Introduction to Stormwater Treatment Practices

Municipal Inland Wetland Commissioner's Training Program

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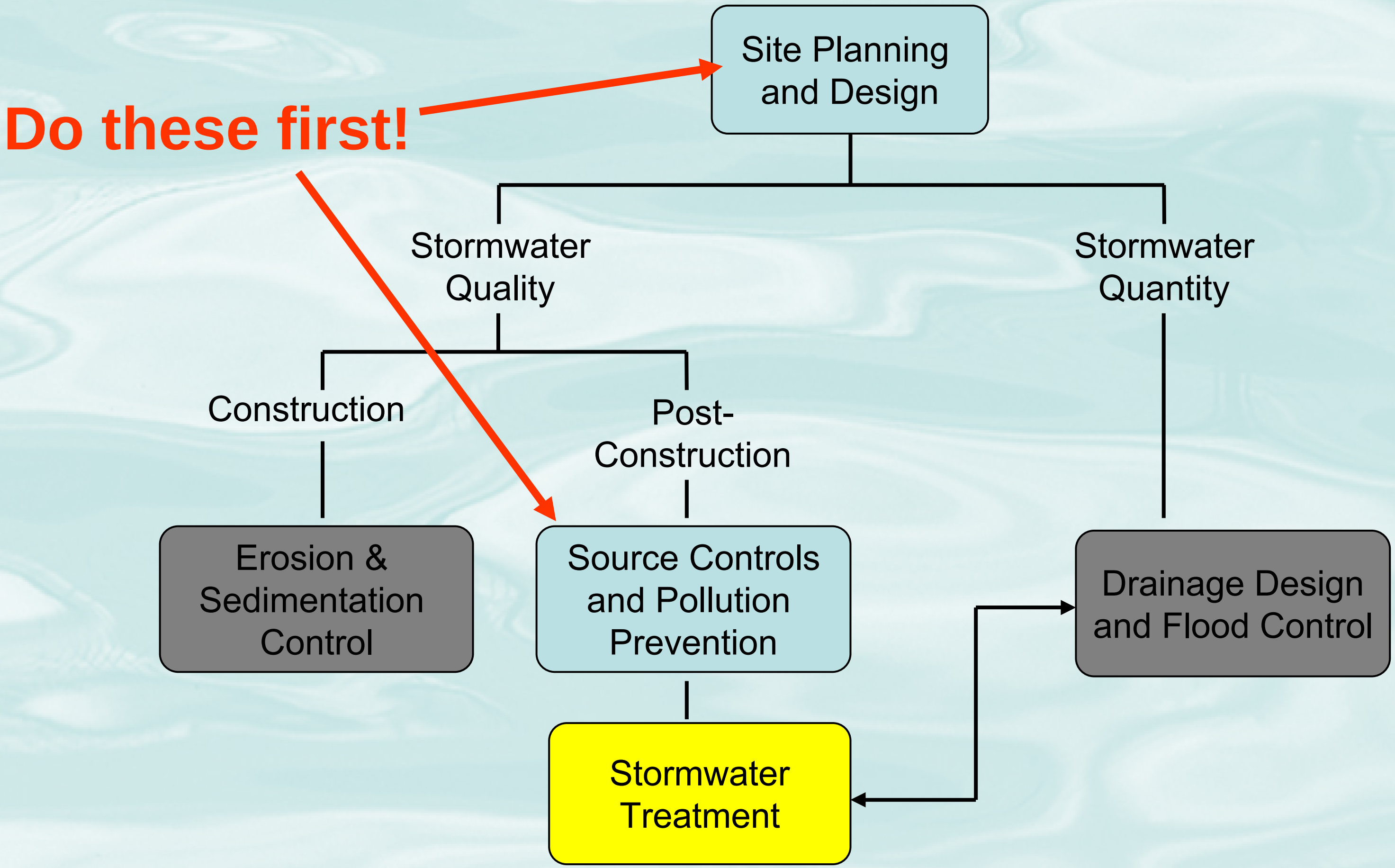
NEMO

Introduction



Outline

- Introduction to Practices (Chapter 6)
- Stormwater Design Criteria
- Treatment Practice Selection
- Site Stormwater Management Plan
- Retrofits
- Stormwater Management Practices
- Appendices

Guiding Principles

- Preserve pre-development hydrology
- After construction, reduce annual solids by 80%
- Preserve and protect wetlands, stream buffers, and natural drainage
- Manage runoff velocity & volume to preserve/protect integrity of existing waterways
- Prevent pollutants from entering receiving waters and wetlands beyond their ability to assimilate
- Seek multiple benefits from stormwater practices

Guiding Principles

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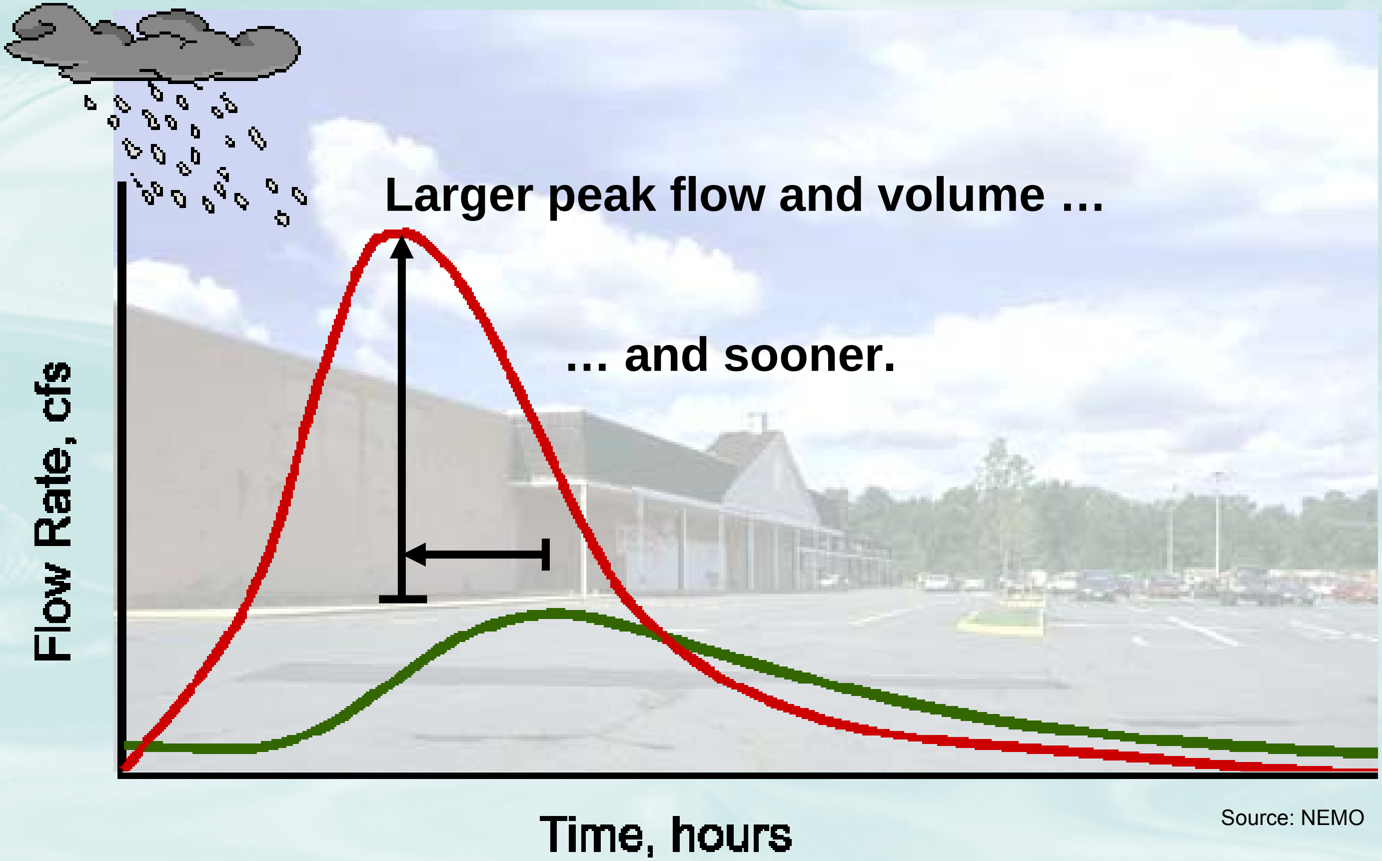

