IOWA STORM WATER MANAGEMENT MANUAL

9.12 STORMWATER DETENTION COMBINATIONS AND RETROFITS

IOWA DEPARTMENT OF NATURAL RESOURCES

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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

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.

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.

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.