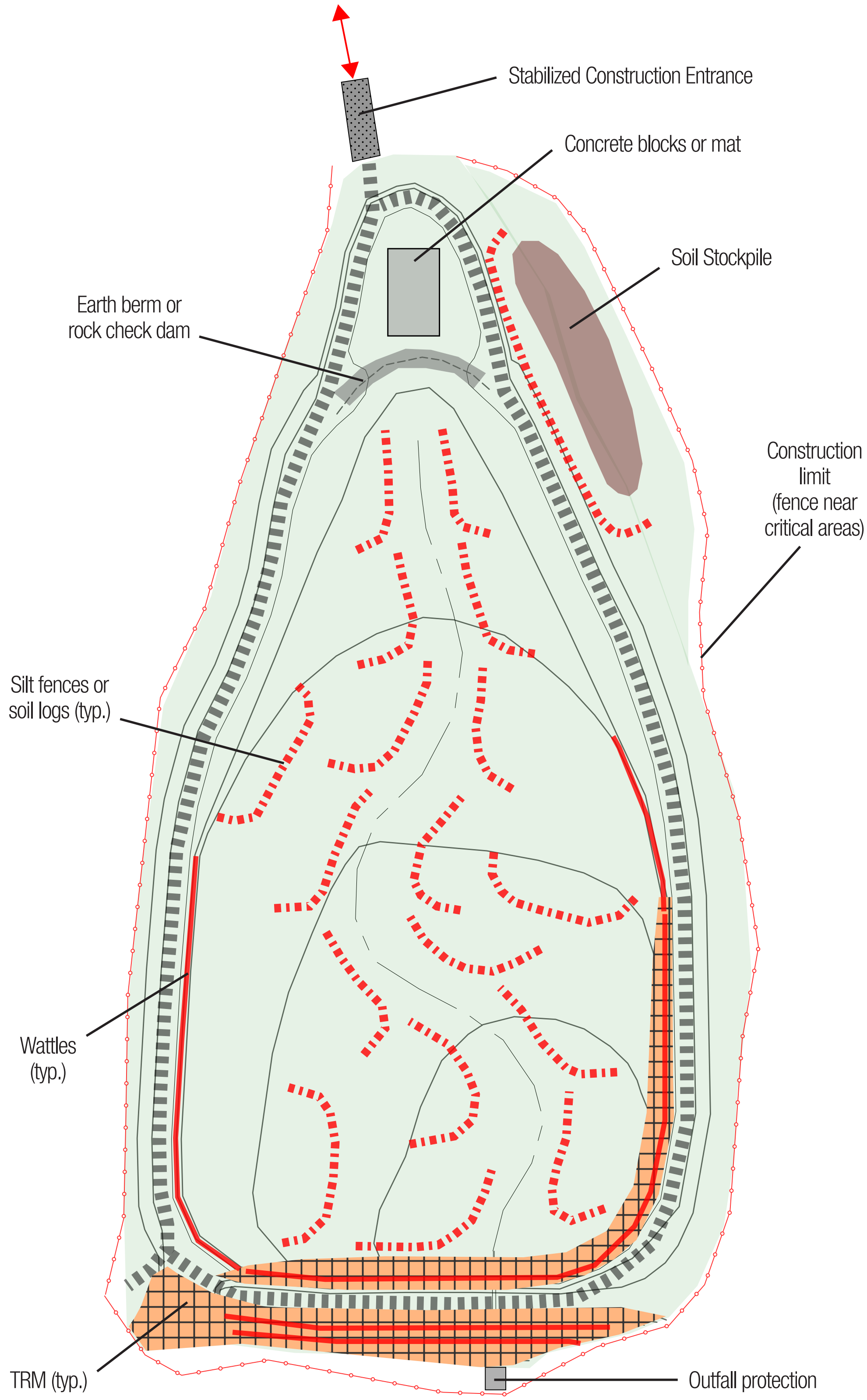


Figure 9.09-3-1-B: Construction Stage Features and Controls



B. CONSTRUCTION SEQUENCING

Major construction operations to create dry detention basins 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. Comply with any permit requirements related to staging of tree removals.

2. **Topsoil stripping and stockpiling**

One of the initial site-disturbing activities is typically removing 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 involve only the moving and shaping of the topsoil materials.

3. **Rough Grading (Major Earthwork Operations)**

The primary movement of earth materials adjusts graded surfaces to approximate elevations (within 6 inches) as needed to allow for placement of topsoil materials. As the dam is constructed, a temporary standpipe could be placed to allow the basin to operate as a sediment basin.

