IOWA STORM WATER MANAGEMENT MANUAL

9.01 STORMWATER DETENTION BEST MANAGEMENT PRACTICES

IOWA DEPARTMENT OF NATURAL RESOURCES

TABLE OF CONTENTS

CONTENTS

9.01-1 OVERVIEW 1

A. Introduction 1
B. Objectives of Stormwater Detention 2
C. General Relationship to Unified Sizing Criteria 5
D. Pre-Design Considerations 6
E. References to Other Sections 7

9.01-2 TYPES OF STORMWATER MANAGEMENT PRACTICES 9

A. Stormwater Wetlands 9
B. Traditional Dry Detention 10
D. Wet Detention 12
E. Underground Chamber Systems 13
F. Hybrids and Stormwater Retrofits 14
G. Infiltration Basins 15

9.01-3 PLANNING CONSIDERATIONS 16

A. Define Practice Goals and Objectives 16
B. Site/Development Scale vs. Regional Management 16
C. Public or Private Ownership 16
D. Service Area of the Practice 17
E. Site Location and Properties 17
F. Public Access and Aesthetics 18
G. Establishing Desired Vegetation and Maintenance 18
H. Online versus Offline Systems 18
I. Discouraged Design Approaches 19

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

9.01-1 OVERVIEW

A. INTRODUCTION

This section provides a general overview of the broad category of **stormwater best management practices (BMPs)** that are most suited to provide downstream flowrate reduction through stormwater detention. This is the first in a series of sections devoted to the planning, site selection and design of these types of practices.

B. OBJECTIVES OF STORMWATER DETENTION

Stormwater detention is the temporary storage of runoff to reduce the peak rate of runoff from a given area. To accomplish this, runoff is collected in a location where there is sufficient space to provide the volume needed to temporarily store (detain) excess runoff. An outfall structure is designed and constructed to limit the **rate** of flow being sent downstream. Since the outflow runoff rate from the storage area is lower than the inflow rate, stormwater will build up in the storage area until such a time during or after the **storm event** when the outflow rate exceeds the inflow rate. At that time, the water elevation in the storage practice will begin to recede, or drawdown.

These graphs show the expected inflow vs. outflow rates of flow from a stormwater management practice designed to meet the Unified Sizing Criteria.

Note the dramatic reduction in outflow during the CPv event (>95%) and the extended period that flow is released (**extended detention**).

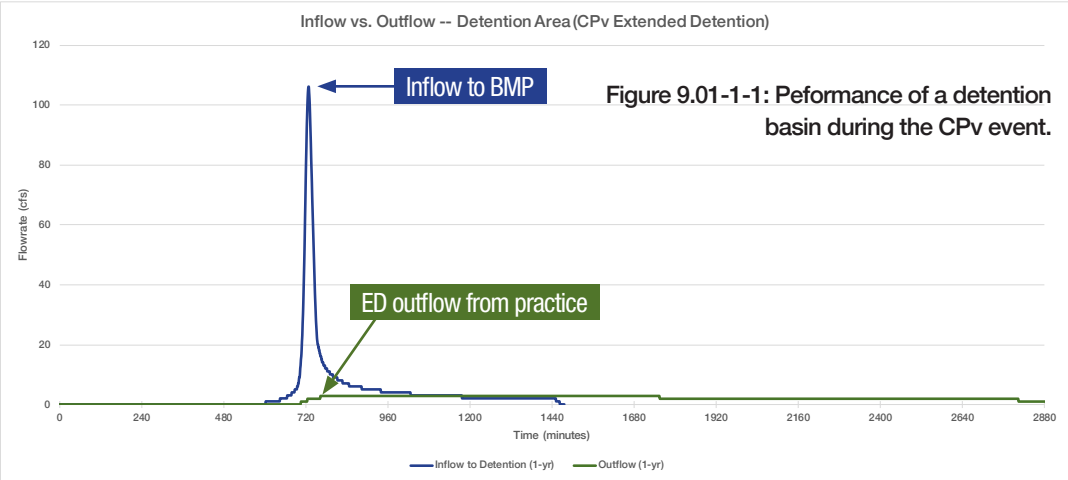


Figure 9.01-1-1: Peformance of a detention basin during the CPv event.

For the 100-year event, outflow is still dramatically reduced from inflow, but not by as large of a percentage.

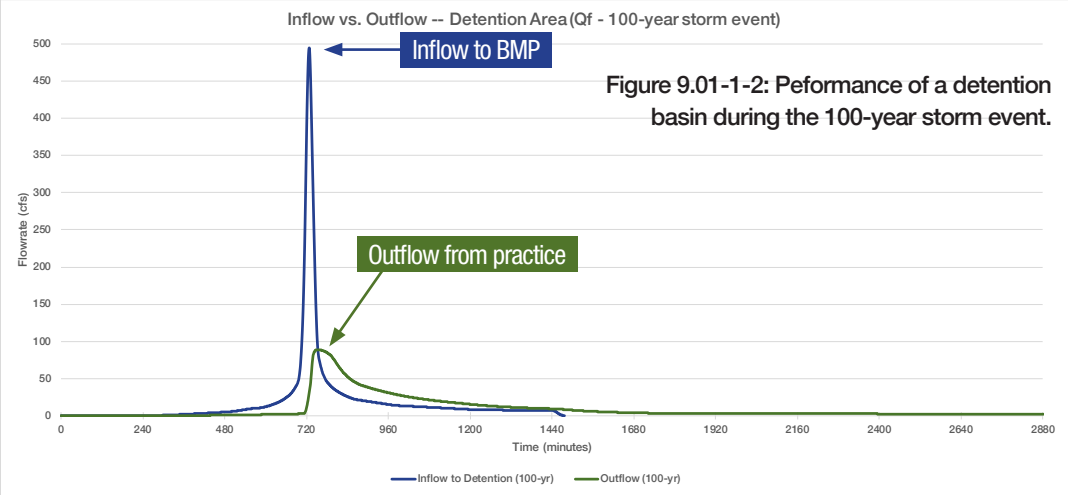


Figure 9.01-1-2: Peformance of a detention basin during the 100-year storm event.

For all storm events, the Unified Sizing Criteria attempts to mimic a more natural peak rate of flow and shape of the outflow curve.

Stormwater detention is most often used in developed, developing or redeveloping areas to counter the effects of land use change on local hydrology. Installation of **impervious surfaces** (roofs, driveways, parking lots, streets, etc.) and soil compaction through grading activities reduce the ability of the land surface to absorb and infiltrate rainfall. This leads to an increase in the frequency and **volume** of runoff created during a rainfall event.

In developed areas, water moves across or through paved surfaces, gutters, storm sewer systems and engineered swales more quickly. As a greater portion of the runoff reaches a given point, this leads to a higher peak rate of flow leaving a given area. **These effects cause the changes in the hydrology of a given watershed area, making higher flow rates and volumes occur more frequently than in pre–project conditions.**

These graphs show the differences in flow rates based on natural (prairie), agricultural and developed conditions (typical suburban development featuring a blend of residential and higher intensity land uses).

Changes are most dramatic for smaller storm events, where peak rates of flow are dramatically increased.

For larger storms, the changes are still very notable, but the rate of increase is less than for smaller storms.

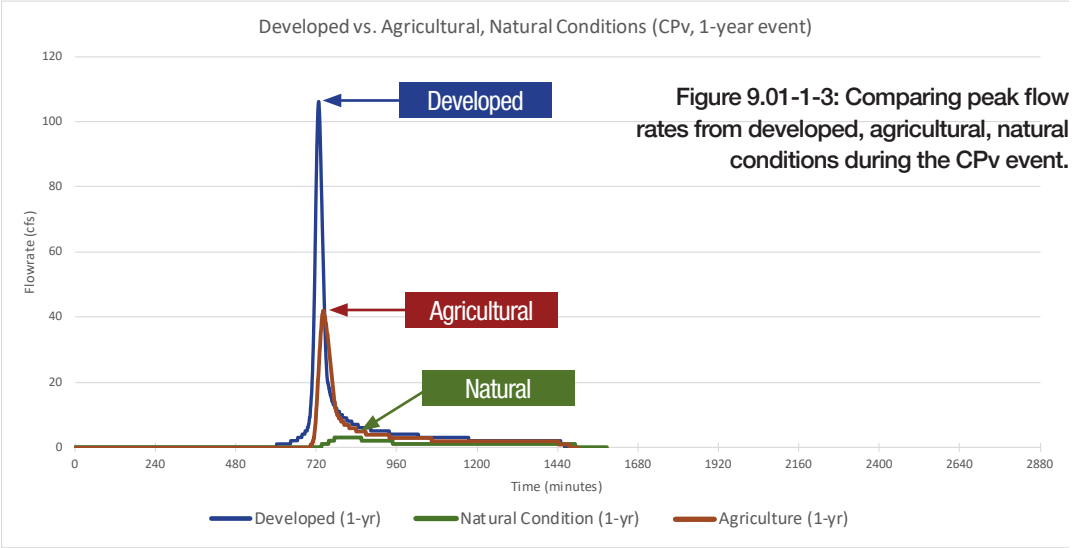


Figure 9.01-1-3: Comparing peak flow rates from developed, agricultural, natural conditions during the CPv event.

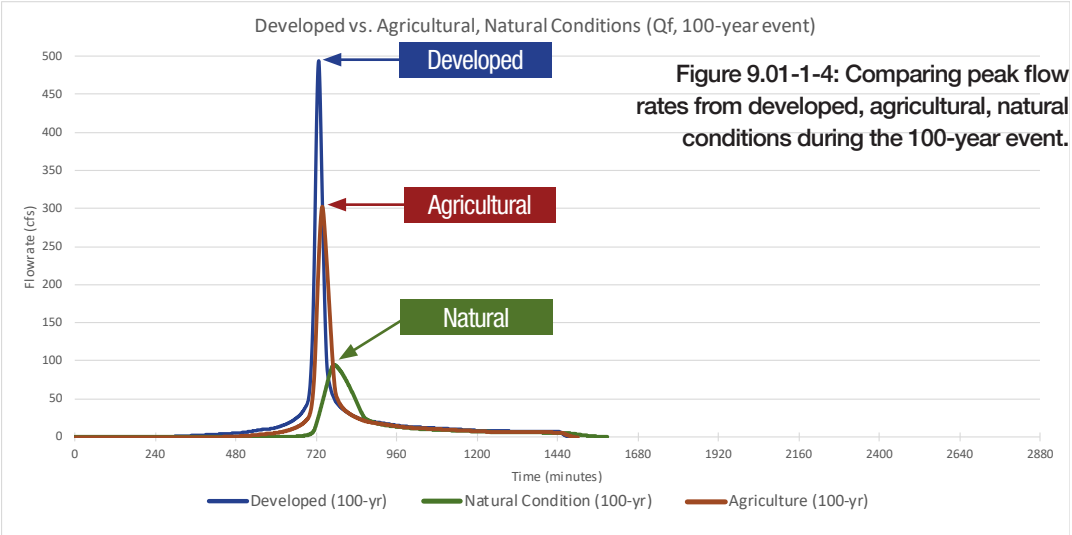


Figure 9.01-1-4: Comparing peak flow rates from developed, agricultural, natural conditions during the 100-year event.

Without stormwater detention, downstream areas can be expected to receive flashy flows more frequently after storm events. This often results in channel erosion and flash flooding which can impact public and private properties and infrastructure. These impacts can lead to further issues related to sediment transport, deposition and poor **water quality**. Addressing channel erosion and infrastructure impacts after they have occurred can be extremely expensive and invasive. These types of repairs often require construction near existing homes, tree removal and often are made more challenging by lack of space for equipment access. For these reasons, it is best to mitigate these effects at the time land use changes are made, to reduce the potential post-project impacts. Each project should include a review of these effects and formulation of a plan to address the need for stormwater detention.

NOTE

Example is for an 80 acre site, changing to a mix of single and multi–family residential land uses.

TABLE 9.01-1.1: EXAMPLE OF RUNOFF VOLUME CHANGES IN A DEVELOPING AREA

			VOLUME					
	TC	CN	1-YEAR		10-YEAR		100-YEAR	
	(MIN)		(CF)	INCREASE	(CF)	INCREASE	(CF)	INCREASE
Natural	95	58	59,000		298,000		898,000	
Agricultural	38	74	221,000	275%	623,000	109%	1,417,000	58%
Developed	22	83	364,000	517%	846,000	184%	1,715,000	91%

TABLE 9.01-1.2: EXAMPLE OF PEAK FLOW RATE CHANGES IN A DEVELOPING AREA

			PEAK FLOW RATE					
	TC	CN	1-YEAR		10-YEAR		100-YEAR	
	(MIN)		(CFS)	INCREASE	(CFS)	INCREASE	(CFS)	INCREASE
Natural	95	58	3		26		95	
Agricultural	38	74	42	1300%	131	404%	303	219%
Developed	22	83	106	3433%	249	858%	494	420%

Impacts in an area without or with inadequate stormwater detention

Photo 9.01-1-1: Example of Streambank and Channel Erosion caused by hydrologic changes in an urbanizing area in Central Iowa

C. GENERAL RELATIONSHIP TO UNIFIED SIZING CRITERIA

The following information is a general overview on how stormwater detention BMPs can be used to address Unified Sizing Criteria (USC) requirements. Refer to the ISWMM Section for each individual practice to see how it can be applied to address aspects of the USC and the details of the design process.

Recharge Volume (Rev)
Recharge Volume is focused on reducing the volume of stormwater surface runoff from a site. It is accomplished by eliminating runoff from the 1" event through the use of practices that reduce, infiltrate, capture, reuse or evaporate water. TARGET

Water Quality Volume (WQv)

The Water Quality Volume is addressed by using best management practices to capture and treat the runoff expected to be generated by the 1.25" rainfall event. Addressing these USC criteria effectively treats runoff from 90% of the rainfall events in Iowa. ESSENTIAL

Some types of detention practices are more effective than others at addressing runoff from the most frequently occurring, small-storm events. Some BMPs selected to provide stormwater detention may need to be paired with other practices to meet any requirements for Rv and WQv.

Channel Protection Volume (CPv)
This criteria reduces the potential for downstream channel erosion by reducing peak outflow rates for a 1-year, 24-hour storm event to more natural levels. This mitigates extreme increases in peak flow rates that would typically be expected from developed sites.

Most detention practices can be used to meet CPv requirements by providing extended detention of this event, with a drawdown period of at least 24 hours. ESSENTIAL

Overbank Flood Protection (Qp) and Extreme Flood Protection (Qf)
These criteria address runoff from larger storm events, up to a 100-year, 24-hour storm event. The goal is to reduce peak runoff rates to mimic natural conditions (or achieve local stormwater management goals). This reduces the potential for storm sewer surcharge, flooding and damage to property and infrastructure downstream of a practice.

Detention practices can be sized to meet these requirements through **temporary storage** of runoff to limit outflow release rates to required levels. ESSENTIAL

Photo 9.01-1-2: Bank erosion caused by detention basin frequently overtopping

NOTE

A brief description of each aspect of the USC is provided here. For more detail on how these are defined and measured, refer to Section 3.01 (Unified Sizing Criteria).

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

TABLE 9.01-1-3: APPLICATION OF BEST MANAGEMENT PRACTICES TO ADDRESS UNIFIED SIZING CRITERIA					
	SMALL STORM			LARGE STORM	
PRACTICE	RV	WQV	CPV	QP	QF
Infiltration Basins	PR	PR	PR	PO	PO
Constructed Stormwater Wetlands	PO	PR	PO	PO	PO
Traditional Dry Detention	NA	NA	NA	PR	PR
Extended Dry Detention	NA	NA	PR	PR	PR
Wet Ponds	PO	PR	PR	PR	PR
Combinations of Water Quality and Quantity Practices	PR	PR	PR	PR	PR
Underground Chamber Systems	AD	AD	PR	PR	PR
Detention Retrofits	AD	AD	AD	AD	AD

PR = Primary Application
PO = Possible Application
AD = May be Adapted to Address
NA = Not Typically Applicable or Little Impact

D. PRE-DESIGN CONSIDERATIONS

Before using this section, and those that follow related to the design of detention practices, the following items should be considered:

- How is stormwater to be managed early in the process of site design? Review drainage patterns. Understand if there is off-site water to be managed. Do the terrain or soils at a given site affect whether a practice is located in a certain part of the site?
- Minimize the need for stormwater management through better site design.
- Are there opportunities to develop a “treatment train” approach, where multiple practices are used in a series to achieve the desired stormwater treatment goals?
- Can the stormwater management practices be located in ways that make them more accessible or aesthetically pleasing? Reducing slopes around the perimeter of a practice, providing paths for access (for public use and maintenance) and selecting, establishing and maintaining desirable vegetation can turn a stormwater management feature into a site amenity.
- How will selected practices be maintained?
  - Who will be the responsible parties for this maintenance?
  - What types of activities will be required?
  - Where will pre-treatment areas be located?
  - What type of maintenance equipment will be necessary?
  - What space will be required to access the site and perform those activities?

E. REFERENCES TO OTHER SECTIONS

This section is intended to be used with other portions of the ISWMM through the planning, practice selection and design process. When planning, designing or reviewing potential stormwater detention practices, users of this manual should refer to these other sections of ISWMM for additional design guidance and information:

Section 1 - Background Information and Reporting

Section 2 - Hydrology

Section 3 - Managing for Water Quality and Quantity

Section 4 - Best Management Practices Overview

Section 5 - Pretreatment Practices

Section 6 - Rainfall Collection and Reuse

Section 7 - Infiltration Best Management Practices

Section 8 - Permeable Pavement Systems

Section 9.02 - Methods to Estimate Required Detention Storage

Section 9.03 - Storage Routing for Final Detention Design

Section 9.04 - Design and Modeling of Outlet Controls

Section 9.05 - Water Balance Calculations

Section 9.06 - Channel Routing

Section 9.07 - Downstream Hydrologic Assessment

Section 9.08 - Stormwater Wetlands

Section 9.09 - Traditional Dry Detention

Section 9.10 - Extended Dry Detention

Section 9.11 - Wet Ponds

Section 9.12 - Detention Retrofits and Hybrid BMPs

Section 9.13 - Underground Chamber Systems

Section 9.14 - Glossary for Detention BMPs

Section 9.15 - References and Resources for Detention BMPs

9.01-2 TYPES OF STORMWATER MANAGEMENT PRACTICES

There are a variety of stormwater BMPs that generally will have sufficient ability to provide temporary storage of runoff that meet stormwater detention requirements. While stormwater for larger storm events has typically been addressed in Iowa through the use of basins and ponds that did not address the increased runoff volume or water quality initiatives, there are a variety of other options that can be considered to collectively meet the objectives of the USC.

A. STORMWATER WETLANDS

Stormwater wetlands are a constructed stormwater management practice that is capable of supporting native wetland vegetation. The wetland is graded in a fashion to maximize the path of flow through a mix of shallow and deep water areas. **Microtopography** (creation of low berms and shallow depressions) can create a "stormwater maze" that forces water to flow along a longer path during most storm events. During larger events, the volume above the wetland is available for temporary detention storage.

Note that stormwater wetlands are designed and constructed for stormwater management. **Existing or natural wetlands should not be used to meet the stormwater management requirements for developing or redeveloping areas.**

Suitable applications of this practice:

- Possible to manage for WQv, CPv, Qp and/or Qf
- Can be integrated into parks and open spaces where a **permanent pool** is desirable and can be used as an amenity or resource
- In **watersheds** of sufficient size and character to maintain the permanent pool
- In areas with high groundwater levels and/or where soils are present that can sustain the permanent pool
- Where ongoing management is planned to maintain the diversity of desired vegetation and control the growth of **invasive species**
- At sites where there is adequate space to include methods of pretreatment, to prevent sedimentation of shallow ponding areas

Figure 9.01-2-1: Illustration of a stormwater wetland

NOTE

Refer to Section 9.08 for more detailed design information

B. TRADITIONAL DRY DETENTION

Dry detention basins are surface depressions created through excavation or construction of a dam where runoff can be captured and held temporarily during large rainfall events. These practices do not include a permanent pool of water. The bottom of the basin is designed with enough slope to provide positive drainage to a pipe outlet or storm inlet structure. The surface is usually stabilized with **native vegetation** or turf grasses. In some cases, swales may be used to direct concentrated flows through the footprint of the basin (from inflow points to the outlet controls). Basins may be designed with flatter areas at higher elevations to serve recreational uses (e.g., playing fields, unprogrammed open spaces, etc.). Such features are usually set so they won't be inundated during a 5-year storm event.

Dry detention basins have been used to manage stormwater for several decades. Historically, these systems have been intended to prevent flash flooding caused by the largest, more infrequent events. These basins, as traditionally designed, often lack features to manage water quality or provide extended detention of CPv. These practices are not expected to achieve pollutant removal at a level considered to be a water quality practice. **When used, traditional dry detention basins will typically need to be paired with other practices to meet local requirements to manage Rv, WQv and CPv.** ADVISORY

Some computational methods used in the past (such as the modified rational method) to size these types of basins may have resulted in these practices having insufficient storage, potentially resulting in overtopping during large rainfall events. (Refer to Section 2.04 for expanded information on this issue). **Designers should review the design of existing traditional dry detention systems when designing new practices downstream.** ADVISORY

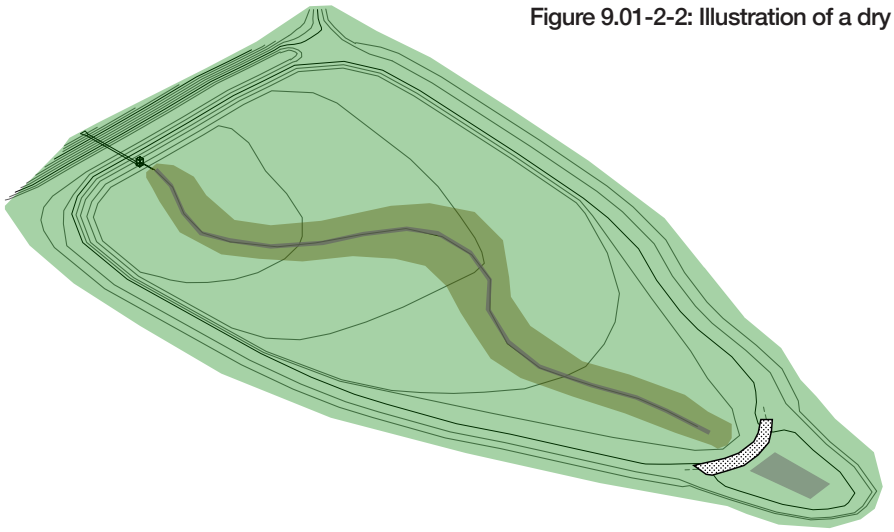
Suitable applications of this practice:

- When management of Rv, WQv and CPv is not required or is managed by other practices
- Where turf grass is preferred
- Where a permanent pool of water is not desired
- Where higher elevations of the basin may be used for athletic fields, trails or other recreational purposes

NOTE

Refer to Section 9.09 for more detailed design information

Figure 9.01-2-2: Illustration of a dry detention basin



C. DRY EXTENDED DETENTION (ED)

Dry detention basins can be adapted to feature a **multi-stage outlet** structure sized to restrict flow to provide an extended drawdown period during a 1-year, 24-hour storm event. This extended drawdown better mimics natural hydrology during smaller storm events, reducing the potential for channel erosion downstream. To provide the minimum 24-hour drawdown of this event, outflow rates will need to be significantly reduced, to better mimic runoff rates from natural conditions (peak rate is often required to be reduced by more than 95% from inflow rates to the basin). Due to more frequent temporary ponding after smaller storm events, these basins often have wetter soils in the bottom surface area. Areas expected to be inundated during the 1-year event are usually stabilized with native perennial vegetation (e.g., native prairie grasses and forbs) which are selected to be sustainable in such moisture conditions.

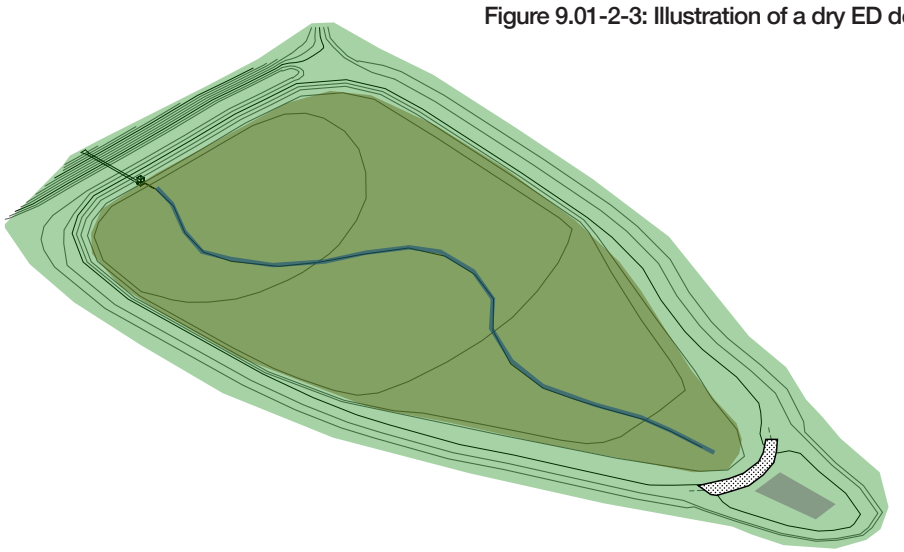
Dry ED basins still lack features that support infiltration, **absorption**, **settling** or other biological processes that raise the quality of outflow runoff to desired levels. Therefore, while dry ED basins may be used to address CPv requirements, it is not recommended to use extended drawdown of the WQv event as a method of providing water quality treatment. **When used, dry ED basins will typically need to be paired with other practices to manage Rv and WQv.** ADVISORY

Suitable applications of this practice:

- When management of Rv and WQv is not required or is managed by other practices
- Where management of CPv or larger storm events is desired
- Where native vegetation is preferred for low-lying areas and ongoing maintenance is planned
- Higher elevations of the basin may be used for athletic fields, trails or other recreational purposes

Dry ED basins should release runoff from small storms over a longer period of time. The bottom surfaces of the basin may remain too wet to effectively mow and maintain turf grass vegetation. A mix of wet mesic and upland native vegetation may be more appropriate to use.

Figure 9.01-2-3: Illustration of a dry ED detention basin



NOTE

The 95% rate reduction mentioned here is merely an estimate used to describe the performance of extended detention. Detailed calculations need to be performed to determine the actual required release rate reductions to achieve extended detention goals.

D. WET DETENTION

Wet detention basins are ponds that support a permanent pool of water. Like dry detention basins, wet ponds have been used as a stormwater detention practice for many years. While historically used to address runoff from larger storm events, their design can be adapted to address smaller storm events. The permanent pool volume may be used to address WQv requirements (to fully address WQv, the pool volume of a wet detention pond must have a volume of at least two times WQv). The temporary storage above the permanent pool may be dedicated to meeting extended detention requirements of the CPv and/or detention of Qp and Qf events. With proper site selection and perimeter grading, these wet detention ponds can be designed to be amenities within public or private open spaces.

Some local jurisdictions have adopted standards requiring WQv to be addressed through infiltration–based practices. In such circumstances, wet detention may not be used to address WQv requirements. ADVISORY

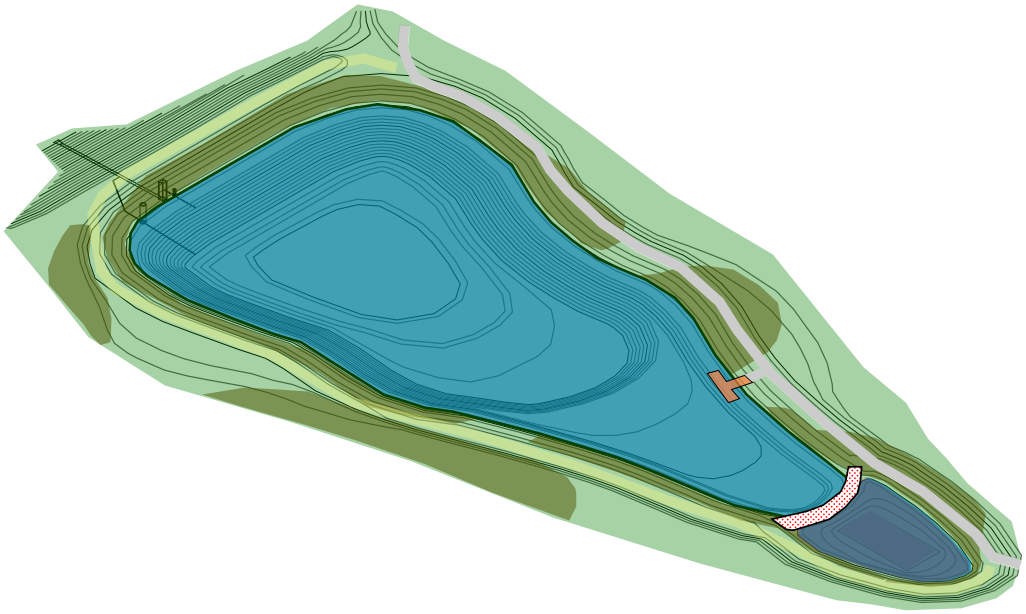
Suitable applications of this practice:

- When management of Rv is not required or is managed by other practices
- Possible to manage for WQv, CPv, Qp and/or Qf
- Within parks and open spaces where a permanent pool is desirable and can be used as an amenity or resource
- In watersheds of sufficient size and character to maintain the permanent pool
- In areas with high groundwater levels and/or where soils are present that can sustain the permanent pool

NOTE

Refer to Section 9.11 for more detailed design information

Figure 9.01-2-4: Illustration of a wet detention pond



E. UNDERGROUND CHAMBER SYSTEMS

Underground chambers are systems of pipes, structures or other devices used to create open volumes below grade that can be used for stormwater detention. **On their own, these systems are similar to dry ED basins, as they lack filtration, settling or methods to provide adequate pollutant removal, to the extent desired, to be used as a stand–alone water quality practice.** ADVISORY

However, an adaptation of these systems could use aggregate layers set below the flowlines of the chambers to infiltrate Rv and/or WQv into the surrounding soils, thereby meeting those requirements. These systems could also be paired with other water quality practices (e.g., a permeable pavement system placed over the chamber system or an upstream bioretention cell) which could be used in combination to address the Rv and WQv requirements.

Suitable applications of this practice:

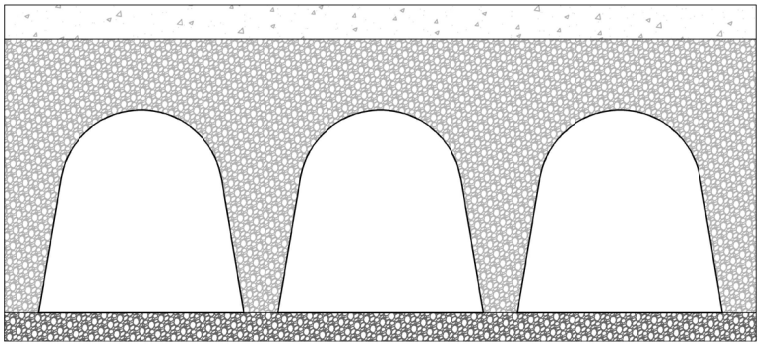
- When management of Rv and WQv is not required or is managed by other practices, or where the system can be adapted to infiltrate these volumes
- The chambers themselves may use an outfall structure featuring a multi-stage design to manage for WQv, CPv, Qp and/or Qf
- Most often used on small sites, redevelopment areas or other locations where there is insufficient open space to meet management requirements above grade
- Where owners have made arrangements for ongoing inspections, removal of sediments and other debris from the underground system, and other maintenance

NOTE

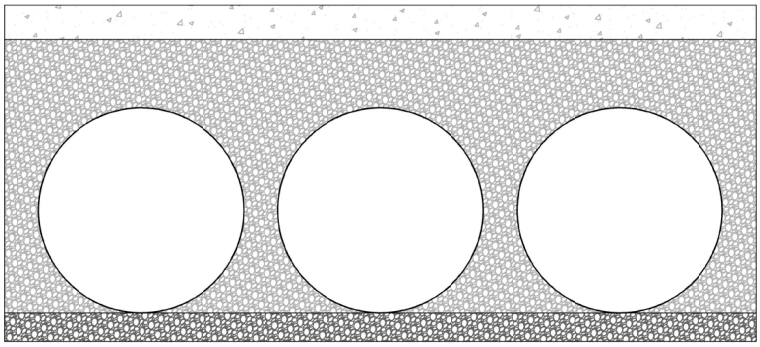
Refer to Section 9.13 for more detailed design information

Figure 9.01-2-5: Illustration of underground chamber systems

STORMWATER CHAMBERS



CMP PIPES



F. HYBRIDS AND STORMWATER RETROFITS

Hybrid systems combine water quality practices with detention practices to meet more of the USC requirements than either practice might be able to achieve as a standalone feature. Water quality practices might be nested within a detention basin or placed upstream of the detention facility. While this can be done, proper planning and design should be done to reduce the potential for compaction of soils or erosion within the water quality practice due to deep or frequent ponding and high-velocity flows.

A few examples of many potential hybrid system applications:

- Bioretention cells on smaller sites with sufficient storage above the footprint to provide detention of larger events
- Bioretention cells or bioswales nested within a larger regional dry ED basin
- Permeable paver systems placed above an underground chamber system
- Green roofs and bioretention cells placed above a traditional dry detention basin
- Underground chamber systems with aggregate storage infiltration layer

Stormwater retrofits will most often be an adaptation of existing dry or wet detention practices to better address aspects of the USC. In some cases, this could involve installing multi-stage outlet structures so that small storms are better managed. Other adaptations may involve conversion of one type of practice into another to more broadly address USC requirements. At some locations, detention areas that were designed with past methods, which appear to have insufficient storage to adequately manage large events, could be adapted to primarily address WQv and/or CPv. In any case, these designs would need to consider the expected changes during both small and large storm events, to ensure that such conversions would not negatively impact surrounding and/or downstream properties.

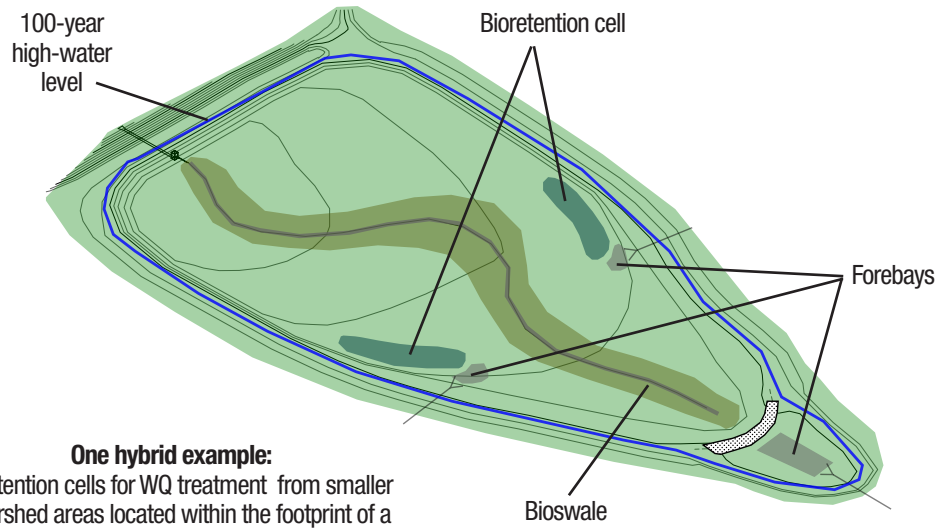
A few examples of many potential stormwater retrofit applications:

- Multi-stage outlet structure retrofits
- Conversion of undersized detention basins into bioretention cells
- Conversion of traditional dry detention systems into wet detention or constructed stormwater wetlands

NOTE

Refer to Section 9.12 for more detailed design information

Figure 9.01-2-6: An example of water quality BMPs placed inside of a dry ED detention basin



One hybrid example:
Bioretention cells for WQ treatment from smaller watershed areas located within the footprint of a dry detention basin serving a larger area

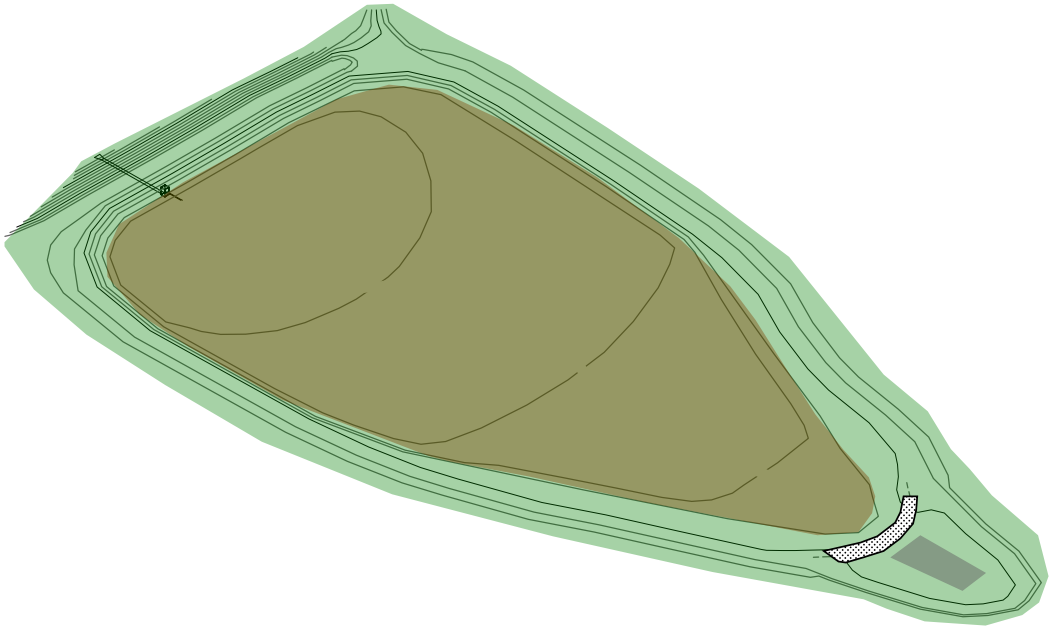
G. INFILTRATION BASINS

Infiltration basins are designed to have a large, flat-bottom surface area, constructed within soils with high permeability or where infiltration potential is improved through installation of amended soils. The basin slope is graded fairly flat to increase retention time and absorption rates. Infiltration basins may serve detention functions to reduce runoff rates to downstream areas. However, as they are categorized as an infiltration-based BMP, details of their design are addressed in other sections of ISWMM.

