<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 – 8:30</td>
<td>Overview of Green infrastructure and the Runoff Reduction Method</td>
</tr>
<tr>
<td>8:30 – 9:30</td>
<td>Green Infrastructure Design Steps and GIPs</td>
</tr>
<tr>
<td>9:30 – 9:45</td>
<td>Break</td>
</tr>
<tr>
<td>9:45 – 10:30</td>
<td>Calculation Tool and Simple Example</td>
</tr>
<tr>
<td>10:30 – 11:00</td>
<td>Nashville Site Example</td>
</tr>
</tbody>
</table>
Overview of Green Infrastructure and the Runoff Reduction Method

Andy Reese
AMEC
EPA is saying:

TSS removal is cute… just not powerful enough…
The regulatory goal can be stated as “volume mimicry”

How much rainfall did nature keep from running off?

OK, do that…
“Green Infrastructure”
to the rescue
Green Infrastructure is...

<table>
<thead>
<tr>
<th>Parks</th>
<th>Cisterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking trails</td>
<td>Bioretention</td>
</tr>
<tr>
<td>Open space plans</td>
<td>Tree planters</td>
</tr>
<tr>
<td>Conservation areas</td>
<td>Reforestation</td>
</tr>
<tr>
<td>Urban forests</td>
<td>Infiltration practices</td>
</tr>
<tr>
<td>Water features</td>
<td>Permeable pavement</td>
</tr>
<tr>
<td>Stream preservation</td>
<td>Green roofs</td>
</tr>
<tr>
<td>Recharge zones</td>
<td>Rain gardens</td>
</tr>
</tbody>
</table>
This sort of boils down to:

“For Metro’s program the right volume must be retained on site”
Why should I Retain?

“For Metro’s program...”
Green Infrastructure: What are the drivers?

- TDEC – MS4: Post Construction Water Quality Treatment
- TMDL Regulatory Mandate
- CSO Reduction
- Rainwater Reuse
- Water Supply
- Groundwater Replenishment
- Pollution Removal
- Sustainable Cities
- LEED and other Ratings
MWS MS4 Permit Approach to Green Infrastructure (GI)

- **Currently voluntary**
  - This is a national standard
  - Try things out and learn together
  - Mistakes are not noncompliance

- **Will be mandatory**
  - We will make compliance-based changes and tweaks based on experience
  - We will be ready
Metro’s incentives for the use of GI

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Requirement/Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiver of Plan Review Fees</td>
<td>Certain stormwater and water/sewer plans review and application fees will be waived if GIPs are implemented according to this Volume.</td>
</tr>
<tr>
<td>Stormwater Fee Reduction</td>
<td>The stormwater user fee can be reduced 75% through implementation of the methods provided in the LID Manual.</td>
</tr>
<tr>
<td>Infill Water Quality</td>
<td>Sites within the Infill Boundary will have a runoff reduction credit of 60% (versus 80%).</td>
</tr>
<tr>
<td>Green Roof Credit</td>
<td>Bonus Runoff Reduction percentage above the actual reduction rate has been incorporated into the Green Roof GIP to further encourage the use of green roofs.</td>
</tr>
<tr>
<td>Cisterns</td>
<td>While previously not allowed, in the LID Manual cisterns can be used to meet water quality requirements.</td>
</tr>
<tr>
<td>Reduced Detention Requirement (see Chapter 3.2.5.)</td>
<td>GIPs can reduce the required stormwater detention quantity.</td>
</tr>
</tbody>
</table>

Information on incentives will be updated on the Metro Stormwater LID Manual webpage

How much should I retain?

“…the right volume….”
Why Is Volume Reduction Important?

- **Why Volume**
  - Groundwater recharge, maintain baseflow, reduce bank erosion
  - Volume is surrogate for pollution
  - Volume carries pollutants

- **Controls that remove volume are “golden”**

  - Old way = 40% TSS removal
  - New way = 82% TSS removal also accounts for volume removal
Routing Pollutants to Soil Media

- Studies have shown that with the exception of runoff from highly polluted urban hotspots, groundwater is not contaminated and pollutants are broken down naturally or the concentrations are insufficient to cause pollution problems.

