To: Brandi Lubliner, RSMP/SAM Coordinator  
From: Alex Taylor, WSU Puyallup Graduate Research Assistant  
Date: April 21, 2017

Subject: Interim Report for Task 2: Bioretention soil preparation

We prepared a bioretention soil mix (BSM) at the Washington State University (WSU) facility in Puyallup. The BSM materials (sand and compost) were tested separately for concentration of metals.

**Deliverable 2.1 = 2 m³ of well characterized bioretention soil media**

The composition of the bioretention soil mix (BSM) was prepared to be the default bioretention soil mix: a 60% sand/40% compost (by volume) mix according to the current Stormwater Management Manual for Western Washington (SMMWW) specifications. Two cubic meters of compost and two cubic meters of sand were generously donated by Cedar Grove Composting, Inc. in August 2016. The product specification sheets provided by Cedar Grove documented that the material met specifications set forth in the Stormwater Management Manual for Western Washington (see Appendices 1 & 2).

Prior to mixing the sand and compost into the BSM, composite samples of compost and sand were collected separately by subsampling 10 locations at various depths throughout each two-yard pile. Subsamples were homogenized and three representative samples isolated for analysis. Sand and compost samples were submitted in triplicate to AmTest Laboratories (Kirkland, WA) for quantification of metals.

To achieve a well-mixed BSM, small batches of BSM were made and later used to fill the experimental drums. Each batch was made of an un-compacted volume of sand (15 L) and compost (10 L). Compost was sifted through a ½ inch screen (100% passing) to break up clods and achieve a relatively even compost density prior to volumetric proportioning. Sand and compost were proportioned by volume in 5-L increments and the wet weight for each increment was recorded. Each volume of sand or compost was randomly collected from the sand or compost pile. A composite sample was collected from each 25-L batch for moisture analysis. Samples for moisture content assessment were collected from the sand and compost fractions between every fifth batch. These measurements provided the data necessary to calculate the dry mass of sand and dry mass of compost in each 25-L batch. In total, 89 individual batches (25 L and 29.0 ± 1.2 kg (wet)) were prepared. This data was used later to proportion BSM in each of twelve field bioretention cells by total dry mass. Details of BSM composition are provided in Table 1.
**Deliverable 2.2 = Report on chemistry of bioretention soil materials**

Sand and compost samples were collected as previously described and were submitted in triplicate to AmTest Laboratories (Kirkland, WA) for quantification of metals by ICP-MS according to method SW-846 6020A. Compost was additionally sent to SoilTest Farm Consultants, Inc. (Moses Lake, WA) for analysis of total nitrogen (ASTM D5373), total carbon (ASTM D5373), nitrate (S-3.10 b), ammonia (S-3.50), total phosphorus (EPA 3050A/6010B), Olsen phosphorus (S-4.20 b), cation exchange capacity (S-10.10 b), and pH. Details of these analyses are provided in Table 2 and Table 3.

The compost contained higher dry-mass concentrations than the sand for all metals except Ni (Table 3). However, the composition of “60:40” BSM on a dry-mass basis is approximately 84% sand and 16% compost. Ultimately, the leachability of these two components of BSM will determine the contribution of each metal to effluents treated by the bioretention system.
### Table 1: Composition characteristics of BSM batches proportioned by volume

<table>
<thead>
<tr>
<th></th>
<th>Gravimetric Moisture Content (%)</th>
<th>BSM Wet Mass (kg)</th>
<th>BSM Dry Mass (kg)</th>
<th>Sand Dry Mass (kg)</th>
<th>Compost Dry Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>2554.49</td>
<td>2132.31</td>
<td>1840.45</td>
<td>297.86</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td></td>
<td>19.82</td>
<td>29.03</td>
<td>24.23</td>
<td>20.91</td>
</tr>
<tr>
<td><strong>St. Dev.</strong></td>
<td></td>
<td>3.01</td>
<td>1.23</td>
<td>0.93</td>
<td>1.02</td>
</tr>
</tbody>
</table>

### Table 2: Chemical characteristics of compost and sand used in BSM

<table>
<thead>
<tr>
<th></th>
<th>Total N</th>
<th>Total C</th>
<th>NO3-N</th>
<th>NH4-N</th>
<th>Total P</th>
<th>OLSEN P</th>
<th>CEC</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>%</td>
<td>%</td>
<td>mg/kg</td>
<td>mg/kg</td>
<td>mg/kg</td>
<td>mg/kg</td>
<td>meq/100g</td>
<td></td>
</tr>
<tr>
<td><strong>D.L.</strong></td>
<td>0.01%</td>
<td>0.02%</td>
<td>0.8</td>
<td>0.7</td>
<td>4.3</td>
<td>0.9</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>1.5</td>
<td>18</td>
<td>233</td>
<td>38</td>
<td>2559</td>
<td>135</td>
<td>40</td>
<td>7.4</td>
</tr>
<tr>
<td><strong>St. Dev.</strong></td>
<td>0.1</td>
<td>2</td>
<td>58</td>
<td>11</td>
<td>51</td>
<td>24</td>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>RSD (%)</strong></td>
<td>6.9%</td>
<td>8.6%</td>
<td>25%</td>
<td>28%</td>
<td>2%</td>
<td>17%</td>
<td>6%</td>
<td>1%</td>
</tr>
</tbody>
</table>

