MDOT Stormwater BMPs:
The Challenge of Design

Janeen McDermott, PE
Dan DeVaun, PE

June 25, 2018
Outline

- Water Quality Treatment
- Water Quality Treatment Volume Guidelines
- Example Project
- BMP Design Challenges
- Guidance Documents in the Works
- Conclusions
Water Quality Treatment

Performance Criteria:

- WQV: Treat runoff from 90% (non-Exceedance) storm events.
- Channel Protection - maintain runoff volume for 2-yr 24-hr event.

This is accomplished with vegetated swales with check dam enhancements.
Water Quality Treatment Volume Guidelines

Water Quality Treatment Volume
(example: 25 acre application - 75% impervious/25% pervious)

• 2015: $WQV = 1" \times (\text{impervious area}) + 0.25" \times (\text{pervious area})$
• 2016: $WQV = 0.9" \times (\text{impervious + pervious area})$
• 2017: $WQV = [0.9" \times (\text{impervious + pervious area})] \times [0.05 + (0.009 \times (\% \text{ Impervious area})]$

Implications: Varying treatment volumes result in varying sizes of vegetated swales required.
Example Project
I-75 State line to Erie Road

- Full reconstruction including shoulder widening, ramp lengthening, and drainage modifications
  - replacement of small and large culverts
  - new vegetated swales
  - catch basins and storm sewer
BMP Design Challenges

• Limiting ponding depth within the clear zone
  - 2ft maximum water depth otherwise guardrail required
  - at least 1.5ft of freeboard

• Flood conveyance and harmful interference
  - design for a 50-year storm event
  - effects of 100-year event should not pond water onto adjacent properties

• Backwater affects due to check dams
BMP Design Challenges

• ROW limitations
  - grading for large swales could require going past ROW
    -> account for that WQV in other parts of the project
      where there is more space
BMP Design Challenges

- Impacts to wetlands
  - existing swales can often be classified as wetlands
  - impacts are often unavoidable
BMP Design Challenges:

- DEQ Ordinary High water Mark (OHM) for Lake Erie
  - bottom of vegetated swales ideally above OHM
  - can be difficult to achieve in low lying areas
  - impact to underdrains
Snowball Effect

- Changes in BMPs result in changes to:
  - grading plan
  - potentially road design impacts (i.e. guardrail required)
  - upstream/downstream connections (culverts, underdrains, other BMPs)
  - plan sheets
  - permitting (impact to wetlands)
Guidance Documents in the Works

- “MDOT Post-Construction Stormwater BMP Design Guidance”

- Supplemental Manual to Aid in Design of Structural BMPs

- Larger list of BMPs compared to previous Drainage Manual

- More detailed description of designs

- Includes pollutant removal, water quality and channel protection design equations, maintenance procedures, design details, etc.

- Draws from SEMCOG manual and BMP manuals from other states
Guidance Documents in the Works

- BMP Screening Tool
  - Excel-based tool helps designers with the selection of BMPs based on:

  (a) New impervious area
  (b) Site Conditions (soils, urban vs. rural)
  (c) Site Risks Impacting Cost/Constructability (high GW, utilities, ROW, accessibility)
  (d) Water Quality Requirements (TSS, metals, P, N, etc.)
## Post-Construction BMP - Scoping Level Planning Tool

### Does your project need BMPs?

<table>
<thead>
<tr>
<th>Total Disturbed Area</th>
<th>100 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there a TMDL on the project? (Refer to mapping tool)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Project Summary

This section to provide general housekeeping notes for the project.

<table>
<thead>
<tr>
<th>Project Name:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td></td>
</tr>
<tr>
<td>Watershed:</td>
<td></td>
</tr>
<tr>
<td>Additional Notes:</td>
<td></td>
</tr>
</tbody>
</table>

### Site Characteristics

This section asks the user to input characteristics about the site in Column C. For guidance, refer to comments in cells in Column B.