...built and maintained to infiltrate, evapotranspire, harvest and/or use... the stormwater runoff generated at a site by the first inch of every rainfall event preceded by 72 hours of no measurable precipitation... no runoff

Section 4.2.5.2.1
New Standard = Old Standard

1.1 Inches 80+% Efficiency

1.0 Inch 100% Efficiency
A one inch storm reflects *approx.* 80% of the total annual rainfall.
Choice of C Soil as Standard

- 72 hr IEDP Storms
- C Soil with turf demonstrates an ability to capture the first inch of most storms and give an overall Rv of 0.20

![Nashville Rainfall Runoff (C Soil)](image)
Capture values based on national data and the Chesapeake Bay approach, modified by local analysis, and simplified

One single criteria: $R_v \leq 0.20$ is compliance
  - If the site has an $R_v \leq 0.20$ then on average the site captures the first inch of rainfall
  - Structures are designed to capture the right volume to bring about an $R_v \leq 0.20$

So – defining a site with an annual $R_v$ of 0.20 is like saying we will capture one inch
What does “retain” mean and how do I do it?

“...must be retained on site”
“retain” means...

Evapotranspiration (“up”)

Alternate Use (“out”)

Infiltration (“down”)
A three-step process to mimic nature and treat 1"
<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
</tr>
</thead>
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</tr>
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<td>10:30 – 11:00</td>
<td>Nashville Site Example</td>
</tr>
</tbody>
</table>
Green Infrastructure Design Steps and Associated GIPs

Andy Reese
AMEC
40% Directly Connected Impervious Area (DCIA), HSG-C, 2.5 Acres
80% capture vs. 58% capture.
Step 1 – Land Cover Layout

1. Landcover lay out

Goal:
(1) minimize impervious cover and mass site grading
(2) maximize the retention of forest and vegetative cover, natural areas and undisturbed soils; especially those most conducive to landscape-scale infiltration.

Design activities: impervious area minimization, reduced soil disturbance, forest preservation, etc.
Establish Site Weighted Rv

Step 1 - Site Cover Runoff Coefficients

<table>
<thead>
<tr>
<th>Soil Condition</th>
<th>Runoff Coefficient (Rv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impervious Cover</td>
<td>0.95</td>
</tr>
<tr>
<td>Hydrologic Soil Group</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Forest Cover</td>
<td>0.02 0.03 0.04 0.05</td>
</tr>
<tr>
<td>Turf</td>
<td>0.15 0.18 0.20 0.23</td>
</tr>
</tbody>
</table>

\[
Rv = \frac{\text{Runoff}}{\text{Rainfall}} \leq 0.2
\]
Step 1 - Rv Calculation

<table>
<thead>
<tr>
<th>Area</th>
<th>Acres</th>
<th>Rv</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>1</td>
<td>0.95</td>
</tr>
<tr>
<td>Turf C</td>
<td>1.5</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>2.5</strong></td>
<td><strong>0.50</strong></td>
</tr>
</tbody>
</table>

Weighted Rv Goal is to get this $\leq 0.20$
Step 1a & 2 – Intrinsic Green Infrastructure Practices (GIPs)

1. Landcover lay out
2. Intrinsic GIPs

Goal: enhance the ability of the background land cover to reduce runoff volume

Design activities: disconnection of impervious areas (e.g. rooftops) to sheet flow, amended soils, green roofs, and reforestation.
## Step 2 Design Information

### Step 2 - Green Infrastructure Practices

<table>
<thead>
<tr>
<th>Soil Condition</th>
<th>Percent Capture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level 1</td>
</tr>
<tr>
<td>Disconnection – downspout</td>
<td>25</td>
</tr>
<tr>
<td>Grass Channel</td>
<td>10/20</td>
</tr>
<tr>
<td>Disconnection – sheet flow</td>
<td>50</td>
</tr>
<tr>
<td>Reforestation (A, B, C, D soils)</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>92</td>
</tr>
<tr>
<td>Green Roof</td>
<td>80</td>
</tr>
</tbody>
</table>

