Pollutant Removal and Maintenance Assessment of Underground Filtration Systems

Todd Shoemaker, PE (MN, IA), CFM
Ali Stone
Surface Sand Filters

- Engineering design & science well understood
- Used for decades in wastewater and stormwater treatment
- Stormwater – poor or contaminated soils
- To be deemed “effective”, the filter must clog
What about here? Where?
Shift to Underground Sand Filter

• Engineers apply design guidelines for surface filters to underground systems
  • Is that appropriate?
  • Similar performance?

• What happens when filter clogs? “Out of sight; out of mind.”

• Intent is to evaluate effectiveness, not point fingers
Generic System Detail

Filtration Volume

Outlet/Overflow

Draintile Outlet

December 17, 2020
Study Goals

• Assess performance

• Pollutant removal
  • Total Suspended Solids
  • Total Phosphorus
  • Total Dissolved Phosphorus
  • Orthophosphate
  • E. coli

• Drawdown time / filtration rate

• Maintenance
  • Has it been maintained?
  • Affecting performance?
Methods

• Four sites
• Pressure transducer to measure water level
• Grab samples
• Six storm events to measure pollutant removal
## Parking Lot Site

### System Description

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year Constructed</strong></td>
<td>2012</td>
</tr>
<tr>
<td><strong>Existing soil</strong></td>
<td>Urban land; likely poor draining soil; possible contamination</td>
</tr>
<tr>
<td><strong>Pretreatment</strong></td>
<td>“Sedimentation” row?</td>
</tr>
<tr>
<td><strong>Drainage Area</strong></td>
<td>1.9 acres</td>
</tr>
<tr>
<td><strong>Storage system</strong></td>
<td>Plastic dome</td>
</tr>
<tr>
<td><strong>Filter media</strong></td>
<td>Clean, washed construction sand</td>
</tr>
</tbody>
</table>

- **100% Impervious**
School Site

System Description

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year Constructed</td>
<td>2018</td>
</tr>
<tr>
<td>Existing soil</td>
<td>Sandy lean clay (HSG D)</td>
</tr>
<tr>
<td>Pretreatment</td>
<td>5’ and 6’ sumps; each with Snout</td>
</tr>
<tr>
<td>Drainage Area</td>
<td>1.7 acres</td>
</tr>
<tr>
<td>Impervious</td>
<td>66% Impervious</td>
</tr>
<tr>
<td>14% parking, 19% roof, 33% playground</td>
<td></td>
</tr>
<tr>
<td>Storage system</td>
<td>Perforated pipe</td>
</tr>
<tr>
<td>Filter media</td>
<td>Clean, washed construction sand with geotextile below sand &amp; drain tile</td>
</tr>
</tbody>
</table>
Office Site

System Description

<table>
<thead>
<tr>
<th>Year Constructed</th>
<th>2016</th>
</tr>
</thead>
</table>
| Existing soil    | Zimmerman fine sand (HSG A)  
                  Braham loamy fine sand (HSG B)  
                  Contamination? |
| Pretreatment     | Upstream BMPs |
| Drainage Area    | 0.92 acres |
| 100% Impervious  |      |
| Storage system   | Perforated pipe |
| Filter media     | Angular, washed 0.75”-2” stone with 30 mil liner below sand & drain tile |
Animal Site

System Description

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Year Constructed</td>
<td>2017</td>
</tr>
<tr>
<td>Existing soil</td>
<td>Urban land / unknown</td>
</tr>
<tr>
<td>Pretreatment</td>
<td>4’ and 5’ sumps</td>
</tr>
<tr>
<td>Drainage Area</td>
<td>2.25 acres</td>
</tr>
<tr>
<td>43% Impervious</td>
<td></td>
</tr>
<tr>
<td>33% roof, 10% pavement</td>
<td></td>
</tr>
<tr>
<td>Storage system</td>
<td>Perforated pipe</td>
</tr>
<tr>
<td>Filter media</td>
<td>Clean, washed construction sand with HDPE liner below sand &amp; draintile</td>
</tr>
</tbody>
</table>
Results

• Storm events
  • Target was ten storm events
  • Measured six storm events
  • Rainfall depths 0.39 to 0.90 inches

• Box plots
  • Pollutant removal
  • Filtration rates
**Total Suspended Solids**

- **Upper hinge**
- **Median**
- **Upper quartile**
- **Lower quartile**
- **Lower hinge**

- **Inlet**
- **Outlet**

- **Parking Lot**
- **School**
- **Office**
- **Animal**

- **74% reduction**
- **29% increase**
- **153% increase**
- **2% reduction**

- **MSM:**
  - 75-90% TSS reduction
  - 5-16 mg/L effluent

**December 17, 2020**
Total Phosphorus

(MSM reports 0.2-0.3 mg/L for runoff concentration)

MSM: 30-55% TP reduction
0.06-0.19 mg/L effluent

- Parking Lot: 0% reduction
- School: 450% increase
- Office: 23% increase
- Animal: 18% reduction

December 17, 2020
Total Dissolved Phosphorus

Reduction not expected but also don’t expect leaching.
Orthophosphate

Removal not expected but also don’t expect leaching.
E. coli

- Parking Lot: 79% reduction
- School: 25% reduction
- Office: 306% increase
- Animal: 90% reduction

MSM: 50% reduction

MN surface water quality standard
Filtration Rates

- Parking Lot (2012)
- Animal (2017)
Good News

- Effluent concentrations for TSS & TP compare favorably with MSM
- E. coli % reduction exceeds MSM value; no evidence of growth within filter media
- 1-inch per hour design filtration rate reasonable (?)
- Maintenance
  - “Oldest” site (2012) = highest TSS removal
  - No significant maintenance issues
  - 2 sites receive regular maintenance inspections
  - No clogging of filter media
Reasons for Concern

• Limited study (4 sites, 6 storms)

• Pollutant reduction
  • TSS and TP lower than expected
  • Some leaching of all parameters
  • Low influent concentrations; need detailed review/parsing of samples

• Fast drawdown / high filtration rate at two sites
• Maintenance access
• Sand washing through draintile?
Recommendations

• Continue study in 2021
  • Target 25 events next year (per 2020 statistical analysis)
  • Private, “big box” sites
  • Refine sample timing

• Designers
  • Educate owners of limitations and maintenance considerations
  • Include draintile as outlet device in model / calculations
  • Human access at inlets, outlets and to bottom of system
  • Consider “layers” of pretreatment instead of just one device
  • Consider MTD instead of sand filter
QUESTIONS?

Responsive partner.
Exceptional outcomes.

tshoemaker@wenck.com
astone@wenck.com