MANUAL OF STORMWATER MANAGEMENT PRACTICES

To Be Used In Conjunction With The Monroe County Land Development Code

June 2020

UPDATED MANUAL OF STORMWATER MANAGEMENT PRACTICES

Original Manual published by Monroe County in 1995 – Updates performed by Jones Edmunds & Associates, Inc.

Prepared for:

Monroe County Department of Planning & Environmental Resources

102050 Overseas Highway

Key Largo, Florida 33037

Prepared by:

Jones Edmunds & Associates, Inc.

2240 Palm Beach Lakes Blvd Suite 300

West Palm Beach, Florida 33409

Jones Edmunds Project No.: 13015-001-01

June 2020

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1 INTRODUCTION

Monroe County has a unique, water-oriented environment and because of the importance of its aquatic environment, both aesthetic and economic, a Stormwater Management Ordinance (hereinafter referred to as the "Ordinance") has been adopted to help protect these resources from the harmful effects of stormwater runoff.

Stormwater is the water that results from a rain event. Runoff is defined as the portion of stormwater that does not percolate into the ground, evaporate, and is not intercepted before reaching a stormwater management system. Stormwater runoff from undeveloped lands usually does not present a management problem since it is relatively clean, and the volume usually is minimal. When natural land is converted to some other land uses, stormwater becomes a problem and should be managed. Soil is often paved over and impervious surfaces are created. When impervious surfaces are created, stormwater is no longer able to percolate into the ground and accumulates on the surface, which can cause flooding in some areas. These impervious areas also allow for pollution accumulation, degrading the quality of stormwater runoff and rendering it a pollution source. For these two reasons, flooding (water quantity) and pollution (water quality), stormwater management practices are implemented in developed areas.

Stormwater runoff quality varies with land use. A multitude of pollutants exist in stormwater runoff as well as the sources for these pollutants. These pollutants can consist of nutrients, solid waste, litter, lead, petroleum products (from automobiles), chemicals, fertilizers, and herbicides applied to lawns, and atmospheric deposition. Higher nutrient loads are generated by residential and industrial land uses while commercial, mixed urban, and roadways generate higher concentrations of metal contamination. Heavy metals are of concern because several are known to be toxic to many aquatic plant and animal species. Motor vehicles and road surfaces are the main sources of heavy metals in stormwater runoff. Nutrients and pesticides from lawn fertilizers and atmospheric deposition can cause algal blooms and similar occurrences if untreated runoff is allowed to enter surface waters. During a rainfall event, stormwater runoff flows over these surfaces, picking up pollutants, and carrying them to surface waters.

Stormwater not only causes adverse environmental impacts, but economic impacts as well. An increase in the number of impervious surfaces increases the potential for flooding and property damage. Stormwater can also lead to reduced fisheries production because of the degradation of water quality. For these reasons, stormwater management practices have been implemented throughout Florida and the United States. This manual is designed as a guide to Best Management Practices (BMPs) for stormwater management in Monroe County.

A stormwater management practice is one that shapes and improves the quality and quantity of stormwater runoff being discharged to receiving waters. BMPs for stormwater are those that meet discharge quantity and quality criteria at a minimal cost (Wanielista and Yousef, 1985).

Section 114-3 of the Monroe County Code addresses the issue of flood protection and water quantity management. Although this Stormwater Management Ordinance does have general criteria for water quantity and flood protection, the main purpose is to provide guidelines related to the control of stormwater-generated pollution and is therefore water-quality based.

The practices and procedures described in this manual are those in common usage throughout Florida and also apply to Monroe County. The bibliography at the end of this manual lists some of the relevant sources of additional information on this subject. This manual will be used to review and approve stormwater management systems permitted by the County and will be modified as appropriate technology dictates.

2 APPLICABILITY

This manual is to accompany the Monroe County Stormwater Management Ordinance. This Ordinance was incorporated into the Monroe County Land Development Code by amendment to the Comprehensive Plan. A Stormwater Management Plan will be required as part of all building permit applications (except those projects exempted pursuant to Section 114-3(c) of the Land Development Code). The definitions used in this manual are consistent with those in the Land Development Code and the Monroe County Stormwater Management Ordinance.

3 CONTENTS OF A STORMWATER MANAGEMENT PLAN

A stormwater management plan is required pursuant to Section 114-3 (g) of the Land Development Code for those projects not exempted pursuant to Section 114–3 (c). A Plan is to be submitted as part of the Monroe County building permit application. The Plan will indicate how project design will incorporate the required stormwater treatment criteria. The following is an outline of those elements that may be required as part of a stormwater management plan. Appendix 5 contains a checklist of these elements. This will allow County staff to determine which of the elements a specific plan should or should not require for each site. Some of these elements are required for other parts of a County building permit, but also need to be considered as part of the Stormwater Management Plan. In these instances, specific criteria are the same as those already required by the County and are not discussed further in this Manual.

1. Site Information:

    a. Detailed location map.
    b. Description of vegetative cover, including wetlands.
    c. Location and size of preservation or mitigation areas.
    d. Site paving, grading, and drainage plans.
    e. Vegetation protection plan.
    f. Soils map and percolation test results.
    g. Wet-season water table elevation.
    h. Future wet-season water table elevation (30-year).
    i. Description of measures to be used during construction to eliminate adverse off-site impacts, such as increased turbidity or siltation, if applicable.
    j. Recent aerial photograph.
    k. Map of drainage basin boundaries including any off-site areas.
    l. Map of floodplain and elevations.

2. Master Stormwater Management Plan:

    a. Location of all existing and proposed on-site water bodies, including wetlands.
    b. Location of all off-site wetlands, water courses, and waterbodies affected by on-site drainage patterns.
    c. Location and detail of all major control structures and elevations. Preliminary construction plans may be submitted for conceptual approval.
    d. Right-of-way and easement locations for stormwater management systems including all areas reserved for stormwater management purposes.
    e. Location and size of on-site stormwater management facilities.
    f. Square footages, acreages, and percentage of property proposed as:
        (1) Impervious surface (excluding waterbodies).
        (2) Impervious surface (waterbodies).
        (3) Pervious surface.
        (4) Total square footage or acreage of the project site.

g. Proposed grading plan.
h. Treatment volumes and discharge rates (if applicable) for stormwater runoff.

3. Legal and Institutional Information:

   a. Entity responsible for operation and maintenance of surface water management system.
   b. If the operational and maintenance entity is to be a public body, a letter from the public body confirming this must be submitted before staff approval. If the entity is a homeowners' association, documents verifying the existence of such organization and its ability to accept operation and maintenance responsibility must be submitted before staff approval.