Percent Capture = 1 - Rv
Step 2 - Rv Calculation

Reforestation and Sheet Flow

New $R_v = 0.322 > 0.20$

Almost there…
If we could sheet flow it all – annual results
Step 3 Structural GIPs

1. Landcover lay out
2. Intrinsic GIPs
3. Structural GIPs

Goal: Use GIPs to attain 1” capture and $R_v \leq 0.20$

Design activities: infiltration trench, bioretention, permeable pavement, cisterns, water quality swales and dry pond.
### Step 3 - Green Infrastructure Practices

<table>
<thead>
<tr>
<th>Soil Condition</th>
<th>Percent Capture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level 1</td>
</tr>
<tr>
<td>Bioretention/Bioinfiltration</td>
<td>60</td>
</tr>
<tr>
<td>Urban Bioretention</td>
<td>60</td>
</tr>
<tr>
<td>Permeable Pavement</td>
<td>45</td>
</tr>
<tr>
<td>Infiltration Trench</td>
<td>50</td>
</tr>
<tr>
<td>Water Quality Swale</td>
<td>40</td>
</tr>
<tr>
<td>Dry Pond (Extended Det.)</td>
<td>0</td>
</tr>
</tbody>
</table>

Percent Capture = 1-Rv

\[
T_v = \frac{PR_v A}{12}
\]
Sizing of Infiltration GIPs

Simplified sizing based on continuous simulation modeling results

CN is reduced for flood control predictions
Can do controls in series
## Design Modifications for Volume

### Table 2. Level 1 and Level 2 Design Summaries

<table>
<thead>
<tr>
<th>Control</th>
<th>Level 1</th>
<th>Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention</td>
<td>C or D soils with Underdrain</td>
<td>Infiltration &gt; 0.5 in/hr or stone sump, 3' media depth, less than 20:1 ratio</td>
</tr>
<tr>
<td>Tree Planter Boxes*</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Permeable Pavement</td>
<td>C or D soils with Underdrain</td>
<td>Infiltration &gt; 0.5 in/hr</td>
</tr>
<tr>
<td>Infiltration</td>
<td>C or D soils with Underdrain</td>
<td>Infiltration &gt; 0.5 in/hr</td>
</tr>
<tr>
<td>Dry Swale</td>
<td>C or D soils with Underdrain</td>
<td>Stone layer or Infiltration &gt; 1.0 in/hr, flat slope</td>
</tr>
<tr>
<td>Grass Channel</td>
<td>C/D soils to A/B soils</td>
<td>Bed of amended soils</td>
</tr>
<tr>
<td>Extended Detention</td>
<td>Lined</td>
<td>Unlined</td>
</tr>
<tr>
<td>Soil Amendment</td>
<td>Downstream from disconnection</td>
<td>Soil surface only</td>
</tr>
<tr>
<td>Disconnection – downspout</td>
<td>To grassy areas C/D soils</td>
<td>To grassy areas A/B soils</td>
</tr>
<tr>
<td>- To amended soils</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>- To rain garden</td>
<td>50</td>
<td>75 with infiltration &gt; 0.5 in/hr</td>
</tr>
<tr>
<td>Disconnection – sheet flow</td>
<td>C or D soils</td>
<td>A or B soils</td>
</tr>
<tr>
<td>Reforestation (A, B, C, D soils)</td>
<td>96</td>
<td>94</td>
</tr>
<tr>
<td>- With amended soils below</td>
<td>98</td>
<td>97</td>
</tr>
<tr>
<td>Rain Tanks/Cisterns</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Green Roof</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Rainwater Tanks/Cisterns

Step 3 - Rv Calculation

Reforestation, Sheet Flow, and Structural GIPs

New Rv = 0.184 < 0.20

You have arrived
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</tr>
<tr>
<td>10:30 – 11:00</td>
<td>Nashville Site Example</td>
</tr>
</tbody>
</table>
Simple Example Site and the Tool

Sara Johnson
AMEC
Runoff Coefficient and Runoff Reduction Credit

\[ R_v \]

