Today’s Presentation Outline

• Understanding filtration systems and optional media mixes
• Up-Flow Filter Sites and Performance Results
• Properties of Media for Nutrient Removal
• Event Based treatment and Inter-event treatment
• Annual Effectiveness
• Real-time installation and some cost data
The Need for Alternative Filtration Systems

- Many wet detention pond underdrain or side bank systems often do not function as designed
  - Traditional filter flow path relies on a diagonal bank side or vertical flow direction;
  - Specifications requires specific criteria for uniformity and hydraulic conductivity parameters;
  - The function of any filter is to block solids;
  - Down flow filters will most likely clog;
  - Biofouling can reduce hydraulic effectiveness.
Upflow Filters offer a Solution to Failed Side or Vertical Filters

• Failing side-bank or vertical down-flow filters is a state-wide problem that effectively reduces WQ treatment volumes.
  – ERP phase inspections require compliance-often uncovering the problem
  – Older filtration systems may require excavation and replacement of media and/or under-drains
  – Replacement of side-bank or vertical filters is costly
Media Filters can Increase Effectiveness of Nutrient Removal

- Sand—the traditional standard
- Zeolite Media-ion exchange
- Biologically Active Media (BAM)-media that promotes attached microbial growth and still allows for hydraulically effective filtration
Possible Bio-sorption Activated Media (BAM) Sources

- Expanded Clay
- Peat
- Sandy/Loamy/Clayey soils
- Sawdust (untreated)
- Paper/Newspaper
- Palm Tree Frauds
- Tire Crumb
- Tire Chips
- Limestone
- Crushed Shells
- Wood Fiber/Chips/
- Compost
- Coconut husk
LABORATORY SOIL COLUMNS

- Test selected media mixtures to quantify their nutrient attenuation capabilities
- Life Expectancy
Bio-Sorption Activated Media (BAM) Scanning Electron Microscope

Figure 5.13-15. SEM of (a) concrete sand 1,000 x, (b) expanded clay 2,200 x, and (c) tire crumb 1,200 x magnification showing the surface structure and characteristics after residing in the 24 days of column testing.
## Comparison of Clay Media Mixes - N Removal

<table>
<thead>
<tr>
<th>Lower Grade Media</th>
<th>Parameter</th>
<th>High Grade Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>Wet Condition</td>
<td>Higher</td>
</tr>
<tr>
<td>Higher</td>
<td>Infiltration Rate</td>
<td>Lower</td>
</tr>
<tr>
<td>Lower</td>
<td>Clay content</td>
<td>Higher</td>
</tr>
<tr>
<td>Lower</td>
<td>CEC</td>
<td>Higher</td>
</tr>
<tr>
<td>Higher</td>
<td>DO</td>
<td>Lower</td>
</tr>
<tr>
<td>Lower</td>
<td>Alkalinity</td>
<td>Higher</td>
</tr>
<tr>
<td>Lower</td>
<td>Organic Carbon</td>
<td>Higher</td>
</tr>
<tr>
<td>Higher</td>
<td>Nitrate</td>
<td>Lower</td>
</tr>
<tr>
<td>No</td>
<td>Nitrate Decline with Time</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Media Moisture Conditions

- Soil moisture data indicate media stays wetter longer when using a BAM mix
- A substantial gas phase fraction is more conducive to $O_2$ diffusion and aerobic groundwater
- Oxygen availability has important implications for denitrification and other biogeochemical processes
Before and After BAM (high grade)

Field measurements were obtained by continuous monitoring using time domain reflectometry and tensiometers.

