BMP Trains 2020 Example Problem 12
Single Catchment (wet detention and side-bank filter)

BMP Trains 2020 Model

By: Ikiensinma Gogo-Abite, PhD.
January 31, 2020
Example Problem 12

Stormwater Wet Detention and Filtration

• Average annual removal of a wet detention pond in series with a Surface Filtration System

• Net improvement analysis

• Located on the East Coast of Florida, in meteorological zone 4

• Mean annual rainfall is 50 inches

• Wet Pond area is 10 acre and permanent pool volume is 5.0 acre-feet

<table>
<thead>
<tr>
<th>Catchment configuration</th>
<th>Pre-development</th>
<th>Post-development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (acres)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Land-use</td>
<td>Low-Intensity Commercial</td>
<td>High-Intensity Commercial</td>
</tr>
<tr>
<td>Non-DCIA CN</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>DCIA (%)</td>
<td>0</td>
<td>30.0</td>
</tr>
</tbody>
</table>
Example Problem

Input data for watershed and catchment area

1. Enter Catchment
2. Enter Treatment
3. Configure Catchments
4. Summary Treatment Report
5. Complete Report
6. Cost Comparisons
**Example Problem**

**Input data for watershed and catchment area**

---

### Watershed Characteristics Worksheet Version: 3.0.0

**Add Catchment:** Catchment 1 Wet Detention with Filtration

**Current Catchment Number (use 1 if single catchment):** 1 Wet Detention with Filtration

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Catchment Name:</th>
<th>Concentrations used in Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Catchment Name:</td>
<td>Pre:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EMC(N) mg/l</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EMC(P) mg/l</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.183</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annual C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Runoff (ac-ft/yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N Loading (kg/yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.971</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P Loading (kg/yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.406</td>
</tr>
</tbody>
</table>

**Pre:**
- Agricultural - Citrus: TN=2.240 TP=0.183
- Single-Family: TN=2.070 TP=0.327

**Post:**
- Agricultural - Citrus: TN=2.070 TP=0.327
- Single-Family: TN=2.070 TP=0.327

**Total Pre-Development Catchment Area (ac):** 10.00

**Total Post-Development Catchment Area (ac):** 10.00

**Pre-Development Non DCIA Curve Number:** 60

**Pre-Development DCIA Percentage (0 - 100%):** 0.0

**Post-Development DCIA Curve Number:** 60

**Post-Development DCIA Percentage (0 - 100%):** 30.0

**Wet Pond Area (No loading from this area, ac):** 1.00

**Groundwater Load (kg/yr):**
- Pre N: 0.000
- Pre P: 0.000
- Post N: 0.000
- Post P: 0.000

-[Report](#)  [Calculate](#)  [Cancel](#)  [Back](#)
Example Problem
Input data for watershed and catchment area

General Site Information for Project File:

- Enter a Name for Your Project: Example Problem #12
- Select Meteorological Zone for Project: Florida Zone 4
- Enter the Mean Annual Rainfall: 54 inches
- Specify Type of Surface Discharge Analysis: Net Improvement
- Conduct a Groundwater Discharge Analysis: No

1. Enter Catchment
2. Enter Treatment
3. Configure Catchments
4. Summary Treatment Report
5. Complete Report
6. Cost Comparisons
Example Problem

Input data for Treatment Options (BMPs)

Select Treatment Options for individual performance, not in series or in multiple catchments. Analysis: Net Improvement Required Removal N: 87% P: 85%

Current: 1 Detention/Filter Media

TYPICAL X-SECTION OF A WET DETENTION SYSTEM

- Top of Bank (TOB)
- Top of Flood Control Attenuation Volume (IF Applicable)
- Overflow Water Elevation (WEIR CREST)
- Emergency Overflow Reduction (EOR)
- Pipe
- PERMANENT POOL
- ANOXIC ZONE
- Optional Littoral Zone
- SHGW = SEASONAL HIGH GROUNDWATER TABLE
- NWL = NORMAL WATER LEVEL
- Outfall
- Infall

