CHALLENGES AND CONSIDERATIONS FOR BMPs IN LINEAR TRANSPORTATION PROJECTS

Michael J. Cook, P.E. Advanced Drainage Systems, Inc.
1. Introduction: BMPs & Linear BMPs
2. Design Challenges: Linear BMPs
3. Design Tools
4. Linear BMP Project Examples
Stormwater Management Goals

• Treat
• Capture / Detain
• Infiltrate
  • Vertical Direction
  • Lateral Direction
• Evapotranspirate
• Reduce volume runoff

SLOW IT DOWN
SPREAD IT OUT
SOAK IT IN
### Table 2

**Structural Post-Construction BMPs & Associated Drain (Drawdown) Times**

<table>
<thead>
<tr>
<th>Best Management Practice</th>
<th>Drain Time of WQv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration Basin or Trench</td>
<td>48 hours</td>
</tr>
<tr>
<td>Permeable Pavement – Infiltration</td>
<td>48 hours</td>
</tr>
<tr>
<td>Permeable Pavement – Extended Detention</td>
<td>24 hours</td>
</tr>
<tr>
<td>Dry Extended Detention Basin</td>
<td>48 hours</td>
</tr>
<tr>
<td>Wet Extended Detention Basin</td>
<td>24 hours</td>
</tr>
<tr>
<td>Constructed Wetland (above permanent pool)</td>
<td>24 hours</td>
</tr>
<tr>
<td>Sand &amp; Other Media Filtration</td>
<td>24 hours</td>
</tr>
<tr>
<td>Bioretention Area/Cell</td>
<td>24 hours</td>
</tr>
<tr>
<td>Pocket Wetland</td>
<td>24 hours</td>
</tr>
</tbody>
</table>
Water Quality and Quantity

- Extended Detention
- Retention Basin
- Bioretention Cell
- Infiltration Trench
- Infiltration Basin
- Constructed Wetlands
Water Quality Only

- Manufactured Systems
- Vegetated Biofilter
- Vegetated Filter Strip

Offline Configuration

ODOT Supplemental Specification 895 and 995
Linear Post-Construction BMPs

- Vegetated Filter Strip
- Shoulder Media Filter Drain
- Infiltration Trench
- Vegetated Biofilter / Swale
- Wetland Channel
Implementing Linear BMPs
Siting Challenges

- Right-of-way limitations
- Land acquisition limitations
- Urban and highly developed sites
- Large volume capture in a limited footprint
- BMP access requirements
- Land availability and cost
- Topography
Implementing Linear BMPs

Other Challenges

• Permitting

• Operation and maintenance requirements

• Public Safety: automobile, bicycle, and pedestrian traffic

• Pollutant considerations

• Alternate BMP selection through variance

• Multiple watersheds

• Public review and scrutiny
Transportation vs. Standard Sites

Greater Average Daily Traffic (ADT) = Greater Runoff Pollutant Load

Roadway sites have more pollutant sources:

- Deicing chemical agents
- Salt
- Sand and grit
- Asphalt
- Hydrocarbons
- Exhaust
- Fuel
- Oils
Highway Runoff Winter Water Quality

Ohio = substantial annual runoff volume from snowmelt

- Chlorides (Cl)
- Solubility of chlorides
- Soil Density
- Grit Loading
- Metals (Ca, Mg, Al)
- Sodium (Na)
Highway Runoff Winter Water Quality

Permeability of soil / media adjacent to the roadway
After the Spring Thaw
Design Challenges: Permitting

- NPDES Phase I & Phase II storm water discharge permits
- NPDES Phase I & II Construction Permits
- Sections 401 and 404 Wetlands Permitting
- Threatened / Endangered species regulations
- Local water quality goals / ordinances
- Total maximum daily load (TMDLs)
- Waste Load Allocations (WLAs)
- Multiple watersheds
Design Challenges: Safety

- **What happens if the BMP is not maintained?**
  - Ponding potential
  - Freezing potential

- **Potential mosquito habitat**
  - Proximity to public / neighborhoods / pedestrian / bicycle

- **Vegetation - Hidden Elevation Change**

- **Operation and Maintenance Procedures**
  - Maintenance Staff
  - Public Safety
Design Challenges: Access and Space