Suitable applications of this practice:

- Where existing or engineered soils have the capacity to infiltrate the desired volume of runoff
- Where turf grass or native vegetation is preferred
- Where a permanent pool of water is not desired

Figure 9.01-2-6: Illustration of an infiltration basin



NOTE

Refer to Section 7.09 for more detailed design information

9.01-3 PLANNING CONSIDERATIONS

Too often, designers jump into sizing and design before considering the purpose of a practice and how it can be best implemented to achieve the desired goals. The following categories should be reviewed early in the planning and site selection process.

A. DEFINE PRACTICE GOALS AND OBJECTIVES

Before selecting the type of practice at a given location, designers should review the goals and objectives this practice is expected to achieve.

Key questions to address:

- What aspect(s) of the USC is the new practice expected to achieve?
  - Managing for water quality, **quantity** or both?
  - Will this practice achieve USC management goals on its own or is it designed to be one of a series of practices to meet those goals?
  - Are there site-specific reasons that management beyond USC requirements is required?
    - » Are there reasons why certain aspects of the USC are exempted?
- Is there a local watershed plan (or other watershed goals) that should be considered in the design process?
- Is public or private recreational access desired as part of this facility?
- What level of maintenance will be required to achieve the desired objectives?
- Are there ways to pick or design a practice that has multiple benefits?

NOTE

This may seem obvious, but there have been cases where designers have focused too early on using a specific practice at a certain site. This can lead to designing a practice that by its nature or the site area available, is not able to efficiently address the aspects of the USC that would be most critical at that location.

B. SITE/DEVELOPMENT SCALE VS. REGIONAL MANAGEMENT

Detention practices can be designed to manage runoff from an individual site or a common plan of development. This is referred to as Site or Development Scale. Detention areas can also serve larger areas, managing runoff from multiple developments or tracts of land.

NOTE

An extensive discussion of Site/Development vs. Regional stormwater management and the benefits and challenges of the scale of the practice and its ownership of best management practices is included in the Unified Sizing Criteria Section, 3.01.

C. PUBLIC OR PRIVATE OWNERSHIP

Determining if a detention practice is to be publicly or privately owned is often related to whether the practice is intended to manage runoff from an individual site or serve a larger regional purpose. Site-/development-scale practices are most frequently owned and maintained by private property owners or a homeowners association. One exception to this arrangement could be if the local jurisdiction determines that a detention area could be successfully integrated into the design of a publicly owned park or open space within or adjacent to the development area being treated.

Ownership and maintenance of regional detention areas is typically beyond the responsibility of an individual property owner. Either a private group will be established that is financially supported by multiple property owners (like a home owner's association) or the local jurisdiction will take on these responsibilities.

NOTE

Local jurisdictions are not required to accept such an arrangement. It is just noted here as an option that might be considered in certain situations.

Key questions to address:

- Will the detention facility be used to manage runoff from an individual site or development, or will it serve a larger watershed area?
- Does a local jurisdiction have any additional requirements to address?
- Who will own and maintain the facility after it is constructed?
  - Is the site to be located within a public park or other open space which may be accessible to the public?
  - What is the vision for maintenance and management of this area?
    - » What entity will be responsible for carrying these out?
    - » What access paths need to be reserved for future equipment access?

D. SERVICE AREA OF THE PRACTICE

To properly design a practice, the watershed it serves and its properties (impervious cover, soil types, etc.) need to be understood. It also needs to be defined whether other areas that would drain to a BMP are considered to be beyond the responsibility of the entity constructing the practice.

Key questions to address:

- For what area is the proposed BMP responsible for meeting the various USC requirements?
- Are there stormwater flows entering the proposed BMP from areas upstream of the area of responsibility?
  - How is stormwater managed in these areas?
  - How do these conditions affect the design of the proposed BMP?
- What are the properties of the service area (and other upstream areas)?
  - What is the total watershed (or subwatershed) size?
  - What soil types are present in the area?
  - How much impervious cover is expected when all areas are fully developed?

As part of this analysis, a detailed watershed map should be created that defines watershed and subwatershed areas to be used in stormwater models. A refined version of this map should be included with the final stormwater management plan for the given project.

E. SITE LOCATION AND PROPERTIES

The characteristics of the land within and around potential locations for stormwater practices will influence what type of practice should be selected at a given site and its ultimate design.

- What other land uses are proposed within, around and upstream of the proposed practice area?
- What land uses exist or are proposed downstream?
- Is additional development or redevelopment planned upstream of the proposed practice area?
- What are the timelines for local developments or other land use changes?
  - How are these related to the expected timeline of construction of the proposed BMP?
- What are the slopes and existing surface conditions in and around the project area?
- Are there wetlands, habitat or other resources that are located within or near the project area?
- Is the project located near a stream or along (or within) an area subject to flooding? Is the practice to be located within an area of flood risk, based on FEMA Flood Insurance Rate Maps?

NOTE

Refer to Section 3.01 for more information about the Stormwater Management Plan

- What type of vegetation is desired within and around the practice?
- Have preliminary estimates of required stormwater storage volume been developed (see Section 9.02)? The estimate procedure can be used to determine the potential area that will need to be devoted to stormwater management.

F. PUBLIC ACCESS AND AESTHETICS

Some detention practices, such as wet ponds and stormwater wetlands, can be constructed as central features within parks or other open spaces. Similarly, dry detention and ED basins can be constructed to provide spaces for recreation and native planting restorations. These areas can be made accessible to the public through trails and walking paths. **The general public may simply see the pond where they fish, the natural area where they birdwatch or the field where they play—without fully realizing that these areas are serving a stormwater management function.** Implementing stormwater management facilities in ways that serve a function beyond managing water quality and quantity is always encouraged.

Careful planning is required during grading design and site selection to create a surface that is approachable and usable by the public. Use of steep slopes around the perimeter of these facilities may reduce the potential for public access and negatively impact the aesthetics of their design. These concepts are explored in greater detail in the sections related to each type of practice. ADVISORY

G. ESTABLISHING DESIRED VEGETATION AND MAINTENANCE

The desired permanent vegetation will vary based on practice type. **Seed and plant materials should be carefully selected based on expected levels of sunlight and soil moisture conditions.** A "one mix fits all" approach will likely be unsuccessful). Plans should identify various zones within and around the practice where various seed mixes or plant materials are to be located. Proper staging and scheduling will be required to make sure that permanent vegetation is delayed until after (or protected from disturbance during) the construction period.

Various activities are required during the first few growing seasons to establish desired vegetation. After that, more routine maintenance is necessary to control weeds, make repairs and maintain plant diversity and aesthetics. Providing adequate space for equipment to access and move around each practice should be considered early in the practice selection process, and will go a long way toward reducing growth of invasive and aggressive species.

H. ONLINE VERSUS OFFLINE SYSTEMS

Detention systems are typically constructed in an "online" configuration—all runoff generated from a given area will pass through the practice. In some cases, a detention area may be constructed "offline." For example, if a dry ED basin is primarily designed to manage runoff from the CPv event, systems may be designed to allow flow from larger events to bypass that facility entirely. Another style of offline configuration is applicable to sites that have a waterway or swale passing through which has a larger watershed area. In such a case, practices designed to treat runoff from smaller areas may be installed on either side of the drainageway so that the flows from the larger watershed aren't required to pass through those practices.

The first type of offline systems described may require designing a diversion structure to direct low flows to the BMP, but allow larger flows to bypass. Details on how to design and size these types of diversion structures can be found in Section 7.07.

I. DISCOURAGED DESIGN APPROACHES

The following design practices reduce the ability of stormwater detention systems to address runoff quality and quantity from small storm events. **Stormwater management practices should be designed to avoid these types of practices:**

1. Passive detention systems.

These systems direct captured runoff through a storm sewer network to the outlet from the site. At that point, a restriction such as an orifice plate is placed, which causes water to surcharge and back up out of an intake into a surface depression for temporary storage during large storm events. **This design method allows runoff from smaller storm events to leave the site directly, without the opportunity to reduce runoff volumes or remove suspended pollutants and debris.** ADVISORY

At this site, stormwater usually bypasses the surface of the detention area. Flow goes down through the intake in the parking area and connects to the larger intake by storm sewer below grade. Water only enters the basin when the downstream pipe capacity is reached, allowing the water to "back up" or surcharge into the basin above.

Photo 9.01-3-1: Passive Detention System Example

Passive detention systems could be used in applications where a practice is only needed to provide temporary detention of large storm events (small storm/water quality considerations are being addressed by other practices).

Photo 9.01-3-2: Example of passive detention at Sunset Park in Denver, Colorado (photo credit Google Maps)

NOTE

At this site, water flow from the parking area enters this inlet and flows below ground to the basin outlet where a restriction to control large storm events has been placed.

Since most flow bypasses the surface of the basin, there is little opportunity for flow volume reduction or to capture and filter pollutants before they are piped downstream.

2. Low-flow flumes and directly connected impervious areas.

These systems prevent infiltration of stormwater runoff and reduce or eliminate the possibility of providing water quality treatment or small–storm management. Virtually any storm event will direct surface runoff from paved areas to the receiving storm sewer system or stream. ADVISORY

In this detention area, concrete flumes convey water between storm sewer segments. There is no area for filtration or absorption of runoff during small events. Flumes can often crack and heave, causing maintenance issues. In this picture, lawn clippings, sediment and algal growth can be seen. Sections of concrete with algal growth can be very slippery, leading to safety concerns

Photo 9.01-3-3: Low-Flow Flume Example

The concrete flumes at this location do not allow for any filtration or infiltration of runoff.

In addition, they make it very easy for lawn clippings and other debris to be washed downstream.

In some conditions, algae growth can make the surface of the flume very slippery.

3. Flow path shortcutting.

When runoff enters a basin or treatment practice at nearly the same point where it outlets from the practice, the opportunity for absorption, infiltration or treatment of stormwater runoff is severely reduced. For this reason, it is recommended that stormwater runoff enter a basin or other treatment practice as far from the outlet as possible. **Pipe outlets, flumes or other points of concentrated stormwater flows should enter a treatment practice or basin at a distance from the outlet of no less than twice the width of the practice,** if feasible (a pipe entering a 30' wide detention basin should be located no closer than 60' from the point where water would leave the treatment area). ADVISORY

Water leaves a parking area through a curb opening and directly enters the storm inlet that collects runoff from the detention area. Runoff does not have to flow across any length of permeable surfaces, which would have allowed for filtration and absorption (see Photo 9.01-3-4, next page).

At this site, flow from a parking area bypasses the detention area that is to the left of the outlet structure and is directed directly into the structure.

This reduces opportunities for infiltration of runoff or filtration of pollutants.

Photo 9.01-3-4: Flow path shortcutting

4. Lack of early planning or practices with insufficient space.

As noted previously, proper space is required for access and to achieve desired aesthetics, potentially creating site amenities from stormwater practices. **However, when stormwater management is not considered early enough in the design process, practices are often crammed into spaces that are too small.** This makes proper access for maintenance difficult, creates barriers for public use and can turn stormwater management areas into a visual liability. ADVISORY

Photo 9.01-3-5: Retaining walls are used at this site to maximize storage within a smaller footprint. The presence of the walls limits access and makes maintenance more difficult.

IOWA STORM WATER MANAGEMENT MANUAL

9.02 METHODS TO ESTIMATE REQUIRED DETENTION STORAGE

IOWA DEPARTMENT OF NATURAL RESOURCES

TABLE OF CONTENTS

CONTENTS

9.02-1 INTRODUCTION 2

9.02-2 PARAMETERS REQUIRED TO ESTIMATE STORAGE 3

9.02-3 ESTIMATING STORAGE REQUIRED 4

A. Design Procedure 4

B. Dead vs. Live Storage..... 6

9.02-4 ESTIMATION PROCEDURE EXAMPLE 7

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

9.02-1 INTRODUCTION

This section includes a procedure to develop preliminary estimates of the amount of storage that will be required to meet desired flow rate reductions through a stormwater detention practice. This can be used by the designer to determine the minimum area needed to provide the estimated storage volume within a reasonable depth for certain events.

It is strongly encouraged that this procedure be completed early in the design process. Many times, practices have been proposed that are unable to meet all aspects of the Unified Sizing Criteria (USC) because insufficient space had been dedicated. In other cases, practices have been installed with steeper side slopes or with greater ponding depths to "squeeze in" a practice that meets the USC goals. This can complicate establishment and maintenance of desired vegetation, make the practice less suitable for public access and reduce the potential to create a valuable resource and amenity out of the site.

Completing this simple method early in the evaluation process can start off the site selection process with a better understanding of the area that should be dedicated—and could reduce the potential for more expensive redesign time later in the process.

9.02-2 PARAMETERS REQUIRED TO ESTIMATE STORAGE

Three design parameters are needed to use the methods described in this section to estimate the required detention storage needed to meet project goals. These are (1) the **allowable outflow release rate** from the practice, (2) the expected **inflow rate** to the practice and (3) the expected **inflow volume** to the practice. If these flow rates are known, a simple method can be used (best incorporated into a spreadsheet) to calculate an estimate of required storage.

A. Events to be Studied

To develop required storage volume estimates to comply with stormwater management guidelines for the entire spectrum of events, the flow information for the following events should be calculated:

- Channel protection event (1-year storm)
- 2-year storm
- 5-year storm
- 10-year storm
- 25-year storm
- 50-year storm
- 100-year storm

B. Allowable Release Rate from Practice

If a stormwater detention basin is being designed to meet the stormwater management needs for the entire watershed area it receives, then solving for the allowable release rate is easier to define. Under these circumstances, follow the guidance below:

1. **Channel protection volume (1–year event):** The allowable release rate is determined by calculations required to provide extended, 24-hour detention of the runoff from this event. Refer to Section 3.02 for details on how to calculate this allowable release rate.

2. **All larger storm events:** The allowable release rate should be the smaller of the these values:

   – The natural condition for a similar storm event (meadow in good condition, similar soil type(?), Tc for natural conditions).

   – The peak flow anticipated to be generated by the 5-year storm event under existing conditions (current at time of design) - requirement may be waived by the local jurisdiction.

Calculations to determine rates and volumes of runoff above typically use the TR-55 method. Refer to Sections 2.05 and 3.01 for additional information.

If the detention area is not expected to meet the stormwater management requirements for the entire area from which it receives runoff (e.g., if a new development receives runoff from an undeveloped adjacent property or an upstream developed area that was built without adequate detention), calculating the allowable release rate is more complicated. Refer to Section 3.01-5 for information on calculating stormwater management release rate requirements in such special cases. The local jurisdiction may also set standards for specific areas to deal with such circumstances.

C. Expected Inflow Rates and Volumes to Practice

Follow guidance in Sections 2.05 and 9.03 to calculate the expected peak flow rates and volumes for each event to be studied. These flow rates should be based on the fully developed conditions for the watershed area that is intended to be served by the practice. Additional analyses may be required in special cases, as described within Section 3.01-5.

9.02-3 ESTIMATING STORAGE REQUIRED

A. DESIGN PROCEDURE

The following procedure can be used to **estimate** the storage volume that will be needed to reduce outflow from a given basin to allowable levels. These storage volume estimates are not intended to be a final value of the storage required for any given event. Compliance with USC related to stormwater detention is based the final design achieving the desired flow rate reductions, not whether a set volume of storage is provided.

However, using the following procedure can quickly give a designer a close approximation of the volume that will be necessary to meet the flow rate reduction requirements of the USC, as applied to a given site by the local jurisdiction. The estimated volume can approximate the required area to be dedicated for stormwater detention. If used early in the design process, an appropriate area for management practices can be set aside and proposed improvements can be planned around that area.

1. For each watershed area or subarea which is expected to drain to the proposed detention area, **calculate the NRCS curve number and time of concentration** for a given watershed or subwatershed. Do this for three conditions: **natural, existing and proposed.** For **urbanized areas**, curve number selection should be based on impervious cover and open space conditions and not selected from a table based on a typical land use. Refer to Section 2.03 and 2.05 for details.
2. **Identify rainfall data values** for the storm events to be analyzed. Select values based on one of the nine regions of the state that the project site is located within. Refer to Section 2.02.
3. Create **TR–55 models for the natural, existing and proposed conditions.** Use a time step analysis interval of 1-minute, when possible. For each event, review the peak flow and volume information for the hydrograph that is entering the detention area to be sized.

From these models, for each event, the following information will be required to complete the estimation procedure:

Output data:

- Peak rate of flow (cfs)
- Total runoff volume (cf)

Software packages may give results for runoff volume in **watershed-inches**, **acre-feet** or **cubic feet**. Note the required conversions for desired volume measurement.

Document the above for each of the following conditions:

- Natural condition (used to establish allowable release rate)
- Existing condition (used to establish allowable release rate, in some circumstances)
- Proposed condition

From this output, **the allowable release rate will need to be determined for each event.** Methods to determine the allowable release rate for a given location is described in detail in Section 3.01. **To determine the allowable release rate for CPv, refer to the procedure in Section 3.02.**

NOTE

This procedure uses similar computational methods to those described in Section 3.02 to estimate requirements for storage of the Channel Protection Volume.

NOTE

If modeling the WQv event is required, use an adjusted Curve Number, as described within Section 2.03.

NOTE

Most software programs running the TR–55 calculation methods can use this time step interval. However, the original Win–TR20 and Win–TR55 software packages are limited to a 0.1 hour (6–minute) interval. It is not recommended to use software with such limitations for watersheds less than 20 acres in size, as the true peak flow rate may occur in between the larger time intervals, resulting in an underestimation of flow.

4. For each event, use Equation 9.02-3-1, Storage volume/Runoff volume relationship, based on outflow/inflow ratio, to **solve for the estimated ratio** of detention storage required compared to the runoff volume from the study area during the storm event (Vs/Vr).

Where: qo = allowable release rate (cfs)

qi = inflow rate to basin, proposed condition (cfs)

Vs = required storage volume (cf, unknown variable at current step)

Vr = total runoff volume to basin (cf)

Equation 9.02-3-1: Storage volume/Runoff volume relationship, based on outflow/inflow ratio

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

5. **Multiply Vr by the (Vs/Vr) ratio calculated in Step 4** to solve for the estimated detention storage volume required (Vs). These formulas can be incorporated into a spreadsheet in a format similar to the one shown below, so that the estimated volume is calculated once peak flow rate and volume data is entered. It is recommended to add 10–15% to these values, as use of extended detention to manage CPv may result in a slight increase in storage needed in final design for larger events.

Figure 9.02-3-1: Example of a spreadsheet used to estimate storage.

Initial Storage Estimation

Storm Event	qo cfs	qi cfs	qo/qi	Vs/Vr	Vr CF	Vs CF	Vs *1.15 CF
1	3.2	106	0.03	0.642	364,000	233,526	268,600
2	6.3	136	0.05	0.620	463,000	287,151	330,200
5	15.1	193	0.08	0.581	655,000	380,406	437,500
10	26.4	249	0.11	0.549	846,000	464,338	534,000
25	48.1	336	0.14	0.510	1,150,000	585,970	673,900
50	69.9	412	0.17	0.484	1,420,000	686,806	789,800
100	94.8	494	0.19	0.463	1,710,000	792,231	911,100

At this point, the preliminary storage volume for each event to be addressed by the detention practice is known. This can be used by the planner or designer to set aside a proper area for the BMP. When doing this, refer the specific ISWMM section dedicated to each practice to identify the recommended temporary ponding depths for each storm event.

Once the proper space has been reserved, more detailed grading plans can be developed of the detention area. This will lead to development of stage-storage relationships that will be used in final basin routing to determine expected performance.

NOTE

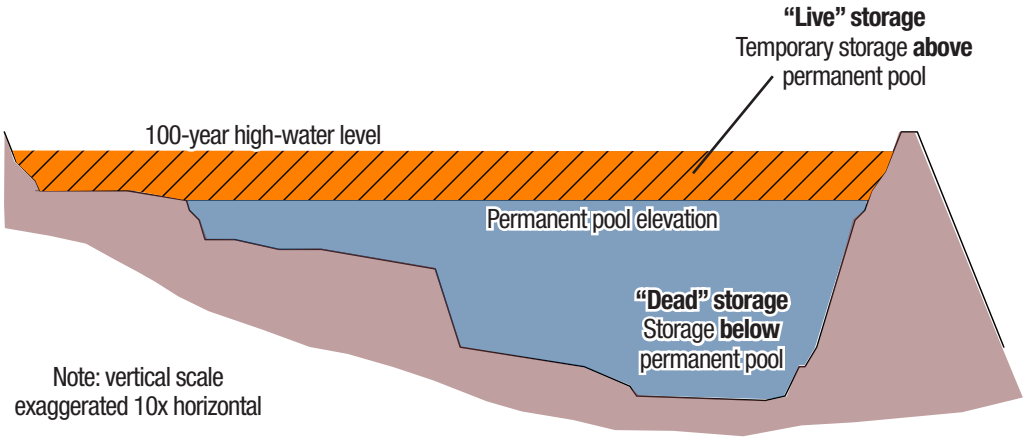
This value is not the final storage volume required. This is an initial estimate to allow the designer to locate a storage area on site with the approximate volume expected to be required.

NOTE

"Dead storage" may be used to address WQv requirements. Refer to the sections for each individual practice for requirements or more information.

B. DEAD VS. LIVE STORAGE

When estimating storage and performing final routing, it should be noted that these calculated values represent the volume available for temporary storage. This is the volume within the basin above any permanent pool or ground surface within the footprint of the basin. Space occupied by water below the normal pool of a pond or wetland is not available for use as temporary storage during a flood event. This is sometimes referred to as "dead storage". These volumes should not be counted toward the volume being used for detention. Essentially, when estimating or performing detention routing calculations, this dead storage should be ignored. The unoccupied space above the pool or bottom of the basin is the volume available for use as detention. This is referred to as "live storage" as it will only be occupied for a period of time after the storm event has passed.



9.02-4 ESTIMATION PROCEDURE EXAMPLE

Example Calculation for Preliminary Storage Estimate

1. **Calculate the NRCS Curve Number and Time of Concentration for each given watershed area; do this for natural (pre–settlement), existing, and proposed conditions.**

Use the TR-55 methods for selecting a curve number and calculating time of concentration for each watershed area.

TABLE 9.02-4.1: CURVE NUMBER AND TIME OF CONCENTRATION

SUBWATER-SHED ID	LAND USE*	AREA (ACRES)	% IMPERVIOUS	CURVE NUMBER			TIME OF CONCENTRATION (MIN)		
				NATURAL	EXISTING	PROPOSED	NATURAL	EXISTING	PROPOSED
1	C	11	73	58	78	92	40.3	18.7	8.2
2	C	9	73	58	78	92	37.2	17.3	7.6
3	M	15	65	58	78	85	45.6	21.2	12.2
4	S	25	43	58	78	75	56.0	26.0	20.5
5	S	20	73	58	78	75	51.2	23.8	18.8

* C= Commercial; M = Multi-family; S = Single-family

2. **Identify rainfall data values for the storm events to be analyzed.**

For this example, the site is in Primghar, Iowa. Use the Section 1 (Northwest Iowa) rainfall data for the 24-hour storm:

TABLE 9.02-4.2: 24-HR STORM

RETURN PERIOD	RAINFALL DEPTH (IN)
1-yr	2.51
2-yr	2.92
5-yr	3.67
10-yr	4.39
25-yr	5.50
50-yr	6.46
100-yr	7.50

3. **Create a TR–55 model for the natural, existing, and proposed conditions. For each storm event, collect the peak rate of flow (cfs) and total runoff volume (cf).**

For this example, Hydraflow Hydrographs 2019 was used to model the inflows using the CN and Tc form step 2.

NOTE

Total site area = 80 acres

TABLE 9.02-4.3: RUNOFF FLOW RATES AND VOLUMES FROM TR-55 MODEL OF NATURAL, EXISTING, AND DEVELOPED CONDITIONS							
		NATURAL		EXISTING		DEVELOPED	
STORM EVENT	RAINFALL (IN)	PEAK RATE (CFS)	VOLUME (CF)	PEAK RATE (CFS)	VOLUME (CF)	PEAK RATE (CFS)	VOLUME (CF)
1	2.51	2.1	39,469	62	231,383	98	291,890
2	2.92	5.7	72,301	86	312,296	127	378,428
5	3.67	17	151,712	135	474,094	183	547,995
10	4.39	33	247,189	184	641,449	239	720,598
25	5.50	65	422,842	263	914,860	329	999,301
50	6.46	97	596,265	333	1,161,569	408	1,248,756
100	7.50	135	801,389	410	1,436,144	494	1,525,034

4. **For each event, use the peak flows (qi) and runoff volumes (Vr) in Equation 9.02–3–1 to solve for the estimated ratio, Vs/Vr, of detention storage required compared to the runoff entering the basin.**

In this example, a local ordinance requires detaining so that the outflow (qo) is the minimum of the natural flow rate and the existing 5-year flow rate. The values for the 10-year event are shown explicitly; Table 9.02-4.4 summarizes only the calculation results.

The allowable 10-year outflow for the basin is the minimum of the 10-year natural peak flow (33 cfs) and the 5-year existing conditions (135 cfs). Use the 10-year natural conditions (33 cfs) for qo. The proposed inflow under fully developed conditions is 239 cfs.

$$\left(\frac{qo}{qi}\right) = \frac{33}{239}$$

$$\left(\frac{qo}{qi}\right) = 0.14$$

10	4.39	33.30	247,189	183.6	641,449	239.4	720,598

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

$$\left(\frac{Vs}{Vr}\right) = 0.683 - 1.43\left(0.14\right) + 1.64\left(0.14\right)^2 - 0.804\left(0.14\right)^3$$

Vs/Vr = 0.514

It shoiuld be noted that the outflow rate for the CPv event is calculated using the procedure shown in Section 3.02.

First, convert the runoff VOLUME for the developed condition to watershed-inches:

Qa = VOLUME (CF) x 12 (inches/foot) ÷ (AREA (acres) x 43,560 (SF/AC))

Qa = 291,890 CF x 12 ÷ (80 ac x 43,560)

Qa = 1.01 watershed-inches

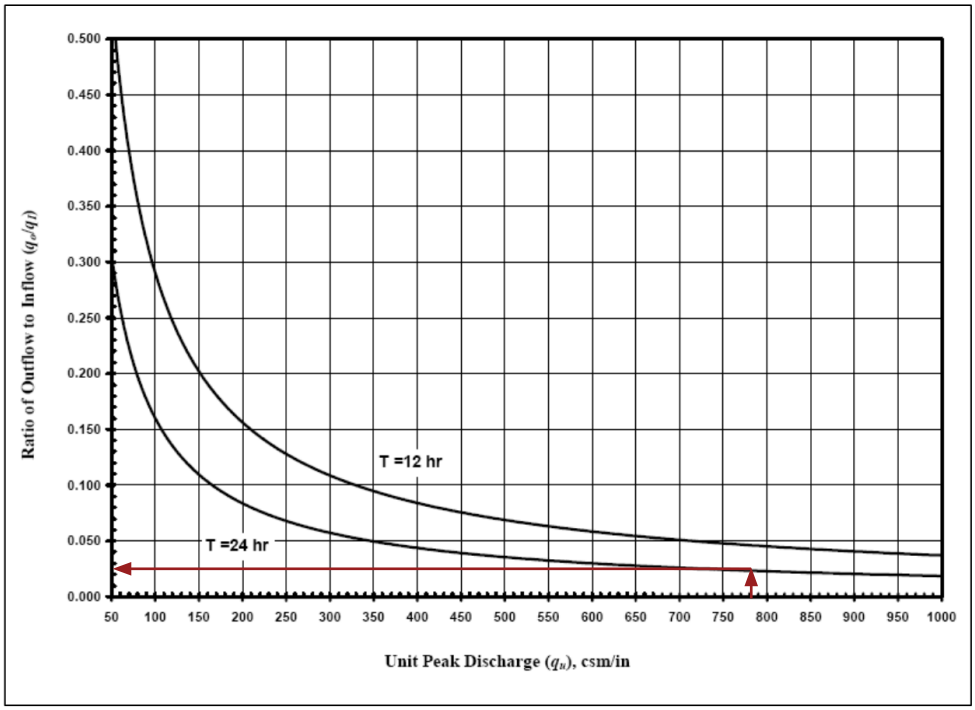
Second, calculate the unit peak discharge rate (qu)

qu = PEAK RATE (cfs) x 640 (acres/mi2) ÷ (Area (acres) x Qa (watershed-inches)

qu = 98.1[1] cfs x 640 (acres/mi2) ÷ (80 acres x 1.01 wtr-in)

qu = 781 (cfs x mi2 / inch or csm/in)

Third, use the chart from Section 3.02 to determine the OUTFLOW to INFLOW RATIO (qo/qi):



For qu = 781 csm/in, qo/qi = 0.025[2]

Finally, multiply the INFLOW RATE to the BMP by the qo/qi RATIO to solve for the allowable outflow rate:

qo (cfs) = qi (cfs) x (qo/qi)

qo = 98.1 cfs x 0.025

qo = 2.5 cfs

1. The PEAK RATE of 98.1 cfs is the developed flow to the practice, during a 1-year storm event. (See the table example on the previous page.)
2. In this example, the peak allowable rate of flow to provide extended detention of the Channel Protection event is slightly larger than the peak rate of flow calculated for natural site conditions (2.1 cfs -- see table on previous page).

TABLE 9.02-4.4: USING INFLOW AND ALLOWABLE OUTFLOW RATES TO DETERMINE VS/VR RATIO				
STORM EVENT	QO (CFS)	QI (CFS)	QO/QI	VS/VR
1	2.5	98	0.025	0.648
2	5.7	127	0.04	0.622
5	17.3	183	0.09	0.562
10	33.3	239	0.14	0.514
25	64.9	329	0.20	0.458
50	96.8	408	0.24	0.425
100	134.5	494	0.27	0.399

5. **Multiply Vr by the Vs/Vr ratio obtained in step 4 by the storage volume, Vs, obtained in step 3. Add 15% to accommodate extended detention needs and provide flexibility in spatial planning.**

For example, the runoff volume proposed for the 10-year event under developed conditions is 720,598 cf.

$$\left(\frac{Vs}{Vr}\right) \times Vr = Vs$$

$$0.514 \times 720{,}598 = 370{,}141$$

Add 15% to accommodate extended detention needs and provide flexibility in spatial planning:

$$Vs \times 1.15 = 370{,}141 \times 1.15$$

$$Vs = 425{,}700 \text{ cf}$$

Table 9.02-4.5 includes the results of similar calculations for other storm events.

TABLE 9.02-4.5: USING VS/VR RATIO AND CALCULATED RUNOFF VOLUMES TO ESTIMATE STORAGE VOLUME, VS				
STORM EVENT	VR (CF)	VS/VR (CF)	VS (CF)	VS X 1.15 (CF)
1-yr	291,890	0.648	189,221	217,600
2-yr	378,428	0.622	235,418	270,700
5-yr	547,995	0.562	307,924	354,100
10-yr	720,598	0.514	370,141	425,700
25-yr	999,301	0.458	458,080	526,800
50-yr	1,248,756	0.425	530,814	610,400
100-yr	1,525,034	0.399	608,373	699,600

At this point, the preliminary storage volume for each event to be addressed by the practice is known.

NOTE

The 15% addition is a factor of safety addition, as in practice it has been shown that this estimation procedure may yield results that are slightly less than what will be the results of final design and modeling.

Incorporating this correction factor should make preliminary storage volumes used be closer to expected final results.

IOWA STORM WATER MANAGEMENT MANUAL

9.03 STORAGE ROUTING FOR FINAL DESIGN

IOWA DEPARTMENT OF NATURAL RESOURCES

TABLE OF CONTENTS

CONTENTS

9.03-1 OVERVIEW 1

9.03-2 USE OF MODELING SOFTWARE 2

A. General Information 2

B. Model Types 2

C. Input Parameters 2

D. Model Outputs 7

9.03-3 DOCUMENTATION FOR REVIEW 9

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

9.03-1 OVERVIEW

Section 9.01 reviews the need for stormwater detention and the types of best management practices (BMPs) that meet those goals.

Section 9.02 reviews methods to develop initial estimates of detention storage needed to provide desired rate reductions. Those methods can be used to start the design process with a better idea of how much area will be required to meet project goals. This can be done before valuable design time is spent developing site-specific grading and utility plans.

This section is dedicated to the methods to be used during creation of more detailed design plans. These methods validate the preliminary storage volume estimates and determine the actual performance of the proposed stormwater detention facility.

Stormwater detention is a **rate–based** standard. That is, compliance is demonstrated by showing the post–project release rate is below a maximum value established to meet project requirements.

NOTE

Methods to determine allowable release rates are described in Section 2.05, 3.02 and 9.02.

9.03-2 USE OF MODELING SOFTWARE

A. GENERAL INFORMATION

Given the variety of available software packages capable of performing calculations consistent with the TR-55 methodology, it is assumed that designers will rarely use techniques to manually develop runoff hydrographs in the methods described. This section is intended to review the required inputs and assumptions that typical software packages use.

B. MODEL TYPES

Designers are not limited to use of Win-TR55 or any specific software package. Any software running the TR-20 or TR-55 calculations may be used. Many newer software packages have incorporated options that facilitate the design process and provide output reports in formats that are easier to read. The designer should be familiar with the basis of such calculations, which are described in detail in Sections 9.03-4 and 9.04.

C. INPUT PARAMETERS

To properly size a detention practice, it is critical that the characteristics of the watershed that are input into the model reflect real-world conditions as closely as possible. Prior to this step, the designer should prepare a map of the watershed to define the various parameters that will need to be input into the model. ESSENTIAL

1. **Watershed size:** Perhaps the most basic parameter, defining the areas of land draining to each practice or conveyance to be studied.

2. **Curve Number:** The curve number is the parameter that determines the portion of rainfall that is converted to runoff from a given landscape. To define this number, site soils and land cover need to be defined for the watershed area being reviewed.

    a. **Hydrologic Soil Group (HSG):** A measure of soil types ranging from A (lowest runoff potential) to D (highest runoff potential). These parameters can be determined from soil maps prepared by the USDA for any county, or through use of the NRCS Web Soil Survey website.

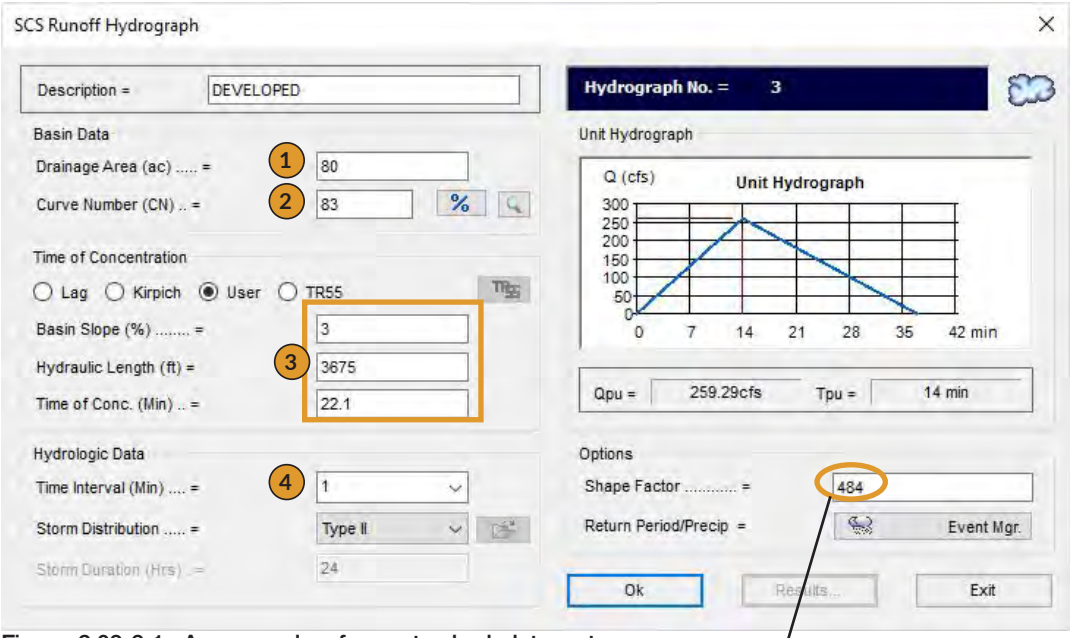
    b. **Land Cover:** The guidance manual for NRCS TR-55 (as well as the related section of ISWMM) includes curve numbers for various land cover types, based on HSG. The curve numbers for these land uses depend on assumptions of impervious cover and the condition of open spaces within those land uses. For this reason, curve numbers should not be selected based on land type. They should be **determined for each subarea based on the current (and/or future) impervious cover and the condition of the open spaces within the given area (depth of topsoil and/or soil quality restoration).** The conditions used for this analysis should be based on the fully developed condition of the area the BMP is intended to serve. If the exact future impervious cover is not known for a given area, the designer should use an assumed value and provide supporting evidence for such assumptions. ESSENTIAL

NOTE

Selection of Curve Numbers is discussed in greater detail in Section 2.05.