4 METHODS OF STORMWATER TREATMENT

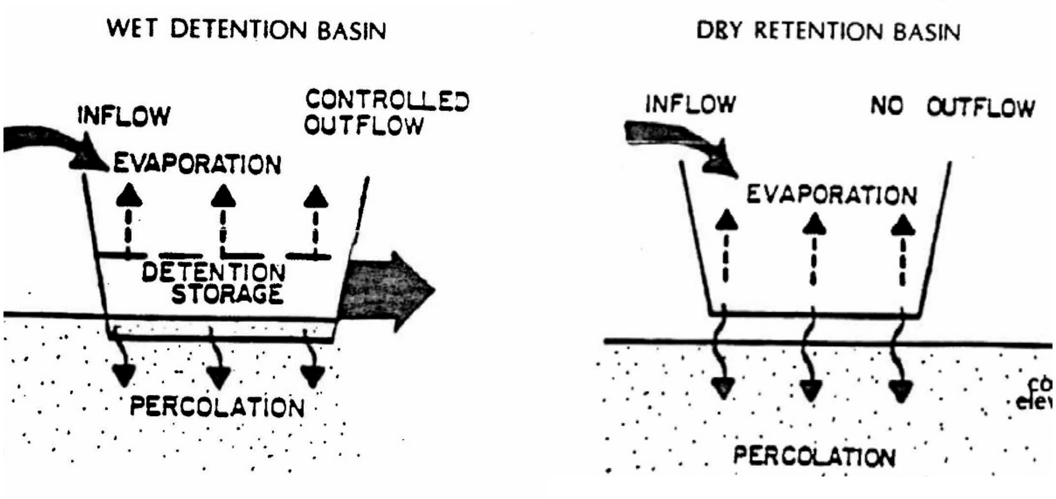
Stormwater treatment facilities are designed to treat stormwater runoff to a level that results in the pollutant loads discharged after development either being less than the pollutant loads discharged before development (a net improvement) or that results in pollutant loads being reduced by 95 percent. The volume to be treated depends on the type of stormwater management facility(ies) used and the land use of the property. The two most commonly used methods of stormwater treatment are wet detention and dry retention. A detention facility collects and temporarily stores a treatment volume to provide for treatment through physical, chemical, or biological processes with subsequent gradual release of the stormwater to a surface water system. A retention facility is designed to prevent the discharge of a given volume; however, it is slowly released from the facility. A retention or detention facility built above the groundwater table is "dry." A facility with the bottom below the control elevation is "wet." Figure 1 conceptually illustrates the differences between each. The wet-season water table plays an important part in the functioning of retention systems. To ensure that stormwater facilities continue to function, a stormwater design will need to include a determination of the wet-season water table and an estimate of the future wet-season water table. The future wet-season water table will be assumed to be increased by the difference in sea level in the year that the wet-season water table determination was made and the projected sea level 30 years after the permitting. The estimated sea level rise projections adopted by the Southeast Florida Climate Change Compact must be used for this determination.

A newer approach to stormwater management is called Low Impact Development or Design (LID). This approach seeks to replicate a more natural hydrologic function on the landscape and uses a combination of stormwater management practices to meet the objective stated above. Some of these practices include pervious pavement, vegetated swales, vegetated filter strips, bioretention systems, cisterns, and green roofs.

Very often a stormwater management system incorporates a combination of treatment methods. It is infeasible to describe all the possible combinations in this manual. The criteria for each individual type of treatment is detailed. The intent is to ensure that the proper volume of runoff is treated in an appropriate manner for the land use. References to guidelines for LID approaches to stormwater management are also provided.

Appendices 3 through 6 provide the design criteria for each type of management system.

Figure 1 Schematics of Two Basic Detention/Retention Stormwater Management Systems



Source: Adapted from Whalen and Cullum, 1988.

4.1 Wet Detention

4.1.1 Definition

Wet detention is the collection and temporary storage of stormwater runoff—before controlled discharge into receiving waters—in a permanently wet impoundment in such a manner as to provide for treatment through physical, chemical, and biological processes with subsequent gradual controlled release of the stormwater. A wet detention facility is a basin or pond with a bottom elevation below the wet-season water table or control elevation.

4.1.2 Requirements as Expressed in this Manual

Stormwater designs must demonstrate a net improvement in nutrient loads or a 95 percent reduction in pollutant loads. This can be demonstrated through methods that are accepted by the South Florida Water Management District (SFWMD). An example of one of these methods is using BMP Trains, which is freely available from the University of Central Florida Stormwater Management Academy (https://stars.library.ucf.edu/bmptrains/).

As an alternative to demonstrating net improvement or 95-percent pollution load reduction, wet detention with pretreatment that meets the following criteria can be used as a stormwater practice and will be presumed to meet the County stormwater treatment objectives:

- Provide a treatment volume sized to the first 1 inch of runoff from the site or the total of 2.5 inches times the percent of impervious area, whichever is greater.
- One-half inch of the detained volume must be released through a control structure within 24 hours.
- Wet detention cannot be used as the sole form of stormwater treatment. Projects using wet detention must provide at least 2.5 inch of runoff pre-treatment in dry retention before discharging into a wet detention facility.

4.1.3 Method of Achievement

Man-made lakes or ponds on the site are generally used for wet detention. These lakes or ponds must meet the design criteria in Appendix 3 of this manual. The retention volume can be achieved using the guidelines in Section 4.2 and Section 4.3 of this manual.

4.2 Retention

4.2.1 Definition

Dry retention is a stormwater system designed to prevent the discharge of a given volume of stormwater runoff into surface waters by complete on-site storage of that volume. A dry-retention facility has a bottom elevation at least 1 foot above the future wet-season water table and is usually dry. Stormwater is released only during times of heavy rainfall or flooding.

4.2.2 Requirements as Expressed in this Manual

Stormwater designs must demonstrate a net improvement in nutrient loads or a 95 percent reduction in pollutant loads. This can be demonstrated through methods that are accepted by the SFWMD. An example of one of these methods is using the BMP Trains, which is freely available from the University of Central Florida Stormwater Management Academy (https://stars.library.ucf.edu/bmptrains/).

As an alternative to demonstrating net improvement or 95-percent pollutant load reduction, dry-retention systems that retain the retention depth listed in Table 1 multiplied by the total project area will be presumed to meet the County stormwater treatment objectives.

4.2.3 Method of Achievement

Examples of dry-retention facilities include infiltration systems (vegetated swales, bioretention systems), and seepage systems (exfiltration trenches, pervious pavement, exfiltration vaults). Of these two, infiltration systems provide better pollution attenuation. The vegetation takes up a percentage of the nutrients commonly found in stormwater runoff. Most heavy metals bind with the soils above the water table, and the potential for them entering the groundwater is reduced.

Seepage systems consist of an underground facility that relies on a mostly outward dispersion of stormwater from the facility to the groundwater. These structures are constructed a minimum of 1 foot above the future wet-season water table. These systems are most suitable for areas where the aquifer has a high transmissivity, such as Monroe County. However, they do not provide the nutrient uptake that is offered with vegetated infiltration systems.

Infiltration systems and seepage systems need a highly permeable substratum to allow the stormwater runoff to percolate into the ground. Seepage systems do not require as much land area as infiltration systems, since they can be installed underground. However, the future wet-season water table at the project site must be at least 1 foot below the seepage structure.