Guiding Principles

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Guiding Principles

- Preserve and protect wetlands, stream buffers, and natural drainage

Source: USDA NRCS

Guiding Principles

- Manage runoff velocity & volume to preserve/protect integrity of existing waterways

Guiding Principles

- Prevent pollutants from entering receiving waters and wetlands beyond their ability to assimilate

Source: NEMO

Guiding Principles

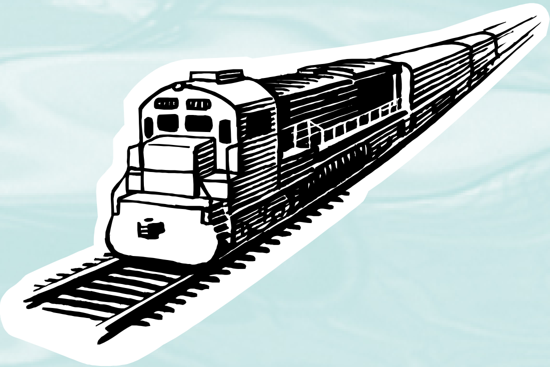
- Seek multiple benefits from stormwater practices

Source: NEMO

Stormwater Management Objectives

- Remove pollutants from runoff
  - Sediment
  - Floatable debris
  - Oil & petroleum products
- Groundwater recharge
- Peak runoff attenuation
- Stream channel protection

Treatment Train Concept



REQUIRED:

- Site Planning
- Source Controls/Pollution Prevention

OPTIONS:

- Primary Treatment Practices (one or more)
- Combination of Secondary and Primary Treatment Practices
- Multiple Secondary Practices (at the discretion of the regulatory authority)
  - Retrofits
  - Ultra-urban sites
  - Significant Source Controls/LID

Primary versus Secondary Treatment Practices

Primary Practices

- Capable of stand-alone treatment
- Provide high level of water quality treatment
- Meet performance standards

Secondary Practices

- Not Suitable as Stand-alone systems
  - Not capable of meeting performance criteria
  - Have not been through evaluation needed to demonstrate capability
- Appropriate in certain applications

Outline

- Introduction to Practices
- Stormwater Design Criteria (Chapter 7)
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Sizing and Design Criteria

Objective	Criteria	Post-Development Storm Magnitude
Pollutant Reduction	Water Quality Volume (WQV) Water Quality Flow (WQF)	First 1" of rainfall
Groundwater Recharge and Runoff Capture	Groundwater Recharge Volume (GRV) Runoff Capture Volume (RCV)	Not Applicable First 1" of rainfall
Peak Flow Control	Stream Channel Protection Conveyance Protection Peak Runoff Attenuation Emergency Outlet Sizing	2-yr, 24-hr 10-yr, 24-hr 10-, 25-, 100-yr, 24-hr 100-yr, 24-hr

Pollutant Reduction

- Water Quality Volume
  - Rationale
    - Majority of pollutant loading from small frequent storms
    - "First flush" concept (traditionally first ½ to 1 inch runoff)
    - 90% Rule: Capture 90% of runoff events annually and majority of pollutant load
    - Northeastern US: Approximately 1 inch rainfall

Pollutant Reduction

- Water Quality Volume
  - Runoff generated by first inch of rainfall over site
  - Equation

$$WQV = \frac{(1'')(R)(A)}{12}$$

  - WQV = acre-ft
  - R = runoff coefficient = 0.05 + 0.009(I)
  - I = % impervious cover
  - A = site area in acres

Pollutant Reduction

- Water Quality Volume
  - Estimating Site Impervious Coverage
    - Directly connected to drainage system
    - From site plan
      - Paved surfaces
      - Roofs
      - Patios, decks
    - Tabulated land use values

R = runoff coefficient = 0.05 + 0.009(I)

Table 7-3
Residential Land Use Impervious Cover

Parcel Size (acres)	Average Percent Impervious Cover
<1/8	39
1/8 to 1/4	28
1/4 to 1/2	21
1/2 to 3/4	16
3/4 to 1	14
1 to 1 1/2	10
1 1/2 to 2	9
>2	8

Groundwater Recharge

- Groundwater Recharge Volume (GRV)
  - Calculation concept
    - Estimate pre-developed recharge volume
    - Determine annual recharge volume lost due to new impervious coverage
  - Hydrologic soil group approach
    - Based on NRCS hydrologic soil groups
    - Average annual recharge
  - Accomplish recharge
    - Primary and secondary practices
    - Site design techniques

Groundwater Recharge

- Groundwater Recharge Volume (GRV)
  - Hydrologic soil group approach (cont.)

$$GRV = \frac{(D)(A)(I)}{12}$$

- D = depth to be recharged
- A = site area
- I = site imperviousness

  - Subtract GRV from WQV
  - Other approaches

Table 7-4
Groundwater Recharge Depth

NRCS Hydrologic Soil Group	Average Annual Recharge	Groundwater Recharge Depth (D)
A	18 inches/year	0.4 inches
B	12 inches/year	0.25 inches
C	6 inches/year	0.10 inches
D	3 inches/year	0 inches (waived)

Groundwater Recharge

- Groundwater Recharge Volume (GRV)
  - Reasons to waive criterion
    - Stormwater “hotspots”
      - Salvage yards
      - High intensity commercial parking
      - Public works storage
      - Industrial facilities
    - Subsurface contamination
    - Groundwater supply
      - Aquifer recharge areas
      - Wellhead protection areas

Outline

- Introduction to Practices
- Stormwater Design Criteria
- Treatment Practice Selection (Chapter 8)
- Site Stormwater Management Plan
- Retrofits
- Stormwater Management Practices
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Treatment Practice Selection

- Stormwater Management Effectiveness
- Land Use
- Physical/site Feasibility
- Downstream Resources
- Maintenance
- Winter Operation
- Nuisance Insects and Vectors
- Natural Wetlands and Vernal Pools

Treatment Practice Selection

- Land Use
  - Land Requirements
  - Pollutant Loads
  - Land Use Compatibility

Table 8-2 Land Use Selection Criteria

Category	Practice	Rural	Residential	Roads and Highways	Commercial/ Industrial	Ultra Urban[3]
Stormwater Pond	Wet pond	●	○	●	●[2]	○
	Micropool extended detention pond	●	◍	●	●[2]	○
	Wet extended detention pond	●	◍	●	●[2]	○
	Multiple pond system	●	○	◍	●[2]	○
Stormwater Wetlands	Shallow wetland	●	○	●	●[2]	○
	Extended detention wetland	●	○	●	●[2]	○
	Pond/wetland system	●	◍	◍	◍[2]	○
Infiltration Practices	Infiltration trench	◍	◍	◍	◍	○
	Infiltration basin	●	◍	●	●	○
Filtering Practices	Surface sand filter	◍	●	●	●[1]	○
	Underground sand filter	○	◍	●	●	●
	Perimeter sand filter	○	○	○	◍	◍
	Bioretention	◍	◍	●	●[1]	◍
Water Quality Swales	Dry swale	●	●	●	◍[1]	○
	Wet swale	●	◍	●	◍	○

Notes:
● Appropriate
◍ Somewhat appropriate
○ Least appropriate

[1]If not designed to infiltrate
[2]May require pond liner
[3]Secondary treatment practices and stormwater treatment trains are typically more appropriate for Ultra Urban land uses

Residential

- Potentially Suitable Practices
  - Alternative site design
  - Permeable pavement
  - LID
  - Bioretention
  - Water quality swales
  - Ponds/wetlands
- Issues/Concerns
  - Public safety
  - Nuisance insects

Jordan Cove, Waterford, Source: UConn

Commercial/Industrial

- Potentially Suitable Practices
  - Alternative site design
  - Parking Lot Bioretention
  - Swales, ponds, wetlands
  - Below-ground detention or infiltration
- Issues/Concerns
  - Litter
  - Hydrocarbons
  - Metals
  - Spills