<table>
<thead>
<tr>
<th>Project Area Within The Right of Way</th>
<th>1.0 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Impervious Area (Treatment Area)</td>
<td>1.0 acres</td>
</tr>
<tr>
<td>Existing Impervious Area</td>
<td>0.0 acres</td>
</tr>
<tr>
<td>New Impervious Area</td>
<td>1.0 acres</td>
</tr>
<tr>
<td>Are there existing structural BMPs onsite?</td>
<td></td>
</tr>
<tr>
<td>Hydrologic Soil Group (Refer to mapping tool)</td>
<td></td>
</tr>
<tr>
<td>Urban or Rural?</td>
<td>Urban</td>
</tr>
</tbody>
</table>
## Water Quality Requirements

This section asks the user to input the water quality requirements the project must meet. Water quality requirements based on outfall/stream impairments. Refer to the mapping tool.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS removal</td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td></td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td></td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td></td>
</tr>
<tr>
<td>Petroleum Hydrocarbons</td>
<td></td>
</tr>
<tr>
<td>Bacteria</td>
<td></td>
</tr>
</tbody>
</table>

## Water Quality - Potential BMPs

This section returns the potential BMPs that should be considered in the scoping level analysis to meet water quality standards. BMPs in this section are based upon inputs in site characteristics and water quality requirements.

- Inlet Structural Device - Debris/Sediment/Hydrocarbons (SS)
- Oil Water Separator (SS)
- Underground Detention System (Pipe, Tank/Vault) ($$$$)
- Biofilters (e.g., StormTreat System) ($$$$)
- Bottomless Catch Basin (SS)
- Catch Basin Sump - Deep (SS)
- Delaware Sand Filter (Underground sand filter) ($$$$)
- Infiltration Trench with Perforated Pipe (SSS) (SSS)
- Hydrodynamic Separator (SS)

($$ - Low Cost; $$ - Medium Cost; $$$ - High Cost; $$$$ - Very High Cost)
Water Quality - Scoping Level Cost Estimate

This section asks the user to estimate the risk levels of various conditions. The cost range is a constant value determined by inputs in prior sections. The anticipated cost based on risks value will vary based on the user inputs in this section. The risk level assignment should consider a broad perspective. For example, instead of thinking just about the risk associated with the specific project area, reflect on the risk in relation to similar projects in the state.

<table>
<thead>
<tr>
<th>Risk of</th>
<th>Scoping Level Cost Range</th>
<th>Anticipated Cost Based on Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility Conflicts</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>High Groundwater Table</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Additional ROW Required (If required, must talk to Real Estate)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Additional Site Constraints (wetlands, floodplain, physical structures, archaeology, threatened and endangered species, protected areas)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Accessibility for construction &amp; maintenance</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Soil Conditions (permeability, stability, contamination)</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Legend

[1] = Low Risk

Channel Protection - Potential BMPs & Anticipated Costs

This section returns the potential BMPs that should be considered in the scoping level analysis to meet channel protection standards. There are BMPs that address both Water Quality and Channel Protection including: bioslope, roadside bioswale, roadside infiltration trench, vegetated swale, bioretention, and infiltration basin. If these BMPs are chosen, the costs between water quality and channel protection are not additive.

<table>
<thead>
<tr>
<th>Potential BMPs</th>
<th>Permeable Pavement, Bottomless Catch Basin, Infiltration Trench w/ Perforated Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration Area (Area Needed to Infiltrate New Impervious Area)</td>
<td>0.20 acres</td>
</tr>
<tr>
<td>Scoping Level Cost Range</td>
<td>$5,001.00 - $50,000.00</td>
</tr>
<tr>
<td>Anticipated Cost Based on Risk</td>
<td>$5,001.00</td>
</tr>
</tbody>
</table>
# Project Summary Spreadsheet

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Number:</td>
<td>-</td>
</tr>
<tr>
<td>Calculated By:</td>
<td>-</td>
</tr>
<tr>
<td>Checked By:</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone (Use Figure, Right)</th>
<th>Primary Hydrologic Soil Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Kenton</td>
<td>C</td>
</tr>
</tbody>
</table>

## Removal Efficiency

Are Multiple BMP In Series Being Used on This Project? | NO
Treatment BMP Being Used | Infiltration Basin
Primary BMP Removal Efficiency | 80%