### Table 2. Site Cover Runoff Coefficients

<table>
<thead>
<tr>
<th>Soil Condition</th>
<th>Volumetric Runoff Coefficient ( (R_v) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impervious Cover</td>
<td>0.95</td>
</tr>
<tr>
<td>Hydrologic Soil Group</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Forest Cover</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Turf</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>0.23</td>
</tr>
</tbody>
</table>

### Table 3. Green Infrastructure Practices Runoff Reduction Credit Percentages

<table>
<thead>
<tr>
<th>Green Infrastructure Practice</th>
<th>% Rainfall Volume Removed/Captured – RR Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level 1</td>
</tr>
<tr>
<td>1. Bioretention</td>
<td>60</td>
</tr>
<tr>
<td>2. Urban Bioretention</td>
<td>60</td>
</tr>
<tr>
<td>3. Permeable Pavement</td>
<td>45</td>
</tr>
<tr>
<td>4. Infiltration Trench</td>
<td>50</td>
</tr>
<tr>
<td>5. Water Quality Swale</td>
<td>40</td>
</tr>
<tr>
<td>6. Extended Detention</td>
<td>15</td>
</tr>
<tr>
<td>7. Downspout Disconnection*</td>
<td>25</td>
</tr>
<tr>
<td>8. Grass Channel</td>
<td>10/20</td>
</tr>
<tr>
<td>9. Sheet Flow *</td>
<td>50</td>
</tr>
<tr>
<td>10. Reforestation (A, B, C, D soils)</td>
<td>96</td>
</tr>
<tr>
<td>11. Rain Tanks/Cisterns</td>
<td>Design dependant</td>
</tr>
<tr>
<td>12. Green Roof</td>
<td>80</td>
</tr>
</tbody>
</table>
Design Considerations

- What lies beneath the surface on a site?
  - What hydrologic soil group: A, B, C, D
  - Depth to seasonal high water table
  - Depth to bedrock, karst features
  - Infiltration rate
  - Existing infiltration issues on site/in vicinity

- Amended soils
  - Must follow specifications for credit
LID Calculation Tool Preview

- 3 Design Steps
- Rv Weighted Average (site)
- Treatment Volume Calculations
- Easy “What if ____?” scenarios
### MWS Green Infrastructure Site Worksheet

#### Project Name
Sample

#### Parcel Identification #
1234

#### Engineer
John E. Designer

#### Address
Low Impact Designers, 100 Green Street, Nashville, TN, 37206

#### E-mail
john.e.designer@green.com

---

#### Basic Land Use Category

<table>
<thead>
<tr>
<th>Basic Land Use Category</th>
<th>Land Use</th>
<th>Code</th>
<th>Rv</th>
<th>R Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impervious Surface</td>
<td>IA</td>
<td>0.96</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Forest A Soil</td>
<td>FA</td>
<td>0.02</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>Forest B Soil</td>
<td>FB</td>
<td>0.03</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td>Forest C Soil</td>
<td>FC</td>
<td>0.04</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>Forest D Soil</td>
<td>FD</td>
<td>0.05</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>Turf A Soil</td>
<td>TA</td>
<td>0.15</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>Turf B Soil</td>
<td>TB</td>
<td>0.18</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>Turf C Soil</td>
<td>TC</td>
<td>0.2</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Turf D Soil</td>
<td>TD</td>
<td>0.23</td>
<td>0.77</td>
<td></td>
</tr>
</tbody>
</table>

#### Step 1a Modified Land Use

<table>
<thead>
<tr>
<th>Reorestation</th>
<th>Code</th>
<th>Rv</th>
<th>R Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>RA</td>
<td>0.04</td>
<td>0.96</td>
</tr>
<tr>
<td>B</td>
<td>RB</td>
<td>0.06</td>
<td>0.94</td>
</tr>
<tr>
<td>C</td>
<td>RC</td>
<td>0.08</td>
<td>0.92</td>
</tr>
<tr>
<td>D</td>
<td>RD</td>
<td>0.1</td>
<td>0.9</td>
</tr>
<tr>
<td>A Amended</td>
<td>RAA</td>
<td>0.02</td>
<td>0.98</td>
</tr>
<tr>
<td>B Amended</td>
<td>RBA</td>
<td>0.03</td>
<td>0.97</td>
</tr>
<tr>
<td>C Amended</td>
<td>RCA</td>
<td>0.04</td>
<td>0.96</td>
</tr>
<tr>
<td>D Amended</td>
<td>RDA</td>
<td>0.05</td>
<td>0.95</td>
</tr>
<tr>
<td>Green Roof</td>
<td>1 G1</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>2 G2</td>
<td>0.1</td>
<td>0.9</td>
</tr>
</tbody>
</table>