UTC Fuel Cells, South Windsor, Source: UTC Fuel Cells

Ultra-Urban

- Potentially Suitable Practices
  - Below-ground detention/treatment
  - Treatment train
  - Green roofs
  - Permeable pavement
  - Bioretention
  - Retrofits
- Issues/Concerns
  - Little available land area
  - Wide range of pollutants
  - Infrastructure constraints

Outline

- Introduction to Practices
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Plan Content

- Applicant/site information
- Project narrative
- Calculations
- Design drawings and specifications
- Construction erosion and sedimentation controls
- Supporting documents and studies
- Other required permits
- Operation and maintenance

PLAN DEVELOPMENT


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- Criteria to require plan
  - Disturbance ≥ 1 acre
  - Residential development
    - ≥ 5 units
    - < 5 units, new road (re)construction
    - < 5 units, > 30 % impervious
  - Discharge to wetlands/watercourse
  - Discharge < 500 ft. from tidal wetlands
  - Land uses with potential for higher pollutant loadings

PLAN DEVELOPMENT

- Criteria to require plan (cont.)
  - Industrial & commercial
    - ≥ 10,000 sq. ft. impervious surface
    - May have specific DEP requirements
  - New highway, road, street construction
  - Storm drainage modifications

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Outline

- Introduction to Practices
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INTRODUCTION

- Retrofit?
  - Modify existing development by…
    - Implementing source controls
    - Installing treatment practices
  - Results: Improved water quality

LID Center

OBJECTIVES AND BENEFITS

- Objectives
  - Old stormwater management systems
    - Remedy problems
    - Improve water quality
  - Re-development
    - Incorporate treatment practices
    - Encourage Low Impact Development
- Benefits
  - Combine quality and quantity controls
  - Remedy local nuisances & maintenance problems
  - Landscape to improve appearance

WHEN IS RETROFITTING APPROPRIATE?

- Table 10-1 site considerations
  - Retrofit purpose
  - Construction/maintenance access
  - Subsurface conditions
  - Utilities
  - Conflicting land use
  - Wetlands, sensitive water bodies
  - Complementary restoration projects
  - Permits and approvals
  - Public safety
  - Cost

Stormwater Retrofit Options

- Stormwater drainage systems
- Stormwater management facilities
- Storm drain outfalls
- Highway rights-of-way
- Parking lots
- In-stream practices
- Wetland creation and restoration

Outline

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Primary Treatment Practices

- Capable of stand-alone treatment
- Provide high level of water quality treatment
- Performance standards:
  - Capture & treat WQV or WQF
  - Remove 80% annual total suspended solids
  - Remove floatable debris, including oil/petroleum
  - Acceptable performance and operational longevity

Primary Treatment Practices

- Chapter 11

Summary

Description

Stormwater Wetlands

Source: Nonpoint Education for Municipal Officials (NEMO).

Treatment Practice Type

Primary Treatment Practice	●
Secondary Treatment Practice	

Stormwater Management Benefits

Pollutant Reduction	
Sediment	■
Phosphorus	■
Nitrogen	■
Metals	■
Pathogens	■ (partial)
Floatables*	■
Oil and Grease*	■
Dissolved Pollutants	■ (partial)
Runoff Volume Reduction	
Runoff Capture	■
Groundwater Recharge	□
Stream Channel Protection	■
Peak Flow Control	■

Key: ■ Significant Benefit; ■ Partial Benefit; □ Low or Unknown Benefit

*Only if a skimmer is incorporated

Implementation Requirements

Cost .... Moderate
Maintenance .... Moderate

Description

Stormwater wetlands are constructed wetlands that incorporate marsh areas and permanent pools to provide enhanced treatment and attenuation of stormwater flows. Stormwater wetlands differ from stormwater ponds in that wetland vegetation is a major element of the overall treatment mechanism as opposed to a supplementary component. This section includes three types of stormwater wetlands:

- *Shallow Wetland*
- *Extended Detention Shallow Wetland*
- *Pond/Wetland System*

While stormwater wetlands can provide some of the ecological benefits associated with natural wetlands, these benefits are secondary to the function of the system to treat stormwater. Stormwater wetlands can be very effective at removing pollutants and reducing peak flows of runoff from developed areas. Removal of particulate pollutants in stormwater wetlands can occur through a number of mechanisms similar to stormwater ponds including sedimentation and filtration by wetland vegetation. Soluble pollutants can also be removed by adsorption to sediments and vegetation, absorption, precipitation, microbial decomposition, and biological processes of aquatic and fringe wetland vegetation. Stormwater wetlands are particularly advantageous when nitrogen and/or dissolved pollutants are a concern.

The key to maximizing pollutant removal effectiveness in stormwater wetlands is maintaining wet conditions adequate to support wetland vegetation. To achieve this, the constructed wetlands must either intercept the groundwater table or must be lined with an impermeable liner and have a watershed large enough to supply storm flows that will maintain wetness even during dry periods.

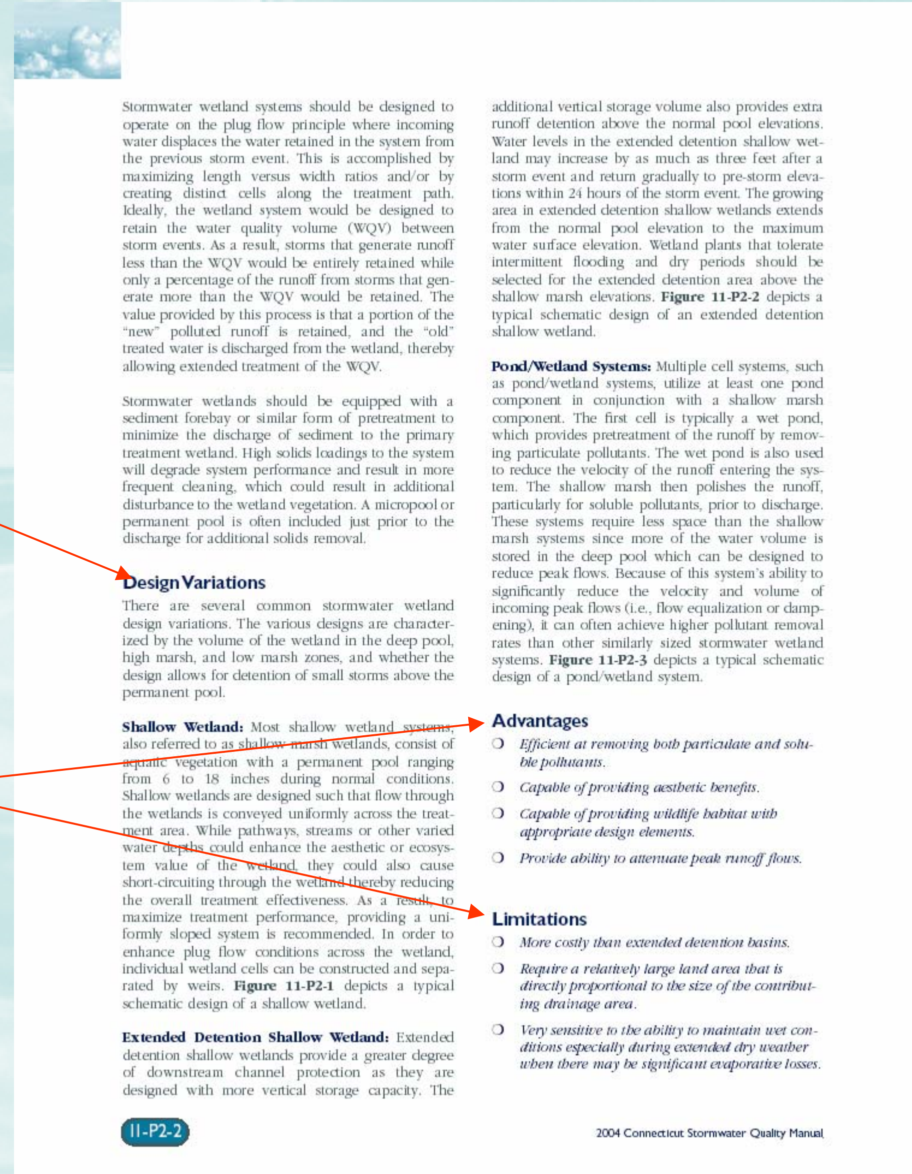
2004 Connecticut Stormwater Quality Manual   11-P2-1

Primary Treatment Practices

- Chapter 11

Design Variations

Advantages/Limitations



Stormwater wetland systems should be designed to operate on the plug flow principle where incoming water displaces the water retained in the system from the previous storm event. This is accomplished by maximizing length versus width ratios and/or by creating distinct cells along the treatment path. Ideally, the wetland system would be designed to retain the water quality volume (WQV) between storm events. As a result, storms that generate runoff less than the WQV would be entirely retained while only a percentage of the runoff from storms that generate more than the WQV would be retained. The value provided by this process is that a portion of the "new" polluted runoff is retained, and the "old" treated water is discharged from the wetland, thereby allowing extended treatment of the WQV.