## Impervious Area - Existing

<table>
<thead>
<tr>
<th>Total Impervious Area Existing (acre)</th>
<th>Streets and Roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic Condition, Existing Impervious</td>
<td>Paved, curbs and storm sewer</td>
</tr>
<tr>
<td>Runoff Curve Number for Exist. Imp. (CN)</td>
<td>98</td>
</tr>
</tbody>
</table>

## Impervious Area - Proposed

<table>
<thead>
<tr>
<th>Total Impervious Area Proposed (acre)</th>
<th>Paved parking lot, roof, driveway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic Condition, Proposed Impervious</td>
<td>-</td>
</tr>
<tr>
<td>Runoff Curve Number for Prop. Imp. (CN)</td>
<td>98</td>
</tr>
</tbody>
</table>

## Pervious Area - Existing

<table>
<thead>
<tr>
<th>Total Pervious Area Existing (acre)</th>
<th>Pasture, grassland or range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic Condition, Existing Impervious</td>
<td>Poor</td>
</tr>
<tr>
<td>Runoff Curve Number for Exist. Perv. (CN)</td>
<td>86</td>
</tr>
</tbody>
</table>

## Pervious Area - Proposed

<table>
<thead>
<tr>
<th>Total Pervious Area Proposed (acre)</th>
<th>Farmsteads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic Condition, Proposed Pervious</td>
<td>-</td>
</tr>
<tr>
<td>Runoff Curve Number for Prop. Perv. (CN)</td>
<td>82</td>
</tr>
</tbody>
</table>

## Runoff Curve Number (CN) Existing, Overall Project

| CN Existing, Overall Project | 93.2 |

## Runoff Curve Number (CN) Proposed, Overall Project

| CN Proposed, Overall Project | 94.8 |

## Water Quality Volume Calculation

| Rainfall, 90% Non-Exceedance (P) (inch) | 0.95 |
| Site Percent Impervious (%) | 80% |
| Area weight runoff coefficient (Rw) | 0.77 |
| Runoff (Q) (inch) | 0.73 |

| Water Quality Volume (VWQ) (ft³) | 265,534.50 |

## Channel Protection Volume Calculation

| Rainfall, 2-Year 24 Hour Storm (P) (inch) | 2.39 |
| Runoff, Pre-Development (ft³) | 614,732.81 |
| Runoff, Post-Development (ft³) | 667,242.56 |

| Channel Protection Volume (VCP) (ft³) | 52,509.74 |

Note: If the Water Quality Volume cannot be met for a project, due to various site constraints, utilize the water quality flow. (See discussion in design guidance document). For the catchment areas where treatment is done through water quality flow in the place of water quality volume, subtract these areas from the proposed treatment area such that only the flow.
### Water Quality and Channel Protection Volume Spreadsheet for Vegetated Swales

