Lesson 3: Design & Implementation of Stormwater BMPs

Environmental Stewards Class
Hillsborough, NJ
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Technical, Engineering Approach
Design Methodology

1. Selected problem areas and estimate drainage area
2. Estimate pollutant loadings and target removal
3. Select appropriate BMP and determine treatment suitability
4. Retrofit problem area with BMP design
5. Design BMP to effectively perform stormwater water quantity management
6. Implement BMP
Selection of Problem Areas

• Perform preliminary field work
• Select areas with suspected sources of nonpoint source pollution
  – Parking lots
  – Roads
  – Fields/lawns (especially those treated with pesticides and fertilizers)
  – Areas frequented by geese and other animals
  – Rooftops and drainpipes
• Select areas in need of renewed aesthetic landscaping
• Select areas near existing storm drains
Calculate Drainage Areas

- Use topographic maps to determine the area that would drain into the proposed BMP during a storm event.
Estimate Pollutant Loadings

- Estimate areas and different land use types within the problem area(s)
  - Land Surveying
  - Create a GIS land use map
  - Aerial photographs
- Use land use pollutant loading coefficients to determine loading rates
- These loading rates are useful in determining the targeted pollutant removal goal.
Target Pollutant Removal

- Use NJDEP BMP Manual to estimate the pollutant removal of the selected BMP

<table>
<thead>
<tr>
<th>Best Management Practice (BMP)</th>
<th>Adopted TSS Removal Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention System</td>
<td>90</td>
</tr>
<tr>
<td>Constructed Stormwater Wetland</td>
<td>90</td>
</tr>
<tr>
<td>Dry Well</td>
<td>Volume Reduction Only¹</td>
</tr>
<tr>
<td>Extended Detention Basin</td>
<td>40 to 60²</td>
</tr>
<tr>
<td>Infiltration Structure</td>
<td>80</td>
</tr>
<tr>
<td>Manufactured Treatment Device</td>
<td>See N.J.A.C. 7:8-5.7(d)³</td>
</tr>
<tr>
<td>Pervious Paving System</td>
<td>Volume Reduction</td>
</tr>
<tr>
<td></td>
<td>0r</td>
</tr>
<tr>
<td></td>
<td>80⁴</td>
</tr>
<tr>
<td>Sand Filter</td>
<td>80</td>
</tr>
<tr>
<td>Vegetative Filter</td>
<td>60-80</td>
</tr>
<tr>
<td>Wet Pond</td>
<td>50-90⁵</td>
</tr>
</tbody>
</table>
## Pollutant Removal

<table>
<thead>
<tr>
<th>Best Management Practice (BMP)</th>
<th>Total Phosphorous Removal Rate (%)</th>
<th>Total Nitrogen Removal Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention Basin</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>Constructed Stormwater Wetland</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Extended Detention Basin</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Infiltration Basin</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Manufactured Treatment Devices</td>
<td>See N.J.A.C. 7:8-5.7(d)</td>
<td>See N.J.A.C. 7:8-5.7(d)</td>
</tr>
<tr>
<td>Pervious Paving²</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Sand Filter</td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>Vegetative Filter</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Wet Pond</td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>
Bioretention systems/rain gardens

- Most effective if they receive runoff as close to its source as possible
- Vary in size and can receive and treat runoff from a variety of drainage areas within a land development site
- Can be installed in lawns, median strips, parking lot islands, unused lot areas, and certain easements
- Intended to receive and filter storm runoff from both impervious areas and lawns
Dry Wells

– The use of dry wells is applicable only where their sub-grade soils have the required permeability rates.
– Dry wells are not appropriate for areas where high pollutant sediment loading is anticipated due to the potential for groundwater contamination.
Retrofit

- Create design plans that incorporate BMP design into the existing landscape
- Re-grading of drainage area may be required to manage stormwater flow direction
- Make use of existing storm drains for exfiltrate
- Consider underdrain system or groundwater recharge
- Consider curb cuts
- Block off existing outfall drains
- Use AutoCAD or other design software
Compute Stormwater Runoff Rates and Volumes

- Use the USDA TR-55 manual for small urban watersheds
- HydroCAD software package

![Graph showing post-development and pre-development flow volumes](image)