---

#### Step 2 Intrinsic GIPs

<table>
<thead>
<tr>
<th>GI Practice</th>
<th>Level</th>
<th>Code</th>
<th>R Credit</th>
<th>Rv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downspout Disconnection</td>
<td>A/B Soil</td>
<td>DAB</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>C/D Soil</td>
<td>DCD</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Amended</td>
<td>DAS</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

| Sheet Flow | Cons Area A/B | SAB | 0.75 | 0.25|
|           | Cons Area C/D | SCD | 0.5  | 0.5 |
|           | Strip A | SA  | 0.5  | 0.5 |
|           | Strip Amended | SAS | 0.5  | 0.5 |

#### Step 3 & 3a Structural GIPs

| Biorentention/ Rain Garden | 1 B1 | 0.6 | 0.4 |
|                           | 2 B2 | 0.8 | 0.2 |
| Water Quality Swales      | 1 S1 | 0.4 | 0.6 |
|                           | 2 S2 | 0.6 | 0.4 |
| Infiltration Trench       | 1 I1 | 0.5 | 0.5 |
|                           | 2 I2 | 0.9 | 0.1 |
| Urban Bioretention        | 1 UB | 0.4 | 0.6 |
| Dry Pond                  | 2 D1 | 0.15| 0.85|

---

#### Instructions
1. Input cells are in Green
2. Break Site Into Sub areas by single soils and land use type combinations
3. Assign a code to each subarea and input the code into column R
4. Input the subarea drainage area in column S
5. Input treatment credit code (Column U) for the first tier of treatments
6. Input additional treatment code as desired (Column X) for any subarea
7. Adjust until you reach 80% reduction or better (Cell AC34 turns green if 80% reached)
8. If 80% reduction is not reached and it has been decided that GIPs in series is an option use Step 3a to place GIPs in series. Their respective treatment volumes are calculated in column AL. This volume is separate from GIPs upstream.
9. When using GIPs in Series the user will look to Cell AI34 for confirmation the 80% goal has been met.
Percent Volume Reduction-Based Calculations

Step 1: Lay out the site and divide it into sub-areas each of a specific land use type and Rv.

Step 1a: Change any basic land use types through reforesting or green roofs - or through use of open space for a GIP.

Step 2: Treat impervious areas through the use of disconnection or sheet flow.

Step 3: Treat primarily impervious areas with structural GIPs either in series with Step 2 intrinsic GIPs or alone downstream from Steps 1 and 1a land use.

Size controls for Step 3 by assigning structure ID to each sub-area, combining sub-areas into one structure if appropriate.

Step 3a: Treatment in Series Calculation - Place Structural GIPs in same row as upstream GIP.

Size controls for Step 3a in series by assigning a sequential structure ID to each area treated in series.

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Step 3 Tv Total: 4,311

Final Tv Total: 4,311

THIS MUST BE 80% OR GREATER
IT WILL TURN GREEN WHEN IT IS

THIS MUST BE 80% OR GREATER
IT WILL TURN GREEN WHEN IT IS
Example Site

- 1 ac site, B soils

**Table 2. Site Cover Runoff Coefficients**

<table>
<thead>
<tr>
<th>Soil Condition</th>
<th>Volumetric Runoff Coefficient (Rv)</th>
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<tbody>
<tr>
<td>Impervious Cover</td>
<td>0.95</td>
</tr>
<tr>
<td>Hydrologic Soil Group</td>
<td></td>
</tr>
<tr>
<td>Forest Cover</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>Turf</td>
<td>0.15</td>
</tr>
</tbody>
</table>