1. The normal wet season tailwater elevation
2. The SHGW minus six (6) inches

- TYPICAL X-SECTION OF A WET DETENTION SYSTEM

Options:
- Retention Basin
- Greenroof
- Rainwater Harvesting
- Wet Detention
- Exfiltration Trench
- Vegetated Buffer
- Permeable Pavement
- Filter or Vegetated Filter Strip
- Stormwater Harvesting
- Rain Garden
- Surface Discharge Filter
- Tree Well
- BMPs in Series
- Tools
- Reset All
- Catchments
- Cost Report
- Back
Example Problem
Input data for Wet Detention Pond – Permanent Pool Volume

Load Diagram for Wet Detention (stand-alone)

Load
N. 28.43 kg/yr
P. 4.49 kg/yr

Treatment
N. 43 %
P. 78 %

Surface Discharge
N. 16.31 kg/yr
P. 0.98 kg/yr

Mass Reduction
N. 12.11 kg/yr
P. 3.51 kg/yr

Permanent Pool Volume (acre-feet):
5

Littoral Zones Improvement Credit (%):
0

Floating Wetland or Mats Improvement Credit (%):
0

Help
Calculate
Cost
Print
Plot
Copy
Back
Example Problem

Input data – Configure Catchment
Example Problem

Input data – Configure Catchment

By using existing and adding new Catchments create a routing configuration. Specify default BMP to be used.
Example Problem
Output Data – Wet Pond Only

Enter a Name for Your Project: Example Problem #12
Select Meteorological Zone for Project: Florida Zone 4
Enter the Mean Annual Rainfall: 54 inches
Specify Type of Surface Discharge Analysis: Net Improvement
Conduct a Groundwater Discharge Analysis: No

1. Enter Catchment
2. Enter Treatment
3. Configure Catchments
4. Summary Treatment Report
5. Complete Report
6. Cost Comparisons
Example Problem
Output Data – Wet Pond Only

Summary Treatment Report Version: 3.0.0

Project: Example Problem #12

Analysis Type: Net Improvement
BMP Types:
  Catchment 1 - Wet Detention

Routing Summary
  Catchment 1 Routed to Outlet

Total nitrogen target removal met? No
Total phosphorus target removal met? No

Summary Report
Nitrogen

Surface Water Discharge
- Total N pre load: 4.97 kg/yr
- Total N post load: 28.43 kg/yr
- Target N load reduction: 83%
- Target N discharge load: 4.97 kg/yr
- Percent N load reduction: 43%
- Provided N discharge load: 16.31 kg/yr
- Provided N load removed: 12.11 kg/yr

Phosphorus

Surface Water Discharge
- Total P pre load: 0.406 kg/yr
- Total P post load: 4.491 kg/yr
- Target P load reduction: 91%
- Target P discharge load: 4.06 kg/yr
- Percent P load reduction: 78%
- Provided P discharge load: 0.981 kg/yr
- Provided P load removed: 3.51 kg/yr
Example Problem

Input data for Treatment Options (BMPs)

[Image of software interface for project setup]

1. Enter Catchment
2. Enter Treatment

Options:
- Open Project
- New Project
- Save Project
- Exit BMPTrains

Additional options:
- Configure Catchments
- Summary Treatment Report
- Complete Report
- Cost Comparisons
Example Problem

Input data for Treatment Options (BMPs)
Example Problem

Input data for Treatment Options (BMPs)
Example Problem

Input data for Treatment Options (BMPs)

Filtration System Worksheet: Analysis
Net Improvement Required: Removal N: 83% P: 91%

Click Button to Select Media: [Media] [Not Specified]

Treatment Depth (0.0-4.0 inches): [0]

Is there an upstream BMP in this Catchment (ex. wet pond?): [ ]

---

Project: Example Problem #12
Date: 1/23/2020

Surface Discharge Filtration Design
Treatment Depth (in) 0.000
Wet detention: effluent?
Hydraulic Capture Efficiency (%)
Media Type: Not Specified

Watershed Characteristics
Catchment Area (acres) 10.00
Contributing Area (acres) 9.00
Non-DCIA Curve Number 60.00
DCIA Percent 30.00
Rainfall Zone: Florida Zone 4
Example Problem
Input data for Treatment Options (BMPs)

Enter Media Mix Information

Select Media Mix: Not Specified

If all runoff are treated: 

- TN Reduction (%): 0
- TP Reduction (%): 0

Back

Enter Media Mix Information

Select Media Mix: B&G CTS24

If all runoff are treated: 

- TN Reduction (%): 75
- TP Reduction (%): 95

Back
Example Problem
Input data for Treatment Options (BMPs)