Table 1 Required Retention Depths for Stormwater Treatment

Percent Impervious	Required Retention Depth (Inches)
20	1.40
25	1.47
30	1.59
35	1.71
40	1.88
45	2.02
50	2.17
55	2.33
60	2.49
65	2.65
70	2.81
75	2.99
80	3.16

4.3 Low Impact Development or Design

4.3.1 Definition

LID is an approach to stormwater and land use management that aims to replicate a more natural hydrologic function by promoting infi tration, fi tration, storage, and evaporation of stormwater runoff. This approach focuses on conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project's design, especially its landscaping and open space. Stormwater management through LID often includes a treatment train consisting of several different stormwater management practices that combine to meet the stormwater quality objectives for the site. Examples of practices that are often included in LID are:

- Minimizing clearing, grading, soil disturbance, and compaction on a site.
- Minimizing impervious area on site.
- Pervious pavement.
- Shallow bioretention systems.
- Vegetated or grassed swales.
- Vegetated filter strips.
- Minimizing directly connected impervious areas.
- Cisterns.
- Stormwater harvesting.

4.3.2 Requirements as Expressed in this Manual

Using a LID approach for stormwater management is encouraged in Monroe County. However, stormwater designs must demonstrate a net improvement or 95percent reduction in pollutant loads. This can be demonstrated through methods that are accepted by SFWMD. An example of one of these methods is using BMP Trains, which is freely available from the

University of Central Florida Stormwater Management Academy (https://stars.library.ucf.edu/bmptrains/).

4.3.3 Method of Achievement

A LID approach to stormwater management starts during the planning and site evaluation and continues through the selection and design of the most appropriate stormwater treatment practices for the site. The goal of stormwater management should be to retain, detain, recharge, filter, and use as much stormwater as possible on a site. A variety of LID design manuals in Florida describe this approach to stormwater management. These include but are not limited to the following:

- Low-Impact Development and Green Infrastructure: Pollution Reduction Guidance for Water Quality in Southeast Florida
- Sarasota County Low-Impact Development Guidance Document
- Duval County Low-Impact Development Stormwater Manual
- Pinellas County Stormwater Manual

The manuals listed above provide design guidelines for a variety of LID stormwater practices, which include:

- Grassed conveyance swales.
- Shallow bioretention.
- Pervious pavement.
- Stormwater harvesting.
- Green roofs.
- Rainwater harvesting (cisterns).
- Detention with biofiltration.

Monroe County will generally accept the LID practices and design consideration described in the LID manuals referenced above, although it should be noted that the performance curves and tables provided in these manuals do not necessarily apply to Monroe County's hydrologic conditions. Pollutant load reductions will need to be determined by the appropriate Florida-registered and licensed professional.

5 CONTROL STRUCTURES

5.1 DEFINITION

A control structure is a device through or over which water is discharged from a stormwater management system. Direct discharge occurs when stormwater is released through a control structure to the receiving water body. If the discharge from the stormwater management system is by a means other than a control structure (e.g., sheet flow or spreader swale), it is considered indirect discharge.

5.2 PURPOSE

The primary purpose of a control structure in a detention facility is to release the calculated runoff volume slowly over a specified period. In a retention facility the control structure allows for volumes in excess of the calculated retention volume to leave the system in a manner that provides for adequate downstream flood protection.

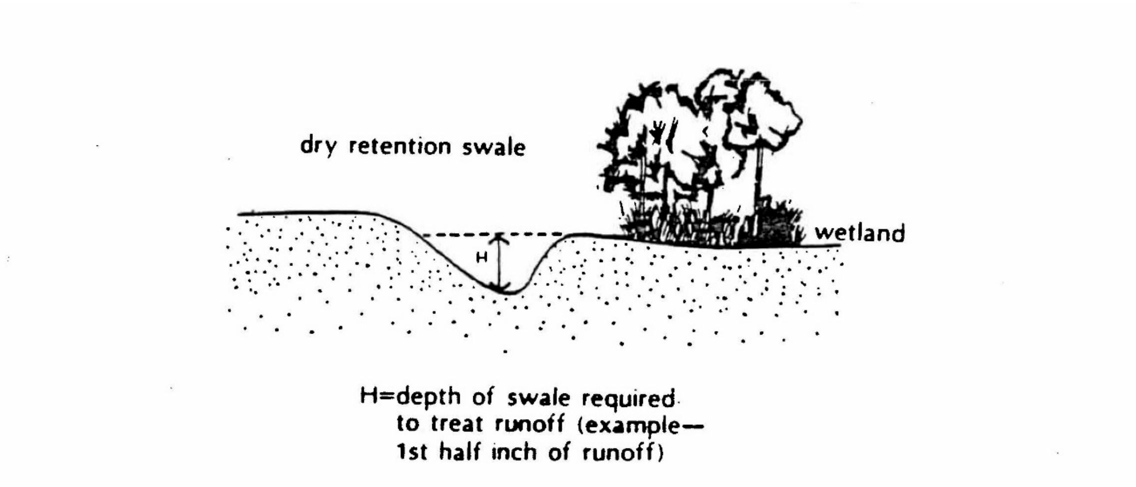
5.3 TYPES OF CONTROL STRUCTURES

Direct discharge from a water management facility to the receiving body is usually achieved through control structures such as weirs and orifices. The following criteria must be met for all methods of direct discharge:

1. Trash-collecting gratings must be on the intake of all structures that discharge to surface waters.
2. Detention facilities must be discharged from the mid-depth of the water column.
3. If the property is greater than 50-percent impervious or contains a system with inlets in paved areas, discharge structures must include a baffle, skimmer, or other suitable mechanism for preventing oil and grease from being discharged. (Appendix 2 describes these mechanisms, which are part of a catch basin).
4. Direct discharge will only be allowed to those areas that by virtue of their large capacity or configuration are able to absorb concentrated discharges.

When using indirect discharge to release stormwater, a spreader swale is commonly used. The swale is positioned parallel to the receiving body, and the side adjacent to the receiving body is lower than the side opposite the receiving body. Figure 2 illustrates this form of discharge. The swale allows the water to flow into the receiving body but not flood the adjoining property. This method works well when trying to maintain a proper water level in wetlands that are used for stormwater management. The spreader swale is also a treatment facility for stormwater runoff. Runoff in excess of the first flush is allowed to enter the wetland system via sheet flow.

Figure 2 Spreader Swale (Indirect Discharge)



6 CRITERIA FOR SINGLE-FAMILY/DUPLEX LOTS

Single family and duplex homes may be exempted from filing a Stormwater Management Plan pursuant to Section 14-3(d), provided guidelines established in the "Layman's Brochure" are used to treat stormwater. The Layman's Brochure and the following design criteria generally use vegetated swales. However, other retention practices may be used. The retention volume specified in these design criteria will provide adequate stormwater treatment on a single-family/duplex lot to meet the criteria of Section 114-3 (f) (2). However, calculations demonstrating a net improvement or 95 percent reduction in nutrient loads may be submitted as an alternative to using the retention volume specified in these design criteria. These stormwater calculations must be completed by an appropriate Florida-registered and licensed professional.

The retention volume depends on the lot size and the stormwater management system used. Stormwater treatment can also be provided through the use of other retention systems such as pervious pavement, exfiltration trenches, or shallow stormwater vault systems.

Required retention depths for single-family/duplex lots are provided in Table 2. These are based on the effective impervious area, which is the sum of all the directly connected impervious areas and half the unconnected impervious area. Unconnected impervious area is an impervious area that has to drain more than 20 feet of pervious area before entering the stormwater system or retention system.