**Diagram**

1. Parking Lot: Rv = 0.95
2. Forest: Rv = 0.03
3. Turf Grass: Rv = 0.18

A = 0.5 ac
A = 0.2 ac
A = 0.3 ac
Step 1- Basic Land Use

- Site Weighted Rv

\[
\text{Site Weighted Rv} = \frac{\sum (A_i \times Rv_i)}{A_T}
\]

Site Weighted Rv = 0.54 >> 0.20
Step 2 – Intrinsic GIPs

- Sheet Flow \( \frac{1}{2} \) of Parking Lot (IA) to Turf B

\[
A = 0.25 \text{ ac} \\
A = 0.2 \text{ ac} \\
A = 0.3 \text{ ac} \\
A = 0.25 \text{ ac}
\]

Forest
\( Rv = 0.03 \)

Turf Grass
\( Rv = 0.18 \)
Step 2 – Intrinsic GIPs

- Sheet Flow ½ of Parking Lot (IA) to Turf B
  - GIP $R_v = R_v \times (1-RR \text{ Credit})$

Impervious Area
Impervious Area to Sheet Flow
B Soil
Forest B soil
Turf B Soil

$R_v = 0.357 > 0.20$
Step 3 – Structural GIPs

- 0.25 ac → Bioretention Level 2 (80% RR Credit)

![Diagram showing different areas and their corresponding Rv values]

- Parking Lot: A = 0.25 ac, Rv = 0.95
- 1
- 2

- A = 0.2 ac
- 3

- Forest: Rv = 0.03
- 4

- Turf Grass: Rv = 0.18
Step 3 – Structural GIPs

- Send remaining impervious to Bioretention Level 2

**Impervious Area to Bioretention Level 2**

- Impervious Area to Sheet Flow B Soil
- Forest B Soil
- Turf B Soil

\[ R_v = 0.167 < 0.20 \]

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<th>Step 2 Intrinsic GIPs</th>
<th>Step 3 Structural GIPs</th>
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<td>% Removal</td>
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Sizing

- Area 1 – Bioretention Level 2

\[ T_v \text{ ft}^3 = 1.25 \times P(\text{in}) \times R_v \times A(\text{ac}) \times 43560(\text{ft}^2/\text{ac}) \]

\[ 12(\text{in/ft}) \]

\[ T_v = 1078 \text{ ft}^3 \]
GIPs in Series

Table 2. Site Cover Runoff Coefficients

<table>
<thead>
<tr>
<th>Soil Condition</th>
<th>Volumetric Runoff Coefficient (Rv)</th>
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<tbody>
<tr>
<td>Impervious Cover</td>
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<td>Hydrologic Soil Group</td>
<td>A</td>
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<td>Forest Cover</td>
<td>0.02</td>
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<tr>
<td>Turf</td>
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A = 0.5 ac
A = 0.2 ac
A = 0.3 ac

Forest
Rv = 0.03

Turf Grass
Rv = 0.18
Step 1 - Site Weighted Rv

Site Weighted Rv

\[
\text{Site Weighted Rv} = \frac{\sum (A_i \times Rv_i)}{A_T}
\]

Site Weighted Rv = 0.54 >> 0.20
GIPs in Series

- 0.5 ac → Grass Channel Amended B soil → Bioretention Level 1

Diagram:
- Parking Lot: A = 0.95 ac
- Forest: A = 0.3 ac
- Turf Grass: A = 0.2 ac

Legend:
- Forest: Rv = 0.03
- Turf Grass: Rv = 0.18
Grass Channel Amended B soil

- GIP \( R_v = R_v \times (1 - \text{RR Credit}) \);
  \( GIP \; R_v = 0.95 \times (1 - 0.4) = 0.57 \)

Site Weighted \( R_v = 0.345 > 0.20 \)
Add Bioretention in Series

GIP $R_v = R_v^* (1 - RR \text{ Credit}) (1 - RR \text{ Credit})$

GIP $R_v = 0.95 (1 - 0.4)(1 - 0.6) = 0.23$

New Site Weighted $R_v$

$= 0.174 < 0.20$
Sizing

- Grass Channel Amended B Soil
- Bioretention Level 1 – 1035 ft³

\[ T_v \text{ ft}^3 = P_{(in)} \times R_v \times A_{(ac)} \times 43560 \text{ (ft}^2/\text{ac) \div 12 \text{(in/ft)}} \]
Adjusted Curve Number

