O&M Maintenance Package

- O&M Maintenance Package
  1. Landscape Maintenance Manual
  2. NDS/LID Maintenance Manual for ROW
  3. Identifiable and detailed levels of service
  4. Porous Pavement
  5. O&M Facility Checklists
  6. Key Performance Indicators
  7. O&M Estimating Database Tool

- Life Cycle Costs
- Risks
Homeowners Landscape Manual

- Landscape Maintenance Manual
- Maintenance personnel
- Homeowners living adjacent to systems
NDS Manual Sections

- Inspection/Checklist and Recommended Maintenance Activities
  1. Vegetation and Landscaping
  2. System Functionality
  3. Hardscape and Infra-Structure
  4. Infiltration Failure – Swale Ponding
  5. Porous Pavement
  6. Recommended Maintenance for Other Elements
  7. Safety, Mobility, and Accessibility
Maintenance Manual

- Summary
  - Routine maintenance activities
  - Non-routine maintenance activities
  - Inspection/checklist
  - Scheduling and performing maintenance activities in the ROW
  - Images and descriptions
Levels of Service (LOS)

- LOS A
  - Excellent effort
- LOS B
  - Good effort
- LOS C
  - Moderate effort
- LOS D
  - Poor effort
Layout and How To

- Select the desired Service Level for maintenance

<table>
<thead>
<tr>
<th>Service Category</th>
<th>Service Level B (Great Effort)</th>
<th>Service Level C (Moderate Effort)</th>
<th>Service Level D (Low Effort)</th>
<th>Recommended Maintenance Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>HARDSCAPE &amp; INFRA-STRUCTURE</td>
<td>Summary</td>
<td>Summary</td>
<td>Summary</td>
<td>Summary</td>
</tr>
<tr>
<td></td>
<td>- Sediment is minimal</td>
<td>- Some sediment is present</td>
<td>- Lots of sediment buildup is observed</td>
<td>- Sediment is blocking 10% of structure</td>
</tr>
<tr>
<td></td>
<td>- Infrastructure is always accessible</td>
<td>- Infrastructure is usually accessible</td>
<td>- Infrastructure is mostly inaccessible</td>
<td>- Sediment is blocking 20% of structure</td>
</tr>
<tr>
<td>Sedimentation structures—TYPE 2</td>
<td>- No competition between roots and pipes</td>
<td>- Small amounts of trash are present</td>
<td>- Significant competition between roots and pipes</td>
<td>- If sediment present, remove trash and unwanted organic debris</td>
</tr>
<tr>
<td></td>
<td>- No trash is present</td>
<td>- Moderate accumulation of organic debris on grates or screens</td>
<td>- Trash is present</td>
<td>- Muck out/vacate structure and dispose of waste properly</td>
</tr>
<tr>
<td></td>
<td>- Small accumulation of organic debris on grates or screens</td>
<td>- Occasional large sediment deposits behind check dams or log weirs</td>
<td>- Heavy accumulations of organic debris on grates or screens</td>
<td>- Sediment is blocking 30% of structure</td>
</tr>
<tr>
<td></td>
<td>- Limited buildup of sediment behind check dams or log weirs</td>
<td>- Minimal erosion and/or undercutting surrounding weir walls</td>
<td>- Frequent large sediment deposits behind check dams or log weirs</td>
<td>- Sediment is blocking 40% of structure</td>
</tr>
<tr>
<td></td>
<td>- No erosion or undercutting surrounding weir walls</td>
<td>- Occasional loose rocks, walls are secure</td>
<td>- Erosion and/or undercutting surrounding weir walls</td>
<td>- Sediment is blocking 50% of structure</td>
</tr>
<tr>
<td></td>
<td>- Nocturnal and walls are stable and secure</td>
<td>- Stormwater sedimentation structures less than 1/2 full (NPDES)</td>
<td>- Loose rocks; walls are not secure</td>
<td>- Sediment is blocking 60% of structure</td>
</tr>
<tr>
<td></td>
<td>- Stormwater sedimentation structures less than 1/2 full (NPDES)</td>
<td></td>
<td>- Stormwater sedimentation structures less than 1/2 full (NPDES)</td>
<td></td>
</tr>
</tbody>
</table>
Ease of Use