D.L. = detection limit; RSD = relative standard deviation

### Table 3: Metal concentrations of compost and sand used in BSM

<table>
<thead>
<tr>
<th></th>
<th>As</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compost</strong></td>
<td>All values in mg/kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D.L.</strong></td>
<td>0.052</td>
<td>0.043</td>
<td>0.086</td>
<td>0.086</td>
<td>0.086</td>
<td>0.086</td>
<td>0.172</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>7.95</td>
<td>0.459</td>
<td>16.6</td>
<td>39.9</td>
<td>11.3</td>
<td>35.7</td>
<td>148</td>
</tr>
<tr>
<td><strong>St. Dev.</strong></td>
<td>4.64</td>
<td>0.045</td>
<td>1.69</td>
<td>8.21</td>
<td>1.08</td>
<td>7.06</td>
<td>34.9</td>
</tr>
<tr>
<td><strong>RSD (%)</strong></td>
<td>58.3%</td>
<td>9.88%</td>
<td>10.1%</td>
<td>20.6%</td>
<td>9.52%</td>
<td>19.8%</td>
<td>23.6%</td>
</tr>
</tbody>
</table>

|                | All values in mg/kg |        |        |        |        |        |       |
| **Sand**       | D.L.     | 0.025  | 0.021  | 0.043  | 0.043  | 0.043  | 0.043  | 0.085 |
| **Mean**       | 0.535   | 0.051  | 14.2   | 16.0   | 17.4   | 1.18   | 17.4  |
| **St. Dev.**   | 0.161   | 0.021  | 4.730  | 1.332  | 3.292  | 0.300  | 0.907 |
| **RSD (%)**    | 30.0%   | 41.2%  | 33.2%  | 8.34%  | 18.9%  | 25.4%  | 5.20% |

D.L. = detection limit; RSD = relative standard deviation
Appendix 1: Cedar Grove compost certificate of analysis

Cedar Grove Composting
Compost Quality Assurance Program 2016

Cedar Grove Fine Grade Compost

Cedar Grove Compost is made from 100% locally recycled landscape and food trimmings, and clean wood waste. Cedar Grove Compost facilities are in compliance with Washington Department of Ecology (WDOE) requirements for compost process and product quality (WAC 173-350-220). Cedar Grove also voluntarily meets the US Composting Council’s Seal of Testing Assurance (STA) and Washington Department of Transportation (WDOT) standards. Results of tests for horticultural values and applicable WDOT standards are shown in Chart 1. WDOE compost quality requirements and Cedar Grove Compost results are in Chart 2.

Chart 1. Cedar Grove Fine Grade Compost Horticultural Values

<table>
<thead>
<tr>
<th>Property</th>
<th>WDOT Standard</th>
<th>Cedar Grove (2/8/2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter</td>
<td>&gt;40%</td>
<td>59.34%</td>
</tr>
<tr>
<td>Carbon to Nitrogen Ratio</td>
<td>&lt;2 electronic</td>
<td>19</td>
</tr>
<tr>
<td>Conductivity</td>
<td>≤4 mhos/cm</td>
<td>3.4 mhos/cm</td>
</tr>
<tr>
<td>Seedling Emergence</td>
<td>&gt;80% of purified water</td>
<td>100%</td>
</tr>
<tr>
<td>Seedling Vigor</td>
<td>&gt;80% of purified water</td>
<td>106% “Healthy”</td>
</tr>
<tr>
<td>pH</td>
<td>6.0-8.5</td>
<td>8.25</td>
</tr>
<tr>
<td>Compost Stability</td>
<td>&lt;7 mg CO₂/  gr. OM/day</td>
<td>3.5 mg CO₂/  gr. OM/day “Stable”</td>
</tr>
<tr>
<td>Dry weight</td>
<td>19 lbs/ cu. ft.</td>
<td></td>
</tr>
</tbody>
</table>