- Post-development (volume = 17.0 ac-ft)
- Pre-development (volume = 9.7 ac-ft)
Maplewood, MN – Rain Gardens Offer Stormwater Control

- City choose rain gardens to improve drainage in older neighborhoods instead of curb and gutter drainage systems
- Two block pilot project resulted in no runoff from the neighborhood – 100% stormwater control
- City offers three standard garden sizes: 12’x24’, 10’x20’, and 8’x16’
- And seven different garden themes: Easy shrub garden, Easy daylily garden, Sunny garden, Sunny border garden, Butterflies and friends gardens, MN Prairie garden, and Shady garden.
- Gardens designed to catch 1/2” of rain.
Design of Backyard Rain Gardens
Rain Garden Placement

- The rain garden should be at least 10 feet from the house so infiltrating water doesn’t seep into the foundation.
- Do not place the rain garden directly over a septic system.
- Do not put rain garden in places where the water already ponds.
- Place in full or partial sunlight.
- Select a flat part of the yard for easier digging.

http://clean-water.uwex.edu/pubs/raingarden/rgmanual.pdf
Rain Garden Placement

http://clean-water.uwex.edu/pubs/raingarden/rgmanual.pdf
Depth

• Between four and eight inches deep
• Depth depends upon lawn slope
  – If the slope is less than 4%, it is easiest to build a 3 to 5-inch deep rain garden.
  – If the slope is between 5 and 7%, it is easiest to build one 6 to 7 inches deep.
  – If the slope is between 8 and 12%, it is easiest to build one about 8 inches deep.

http://clean-water.uwex.edu/pubs/raingarden/rgmanual.pdf
Find the Slope of the Lawn

\[ \frac{\text{Height}}{\text{Width}} \times 100 = \%\text{Slope} \]
Keep Your Rain Garden Level

Figure 4. Plants at base of a 6-inch deep Rain Garden
Digging Your Garden (3-8% Slope)

a. Between 3% and 8% slope lawn

Before Digging
- downhill stake
- string
- 5% slope
- start digging here
- uphill stake
- 6''
- 10'

After Digging
- downhill stake
- berm
- string
- old lawn surface
- base of raingarden
- uphill stake
- 6''
- 10'
Digging Your Garden (>8% Slope)

b. Greater than 8% slope lawn

Before Digging
- downhill stake
- string
- 10% slope
- start digging here

After Digging
- downhill stake
- string
- old lawn surface
- berm
- uphill stake

Dimensions:
- 8"
- 12"
- 4"
- 10'
Other Considerations

- Is the soil type suitable?
  - hole test/perc test
  - texture test

- Is the rain garden able to handle the drainage area?
  - if not, consider multiple rain gardens

http://clean-water.uwex.edu/pubs/raingarden/rgmanual.pdf
Size of the Rain Garden

- The size of the rain garden is a function of volume of runoff to be treated and recharged.

- Typically, a rain garden is sized to handle the water quality design storm: 1.25 inches of rain over two hours.

- A typical residential rain garden ranges from 100 to 300 square feet.
Example in Sizing

**Problem:**

How big does a rain garden need to be to treat the stormwater runoff from my driveway?
Driveway Area
50' x 15' = 750 square feet
25' x 10' = 250 square feet
Total Area = 1,000 square feet

One-Quarter of the Roof
25' x 12.5' = 312.5 square feet
## Rain Garden Sizing Table
for NJ’s Water Quality Design Storm

<table>
<thead>
<tr>
<th>Area of Impervious Surface to be Treated (ft²)</th>
<th>Size of 6” deep Rain Garden (ft²) or [w x d]</th>
<th>Size of 12” deep Rain Garden (ft²) or [w x d]</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>100 or 10’x10’</td>
<td>50 or 10’x5’</td>
</tr>
<tr>
<td>750</td>
<td>150 or 15’x10’</td>
<td>75 or 10’x7½’</td>
</tr>
<tr>
<td>1,000</td>
<td>200 or 20’x10’</td>
<td>100 or 10’x10’</td>
</tr>
<tr>
<td>1,500</td>
<td>300 or 30’x10’</td>
<td>150 or 15’x10’</td>
</tr>
<tr>
<td>2,000</td>
<td>400 or 20’x20’</td>
<td>200 or 20’x10’</td>
</tr>
</tbody>
</table>
Example in Sizing

- Drainage Area = 1,000 square feet
- 1.25 inches of rain = 0.1 feet of rain
- 1,000 sq. ft. x 0.1 ft. = 100 cubic feet of water for the design storm
- Let’s design a rain garden that is 6 inches deep

**Answer:**
10 ft wide x 20 ft long x 0.5 feet deep
= 100 cubic feet (10 ft x 10 ft garden)
How much water does this treat?