- Consideration for BMP spacing / access requirements early in the Design Phase
  - Conceptual phase
  - Consult manufacturer
  - Site visit to an existing project site application

- Maintenance of Traffic requirements

- Maintenance vehicles – space required beyond vehicle footprint
• **Consideration for BMP O&M requirements early in the Design Phase**
  - Conceptual phase
  - Could affect access and space

• **Understanding of O&M requirements related to space**
  - Size of maintenance vehicles
  - Maintenance of traffic

• **Client knowledge / education**
  - O&M Manual
  - Training
  - Consult manufacturer
  - Interview / site visits

• **Resources for O&M**
  - Staff
  - Equipment
  - Costs
BMP Design Life

• Vegetation maintenance
  • Effects of salt and winter
  • Introduction of unwanted species
  • Prolonged drought
  • Re-planting / reconstruction

• Considerations for future road widening and improvements

• Soil / Engineered media / Stone trench
  • Consolidation over time
  • Grit accumulation
  • Reduced permeability
  • Reduced volume capacity

• Invasive Species
Ohio’s Research Initiative for Locals (ORIL)
BMP research study completed September 2015
# BMP Screening Process

<table>
<thead>
<tr>
<th>Step Titles</th>
<th>Description of tab / step in tool</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start Screen</strong></td>
<td>This tab identifies steps to be completed before using the tool.</td>
</tr>
<tr>
<td><strong>Tool Overview</strong></td>
<td>Refer to this tab for tool background and guidance on how to use the tool, including a legend.</td>
</tr>
<tr>
<td><strong>User Worksheet</strong></td>
<td>(OPTIONAL): Use this tab to document project name, BMP application information, tool user, and tool.</td>
</tr>
<tr>
<td><strong>Detailed BMP Matrix</strong></td>
<td>This tab includes all BMP details for screening. You may reference this at any time, or after screening.</td>
</tr>
</tbody>
</table>
| **Step 1 ->** | Determine Post-Construction Applicability  
Use this tab to determine applicability of post-construction requirements toward your project. |
| **Step 2 ->** | Review List of BMPs Included in Tool  
Use this tab to review the full list of BMPs that are included in this tool before beginning the screening. |
| **Step 3A ->** | Answer Questions for Screening Phase 1  
Use this tab to answer questions for Screening Phase 1, related to BMP methodology. |
| **Step 3B ->** | Review Screening Phase 1 Results  
Use this tab to review the results of Screening Phase 1. |
| **Step 4A ->** | Answer Questions for Screening Phase 2  
Use this tab to answer questions for Screening Phase 2, related to potential site and design. |
| **Step 4B ->** | Review Screening Phase 2 Results  
Use this tab to review the results of Screening Phase 2. |
| **Step 5A ->** | Answer Questions for Screening Phase 3  
Use this tab to answer questions for Screening Phase 3, related to BMP O&M and aesthetics. |
| **Step 5B ->** | Review Screening Phase 3 Results  
Use this tab to review the results of Screening Phase 3. |
| **Step 6 ->** | Review Final BMP List After Screening  
Use this tab to review final screening results for all BMPs, along with summarized O&M and capital cost. |
| **Reference ->** | Water Quality Calculations - ODOT Methodology  
Refer to this tab to perform water quality calculations in accordance with ODOT L&Q Vol 2. |
| **Reference ->** | Water Quality Calculations - General Methodology  
Refer to this tab to perform water quality calculations in accordance with Ohio EPA CIP. |
| **Acronyms and Abbreviations List** | Refer to this tab for definitions of acronyms used in this tool. |
| **Glossary of Terms** | Refer to this tab for definitions of terms used in this tool. |
### Step 1 - Determine Applicability of Post-Construction Requirements

**GUIDANCE:** It is strongly recommended that users complete this step to understand potential project applicability or exemption from post-construction requirements. Please note that this worksheet is intended to facilitate project planning only, and is not intended to provide proof of regulatory exemptions or requirements. If project applicability is uncertain, users are encouraged to confirm applicability or exemptions through review of the permit, ODOT L&D Vol. 2 and local storm water manuals, or consultation with appropriate regulatory agencies.