Filtration System Worksheet Analysis: Net Improvement Required Removal N: 83% P: 91%

Click Button to Select Media: Media B&G CTS24

Treatment Depth (0.0-4.0 inches): 0

Is there an upstream BMP in this Catchment (ex. wet pond)?
Example Problem
Input data for Treatment Options (BMPs)

Click Button to Select Media: Media B&G CTS24

Treatment Depth (0.0-4.0 inches): 1.75

Is there an upstream BMP in this Catchment (ex. wet pond)? Yes

Project: Example Problem #12
Date: 1/24/2020

Surface Discharge Filtration Design
Treatment Depth (in) 0.000
Wet detention effluent?
Hydraulic Capture Efficiency (%)
Media Type B&G CTS24

Watershed Characteristics
Catchment Area (acres) 10.00
Contributing Area (acres) 9.000
Non-DCIA Curve Number 60.00
DCIA Percent 30.00
Rainfall Zone Florida Zone 4
Example Problem
Input data for Treatment Options (BMPs)

Filtration System Worksheet Analysis: Net Improvement Required Removal N: 83% P: 91%

Click Button to Select Media: Media B&G CTS24

Treatment Depth (0.0-4.0 inches): 1.75

Is there an upstream BMP in this Catchment (ex. wet pond)?

Yes

TP Concentration (mg/L) 0.037

Load Diagram for Surface Discharge Filtration (stand-alone)

Load
N: 28.43 kg/yr
P: 4.49 kg/yr

Treatment
N: 71 %
P: 89 %

Surface Discharge
N: 8.39 kg/yr
P: 0.48 kg/yr

Mass Reduction
N: 20.04 kg/yr
P: 4.01 kg/yr

Cost
Calculate
Print
Plot
Copy
Back
Example Problem

Input data for Treatment Options (BMPs)
Example Problem

BMP in Series Calculator
Example Problem

BMP in Series Calculator

1. Enter Catchment
2. Enter Treatment
3. Configure Catchments

Select Catchment Configuration

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Area</th>
<th>BMP Used</th>
<th>Edit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>10.00</td>
<td>Wet Detention</td>
<td></td>
</tr>
</tbody>
</table>

Routing Catchment From: 1

Select Catchment to Route to: Outlet
Select BMP to use in routing: Wet Detention

Catchment Active: Disable Catchment
Delay Time (hr): 0
Example Problem

BMP Configuration Analysis

By using existing and adding new Catchments create a routing configuration. Specify default BMP to be used.
Example Problem
Nutrient Reduction Results

**Analysis Type: Net Improvement**

**BMP Types:**
- Catchment 1 - Multiple BMP

Total nitrogen target removal met? Yes
Total phosphorus target removal met? Yes

### Nitrogen

**Surface Water Discharge**

- Total N pre load: 4.97 kg/yr
- Total N post load: 28.43 kg/yr
- Target N load reduction: 83%
- Target N discharge load: 4.97 kg/yr
- Percent N load reduction: 83%
- Provided N discharge load: 4.81 kg/yr 10.61 lb/yr
- Provided N load removed: 23.61 kg/yr 52.07 lb/yr

<table>
<thead>
<tr>
<th></th>
<th>Total N pre load</th>
<th>Total N post load</th>
<th>Target N load reduction</th>
<th>Target N discharge load</th>
<th>Percent N load reduction</th>
<th>Provided N discharge load</th>
<th>Provided N load removed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nitrogen</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.97 kg/yr</td>
<td>28.43 kg/yr</td>
<td>83%</td>
<td>4.97 kg/yr</td>
<td>83%</td>
<td>4.81 kg/yr 10.61 lb/yr</td>
<td>23.61 kg/yr 52.07 lb/yr</td>
</tr>
</tbody>
</table>

### Phosphorus

**Surface Water Discharge**

- Total P pre load: .406 kg/yr
- Total P post load: 4.491 kg/yr
- Target P load reduction: 91%
- Target P discharge load: .406 kg/yr
- Percent P load reduction: 98%
- Provided P discharge load: .105 kg/yr .23 lb/yr
- Provided P load removed: 4.386 kg/yr 9.67 lb/yr