<table>
<thead>
<tr>
<th>Individual Vegetated Swale Drainage Area Information</th>
<th>Watershed Information (All Calculated)</th>
<th>Time of Concentration Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Pervious Area (ft²) 10,000</td>
<td>C 0.70</td>
<td>Flow Type Sheet Flow Waterway</td>
</tr>
<tr>
<td>Primary Land Cover, Existing Pervious Meadow</td>
<td>Tc [See Right] 38.90</td>
<td>Upstream Elev. 500</td>
</tr>
<tr>
<td>Hydrologic Condition, Existing Pervious</td>
<td></td>
<td>Downstream Elev. 500</td>
</tr>
<tr>
<td>Runoff Curve Number for Exist. Perv. (CN) 71</td>
<td></td>
<td>Slope (ft/ft) 0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Velocity (ft/s) 0.215</td>
</tr>
<tr>
<td>Existing Impervious Area (ft²) 5,000</td>
<td></td>
<td>Tc (hours) 0.65</td>
</tr>
<tr>
<td>Primary Land Cover, Existing Impervious Streets and Roads</td>
<td></td>
<td>Tc, Hours 0.65</td>
</tr>
<tr>
<td>Hydrologic Condition, Existing Impervious Paved, open ditches</td>
<td></td>
<td>Tc, Minutes 38.82</td>
</tr>
<tr>
<td>Runoff Curve Number for Exist. Imp. (CN) 92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposed Pervious Area (ft²) 5,000</td>
<td>Manning's Equation - For Freeboard Calculations</td>
<td></td>
</tr>
<tr>
<td>Primary Land Cover, Prop Pervious Meadow</td>
<td>Q, Rational (ft³/s) 0.61</td>
<td></td>
</tr>
<tr>
<td>Hydrologic Condition, Prop Pervious</td>
<td>Q, Manning's (ft³/s) 2.95</td>
<td></td>
</tr>
<tr>
<td>Runoff Curve Number for Prop. Perv. (CN) 71</td>
<td>V (ft/s) 1.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A (ft²) 1.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>WP (ft) 6.72</td>
<td></td>
</tr>
<tr>
<td>Proposed Impervious Area (ft²) 10,000</td>
<td>Freeboard Calculations</td>
<td></td>
</tr>
<tr>
<td>Primary Land Cover, Proposed Impervious Streets and Roads</td>
<td>Swale Bottom Elev. 821.4</td>
<td></td>
</tr>
<tr>
<td>Hydrologic Condition, Proposed Impervious Paved, open ditches</td>
<td>Shoulder Elevation 823.5</td>
<td></td>
</tr>
<tr>
<td>Runoff Curve Number for Prop. Imp. (CN) 92</td>
<td>ROW Elevation 823.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Freeboard, Road (ft) 1.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Freeboard, ROW (ft) 1.7</td>
<td></td>
</tr>
<tr>
<td>Vegetated Swale Geometry</td>
<td>Storage Requirement, Channel Protection Volume</td>
<td></td>
</tr>
<tr>
<td>Swale Beginning Elevation 826</td>
<td>Swale Storage Volume (ft³) 4,715</td>
<td></td>
</tr>
<tr>
<td>Swale Ending Elevation 813</td>
<td>WOW Required (ft³) 772</td>
<td></td>
</tr>
<tr>
<td>Bottom Width (ft) 4</td>
<td>Percent of Total WOW Treated 1.8%</td>
<td></td>
</tr>
<tr>
<td>Side Slope (horizontal) 4</td>
<td>CPV Required (ft³) 467</td>
<td></td>
</tr>
<tr>
<td>Length of swale (ft) 681</td>
<td>Percent of Total CPV Treated 1%</td>
<td></td>
</tr>
<tr>
<td>Channel Slope (S) (ft/ft) 0.02</td>
<td>Manning's Coefficient 0.05</td>
<td></td>
</tr>
<tr>
<td>Manning's Coefficient 0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check Dam Geometry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fc (ft) 1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Name:</td>
<td>Allignment:</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>Job Number:</td>
<td>Side: LT</td>
<td></td>
</tr>
<tr>
<td>Calculated By:</td>
<td>Beginning Station: 00+00.00</td>
<td></td>
</tr>
<tr>
<td>Checked By:</td>
<td>End Station: 00+00.00</td>
<td></td>
</tr>
</tbody>
</table>

### Individual Rain Garden Drainage Area Information

<table>
<thead>
<tr>
<th>Existing Pervious Area (ft²)</th>
<th>Total Drainage Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,000</td>
<td>53,502</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary Land Cover, Existing Pervious</th>
<th>Rain Garden Bottom Surface Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meadow</td>
<td>10,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydrologic Condition, Existing Pervious</th>
<th>Loading Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paved, open ditches</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Runoff Curve Number for Exist. Perv. (CN)</th>
<th>Loading Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Existing Impervious Area (ft²)</th>
<th>Rain Garden Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>Filter Bed Depth (ft)</td>
</tr>
<tr>
<td>Streets and Roads</td>
<td>4.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary Land Cover, Existing Impervious</th>
<th>Coefficient of Permeability (Filter Media (ft/day))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meadow</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydrologic Condition, Existing Impervious</th>
<th>Average Height Water Above Filter Bed (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paved, open ditches</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Runoff Curve Number for Exist. Imp. (CN)</th>
<th>Rain Garden Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>92</td>
<td></td>
</tr>
</tbody>
</table>