#### Step 1.1 - Confirm Potential Applicability of State Post-Construction Regulatory Requirements

<table>
<thead>
<tr>
<th>Question</th>
<th>Dropdown Options</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Does any portion of project drain to a separate storm sewer, open channel, or receiving water?</strong></td>
<td>[Yes], [No]</td>
<td>[Yes]</td>
</tr>
<tr>
<td><strong>Is project located within Big Darby Creek watershed or Olentangy River watershed?</strong></td>
<td>[Yes], [No]</td>
<td>[Yes]</td>
</tr>
</tbody>
</table>

**Permit Applicability:**

- Please complete all data entries for this section, if possible.

#### Step 1.2 - Determine Disturbance Area Threshold (in Portions of Project Not Draining to Combined Sewers)

**Enter Project Earth Disturbing Activity (EDA), in acres:**

- Enter value

**Disturbance Area Assessment:**

- Please complete all data entries for this section, if possible.
## Initial BMP List

### Step 2 - Review Initial List of BMPs Included in Tool

**GUIDANCE:** This tab provides an overview of the full list of BMPs included in the tool, before beginning the screening process. The table below provides the full list of BMPs, along with their inclusion in the Ohio EPA CGP and ODOT L&D Vol. 2.

<table>
<thead>
<tr>
<th>Category</th>
<th>Full BMP List</th>
<th>Alias</th>
<th>ODOT L&amp;D Vol. 2 Basis</th>
<th>ODOT L&amp;D Vol. 2 BMP Name</th>
<th>Standard BMP (in Ohio EPA CGP Table 2)</th>
<th>Alternate BMP (Not in Ohio EPA CGP Table 2)</th>
<th>Ohio EPA CGP BMP Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground Systems</td>
<td>Hydrodynamic Separator</td>
<td>Hydrodynamic Device, Vortex Settler</td>
<td>Yes</td>
<td>Manufactured Systems</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Underground Detention and Sedimentation Vault</td>
<td>Subsurface Vault, Underground Detention</td>
<td>Yes</td>
<td>Underground Detention (Extended Detention)</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Modular Manufactured Filtration Systems</td>
<td>Cartridge Filter, Filter Vault, Sand &amp; Other Media Filtration, Fluidized Bed Filter, Upflow Media Filter</td>
<td>No</td>
<td>Manufactured Systems - Note this BMP does not appear on ODOT Qualified Products List</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Multi-Chamber Treatment Train</td>
<td>MCTT, Subsurface Treatment Train</td>
<td>No</td>
<td>Manufactured Systems - Note this BMP does not appear on ODOT Qualified Products List</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Subsurface Bed Filters</td>
<td>Sand &amp; Other Media Filtration, Media Filter Vault, Sand and Organic Filters, Delaware Sand Filter</td>
<td>No</td>
<td>N/A</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Infiltration Gallery</td>
<td>Pipe Gallery, Infiltration Vault</td>
<td>No</td>
<td>N/A</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Subsurface Flow Wetland</td>
<td>Gravel Wetland, Submerged Wetland</td>
<td>No</td>
<td>N/A</td>
<td>No</td>
<td>Yes</td>
<td>N/A</td>
</tr>
</tbody>
</table>
### Step 3A - Answer Questions for Screening Phase 1

**GUIDANCE:** This first screening phase reduces the list of BMPs initially based on the standards being used for BMP selection and design, as well as based on willingness to consider potential alternative BMPs that would require approval from Ohio EPA. Screening is also performed based on the functions that the BMP is required to provide.

#### Step 3A.1 - BMP Selection Basis

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will your project be performing BMP sizing and selection strictly in accordance with ODOT L&amp;D Vol. 2?</td>
<td>(Dropdown) If &quot;Yes,&quot; the BMP list will be limited to those BMPs in ODOT L&amp;D Vol. 2. If unsure, respond &quot;No&quot; or &quot;Unknown&quot; to screen out fewer BMPs.</td>
</tr>
<tr>
<td>If you are not strictly following ODOT L&amp;D Vol. 2, are you required to select and design BMPs in accordance with a local storm water manual?</td>
<td>(Dropdown) If &quot;Yes,&quot; the full set of BMPs will be retained initially, since the available BMPs provided in the local manuals are unknown.</td>
</tr>
<tr>
<td>If you are not strictly following ODOT L&amp;D Vol. 2 or a local storm water manual, are you willing to consider &quot;Alternative BMPs&quot; (i.e. BMPs not pre-approved by Ohio EPA) in your initial review and planning for project BMPs?</td>
<td>(Dropdown) If &quot;No,&quot; the BMP list will be limited to those BMPs listed in Table 2 of the Ohio EPA CGP. If &quot;Yes,&quot; the full set of BMPs will be retained initially. Please note that Alternative BMPs require approval from Ohio EPA to count toward water quality requirements.</td>
</tr>
</tbody>
</table>

**BMP Selection Basis**

Please complete all data entries for this section, if possible.