3. **Time of concentration (Tc):** This parameter is a measure of the shape and length of the watershed. It defines the time expected for runoff to pass from the most hydraulically distant point in a given subarea to the outfall point of that area. **Calculation of time of concentration should be done with great care.** Underestimation of Tc can lead to a higher expected flow rate. If a shorter Tc is used in calculating the natural or existing flows (often used to determine the allowable release rate from a practice), this could result in allowing water out of the practice too quickly. If a longer Tc is used, the peak flow rates might be underestimated, resulting in undersizing of detention storage or conveyance structures.

4. **Time step for modeling:** Models will compute flow rates and volumes for each time step as defined by the user. In smaller watersheds (< 10 acres), a shorter interval is important, as the true peak flow rate might be missed if a longer step interval is used. Under most conditions, a calculation time step interval of 1 minute is preferred. For practices with watersheds greater than 10 acres in size, a time interval of 2 minutes may be used. ESSENTIAL



Always 484 for central Iowa

Figure 9.03-2-1: An example of a watershed data entry screen for a stormwater modeling software program.

Source: Hydraflow Hydrographs Extension

5. **Stage vs. storage relationship of the detention area:** Most software programs include a table to enter these properties. At specific elevations, the area available for temporary water storage is defined. This is most typically done in increments of 0.5 or 1.0 foot of elevation change. This information needs to be entered starting at the lowest elevation used for temporary storage. For a dry or dry ED basin, this would be the elevation of the lowest surface inlet. For wet ponds or stormwater wetlands, this would be the normal water surface elevation (permanent pool). Grading plans or contour maps are used to gather the data for this stage vs. storage relationship.

NOTE

Calculation of Tc is discussed in greater detail in Section 2.03.

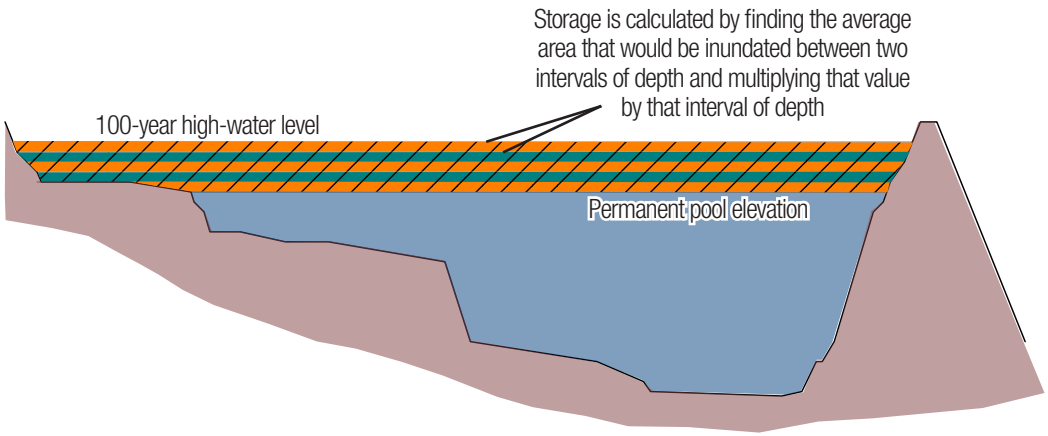


Figure 9.03-2-2: An illustration of how temporary detention storage is calculated for a wet detention pond.

Pond Name: POND FINAL DESIGN

Row	Stage	Elevation	Contour Area	Incremental Storage	Total Storage	Total Discharge
	(ft)	(ft)	(sqft)	(cuft)	(cuft)	(cfs)
0	0.00	100.00	125,900	0.000	0.000	0.000
1	1.00	101.00	144,500	135,200	135,200	2.127
2	2.00	102.00	163,500	154,000	289,200	3.008
3	3.00	103.00	210,600	187,050	476,250	17.00
4	4.00	104.00	249,300	229,950	706,200	41.93
5	5.00	105.00	261,400	255,350	961,550	90.65
6	6.00	106.00	273,700	267,550	1,229,100	124.49
7	7.00	107.00	286,300	280,000	1,509,100	244.63

Figure 9.03-2-3: An example of a stage-storage data entry screen for a stormwater modeling software program.

Source: Hydraflow Hydrographs Extension

NOTE

The methods, formulas and parameters used to predict outflow rates through given types of control devices is discussed in greater detail in Section 9.04.

6. **Stage vs. discharge relationship of the outfall structure:** This information is used in the routing calculations to determine the expected release rate as water levels within the practice change during a storm event. These outflow rates are typically computed by software. In more unique cases, the outfall rates may need to be computed manually or using a spreadsheet program and then input into a model.

   The designer needs to input this information carefully to ensure that the model most accurately reflects the intent of the designer. Some key advisory points related to using software programs in multi-stage design:

   a. **Orifices/culverts:** Typically software packages provide a space to input a number of orifice or pipe controls. The designer should refer to a given software package's user manual for specific guidance and understanding of the assumptions made by the program.
   Often, these packages use "Culvert A" as the primary pipe spillway out of the detention basin. This is most typically the orifice, pipe or culvert that flow must pass through when passing out of the multi-stage control devices and leaving the practice. Other culverts or orifices can be specified that control flow upstream of Culvert A. Such controls are considered to be operating

as “multi-stage” by the program. In such cases, “Yes” should be selected as the multi-stage option in this arrangement. Any control that conveys flow that will bypass Culvert A should have “No” selected in the multi-stage option. (This applies to both culverts and weir design options).

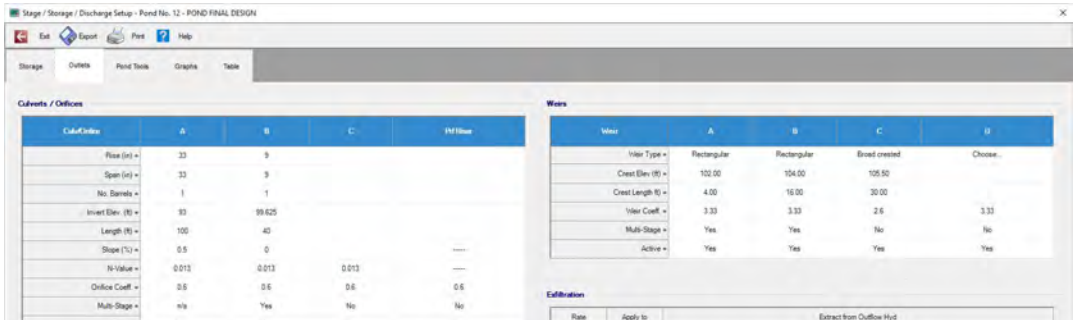
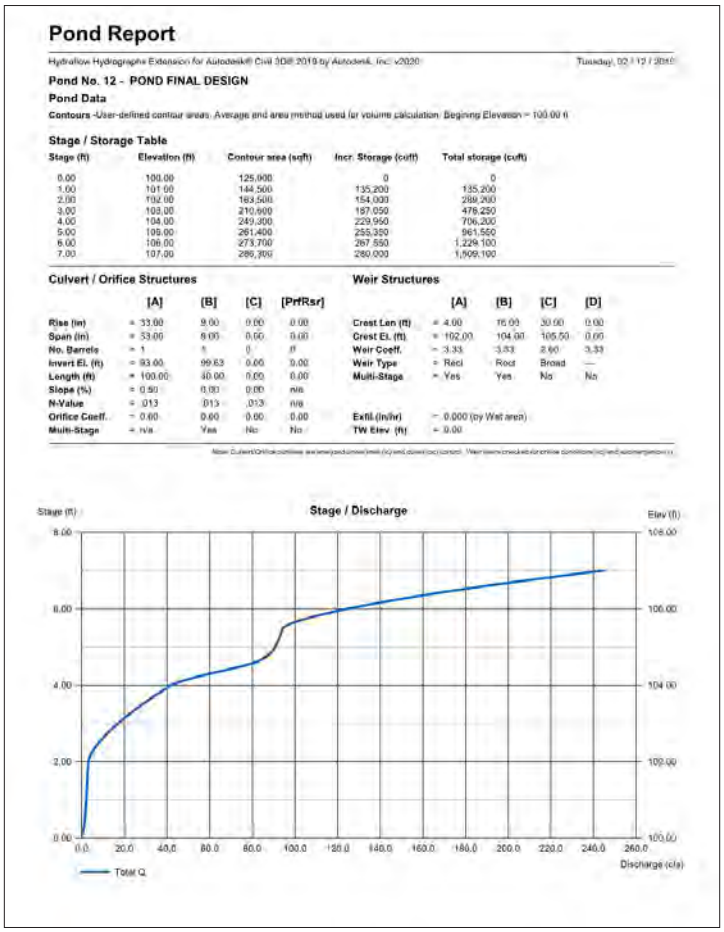


Figure 9.03-2-4: An example of outlet data entry screen for a stormwater modeling software program.

Source: Hydraflow Hydrographs Extension

Figure 9.03-2-5: An example of a pond data and stage-discharge graph generated by a stormwater modeling software program.

Source: Hydraflow Hydrographs Extension



Stage-storage relationships

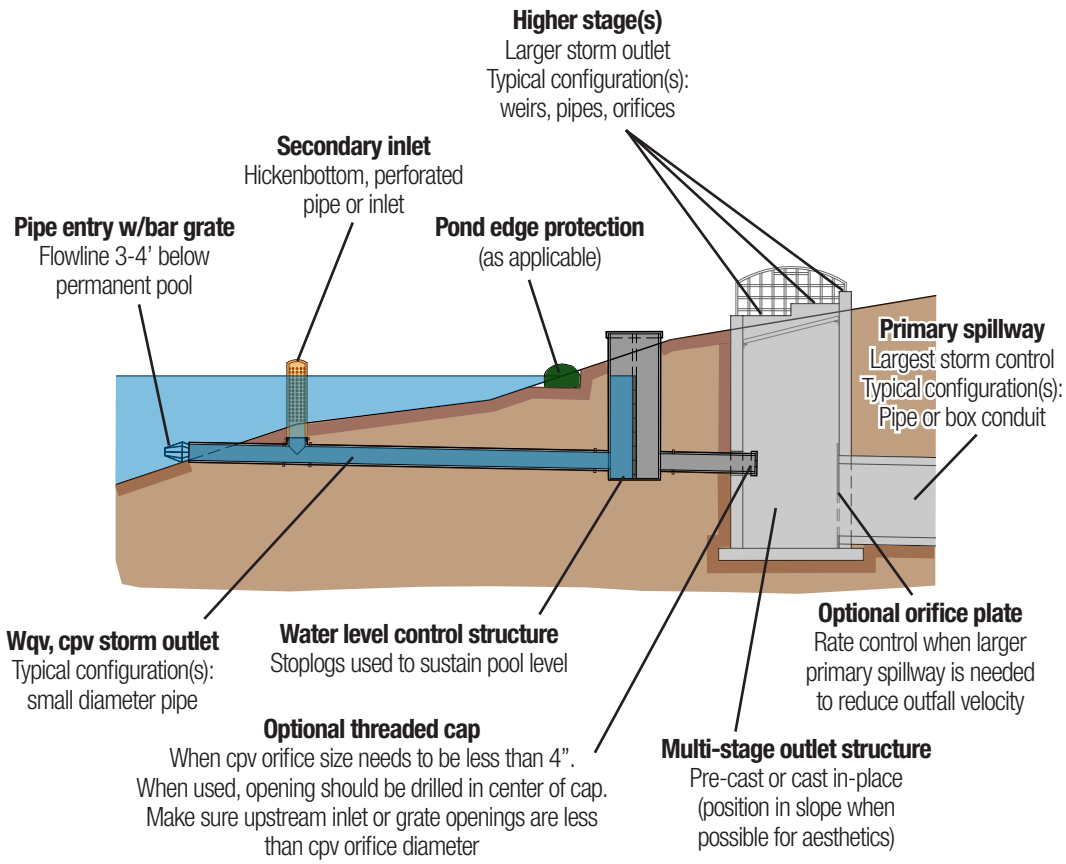
Outfall design configuration

Stage-discharge relationships

The designer must input the correct size, shape and elevation information for each orifice or culvert, along with any required coefficients or constants.

b. **Weirs/auxiliary spillways:** Software packages usually provide a space to input parameters for weir controls as well. Some weirs might be the top edges of an inlet structure whose outlet is Culvert A. These weirs are most often rectangular or V-notch weirs. Auxiliary spillways usually modeled as broad-crested weirs and usually will bypass Culvert A (hence, "No" should be selected as the multi-stage option).

Figure 9.03-2-6: An example of a multi-stage outlet used for flow control at a wet detention pond.



7. **Watershed routing path:** The designer must input the way that subareas are added or routed to the detention practice. All areas that will drain through the detention area should be added together. In some cases, channel reaches need to be input into the model to simulate the time it takes for flow from an upstream area to pass through a downstream area. Once added, the total inflow hydrograph is selected as the input flow to be routed through the correct basin.

D. MODEL OUTPUTS

Most software programs will provide output in tabular or graphical form. Graphical output is most useful for reviewing inflow/outflow vs. highwater elevation vs. time relationships for key storm events to understand the expected operation of the detention basin. Other summary data such as runoff volumes and peak flow rates from different subwatershed areas is often presented in tabular form.

This output information should be presented to the local jurisdictional review authority along with the stormwater management plan (as described within Section 3.01). Details of the information to be provided, related to stormwater detention design is included in Section 9.03-3.

Hydrograph Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020 — Tuesday, 02 / 12 / 2019

Hyd. No. 16

OUT WETLAND FINAL

Hydrograph type	= Reservoir	Peak discharge	= 2.824 cfs
Storm frequency	= 1 yrs	Time to peak	= 18.80 hrs
Time interval	= 1 min	Hyd. volume	= 303,391 cuft
Inflow hyd. No.	= 3 - DEVELOPED	Max. Elevation	= 101.76 ft
Reservoir name	= POND FINAL DESIGN	Max. Storage	= 252,804 cuft

Storage Indication method used.

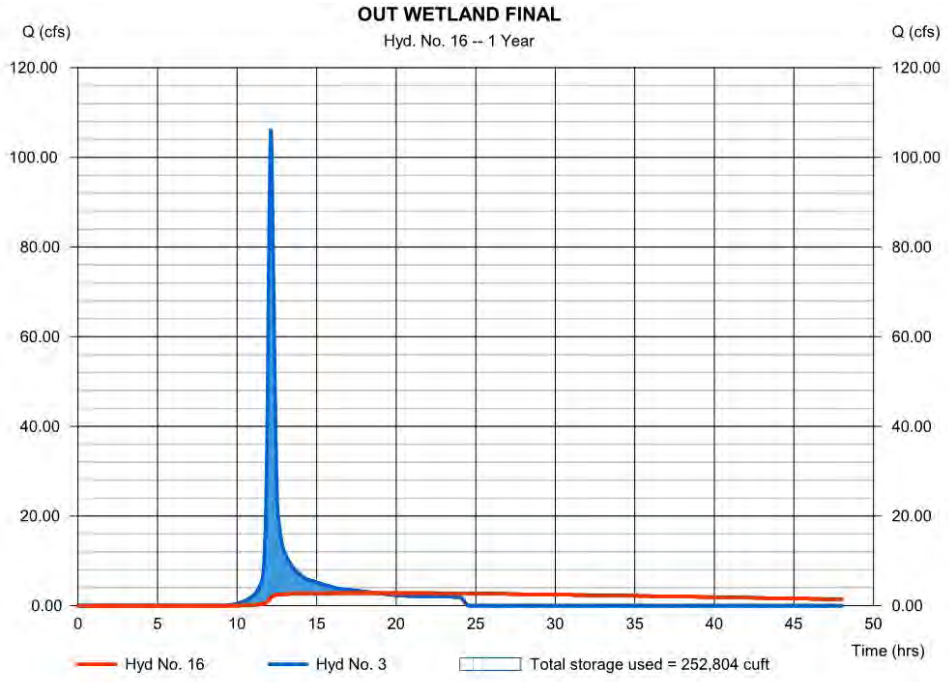


Figure 9.03-2-7: An example of inflow-outflow hydrographs generated by a stormwater modeling software program.

Source: Hydraflow Hydrographs Extension

9

Hydrograph Summary Report

Hydraflow Hydrographs Extension for Autodesk® Civil 3D® 2019 by Autodesk, Inc. v2020

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	5.339	1	740	33,932	------	------	------	1 (commercial, pre-settle)
2	SCS Runoff	4.659	1	738	27,921	------	------	------	2 (commercial, pre-settle)
3	SCS Runoff	6.678	1	744	46,272	------	------	------	3 (multifamily, pre-settle)
4	SCS Runoff	9.604	1	750	77,119	------	------	------	4 (single family, pre-settle)
5	SCS Runoff	8.051	1	748	61,944	------	------	------	5 (single family, pre-settle)
7	Combine	33.30	1	747	247,189	1, 2, 3, 4, 5,	------	------	Pre-settle
9	SCS Runoff	28.11	1	725	87,939	------	------	------	1 (commercial, eg)
10	SCS Runoff	24.00	1	724	71,132	------	------	------	2 (commercial, eg
11	SCS Runoff	36.76	1	726	121,069	------	------	------	3 (multifamily, eg)
12	SCS Runoff	53.89	1	729	201,422	------	------	------	4 (single family, eg)
13	SCS Runoff	44.78	1	728	159,888	------	------	------	5 (single family, eg)
15	Combine	183.58	1	727	641,449	9, 10, 11, 12, 13,	------	------	existing (row crop ag)
17	SCS Runoff	59.83	1	718	136,074	------	------	------	1 (commercial, prop)
18	SCS Runoff	48.95	1	718	111,334	------	------	------	2 (commercial, prop)
19	SCS Runoff	58.87	1	721	150,567	------	------	------	3 (multifamily, prop)
20	SCS Runoff	54.21	1	726	179,998	------	------	------	4 (single family, prop)
21	SCS Runoff	45.27	1	725	142,627	------	------	------	5 (single family, prop)
23	Combine	239.38	1	720	720,598	17, 18, 19, 20, 21,	------	------	proposed conditions

Estimate_Storage.gpw	Return Period: 10 Year	Monday, 07 / 29 / 2019

Figure 9.03-2-8: An example of summary pages generated by a stormwater modeling software program.

Source: Hydraflow Hydrographs Extension

9.03-3 DOCUMENTATION FOR REVIEW

The basis of design for a given stormwater detention BMP should be included in a stormwater drainage report prepared for local jurisdictional review (and other agencies with project interest). The following information should be highlighted within the narrative section of that report, and details incorporated into its appendices. ESSENTIAL

1. **Rainfall depths for reviewed storms** (WQv, 1-, 5-, 10-, 25-, 50- and 100-year events) consistent with prescribed values for the site location. Use values for the appropriate region of the state as listed within Section 2.02. Models for 24-hour storms should indicate that a Type-II rainfall distribution was used.

2. **Drainage maps identifying watershed (and subwatersheds) areas.** Flow paths and land uses for both **natural**, existing and post-development conditions should be identified. Clearly identify drainage boundaries, areas and flowpaths on the drainage maps. Label subwatershed areas clearly with numbers or letters that correspond to identification of subareas. This naming system should be reflected in other calculations and data so that the design assumptions are easily reviewed.

3. **Soil maps** supporting selection of hydrologic soil group (HSG) categories (A through D). The NRCS Web Soil Survey website is the preferred source for initial soil information. This site starts by site selection at the state and county level, then allows you to focus down to an individual site area. The specific site boundary can be selected, allowing the user to navigate through a variety of soils information.

   The soil map data is based on general assumptions of soil properties based on local observations. If soil borings are completed during the design process, the geotechnical report should be used to address whether the soil types listed on the Web Soil Survey site are accurate for a given site. This information should be used to adjust the HSG groups used for final design, as appropriate.

4. **Subwatershed properties** in tabular form identifying the soil type, impervious cover and land uses in each subwatershed area (for both existing and post-developed conditions). This should include properties for off-site, upstream watershed areas.

5. **Details of calculations of time of concentration,** consistent with preferred design assumptions. Include software input/output, spreadsheets or other calculations used for Tc in an appendix to the Stormwater Management Plan.

6. **Details of calculation of curve numbers,** as the basis of their selection consistent with preferred design assumptions listed within Section 2.05. Include software input/output, spreadsheets or other calculations used in an appendix to the Stormwater Management Plan.

7. Provide **documentation of model inputs and outputs.** This should include the following information, for natural, existing and post-developed conditions:

   a. **A summary of volumes and peak rates of flow for all events** listed in item #1 above. These summaries should include this information for each watershed area that feeds into the detention area(s) and the routing output of flows leaving each basin.

   b. **Watershed model input** documenting the following for each subwatershed area for each condition:

NOTE

These items could be used as a checklist for calculation/design assumption information to be provided along with the narrative for a Stormwater Management Plan (SMP). Refer to Section {#.##} for more information on the narrative and other information to be included as part of the SMP.

NOTE

Older county soil maps and other sources of information may not be updated as frequently as the NRCS Web Soil Survey website:

websoilsurvey.nrcs.usda.gov

Where soils are listed as "urban" assume:

HSG B soil for natural
HSG D soil for developed
–OR–
Conduct geotechnical explorations to classify soil types based on soil samples collected from the site.

i. Watershed area (in acres)

ii. Curve number

iii. Time of concentration (in minutes)

c. Graphical versions of **the inflow hydrographs for the 1–, 5–, 10– and 100–year storm event should be provided. For other events modeled, a tabular summary of volumes and peak flow rates listed in item #7a above is sufficient detail for review.**

d. For each detention practice, document **stormwater detention area properties,** including the following:

i. **Basin characteristics:**

01. **Stage–storage volume relationship** of the reservoir area. No less than 1-foot intervals. More frequent intervals may be required for some practices.

02. **Stage–discharge relationship of basin outlet.** Calculations should identify all stages of outflow design (riser pipe, orifice, weir, discharge pipe, overflow spillway, etc.) and include characteristics of each (elevation, size, etc.) that match plan dimensions.

- Calculations should include either detailed calculations of flow through each outlet stage, or graphical representation of stage-discharge relationship from calculation output from the software package used.
- The calculations should note whether the flow from a given stage is routed through the primary spillway (multi-stage) or a secondary overflow.

03. **Weir and/or orifice coefficients** that account for energy loss (resistance to flow).

04. Include information related to subitems 1) through 3) above for assumptions about existing detention facilities that are expected to have flow passing through the proposed site or practice(s).

05. If performing routing calculations manually or via spreadsheet tools, refer to Section 9.04. Methods, assumptions and calculations used in routing should be consistent with these sections, except as amended by local jurisdictions.

ii. **Target allowable peak discharge** from the reservoir (for each event to be considered).

iii. Routing output results:

01. **Outflow hydrograph** from routing output identifying flow rate (in cfs) versus time, the peak flow rate, time of occurrence of peak flow in relation to the rainfall event. For analyses involving the 1-, 10- and 100-year events identified in this report, provide a numeric or graphic representation of the entire outlet hydrograph through the duration of the storm event.

02. **A graph of storage volume or elevation versus time** for the 1-, 10- and 100-year {design} events. Review drawdown for extended detention of small storms (minimum 24-hour drawdown after storm event, maximum 72-hour drawdown).

03. **Identify maximum storage volume and water surface elevation** for each event reviewed.

04. For each event, calculate the **maximum storage volume in watershed–inches** (equivalent depth of water over the area served by the basin) and as a **percentage of total runoff** (maximum storage volume divided by total runoff volume).

Equation 9.03-3-1

$$\text{Max Storage Volume (watershed-inches)} = \frac{\text{High Water Storage Volume (CF)}}{\text{Watershed Area (AC) x 43,560 (SF/AC)}} \times \frac{\text{12 inches}}{\text{1 foot}}$$

8. For models with multiple subareas, where hydrographs are to be combined with or routed through downstream areas or basins, **provide a flow chart, schematic plan or map that identifies how separate hydrographs have been routed or combined.** This will help clarify how models were built to route flows from various areas through proposed management practices.

9. Provide information in a summary table in a format similar to the one below:

TABLE 9.03-3-1: DETENTION PRACTICE PERFORMANCE						
STORM EVENT	RAINFALL	ALLOWED	OUT	HIGH-WATER ELEV.	MAX TEMP. STORAGE ABOVE POOL	
CPV		CFS	CFS	FEET	CF	WS INCHES
1-year						
2-year						
5-year						
10-year						
25-year						
50-year						
100-year						

TABLE 9.03-3-2: DETENTION PRACTICE METRICS						
STORM EVENT	MAX. RAINFALL VOLUME STORED	PEAK DELAY IN VS. OUT	PEAK FLOW REDUCTION IN VS. OUT	INITIAL STORAGE ESTIMATE*	FINAL STORAGE ROUTING RESULT	FINAL/ ESTIMATE
CPV	%	MIN	%	CF	CF	
1-year						
2-year						
5-year						
10-year						
25-year						
50-year						
100-year						

* Original "Vs" Storage Estimate Without Safety Factor

NOTE

This table provides a quick summary for a reviewer, comparing the BMP performance to required outflow rates.

The high–water elevation can be used to evaluate if ISWMM design thresholds for water depth are achieved.

The maximum temporary storage can be used as a metric to identify "red flags," checking the amount of water that is stored in the practice when it is fullest.

NOTE

This table provides other metrics that can be used to evaluate the effectiveness of a BMP at reducing flow rates and delaying peak flow times.

It also provides a "check back" to compare final results to the initial storage estimates.

IOWA STORM WATER MANAGEMENT MANUAL

9.09 TRADITIONAL DRY DETENTION

IOWA DEPARTMENT OF NATURAL RESOURCES

TABLE OF CONTENTS

CONTENTS

9.09-1 LAYOUT AND DESIGN 1

A. Summary 1

B. Application 2
Ability to Address the Unified Sizing Criteria 2

C. Site Feasibility 3
Soils 3
Minimum Depth to Water Table 3
Existing Vegetation 4
Existing Wetlands 4
Tributary Drainage Area 4
Space Required 4
Site Topography 4

D. Setbacks 4

E. Design Elements and Parameters 6
Pre-Treatment 6
Basin Shape and Size 7
Pilot Channels 7
Basin Floor 9
Perimeter Slopes 9
Outlet Structures 10
Temporary Storage Volume 11
Dam Construction and Auxiliary Spillway 11
Outfalls 12

E. Maintenance, Access and Safety 14
Planning for Maintenace Access 14
Safety Features 15

F. Landscaping 15

G. Design Alternatives 16

H. Special Case Adaptations 16
Flood Plains 16
Stream Morphology 16

9.09-2 SIZING CALCULATIONS 19

A. Calculation Procedure 19

B. Design Example 21
Project Watershed Data 21
Detailed Design of Forebay 29

9.09-3 CONSTRUCTION 32

A. Pollution Prevention 32
Stormwater Pollution Prevention Plan and NPDES Permit Requirements 32

B. Construction Sequencing 35

C. Construction Observation 36
Post-Construction Documentation 37

9.09-4 MAINTENANCE 39

A. Establishment Period (Short-Term Maintenance) 39
YEAR ONE—MAINTENANCE ACTIVITIES 39
YEAR TWO AND THREE—MAINTENANCE ACTIVITIES 40

B. Routine or Longer-Term Maintenance Activities 40

9.09-5 SIGNAGE RECOMMENDATIONS 42

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

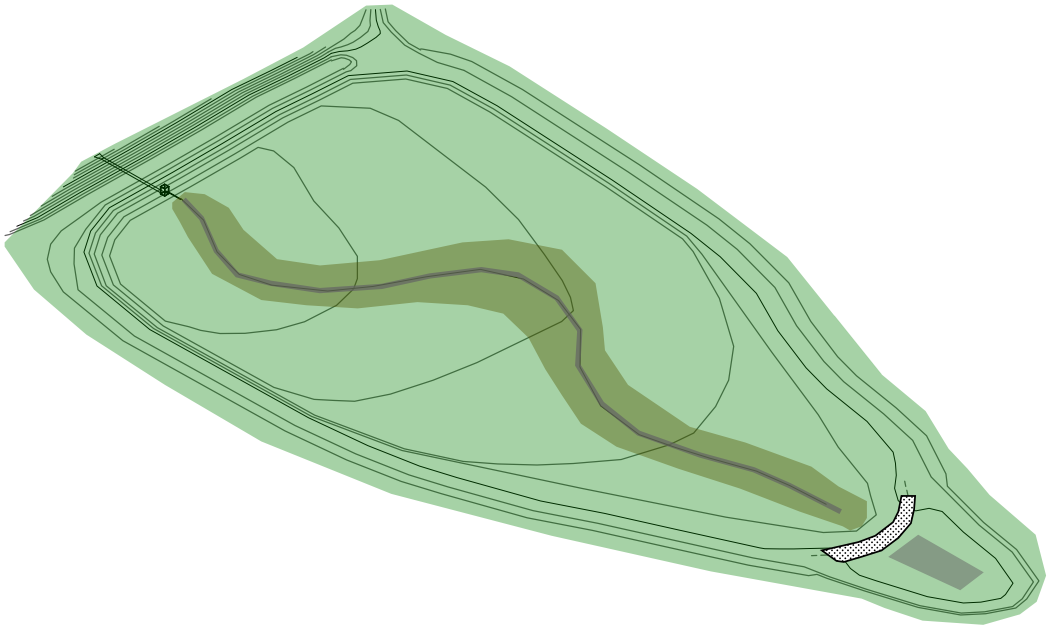
Long-term (ongoing)

- 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.

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

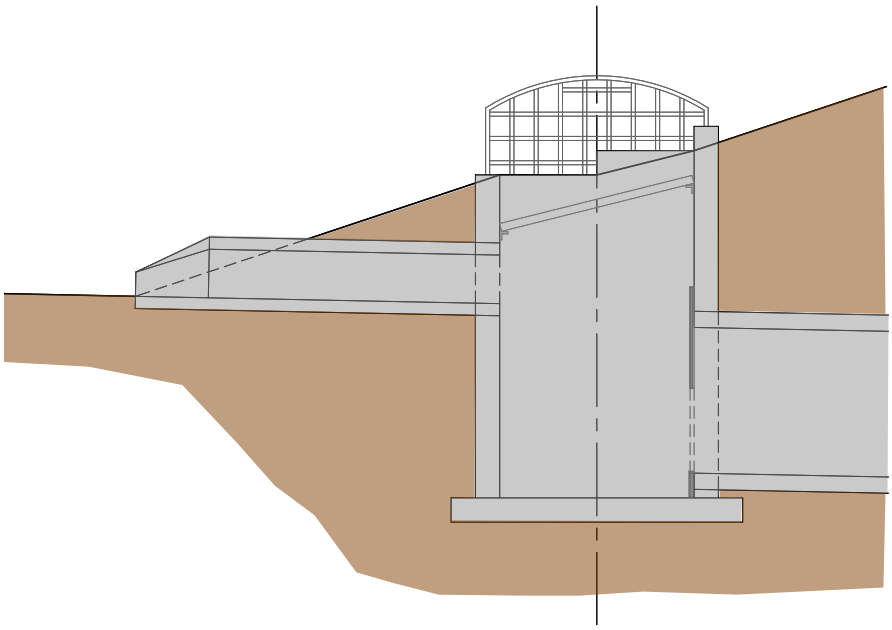
NOTE

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

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

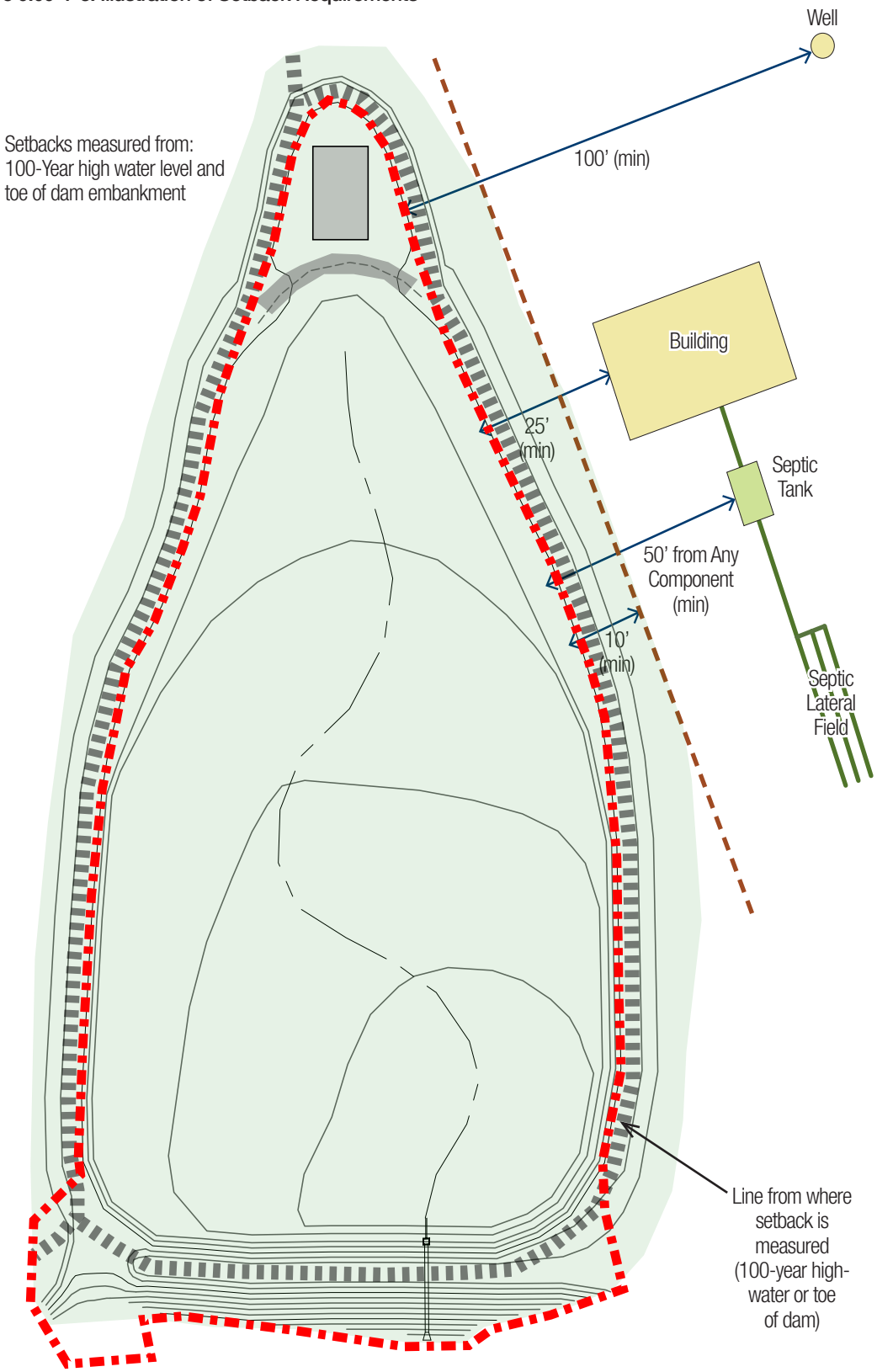
Site grading costs may be elevated at sites with steeper **topography**. Designers should consider whether the basin can be constructed by excavation into the existing surface, creation of a dam embankment or some combination of these grading methods.

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

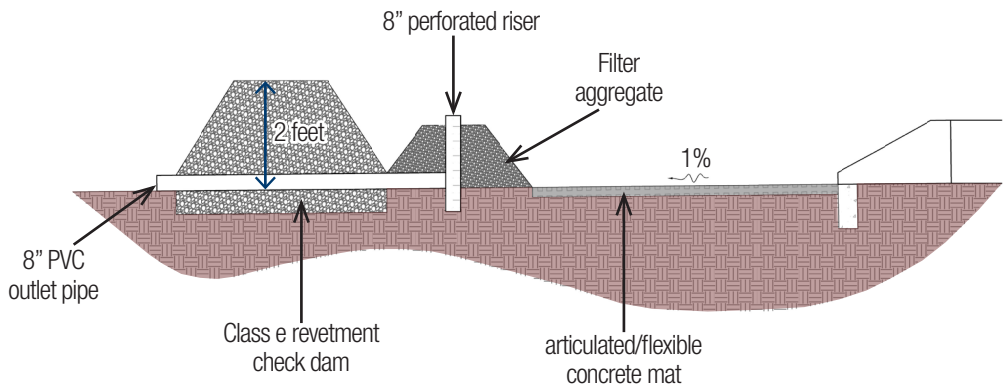


E. DESIGN ELEMENTS AND PARAMETERS

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

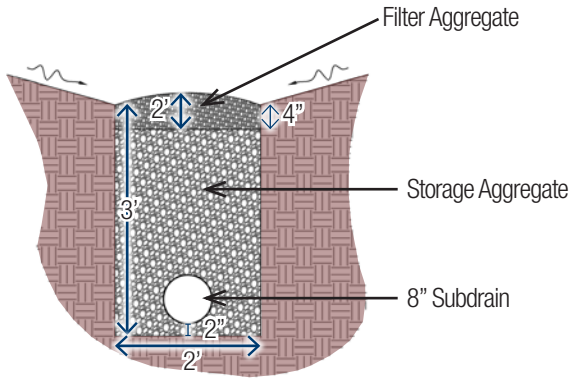
PILOT CHANNELS

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.