### Required Storage Volume - Water Quality

<table>
<thead>
<tr>
<th>Proposed Pervious Area (ft²)</th>
<th>Water Quality Volume Required (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000</td>
<td>3,668</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary Land Cover, Prop Pervious</th>
<th>Drain Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meadow</td>
<td>1.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydrologic Condition, Prop Pervious</th>
<th>% of Total Water Quality Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paved, open ditches</td>
<td>Required on Project</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Runoff Curve Number for Prop. Perv. (CN)</th>
<th>% of Total Water Quality Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td></td>
</tr>
</tbody>
</table>

### Required Storage Volume - Channel Protection

<table>
<thead>
<tr>
<th>Proposed Impervious Area (ft²)</th>
<th>Channel Protection Volume Required (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48,502</td>
<td>6,011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary Land Cover, Proposed Impervious</th>
<th>Drain Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streets and Roads</td>
<td>2.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hydrologic Condition, Proposed Impervious</th>
<th>% of Total Water Quality Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paved, open ditches</td>
<td>Required on Project</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Runoff Curve Number for Prop. Imp. (CN)</th>
<th>% of Total Water Quality Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>92</td>
<td></td>
</tr>
</tbody>
</table>

### Sediment Forebay Sizing

| Sediment Forebay Size (ft³) | Sediment Forebay Size (ft³) |
|-----------------------------|-----------------------------
| 1,000                       | 1,000                         |

**If a sediment forebay is not feasible, choose an extra deep sump or pre-fabricated, engineered system for pre-treatment.**
### Individual Infiltration Basin Drainage Area Information

| Existing Pervious Area (ft²) | 2,000 |
| Primary Land Cover, Existing Pervious | Woods |
| Hydrologic Condition, Existing Pervious | Fair |
| Runoff Curve Number for Exist. Perv. (CN) | 73 |

| Existing Impervious Area (ft²) | 8,500 |
| Primary Land Cover, Existing Impervious | Streets and Roads |
| Hydrologic Condition, Existing Impervious | Gravel |
| Runoff Curve Number for Exist. Imp. (CN) | 89 |

| Proposed Pervious Area (ft²) | 50 |
| Primary Land Cover, Prop Pervious | Meadow |
| Hydrologic Condition, Prop Pervious | - |
| Runoff Curve Number for Prop. Perv. (CN) | 71 |

| Proposed Impervious Area (ft²) | 450,000 |
| Primary Land Cover, Proposed Impervious | Streets and Roads |
| Hydrologic Condition, Proposed Impervious | Paved, open ditches |
| Runoff Curve Number for Prop. Imp. (CN) | 92 |

### Required Storage Volume - Water Quality

| WQV Required (ft³) | 33,844 |

### Required Storage Volume - Channel Protection

| CPV Required (ft³) | 58,676 |

### Which of the storms should I design for?

Treat for the Channel Protection Design Storm

### Basin Drainage Site Information

| Infiltration Rate (inch/hour) (measured) | 5.00 |
| Desired Drain Time (hours) | 48.00 |
| Manning’s n (-) | 0.05 |

### Pre-Treatment

| Sediment Forebay Volume (ft³) | 880.00 |

**If a sediment forebay is not feasible, choose an extra deep sump or pre-fabricated, engineered system for pre-treatment.**

### Infiltration Basin Geometric Information - Channel Protection Volume

| Maximum Pond Depth (ft) | 10.00 |
| Minimum Surface Area, Basin Bottom (ft²) | 141.02 |
| Bottom Width of Basin (ft) | 8.00 |
| Bottom Length of Basin (ft) | 20.00 |
| Basin Side Slope (H:V) | 4.0 |
| Surface Storage Area (ft²) (CPV) | 8800.00 |
| Bottom Slope of Basin (ft/ft) | 0.001 |

### Freeboard Calculation

| Basin Bottom Elevation | 819 |
| Shoulder Elev. | 831 |
| ROW Elev. | 830.5 |
| Freeboard, Shoulder (ft) | 2.0 |
| Freeboard, ROW (ft) | 1.5 |
Conclusions

• Design of BMPs as part of MDOT projects have unique challenges and have cascading affects on the project as a whole.

• New design tools are forthcoming and will help designers select the best BMPs to meet design guidelines and site constraints.

• Development of these tools and design guidance will take time and be an evolutionary process for MDOT.
Questions??

Thank You!

Janeen.mcdermott@aecom.com
Dan.devaun@aecom.com

June 25, 2018