Figure 9.09-3-2: Construction phase

4. **Surface Roughening**

Equipment creates grooves and loosens the surface of soil materials after placement. These grooves limit the potential for sheet and rill erosion across slopes and prepare the soil for seedbed preparation.

5. **Storm Structure and Pipe Installation**

Installation of the outlet structures and pipes allows for control of the water level, providing for drier soil conditions for finished (or fine) grading and seeding.

6. **Verify Elevations**

Complete a site survey to verify "as-built" elevations of structures and the surface of the basin. Confirm that structures meet the intent of the plan and that it appears the storage provided in the basin will meet project requirements, considering that soil quality restoration (SQR) techniques are yet to be completed. Make grading adjustments as needed prior to proceeding with SQR operations.

7. **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 to a minimum depth of 8 inches. Do not move, grade or place wet topsoil materials.

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

Refer to ISWMM Section 7.03 for additional information.

8. **Surface Roughening**

Surface roughening may be re-completed after placement of topsoil materials to de-compact soils and limit the potential for sheet and rill erosion across slopes.

9. **Landscaping**

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

10. **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 desired permanent vegetation.

Where native vegetation is specified, a separate contract for establishment of permanent vegetation and maintenance service for a period of three 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 re-spread 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. Verify that 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.
- 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 is in compliance with the contract documents.
- As per Construction Sequencing item #6, review results of an as-built or record survey to verify that the surface elevation of the basin 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 said issues in a punch list and confirm when all such items are installed.
- 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.

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

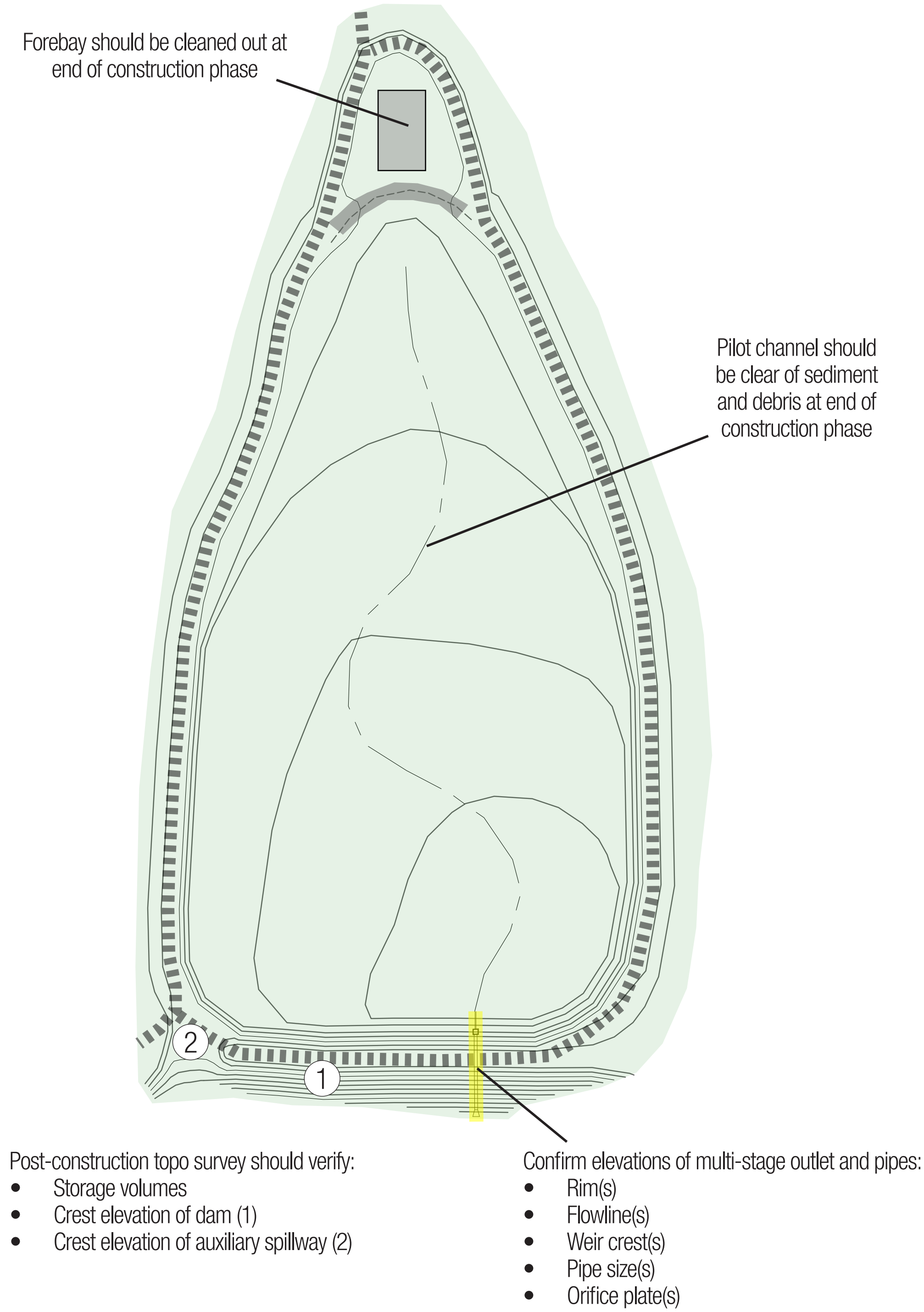
- Maintain and update the SWPPP document and retain records.
- Conduct site inspections as required by the general permit.
- Throughout construction, work with the erosion and sediment control contractor to coordinate proper installation of all BMPs.
- Verify that exterior sediment and erosion BMPs are 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 be completed and submitted to the IDNR.