- 90% of rainfall events are less than 1.25”
- New Jersey has approx. 44” of rain per year
- The rain garden will treat and recharge: 
  \[0.9 \times 44” = 40”/\text{year} = 3.3 \text{ ft/year}\]
- The rain garden receives runoff from 1,000 sq.ft.
- Total volume treated and recharged by the rain garden is 1,000 sq. ft. \(\times\) 3.3 ft. = 3,300 cubic feet, which is 25,000 gallons per year
- **Build 40 of these and we have treated and recharged 1,000,000 gallons of water per year!**
Use string to outline planting scheme

http://clean-water.uwex.edu/pubs/raingarden/rgmanual.pdf
Types of Plants

- Obligate Wetland (OBL) – plants that nearly always (more than 99% of the time) occur in wetlands under natural conditions.

- Facultative Wetland (FACW) – plants that usually occur in wetlands (from 67 to 99% of time), but are occasionally found in nonwetlands.

- Facultative (FAC) – plants that are equally likely to occur in wetlands and nonwetlands and are found in wetlands from 34 to 66% of the time.

- Facultative Upland (FACU) – plants that usually occur in nonwetlands (from 67 to 99% of the time), but are occasionally found in wetlands (from 1 to 33% of the time).

- Upland (UPL) – plants that almost always (more than 99% of the time), under natural conditions, occur in nonwetlands.
### Planting Options

<table>
<thead>
<tr>
<th>Trees</th>
<th>Shrubs</th>
<th>Herbaceous Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer rubrum</td>
<td>Clethra alnifolia</td>
<td>Andropogon glomeratus</td>
</tr>
<tr>
<td>Red Maple</td>
<td>Sweet Pepperbush</td>
<td>Lowland broomsedge</td>
</tr>
<tr>
<td>Betula nigra</td>
<td>Ilex verticillata</td>
<td>Eupatorium purpureum</td>
</tr>
<tr>
<td>River Birch</td>
<td>Winterberry</td>
<td>Joe Pye Weed</td>
</tr>
<tr>
<td>Juniperus virginiana</td>
<td>Cephalathus occidentalis</td>
<td>Scripus pungens</td>
</tr>
<tr>
<td>Eastern red cedar</td>
<td>Buttonbush</td>
<td>Three square bulrush</td>
</tr>
<tr>
<td>Chionanthus virginicus</td>
<td>Hamamelis virginiana</td>
<td>Iris versicolor</td>
</tr>
<tr>
<td>Fringe-tree</td>
<td>Witch hazel</td>
<td>Blue flag</td>
</tr>
<tr>
<td>Nyssa sylvatica</td>
<td>Vaccinium corymbosum</td>
<td>Lobelia cardinalis</td>
</tr>
<tr>
<td>Black gum</td>
<td>Highbush blueberry</td>
<td>Cardinal flower</td>
</tr>
<tr>
<td>Quercus palustris</td>
<td>Ilex glabra</td>
<td>Panicum virgatum</td>
</tr>
<tr>
<td>Pin oak</td>
<td>Inkberry</td>
<td>Switchgrass</td>
</tr>
<tr>
<td>Salix nigra</td>
<td>Viburnum dentatum</td>
<td>Vernonia noveboracensis</td>
</tr>
<tr>
<td>Black willow</td>
<td>Arrowwood</td>
<td>New York ironweed</td>
</tr>
</tbody>
</table>

- Examples of New Jersey Native Species (NJDEP)
Vegetation
Planting Methods

• Example Planting Scheme

Each color represents different native plant type (see NJDEP BMP Manual for native plants of NJ)

http://clean-water.uwex.edu/pubs/raingarden/rgmanual.pdf
The Demonstration Rain Garden

1. Display a sign
2. Offer educational materials
3. Allow for use in educational programs
4. Leverage into three to five new rain gardens in the community

Are these requests reasonable?
Rain Garden

Water Quality and Habitat Enhancement Project
This garden is designed to intercept, treat, and infiltrate stormwater at the source, before it becomes runoff. The plants are native to the region and help retain pollutants that could otherwise harm nearby waterways.