Laboratory derived soil moisture retention curves were measured for the main drying curve on undisturbed soil cores using the pressure cell method.
Denitrifying Organisms Present

- For a high grade media shown in a shaded color, evidence of denitrification is supported by real-time PCR (DNA) results indicating elevated nitrite reductase gene densities at depths of 1.4 m.
For Wet Detention Ponds (On-Line)
Chamber Up-flow Filter with Skimmer (CUFS)

- CUFS

Red Bug Detention Pond “B”

Upflow Filter

Skimmer

Pond Outlet (Circular Orifice/Inlet Grate)

Pond Concrete Outlet Pipe

E

N

W

S
Cleaning the Upflow Filter
Done once in 4 years, others may require more frequent cleaning
Percent Removal

<table>
<thead>
<tr>
<th></th>
<th>TN</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond</td>
<td>35%</td>
<td>83%</td>
</tr>
<tr>
<td>CUFS</td>
<td>25%</td>
<td>17%</td>
</tr>
<tr>
<td>Pond</td>
<td>47%</td>
<td>87%</td>
</tr>
</tbody>
</table>
Typical Failure Problems Associated with Side Bank Filters

Some Failure Problems

• Filters are difficult to access to properly clean
• Because of slow filtration or no filtration, exotics take over
• Often difficult or very costly to replace
Example Pond Retrofit Design for Upflow Filter

THE NEW UP-FLOW FILTER REPLACES AN OLD UN-SERVICEABLE SIDE BANK SYSTEM
THE UP-FLOW FILTER DESIGN ALLOWS FOR EASY INSPECTION AND SERVICE OF THE MEDIA
Up-Flow Filter Installation by Suntree Technologies
Improved Treatment Using An Up-flow Filter with Wet Pond

**Observations**

- Filters can be designed to remove nitrogen without media replacement
- For phosphorus, media replacement time is specified
- Can be easily cleaned
- Can be used in BMP Treatment Train
Up-Flow with Wet Detention Performance Data

- **Summary Data**
  - Concentration data based
  - Averages based on 6 events
  - Construction cost less than under drains
  - Average yearly based
  - 1.0 inch design for filter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TN</th>
<th>TP</th>
<th>TSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Influent Concentration (mg/L)</td>
<td>1.83</td>
<td>0.73</td>
<td>42.7</td>
</tr>
<tr>
<td>Average Filter Removal (%)</td>
<td>22</td>
<td>25</td>
<td>60</td>
</tr>
<tr>
<td>Average Pond Removal (%)</td>
<td>62</td>
<td>63</td>
<td>79</td>
</tr>
<tr>
<td>Average Pond + Filter Removal (%)</td>
<td>70</td>
<td>72</td>
<td>91</td>
</tr>
<tr>
<td>Average Annual System Performance</td>
<td><strong>67</strong></td>
<td><strong>70</strong></td>
<td><strong>89</strong></td>
</tr>
</tbody>
</table>
INTRODUCTION PAGE

Model requires the use of Excel 2007 or newer

1) There is a users manual to help navigate this program and it is available at www.stormwater.ucf.edu

2) This spreadsheet is best viewed at 1280 BY 1080 PIXELS screen resolution. If the maximum resolution of your computer screen is lower than 1280 BY 1080 PIXELS you can adjust the view in the Excel VIEW menu by zooming out to value smaller than 100 PERCENT.

3) This spreadsheet has incorporated ERROR MESSAGE WINDOWS. Your analysis is not valid unless ALL ERROR MESSAGE WINDOWS are clear.

4) PRINTING INSTRUCTIONS: Print the page to MICROSOFT OFFICE DOCUMENT IMAGE WRITER (typically the default) or ADOBE PDF, save the page as an image document, then print the document you saved.

5) Click on the button located on the top of this window titled CLICK HERE TO START to begin the analysis.

Disclaimer: These workbooks were created to assist in the analysis of Best Management Practice calculations. All users are responsible for validating the accuracy of the internal calculations. If improvements are noted within this model, please e-mail Marty Wanielista, Ph.D., P.E. at martin.wanielista@ucf.edu with specific information so that revisions can be made.