If swale(s) are used, they must meet the following criteria:

- Runoff from site must be drained to swale.
- Swale length must be greater than its width.
- Swale side slope must be 4:1 or shallower (horizontal to vertical).
- Swale must be placed so that any natural areas to be preserved are not disturbed.
- Swale must be at least 6 inches deep.
- Swales should be vegetated. If a swale is not vegetated, then a 6-inch layer of soil amendment formulated to reduce nutrient loading must be installed directly below the swale. Specifications and published nutrient reduction test results for the media must be provided at the time of testing. Examples of acceptable media are NutriGone™ (distributed by EcoSense International) and Bold and Gold® (distributed by Environmental Conservation Solutions).

Retention systems must discharge off-site to prevent flooding. For retention systems, a control structure will allow runoff in excess of the volume of the swale to be discharged to the receiving body. There may be more than one retention system present on the property, provided each meets these criteria and the total volume of the swales is at least the calculated volume. Vegetated swales may be incorporated into the set-back area of land required by the Monroe County Code. Appendix 6 contains sample calculations for single-family/duplex lots. Florida-Friendly Landscaping™ is encouraged for vegetated swales.

Table 2 Required Retention Depth for Single Family/Duplex Lots

Effective Impervious Area to Disturbed Area Ratio	Required Retention Depth (feet)	Required Retention Depth (inches)
0.20	0.138	1.66
0.25	0.146	1.75
0.30	0.153	1.84
0.35	0.164	1.97
0.40	0.177	2.12
0.45	0.188	2.26
0.50	0.203	2.44
0.55	0.215	2.58
0.60	0.228	2.74
0.65	0.243	2.92
0.70	0.256	3.07
0.75	0.271	3.25
0.80	0.286	3.43

Appendices

The Appendices contain the specific design criteria for the BMPs discussed in this manual. These criteria are based on best available knowledge in the area of stormwater management. As technology dictates, these criteria will change.

Appendix 1

Control Structures

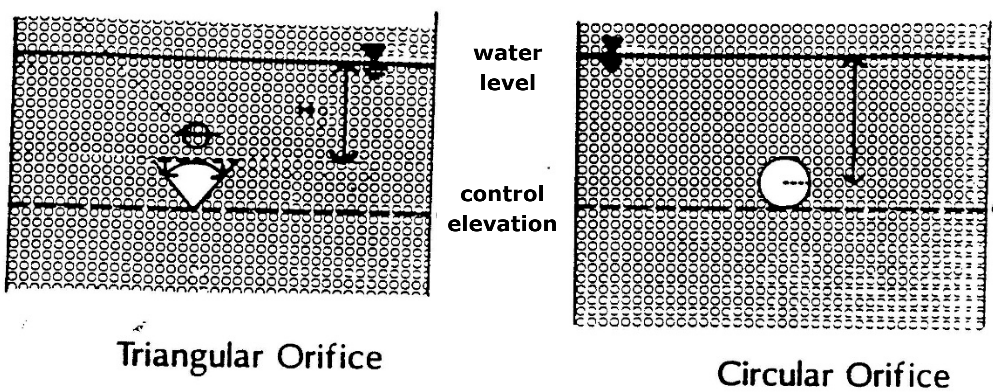
APPENDIX 1 – CONTROL STRUCTURES

This Appendix contains details on the designs for four types of control structures: a triangular orifice, a circular orifice, a v-notched weir, and a rectangular weir.

Orifices and V-notched weirs are generally used with control structures associated with detention facilities. These structures are commonly referred to as bleed-down mechanisms and allow for controlled release of a portion of detained volume over a specified period (usually 1/2 inch in 24 hours). Rectangular weirs are commonly used with detention and retention facilities. In retention facilities, a rectangular weir allows for the runoff in excess of the retained volume to leave the facility. Rectangular weirs serve the same purpose in detention facilities, using a circular or triangular orifice as the bleed -down device. Figures 3A through 3C illustrate these different types of control structures and their use.

The retained and detained volumes used in the determination of the dimensions of the control structures are calculated from the equations following each drawing.

Figure 3A Orifice Weirs



$$A = \frac{Q}{4.8H^{3/2}}$$

Where: Q = discharge (cfs).

A= Area of orifice (square feet).

H=Head above orifice centroid* (feet).

*Centroid for a circular orifice is the center; centroid for a triangular orifice is two-thirds the distance from the vertex.

An orifice is a device that allows for discharge from the center of the control structure. Simply put, it is an opening in the structure that lets water slowly pass. Detention facilities use orifices. The rate that water is discharged depends on the cross-sectional area of the orifice. Figure 3A shows the two types of orifices.

The first is a circular orifice. As the name and illustration implies, it is a round opening. The bottom of the opening is at the control elevation. In the case of dry detention, the bottom of the circle is at the ground elevation. The most common method for constructing a circular orifice is placing a PVC pipe in the control structure. This pipe then discharges to the receiving body or to a conveyance system discharging to the receiving body.

The second type of orifice is a triangular orifice which is an inverted triangular opening in the control structure. The vertex of the orifice is at the control elevation. If the facility is a dry detention facility, the vertex is at the ground elevation.

For maintenance purposes, the cross-sectional area of the orifice in any control structure must be greater than 6 square inches to ensure that the structure allows for free flow of water and does not become clogged. The above formula is used to calculate the cross-sectional area of the orifice.

Below is an example calculation for an orifice in a control structure which is part of a wet detention facility. The following assumptions are made:

- H = 3 feet
- One-half inch of retained stormwater = 400,000 cubic feet
  - First, the discharge rate (Q) must be calculated:

$$Q=\frac{400{,}000\ ft^3}{24\ hours} \times \frac{1\ hour}{3600\ sec.}$$

$$Q= 4.63\ cfs$$

$$A= \frac{Q}{4.8\ H^{1/2}}$$

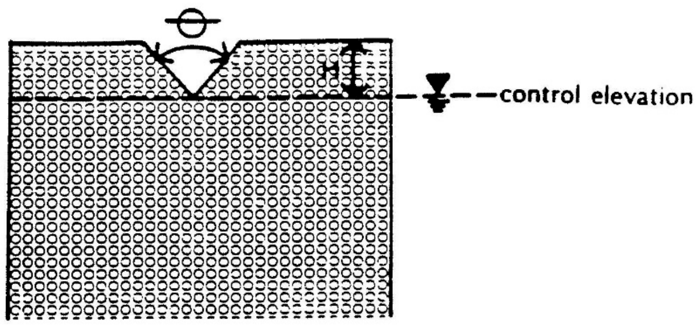
$$A=\frac{4.63}{(4.8)(3^{1/2})}$$

$$A=\frac{4.63}{8.31}$$

$$A=0.56\ ft^2$$

This meets the minimum dimensional criteria for orifices in detention facilities.

Figure 3B V-Notched Weir



V-Notched Weir

$\theta = 2\arctan\left(0.492 \cdot \frac{V_{det}}{H^{2.5}}\right)$

θ = notch angle (degrees)

Vdet = 1/2 inch of detention volume to be released (acre-feet)*

H = distance from weir crest to vertex angle (feet)

* 1 cubic foot = 2.29×10^{-5} acre-feet

V-notched weirs are used with wet- and dry- detention facilities. The configuration of the opening allows for slow discharge of detained water over time. The rate of discharge depends on the angle of the V-notch. When designing a control structure with a V-notch weir, the angle is calculated using the above formula. V_{det} refers to 1/2 inch of the detained volume that must be discharged within 24 hours.