Stormwater wetlands should be equipped with a sediment forebay or similar form of pretreatment to minimize the discharge of sediment to the primary treatment wetland. High solids loadings to the system will degrade system performance and result in more frequent cleaning, which could result in additional disturbance to the wetland vegetation. A micropool or permanent pool is often included just prior to the discharge for additional solids removal.

Design Variations

There are several common stormwater wetland design variations. The various designs are characterized by the volume of the wetland in the deep pool, high marsh, and low marsh zones, and whether the design allows for detention of small storms above the permanent pool.

Shallow Wetland: Most shallow wetland systems, also referred to as shallow marsh wetlands, consist of aquatic vegetation with a permanent pool ranging from 6 to 18 inches during normal conditions. Shallow wetlands are designed such that flow through the wetlands is conveyed uniformly across the treatment area. While pathways, streams or other varied water depths could enhance the aesthetic or ecosystem value of the wetland, they could also cause short-circuiting through the wetland thereby reducing the overall treatment effectiveness. As a result, to maximize treatment performance, providing a uniformly sloped system is recommended. In order to enhance plug flow conditions across the wetland, individual wetland cells can be constructed and separated by weirs. **Figure 11-P2-1** depicts a typical schematic design of a shallow wetland.

Extended Detention Shallow Wetland: Extended detention shallow wetlands provide a greater degree of downstream channel protection as they are designed with more vertical storage capacity. The additional vertical storage volume also provides extra runoff detention above the normal pool elevations. Water levels in the extended detention shallow wetland may increase by as much as three feet after a storm event and return gradually to pre-storm elevations within 24 hours of the storm event. The growing area in extended detention shallow wetlands extends from the normal pool elevation to the maximum water surface elevation. Wetland plants that tolerate intermittent flooding and dry periods should be selected for the extended detention area above the shallow marsh elevations. **Figure 11-P2-2** depicts a typical schematic design of an extended detention shallow wetland.

Pond/Wetland Systems: Multiple cell systems, such as pond/wetland systems, utilize at least one pond component in conjunction with a shallow marsh component. The first cell is typically a wet pond, which provides pretreatment of the runoff by removing particulate pollutants. The wet pond is also used to reduce the velocity of the runoff entering the system. The shallow marsh then polishes the runoff, particularly for soluble pollutants, prior to discharge. These systems require less space than the shallow marsh systems since more of the water volume is stored in the deep pool which can be designed to reduce peak flows. Because of this system's ability to significantly reduce the velocity and volume of incoming peak flows (i.e., flow equalization or dampening), it can often achieve higher pollutant removal rates than other similarly sized stormwater wetland systems. **Figure 11-P2-3** depicts a typical schematic design of a pond/wetland system.

Advantages

- *Efficient at removing both particulate and soluble pollutants.*
- *Capable of providing aesthetic benefits.*
- *Capable of providing wildlife habitat with appropriate design elements.*
- *Provide ability to attenuate peak runoff flows.*

Limitations

- *More costly than extended detention basins.*
- *Require a relatively large land area that is directly proportional to the size of the contributing drainage area.*
- *Very sensitive to the ability to maintain wet conditions especially during extended dry weather when there may be significant evaporative losses.*

Primary Treatment Practices

- Chapter 11

Siting Considerations

Design Criteria

- *May cause thermal impacts to receiving waters and thereby should not discharge directly to cold water fish habitats.*
- *Potential breeding habitat for mosquitoes, particularly for systems with isolated pockets of standing water (standing longer than 5 days). Circulating water in the permanent pool may minimize this problem. This may be a more significant problem for lined systems.*
- *Wetland systems with steep side slopes and/or deep wet pools may present a safety issue to nearby pedestrians.*
- *Stormwater wetlands can serve as decoy wetlands, intercepting breeding amphibians moving toward vernal pools. If amphibians deposit their eggs in these artificial wetlands, they rarely survive due to the sediment and pollutant loads, as well as fluctuations in water quality, quantity, and temperature.*

Siting Considerations

Drainage Area: Stormwater wetlands that utilize a liner system to maintain the desired permanent pool should have a contributing drainage area that is adequate to maintain minimum water levels. Typically, minimum contributing drainage areas are twenty-five acres, especially for shallow systems. A water budget for the wetlands should be calculated to ensure that evaporation losses do not exceed inflows during warm weather months.

Groundwater: Unlined basins must intersect the groundwater table in order to maintain the desired permanent pool. In this case, the elevations of the basin should be established such that the groundwater elevation is equal to the desired permanent pool elevation. Seasonal variations of groundwater elevations should be considered, which can be very pronounced in low permeability soils.

Land Uses: Land uses will dictate potential pollutants-of-concern and potential safety risks. For those land uses where there is significant potential for soluble pollutants, especially those that are highly susceptible to groundwater transport, the use of a liner is recommended. An impermeable liner may not be required, depending on the risk of downgradient contamination, but a low permeable liner constructed in till soils may be acceptable. Adjacent residential land uses pose the greatest public safety risks where mosquito breeding and water hazards must be considered.

Baseflow: A small amount of baseflow is desirable to maintain circulation and reduce the potential for low dissolved oxygen levels during late summer, and to reduce mosquito breeding. This baseflow can be provided by groundwater infiltrating into either the wetland or the collection system above the pond.

Site Slopes: Steep on-site slopes may result in the need for a large embankment to be constructed to provide the desired storage volume and could require a dam construction permit from the Connecticut DEP. Steep slopes may also present design and construction challenges, and significantly increase the cost of earthwork.

Receiving Waters: The sensitivity of receiving waters should be evaluated to determine whether the effects of the warmer stormwater discharges from the wetland could be detrimental to cold-water fish or other sensitive aquatic species.

Flood Zones: Constructed wetlands should not be located in floodways, floodplains, or tidal lands, especially those that require construction of an embankment. Floodwaters could flush out stored pollutants or damage pond embankments.

Natural Wetlands/Vernal Pools: Natural wetlands and vernal pool depressions should not be used, either temporarily or permanently, as a stormwater pond or wetland. Stormwater wetlands should be located at least 750 feet from a vernal pool. They should not be sited between vernal pools or in areas that are known primary amphibian overland migration routes.

Design Criteria

Wetland designs may vary considerably due to site constraints, local requirements, or the designer's preferences. The five common design elements that should be considered for all stormwater wetlands are:

- *Pretreatment*
- *Treatment*
- *Conveyance*
- *Maintenance reduction*
- *Landscaping*

Design considerations for stormwater wetlands are presented below and summarized in **Table 11-P2-1**.