<table>
<thead>
<tr>
<th></th>
<th>Total P pre load</th>
<th>Total P post load</th>
<th>Target P load reduction</th>
<th>Target P discharge load</th>
<th>Percent P load reduction</th>
<th>Provided P discharge load</th>
<th>Provided P load removed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phosphorus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.406 kg/yr</td>
<td>4.491 kg/yr</td>
<td>91%</td>
<td>.406 kg/yr</td>
<td>98%</td>
<td>.105 kg/yr .23 lb/yr</td>
<td>4.386 kg/yr 9.67 lb/yr</td>
</tr>
</tbody>
</table>

TN Removal = 83% ≥ 83% Met
TP Removal = 98% ≥ 91% Met
Calculation for Filter Media Surface Area
Calculation for Filter Media Surface Area

These are tools designed to assist with the complex tables and calculations used in BMP Trains.

Information entered in these forms is not saved and does have any effect elsewhere in the program.

- Pervious Pavement Storage Calculator
- Harvesting Efficiency Table
- Rational Coefficient Lookup Table
- Retention Efficiency Lookup Tables
- Media Filter Area in Square Feet
- Media Filter Service Life in Years

Back
Calculation for Filter Media Surface Area

Select Catchment: None - Enter EIA

Effective Impervious Area (ac): 
Treatment Depth (0.05 in - 4 in): 
Rate in GPM/SF (0.02-10.0): 0.000 Not Specified

Half of the runoff volume is treated in day one

Calculate
Copy
Print
Back

Select Catchment: Catchment 1

Effective Impervious Area (ac): 
Treatment Depth (0.05 in - 4 in): 
Rate in GPM/SF (0.02-10.0): 0.000 Not Specified

Half of the runoff volume is treated in day one

Calculate
Copy
Print
Back
Calculation for Filter Media Surface Area

Minimum Filter Area (SF) = 1,202.1
Minimum Filter Volume (CF) = 2,404.2
Calculation for Actual Filter Media Surface Area from Drawdown Analysis

- **Methodology**
  1. FDOT – FDOT Drainage Design Guide
  2. SJRWMD – Permit Information Manual
  3. SWFWMD – Drainage Spreadsheet (ERP Applicant’s Handbook Vol. II)

- **Filtration Options:**
  1. Vertical Filter – Underdrain (Retention Pond)
  2. Lateral Filter – Side-bank or Shelf Filter (Retention/Detention Pond)
  3. Upflow Filter – Vaults
Examples of Filter Systems

- Sidebank Filter
- Constant Filter Area
- Pond Bottom Filter
- Constant and Variable Filter Area
- Trench Underdrain
- Variable Filter Area
Side-bank Filter System

Shelf Filter System

Underdrain Filter System
Calculation for Filter Media Surface Area

- **SJRWMD methodology for drawdown analysis**
  - Side-bank filter
  - Shelf filter

- **Required Input Data**
  - Permeability of Filter media
  - Stage-Storage chart
  - Pipe invert elevation – Tailwater elevation or SHGWT elevation
  - Pond configuration and dimensions
  - Treatment volume
## Basic Information

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Data</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter Permeability (k)</td>
<td>1.04</td>
<td>ft/hr</td>
</tr>
<tr>
<td>Basin Side Slope (h/v)</td>
<td>4</td>
<td>ft/ft</td>
</tr>
<tr>
<td>Top of Treatment Volume Elevation</td>
<td>18.30</td>
<td>ft</td>
</tr>
<tr>
<td>Bottom of Treatment Volume Elevation</td>
<td>16.50</td>
<td>ft</td>
</tr>
<tr>
<td>Number of Increments</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Storage Volume</td>
<td>13,027</td>
<td>cf</td>
</tr>
<tr>
<td>Pipe Capacity (Inside Diameter)</td>
<td>7.65</td>
<td>in.</td>
</tr>
</tbody>
</table>

## Filter Pipe Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Data</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Pipe (L)</td>
<td>275</td>
<td>ft</td>
</tr>
<tr>
<td>Pipe Diameter (d)</td>
<td>8.0</td>
<td>in.</td>
</tr>
<tr>
<td>Pipe Invert Elevation</td>
<td>14.43</td>
<td>ft</td>
</tr>
<tr>
<td>Horizontal Distance (Dh)</td>
<td></td>
<td>ft</td>
</tr>
<tr>
<td>Envelope Height above Pipe</td>
<td>3.00</td>
<td>in.</td>
</tr>
<tr>
<td>Average Envelope Width</td>
<td>3.00</td>
<td>in.</td>
</tr>
<tr>
<td>Manning’s n</td>
<td>0.016</td>
<td></td>
</tr>
<tr>
<td>Slope (ft per ft)</td>
<td>0.0012</td>
<td>ft/ft</td>
</tr>
</tbody>
</table>