For maintenance and functional purposes, the angle of the V-notch should not be less than 20 degrees being the minimum to allow for adequate flow of water and to prevent blockage of the weir.

The following is an example calculation for a V-notched weir, which is part of a 2-foot-deep dry-detention facility, making the following assumptions:

H=2.0 feet (depth of detention facility)

$V_{det} = 500\ ft^2$, therefore, $V_{det} = 0.01$ acre feet

then,

$\theta = 2 \arctan (0.492) ((V_{det}/H^{2.5}))$

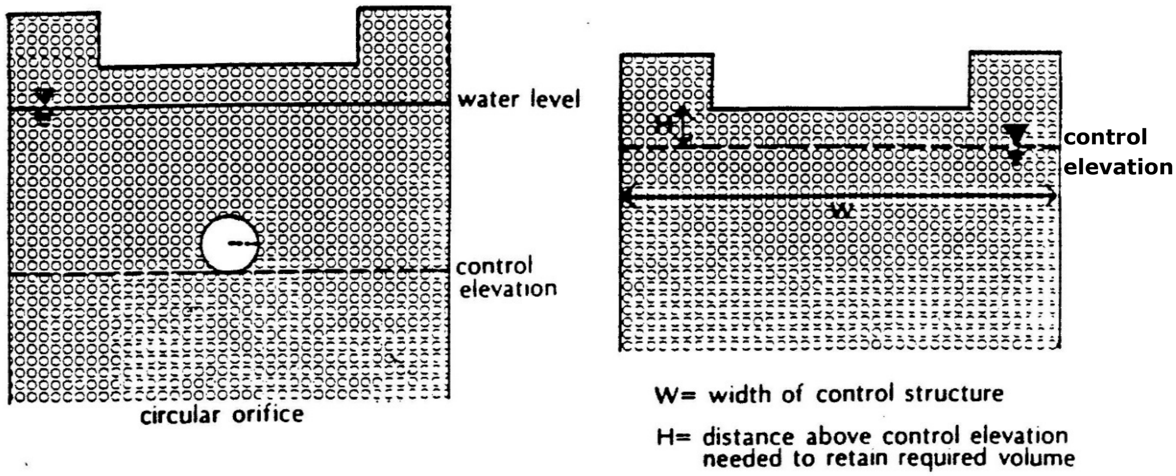
$\theta = 2 \arctan (0.492) ((0.01/2^{2.5}))$

$\theta = 2 \arctan (0.03)$

$\theta = 3.19$ degrees

Since the calculated angle is less than 20 degrees, and the angle of the V-notch must be at least 20 degrees, this facility will need a 20-degree angle. Because most of the stormwater management facilities reviewed by County staff will be small, calculations in which the angle of the notch is less than 20 degrees will be common.

Figure 3C Rectangular Weir



A rectangular weir is a structure that allows excess volumes of water to leave a stormwater management facility. A rectangular weir is used with retention facilities to discharge runoff in excess of the retained volume. A rectangular weir can also be used in conjunction with a detention facility that has an orifice for the delayed release of stormwater runoff. The rectangular weir allows for the discharge of excess runoff during severe rain events. The weir is constructed on top of the control structure. Rectangular weirs are used in areas where a receiving water body exists for excess runoff or a method of conveying excess runoff to a receiving water body.

Control structures can be made of several different types of materials. Those commonly used include concrete, aluminum, and earthen material. Polyvinyl chloride (PVC) pipe is often used as a bleed-down mechanism (circular orifice).

All control structures must discharge to a receiving body of water that has the capacity to handle the discharge. If no receiving water body exists adjacent to the stormwater management facility, some system for conveying the stormwater must be provided and is commonly done by using swales, culverts, or similar mechanisms. However, an assurance that water will not stand in enclosed structures (i.e., culverts) for extended periods must be provided since this may lead to water quality problems.

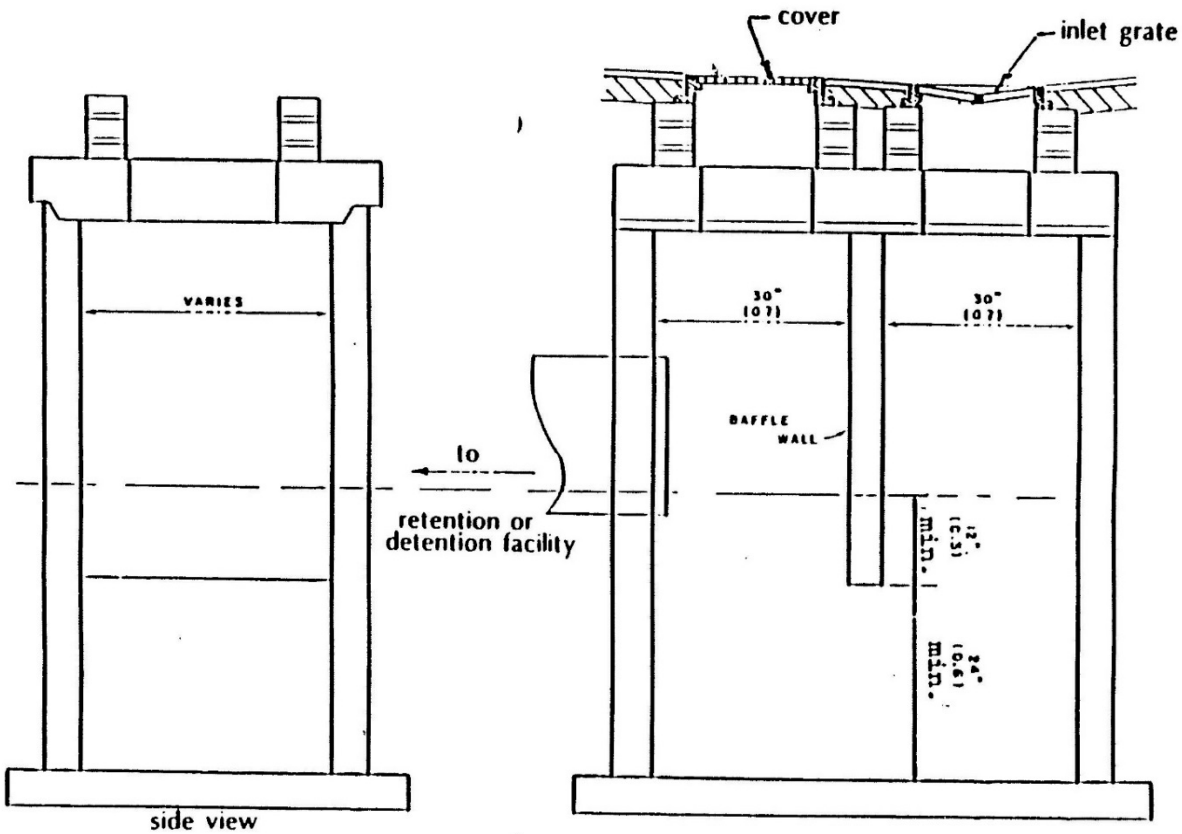
Appendix 2

Catch Basins and Pollutant-Retardant Structures

APPENDIX 2 – CATCH BASINS AND POLLUTANT-RETARDANT STRUCTURES

Catch basins are often used to collect stormwater from areas with large percentages of impervious surfaces and convey it to a treatment facility. These structures need to be designed and certified by a professional engineer and be equipped with pollutant-retardant structures. The structures in Figures 4A through 4C allow for pollution control and sedimentation collection before discharge to the stormwater treatment facility. In Figure 4A, the center column acts as a baffle. Oils, greases, and debris will remain on top of the water column in the right-hand chamber. Only water below the baffle will be able to flow out of the pipe. In Figures 4B and 4C, the down-turned pipe serves the same purpose. This pipe is removable so it can be cleaned and maintained. Periodic cleaning and maintenance are necessary to prevent clogging, ensure adequate treatment, and prolong the life of the facility.