Flood Control Sizing
Adjusted Curve Number

- Accounts for removal of volume by upstream GIPs
- $\text{CN}_{\text{adj}}$: “effective SCS curve number” < CN
Adjusted Curve Number

- **Step 1.** Calculate Total Runoff for Storm (Q)
  \[ Q = \frac{(P - 0.2 \times S)^2}{(P + 0.8 \times S)} \quad \text{and} \quad S = \frac{1000}{CN} - 10 \]

- **Step 2.** Calculate GIP Capture Volume (Tv)
  \[ T_v = P(CDA)(R_v) \left( \frac{43,560 \text{ ft}^2}{1 \text{ ac}} \right) \left( \frac{1 \text{ ft}}{12 \text{ in}} \right) \]

- **Step 3.** Calculate Adjusted Total Runoff (Q_adj)
  \[ Q_{\text{adj}} = Q - \frac{12 \times T_v}{43,560 \times CDA} \]

- **Step 4.** Calculate Adjusted Curve Number (CN_adj)
  \[ CN_{\text{adj}} = \frac{1000}{10 + 5P + 10Q_{\text{adj}} - 10(Q_{\text{adj}}^2 + 1.25Q_{\text{adj}}P)^{1/2}} \]
**Adjusted Curve Number Example**

- **Step 1**
  - $P_{(100yr)} = 7.53$ in, $CN = 98$
  - $S = \frac{1000}{98} - 10 = 0.20$
  - $Q = 7.30$ in

- **Step 2**
  - $Tv = 1\text{in} \times 0.95 \times 1.5\text{ac} \times \frac{43560}{12} = 5,173 \text{ ft}^3$
Example

- **Step 3**
  - \( Q_{\text{removed}} = \frac{5,173\text{ft}^3 \times 12}{43560 \times 1.5\text{ac}} \)
    - \( = 0.95 \text{ in} \)
  - \( Q_{\text{adj}} = 7.30 - 0.95 = 6.35 \text{ in} \)
Example

- **Step 4**

\[
CN_{adj} = \frac{1000}{10 + 5P + 10Q_{adj} - 10(Q_{adj}^2 + 1.25Q_{adj}P)^{1/2}}
\]

- \(CN_{adj} = 90\)

Parking Lot
CN = 98 → 90
Area = 1.5 Ac

Bioretention Level 1

Detention Pond
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<td>Green Infrastructure Design Steps and GIPs</td>
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<td>9:30 – 9:45</td>
<td>Break</td>
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<td>9:45 – 10:30</td>
<td>Calculation Tool and Simple Example</td>
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<td>10:30 – 11:00</td>
<td>Nashville Site Example</td>
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Nashville Site

Sara Johnson
AMEC
Nashville Site

Site Area = 0.56 ac
100% Impervious
Step 1 – Basic Land Use

- 0.56 Acre Site
- Assume 100% Impervious
- Building Addition and Parking Lot Improvement
Step 1 – Basic Land Use

- 0.56 Acre Site
- Assume 100% Impervious
- Rv = 0.95

**Step 1: Lay out the site and divide it into sub-areas each of a specific land use type and Rv.**

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**Weighted Rv**

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<td>% Removal (Goal ≥80%)</td>
<td>5.0%</td>
</tr>
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</table>
Step 1a – Modify Land Use

- Impervious Area, $A = 0.44$ ac
- Turf C Soil, $A = 0.12$ ac

Site Weighted $R_v = 0.79$

- Step 1a: Change any basic land use types through reforesting or green roofs - or through use of open space for a GIP.