Primary Treatment Practices

- Chapter 11

Cold Climate Design Considerations

Construction Considerations

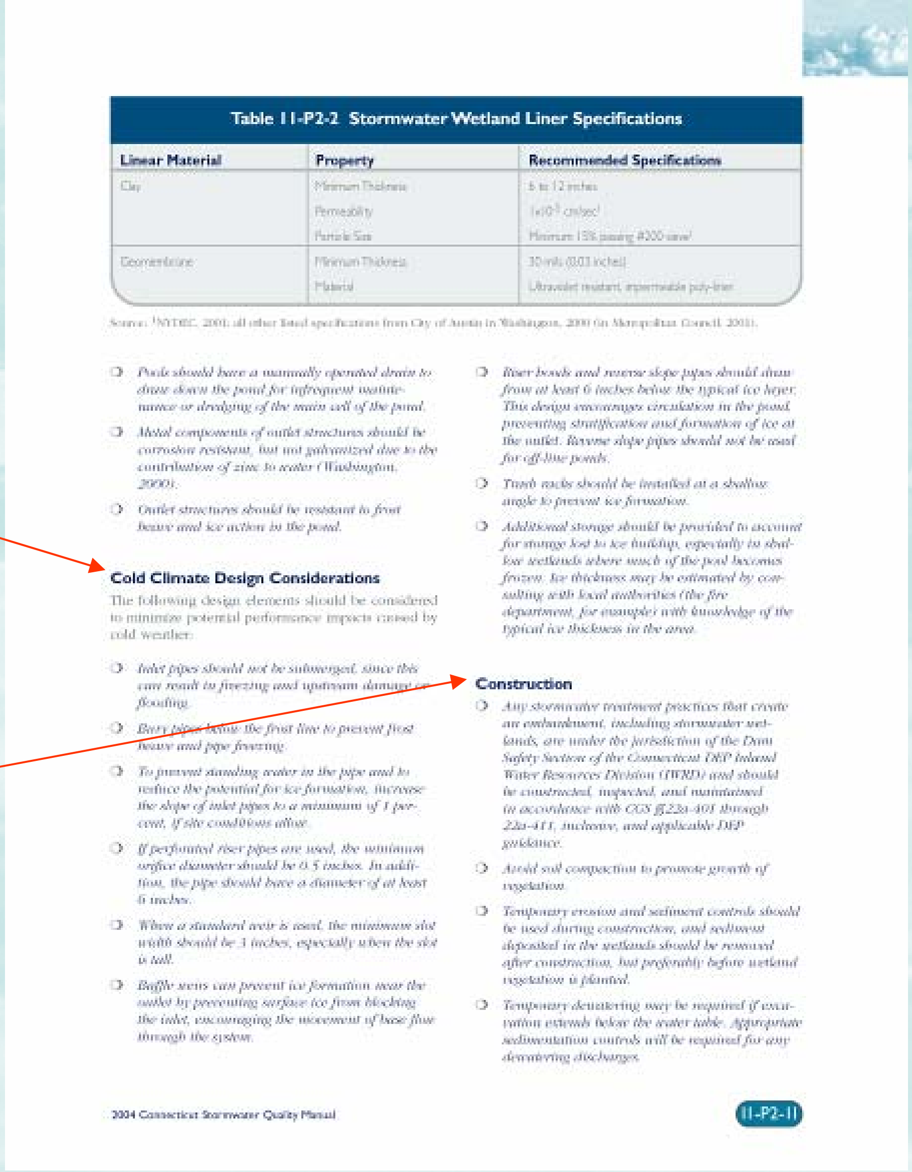


Table 11-P2-2 Stormwater Wetland Liner Specifications

Linear Material	Property	Recommended Specifications
Clay	Minimum Thickness	6 to 12 inches
	Permeability	1x10⁻⁶ cm/sec[1]
	Particle Size	Minimum 15% passing #200 sieve[1]
Geomembrane	Minimum Thickness	30 mils (0.03 inches)
	Material	Ultraviolet resistant, impermeable poly-liner

Source: [1]NYDEC, 2001; all other listed specifications from City of Austin in Washington, 2000 (in Metropolitan Council, 2001).

Cold Climate Design Considerations

The following design elements should be considered to minimize potential performance impacts caused by cold weather:

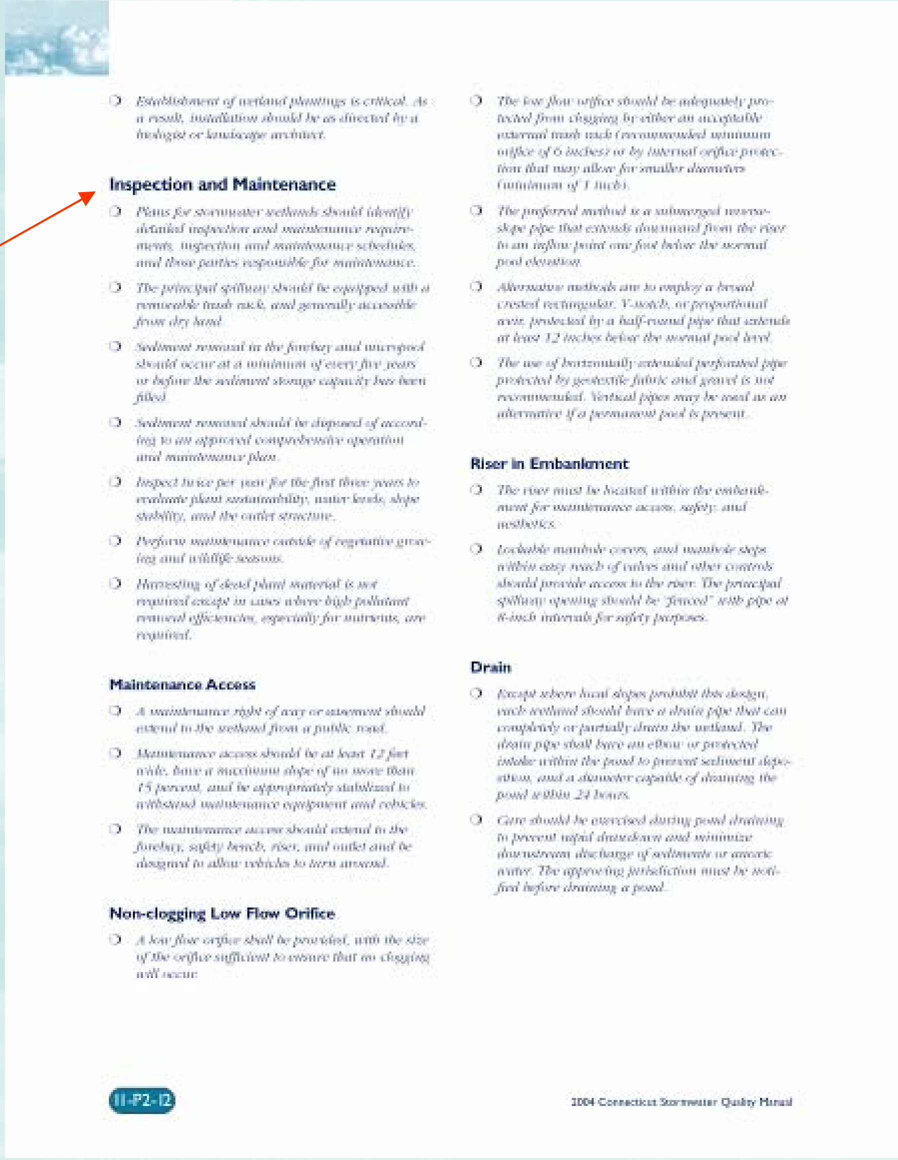
Construction

2004 Connecticut Stormwater Quality Manual 11-P2-11

Primary Treatment Practices

- Chapter 11

Inspection and Maintenance



- Establishment of wetland plantings is critical. As a result, installation should be as directed by a biologist or landscape architect.

Inspection and Maintenance

- Plans for stormwater wetlands should identify detailed inspection and maintenance requirements, inspection and maintenance schedules, and those parties responsible for maintenance.
- The principal spillway should be equipped with a removable trash rack, and generally accessible from dry land.
- Sediment removal in the forebay and micropool should occur at a minimum of every five years or before the sediment storage capacity has been filled.
- Sediment removed should be disposed of according to an approved comprehensive operation and maintenance plan.
- Inspect twice per year for the first three years to evaluate plant sustainability, water levels, slope stability, and the outlet structure.
- Perform maintenance outside of vegetative growing and wildlife seasons.
- Harvesting of dead plant material is not required except in cases where high pollutant removal efficiencies, especially for nutrients, are required.