NOTES:
Sign to be manufactured from 1/8” aluminum sheeting.
Sign to be mounted with screws at 45 angle on 6”x6” bollard at a height of 24”.
Locate signs as indicated on the plans.

"RAIN GARDEN" SIGN DETAIL

1
1

N.T.S.
Federal and State Regulatory Initiatives – the Clean Water Act
What is a Total Maximum Daily Load (TMDL)?

A TMDL is a quantitative assessment of water quality problems, contributing sources, and load reductions or control actions needed to restore and protect individual water bodies.
What is the process?

• What is the Process?
  1. Identify Quality Limited Waters
  2. Establish Priority Waters/Watersheds
  3. Develop TMDLs
  4. Implement the water quality improvement for each segment
  5. Assess water quality improvement for each segment
TMDL Components

- Problem statement
- Numeric target(s)
- Source analysis
- Loading capacity estimate
- Allocations of the available loads to sources
- Implementation elements
TMDL = WLA + LA + MOS

(690 kg/yr = 0 + 460 + 230)

TMDL development phase

TMDL = \text{State water quality standard for the pollutant given the stream’s designated beneficial use} + \text{(point source waste load allocation)} + \text{(nonpoint load allocation)} + \text{(margin of safety)}
## NPS Sources of Phosphorus Loads

<table>
<thead>
<tr>
<th>Nonpoint Source</th>
<th>Davidson’s Mill Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acres</td>
</tr>
<tr>
<td>Medium/High Density Residential</td>
<td>329.1</td>
</tr>
<tr>
<td>Low Density/Rural Residential</td>
<td>566.5</td>
</tr>
<tr>
<td>Commercial</td>
<td>114.7</td>
</tr>
<tr>
<td>Industrial</td>
<td>573.3</td>
</tr>
<tr>
<td>Mixed Urban/Other Urban</td>
<td>1357.4</td>
</tr>
<tr>
<td>Agricultural</td>
<td>1853.8</td>
</tr>
<tr>
<td>Forest, Wetlands</td>
<td>4427.8</td>
</tr>
<tr>
<td>Barren Land</td>
<td>346.6</td>
</tr>
<tr>
<td>Direct Air Deposition on Lake Surface</td>
<td>26.1</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>9595.3</td>
</tr>
</tbody>
</table>
## TMDL Allocations

<table>
<thead>
<tr>
<th>Category</th>
<th>Kg TP/yr</th>
<th>% of Load Capacity</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Med/High Density Residential</td>
<td>18</td>
<td>2.5%</td>
<td>92%</td>
</tr>
<tr>
<td>Low Density/Rural Residential</td>
<td>13</td>
<td>1.9%</td>
<td>92%</td>
</tr>
<tr>
<td>Commercial</td>
<td>7.7</td>
<td>1.1%</td>
<td>92%</td>
</tr>
<tr>
<td>Industrial</td>
<td>33</td>
<td>4.7%</td>
<td>92%</td>
</tr>
<tr>
<td>Mixed Urban/Other Urban</td>
<td>45</td>
<td>6.5%</td>
<td>92%</td>
</tr>
<tr>
<td><strong>Agricultural</strong></td>
<td><strong>93</strong></td>
<td><strong>13%</strong></td>
<td><strong>92%</strong></td>
</tr>
<tr>
<td>Forest, Wetlands</td>
<td>180</td>
<td>26%</td>
<td>0%</td>
</tr>
<tr>
<td>Barren Land</td>
<td>70</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Direct Air Deposition</td>
<td>0.74</td>
<td>0.11%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td><strong>460</strong></td>
<td><strong>66%</strong></td>
<td></td>
</tr>
</tbody>
</table>
NJ’s TMDLs

- **Fecal Coliform**
  - 2,226 square miles of watersheds
  - 363 square miles of agricultural land use
  - Average required reductions = 87%

- **Total Phosphorus**
  - 288 square miles of watersheds
  - 75 square miles of agricultural land use
  - Up to 94% reductions are required
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