#### Step 3A.2 - ODOT L&D Vol. 2 Quantity / Quality Control Requirements

If following ODOT L&D Vol. 2, answer the questions below to determine if the BMP must provide quantity control.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will project create one or less acre of new impervious area in the new permanent right-of-way being acquired for the project?</td>
<td>(Dropdown)</td>
</tr>
<tr>
<td>Does project site drain directly to a large river (fourth order or greater, i.e. &gt;100 square mile tributary area to stream) or to a lake and where the development area is less than 5 percent of the watershed area upstream of the development site?</td>
<td>(Dropdown)</td>
</tr>
<tr>
<td>Is project performing redevelopment within an ultra-urban setting (i.e. 100 percent Impervious or the storm water discharge is directed into an existing storm sewer system), without increasing the existing runoff</td>
<td>(Dropdown) If you respond &quot;Yes&quot; to one or more of the three questions to the left, ODOT L&amp;D Vol. 2 requires that BMPs provide only quality control, and BMPs will be screened down to those that are listed as addressing quality in ODOT L&amp;D Vol. 2. If all responses are &quot;No&quot;, BMPs will be screened to those that are listed as addressing both quantity and quality in ODOT L&amp;D Vol. 2.</td>
</tr>
</tbody>
</table>
## Final BMP List

### Step 6 - Review Final BMP List After Screening

**GUIDANCE:** This tab summarizes the final BMP list after three screening phases. BMPs that are listed as “Not Screened Out” under Phase 3 Screening Results meet user-defined criteria in all three phases of screening. If the remaining BMP list is too limiting, users are encouraged to revisit the phases where preferable BMPs were screened out, and confirm user responses to screening questions.

<table>
<thead>
<tr>
<th>Category</th>
<th>BMP Name</th>
<th>BMP Tool Screening Results</th>
<th>O&amp;M Level of effort</th>
<th>Capital Cost Range² (Per Acre Treated)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Phase 1 Screening Results (Steps 3A/3B)</td>
<td>Phase 2 Screening Results (Steps 4A/4B)</td>
<td>Phase 3 Screening Results (Steps 5A/5B)</td>
</tr>
<tr>
<td>Hydrodynamic Separator</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Medium</td>
</tr>
<tr>
<td>Underground Systems</td>
<td>Underground Detention and Sedimentation Vault</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Medium</td>
</tr>
<tr>
<td>Modular Manufactured Filtration Systems</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>High</td>
</tr>
<tr>
<td>Multi-Chamber Treatment Train</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>High</td>
</tr>
<tr>
<td>Subsurface Bed Filters</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>High</td>
</tr>
<tr>
<td>Infiltration Gallery</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Medium</td>
</tr>
<tr>
<td>Subsurface Flow Wetland</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Medium</td>
</tr>
<tr>
<td>Linear Systems</td>
<td>Vegetated Filter Strip</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Shoulder Media Filter Drain</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Infiltration Trench</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Vegetated Biofilter / Swale</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Wetland Channel</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>High</td>
</tr>
<tr>
<td>Basin Systems</td>
<td>Bioretention With Underdrain</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Bioretention Without Underdrain</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Constructed Wetland</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Wet Extended Detention Basin</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Dry Extended Detention Basin</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Infiltration Basin</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Surface Bed Filter</td>
<td>Not Screened Out</td>
<td>Not Screened Out</td>
<td>Medium</td>
</tr>
</tbody>
</table>
### Water Quality Calculations - ODOT Methodology

**GUIDANCE:** This worksheet provides water quality calculation guidance for users that are following the ODOT L&D Vol. 2 post-construction BMP methodology (Section 1115 of ODOT L&D Vol. 2). If not following ODOT L&D Vol. 2 methodology, please use the "WG Calcs-General" tab instead. Before using this tab, please complete Step 1 to confirm the applicability of post-construction requirements. Please refer to Step 3A (Screening Phase 1) to confirm quality and quantity control requirements per the ODOT L&D Vol. 2.