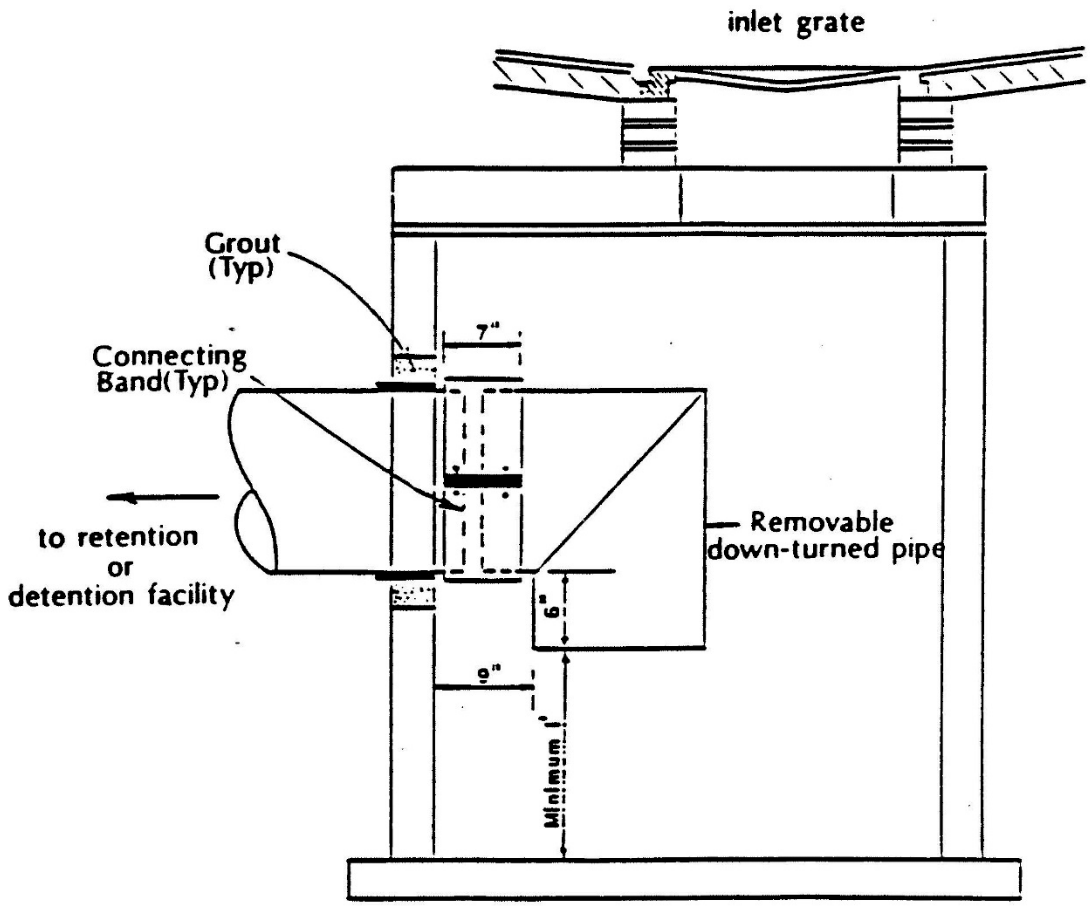
Figure 4A Pollutant-Retardant Catch Basin



Notes:

1. Figures in Parenthesis are meters.
2. Inverts of pipes, bottom of baffle to be placed to achieve intent of design and to accommodate hydraulic requirements.
3. Adapted from Broward County, 1987