The authors of this program were Christopher Kuzio, Marty Wanielista, Mike Hardin, and Ikienznima Gogo-Abite. This is version 7.1 of the program, updated on April 8 2014. Comments are appreciated.
BMPTRAINS MODEL COMPARISON TO FIELD COLLECTED DATA

NOTE: average annual removal

<table>
<thead>
<tr>
<th>Percent Removal</th>
<th>TN (Field)</th>
<th>TN (Model)</th>
<th>TP (Field)</th>
<th>TP (Model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pond + Filter</td>
<td>67</td>
<td>66</td>
<td>70</td>
<td>78</td>
</tr>
</tbody>
</table>

Note: Pond input measured TP is of 0.73 mg/L is high and 81% of TP is dissolved.
## Field Data

<table>
<thead>
<tr>
<th>Date</th>
<th>pH</th>
<th>Turbidity</th>
<th>DO</th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pond In</td>
<td>Filter In</td>
<td>Filter Out</td>
<td>Pond In</td>
</tr>
<tr>
<td>3/25</td>
<td>7.14</td>
<td>7.25</td>
<td>7.05</td>
<td>10.5</td>
</tr>
<tr>
<td>4/8</td>
<td>7.20</td>
<td>7.40</td>
<td>7.30</td>
<td>39.0</td>
</tr>
<tr>
<td>4/14</td>
<td>7.15</td>
<td>7.20</td>
<td>7.05</td>
<td>4.40</td>
</tr>
<tr>
<td>4/15</td>
<td>6.90</td>
<td>6.85</td>
<td>6.8</td>
<td>32.5</td>
</tr>
<tr>
<td>4/28</td>
<td>6.76</td>
<td>6.67</td>
<td>6.45</td>
<td></td>
</tr>
<tr>
<td>AVG</td>
<td>7.03</td>
<td>7.07</td>
<td>6.93</td>
<td>21.6</td>
</tr>
</tbody>
</table>

% Change based on pond influent: 86% 89% 7% 89%
% Change due to filter: 18% 88%

**USING 5 SAMPLES:** NOx (mg/L) IN=0.77 OUT=0.025 97% removal
On-Line Filter in an Ultra Urban Area
Kissimmee Florida (DCIA = 0.47 acres)
Designed and Installed by SunTree for the City of Kissimmee

LOW FLOW CONDITIONS

Influent

Trash Collector

Floatable Weir

Effluent

detention

8’x 14’
By 11’ deep

BOLD & GOLD
Sampling Results (estimated 70% of flow through filter)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total Nitrogen</th>
<th>Total Phosphorus</th>
<th>Total Suspended Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Influent Concentration (mg/L)</td>
<td>1.87</td>
<td>0.281</td>
<td>105</td>
</tr>
<tr>
<td>Average Filter Removal (%)</td>
<td>45</td>
<td>58</td>
<td>40</td>
</tr>
<tr>
<td>Average System Removal (%)</td>
<td>67</td>
<td>79</td>
<td>81</td>
</tr>
<tr>
<td>Average Annual Removal (%) (cleaned*)</td>
<td>54</td>
<td>67</td>
<td>70</td>
</tr>
<tr>
<td>Average Annual Removal (%) (upset)</td>
<td>50</td>
<td>59</td>
<td>61</td>
</tr>
</tbody>
</table>

* NOTE: Cleaned (solids pumped) as regular maintenance
Off-Line Ultra Urban Filter
Dunnellon and FDOT (DCIA = 1.5 Ac)
Design by FDOT Deland and CH2M Hill

DIVERSION BOX (SMART)

EXISTING 36 INCH CMP

FIBERGLASS REINFORCED PLASTIC
SEE SHEET 5 FOR DETAILS
FOR MATERIAL SPECIFICATIONS
SEE TECHNICAL PROVISIONS

TO S-2

INTEGRAL 6" REINFORCED CONCRETE WEIR
60 KSI STEEL - AREA 0.50 SF

OFF-LINE FILTER

SECTION

24 inch RCP

Roast and Gold filter treatment media
### Sampling Results and Installation Photos

70% of flow through filter (photo credit: FDOT Ocala)

#### Average Concentration and % Removal

<table>
<thead>
<tr>
<th></th>
<th>TN</th>
<th>TP</th>
<th>TSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration from the Street (mg/L)</td>
<td>2.10</td>
<td>0.360</td>
<td>100</td>
</tr>
<tr>
<td>Concentration to the Filter (mg/L)</td>
<td>1.27</td>
<td>0.180</td>
<td>35</td>
</tr>
<tr>
<td>Concentration from the Filter (mg/L)</td>
<td>0.502</td>
<td>0.098</td>
<td>17</td>
</tr>
<tr>
<td>Average Filter Removal (%)</td>
<td>60</td>
<td>46</td>
<td>51</td>
</tr>
<tr>
<td>Overall Average Removal (%)</td>
<td>76</td>
<td>73</td>
<td>83</td>
</tr>
<tr>
<td>Annual Average Removal (%)</td>
<td>59</td>
<td>63</td>
<td>73</td>
</tr>
</tbody>
</table>