Maintenance Access

- A maintenance right of way or easement should extend to the wetland from a public road.
- Maintenance access should be at least 12 feet wide, have a maximum slope of no more than 15 percent, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- The maintenance access should extend to the forebay, safety bench, riser, and outlet and be designed to allow vehicles to turn around.

Non-clogging Low Flow Orifice

- A low flow orifice shall be provided, with the size of the orifice sufficient to ensure that no clogging will occur.
- The low flow orifice should be adequately protected from clogging by either an acceptable external trash rack (recommended minimum orifice of 6 inches) or by internal orifice protection that may allow for smaller diameters (minimum of 1 inch).
- The preferred method is a submerged reverse-slope pipe that extends downward from the riser to an inflow point one foot below the normal pool elevation.
- Alternative methods are to employ a broad crested rectangular, V-notch, or proportional weir, protected by a half-round pipe that extends at least 12 inches below the normal pool level.
- The use of horizontally extended perforated pipe protected by geotextile fabric and gravel is not recommended. Vertical pipes may be used as an alternative if a permanent pool is present.

Riser in Embankment

- The riser must be located within the embankment for maintenance access, safety, and aesthetics.
- Lockable manhole covers, and manhole steps within easy reach of valves and other controls should provide access to the riser. The principal spillway opening should be "fenced" with pipe at 8-inch intervals for safety purposes.

Drain

- Except where local slopes prohibit this design, each wetland should have a drain pipe that can completely or partially drain the wetland. The drain pipe shall have an elbow or protected intake within the pond to prevent sediment deposition, and a diameter capable of draining the pond within 24 hours.
- Care should be exercised during pond draining to prevent rapid drawdown and minimize downstream discharge of sediments or anoxic water. The approving jurisdiction must be notified before draining a pond.

Primary Treatment Practices

Stormwater Ponds
Stormwater Wetlands
Infiltration Practices
Filtering Practices
Water Quality Swales

Primary Practice: Stormwater Ponds

- Permanent pool
- May have extended detention
- Pollutant removal
  - Sedimentation
  - Biological uptake
  - Microbial breakdown
  - Gas exchange
  - Volatilization
  - Decomposition
- Various wet pond designs
  - Wet ponds
  - Micropool extended detention ponds
  - Wet extended detention ponds
  - Multiple pond systems

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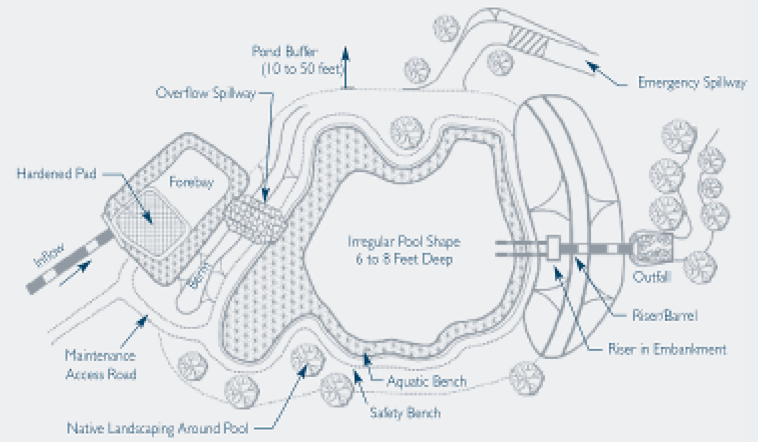
Figure 11-P1-1 Wet Pond



Plan View

Primary Practice: Stormwater Wetlands

- Constructed wetlands systems
- May not have the full range of functions of either natural or mitigation wetlands
- Typical components
  - Sediment forebay
  - Shallow & deep pool areas
  - Meandering flow paths
  - Vegetation
- Design Types
  - Shallow Wetland
  - Extended Detention
  - Pond/wetland system

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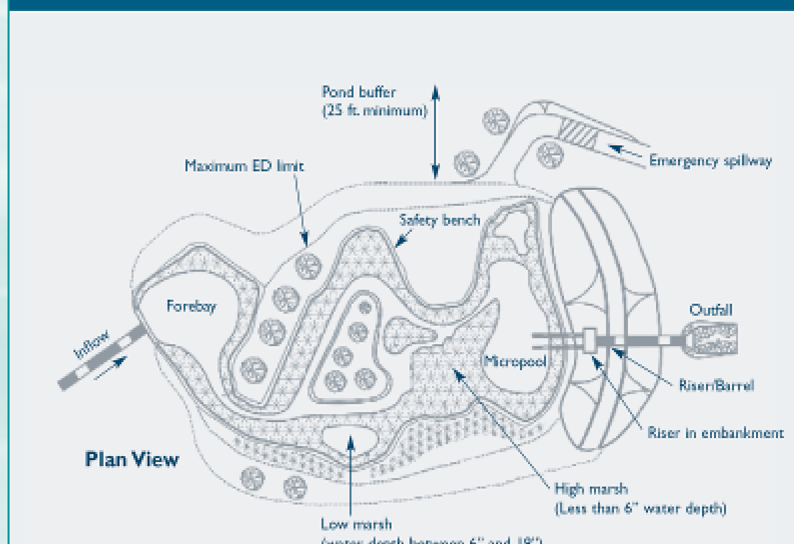
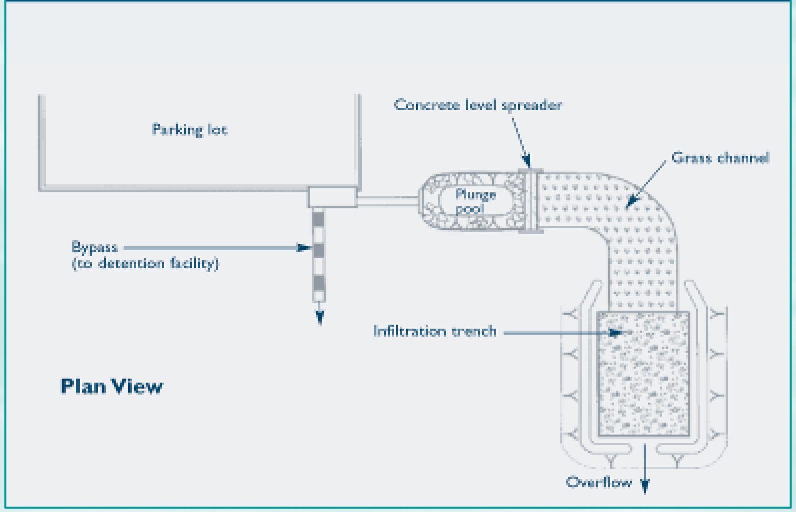
Figure 11-P2-2 Extended Detention Shallow Wetland



Primary Practice: Infiltration

- Function
  - Capture
  - Temporarily store
  - Infiltrate into permeable soils
- Pollutant removal
  - Adsorption onto soil particles
  - Biological & chemical conversion
- Must be carefully designed, constructed, and maintained to prevent premature clogging
- Pretreatment is critical!
- Design Types
  - Trench
  - Basin

Figure 11-P3-1 Infiltration Trench



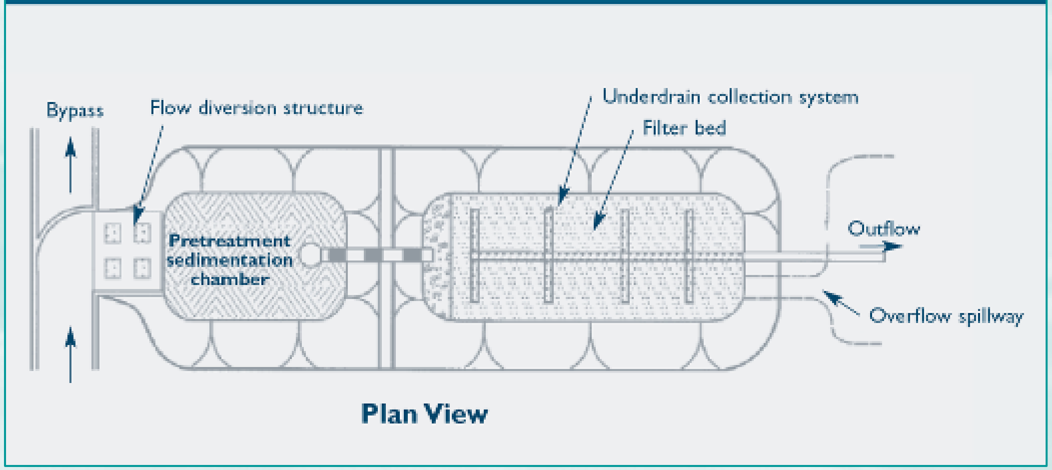
Primary Practice: Filtration

- Capture, store and filter through:
  - Sand
  - Soil
  - Organic Material
  - Other Porous Media
- Pollutant removal
  - Physical straining
  - Adsorption
- Pretreatment is critical!
- Design Types
  - Surface filters
  - Bioretention
  - Underground filters