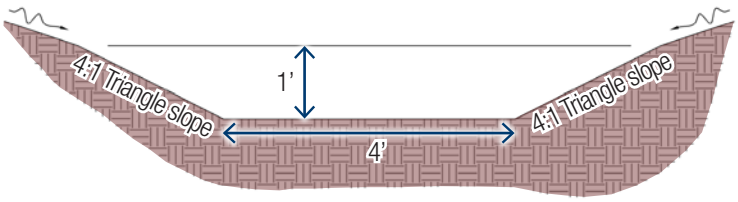
Pilot channels should have a minimum slope of 0.5% (infiltration trenches with subdrains may be flatter), with side slopes as noted on details. Channels will typically be only as deep as needed to convey daily baseflows, allowing flow to quickly spread across the bottom of the basin during storm events.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

Figure 9.09-1-5: Pilot Channel Alternatives

Infiltration Trench



Wet Swale



Articulated/Flexible Concrete Mats

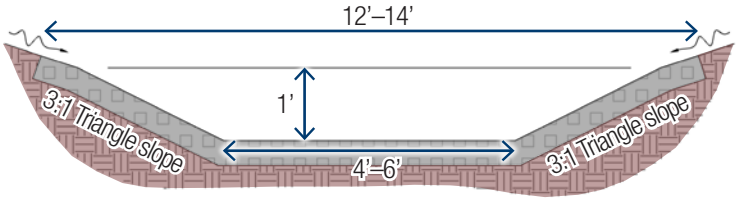
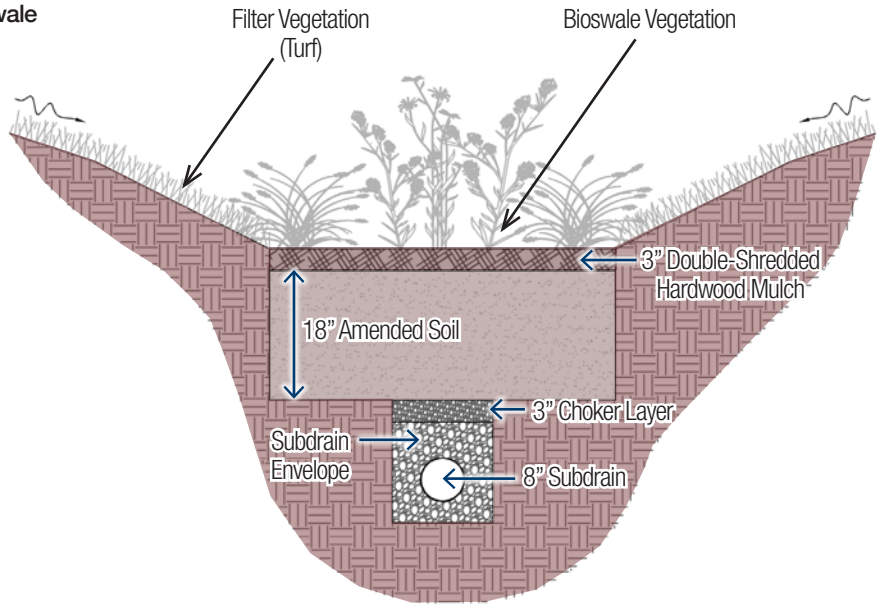
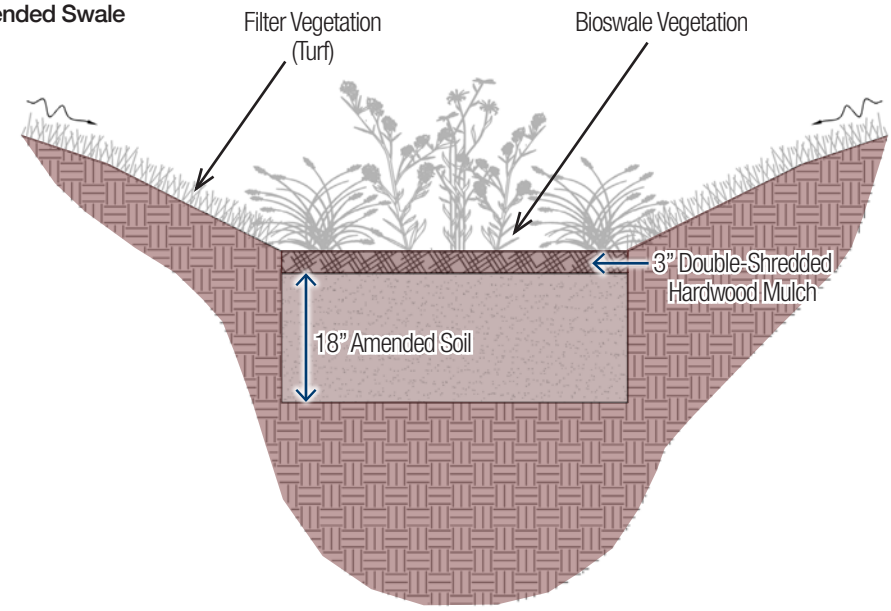


Figure 9.09-1-5: Pilot Channel Alternatives (continued)

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

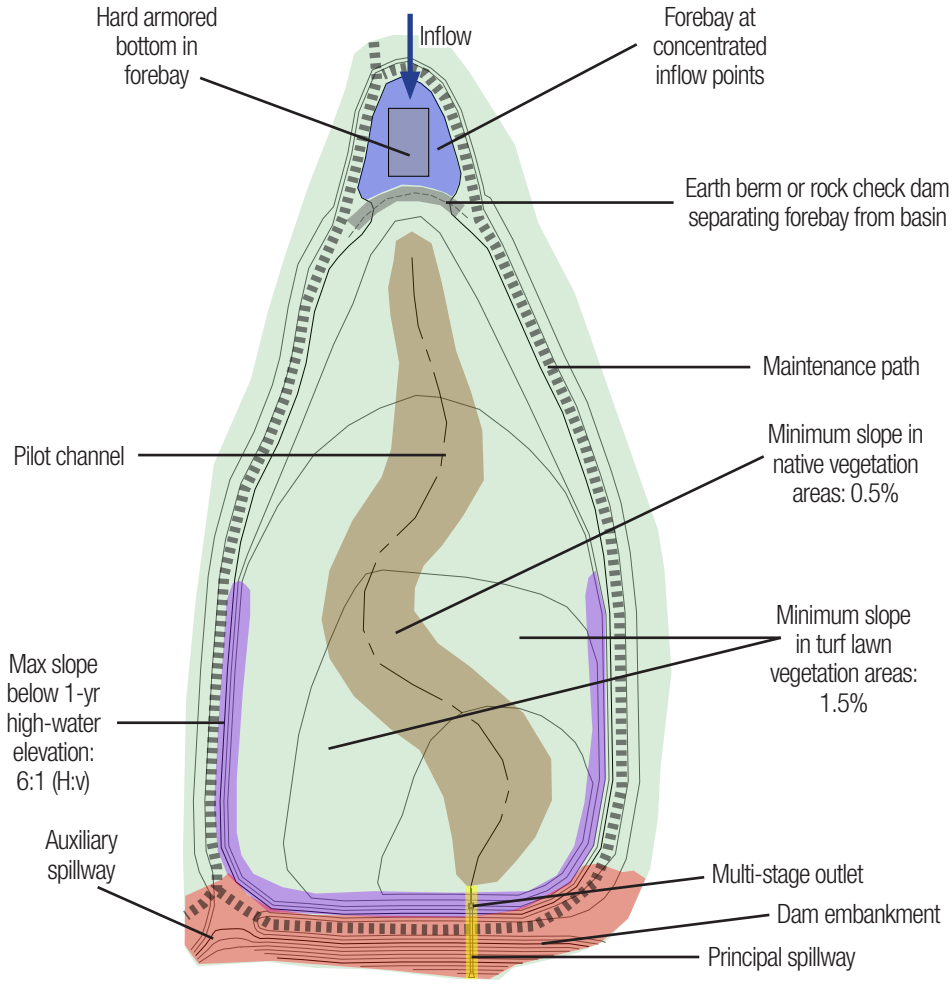
PERIMETER SLOPES

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

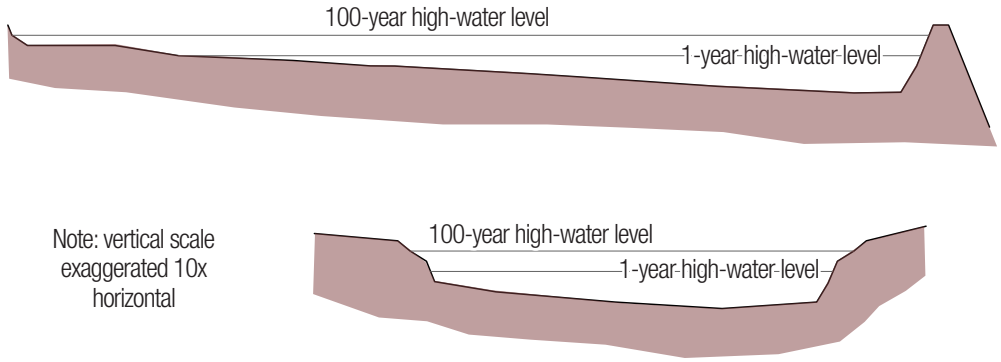
Figure 9.09-1-6: Typical Features of a Dry Detention Basin



NOTE

Flatter bottoms may require careful plant selections.

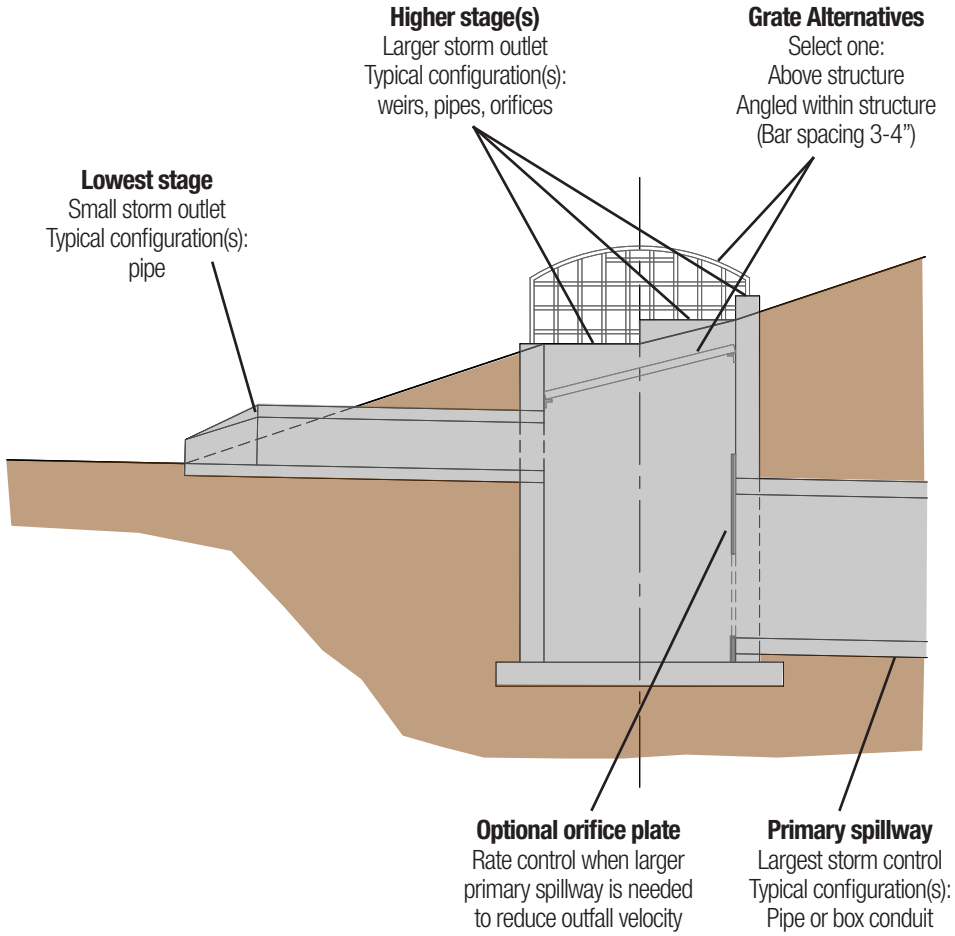
Figure 9.09-1-7: Cross-Section View Graphic of Detention Features



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

Figure 9.09-1-9: Dam Crest Parameters

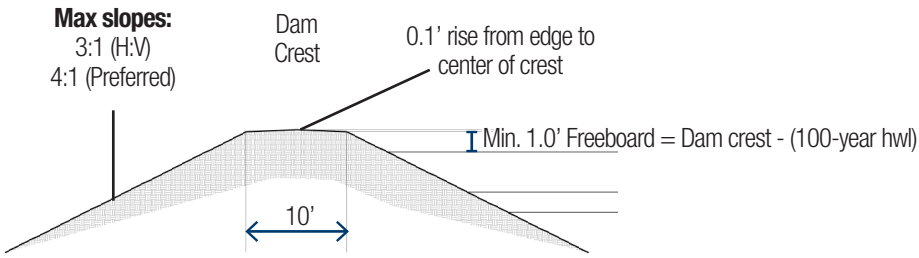
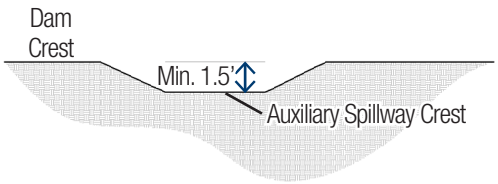


Figure 9.09-1-10: Auxiliary Spillway Parameters



NOTE

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

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

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

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")

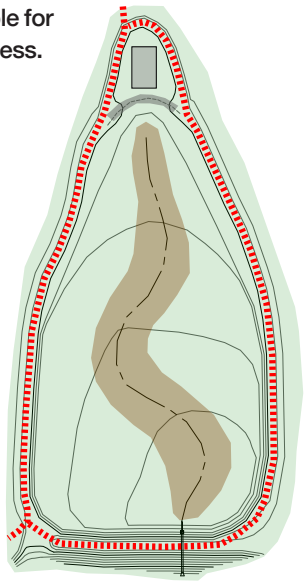
E. MAINTENANCE, ACCESS AND SAFETY

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.

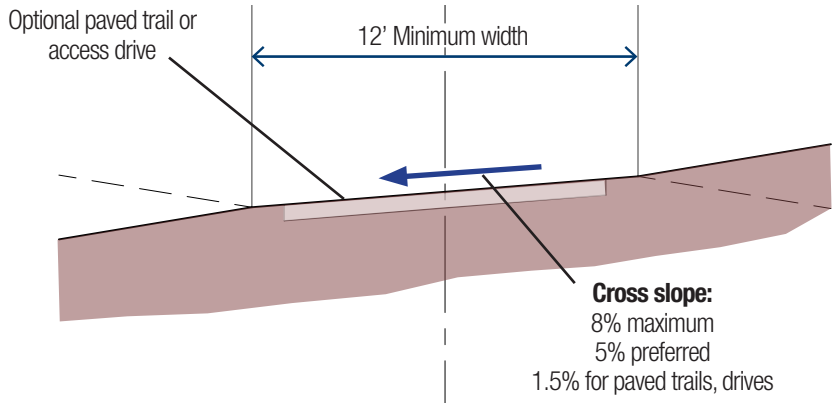
Figure 9.09-1-13: Maintenance Path Needs



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.

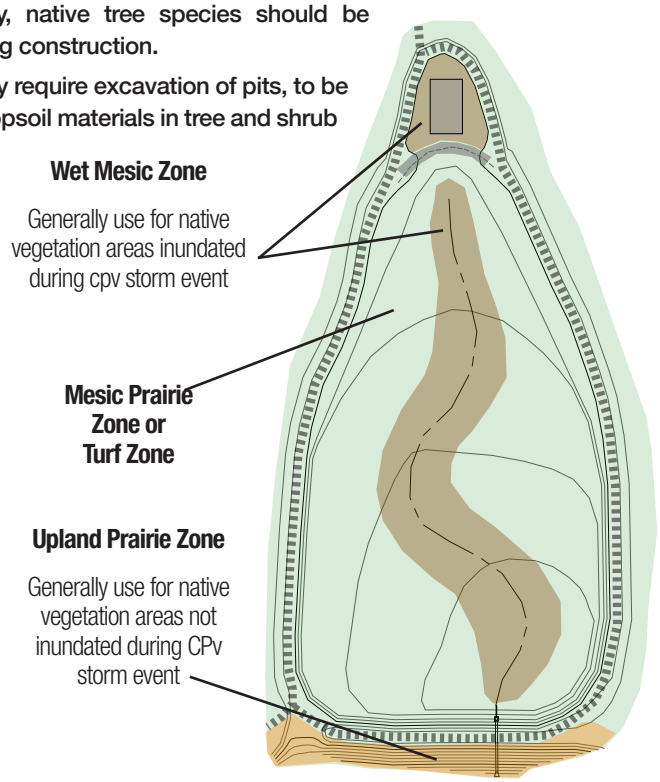


Figure 9.09-1-15: Landscaping Zones

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.

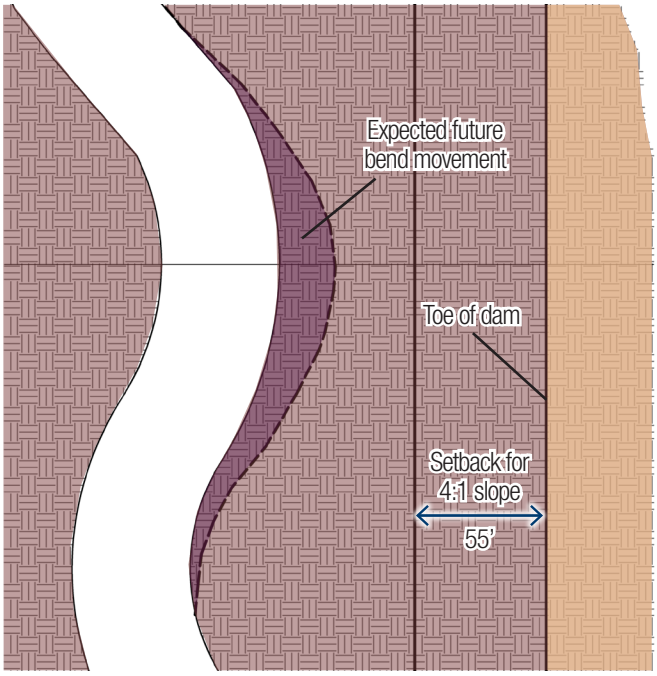
NOTE

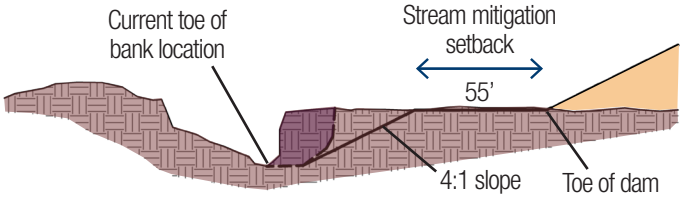
Locating dry detention basins within flood prone areas is discouraged.

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

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.

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.

NOTE

Refer also to IDNR Form 542–1014.

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.

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 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.`

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.**

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.

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).

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)

NOTE

WQv was determined in Step 3.

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:

- 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.

* Volumes of forebay storage added to the basin.

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/s^2
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/s^2
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.

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

- 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.

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.

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.

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.

$Q = C \times L \times H3/2$

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

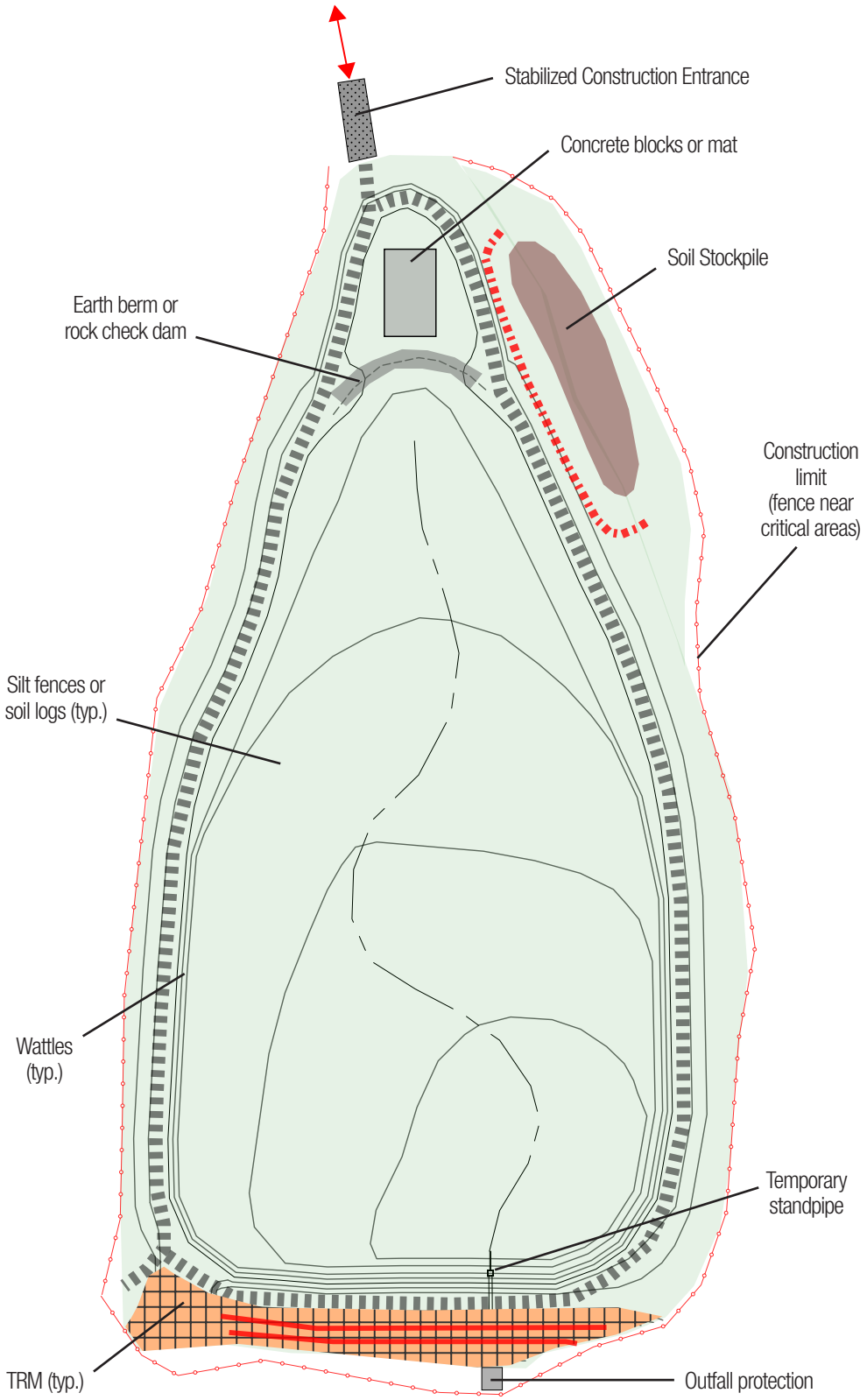
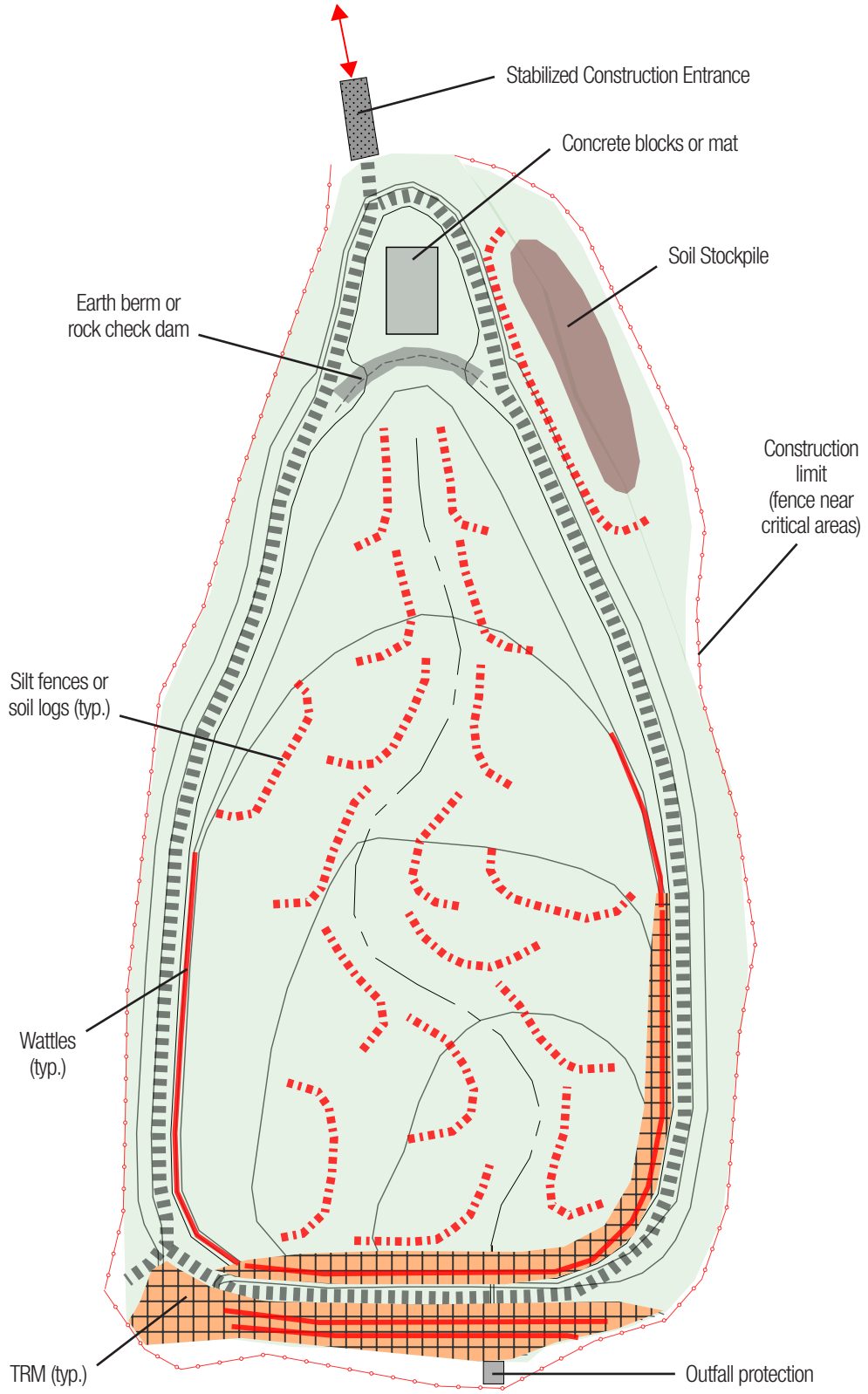


Figure 9.09-3-1-B: Construction Stage Features and Controls



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:

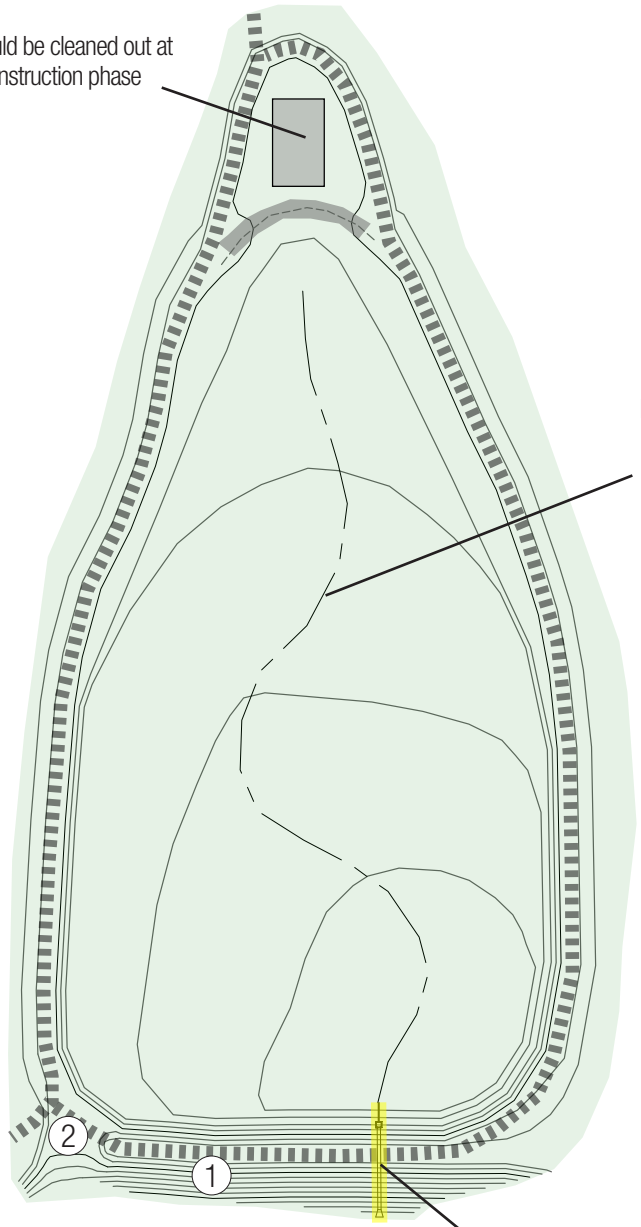
- Maintain and update the SWPPP document and retain records.
- Conduct site inspections as required by the general permit.
- Throughout construction, work with the erosion and sediment control contractor to coordinate proper installation of all BMPs.
- Verify that exterior sediment and erosion BMPs are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



Post-construction topo survey should verify:

- Storage volumes
- Crest elevation of dam (1)
- Crest elevation of auxiliary spillway (2)

Confirm elevations of multi-stage outlet and pipes:

- Rim(s)
- Flowline(s)
- Weir crest(s)
- Pipe size(s)
- Orifice plate(s)

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

IOWA STORM WATER MANAGEMENT MANUAL

9.10 EXTENDED DRY DETENTION

IOWA DEPARTMENT OF NATURAL RESOURCES

TABLE OF CONTENTS

CONTENTS

9.10-1 LAYOUT AND DESIGN 1

A. Summary 1

B. Application 2
Ability to Address the Unified Sizing Criteria 2

C. Site Feasibility 3
Soils 3
Minimum Depth to Water Table 3
Existing Vegetation 3
Existing Wetlands 3
Tributary Drainage Area 3
Space Required 3
Site Topography 4

D. Setbacks 4

E. Design Elements and Parameters 5
Pre-Treatment 5
Basin Shape and Size 6
Pilot Channels 6
Basin Floor 8
Perimeter Slopes 8
Outlet Structures 9
Temporary Storage Volume 10
Dam Construction and Auxiliary Spillway 10
Outfalls 11

E. Maintenance, Access and Safety 12
Planning for Maintenace Access 12
Safety Features 14

F. Landscaping 14

G. Design Alternatives 15
Recreational Features Within Basin 15
Urban Flood Storage Retrofits 16

H. Special Case Adaptations 18
Flood Plains 18
Stream Morphology 18

9.10-2 SIZING CALCULATIONS 19

A. Calculation Procedure 19

B. Calculation design example 21
Project Watershed Data 21

9.10-3 CONSTRUCTION 34

A. Pollution Prevention 34
Stormwater Pollution Prevention Plan and NPDES Permit Requirements 34

B. Construction Sequencing 37

C. Construction Observation 39
Post-Construction Documentation 40

9.10-4 MAINTENANCE 41

A. Establishment Period (Short-Term Maintenance) 41
YEAR ONE—MAINTENANCE ACTIVITIES 41
YEAR TWO AND THREE—MAINTENANCE ACTIVITIES 42

B. Routine or Longer-Term Maintenance Activities 42

9.10-5 SIGNAGE RECOMMENDATIONS 44

Refer to the glossary for words in **bold black text**.

9.10-1 LAYOUT AND DESIGN

A. SUMMARY

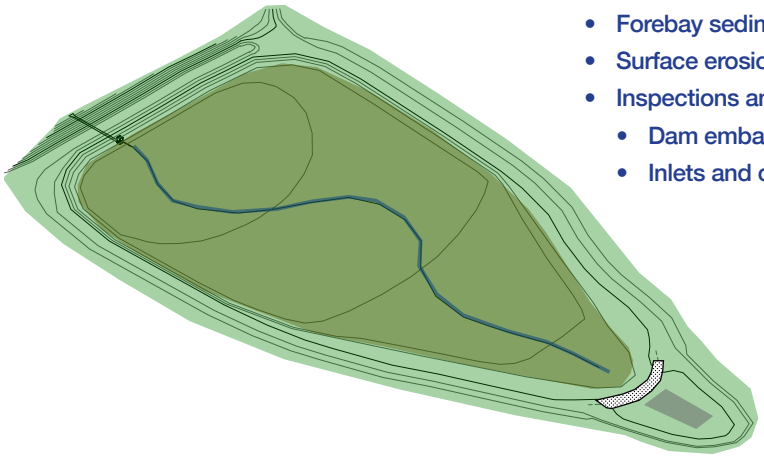
Extended Dry Detention Basins are an adaptation of Traditional Dry Detention practices. Storage volume in the detention area is created by excavation and/or construction of a dam. These basins are still called "dry" because they do not retain a permanent pool of water between rainfall events. The entire basin surface is designed to drain out after rainfall events.

These types of basins feature an outlet structure that is designed to provide **extended detention** of the CPv event (1-year, 24-hour storm). This is accomplished by providing a lower first stage of an outlet structure that is smaller, restricting flow to a point where it is slowly released over a period of no less than 24 hours. These practices still do not include features that capture and clean runoff to address the WQv **storm event**.

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

Figure 9.10-1-1: Dry ED Detention Perspective Illustration



KEY MAINTENANCE CONSIDERATIONS

Depends on type of perennial vegetation cover

Short-term

- 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 9.10–4 for more detail on maintenance requirements.

B. APPLICATION

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

ABILITY TO ADDRESS THE UNIFIED SIZING CRITERIA

Recharge Volume (Rev) and Water Quality Volume (WQv)

Extended dry detention basins are not constructed with features that maximize capture, infiltration or treatment of stormwater. **Therefore, they are not intended to meet these aspects of the USC. These practices will need to be paired with other BMPs to meet these USC requirements.** ADVISORY

Channel Protection Volume (CPv)

Outlet structures of these types of basins are designed with multi–stage outfall structures that are intended to slowly release runoff from the CPv event. Often, this results in a rate reduction of 95% or greater when comparing inflow to outflow rates. ESSENTIAL

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

Extended 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

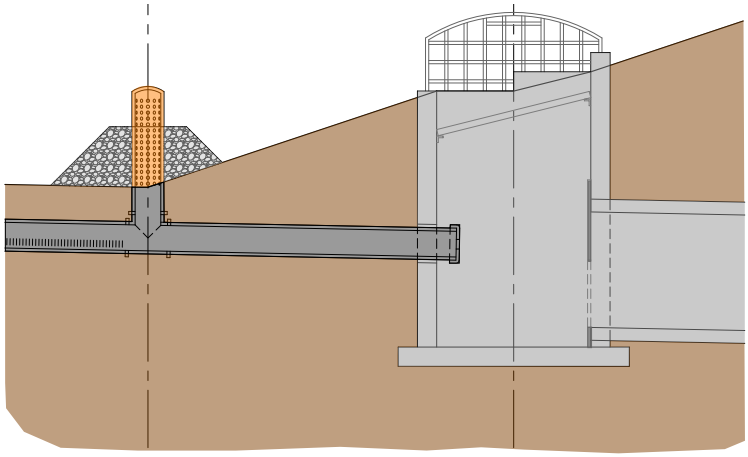
To reduce risks for vegetation, public safety and erosion, avoiding extreme ponding depths is recommended. Refer to the table below: TARGET

TABLE 9.10-1.1: MAXIMUM TEMPORARY STORAGE DEPTHS FOR EXTENDED DRY DETENTION

STORM RECURRENCE INTERVAL	PREFERRED HIGH-WATER DEPTH *	ALLOWABLE HIGH-WATER DEPTH *
CPv event	2.0 feet	2.5 feet
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 9.10-1-2: Multi-stage outlet example



NOTE

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

NOTE

Meeting CPv storage requirements often controls the bottom area required for the basin.

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. Lower stages of the basin may be planted with native vegetation acclimated to wetter conditions, or 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 might 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 or limited to the maximum extent possible. 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 9.10–2 details methods to determine the actual space a practice may require.***

SITE TOPOGRAPHY

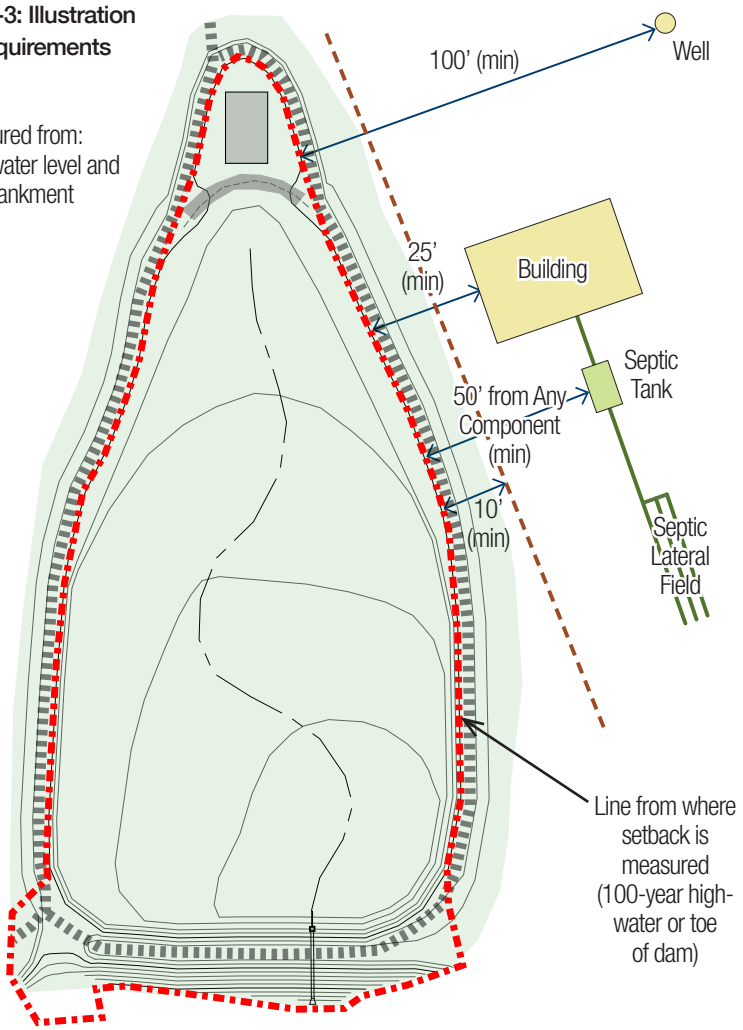
Site grading costs may be elevated at sites with steeper **topography**. Designers should consider whether the basin can be constructed by excavation into the existing surface, creation of a dam embankment or some combination of these grading methods.