Major Nutrients

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>WDOT Standard</th>
<th>Cedar Grove (2/5/2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Nutrients</td>
<td>Total Nitrogen</td>
<td>1.9%</td>
</tr>
<tr>
<td>Phosphorous (P₂O₅)</td>
<td>7.4%</td>
<td></td>
</tr>
<tr>
<td>Potassium (K₂O)</td>
<td>7.9%</td>
<td></td>
</tr>
<tr>
<td>Sulfate</td>
<td>16 kg/ha</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>2.9%</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.31%</td>
<td></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Property</th>
<th>WDOT Standard</th>
<th>Cedar Grove (2/5/2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Parts per million (mg/kg), dry wt.</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>≤20</td>
<td>7.9</td>
</tr>
<tr>
<td>Cadmium</td>
<td>≤10</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Copper</td>
<td>≤750</td>
<td>61</td>
</tr>
<tr>
<td>Lead</td>
<td>≤150</td>
<td>29</td>
</tr>
<tr>
<td>Mercury</td>
<td>≤8</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>≤9</td>
<td>1.4</td>
</tr>
<tr>
<td>Nickel</td>
<td>≤210</td>
<td>15</td>
</tr>
<tr>
<td>Selenium</td>
<td>≤18</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>≤1400</td>
<td>160</td>
</tr>
<tr>
<td>pH</td>
<td>5-10 (range)</td>
<td>8.25</td>
</tr>
<tr>
<td>Salmonella (Pathogen indicator)</td>
<td>&lt; 3 MPN / 4 grams of total solids</td>
<td>Pass</td>
</tr>
<tr>
<td>Sharps</td>
<td>0 percent</td>
<td>None Detected</td>
</tr>
<tr>
<td>Manufactured Insects</td>
<td>&lt; 0.5 percent</td>
<td>&lt;0.1 percent</td>
</tr>
</tbody>
</table>

Chart 3. WDOT Particle Size Specifications by Compost Grade

<table>
<thead>
<tr>
<th>Sieve size</th>
<th>WDOT “Fine” Compost</th>
<th>Cedar Grove (2/5/2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1”</td>
<td>95-100%</td>
<td>100%</td>
</tr>
<tr>
<td>5/8”</td>
<td>90-100%</td>
<td>100%</td>
</tr>
<tr>
<td>¾”</td>
<td>75-100%</td>
<td>75%</td>
</tr>
</tbody>
</table>

All tests performed by Soil Control Lab, Watsonville, CA; using TMECC/STA specified methods.
### GRAIN SIZE ANALYSIS - MECHANICAL ASTM D422

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Project Number</th>
<th>Date Sampled</th>
<th>Date Tested</th>
<th>Tested By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar Grove</td>
<td>KE140069A</td>
<td>5/12/2016</td>
<td>5/17/2016</td>
<td>MS</td>
</tr>
<tr>
<td>Sample Source</td>
<td>Sample No. 756255</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar Grove</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Sample Dry Wt. (g)</td>
<td>596.1</td>
<td>Moisture Content (%)</td>
<td>4</td>
<td>D_{50} (mm)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sieve No.</th>
<th>Diam. (mm)</th>
<th>Cum. Wt. Ret. (g)</th>
<th>% Ret. by Wt.</th>
<th>% Passing by Wt.</th>
<th>% Specs. Pass. by Wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>76.1</td>
<td></td>
<td>0.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>64</td>
<td></td>
<td>0.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>50.8</td>
<td></td>
<td>0.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>38.1</td>
<td></td>
<td>0.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>25.4</td>
<td></td>
<td>0.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>19</td>
<td></td>
<td>0.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>3/8</td>
<td>9.51</td>
<td></td>
<td>0.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>4.76</td>
<td>2.3</td>
<td>0.4</td>
<td>99.6</td>
<td></td>
</tr>
<tr>
<td>#8</td>
<td>2.38</td>
<td>82.8</td>
<td>13.9</td>
<td>86.1</td>
<td></td>
</tr>
<tr>
<td>#10</td>
<td>2</td>
<td>112.1</td>
<td>18.8</td>
<td>81.2</td>
<td></td>
</tr>
<tr>
<td>#20</td>
<td>0.85</td>
<td>273.4</td>
<td>45.9</td>
<td>54.1</td>
<td></td>
</tr>
<tr>
<td>#40</td>
<td>0.42</td>
<td>428.2</td>
<td>71.8</td>
<td>28.2</td>
<td></td>
</tr>
<tr>
<td>#60</td>
<td>0.25</td>
<td>524.0</td>
<td>87.9</td>
<td>12.1</td>
<td></td>
</tr>
<tr>
<td>#100</td>
<td>0.149</td>
<td>565.7</td>
<td>94.9</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>#200</td>
<td>0.074</td>
<td>584.6</td>
<td>98.1</td>
<td>1.9</td>
<td></td>
</tr>
</tbody>
</table>

**Soil Description:** SAND, trace silt, trace gravel (SP)

**Reference Specification:**

---

Appendix 2: Cedar Grove sand certificate of analysis