Jordan Cove, Waterford (UConn)

UConn, Storrs

Figure 11-P4-1 Earthen Surface Sand Filter

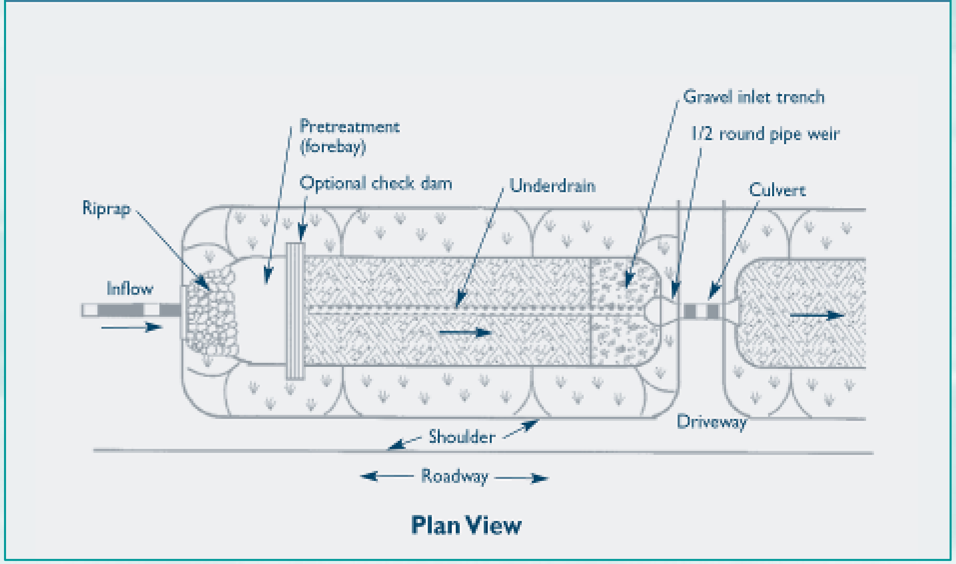


Primary Practice: Water Quality Swales

- Reduce Velocity
- Temporarily Store Runoff
- Promote Infiltration
- Differ from conveyance swales
- Design Types
  - Dry swale
  - Wet swale

UTC Fuel Cells, South Windsor

Figure 11-P5-1 Dry Swale – Parabolic Cross Section



Secondary Practices

- Not Suitable as Stand-alone
  - Are not capable of meeting performance criteria
  - Have not been through evaluation needed to demonstrate capability
- Appropriate Applications
  - Pretreatment
  - Use in treatment train to meet specific objectives
- Conventional Practices
- Innovative/Emerging

Secondary Treatment Practices

- Chapter 11

Summary

Description

Reasons for Limited Use

Suitable Applications

Dry Detention Ponds

Source: Nonpoint Education for Municipal Officials (NEMO)

Treatment Practice Type

Treatment Practice Type	
Primary Treatment Practice	
Secondary Treatment Practice	●

Stormwater Management Benefits

Pollutant Reduction	
Sediment	Partial Benefit
Phosphorus	Low or Unknown Benefit
Nitrogen	Low or Unknown Benefit
Metals	Low or Unknown Benefit
Pathogens	Low or Unknown Benefit
Floatables*	Partial Benefit
Oil and Grease*	Partial Benefit
Dissolved Pollutants	Low or Unknown Benefit
Runoff Volume Reduction	
Runoff Capture	Low or Unknown Benefit
Groundwater Recharge	Partial Benefit
Stream Channel Protection	Significant Benefit
Peak Flow Control	Significant Benefit

Key: Significant Benefit; Partial Benefit; Low or Unknown Benefit

*Only if a skimmer is used.

Suitable Applications

Pretreatment	Low or Unknown Benefit
Treatment Train	Significant Benefit
Ultra-Urban	Low or Unknown Benefit
Stormwater Retrofits	Low or Unknown Benefit
Other	Low or Unknown Benefit

Description

Dry detention ponds, also known as "dry ponds" or "detention basins", are stormwater basins designed to capture, temporarily hold, and gradually release a volume of stormwater runoff to attenuate and delay stormwater runoff peaks. Dry detention ponds provide water quantity control (peak flow control and stream channel protection) as opposed to water quality control. The outlet structure of a dry detention pond is located at the bottom of the pond and sized to limit the maximum flow rate. Dry ponds are designed to completely empty out, typically in less than 24 hours, resulting in limited settling of particulate matter and the potential for re-suspension of sediment by subsequent runoff events. Conventional dry detention ponds differ from extended detention ponds, which provide a minimum 24-hour detention time and enhanced pollutant removal (see Stormwater Ponds section of this chapter). Dry detention ponds are not suitable as infiltration or groundwater recharge measures, and therefore do not reduce runoff volumes. **Figure 11-S1-1** shows a schematic of a typical dry detention pond.

Reasons for Limited Use

- *Not intended for water quality treatment. Most dry detention ponds have detention times of less than 24 hours and lack a permanent pool, providing insufficient settling of particles, and minimal stormwater treatment.*
- *Susceptible to re-suspension of settled material by subsequent storms.*
- *Generally require a drainage area of 10 acres or greater to avoid an excessively small outlet structure susceptible to clogging.*

Suitable Applications

- *Primarily for water quantity control to attenuate peak flows, limit downstream flooding, and provide some degree of channel protection.*

2004 Connecticut Stormwater Quality Manual

11-S1-1

Secondary Treatment Practices

- Chapter 11

Design Considerations

- *Low-density residential, industrial, and commercial developments with adequate space and low visibility.*
- *As part of a stormwater treatment train, particularly in combination with other primary or secondary treatment practices that provide pollutant reduction, runoff volume reduction, or groundwater recharge. The size of dry ponds can be reduced substantially by placing them at the end of the treatment train to take advantage of reduced runoff volume resulting from upstream practices that employ infiltration.*
- *Less frequently used portions of larger or regional dry detention basins can offer recreational, aesthetic, or open space opportunities (e.g., athletic fields, jogging and walking trails, picnic areas).*

Design Considerations

The design of detention ponds is dictated by local stormwater quantity control requirements. Local ordinances typically require that post-development peak flows be controlled to pre-development levels for storms ranging from 2-year through 100-year return periods. Control of more frequent events may also be required. The reader should consult the local authority for specific quantity control requirements, as well as the following references for guidance on the design and implementation of conventional dry detention ponds for stormwater quantity control:

- Connecticut Department of Transportation (ConnDOT). *Connecticut Department of Transportation Drainage Manual*, October 2000.
- Water Environment Federation (WEF) and American Society of Civil Engineers (ASCE). *Design and Construction of Urban Stormwater Management Systems (Urban Runoff Quality Management (WEF Manual of Practice FD-20 and ASCE Manual and Report on Engineering Practice No. 77)*, 1992.

Whenever possible, detention ponds should be designed as extended detention ponds or wet ponds, or used in conjunction with other stormwater treatment practices to provide water quality benefits. Extended detention ponds, which are considered primary stormwater treatment practices (see the Stormwater Ponds section of this chapter), are modified dry detention ponds that incorporate a number of enhancements for improved water quality function. Older, existing dry ponds are also good candidates for stormwater retrofits by incorporating these recommended enhancements (see Chapter Ten), which are summarized below.