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 within the basin) 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 9.10-1-3: Illustration of setback requirements

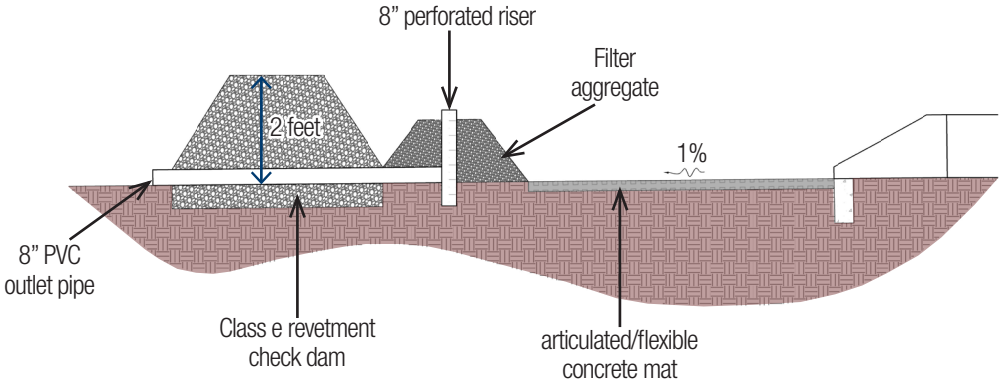


E. DESIGN ELEMENTS AND PARAMETERS

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 9.10-1-4: 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 pond, 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 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

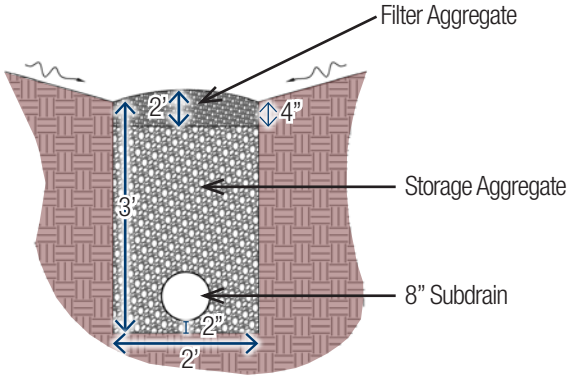
PILOT CHANNELS

Pilot channels are recommended in most applications [that may be constructed in areas] 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 9.10-1-5. 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.

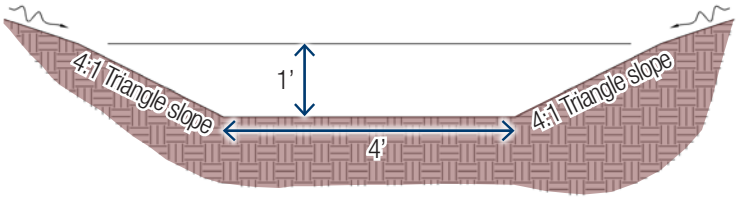
Pilot channels should have a minimum slope of 0.5% (infiltration trenches with subdrains may be flatter), with side slopes as noted on details. Channels will typically be only as deep as needed to convey daily baseflows, allowing flow to quickly spread across the bottom of the basin during storm events.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

Figure 9.10-1-5: Pilot Channel Alternatives

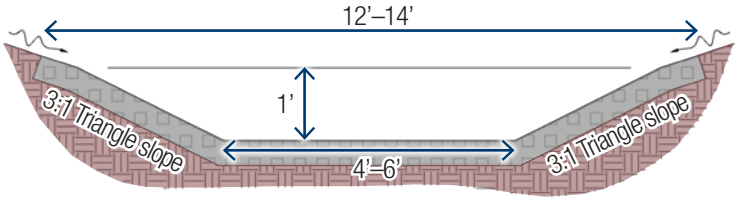
Infiltration Trench



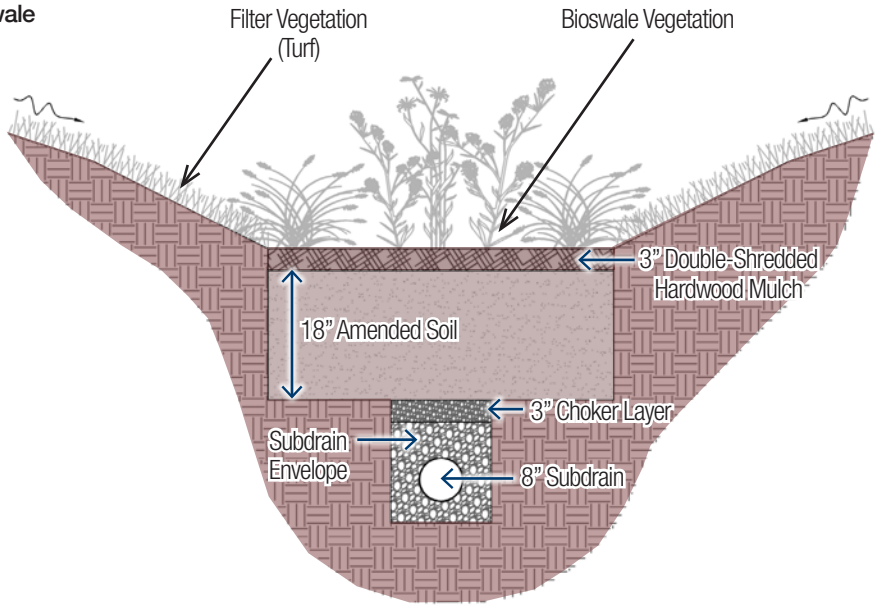
Wet Swale



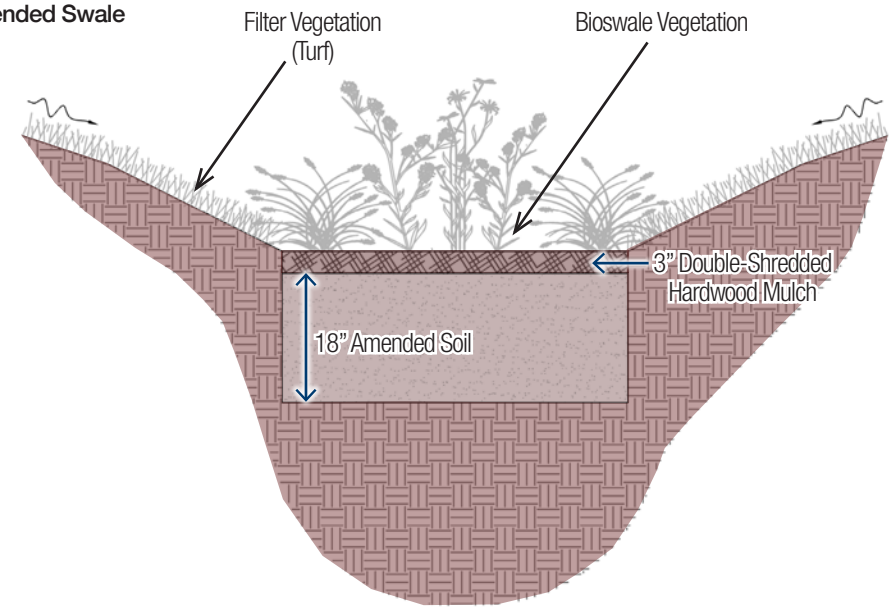
Articulated/Flexible Concrete Mats



Bioswale



Amended Swale



NOTE

Flatter bottoms may require careful plant selections.

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 9.10-1-6: Typical Features of a Dry ED Detention Basin

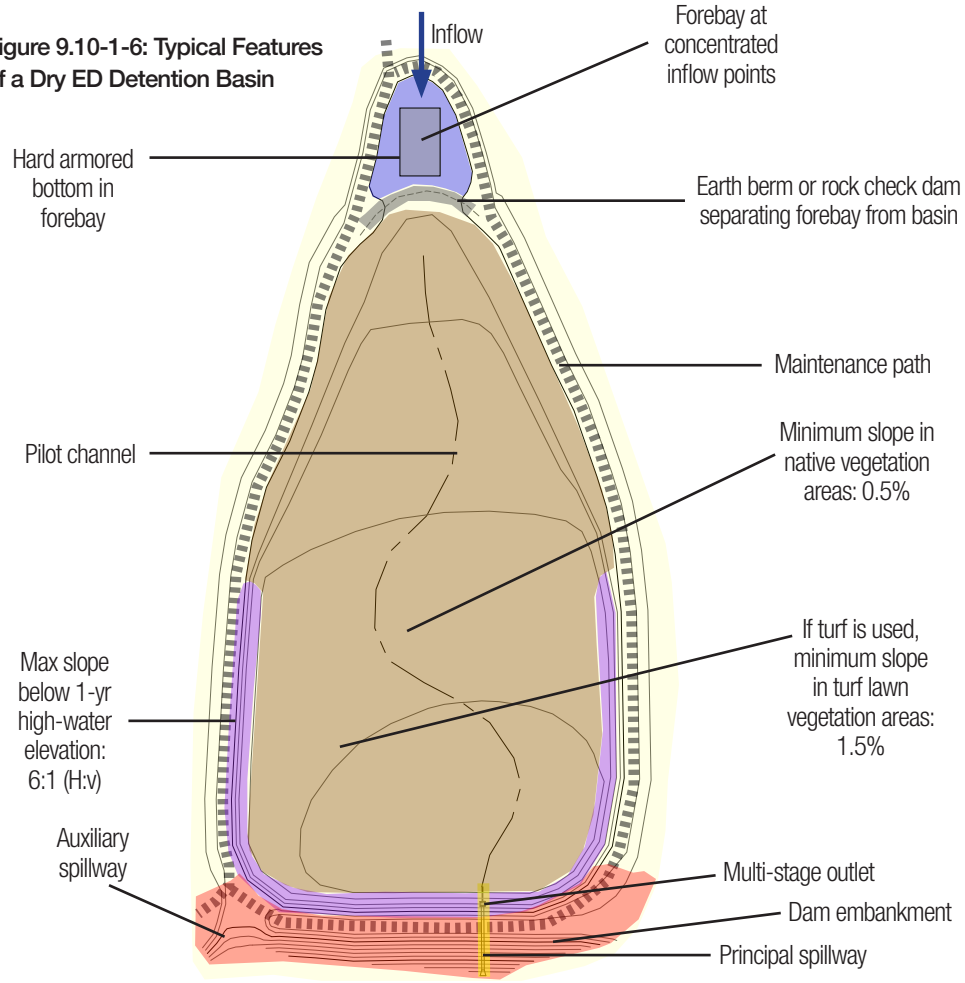
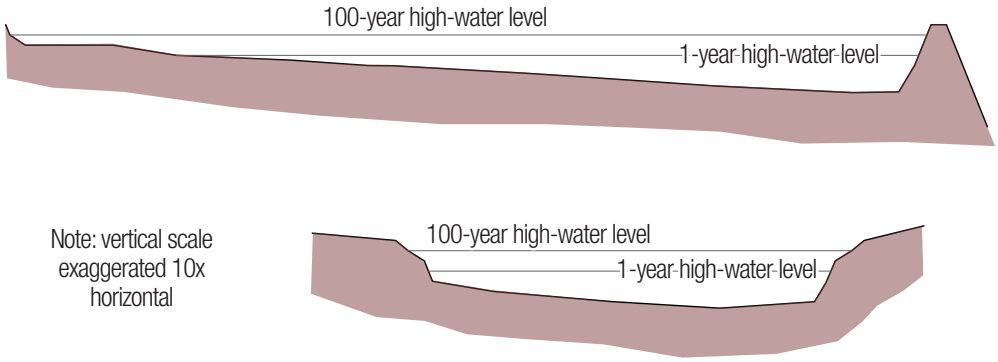


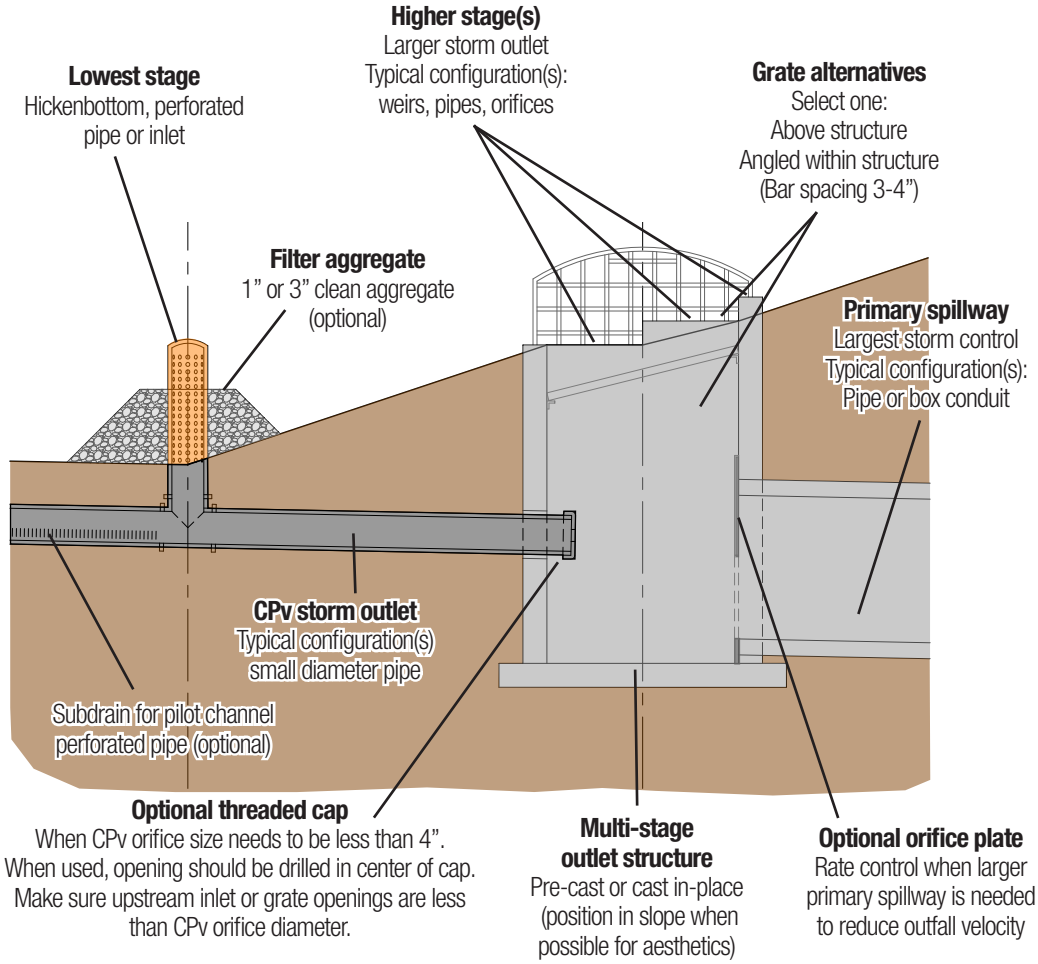
Figure 9.10-1-7: Cross-Section View Graphic of Detention Features



OUTLET STRUCTURES

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

Figure 9.10-1-8: 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 generally level as it runs along the centerline of the dam to allow it to spread over a longer width. 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 at an elevation with 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 9.10-1-9: Dam Crest Parameters

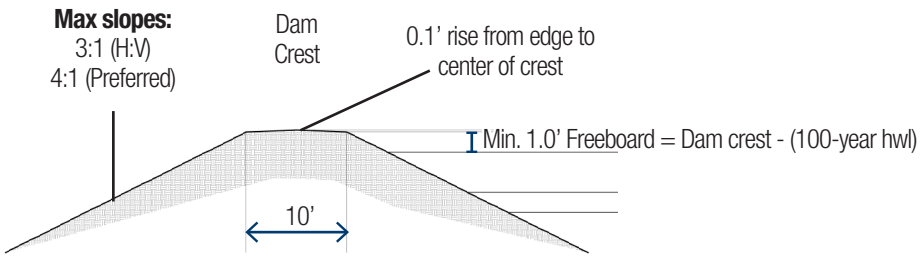
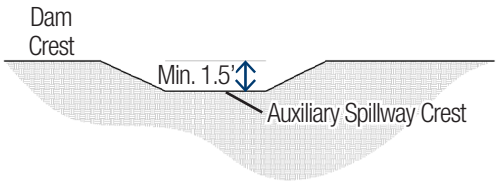


Figure 9.10-1-10: Auxiliary Spillway Parameters



OUTFALLS

Outfalls from the basin should be placed in stable locations, with adequate protection from erosion. 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 TARGET

Figure 9.10-1-11: Unstable outfall

Figure 9.10-1-11-A: Level spreader outlet structure

Heritage Park in Minneapolis, MN.
(photo courtesy - Mississippi Watershed Management Organization mwmo.org)

NOTE

When designing outfalls to waterways, pay careful attention to signs of bank erosion or **stream migration**. Avoid placement of outfalls on the outside bends of streams, where higher levels of shear stress frequently occur. Outfalls should be placed as close to the normal flow elevation as possible to reduce the potential for surface erosion or downcutting below the outlet. Revetment storm materials or other protection methods can minimize opportunities for soil erosion below or around the pipe.

Figure 9.10-1-11-B: Concrete level spread

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")*

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

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).

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, 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.** (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 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.

Figure 9.10-1-13:
Maintenance Path Needs

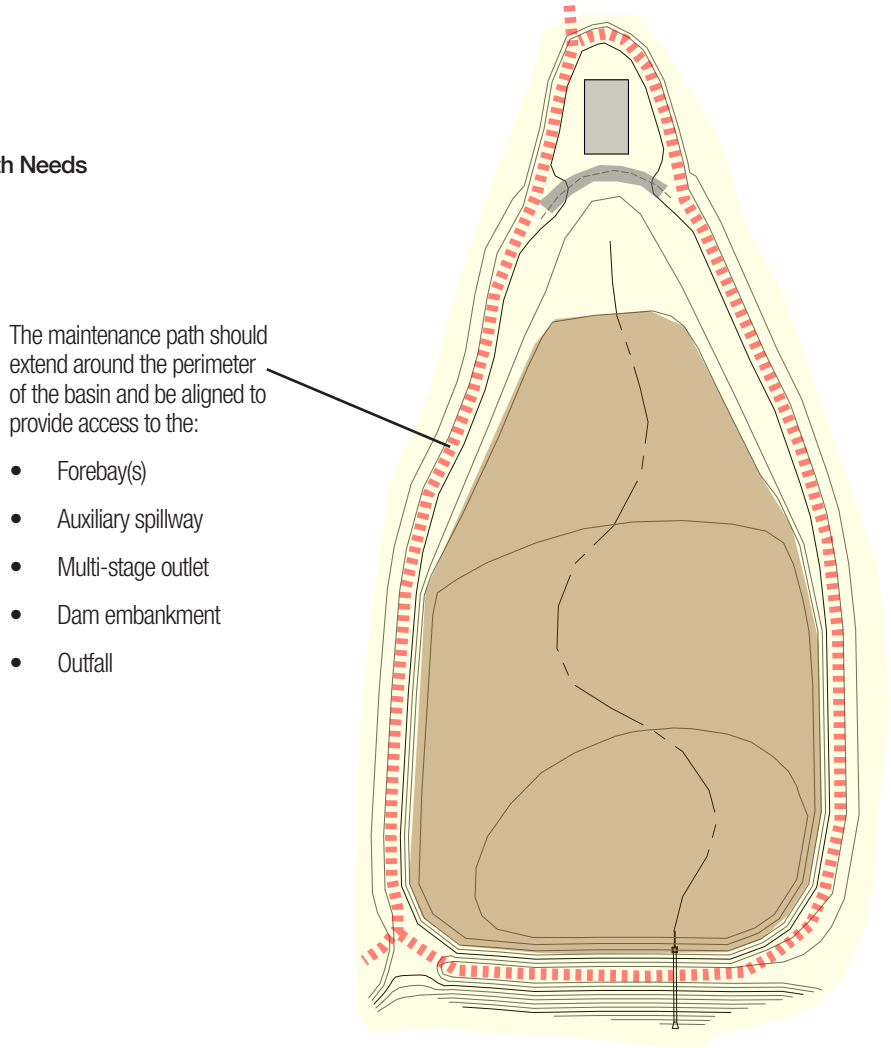
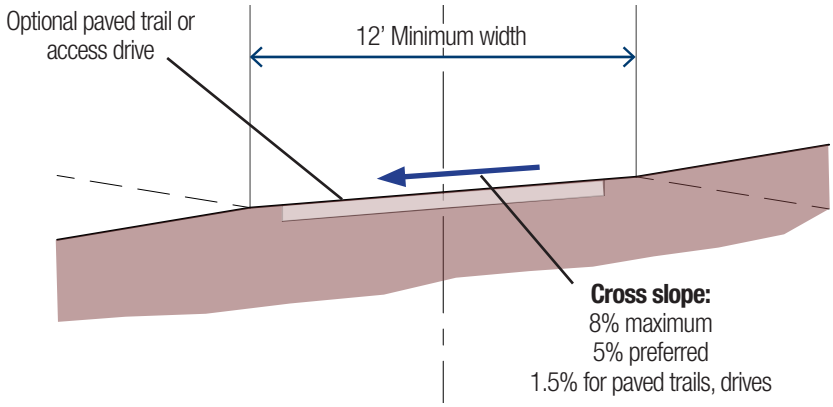


Figure 9.10-1-14:
Cross-section of maintenance path



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

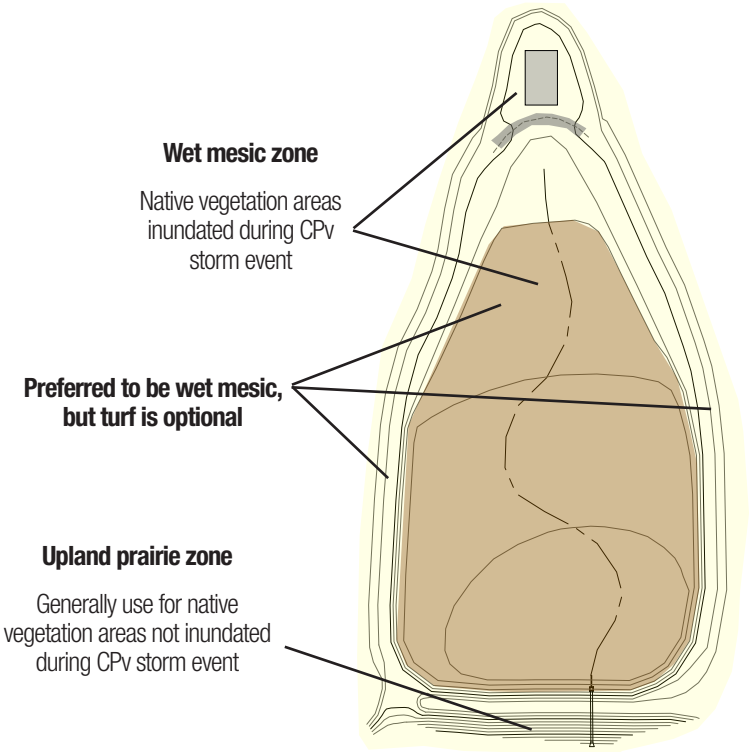
D. Pipe outfalls of greater than 48 inches in height may require a fence or railing to reduce fall risks. ESSENTIAL

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 9.10-1-15: Landscaping Zones



G. DESIGN ALTERNATIVES

RECREATIONAL FEATURES WITHIN BASIN

Extended detention facilities may be constructed with recreational features (such as soccer/football fields), playgrounds or other open spaces set on a higher plateau. These areas may be inundated by moderate to large storm events (5-year, 24-hour storm or larger), but would remain dry in most circumstances. Building structures would need to be located outside of areas expected to be inundated by the 100-year storm event.

The lower elevations of the basin would typically be maintained as native perennial vegetation, with plant selection zones determined by frequency and depth of inundation.

In these circumstances, the maximum storage depths would be amended as follows:

TABLE 9.10-1.2: MAXIMUM TEMPORARY STORAGE DEPTHS FOR EXTENDED DRY DETENTION

STORM RECURRENCE INTERVAL	PREFERRED HIGH-WATER DEPTH *	ALLOWABLE HIGH-WATER DEPTH *
CPv event	3.0 feet	3.5 feet
5-year, 24-hour duration*	4.0 feet	5.0 feet
10-year, 24-hour duration	5.0 feet	6.0 feet
100-year, 24-hour duration	7.0 feet	8.0 feet

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

** All recreational features should be set above the expected high-water elevation of the 5-year, 24-hour duration storm event.

URBAN FLOOD STORAGE RETROFITS

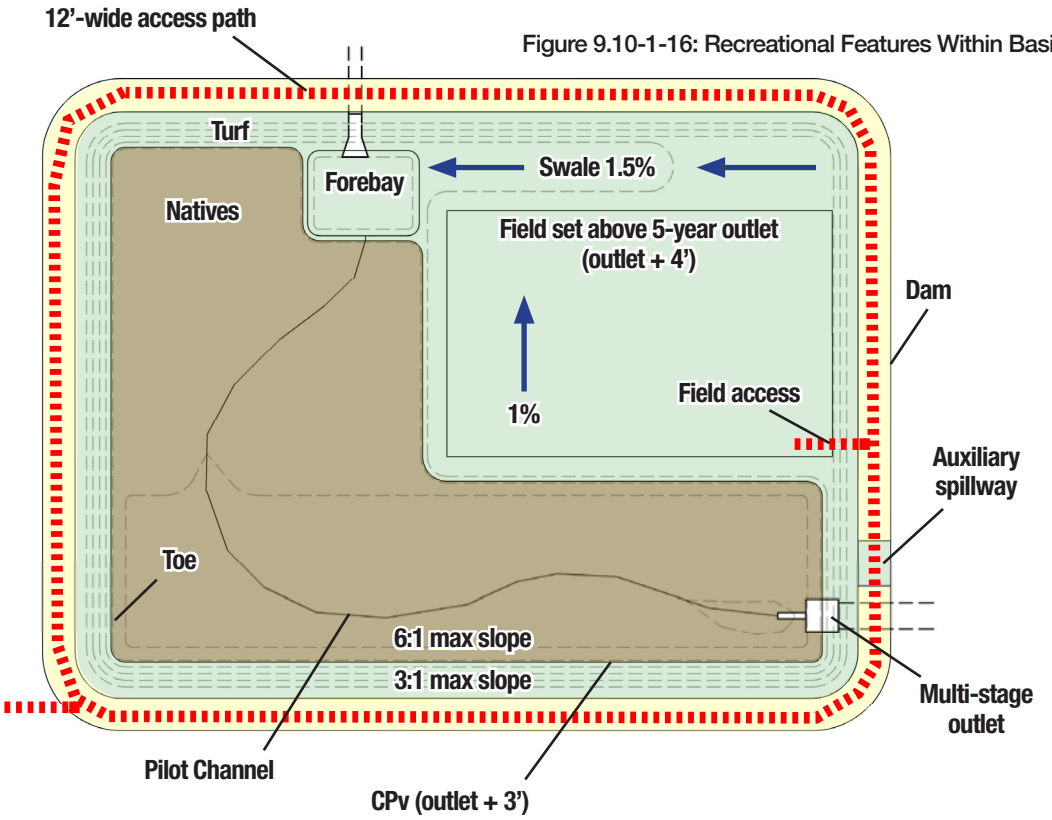


Figure 9.10-1-16: Recreational Features Within Basin

In the past, some detention facilities have been constructed in flood-prone areas to provide local flood control. These systems were often designed without thought of providing management of small storm events. These sites may be candidates for retrofits to provide extended detention.

There may be other heavily developed areas in which new stormwater facilities could be constructed to provide additional flood storage. Many of these types of practices were/are constructed with deeper ponding depths, so they can maximize flow reduction within the available surface area.

In such circumstances, the maximum storage depths would be amended as follows:

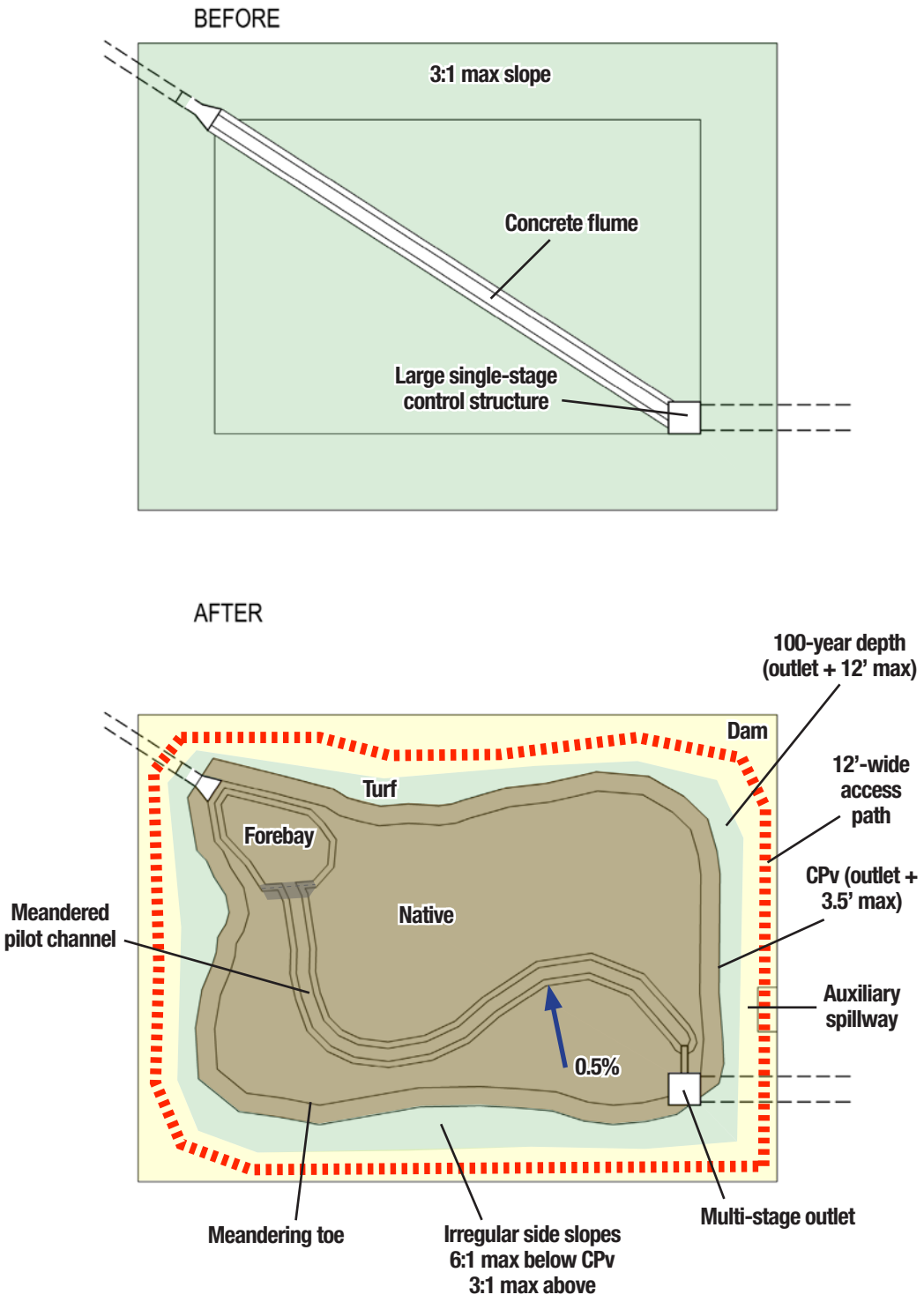
TABLE 9.10-1.3: MAXIMUM TEMPORARY STORAGE DEPTHS FOR EXTENDED DRY DETENTION

STORM RECURRENCE INTERVAL	PREFERRED HIGH-WATER DEPTH *	ALLOWABLE HIGH-WATER DEPTH *
CPv event	3.0 feet	3.5 feet
10-year, 24-hour duration	6.0 feet	7.0 feet
100-year, 24-hour duration	10.0 feet	12.0 feet

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

Due to the potential for deeper water occurring more frequently, signage should provide the public with information about the potential for rapidly rising water levels. Alternatively, access could be restricted by fencing or other means. However, it is always encouraged, to the greatest extent possible, to develop stormwater management systems that treat water as a valuable resource and encourage safe public access to make the best use of that resource.

Figure 9.10-1-17: Flood Control Basin Retrofit



H. SPECIAL CASE ADAPTATIONS

FLOOD PLAINS

It is preferred that dry ED 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

NOTE

Locating dry ED 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

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.

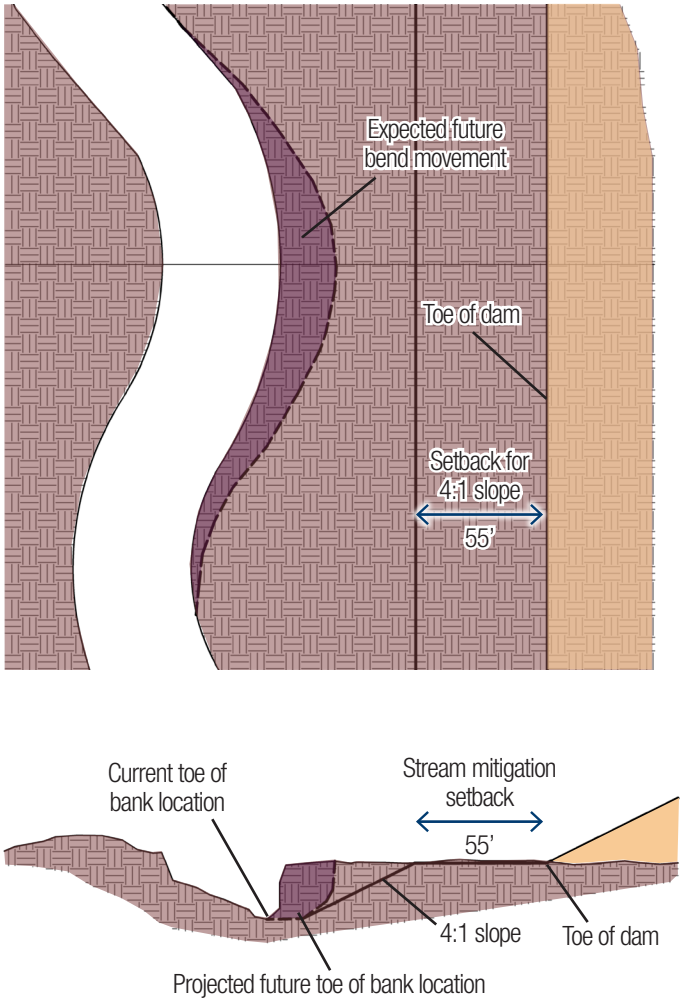


Figure 9.10-1-18: Stream Morphology Considerations

9.10-2 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 9.10–1.

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. Note that the release rate for the CPv event is determined by methods outlined in Section 3.02.

TABLE 9.10-2.1: 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)

Step 4. Estimate required storage volumes to meet the aspects of the Unified Sizing Criteria to be managed by the practice. For extended dry detention practices, this is typically the CPv 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.

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 9.10-1.1 for maximum storage depth requirements for key storm events.

NOTE

Refer also to IDNR Form 542–1014.

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.

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 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 9.10-1.1.

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. CALCULATION DESIGN EXAMPLE

PROJECT WATERSHED DATA

TABLE 9.10-2.2: 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 an extended dry detention basin. Consider the Application and Feasibility criteria in Section 9.10-1.

For this example, assume site feasibility criteria have been reviewed and the site is suitable for an extended dry detention basin. The recharge and water quality volume are treated upstream.

Step 2. Confirm any state, federal 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.

Refer to Section 9.10-1.H. For this example, the basin 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).

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

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 ISWMM and requires the following related to application of the Unified Sizing Criteria.

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

- 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 shall 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. 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. Note that the release rate for the CPv event is determined by methods outlined in Section 3.02.

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 pre–settlement conditions.

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 9.10-2.3: TABLE C8-3: 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

A *Water Quality Volume*

- Calculate the WQv volume required to be treated to size forebay

TABLE 9.10-2.4: TABLE C8-4: 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%**

NOTE

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

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**

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 9.10-2.5: 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 9.10-2.6: 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	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)

- 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.

Since we are treating the channel protection volume, follow steps A-F below to determine the storage requirements to provide the extended detention. For the other storm events, (qo / qi) is determined by the jurisdictional release rate requirements (i.e. qo is the minimum of the pre-settlement conditions and the 5-year existing outflow rates). For events larger than the 1-year, 24-hour, skip steps A-D.

A. For CPv, the total runoff volume (Qa) from Table C8-6. 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

B. 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)

C. 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)

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

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

E. The estimated storage required can be calculated using the equation below…

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

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

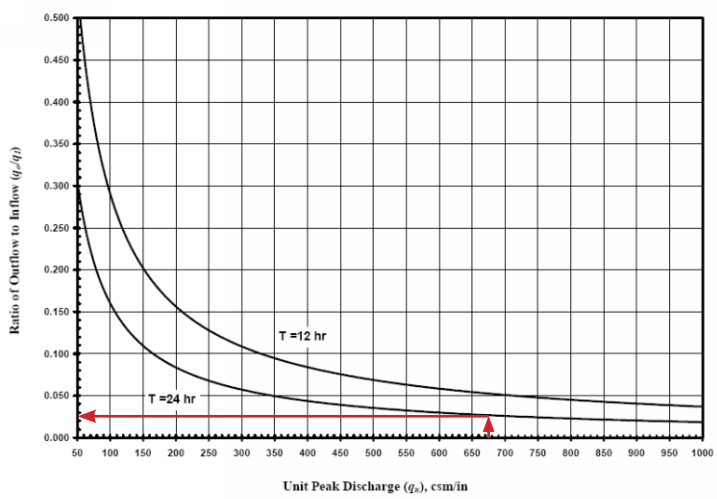


Figure C3-S6- 1: Detention time vs. discharge ratios (qo/qi)

F. 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 = 234,000 CF

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.