#### Determine Project Treatment Requirements Based on Project EDA

<table>
<thead>
<tr>
<th>Description</th>
<th>Formula</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Earth Disturbing Activity (Project EDA)</td>
<td>Enter value</td>
<td>ac</td>
</tr>
<tr>
<td>Existing Project Area Within the ROW, $A_{\text{existing}}$</td>
<td>Enter value</td>
<td>ac</td>
</tr>
<tr>
<td>Existing Impervious Area, $A_{\text{ix}}$</td>
<td></td>
<td>ac</td>
</tr>
<tr>
<td>New Impervious Area in New Permanent ROW, $A_{\text{in}}$</td>
<td>Enter value</td>
<td>ac</td>
</tr>
<tr>
<td>Final Project Impervious Area ($A_{\text{ix}} + A_{\text{in}}$)</td>
<td></td>
<td>ac</td>
</tr>
<tr>
<td>Required Treatment Percentage, $T% = (20% \times A_{\text{ix}} + 100% \times A_{\text{in}}) / (A_{\text{ix}} + A_{\text{in}})$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area Requiring Treatment (Project EDA x T%)</td>
<td></td>
<td>ac</td>
</tr>
</tbody>
</table>

Determine the area of earth disturbing activity that falls within the project construction limits, as defined in Section 1112.1 of ODOT L&D Vol. 2.

Enter the portion of the Project EDA that falls within the existing ROW.

Per ODOT L&D Vol. 2, the tool assumes 100% of existing ROW is impervious, so $A_{\text{ix}} = A_{\text{existing}}$.

Enter the actual planned impervious area within the new ROW. Do not include grass or other pervious areas. Please note that if this value is greater than 1 acre, quantity control may be required (see Step 3A to confirm quantity/quality control requirements per ODOT L&D Vol. 2).

This is the total impervious area after adding new ROW (existing + proposed impervious).

This is the portion of the Water Quality Volume or Flow that is required to be treated, based on a weighted average of 20% in redevelopment areas and 100% in new development areas.

Per ODOT L&D Vol. 2, Section 1115.7, projects may treat 7% of the WQV or WQF, for 100% of the Project EDA, or treat 100% of the WQV or WQF for the Project EDA. The value at the left represents 7% of the Project EDA, which is the total area that would need to be treated to meet project treatment requirements. Compare this area to the BMP tributary area to determine if the planned BMP meets project treatment requirements, or if a larger tributary area or additional BMPs are required to fully meet project requirements.

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**BMP screening (excel file) available online:**
[https://www.dot.state.oh.us/groups/oril/Pages/BMP-Tool.aspx](https://www.dot.state.oh.us/groups/oril/Pages/BMP-Tool.aspx)
Maximizing Storage in a Small Linear Urban Footprint

Borough of Queens - New York City DOT

Pervious Pavement with Linear Infiltration Chambers
City of Johnstown, Iowa
NW 55th Avenue Improvements

Bioretention – Water Quality

Linear Infiltration Chambers
Shandon Neighborhood
City of Columbia, SC

Extensive Green Roof retrofit
Disconnected downspout into infiltration planter
Intensive Greenroof retrofit

Pervious pavement in driving lanes with storage under pavement
Pervious pavement or pavers in parking lane; pavement width may be reduced

Street tree in infiltration trench 2.5 ft. deep with 4” underdrain tied into stormsewer
Utilities in center lane under water storage media

Curbs with curb cuts directed to street planters (Planter width varies, 3’ minimum)

Awning retrofit cools sidewalk, directs water to permeable pavement
Permeable pavers in crosswalks

Gutters directed into bioretention media along the gutter route
Bioretention media for planting mix

Decentralized Stormwater Controls in Urban Retrofit Streetscape
Shandon Neighborhood
City of Columbia, SC

Linear BMPs – Residential Roadways

- Infiltration Chambers (under pervious pavement)
- Bioretention
- Stone Trench (under pervious pavement)
Linear Extended Detention within the Right-of-Way

City of Windermere, Florida (near Orlando)
Downtown Revitalization Project
Linear BMP Retrofits
CHALLENGES AND CONSIDERATIONS FOR BMPs IN LINEAR TRANSPORTATION PROJECTS

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