<table>
<thead>
<tr>
<th>Code</th>
<th>Acres</th>
<th>Eff $R_v1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>0.03</td>
<td>0.95</td>
</tr>
<tr>
<td>IA</td>
<td>0.03</td>
<td>0.95</td>
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</tbody>
</table>

Weighted $R_v = 0.789$

Total Area = 0.56

% Removal = 21.1%
Step 2 – Intrinsic GIPs

- Downspout Disconnection of new roof area to C soil

\[ R_v = 0.78 \]

<table>
<thead>
<tr>
<th>Code</th>
<th>Trmt VR1</th>
<th>Eff Rv2</th>
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</thead>
<tbody>
<tr>
<td>DCD</td>
<td>0.25</td>
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</tbody>
</table>

Weighted \( R_v \) = 0.777

% Removal = 22.3%
Step 3 – Structural GIPs

- Permeable Pavement
  – Sub Area 2

- Bioretention
  – Sub Area 1, 3, 4, and 5
Step 3 - Structural GIPs

Site Weighted Rv = 0.19

<table>
<thead>
<tr>
<th>Step 2 Intrinsic GIPs</th>
<th>Step 3 Structural GIPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
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<tr>
<td>Weighted Rv</td>
<td>0.777</td>
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<tr>
<td>% Removal</td>
<td>22.3%</td>
</tr>
</tbody>
</table>
Specifications

- **Permeable Pavement Level 2**
  - 1.1*P
  - No Run-On
  - Soil Infiltration Rate >0.5 in/hr
  - Underdrain not required

- **Bioretention Level 2**
  - 1.25*P
  - CDA < 2.5 acres
  - Media Depth 3-6ft
  - Infiltration Rate > 0.5 in/hr for no underdrain
  - Measures to prevent short circuiting
Sizing

- Permeable Pavement Level 2
  \[ T_v \text{ ft}^3 = 1.1 \times P \times R_v \times A \times 3630 \text{ ft}^3/\text{ac-in} \]

- Bioretention Level 2
  \[ T_v \text{ ft}^3 = 1.25 \times P \times R_v \times A \times 3630 \text{ ft}^3/\text{ac-in} \]
Sizing

- Area 1 – B2 – 97 ft³
- Area 2 – P2 – 114 ft³
- Area 3 – B2 – 647 ft³
- Area 4 – B2 – 603 ft³
- Area 5 – B2 – 647 ft³

Step 3: Treat primarily impervious areas with structural GIPs either in series with Step 2 intrinsic GIPs or alone downstream from Steps 1 and 1e land use.

Size controls for Step 3 by assigning structure ID to each sub-area, combining sub-areas into one structure if appropriate.

<table>
<thead>
<tr>
<th>Step 3 Structural GIPs</th>
<th>Structure ID</th>
<th>IA Capture</th>
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</thead>
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<td>Weighted Rv</td>
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<tr>
<td>% Removal</td>
<td>80.73%</td>
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Step 3 Total: 1,849
- GIPs fit within existing site plan
Drainage Connection

- Tie into existing drainage system
What if…?

- **…a Green Roof considered on the addition?**
  - Site $R_v = 0.19$

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<th>Code</th>
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<th>Base $R_v$</th>
<th>Code</th>
<th>Acres</th>
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<th>Code</th>
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<th>Eff $R_v2$</th>
<th>Code</th>
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<th>Eff $R_v3$</th>
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<tr>
<td>% Removal (Goal ≥80%)</td>
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<td>% Removal</td>
<td>25.6%</td>
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<td></td>
<td>% Removal</td>
<td>25.6%</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Infill Boundary Incentive

- If within the Metro Planning Infill Boundary:
  - Sites with a pre-redevelopment Rv of > 0.4 will have to reach only an Rv of 0.4 (obtain 60% runoff reduction)
  - Sites with a pre-redevelopment Rv ≤ 0.4 will need to reach and Rv of 0.2 (obtain 80% runoff reduction)
# Today’s Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 – 8:30</td>
<td>Overview of Green infrastructure and the Runoff Reduction Method</td>
</tr>
<tr>
<td>8:30 – 9:30</td>
<td>Green Infrastructure Design Steps and GIPs</td>
</tr>
<tr>
<td>9:30 – 9:45</td>
<td>Break</td>
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<tr>
<td>9:45 – 10:15</td>
<td>Calculation Tool and Simple Example</td>
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<tr>
<td>10:15 – 11:00</td>
<td>Nashville Site Example</td>
</tr>
</tbody>
</table>