Step 4. Estimate required storage volumes to meet the aspects of the Unified Sizing Criteria to be managed by the practice.

For extended dry detention practices, this is typically the CPv 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.

The estimated storage volumes for each storm event are summarized below. Note that for all events except the 100-year, the outflow will be restricted to the pre-settlement conditions. The 100-year event will be restricted to the 5-year, 24-hour existing conditions.

TABLE 9.10-2.7: INITIAL ESTIMATES OF REQUIRED DETENTION

STORM EVENT	QO (CFS)	QI (CFS)	QO/QI	VS/VR	VR (CF)	VS (CF)	VS *1.15 (CF)
1-year	3.1	106	0.03	0.6431	364,000	234,000	269,200
2-year	6.3	136	0.05	0.6203	463,000	287,195	330,300
5-year	15	193	0.08	0.5808	655,000	380,406	437,500
10-year	26	249	0.11	0.5489	846,000	464,338	534,000
25-year	48	336	0.14	0.5095	1,150,000	585,970	673,900
50-year	70	412	0.17	0.4837	1,420,000	686,806	789,800
100-year	95	494	0.19	0.4633	1,710,000	792,231	911,100

The same equation used to estimate storage required for CPv can be used to calculate estimated storage for other larger events.

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

Step 5. Determine pre-treatment 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).

Pre-Treatment Measure #1 – 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)*

- 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 10,367 CF of storage (20,733 CF / 2). In reality, the outflow rates from each subwatershed should be calculated seperately and the forebays should be sized proportionately.

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 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 9.10-1.1 for maximum storage depth requirements for key storm events.

- To start, select a preliminary elevation for the basin bottom.

For this example, we are using elevation 100 as the expected basin bottom.

- Next, figure the area required to provide the estimated CPv calculated in Step 4 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. We will use native vegetation, so the minimum basin bottom 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.

Start with a desired footprint shape; in this case, the basin is generally triangular to align with the sub-watershed boundaries. This basin must drain down completely, so the area of the first contour at elevation 100.00' is effectively 0 square feet. We intend to plant native Iowa species, so the minimum slope is 0.5%. The maximum recommended slope is 6:1. Use this range to set the next two contours, maintaining the desired footprint shape.

NOTE

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 and potential utility conflicts, as well as inflow and outflow conditions to determine the best elevation for the basin bottom.

TABLE 9.10-2.8: ESTIMATED CONTOUR AREA/STORAGE BELOW CPV TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)	TARGET VOLUME VS X1.15 (CUBIC FT)
0	100	-	-	-	-
1	101	30,515	15,402	15,402	-
2	102	129,674	80,095	95,497	269,200

The storage provided at the 2-ft stage is less than the CPv. Since there the minimum basin slope is 0.5%, it may be difficult to acquire additional storage in the given footprint shape. Check the storage provided at 3 feet; if the storage is still insufficient, consider a different footprint shape. Since the high-water mark from the CPv is expected to be above the 2-ft contour, the basin side slopes should continue to be no steeper than 6:1.

TABLE 9.10-2.9: ESTIMATED CONTOUR AREA/STORAGE ABOVE CPV TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)	TARGET VOLUME VS X1.15 (CUBIC FT)
3	103	290,000	210,540	306,037	534,000

The total storage at 3 feet satisfies the CPv, but not the 10-year event. Set the next 2 contours at slopes no steeper than the recommended 4:1, and check the storage provided.

TABLE 9.10-2.10: COMPARISON OF ESTIMATED REQUIRED / PRELIMINARY DESIGN STORAGE VOLUMES

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)	TARGET VOLUME VS X1.15 (CUBIC FT)
4	104	307,135	296,548	602,584	-
5	105	315,247	311,191	913,775	911,100

The 10-year storage is provided between the 3- and 4-ft contours, and the 100-year is satisfied below the 5-ft contour. Accept this as the preliminary stage-storage relationship. We will provide an auxiliary spillway at elevation 105.00' to allow flows in excess of the 100-year to pass without overtopping the embankment.

Step 7. Investigate potential pond/wetland hazard classification.

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:

- The dam has an emergency spillway, and has a sum of 914,000* CF of temporary storage (nearly 21.0 **acre-feet**). For this grading plan, the dam has a height of less than 5 feet (basin 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 basin provides no permanent storage and 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 basin is within an incorporated area. The total storage is 21.0 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.

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.

"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' (to provide sufficient cover). 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 95 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) =	*102.0*	*(CPv target high-water)*
	– 93.0	*(flowline of pipe)*
	– 1.5	*(assumed radius of pipe)*
	= 7.5	**feet**

A = 95 cfs / [0.6 x (2 x 32.2 x 7.5)$^{1/2}$] = **7.2 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).

Our goal is to limit outflow from the CPv (1-year, 24-hour) event to 3.2 cfs (from Step 4).

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

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	*(centerline of orifice)*
	= 2.0	**feet**

A = 3.2 cfs / [0.6 x (2 x 32.2 x 2.0)$^{1/2}$] = **0.470 SF**

r = (A / π)$^{1/2}$ = (0.470 SF / π)$^{1/2}$ = **0.386 feet, OK**

d = 2r = 0.764 feet (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 3.46 cfs during the CPv event (< 3.2 cfs, **NOT OK**) The orifice was adjusted down to 8" to reduce the outflow rate further.

CULVERT/ORIFICE	A	B	C
Rise	36"	9"	8"
Span	36"	9"	8"
Invert Elevation	93.00'	99.63'	99.67
Length	100'	40'	40'
Slope	0.50%	0.00%	0.00%
N-Value	0.013	0.013	0.013
Orifice Coefficient	0.6	0.6	0.6
Multi-Stage	NA	Yes	Yes
Active	Yes	Iteration 1	Iteration 2

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 102.80—a 4'-long rectangular weir (could be the front face of a 4' x 4' inlet structure).

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

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.

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.

TABLE 9.10-2.11: ITERATIONS OF WEIR LENGTHS, GIVEN WATER SURFACE TARGETS

WEIR	A	B	C	D
Weir Type	Rectangular	Rectangular	Rectangular	Broad-Crested
Crest Elevation	102.80'	103.80'	104.30'	105.00'
Crest Length	Varies per iteration			40.0'
Weir Coefficient	3.33			2.6
Multi-Stage	Yes			No
Active (Iteration No.)	3–7	4–7	5–7	Yes

Entering the 4' weir (Weir A) into the software program yields an outflow rate of 14.4 cfs during the 10-year event (< 26.4 cfs from Step 4, **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.

Try setting a third stage at elevation 103.80'—A 12' long rectangular weir (remaining three sides of the 4' X 4' inlet structure). For this example, we will set the emergency spillway above the desired high-water elevation for the 100-year event.

Entering the 12' weir (Weir B) and emergency spillway (Weir C) into the software program yields an outflow rate of 108 cfs during the 100-year event (> **95** cfs from Step 3c, **NOT OK**) Since the emergency spillway is designed to only pass events larger than the 100-year event, the multi-stage outfall must limit the outflow to the 100-year release rate of 95 cfs. Downsize the outfall pipe to 33" in diameter.

Try setting a fourth stage elevation at 104.30'—a 4' rectangular wier (the remaining side of the 4' x 4' inlet structure).

Iteration 5: Enter the length of Weir B as 8'. Add a third weir to the multistage outlet (Weir C) at elevation 104.30' and try 4' long. This iteration has an acceptable flow rate of 88.25 cfs (< 95) but has a high water surface elevation at 105.04 (> 105.00', **NOT OK**)

For Iteration 5, raising the emergency spillway slightly so it would not be overtopped would be another option that could have been pursued.

Iteration 6: Adjust the weir sizes to 8' for Weir A, 4' for Weir B, and 4' for Weir C. This configuration does not overtop (104.97' < 105.00', OK), but the 50-year flow rate is 71 cfs (> 70 cfs, **NOT OK**)

Iteration 7: Adjust the weir sizes to 6' for Weir A, 6' for Weir B, and 4' for Weir C. This configuration does not overtop (105.00' is right at the overflow weir, Weir D) and passes 89 cfs (< 95 cfs, **OK**). The smaller events also pass less than the maximum allowable for each event. Accept this outfall configuration.

The design iterations are summarized in the table below. For the final iteration (iteration 7), the projected release rates for each event are below the maximum allowable release rate.

TABLE 9.10-2.12: SUMMARY OF OUTFALL DESIGN ITERATIONS 2-4 AND RESULTS

		RESULTS OF DESIGN ITERATIONS							
ITERATION		1	2	3	4	5	6	7	
Culvert A		36"	36"	36"	36"	33"	33"	33"	Elev = 93.00'
Culvert B		9"							Elev = 99.63' *
Culvert C			8"	8"	8"	8"	8"	8"	Elev = 99.67' *
Weir A				4'	4'	4'	8'	6'	Elev = 102.80'
Weir B					12'	8'	4'	6'	Elev = 103.80'
Weir C						4'	4'	4'	Elev = 104.30'
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	HIGH-WATER ELEV. (ITERATION #7)
1-year (CPv)	3.1	3.5	2.8	2.8	2.8	2.8	2.8	2.8	Elev = 102.73'
2-year	6.3	3.7	3.0	4.3	4.3	4.3	5.1	4.7	Elev = 103.00'
5-year	15	4	3	9	9	9	12	10	Elev = 103.31'
10-year	26	4	3	14	14	14	21	18	Elev = 103.62'
25-year	48	5	overtop	26	33	33	44	37	Elev = 104.12'
50-year	70	overtop	overtop	38	61	33	71	63	Elev = 104.54'
100-year	95	overtop	overtop	overtop	99	overtop	90	89	Elev = 105.00'

* Actual invert elevation is intended at 100.00', and set lower in the software program to evaluate the routing at pipe centerline

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 9.10-1.1.

The high-water elevations are in compliance for the 10-year year and 100-year design storms, but not for the CPv. Adjust the stage storage relationships to provide maximum water surface elevations within the acceptable range. The slopes around the perimeter (above the CPv) may not be steeper than 4:1.

TABLE 9.10-2.13: ESTIMATED CONTOUR AREA/STORAGE ABOVE CPV TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)	TARGET VOLUME VS X1.15 (CUBIC FT)
0	100	-	-	-	
1	101	75,195	37,742	37,742	
2	102	231,890	153,542	191,284	269,200
3	103	395,569	313,729	505,013	534,000
4	104	404,701	400,135	905,148	
5	105	413,935	409,318	1,314,466	911,100

The high water elevations and outflows indicate that the fourth weir stage is not necessary. The final multi-stage configuration and routing results are listed in the following table:

NOTE

The temporary storage depth of 2.73' found in Step 8, exceeds the required level of 2.50'.

TABLE 9.10-2.14: RESULTS OF DESIGN ITERATIONS

ITERATION		8	
Culvert A		33"	Elev = 93.00'
Culvert C		8"	Elev = 99.67' *
Weir A		4'	Elev = 102.80'
Weir B		12'	Elev = 103.80'
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (ITERATION #7)
1-year (CPv)	3.1	2.5	Elev = 102.21'
2-year	6.3	2.6	Elev = 102.49'
5-year	15	4	Elev = 102.98'
10-year	26	9	Elev = 103.24'
25-year	48	14	Elev = 103.65'
50-year	70	24	Elev = 103.99'
100-year	95	43	Elev = 104.32'

* Actual invert elevation is intended at 100.00', and set lower in the software program to evaluate the routing at pipe centerline

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.

Since the final release rates in this design example for larger events are well below what is allowed to be discharged. The basin outlet controls could be adjusted to allow more flow which might allow the basin size to be reduced.

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).

From the continuity equation, check the velocity of the outfall pipe based on the 100-year rate of 43.57 cfs and the design diameter 33 inches.

43.57 cfs = 5.9 square feet x V
43.57 cfs / 5.9 square feet = V = 7.34 fps

In this example, flow is connecting to a storm sewer system, and this velocity is acceptable. If this pipe were directed to the ground surface, some protections against erosion may be necessary. 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 emergency spillway (if any overflow occurs during the 100-year 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.

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.

9.10-3 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 9.10-3-1A: Construction Stage Features and Controls

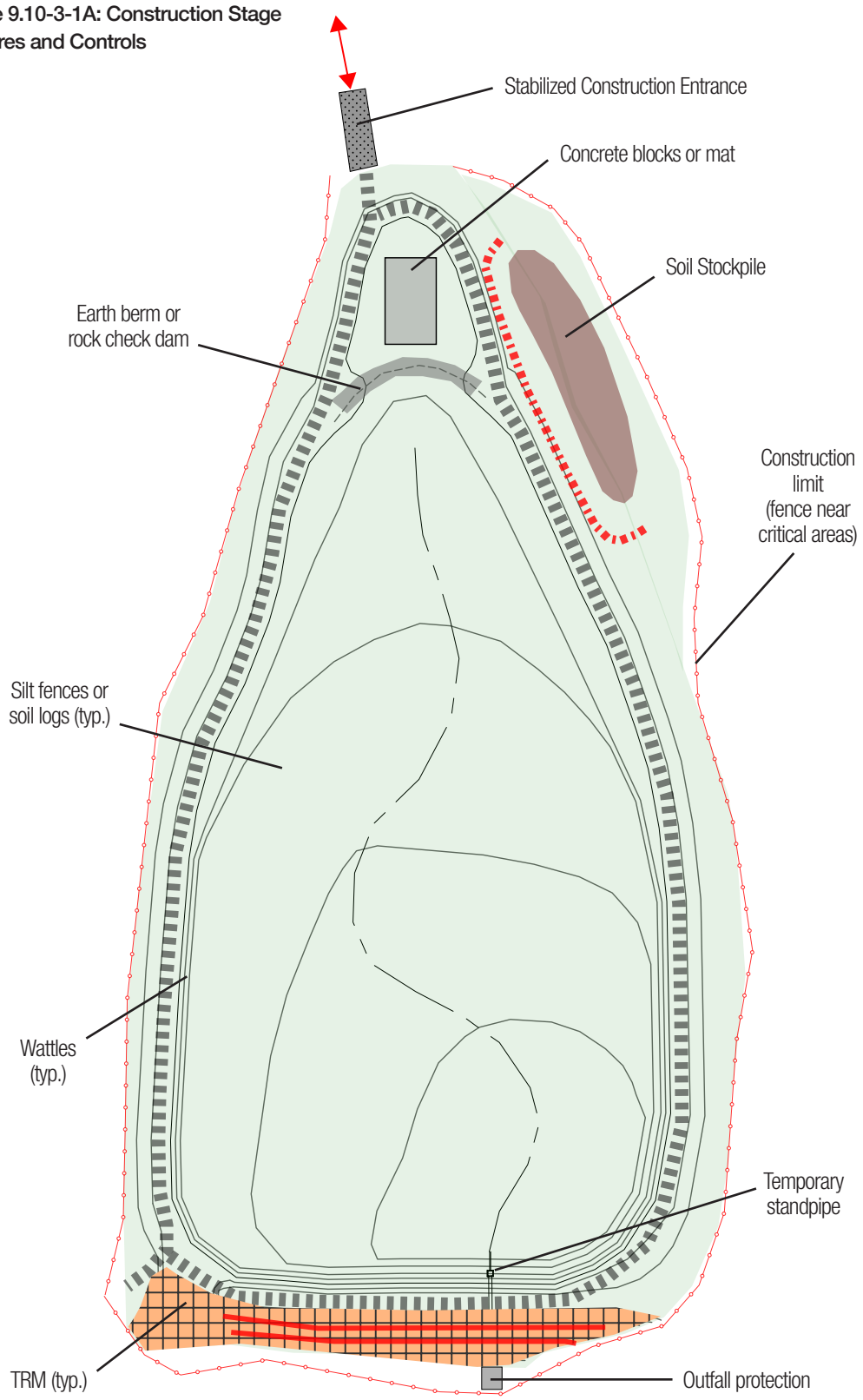
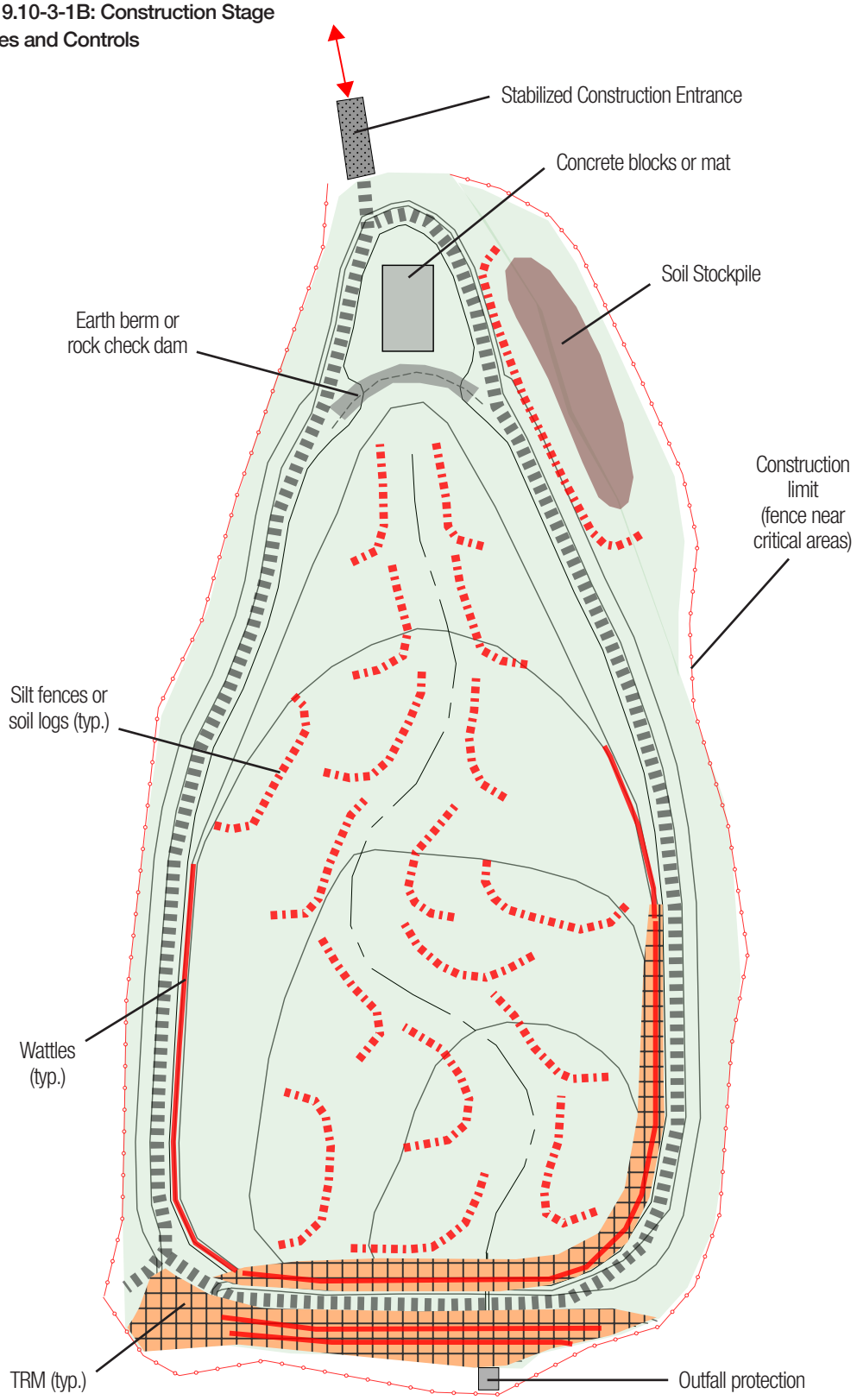


Figure 9.10-3-1B: Construction Stage Features and Controls



B. CONSTRUCTION SEQUENCING

Major construction operations to create extended dry detention practices 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 9.10-3-2: 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.

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.

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

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, limit the potential for sheet and rill erosion across slopes and prepare the soil for seedbed preparation.

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 and a diverse system of desired native 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.
- 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.
- Verify that exterior sediment and erosion BMPs are in place prior to initiation of site-disturbing activities.
- Throughout construction, work with the erosion and sediment control contractor to coordinate proper installation of all BMPs.
- As per Construction Sequencing item #6, review results of an as-built or record survey to 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.

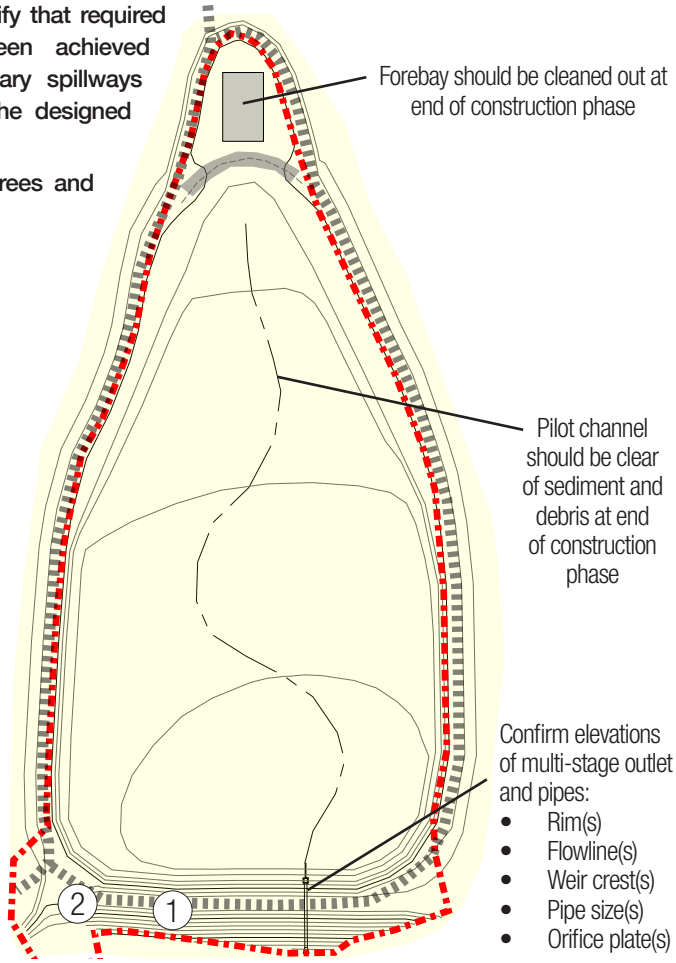


Figure 9.10-3-3: Features to Check Post-Construction

9.10-4 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.

NOTE

When applying herbicides on turf areas adjacent to native planting areas, be careful not to overspray or allow applied chemicals to wash into native planting areas.

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 dry ED 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.

9.10-5 SIGNAGE RECOMMENDATIONS

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 9.10-5-1: Signage example

IOWA STORM WATER MANAGEMENT MANUAL

9.11 WET DETENTION PONDS

IOWA DEPARTMENT OF NATURAL RESOURCES

TABLE OF CONTENTS

CONTENTS

9.11-1 LAYOUT AND DESIGN 1

A. Summary 1

B. Application 2
Ability to Address the Unified Sizing Criteria 2

C. Site Feasibility 3
Soils 3
Minimum Depth to Water Table 3
Existing Vegetation 3
Existing Wetlands 3
Tributary Drainage Area 4
Space Required 4
Site Topography 4

D. Setbacks 4

E. Design Elements and Parameters 6
Pre-Treatment 6
Temporary Storage Volume 6
Pond Shape and Size 6
Pool Depth and Slopes 7
Safety Bench/Pond Edge 9
Shoreline Erosion Protection 10
Fishing Nodes 10
Subsurface Habitat Improvements 10
Perimeter Slopes 11
Outlet Structures 11
Dam Construction and Auxiliary Spillway 13
Outfalls 14

E. Maintenance, Access and Safety 16
Planning for Maintenace Access 16
Safety Features 17

F. Landscaping 17

G. Design Alternatives 18

H. Special Case Adaptations 18
Flood Plains 18
Stream Morphology 19

9.11-2 SIZING CALCULATIONS 20

A. Calculation Procedure 20

B. Design Example 22
Detailed Design of Forebay 32

9.11-3 CONSTRUCTION 35

A. Pollution Prevention 35
Stormwater Pollution Prevention Plan and NPDES Permit Requirements 35

B. Construction Sequencing 37

C. Construction Observation 39
Post-Construction Documentation 40

9.11-4 MAINTENANCE 42

A. Establishment Period (Short-Term Maintenance) 42
YEAR ONE—MAINTENANCE ACTIVITIES 42
YEAR TWO AND THREE—MAINTENANCE ACTIVITIES 43

B. Routine or Longer-Term Maintenance Activities 43

9.11-5 SIGNAGE RECOMMENDATIONS 45

Refer to the glossary for words in **bold black text**.

9.11-1 LAYOUT AND DESIGN

A. SUMMARY

Wet detention ponds have been a common practice to manage stormwater runoff. Typically they have been designed as an aesthetic feature or to reduce runoff from larger **storm events**. These practices can improve **water quality**, provide valuable habitat and create opportunities for recreation.

These features are intended to maintain a permanent pool of water. For this reason, the practice must receive runoff from a large enough **watershed** to fill and sustain that pool.

Wet ponds use water as a resource, creating amenities in parks or other spaces open to the public. People might see these areas as a place to fish, birdwatch or go for a walk, without understanding the stormwater management function of the practice. These practices address the "triple bottom line"—features that provide social, environmental and financial benefits to the community. To realize these benefits, a number of skill sets and disciplines may be involved in their planning, design, construction and maintenance.

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

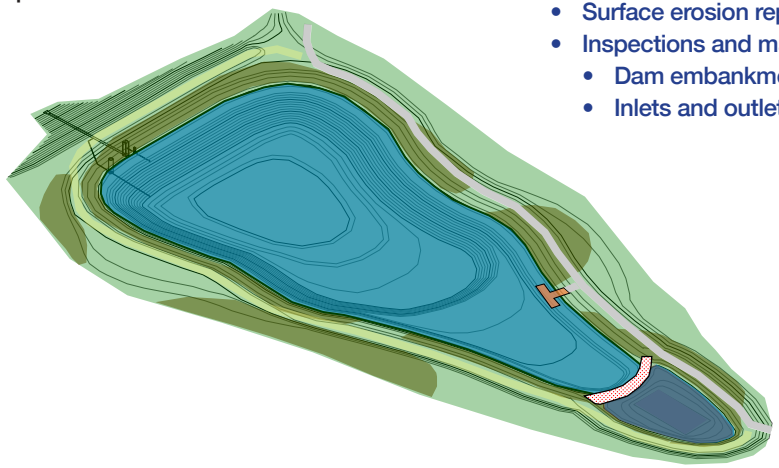
Depends on type of perennial vegetation cover

Short-term
- 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

Figure 9.11-1-1: Wet Detention

Perspective Illustration



NOTE

See Section 9.11–4 for more detail on maintenance requirements.

B. APPLICATION

Wet detention ponds must have enough watershed area to maintain a permanent pool and must maintain a proper ratio of watershed area to pond surface area. They can address most aspects of the Unified Sizing Criteria.

ABILITY TO ADDRESS THE UNIFIED SIZING CRITERIA

Recharge Volume (Rev)

Wet basins do not include features to reduce overall runoff volume. Therefore, they will need to be paired with other BMPs to meet Recharge Volume requirements. ADVISORY

Water Quality Volume (WQv)

Wet detention ponds have a demonstrated ability to improve water quality through **settling** and biological processes. **WQv requirements are addressed by providing storage of 2 x WQv in the permanent pool** (dead storage). ESSENTIAL

Channel Protection Volume (CPv)

These types of basins are designed with multi–stage outfall structures that are intended to slowly release runoff from the CPv event. This often results in a rate reduction of 95% or greater when comparing inflow to outflow rates. ESSENTIAL

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

Wet ponds typically have sufficient surface area 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

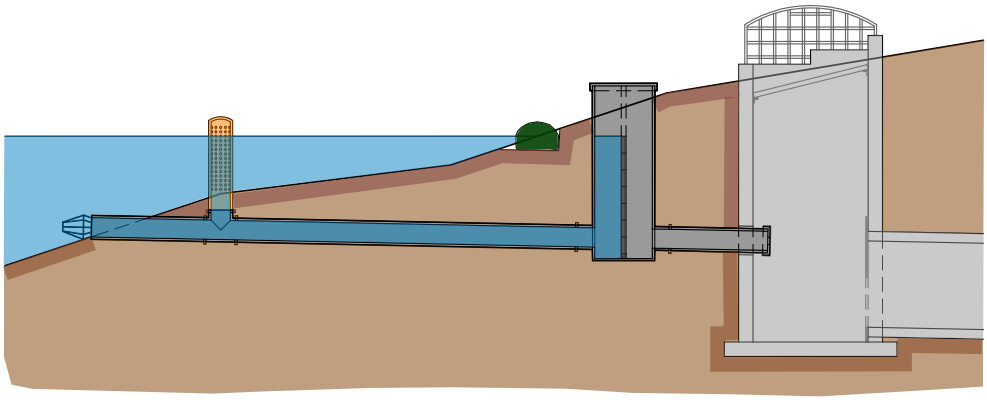
To reduce risks for vegetation, public safety and erosion, avoiding extreme ponding depths is recommended. Refer to the table below: TARGET

TABLE 9.11-1.1: MAXIMUM TEMPORARY STORAGE DEPTHS FOR WET PONDS

STORM RECURRENCE INTERVAL	PREFERRED HIGH-WATER DEPTH *	ALLOWABLE HIGH-WATER DEPTH *
CPv event	2.0 feet	2.5 feet
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 9.11-1-2: Multi-Stage Outlet Example



C. SITE FEASIBILITY

SOILS

Native soils of **hydrologic** soil groups C and D can often create a clay **liner** to maintain the permanent pool. In some cases, selective removals and replacements may be needed to seal off sand seams or other paths for water loss. **Bentonite** materials and synthetic liners can sustain the permanent pool at sites without sufficient native soil materials to create an adequate liner. County soil map information (NRCS Web Soil Survey) may be used for initial site screening. Consult a geotechnical engineer or a soil scientist on a case-by-case basis for final design.

MINIMUM DEPTH TO WATER TABLE

There are no constraints at most sites. At locations within 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 pond 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.

EXISTING VEGETATION

Impacts to prairie remnants, established native vegetation or well–maintained savanna woodland areas should be avoided or limited to the maximum extent possible. 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

Wet ponds should have a minimum drainage area of 10 acres. The recommended minimum watershed-to-pond surface area ratio is 12:1 (especially for recreational lakes where fishing is desired), with 20:1 being preferable. Ratios lower than these values are desirable. TARGET

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 and to meet the watershed to pond surface area ratios, 5–12% of the tributary drainage area may be required. ***This value is only an estimate to be used very early in the design process. Section 9.11–2 details methods to determine the actual space a practice may require.***

SITE TOPOGRAPHY

Site grading costs may be elevated at sites with extreme **topography** (either very steep or very flat). Sites with a natural valley or depression may require less earthwork to achieve required pool storage volumes. Designers should consider if the basin can be constructed by excavation into the existing surface, creation of a dam embankment or some combination of these grading methods.

NOTE

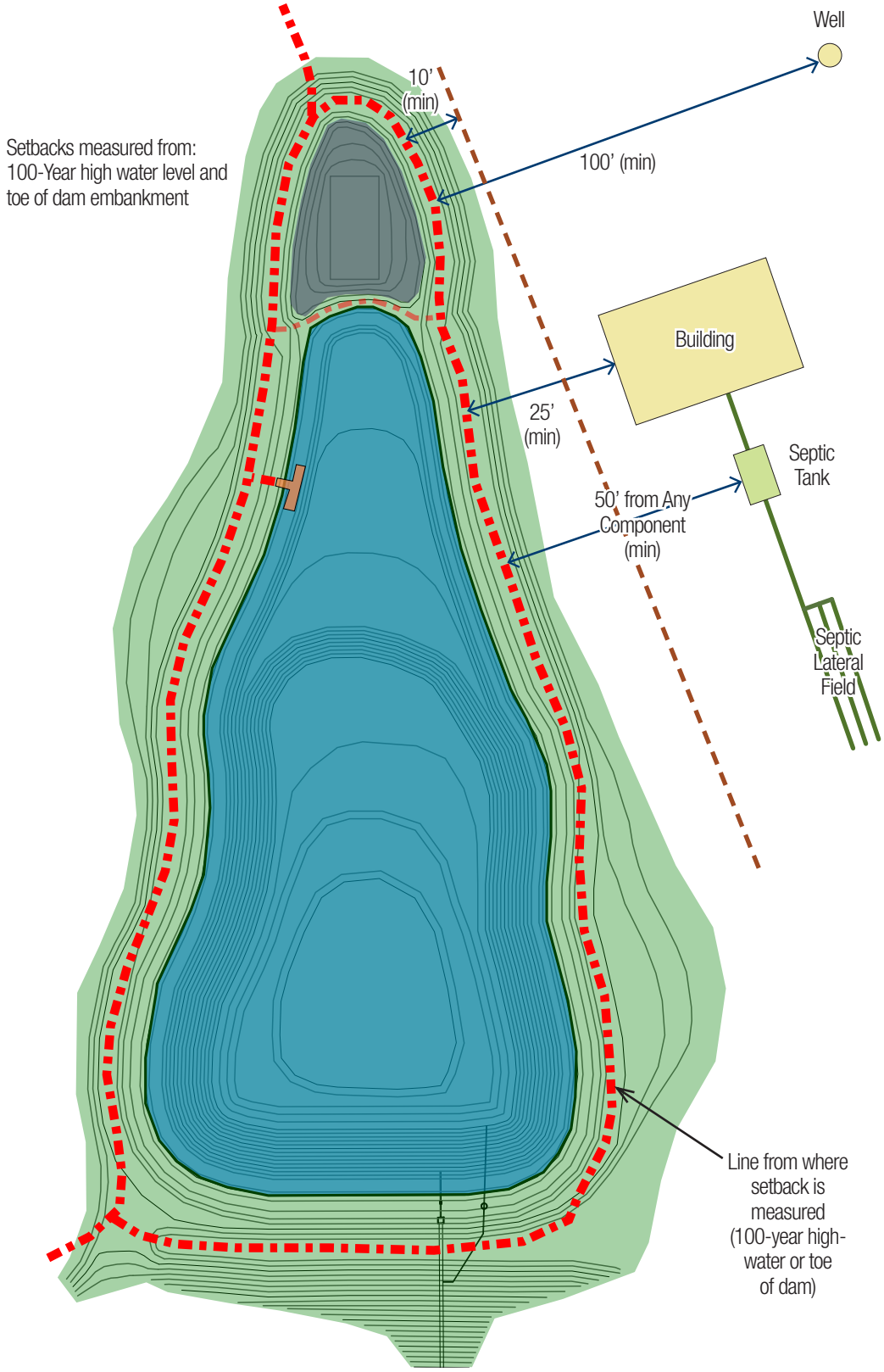
Final designs should take care not to plan excavation too close to what will be the core trench of the dam.

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 within the basin) 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 9.11-1-3: Illustration of Setback Requirements



E. DESIGN ELEMENTS AND PARAMETERS

PRE-TREATMENT

Sediment **forebays** (or other equivalent pre-treatment practices) should be located at 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.

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 pond, each forebay should be physically separated from the wet pond 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 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.

TEMPORARY STORAGE VOLUME

The empty space above the permanent pool is the storage volume for stormwater detention (live storage). This is created through excavation (cut) or creation of a dam embankment (fill) to store water as needed to limit release rates.

POND SHAPE AND SIZE

The pond 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, pond should be longer than it is wide, to promote greater flow length through the pond and reduce flowpath shortcutting. **A minimum length to width ratio of 2:1 is desired.** TARGET

Where fishing is desired, the surface area of the permanent pool should not be less than 0.5 acres. ESSENTIAL

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.

POOL DEPTH AND SLOPES

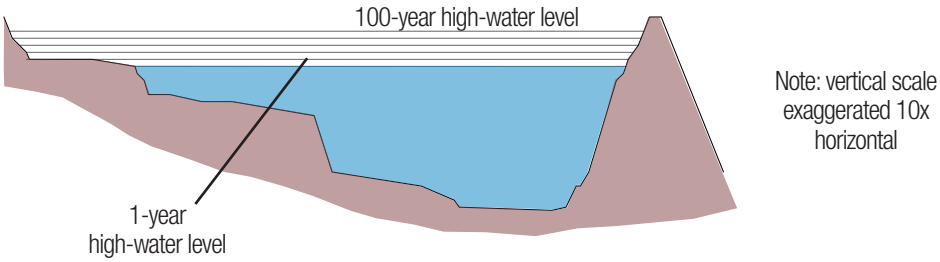
The pool depth should be designed to maintain a deepest depth of 8–10 feet after construction. For this reason, the design depth of the pond should be 12 feet or greater to account for the potential for sedimentation caused by construction in the upstream area. At least 25% of the surface area of the pond should have a depth exceeding 8 feet after construction. In the northern two tiers of counties in Iowa, this criteria should be increased to 10 feet. **These depth requirements are set to ensure sufficent volume remains unfrozen through the winter months to preserve a fish population.** ESSENTIAL

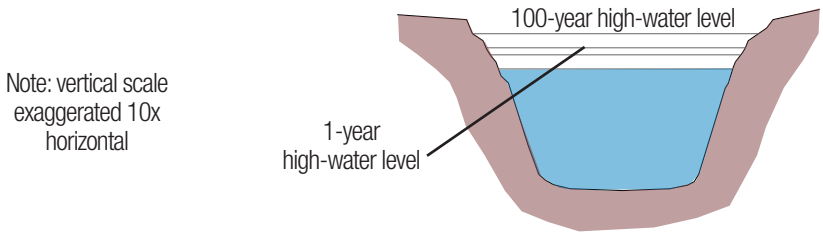
Deeper depths are preferable, where feasible. Greater maximum depths are expected to increase the potential for phosphorus retention over the long term. **Ideally, the pool would have an average depth of 8–10 feet, with a maximum depth of 15–30 feet.** The IDNR does not recommend stocking a pond with fish that has a maximum depth of less than 10 feet. TARGET

Most of the pond should be as deep as possible, as feasible working with local terrain. Shallower depths of 4–6 feet are more desirable near the inlet points to the pond from forebays to concentrate any remaining sediment deposition in a smaller, more concentrated area that may be easier to access.