**NOTE:** Not cleaned during sampling period
“Benefits” from using Up-flow filter

• Low cost: 4 yr. replacement time: Construction cost = $10,000/CY and $350/CY for replacement
• Longer operating life of the draw down filtration system relative to the use of side under drains.
• Post=Pre Loadings improvement or compensatory if over treatment targets.
• Effectiveness is part of a treatment train.
• The more water filtered the greater the average annual removal, so in dry periods use the filter, but need a pump system. Also can treat water not in the pond.
Up-flow Inter-event Treatment Options

• Pumped or induced stormwater flow vs. waiting on the storm for treatment
• May operate continuously to remove larger volume mass of TSS and nutrients
• May include multiple treatment units to achieve optimum results
Sarasota County Briarwoods Inter-event Up-flow Filters

- Four 160 LF by 5 FT diameter parallel upflow filters
- 8 Ft Deep anaerobic rock zone
- Integrated wetland treatment
- Two pump stations that continuously treat 2 MGD
Briarwoods Inter-event Up-flow Filters Mass TSS Removaal

**BRIARWOOD LAKES STORMWATER TREATMENT**
**INTER-EVENT TSS REMOVAL ESTIMATES**

<table>
<thead>
<tr>
<th>LBS TSS REMOVED IN 60 DAY SAMPLE PERIOD</th>
<th>TSS MASS REMOVAL</th>
<th>TSS REMOVAL GOAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIMONTHLY PERIOD 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIMONTHLY PERIOD 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIMONTHLY PERIOD 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIMONTHLY PERIOD 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-4,000 -2,000 0 2,000 4,000 6,000 8,000 10,000 12,000
Briarwoods Inter-event Up-flow Filters Mass TN Removals

BRIARWOOD LAKES STORMWATER TREATMENT
INTER-EVENT TN REMOVAL ESTIMATES

LBS TN REMOVED IN 60 DAY SAMPLE PERIOD

BIMONTHLY PERIOD 1
BIMONTHLY PERIOD 2
BIMONTHLY PERIOD 3
BIMONTHLY PERIOD 4

TN MASS REMOVAL
TN REMOVAL GOAL
Briarwoods Inter-event Up-flow Filters Mass TP Removals

BRIARWOOD LAKES STORMWATER TREATMENT
INTER-EVENT TP REMOVAL ESTIMATES

LBS TP REMOVED IN 60 DAY SAMPLE PERIOD

TP MASS REMOVAL
TP REMOVAL GOAL

BIMONTHLY PERIOD 1  BIMONTHLY PERIOD 2  BIMONTHLY PERIOD 3  BIMONTHLY PERIOD 4
Cost Data for Inter-event Treatment

• **Land Cost:** This project used “reclaimed” property. Land value may be considered.

• **Construction Cost:** The final construction cost is estimated at **$1.8 Million** (this includes the filter and wetland treatment, pump stations, and controls).

• **Annual Operations and Maintenance Cost:**

• **Operating Cost per Annual Volume Treated:** Natural and Recycled Materials can be used in the up-flow filter for Nutrient Removal.

• **Projected Life Cycle Cost:**
General Recommendations

• Up-flow filters can re-place under drains.
• Natural and Recycled Materials can be used in up-flow filters for Nutrient Removal.
• Yearly removal or effectiveness has been estimated.
• The media mix should include materials to insure high moisture content. BOLD & GOLD will do the job.
• Consider Inter-event treatment for large mass reductions, where possible.
Up-Flow Filtration for Wet Detention Ponds
Marty Wanielista and Mark flint

Martin.wanielista@ucf.edu  mflint@watermarkengineers.com

Thank You: Discussion and Comments