POST-CONSTRUCTION DOCUMENTATION

During construction, records should be kept by the contractor (and site observer) that will allow record drawings of constructed 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.
- A topographic survey to verify that required storage volumes have been achieved and dam crests and auxiliary spillways have been established to the designed elevations.
- Confirmation that required trees and shrubs have been installed.

Figure 9.09-3-3: Features to Check Post-Construction



9.09-4 MAINTENANCE

A. ESTABLISHMENT PERIOD (SHORT-TERM MAINTENANCE)

Where native vegetation is proposed, a more intense maintenance program is required for a period of at least three 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 (three 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, the 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 three years).

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

YEAR ONE—MAINTENANCE ACTIVITIES

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

- Maintain erosion and sediment controls until full establishment of perennial vegetation.
- 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 shall be closer than 8 inches to ground surface.
- Do not mow over mulched areas, plugs or other planted native perennials; only trim around these features.
- Systemic herbicide treatment of areas larger than 20 square feet where weeds are the dominant plant material.
- Hand-wiping systemic herbicide on invasive weeds and woody species where native plants are the dominant plant material, taking care not to damage nearby native plants.
- Removing above-ground portion of previously treated dead or dying weeds and woody species from planting areas.
- Adding 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-seeding areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- Applying mulch to areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- Pruning dead or dying material in trees or shrubs.
- Removal of weeds from the mulched areas around trees and shrubs.
- Application of appropriate insecticides and fungicides as necessary to trees and shrubs, only to maintain plants that are free of insects and disease. Follow manufacturer's instructions on any herbicide application.

YEAR TWO AND THREE—MAINTENANCE ACTIVITIES

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

- Remove all temporary erosion and sediment controls upon full establishment of perennial vegetation.
- Weed suppression 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 shall be closer than 12 inches to ground surface.
- Do not mow over-mulched areas, plugs or other planted native perennials; only trim around these features.
- 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.
- Systemic herbicide treatment of areas larger than 20 square feet where weeds are the dominant plant material.
- Hand-wiping systemic herbicide on invasive weeds and woody species where native plants are the dominant plant material, taking care not to damage nearby native plants.
- Removing above-ground portion of previously treated dead or dying weeds and woody species from planting areas.
- Adding 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-seeding areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- Applying mulch to areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- Pruning dead or dying material in trees or shrubs.
- Removal of weeds from the mulched areas around trees and shrubs.
- Application of appropriate insecticides and fungicides as necessary to trees and shrubs, only to maintain plants that are free of insects and disease.
- On final trip: remove staking wires from trees but leave stakes in place. Follow manufacturer's instructions on any herbicide application.

B. ROUTINE OR LONGER-TERM MAINTENANCE ACTIVITIES

During the design process, the entity responsible for routine and long-term maintenance should be established. These tasks are necessary to maintain the detention basin's 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
Inspect storm inlets, outlets for debris. 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 forebays and other pretreatment areas.	At least twice annually
Remove accumulated sediment from forebay.	When forebay is 1/2 full OR at least once every 5 years
Clean and remove debris from inlet and outlet structure.	At least three times annually
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 hydrocarbon build-up and remove accordingly.	Annually
Repair undercut or eroded areas.	When observed
Harvest plants that have been “choked out” by sediment accumulation.	Annually

- Sediments excavated from stormwater detention areas that do not receive runoff from designated hotspots 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 hotspot land use is present.
- Sediment removed from stormwater detention during construction should be disposed of according to an approved SWPPP.

9.09-5 SIGNAGE RECOMMENDATIONS

Signage at dry detention areas is not required, as it is often not needed. But signage could be provided as an educational tool to explain the area's 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 of native planting areas and broad application of herbicides.

Figure 9.09-5-1: Signage example