Below the water surface, the slope of the soil materials along bottom of the pond should not exceed 3:1. ESSENTIAL

FIgure 9.11-1-4: Cross-Section View Graphic of Detention Features





NOTE

Even if ponds are not planned to be stocked with fish, it is advisable they be designed to sustain fish populations.

It may be desired to stock them at a later date. It is also possible that they may be illegally stocked by local residents or other persons.

Fish kills have been frequently reported to the IDNR in the spring in urban ponds that were not intended to be stocked.

For these reasons it is advisable to design wet ponds as if they were planned to be stocked.

Stocking of ponds should only be done in coordination with the IDNR.

FIgure 9.11-1-5: Typical Features of a Wet Detention Basin

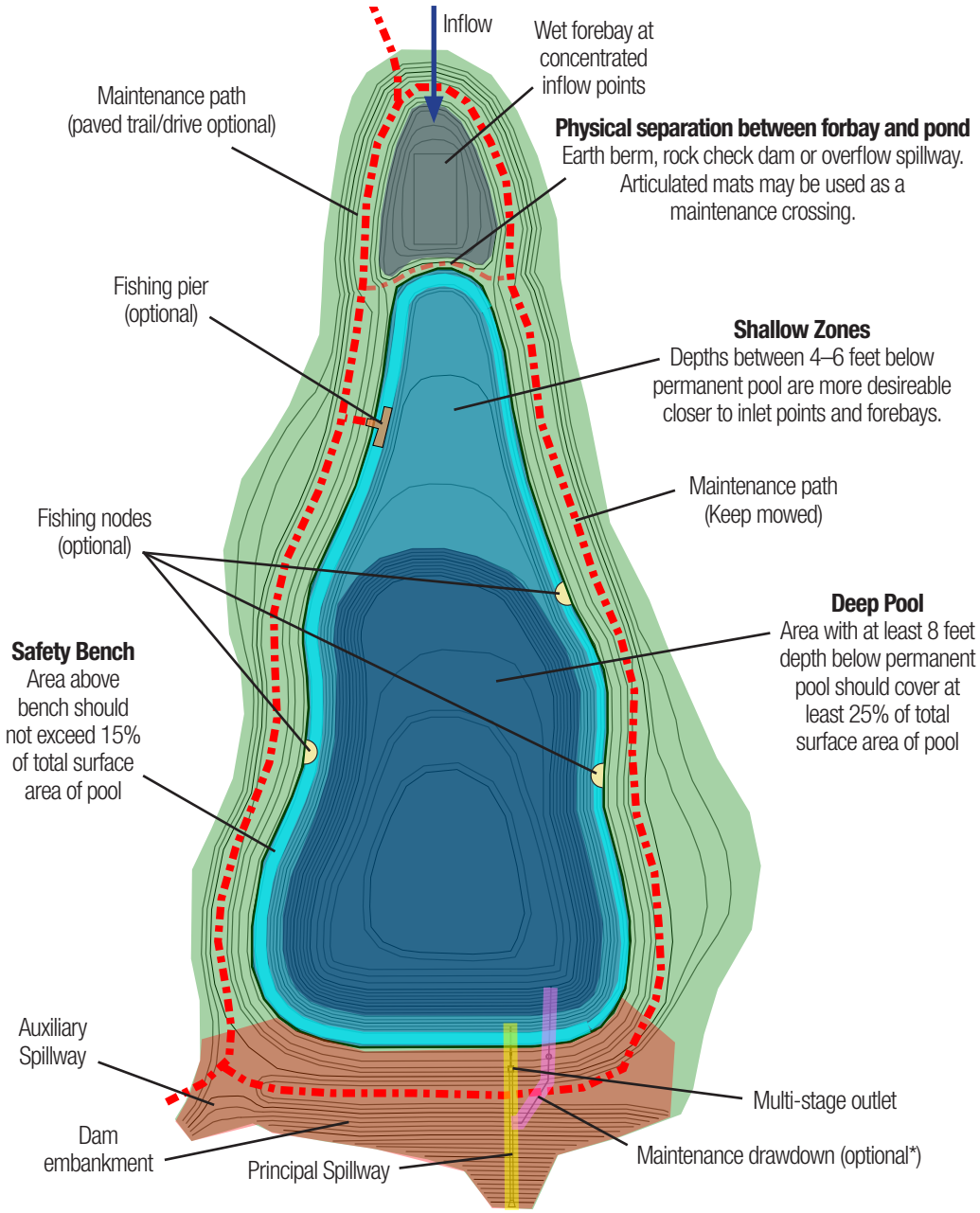


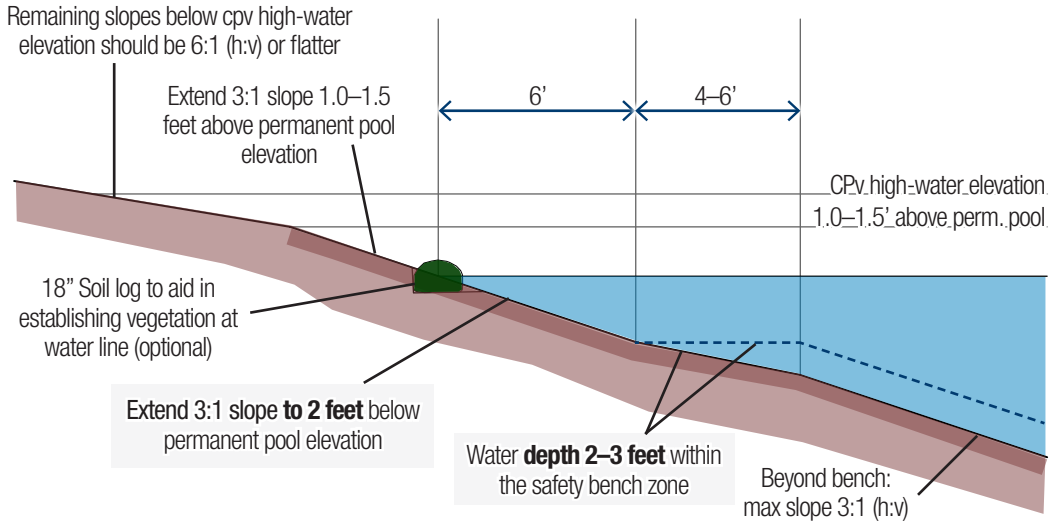
FIgure 9.11-1-6: Habitat improvements

SAFETY BENCH/POND EDGE

Along the edge of the pond, a safety bench should be provided to reduce the potential of someone falling into deep water, and also to promote growth of aquatic vegetation to aid in water quality improvement. This safety bench also reduces the potential of shoreline erosion. There are two types of safety benches that may be provided: ESSENTIAL

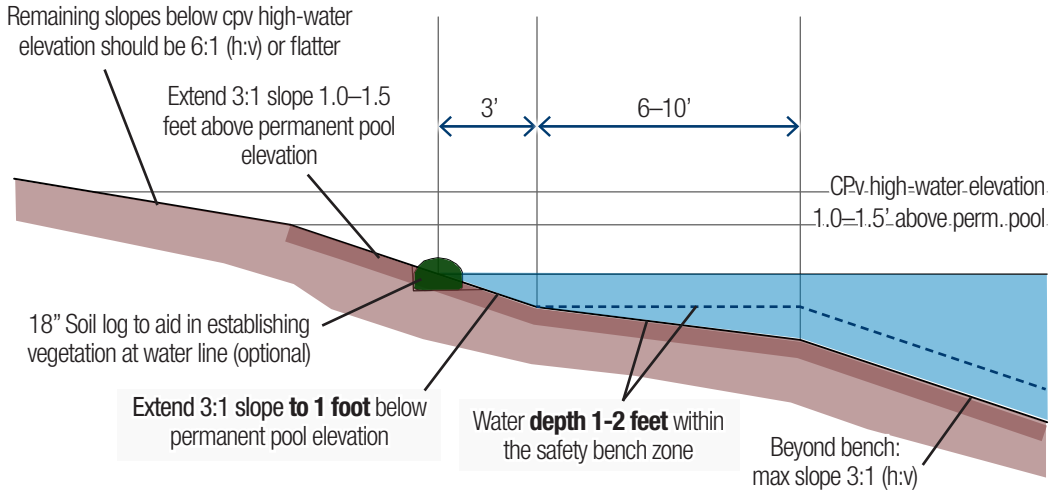
Narrow bench (fishing option): A smaller bench can be provided to make it easier for fishing, with lines cast across the bench. For this option the bench should be 4–6 feet wide, measured from toe of the steeper slope along the shoreline. Water depth above the bench should be 2–3 feet deep.

Figure 9.11-1-7: Narrow bench cross section



Wider bench (wetland edge option): If a wider edge of wetland vegetation is desired, the safety bench can be wider, from 6–10 feet in width, measured from the toe of the steeper shoreline slope. Water depth for this option can be reduced to 1–2 feet above the safety bench.

Figure 9.11-1-8: Wider bench cross section



Using either option, the shallow water portion of the pond should not exceed 15% of the total surface area covered by the permanent pool. TARGET

For either option, the slope of the shoreline along the perimeter of the safety bench should not be steeper than 3:1. This steeper slope should extend up no more than 1.5 feet above the normal pool elevation (measured vertically), before transitioning to the flatter perimeter slopes. ESSENTIAL

NOTE

If used, the type of reinforcement matting should be selected that would not inhibit the growth of native forbs and wildflowers.

SHORELINE EROSION PROTECTION

The safety bench and taller, erosion-resistant **native vegetation** can be an effective prevention measure against shoreline erosion. However, protection with revetment stone, reinforcement matting or boulders may be needed where the shoreline passes along the face of the dam, or where wind is expected to drive across a longer length of the lake, causing increased wave action. In some areas, a soil-filled log may be considered to promote initial establishment of vegetation along the shoreline, where wave action may impede the ability of seeding to take hold. TARGET

FISHING NODES

When promoting fishing is desired, stone outcroppings can lure fishers to select access points that extend further out across the safety bench. These features generally project out into the water in an arc or other natural shape. The safety bench may be omitted along the points of these features. A mowed path or other means of access should be provided to these locations. TARGET

NOTE

One resource for the selection and design of fish habitat improvements is *Nebraska Pond Management,* Nebraska Game and Parks Commission, May 2006.

SUBSURFACE HABITAT IMPROVEMENTS

When ponds are intended to be stocked with fish, subsurface habitat improvements are recommended. Gravel spawning beds, rock piles, woody materials and other features can be installed during or after lake construction to enhance habitat for fish. Other features such as humps, points and channels can be created through finished grading techniques. TARGET

FIgure 9.11-1-9:
Habitat improvements

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 10% annual recurrence event (10-year, 24-hour storm). To improve access and aesthetics, it is strongly encouraged to make slopes within 20 feet (measured horizontally) of the edge of the normal pool, 8:1 or flatter (except as noted for shoreline edge). TARGET

Above the high-water elevation of the 10-year 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.
- Grading designs should include flatter paths for access, especially to areas intended for more frequent public access (such as fishing piers, trails, walking paths and fishing nodes).
- To improve aesthetics and access, it is recommended that slopes be 6:1 or flatter for a minimum of 40% of the area between the high-water elevations of the 10% and 1% AR events (100-year, 24-hour event). TARGET

To improve public access, slopes should be flatter than maximum levels at multiple locations to allow people to walk more easily to the water's edge, especially to access key features (such as fishing nodes). ESSENTIAL

Use of walls or earth-retaining structures within and around the perimeter of the detention area should be as limited as 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

OUTLET STRUCTURES

Multi-stage outlets will typically be needed to meet release rate reduction targets for various storm events. These types of structures are preferred over single-stage culverts or weirs.

The first stage (typically controlling flow to provide extended detention of the CPv event) should provide a method to draw water out of the pond from 3–4 feet below the permanent pool. A water level control structure can be installed along this pipe, which uses stop logs to maintain the desired normal pool elevation of the pond. TARGET

Higher stages are generally set above the high-water elevation of the CPv event. These are often weirs, orifices or other openings cast or cut into storm intake structures. For most watersheds, precast storm intake structures can be modified for use as a multi-stage structure. More unique outfall structures may be needed in larger watersheds. TARGET

Fish loss through outfall structures is a concern. Smaller orifices (especially those below the surface) should include bar guards, perforated risers or trash racks. Spacing of 3 inches is preferred to prevent adult fish passage, while reducing the potential for clogging. When area intakes are used for higher inlet stages, horizontal bars are preferable over vertical bars, with a clear bar spacing of 3 inches. TARGET

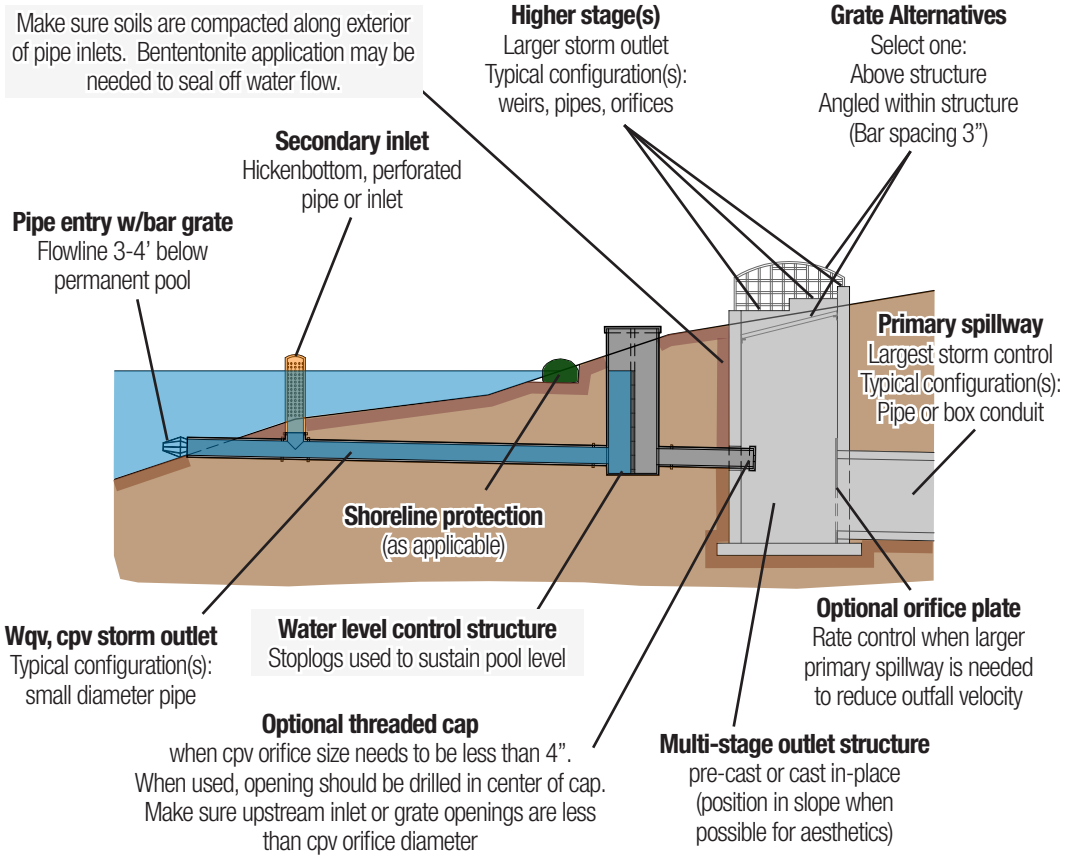
NOTE

Subsurface water withdrawal reduces the potential for floatables to clog the outlet, minimizes discharge of water near the surface which may be warmest (less desirable to discharge) and have higher dissolved oxygen content (desirable to keep in pond).

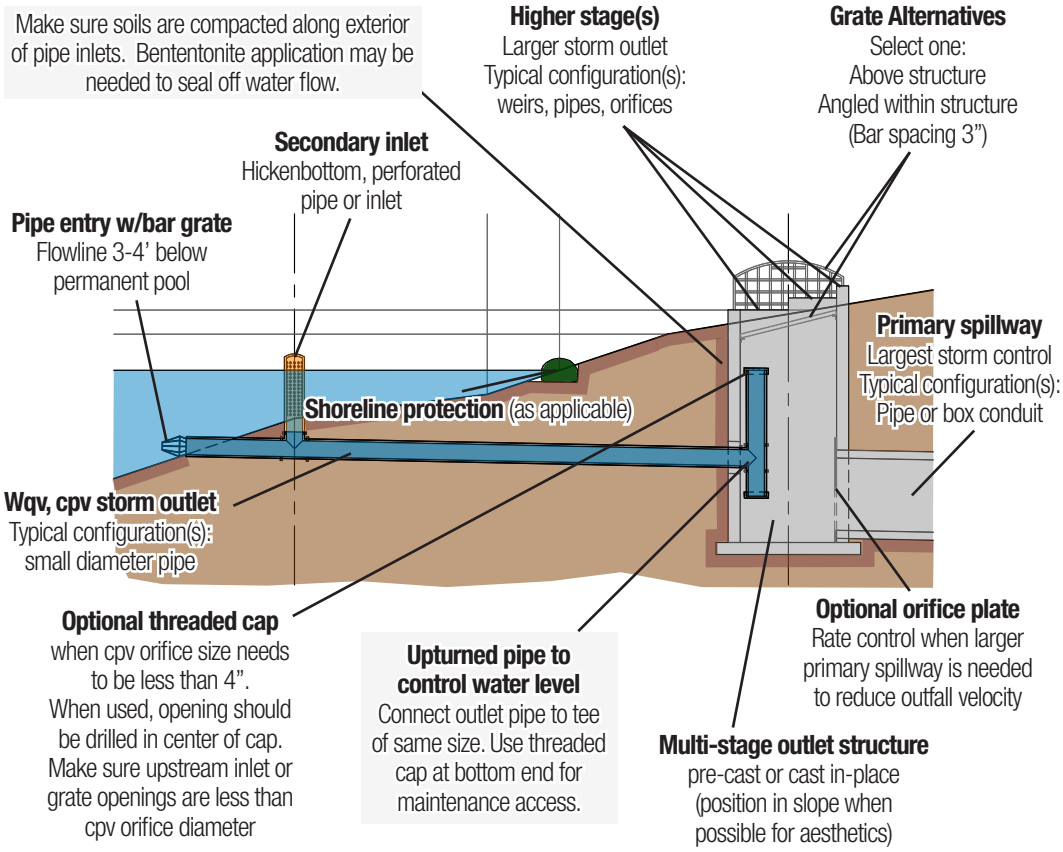
Figure 9.11-1-10: Grates

Figure 9.11-1-11: Multi-Stage Outfall Structure Example Elements

PREFERRED OPTION -- WATER LEVEL CONTROL STRUCTURE



ALTERNATIVE OPTION -- UPTURNED PIPE WITHIN MULTI-STAGE OUTLET



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. 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 generally level as it runs along the centerline of the dam to allow it to spread over a longer width. 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

NOTE

Drawing water from below the surface has two key benefits:

- Leaves the water near the surface that typically has higher oxygen content in the pond.
- Reduces thermal effects downstream, as surface water temperature may be elevated by sunlight.

NOTE

Check with local jurisdictions about freeboard requirements, which may be more restrictive.

NOTE

When designing outfalls to waterways, pay careful attention to signs of bank erosion or **stream migration**. Avoid placement of outfalls on the outside bends of streams, where higher levels of shear stress frequently occur. Outfalls should be placed as close to the normal flow elevation as possible to reduce the potential for surface erosion or downcutting below the outlet. Revetment storm materials or other protection methods can minimize opportunities for soil erosion below or around the pipe.

The crest of the dam should be set at an elevation with 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

Figure 9.11-1-12: Dam Crest Parameters

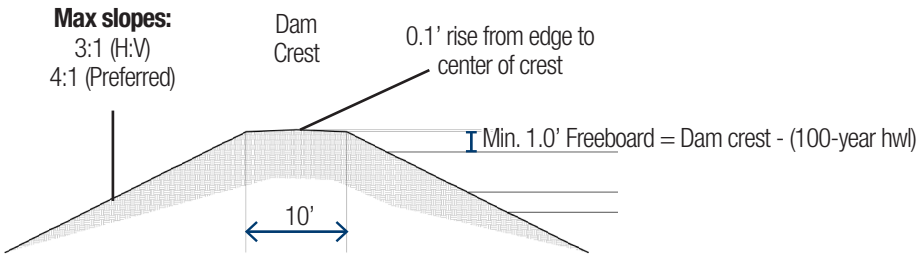
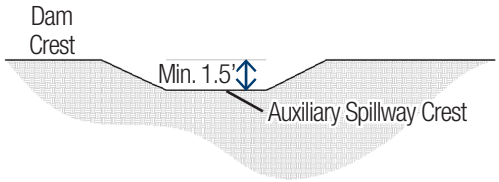


Figure 9.11-1-13: Auxiliary Spillway Parameters



OUTFALLS

Outfalls from the basin should be placed in stable locations, with adequate protection from erosion. 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 TARGET

Figure 9.11-1-14: Unstable outfall photo

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")

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).

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

Figure 9.11-1-16: Stilling Basin

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).
- **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 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.

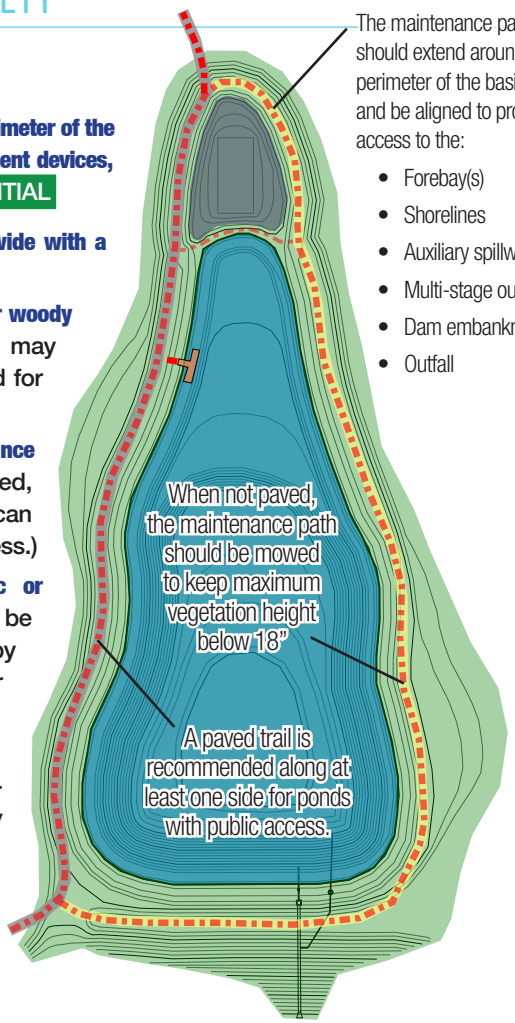
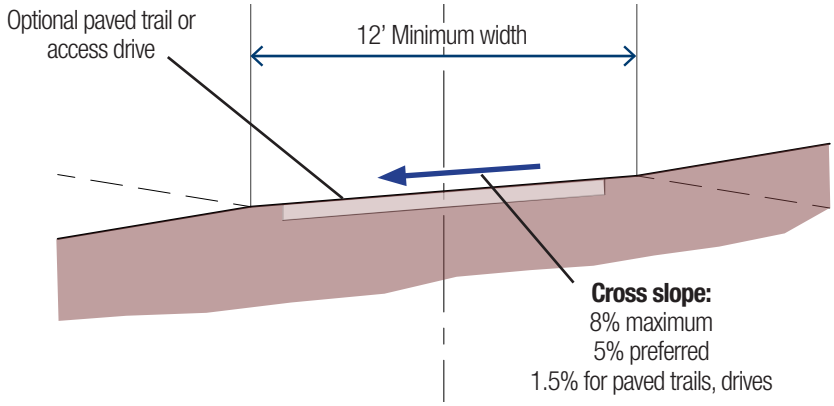


Figure 9.11-1-15: Maintenance Path Needs

Figure 9.11-1-17: Cross-section of maintenance path



SAFETY FEATURES

A. 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. The safety bench around the perimeter of deep pool areas eliminates rapid drop-offs into deep water, reducing the potential for accidental drowning. ESSENTIAL

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

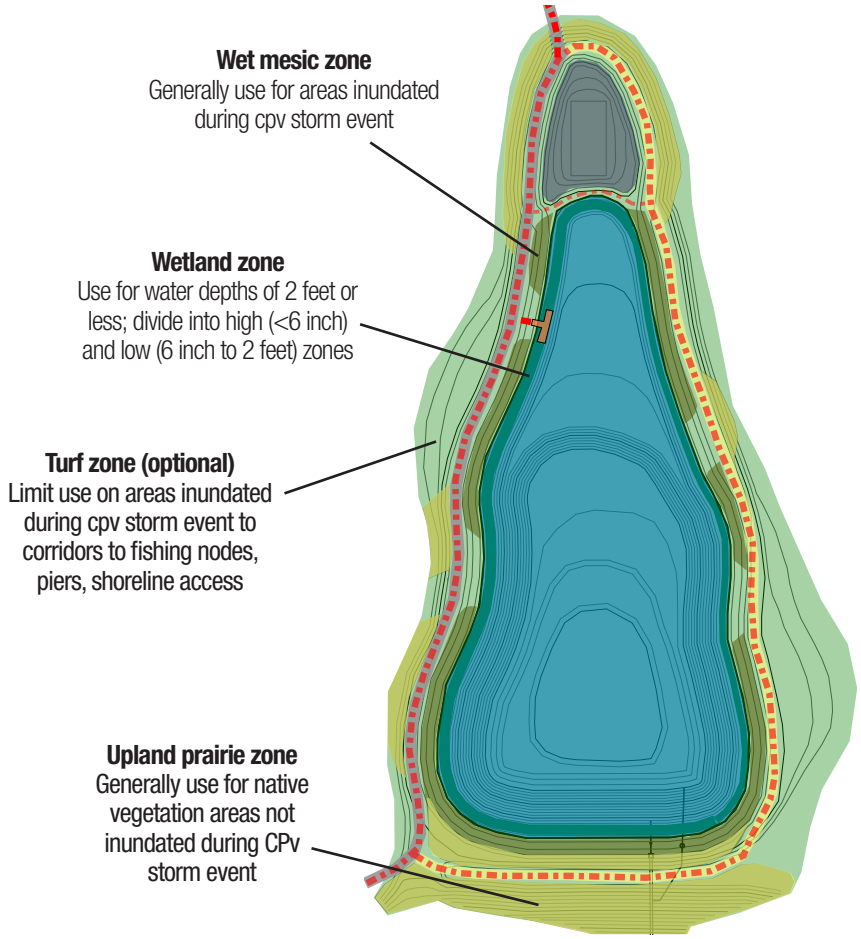
E. Pipe outfalls of greater than 48 inches in height may require a fence or railing to reduce fall risks. ESSENTIAL

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 should be considered for areas expected to be inundated more frequently (e.g., below the **high water** of the CPv event).
- Woody vegetation should 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. Any new tree and shrub plantings should be species that are native to Iowa and appropriate to the climate region at a given site.
- 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 9.11-1-18: Landscaping Zones



G. DESIGN ALTERNATIVES

None detailed in this section.

H. SPECIAL CASE ADAPTATIONS

FLOOD PLAINS

It is preferred that wet detention ponds 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. However, 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.

NOTE

Locating wet detention ponds 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

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 pond 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. For this reason, wet ponds should not be constructed in areas where such deposition is frequently observed.

STREAM MORPHOLOGY

Stormwater wet ponds 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.

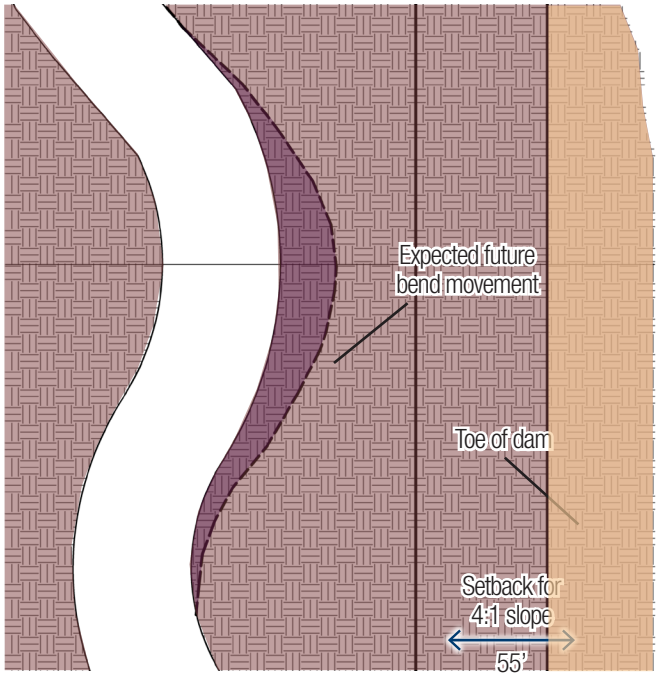
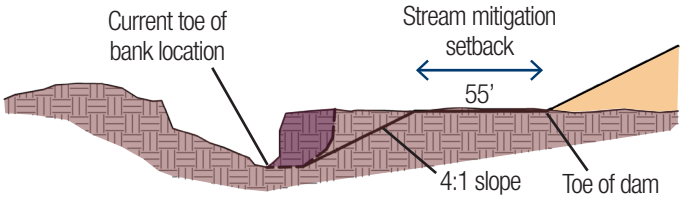


Figure 9.11-1-19: Stream Morphology Considerations



9.11-2 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 9.10–1.

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)

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 additional restrictions and/or surface water or watershed requirements that may apply. (State Dam Safety requirements will be checked in Step 8).

Step 3a. Calculate the Water Quality volume to be treated by the stormwater pond.

Step 3b. Develop a stormwater model (TR–55) for the watershed area for the practice. The model should determine peak flowrates 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.

TABLE 9.11-2.1: EVENTS TO BE STUDIED, DATA OUTPUT TO COLLECT

		PRE-SETTLEMENT		EXISTING		POST-DEVELOPMENT	
		CN	TC	CN	TC	CN	
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 wet pond detention practices, this is typically the CPv 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 goals to be planned around that reserved open space.

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.

NOTE

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.

Step 5. Determine pre–treatment 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 a pool volume of double the WQv calculated in Step 3 and the estimated temporary detention storage volumes required as calculated in Step 4. Refer to Table 9.11-1.1 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.

Refer also to IDNR Form 542-1014.

- 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 9.11-1.1.

Step 10. Finalize practice location and refine the grading plan and outlet design. Confirm that the pool retains at least double the required WQv treatment volume. Check that the footprint area of the safety bench does not exceed 15% of the surface area of the normal pool. Verify that 25% of the normal pool area meets the minimum depth criteria (8 feet in most locations, 10 feet in the northern two tiers of counties in Iowa). Alter the model 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 maximum allowable levels and that 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.

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.

B. DESIGN EXAMPLE

TABLE 9.11-2.2: EXAMPLE PROJECT WATERSHED DATA

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 wet detention pond. 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 wet detention pond.

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 food risk areas are present.

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

Refer to Section 9.11-1H. For this example, the detention basin is assumed to be outside areas of known food risk and away from expected impacts that could be caused by stream movement.

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 Unifed Sizing Criteria

» The requirements for Recharge Volume (Rev)are being achieved by upstream practices (as part of site development).

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

- Natural conditions for the same rainfall event, based on HSG B soils (CN=58).
- Existing conditions for the 5-year, 24-hour rainfall event.

Step 3. Calculate the Water Quality volume to be treated by the stormwater pond.

Calculate the Water Quality Volume using the method recommended in the Unified Sizing Criteria chapter.

TABLE 9.11-2.3: 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**

Step 4. Develop a stormwater model (TR-55) for the watershed area for the practice.

The model should determine peak flowrates 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 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 9.11-2.4: 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 that criteria, refer to Section 9.05 for Water Balance calculations.

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 pre–settlement conditions.

TABLE 9.11-2.5: EXAMPLE PROJECT "STANDARD" CN CALCULATIONS

		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 9.11-2.6: TR-55 RUNOFF MODEL TO DETENTION SITE

		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)
1-year	2.77"	3.1	59,100	42	221,000	106	364,000
2-year	3.20"	6.2	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 wet pond detention practices, this is typically the CPv 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.

The following initial estimates of required detention using the procedure described in Section 9.02-3.

Since we are treating the channel protection volume, follow steps A-F below to determine the storage requirements to provide the extended detention. For the other storm events, (qo / qi) is determined by the jurisdictional release rate requirements (i.e. qo is the minimum of the pre-settlement conditions and the 5-year existing outflow rates). For events larger than the 1-year, 24-hour, skip steps A-D.

A. For CPv, the total runoff volume (Qa) from Table C8-6. 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

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.

B. 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)

C. 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)

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

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

E. The estimated storage required can be calculated using the equation below…

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

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

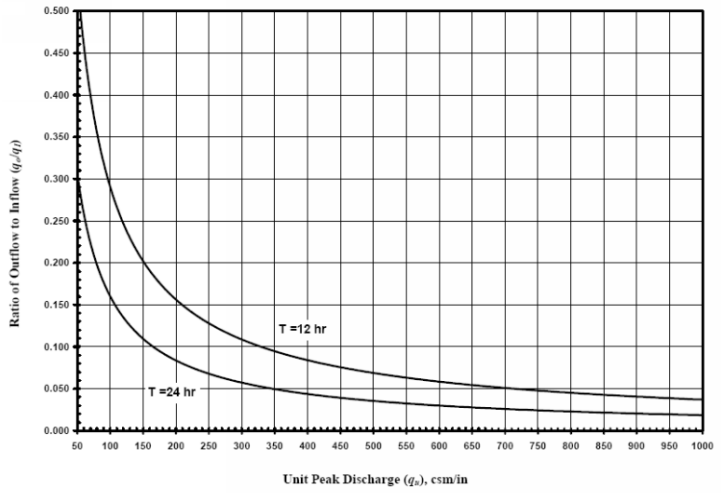


Figure C3-S6- 1: Detention time vs. discharge ratios (qo/qi)

F. 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 = 234,000 CF

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.

TABLE 9.11-2.7: 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)
1	3.2	106	0.03	0.642	364	233,526	268.6
2	6.3	136	0.05	0.620	463	287,195	330.3
5	15	193	0.08	0.581	655	380,406	437.5
10	26	249	0.11	0.549	846	464,338	534.0
25	48	336	0.14	0.510	1,150	585,970	673.9
50	70	412	0.17	0.484	1,420	686,806	789.8
100	95	494	0.19	0.463	1,710	792,231	911.1

For this calculation example, assume that sufficient space has been reserved to afford the preferred high-water depths from Table 9.11-1.1. The initial storage volume targets are the CPv (1-year) event in 2 feet of depth, the 10-year event in 3 feet of depth, and the 100-year in 5 feet of depth.

TABLE 9.11-2.8: INITIAL ESTIMATES OF REQUIRED FOOTPRINT

STORM EVENT	TARGET DEPTH (FEET)	EST. FOOTPRINT (SF)
CPv	2	134,600
10	3	178,000
100	5	182,220

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).

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

Ptv = 10% x WQv = 0.1 x 207,330 = 20,733 CF

Pre-Treatment Measure #1—Sediment Forebays

For this design, it is assumed that all of the watershed area enters the wetlands through two outfall pipes.

- 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 10,367 CF of storage (20,733 CF / 2).

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 6. Review site topography and develop a preliminary grading plan to identify preliminary stage-storage relationships that provide a pool volume of double the WQv calculated in Step 3 and the estimated temporary detention storage volumes required as calculated in Step 4. Refer to Table 9.11-1.1 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 100.00 as the permanent pool elevation.

- Develop a preliminary stage-storage relationship for the temporary (live) storage above the permanent pool.

Next, figure the average area required to provide the estimated CPv calculated in Step 4 at the recommended depth of 2 feet. That area will be used as the initial design contour 1 foot above the permanent pool (1/2 of the target CPv depth), which is elevation 101.00 for this example. As per figure 9.11-1-5, the slope along the pond edge immediately above the water surface should be 3:1, so that slope will be assumed for the area between the 101.00 and 100.00 (normal pool) elevations. Above the 101 contour, a slope of 10:1 is assumed up to the CPv high-water elevation. The storage provided with this configuration at the 2-ft depth is 275,450 CF. The CPv (Vs * 1.15 = 268,600 CF) fits entirely within the 2-ft depth. Grade so that it will not exceed the maximum allowable depth of 3 feet.

TABLE 9.11-2.9: ESTIMATED CONTOUR AREA/STORAGE BELOW CPV-EVENT TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
0	100	130,500		
1	101	134,600	132,550	132,550
2	102	151,200	142,900	275,450

* Stage 0 is normal pool

The slope should be no steeper than 6:1 up to the high-water elevation of the CPv event, so for this example we will plan on extending 6:1 grade up to at least elevation 103. Above that, we will assume a 4:1 slope is provided to check the storage provided to the 10- and 100-year storm events. The 10-year (Vs * 1.15 = 534,000 CF) does not fit entirely within the 3-ft depth, but will not exceed the 4-ft maximum allowable depth. The 100-year (911,100 CF) will fit within the 5-ft target depth. Check that it will not exceed the maximum allowable depth of 6 feet.

TABLE 9.11-2.10: ESTIMATED CONTOUR AREA/STORAGE BETWEEN THE CPV-EVENT AND 10-YEAR EVENT TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
3	103	168,000	159,600	435,050
4	104	178,400	173,200	608,250
5	105	189,200	183,800	792,050
6	106	196,500	192,850	984,900

* Stage 0 is normal pool

The 100-year should fit within the maximum allowable 6 ft depth.