Figure 4B Pollutant-Retardant Catch Basin with Removable Down-Turned Pipe

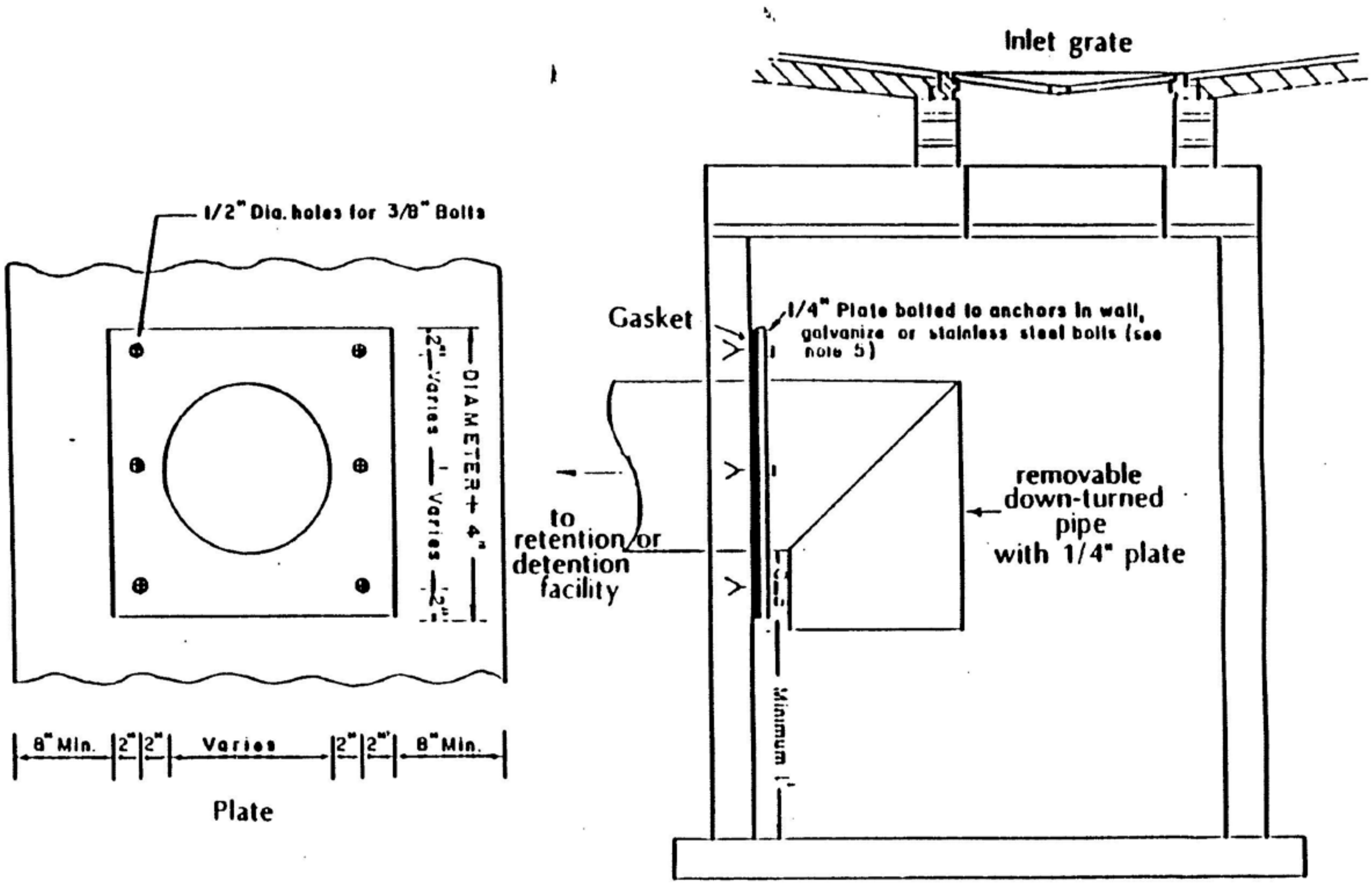


Notes:

1. Inverts of pipes to be placed to achieve intent of design and to accomodate hydraulic requirements.

2. Adapted from Broward County, 1987.

Figure 4C Pollutant-Retardant Catch Basin with Removable Down-Turned Pipe



Notes:

1. Inverts of pipes to be placed to achieve intent of design and to accomodate hydraulic requirements.
2. Adapted from Broward County, 1987.

Appendix 3

Wet-Detention Facilities

APPENDIX 3 – WET-DETENTION FACILITIES

A wet -detention facility is usually wet and allows for 1/2 inch of the required detained volume (1 inch or the total of 2.5 inches times the percent of impervious area, whichever is greater) to be discharged through a control structure in no less than 24 hours. Catch basins, pipes, swales, or channels are used in areas with large amounts of impervious surface to collect runoff and convey it to the detention facility. The required design criteria of a wet detention facility are detailed below:

- The lakes must be at least 0.25 acre and at least 50 feet wide for lakes in excess of 100 feet in length.
- Irregularly shaped lakes may be narrower than 50 feet in some portions but should average 50 feet in width.
- Projects with single-owner entities or entities with a full-time maintenance staff with obvious interests in maintaining the areas for water quality purposes may have the area and width criteria waived.
- The lake slopes should be at least 4:1 (horizontal to vertical), to a depth of 2 feet for safety reasons and to allow a littoral habitat to form.
- Discharge should be from the center of the water column.
- The control structure is at one point in the detention facility. Trash collection screens are required on structures discharging to all surface waters.
- The control structure must be opposite from where the runoff enters the facility to prevent hydraulic short-circuiting and ensure full treatment.

Wet detention cannot be used as the sole form of stormwater. If wet detention is used, at least 2.5 inches of dry retention must be provided before discharging into a wet-detention facility.

Appendix 4

Dry-Retention Facilities

APPENDIX 4 – DRY- RETENTION FACILITIES

Two types of dry-retention facilities exist – infiltration facilities and seepage facilities. The most common form of infiltration is vegetated swales or basins. Runoff is routed to a vegetated area, either directly or through a catch basin and conveyance system.

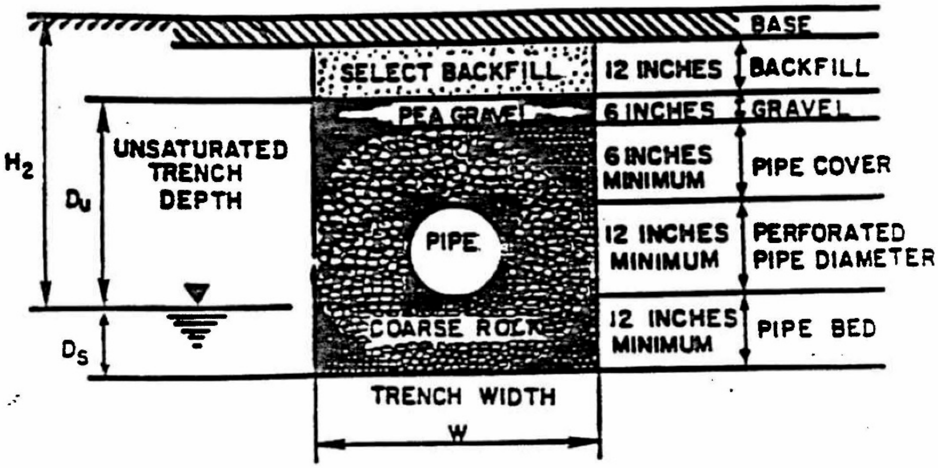
A control structure, usually a rectangular weir, is at one end of the swale or basin to allow for excess runoff to be discharged to a receiving body. A spreader swale can also be used in conjunction with this form of treatment. This type of discharge is most often used to release water through sheet flow to wetland areas or to prevent erosion.

The seepage method of dry retention involves allowing the water to disperse outward from an underground facility. The runoff is routed to a catch basin and is conveyed to a seepage system. Exfiltration trenches are the most commonly used types of seepage systems. They are used in conjunction with catch basins and consist of a perforated pipe surrounded by coarse rock. Figure 5 shows that the system is in the ground, but above the wet-season water table. Water enters the pipe and seeps out. The retained volume will exfiltrate over 1 hour. The length of the pipe is dependent on several factors – the volume of runoff to be treated, the width of the trench, the depth to the water table, and the hydraulic conductivity of the soils. When calculating the volume of an exfiltration trench, a safety factor of 2 is used to allow for geologic uncertainties.

The formula shown in Figure 5 illustrates how to design an exfiltration trench. An overflow system allowing for volumes in excess of the retained volume is usually located at the end of the trench opposite the point where the runoff enters the system and discharges to the receiving waters. Although exfiltration trenches provide adequate stormwater treatment and allow more land for development, they must be inspected regularly and cleaned from time to time. The pipe can become clogged and not allow proper seepage. When this occurs, the pipe acts like a conduit for untreated stormwater. Ensuring that the catch basins are maintained is one way of preventing failure of the trench.

Required retention depth is based on Table 1.