## Incremental Method for Calculating Drawdown Time for Side-Bank Filter Systems Using Darcy’s Equation

### Basic Information

| Elevation (ft) | Storage (cf) | Storage Increment, V (cf) | Distance of Flow Path Through Filter Media, D (ft.) | Average Flow Distance, D (ft) | Change in Elevation, H (ft) | Hydraulic Gradient, i | Average Filter Width, W (ft.) | Average Filter Flow Area, A (sf) | Instantaneous Discharge, Q (cfh) | Average Discharge per Increment, Qave (cfh) | Drawdown Time per Increment, ti (hrs.) | Total Drawdown Time, T (hrs) |
|----------------|--------------|---------------------------|-----------------------------------------------------|-------------------------------|-----------------------------|-----------------------|--------------------------------|----------------------------------|---------------------------------|---------------------------------|---------------------------------|--------------------------------
| 18.30          | 13,027       |                           |                                                     |                               |                             |                       |                                 |                                  |                                 |                                 |                                 |                                 |
|                |              |                           |                                                     |                               |                             |                       |                                 |                                  |                                 |                                 |                                 |                                 |
| 17.94          | 10,253       |                           |                                                     |                               |                             |                       |                                 |                                  |                                 |                                 |                                 |                                 |
| 17.58          | 7,537        |                           |                                                     |                               |                             |                       |                                 |                                  |                                 |                                 |                                 |                                 |
| 17.22          | 4,939        |                           |                                                     |                               |                             |                       |                                 |                                  |                                 |                                 |                                 |                                 |
| 16.86          | 2,427        |                           |                                                     |                               |                             |                       |                                 |                                  |                                 |                                 |                                 |                                 |
| 16.50          | 0            |                           |                                                     |                               |                             |                       |                                 |                                  |                                 |                                 |                                 |                                 |

### Filter Pipe Information

- Length of Pipe (L): 275 ft
- Pipe Diameter (d): 8.0 in
- Pipe Invert Elevation: 14.43 ft
- Horizontal Distance (Dh): ft
- Envelope Height above Pipe: 3.00 in
- Average Envelope Width: 3.00 in
- Manning’s n: 0.016
- Slope (ft per ft): 0.0012

### Filter Pipe Information

- Drawdown Time per Increment, ti (hrs): 0.0012
- Total Drawdown Time, T (hrs): 67.86

### Notes

- **Incremental Method for Calculating Drawdown Time for Side-Bank Filter Systems Using Darcy’s Equation**
- Bold & Gold CTS Filter Media
- Side-Bank Filter
Length of Side-bank = 275 ft.
Volume of filter media = 2,778 CF. (use for service life calculation, if greater than minimum)
Service Life Calculations

Questions:
1. How long before it becomes ineffective?
2. How often will the filter media be replaced?
3. How can I determine the replacement cycle?

Responses:
• Nitrate conversion is a **biological** process
• Orthophosphate (OP) is by **adsorption**
• Loading rate of OP – **OP is a fraction of TP** (site-specific parameter)
• **Sorption rate**: 0.2 mg of OP per gram of moist filter media (0.0032 oz. of OP per pound of moist filter media)
Service Life Calculations

These are tools designed to assist with the complex tables and calculations used in BMP Trains.

Information entered in these forms is not saved and does have any effect elsewhere in the program.

Select Catchment: Catchment 1

Select BMP:

Amount Removed (kg TP/yr):
Removal Rate in mg OP/g media (0.01-10.0):
Filter Volume Provide (cf):
Saturated Weight of Media (lbs/cf):
Fraction OP in TP (< 1.0):

Calculate
Copy
Print
Back
Service Life Calculations

Inputs
1. Filter media depth = 2',
2. Length = 275' and width = 6.6'
3. Fraction of TP (approx.) = 0.9
4. Volume of Filter Media = 2,778 CF
Service Life Calculations

Service Life $\approx 30$ years

Service Life = OP Removal Capacity of Media divided by the OP supplied to the filter per year.