Sediment Forebay: A sediment forebay is an additional storage area near the inlet of the pond that facilitates maintenance and improves pollutant removal by capturing large particles. Sediment forebays can be created by berms or baffles constructed of stone, riprap, gabions or similar materials. The forebay should include a deep permanent pool to minimize the potential for scour and re-suspension (Metropolitan Council, 2001).

Extended Detention Storage: Extended detention requires sufficient storage capacity to hold stormwater for at least 24 hours to allow solids to settle out. The additional storage volume is usually provided in the lower stages of the pond for treatment of smaller storms associated with the water quality volume, while the upper stages provide storage capacity for large, infrequent storms. To reduce the potential for mosquito breeding, detention ponds should not be designed to hold water for longer than 5 days.

Any stormwater treatment practices that create an embankment, including stormwater detention ponds, are under the jurisdiction of the Dam Safety Section of the Connecticut DEP Inland Water Resources Division (IWRD) and should be constructed, inspected, and maintained in accordance with Connecticut General Statutes §§22a-401 through 22a-411, inclusive, and applicable DEP guidance.

Outlet Wet Pool: A relatively shallow, permanent pool of water at the pond outlet can provide additional pollutant removal by settling finer sediment and reducing re-suspension. The wet pool or micropool can also be planted with wetland species to enhance pollutant removal.

Pond Configuration: The inlet and outlet of the pond should be positioned to minimize short-circuiting. Baffles and internal grading can be used to lengthen the flow path within the pond. A minimum length-to-width ratio of 2:1 is recommended, and irregularly shaped ponds are desirable due to their more natural and less engineered appearance.

Low Flow Channels: Low flow channels prevent erosion as runoff first enters a dry pond during the initial period of a storm event, and after a storm, route the final portion to the pond outlet.

Secondary Practices

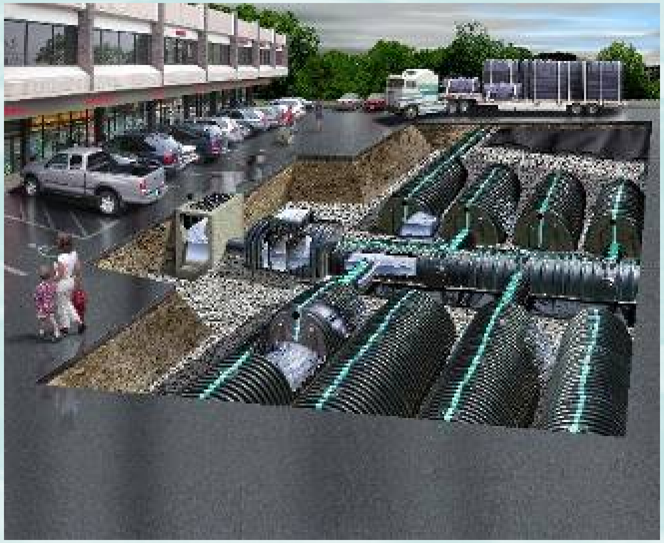
- Conventional Practices
  - Dry detention basins
  - Underground detention facilities
  - Deep sump catch basins
  - Oil/particle separators
  - Dry wells
  - Permeable pavement
  - Vegetated filter strips/ level spreaders
  - Grass drainage channels
- Innovative/Emerging Technologies
  - Catch basin inserts
  - Hydrodynamic separators
  - Media filters
  - Underground infiltration systems
  - Alum injection

Secondary Practice: Dry Detention Basins

- Reasons for limited use
  - Limited or no water quality treatment
  - Subject to re-suspension of materials
- Suitable applications
  - Peak flow control
  - Channel protection

Secondary Practice: Underground Detention and Infiltration

- Reasons for limited use
  - Not intended for pollutant removal
  - Particulates can be re-suspended
  - Risk of groundwater contamination
- Suitable applications
  - Peak flow control/groundwater recharge
  - Stormwater retrofits
  - Space-limited sites
  - Must have pretreatment



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Secondary Practice: Grass Drainage Channels

pasture.ecn.purdue.edu

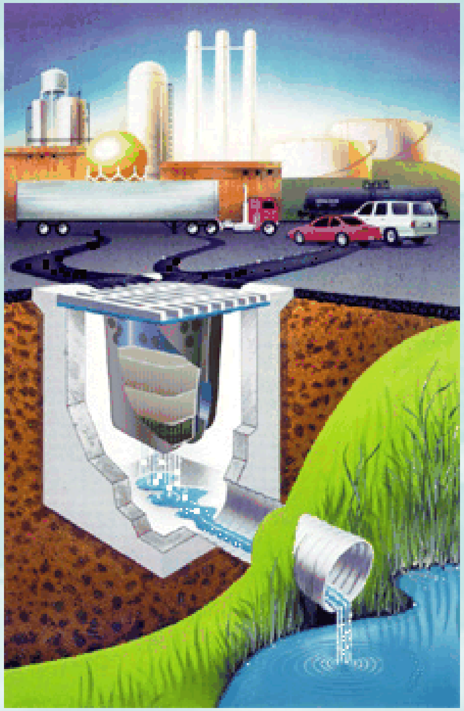
clean-water.uwex.edu

- Reasons for limited use
  - Can’t achieve 80% TSS removal
  - Require moderate maintenance
  - Impractical in areas with steep grades or very flat sites
  - Large area requirements
- Suitable applications
  - Part of conveyance system
  - Replace curb & gutter drainage
  - Highway road runoff

These are not the same as Water Quality Swales!

Secondary Practice: Catch Basin Inserts

- Reasons for limited use
  - High maintenance
  - Susceptible to clogging
- Suitable applications
  - Stormwater retrofits and pretreatment
  - Temporary construction sediment control
  - Oil control for small areas
  - Target specific pollutant

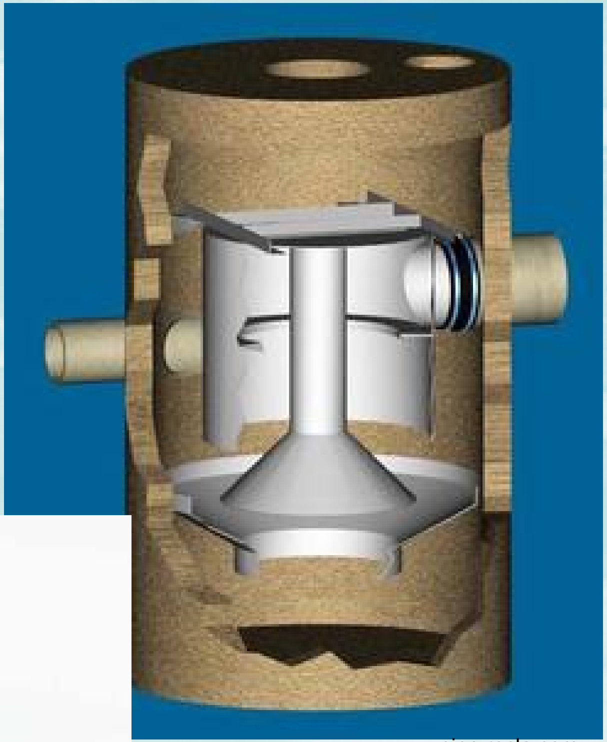


hydrocompliance.com

mayportnelp.com

Secondary Practice: Hydrodynamic Separators

- Reasons for limited use
  - Limited peer-reviewed data
  - Soluble and fine particles not removed
  - Source of pollutants if not maintained
- Suitable applications
  - Sediment removal over range of flow conditions
  - Pretreatment
  - Stormwater retrofits
  - Ultra-urban sites



pipe.rocla.com

Secondary Practices: Other Innovative Strategies

Outline

- Introduction to Practices
- Stormwater Design Criteria
- Treatment Practice Selection
- Site Stormwater Management Plan
- Retrofits
- Stormwater Management Practices
- Appendices

Appendices

- A: Plant List
- B: Calculation Guidance
- C: Model Ordinances
- D: Site Plan Checklist
- E: Maintenance Checklist
- F: Glossary