Figure 5 Typical Exfiltration Trench



$$L = \frac{V}{K(H_2W + 2H_2D_U - D_U^2 + 2H_2D_S) + (1.39 \times 10^{-4})WD_U}$$

L = LENGTH OF TRENCH REQUIRED (FEET)

V = VOLUME TREATED (ACRE-INCHES)*

W = TRENCH WIDTH (FEET)

K = HYDRAULIC CONDUCTIVITY (CFS/FT.^{2}-FT.HEAD)**

H_2 = DEPTH TO WATER TABLE (FEET)

D_U = NON-SATURATED TRENCH DEPTH (FEET)

D_S = SATURATED TRENCH DEPTH (FEET)

CUBIC FOOT = 2.75×10^{-4} ACRE-INCHES

HYDRAULIC CONDUCTIVITY (K) IS OBTAINED FROM THE PERCOLATION TEST

Appendix 5

Stormwater Management Plan Checklist

APPENDIX 5 – STORMWATER MANAGEMENT PLAN CHECKLIST

	Required	Not Required	Sufficient
A. Site Information			
▪ Detailed location map			
▪ Description of vegetative cover			
▪ Location and size of preservation or mitigation areas			
▪ Vegetation protection plan			
▪ Soils map			
▪ Percolation test results			
▪ Current wet season high water table			
▪ Future wet-season water table			
▪ Measures to be taken to eliminate off-site adverse impacts, such as turbidity, flooding, etc.			
▪ Recent aerial photo (if available)			
▪ Map of drainage basin boundaries including off-site areas			
▪ Map of flood pain and elevations			
B. Master Stormwater Management Plan			
▪ Location of all existing and proposed on-site waterbodies (including wetlands)			
▪ Location of all off-site wetlands and waterbodies to be affected by on-site drainage patterns			
▪ Location of all major control structures and elevations (preliminary construction plan may be submitted for conceptual review)			
▪ Right-of-way and easement locations for stormwater management systems, including all areas reserved for stormwater management purposes			

	Required	Not Required	Sufficient
▪ Location and size of on-site water management facilities			
▪ Square footages, acreages, and percentage of property proposed as: ▪ Impervious surface (excluding waterbodies) ▪ Impervious surface (waterbodies) ▪ Pervious surface ▪ Total square footage or acreage of project site			
▪ Proposed grading plan			
▪ Treatment volume and discharge rate (if applicable) for stormwater management system			
C. Legal and Institutional Information			
▪ Entity responsible for operation and maintenance of stormwater management facility*			

* If the operational and maintenance entity is to be a public body, a letter from the public body confirming this must be submitted before staff approval. If the entity is a homeowners' association, documents verifying the existence of such organization and its ability to accept operation and maintenance ability must be submitted before staff approval.

Appendix 6

Single-Family/Duplex Lot
Sample Calculations

APPENDIX 6 – SINGLE-FAMILY/DUPLEX LOT SAMPLE CALCULATIONS

An 8,000-square-foot lot with a house, patio, and driveway using dry-retention swales:

- House 1,600 square feet (800 directly connected and 800 unconnected).
- Driveway 560 square feet.
- Concrete Patio 840 square feet.

Total impervious 3,000 square feet.

Effective Impervious (sum of directly connected impervious and half the unconnected impervious) 2,600 square feet.

Total lot size (disturbed area) = 8,000 square feet.

Ratio of effective impervious area to disturbed area = 32.5 percent.

Required retention depth = 0.1585 feet (from Table 2).

The following equation is used to size the swale:

- Required swale volume (cubic feet) = effective impervious area (square feet) x 0.1585-foot required retention depth (feet).
- Required swale volume = 2,600 x 0.1585.
- Required swale volume = 412.1 cubic feet.

Assuming a 4:1 (horizontal to vertical) slope for the swales to a 1-foot depth and a 2-foot bottom width, the cross-sectional area (A) of the swale is 6.0 square feet.

Therefore, the required length of the swale is determined as follows:

- Required length of swale (feet) = required volume/A.
- Required length of swale = 412.1/6.
- Required length of swale = 68.7 feet.

In areas where a receiving water body is adjacent to the property, a rectangular weir should be placed at one end of the swale for discharge of excess runoff. To reduce the required length of the swale opportunities to reduce the directly connected impervious area, replace impervious surfaces with pervious surfaces, and minimize site disturbance could be evaluated. These changes would reduce the required swale length.

Appendix 7

Bibliography

APPENDIX 7 – BIBLIOGRAPHY

Ammon, D.C.; W.C. Huber; and J.P. Heany. 1981. *Wetlands' Use for Water Management in Florida.* J. Water Res. Planning Management Div. Proceeding of ASCE 107 (WR2):315-327.

Branscome, J,. and R.S. Tomasello. 1988. *Field Testing of Exfiltration Systems.* South Florida Water Management District, Tech. Pub. 87-5, West Palm Beach, Florida. 50 pp.

Camp Dresser and McKee, Inc. (CDM). 1985. *An Assessment of Stormwater Management Programs.* J.P. Hartiganm, S.V. Plante, L.A. Rosner. Maitland, Florida.

Chesters, G,. and L.J. Schierow. 1985. *A Primer on Nonpoint Pollution.* J. Soil Water Conserv. 40(1):9-13.

Cox, J.H. 1985. *Overview of BMP's and Urban Stormwater Management. Proceedings: Stormwater Management – "an update".* M.P. Wanielista and Y.A. Yousef, Eds. Univ. of Central Florida Environ. Systems Engr. Institute, Pub. #85-1,. Orlando, Florida.

Duval County. *Duval County Low-Impact Development Stormwater Manual*. Jacksonville, FL

Ferrara, R.A. 1982. *Stormwater Detention and Nonpoint Source Pollution Control.* In the International Symposium on Urban Hydrology, Hydraulics, and Sediment Control, University of Kentucky, Lexington, Kentucky, pp. 91-91.

Florida Department of Environmental Protection. 2019. *Low-Impact Development and Green Infrastructure: Pollution Reduction Guidance for Water Quality in Southeast Florida.*

Harper, H.H.; Y.A. Yousef; and M.P. Wanielista. 1984. *Efficiency of Roadside Swales in Removing Heavy Metals from Highway Associated Nonpoint Source Runoff.* Conference on Options for Reaching Water Quality Goals, American Water Res. Assoc.

Livingston, E.H. 1985. *Overview of Stormwater Management.* Florida Department of Environmental Regulation, Tallahassee, Florida.

Mass, R.P.; M.D. Smolen; and S.A. Dressing. 1985. *Selecting Critical Areas for Nonpoint-Source Pollution Control.* J. Soil Water Conserv. 40(1):68-71.

Mason, Jr., J.M. 1984. *Development of a Stormwater Management Plan.* In the international symposium on Urban Hydrology, Hydraulics, and Sediment Control, University of Kentucky, Lexington, Kentucky, pp. 201-205.

Sarasota County. 2015. *Sarasota County Low-Impact Development Guidance Document*. Sarasota FL.

South Florida Water Management District (SFWMD). In review. *An Assessment of Land Use and Related Stormwater Runoff Quality Treatment Efficiencies Associated with Selected Stormwater Management Systems.* Resource Planning Department, West Palm Beach, FL.

South Florida Water Management District (SFWMD). *Environmental Resource Permit Applicant's Handbook, Vol II*. West Palm Beach, FL.

Wanielista, M.P., and Y.A. Yousef. 1985. *Overview Stormwater Manage Practices. Proceedings: Stormwater Management – "an update".* M.P> Wanielista and Y.A. Yousef, Eds. Univ. of Central Florida, Environ. Systems Engr. Institute, Pub. #85-1., Orlando, Florida.

Whalen, P.J. and M.G. Cullum. 1988. *As Assessment of Urban Land Use/Stormwater Runoff Quality Relationships and Treatment Efficiencies of Selected Stormwater Management System*. Technical Publication 88-9, South Florida Water Management District. West Palm Beach, Florida.