- Develop a preliminary relationship for the storage in the permanent pool (dead storage):

NOTE

Elevation 100.00 is used as a reference datum for this design example.

For a real project, the designer would need to consider site topography and other factors when selecting the best permanent pool elevation for a given site.

TABLE 9.11-2.11: COMPARISON OF ESTIMATED REQUIRED / PRELIMINARY DESIGN STORAGE VOLUMES

STAGE * (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
0.0	100.0	130,500		
1.0	101.0	126,100	128,300	128,300
-2.0	98.0	115,800	120,950	249,250
-3.0	97.0	112,000	113,900	363,150
-4.0	96.0	82,324	97,162	460,312
-5.0	95.0	76,339	79,332	539,644
-6.0	94.0	68,000	72,170	611,813
-7.0	93.0	60,679	64,340	676,153
-8.0	92.0	54,300	57,490	733,642
-9.0	91.0	52,100	53,200	786,842
-10.0	90.0	51,800	51,950	838,792
-11.0	89.0	48,900	50,350	889,142
-12.0	88.0	46,200	47,550	936,692
-13.0	87.0	43,600	44,900	981,592
-14.0	86.0	41,600	42,600	1,024,192
-15.0	85.0	38,700	40,150	1,064,342
-16.0	84.0	26,900	32,800	1,097,142
-17.0	83.0	21,300	24,100	1,121,242
-18.0	82.0	18,500	19,900	1,141,142
-19.0	81.0	10,600	14,550	1,155,692
-20.0	80.0	8,200	9,400	1,165,092

* Stage 0 is normal pool

The preliminary pool design should consider the perimeter bench requirements outlined in 9.11-1-5 with a slope no steeper than 3:1 below the perimeter benches.

The required WQv calculated in Step 3 is 207,330 CF. Any storage provided in the forebay can be credited toward meeting that requirement. The permanent pool must store at least twice the remaining WQv volume.

Using this preliminary design, the permanent pool will hold 1,165,092 (more than twice the WQv). This pond design has sufficient depth to support a fish population, with a permanent pool design depth of 20.0'.

- Check that the shallow water depths above the perimeter bench do not exceed 15% of the water surface area. For this example, we will check that the area within the contour 3 feet below the permanent pool (100 – 3 = 97) is at least 85% of the contour area that defines the permanent pool.
  - The 100-ft and 97-ft contour areas are 130,500 SF and 112,000 SF, respectively.
  - **112,000 / 130,500 SF = 0.859 (>0.85 OK)**
- Since the pond is meant to support a fish population, check that the water depths of at least 8 feet are in excess of 25% of the water surface area (assume site is not in upper two tiers of counties in Iowa). For this example, we will check that the area within the contour 8 feet below the permanent pool (100 – 8 = 92) is at least 25% of the contour area that defines the permanent pool.
  - The 8-ft depth contour (92-ft contour) area is 54,300 SF.
  - **54,300 / 130,500 = 0.416 (>0.25 OK)**

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:

- The dam has an emergency spillway, and has a sum of 2,170,727 CF of combined temporary and permanent storage (49.8 **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 49.8 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.

* Volumes of forebay storage added to the basin.

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 36" 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/s^2
h = head measured from high-water to center of opening (feet)

h (feet) =	*102.0*	*(CPv target high-water)*
	– 93.0	*(flowline of pipe)*
	– 1.5	*(assumed radius of pipe)*
	= 7.5	feet

A = 95 cfs / [0.6 x (2 x 32.2 x 7.5)$^{1/2}$] = 7.2 SF

Area of 36" pipe = $\pi r^2 = \pi(1.5 \text{ feet})^2$ = 7.07 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/s^2
h = head measured from high-water to center of opening (feet)

h (feet) =	*102.0*	*(CPv 2-year event target high-water)*
	– 100.0	*(permanent pool)*
	= 2.0	feet

A = 3.2 cfs / [0.6 x (2 x 32.2 x 2.0)$^{1/2}$] = 0.47 SF

r = (A / π)$^{1/2}$ = (0.47 SF / π)$^{1/2}$ = 0.386 feet

d = 2r = 0.774 feet = (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.

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.

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 2.9 cfs during the CPv event (< 3.2 cfs, OK)

C. Set a second stage for larger storms above the expected high-water elevation of the CPv 2-year event.

CULVERT/ORIFICE	A	B
Rise	36"	9"
Span	36"	9"
No. Barrels	1	1
Invert Elevation	93'	99.63'
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

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.

The high-water elevation for the CPv event with the 9" orifice in place is 101.83'. Set the second stage at 102.00' and try a 3'-long rectangular weir (could be in the front face of a 4' x 4' inlet structure). Since the weir is set above the maximum water surface elevation of the CPv, the CPv expected outflow should still be acceptable.

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.

WEIR	A
Weir Type	Rectangular
Crest Elevation	102.00'
Crest Length	3'
Weir Coefficient	3.33
Multi-Stage	Yes
Active	Yes

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.

Entering the 3' weir (Weir A) into the software program yields a 10-year storm event outflow rate of 20cfs (< 26 cfs, OK). The 10-year water surface elevation is 103.35 (above the target, but less than the maximum 4-ft depth, OK). The CPv remains unchanged , so no further adjustment of the second control stage is necessary..

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.

Enter a second 3' weir (Weir B) at elevation 104.25'—above the 10-year maximum water surface elevation (103.35'). The stage-storage-discharge routing yields an expected outflow rate of 93 cfs for the 100-year storm event (< 95, OK). The maximum water surface elevation is 105.79.

F. For this example, provide a third weir for events greater than the 100-year storm event. This is not required, but may reduce the instances of flow over the emergency spillway throughout the life of the basin.

WEIR	B
Weir Type	Rectangular
Crest Elevation	104.25'
Crest Length	3'
Weir Coefficient	3.33
Multi-Stage	Yes
Active	Yes

NOTE

The 10' weir would be the remainder of the sides of the 4' x 4' inlet structure.

(16' – 3' – 3' = 10')

Set a 10' weir (Weir C) at 105.75'—right above the 100-year maximum water surface elevation (105.35'). Since the weir is above the maximum water surface elevation, we can move on to adding the emergency overflow.

G. Set the emergency spillway elevation higher than the last weir.

WEIR	C
Weir Type	Rectangular
Crest Elevation	105.75'
Crest Length	10'
Weir Coefficient	3.33
Multi-Stage	Yes
Active	Yes

For this example, the emergency spillway is set at 106.00'. The outfall design program entires are summarized in Table 9.11-2.11.

TABLE 9.11-2.12: SUMMARY OF OUTFALL DESIGN ITERATIONS AND RESULTS

ITERATION		1	2	3	4	ELEVATION
Culvert A		36"	36"	36"	36"	93.00'
Culvert B		9"	9"	9"	9"	99.63' *
Weir A			3'	3'	3'	102.00'
Weir B				3'	3'	104.25'
Weir C					10'	105.75'
Weir D					40'	106.00'
STORM EVENT	ALLOWED	OUT	OUT	OUT	OUT	HIGH WATER ELEVATION (ITERATION #4)
1-year (CPv)	3.2	2.9	2.9	2.9	2.9	101.83'
2-year	6.3		4.5	4.5	4.5	102.25'
5-year	15		11	11	11	102.81'
10-year	26		20	20	20	103.35'
25-year	48		38	38	38	104.23'
50-year	70		56	62	62	104.96'
100-year	95		79	93	93	105.71'

* Actual invert elevation is intended at 100.00', and set lower in the software program to evaluate the routing at pipe centerline

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.

DETAILED DESIGN OF FOREBAY

In the forebays, 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 forebays 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.

$Q = C \times L \times H^{3/2}$

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

Using the 100-year peak inflow, 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.

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.

The outlet design has sufficient capacity to pass all of the events within the maximum allowable release rates, and to keep the maximum water surface elevations near the target elevations (below the maximum allowable). The routed storage and depth values are summarized in Table 9.11-2.12.

TABLE 9.11-2.13: DESIGNED STORAGE SUMMARY

STORM EVENT	TARGET DEPTH (FEET)	DESIGN DEPTH (FEET)	MAX. ALLOWABLE DEPTH (FEET)	VR (CF)	VS (CF)	VS *1.15 (CF)	MAXIMUM STORAGE USED (CF)
CPv	2	1.83	3	364,000	234,076	269,200	251,638
10-YEAR	3	3.35	4	846,000	464,338	534,000	495,518
100-YEAR	5	5.71	6	1,710,000	792,231	911,100	928,659

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.

Since sufficient space was set aside during initial development, finalizing the practice location and refining the grading plan is possible without changes to the calculated storage. No additional adjustments were necessary, but if there were limits to grading extents or other utility constraints, this step would address those changes.

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 100-year flow rate of 93 cfs and the design diameter 36 inches.

93 cfs = 7.1 square feet x V
93 cfs / 7.1 square feet = V = **13.1 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 emergency 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.

9.11-3 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

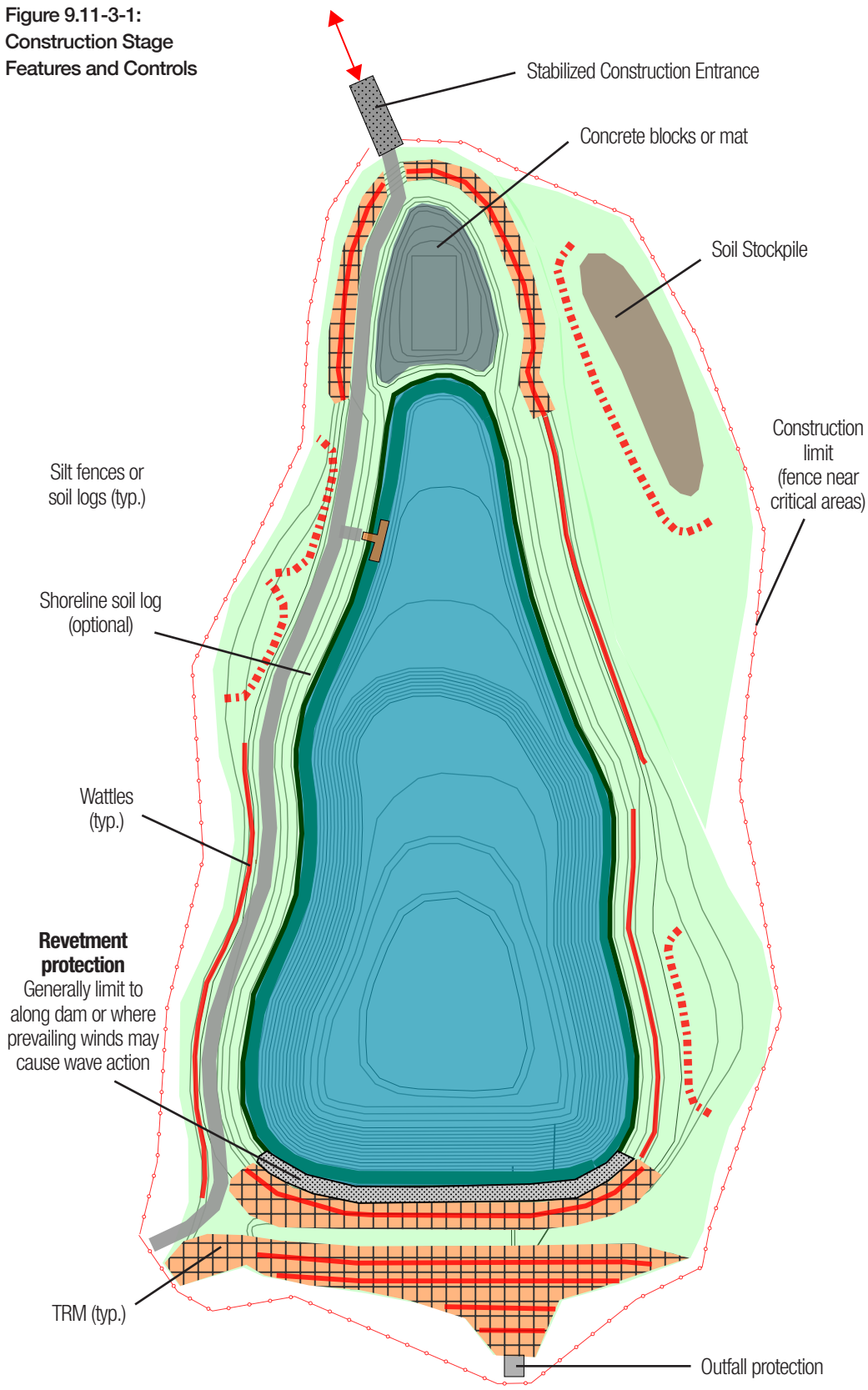
As construction activities commence, internal controls will be added to prevent erosion and sediment loss from the site area.

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 9.11-3-1: Construction Stage Features and Controls



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. 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 9.11-3-2: Construction phase

4 – Storm Structure and Pipe Installation

Installation of the maintenance drawdown, outlet structures and pipes allows for control of the water level, providing drier soil conditions for finish grading and seeding and allowing staged filling of the pond after installation.

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 – 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 liner installation and **soil quality restoration** (SQR) techniques are yet to be completed. Make grading adjustments as needed prior to proceeding with liner construction and/or SQR operations.

6 – Liner Installation

Placement of impermeable materials supports storage of a permanent pool of water at the desired elevation and coverage area.

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

7 – Finish Grading

Fine grading, usually accomplished with smaller equipment, may be needed to establish subtle variations of the finished surface near habitat features. Care needs to be taken to not disturb the liner during finish grading operations.

8 - Habitat Features

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

9 - Surface Roughening

Equipment creates grooves and loosens the surface of soil materials after placement. These grooves limit the potential for sheet and rill erosion. This would typically be omitted in areas where the liner has been prepared; however, the liner should be protected from surface erosion until the pond is filled to its normal pool elevation.

10 - Soil Quality Restoration

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 pool zone 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.

11 - Surface Roughening

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

12 - Landscaping

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

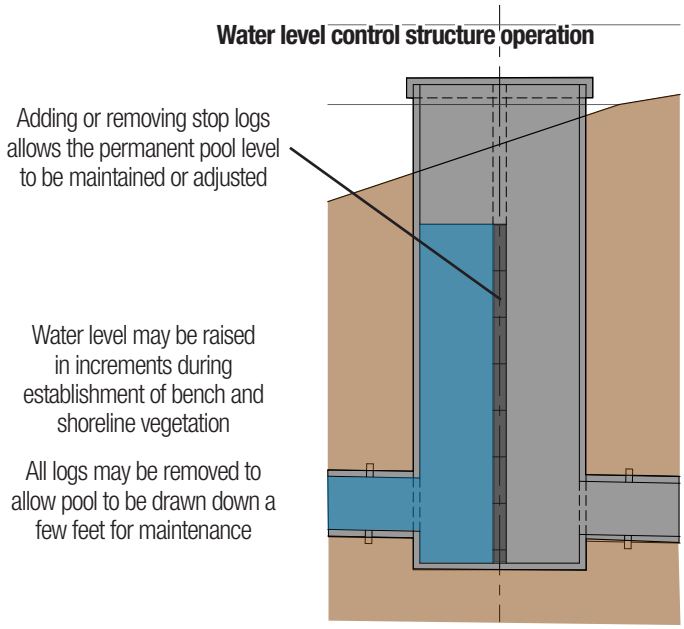
13 - Staged Filling

To promote better establishment of desired vegetation, it is recommended to use outlet controls that allow the water surface to be adjusted. This will allow the pond 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.

It is recommended to wait 2–3 weeks after initial establishment of vegetation within the safety bench zone, to raise water levels to the final design permanent pool elevation.

Figure 9.11-3-3: Using Water Level Control Structure During Establishment



14 – 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.

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.

- Verification that the liner (if required) has been constructed as per construction documents. Collect any test results needed to document its proper construction. (Such tests are often performed by a geotechnical engineer.)
- Observe that finished grading has created the desired features.
- Observe that habitat features have been constructed properly. Verify that the gradation of stone or other materials to construct these features 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 is in compliance with the contract documents.
- Inspect outlet control structures to ensure that stop logs, valves or other control structures are operated to allow for staged filling of the permanent pool.
- As per Construction Sequencing item #5, review results of an as-built or record survey to verify that the final elevation of the permanent pool matches the proposed design.
- 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.
- 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 in a manner similar to plan elevations.
- Footprint of check dams or grade control features and their crest width and top-over elevation.
- Confirmation that required trees and shrubs have been installed.

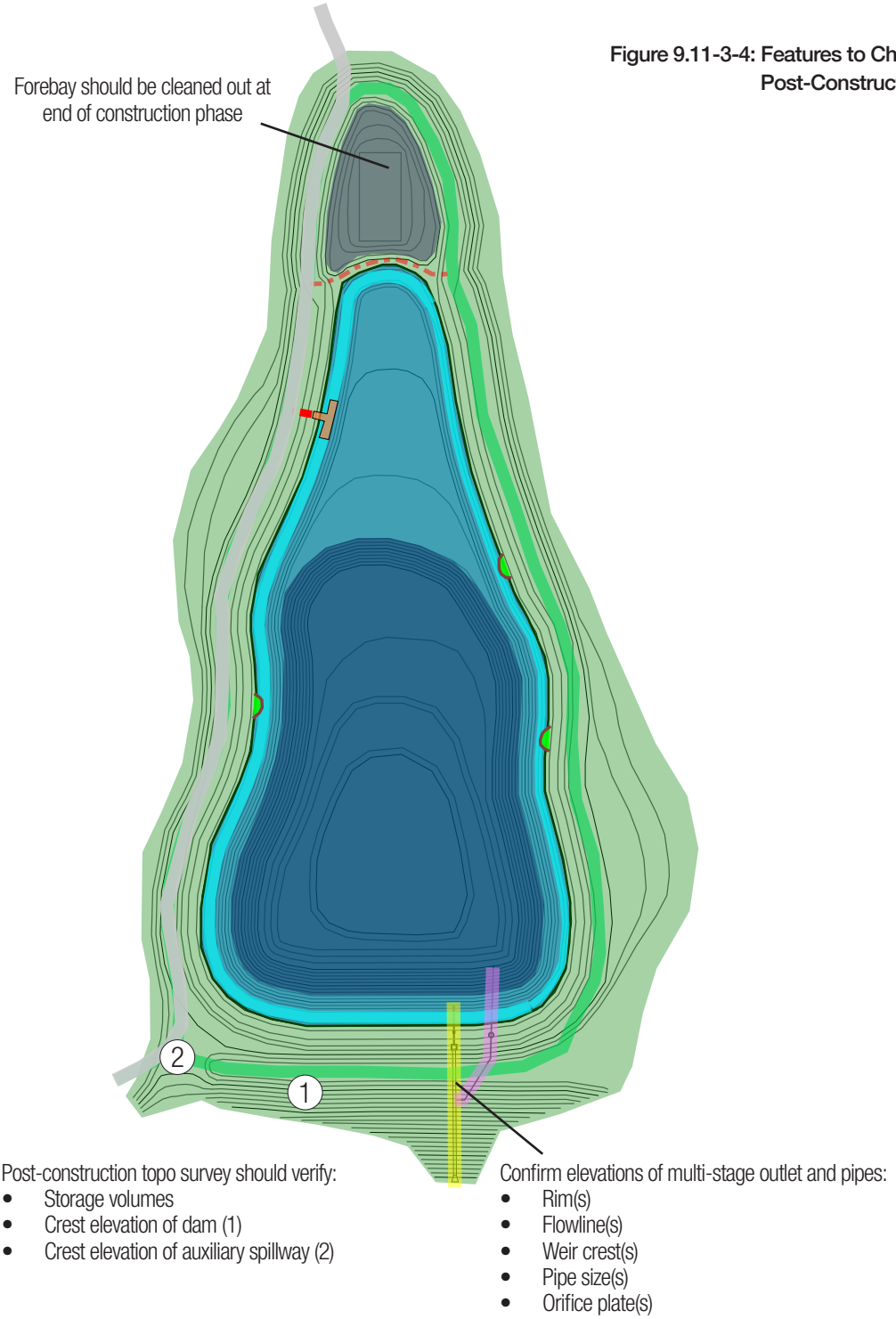


Figure 9.11-3-4: Features to Check Post-Construction

9.11-4 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.

NOTE

When applying herbicides on turf areas adjacent to native planting areas, be careful not to overspray or allow applied chemicals to wash into native planting areas.

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.
- 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-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.
- 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-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 wet pond'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
Monitor vegetation and perform replacement planting as necessary.	Annually (after short-term establishment period)
• Examine stability of the safety bench and shoreline edge. • 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.	Annual Inspection
Repair undercut or eroded areas.	When observed
Harvest wetland plants that have been "choked out" by sediment accumulation.	Annually
Remove sediment when total pool volume has become reduced significantly (~25%), when plants along pond edge are "choked" with sediment or the pond becomes eutrophic. (Estimated time: every 10–20 years)	As needed; when approximately 25% of the total pool volume has been lost, or as noted

- 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.

9.11-5 SIGNAGE RECOMMENDATIONS

Signage may be provided as an educational tool to explain the area's purpose and stormwater management function to the general public. Signage may also be used to advise maintenance staff against discouraged practices, such as frequent mowing of native planting areas and broad application of herbicides. It may also be used to direct the public along access paths or provide warnings about any safety risks, or limitations of public use.

Figure 9.11-5-1: Signage example

IOWA STORM WATER MANAGEMENT MANUAL

9.12 STORMWATER DETENTION COMBINATIONS AND RETROFITS

IOWA DEPARTMENT OF NATURAL RESOURCES

TABLE OF CONTENTS

CONTENTS

9.12-1 OVERVIEW 1

9.12-2 PRACTICES IN SERIES 2

A. Parameters for Series of BMPs 2

B. Documentation 3

9.12-3 HYBRID DESIGNS 5

A. Parameters for Bioretention Features Within Detention Areas 5

B. Parameters for Permeable Pavers with Subsurface Detention 6

C. Parameters for Stormwater Wetland/ Wet Detention Pond Combinations 7

9.12-4 RETROFIT OPPORTUNITIES 9

A. Small-Scale Detention Retrofits 9

B. Larger-Scale Detention Retrofits 10

Some items of emphasis are listed in **bold blue text**.

9.12-1 OVERVIEW

This section reviews parameters for combinations, adaptations and retrofits of stormwater best management practices (BMPs). This section directly addresses these scenarios:

1. Multiple practices are used in series to meet stormwater objectives
2. Combinations and hybrids of different types of practices to meet both water quality and quantity goals
3. Retrofits of existing practices

9.12-2 PRACTICES IN SERIES

NOTE

Practices for water quantity are evaluated by reviewing routing models to determine if overall release rate requirements for a given site are being met.

Using a set of BMPs in a series to meet stormwater objectives is a recommended approach. However, care must be taken to not overload any one practice. This could lead to poorer performance of such practices, sacrificing their performance and overall quality and aesthetics. It also could lead to more frequent or extensive maintenance of undersized practices. For this reason, this section reviews parameters and documentation needs for designing practices that operate collectively to manage water quality requirements.

A. PARAMETERS FOR SERIES OF BMPS

When multiple practices are used in a series to meet a water quality treatment goal, the following parameters should be followed:

1. To avoid overwhelming any one practice, size each BMP element to manage at least 30% of the WQv requirements for the area that drains directly to the practice in addition to any remainder of WQv not treated by upstream practices. TARGET
2. A practice may not satisfy more than 100% of the WQv requirements for the watershed area upstream of the practice or manage WQv requirements already managed by an another practice located upstream. (It is not allowed to provide excess management in one area to offset insufficient management in downstream areas.) ESSENTIAL
3. Provide properly sized pretreatment measures (sized for all areas that have not passed through another pretreatment or treatment practice upstream). ESSENTIAL
4. Bypass untreated runoff from off-site areas around such a series of BMPs. Alternatively, if untreated runoff is allowed to enter a practice from off-site areas, size the practice as needed to manage this runoff. TARGET
5. Design calculations demonstrate that erosion would not be expected near points of water entry during a 10-year or 100-year storm event. This is checked by verifying that flow velocities would not exceed 5 fps for the 10-year and 10 fps for the 100-year event. ESSENTIAL
6. Provide calculations to demonstrate capacities of storm inlets and pipes (or surface overflow paths) that connect the BMP series for the 1-year through 100-year storm events. TARGET
7. Through the series of BMPs, satisfy 100% of the WQv requirements for the given site area. As runoff leaves the most downstream practice, verify that all elements of the USC required by the local jurisdiction have been achieved. ESSENTIAL

B. DOCUMENTATION

When designing water quality BMPs that operate in a series, provide the following documentation:

1. Calculations for each BMP showing that it is sized to manage at least {30%} of the WQv requirements for the area that drains directly to the practice, in addition to any remainder of WQv not treated by upstream practices
2. Calculations for sizing pretreatment measures
3. Calculations demonstrating that erosion would not be expected near points of water entry during a 10-year or 100-year storm event, as noted in Part A.
4. Calculations demonstrating capacities of storm inlets and pipes (or surface overflow paths) that connect the BMP series for the 1-year through 100-year storm events (as needed)
5. A summary table demonstrating the portion of the service area WQv requirements that are addressed by each practice. The total WQv managed by all practices in combination should satisfy 100% of the WQv requirements

TABLE 9.12-2-1: EXAMPLE WQV COMPLIANCE TABLE

Practice	Area to be Treated by BMP	% Impervious	Rv	WQv of Area to be Treated	Untreated WQv from Upstream BMPs	Total WQv to BMP	WQv Treated by BMP	% of WQv Treated by BMP	Untreated WQv to Downstream BMP	Downstream BMP
	(acres)	(%)		(CF)	(CF)	(CF)	(CF)	(%)	(CF)	
Green Roof	0.50	100%	0.950	2,155	0	2,155	1,724	80%	431	Bioretention Cell #2
Bioretention Cell #1	2.00	50%	0.500	4,538	0	4,538	2,723	60%	1,815	Bioretention Cell #2
Bioretention Cell #2	1.00	50%	0.500	2,269	2,246	4,515	3,160	70%	1,354	Stormwater Wetland
Stormwater Wetland	20.00	65%	0.635	57,626	1,354	58,981	58,981	100%	0	Discharge from Site

9.12-3 HYBRID DESIGNS

In some cases, different BMPs are combined to meet various aspects of the USC. This subsection explores some of these potential combinations and how designs should be adapted in such cases.

A. PARAMETERS FOR BIORETENTION FEATURES WITHIN DETENTION AREAS

Bioretention cells may be set within the footprint of dry or extended dry detention practices. A bioretention cell itself may be designed to provide detention storage above the cell. However, there are challenges to this approach. Soil materials within the bioretention cell need to be protected from compaction by the long-term presence of deeper water storage. Also, flows from extended detention should draw down quick enough to prevent damage to desired permanent vegetation.

When providing stormwater detention above bioretention cells, follow these parameters:

1. Detention ponding depth requirements above the level surface of the bioretention cell should be as follows: ESSENTIAL

TABLE 9.12-3.1: MAXIMUM TEMPORARY STORAGE DEPTHS OVER BIORETENTION CELLS

EVENT	RECOMMENDED DEPTH	ALLOWABLE DEPTH
	INCHES	INCHES
WQv event	9	
CPv event	18	24
10-year event	24	30
100-year event	48	60

2. While it is desired to reduce outflow rates to provide extended detention of the CPv event with a 24-hour draw-down, it is important to not "overdetain" such runoff so that draw-down will be extended over several days, which could make it difficult to maintain the desired level of diversity in permanent vegetation. For this reason, the outflow rate should be no less than 50% of the maximum allowable release rate calculated for the CPv event. Review modeled water surface elevations during the draw-down period. Adjust plant materials as needed based on the expected inundation period. Note plant selection resource based on inundation levels and duration. TARGET

3. For the same reasons as parameter #2, employ multi-stage outlets that release runoff from larger storm events (2-year to 100-year) at rates that are no less than 50% of the allowable release rates. This is to meet the stormwater management goals set forth in the USC, but limit the length of time that higher depths of temporary storage are observed. TARGET

NOTE

Permanent vegetation should be selected with care for areas that are expected to have deeper depths of inundation, or where such inundation may last for a longer period.

B. PARAMETERS FOR PERMEABLE PAVERS WITH SUBSURFACE DETENTION

In some cases, additional aggregate may be installed below permeable pavement systems to provide stormwater detention of larger storm events. Subsurface stormwater chambers may reduce the depth or footprint of aggregate layers to achieve this goal.

When designing permeable pavement systems that are paired with aggregate or stormwater chambers for stormwater detention, consider the following:

1. All the flow from the WQv event should pass through the surface of the permeable pavement surface. An exception to this requirement is that water from roof drains may be directed to the subsurface aggregate layers or chambers by pipes or subdrains. Refer to Section 8.01 on properly sizing the surface area of the permeable pavement installation to meet this criteria. ESSENTIAL
2. Determine how runoff from larger storms will be routed into the subsurface storage volume. This can be accomplished in one of two ways: ESSENTIAL
   a. Increase the size of the permeable paver installation to allow infiltration of these larger events.
   b. Provide an alternate way for runoff to enter the subsurface storage volume. Surface inlets can be designed to catch flows that exceed the capacity of the paver surface and allow those flows to enter a subsurface chamber system or exfiltrate from distribution pipes into an aggregate storage layer. In some cases, subsurface chambers may be needed to act as a manifold to allow runoff to enter aggregate layers quickly enough to prevent upstream surcharge of the system.
3. Design a multi-stage outlet control for the subsurface detention system that will restrict the release rate from the aggregate layers or stormwater chambers to allowable levels. ESSENTIAL

C. PARAMETERS FOR STORMWATER WETLAND/ WET DETENTION POND COMBINATIONS

When designing a stormwater wetland that will provide stormwater treatment above a wet detention pond (that is being designed as a separate practice downstream), follow the following parameters:

CASE #1: THE POND / WETLAND SYSTEM ARE SEPARATE AND DISTINCT PRACTICES, SEPARATED BY AN EARTHEN BERM, DAM OR RIDGE.

1. A piped connection and auxiliary spillway would usually be required to route runoff from the upstream to the downstream practice.
2. The upstream pond or wetland should be sized to manage at least 30% of the WQv requirements for the area that drains directly to the practice in addition to any remainder of WQv not treated by upstream practices. ESSENTIAL
3. The downstream practice should manage the remainder of the WQv requirements that are not being managed by the practice directly upstream, or other upstream practices. ESSENTIAL
4. Refer to the ISWMM Sections for Stormwater Wetlands and Wet Detention Ponds. Design each practice as described within the applicable section.
5. Perform routing models that demonstrate that outflow rates leaving the combined practices are below allowable levels set by the USC. ESSENTIAL

CASE #2: THE POND / WETLAND SYSTEM ARE NOT SEPARATE AND DISTINCT.

1. This arrangement may create a conflict between the guidance for wetlands and ponds.
   a. Stormwater Wetlands should have water depths of more than 1.5 feet for no more than 35% of the total surface area of the permanent pool.
   b. Stormwater ponds should have no more than 15% of the total surface area of the permanent pool in shallow water zones.
2. Recognizing this issue, pond / wetland combinations in this arrangement may have proportions of shallow and deep zones that fall between these two guidelines.
   a. In such a circumstance, Water Quality volume treatment levels should be determined by the following: ESSENTIAL

TABLE 9.12-3.2: RELATIONSHIP BETWEEN DEEP POOL AREA AND WQV STORAGE ADJUSTMENT

% OF PERMANENT POOL SURFACE AREA WITH DESIGN WATER DEPTH GREATER THAN 1.5 FEET	TOTAL SHALLOW AND DEEP POOL VOLUMES SHOULD PROVIDE AT LEAST THIS % OF WQV TO BE TREATED BY THE BMP
Below 35%	100% (follow Stormwater Wetland Section)
35%	100%
40%	110%
45%	120%
50%	130%
55%	140%
60%	150%
65%	160%
70%	170%
75%	180%
80%	190%
85%	200%
Above 85%	200% (follow Wet Detention Pond Section)

3. Within these combined practices, the design should denote separate wetland and wet pond zones. Refer to the Stormwater Wetland Section (9.08) for the design of wetland areas and the Wet Detention Pond Section (9.11) for the design of pond areas in such arrangements.

9.12-4 RETROFIT OPPORTUNITIES

Many older detention areas were sized using methods that did not consider management of small storm events. Some of these methods also have not provided effective storage for larger storm events. These methods often resulted in practices with a single-stage outlet control. This outlet, inlet or pipe was often too large to effectively control outflow during smaller events. The storage provided within the basin was often insufficient to store runoff expected from a 100-year, 24-hour storm event.

Practices expected to be less effective at stormwater management may be adapted to better manage runoff from smaller storm events. Instead of practices that are marginally effective at managing rare storm events, practices may be retrofitted to provide higher levels of management from more frequently occurring events.

NOTE

Remember that 98% of all rainfall events in Iowa fall below the CPv level, so effective management of these events may provide the greatest benefits to reduction of flash flooding and channel erosion in urban watersheds.

A. SMALL-SCALE DETENTION RETROFITS

These retrofits may be applied to a detention area for an individual site or development area. Typically such retrofits will serve watersheds of 40 acres or less. These practices may be adapted to provide extended detention of the CPv or even adapted into practices that can manage for water quality.

Under existing conditions, detailed modeling of such practices may show limited reductions for outflows during small storm events. These practices may also be projected to overtop during longer-duration larger storm events. For this reason, such practices may be retrofitted to provide better detention of smaller storm events, while using a multi-stage design to more effectively pass flows from larger events downstream.

When considering such retrofits, refer to the following guidance:

1. Does the geometry and topography of the current practice allow for it to be adapted to include water quality management features (such as a bioretention cell or stormwater wetland), referring to Section 9.12-3?
2. Develop a NRCS TR-55 model of the practice, using existing storage volumes and outlet controls. The model should review events from the WQv event up to the 500-year, 24-hour storm event.
3. Review the outfall controls. Are they single-stage or multi-stage in nature?
4. Develop designs that include multi-stage outlet controls.
    a. A smaller-diameter lower stage may be needed to provide extended detention of the WQv or CPv event, or to maximize reductions in peak flows as much as possible. TARGET
    b. Check to see if this event can be detained without overtopping the existing detention basin.
    c. Adjust the outfall design as needed to prevent overtopping. TARGET

5. Develop higher-stage controls to control runoff from larger storm events. Meeting USC requirements for these events is encouraged, but often will not be feasible in older, undersized detention facilities.
    a. The multi-stage outfall should be designed so that the 10-year storm event is allowed to pass through the primary spillway (outfall pipe) and the detention area will not overtop. TARGET
    b. Flows from larger events may overtop the basin. Make sure a well defined auxiliary spillway is provided, set 1.5 feet below the crest elevation of the remainder of the dam or grading that defines the basin. ESSENTIAL
    c. Check flow spreads and velocities over the auxiliary spillway to make sure the flows from the 500-year storm event will be passed within the defined spillway area. Evaluate the need for surface erosion protection of this spillway based on frequency of overtopping and expected flow velocities. ESSENTIAL
6. Review expected changes in the function of the detention area.
    a. How much are flow rates increased/decreased during various flow events? Will increases in flow rates during larger flow events negatively impact properties or structures downstream?
    b. What are changes in the high-water elevations within the basin during the events studied? Will this increase flooding risk for structures, properties or vehicles within or upstream of the detention area? ESSENTIAL
    c. Upon completing this evaluation, determine if such a retrofit is advisable at the given site, based on the parameters above.

B. LARGER-SCALE DETENTION RETROFITS

These retrofits may be applied to a detention area for multiple-site or regional stormwater management. Typically such retrofits will serve watersheds of 40 acres or more. Such facilities could be adapted to dry ED basins, stormwater wetlands and wet detention ponds.

When considering such retrofits, refer to the following guidance:

1. Is there sufficient area within the practice to adapt its use to a dry ED basin, stormwater wetland or wet pond? Refer to the applicable section of ISWMM for design guidance.
2. Develop a NRCS TR-55 model of the practice, using existing storage volumes and outlet controls. The model should review events from the WQv event up to the 500-year, 24-hour storm event.
3. Review the outfall controls. Are they single-stage or multi-stage in nature?
4. Develop designs that include multi-stage outlet controls.
    a. A smaller-diameter, lower stage may be needed to attempt to provide extended detention of the WQv or CPv event, or to maximize reductions in peak flows.
    b. Check to see if this event can be detained without overtopping the existing detention basin. TARGET
    c. Adjust the outfall design as needed to prevent overtopping. TARGET

5. Develop higher stage controls to control runoff from larger storm events. Meeting USC requirements for these events is encouraged, but often will not be feasible in older, undersized detention facilities.
    a. The multi-stage outfall should be designed so that the 25-year storm event is allowed to pass through the primary spillway (outfall pipe) and the detention area will not overtop. TARGET
    b. Flows from larger events may overtop the basin. Make sure a well defined auxiliary spillway is provided, set 1.5 feet below the crest elevation of the remainder of the dam or grading that defines the basin.
    c. Check flow spreads and velocities over the auxiliary spillway to make sure the flows from the 500-year storm event will be passed within the defined spillway area. Evaluate the need for surface erosion protection of this spillway based on frequency of overtopping and expected flow velocities. ESSENTIAL
6. Review expected changes in the function of the detention area.
    a. How much are flowrates increased/decreased during various flow events? Will increases in flow rates during larger flow events negatively impact properties or structures downstream?
    b. What are changes in the high-water elevations within the basin during the events studied? Will this increase any risk of flooding of structures or properties within or upstream of the detention area? For this scale of practice, this will often be a determining factor as to whether retrofits are possible. Such retrofits should not substantially increase the risk of flooding building structures upstream or around the practice. ESSENTIAL

Upon completing this evaluation, determine if such a retrofit is advisable at the given site.