<table>
<thead>
<tr>
<th>Service Category</th>
<th>Service Level A (Excellent Effort)</th>
<th>Service Level B (Good Effort)</th>
<th>Service Level C (Moderate Effort)</th>
<th>Service Level D (Poor Effort)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• No erosion, channelization or scouring</td>
<td>• Some erosion, channelization or scouring</td>
<td>• The presence of long-term ponding (&gt; 72 hours)</td>
<td>• The presence of long-term ponding (&gt; 72 hours)</td>
</tr>
<tr>
<td></td>
<td>• Water drains within 24 hours</td>
<td>• Most water drains within 24 hours, minimal long-term ponding</td>
<td>• Many bare spots</td>
<td>• Many bare spots or noxious weeds/grass</td>
</tr>
<tr>
<td></td>
<td>• Minimal bare spots</td>
<td>• A few bare spots</td>
<td>• Significant build up of sediment or debris</td>
<td>• Significant build up of sediment or debris</td>
</tr>
<tr>
<td></td>
<td>• Acceptable level of sediment or debris accumulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swale bottom vegetation</td>
<td><img src="image1" alt="Swale bottom vegetation A" /></td>
<td><img src="image2" alt="Swale bottom vegetation B" /></td>
<td><img src="image3" alt="Swale bottom vegetation C" /></td>
<td><img src="image4" alt="Swale bottom vegetation D" /></td>
</tr>
<tr>
<td>Sediment or debris accumulation</td>
<td><img src="image5" alt="Sediment or debris accumulation A" /></td>
<td><img src="image6" alt="Sediment or debris accumulation B" /></td>
<td><img src="image7" alt="Sediment or debris accumulation C" /></td>
<td><img src="image8" alt="Sediment or debris accumulation D" /></td>
</tr>
<tr>
<td>Conveyance</td>
<td>• Healthy vegetation</td>
<td>• Mostly healthy vegetation</td>
<td>• Some vegetation</td>
<td>• Poor or no vegetation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1-Vegetation and Landscape Maintenance

- Inspection/checklist
- Bio-retention swales are mostly self sustaining
- Maintenance for functionality after establishment period

Level of Service B – Good Effort
1-Vegetation and Landscape Maintenance

- Inspection/ checklist
- Vegetation is mostly healthy
- Good appearance
- Small quantities of weeds
- Edges are loosely defined
- Grass encroaching on the swale (or vice versa)

Levels of Service B - Good
Levels of Service B - Good

- Inspection/ checklist
  - Plants growing onto the street or sidewalk
  - Mulch is present with occasional bare spots
  - Erosion is likely unless maintenance is improved
  - Some shoulder compaction adjacent to the swale
  - Plant palette is mostly working for the facility
Noxious and Nuisance Weeds

- Special considerations need to be identified
- Provide link to jurisdiction’s web site
- Photos
- Identification key
- Reporting requirements – *if applicable*
3-Hardscape and Infra-Structure

- Debris and sediment removal
- Clearing and cleaning
Inspection LOS D - Poor effort

- Inspection/checklist
- Sediment is significant
- Infrastructure is mostly inaccessible
- Trash is present
- Significant competition between roots and any pipes

Viewlands Cascade
Hardscape and Infra-Structure – Long Term Maintenance

- Every fifteen years
- Remove and replace top two inches of sediment
- Prevent swale clogging
- Maintains infiltration rates
All Levels of Service

- Stormwater sedimentation structures are less than ½ full or in accordance with NPDES requirements
4-Infiltration Failure

- Evidence of a cell holding water for more than 24 hours needs to be reported
- Operations and Maintenance Asset Manager
- Monitor swale for ponding water
- Retrofit swale
Porous Pavement

- SPU porous pavement spec
- Inspector and installer checklists
- BMP’s
- Levels of services
- Frequency/schedule
- Standardized infiltration testing
- Recommended maintenance activities
- Paper available
<table>
<thead>
<tr>
<th>Combinations Treatments</th>
<th>Pre Cleaning Infiltration Rate (in/ hr)</th>
<th>Post Cleaning Infiltration Rate (in/ hr)</th>
<th>Improved Infiltration %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Blower/ Pressure Washer/ Street Sweeper</td>
<td>0.75</td>
<td>5.3</td>
<td>85.8</td>
</tr>
<tr>
<td>Leaf Blower/ Pressure Washer</td>
<td>2.25</td>
<td>41.5</td>
<td>94.6</td>
</tr>
<tr>
<td>Pressure Washer/ Vacuum</td>
<td>0.75</td>
<td>208.9</td>
<td>99.6</td>
</tr>
<tr>
<td>SPU Vactor Truck Pressure Washer/ SDOT Pressure Washer</td>
<td>0</td>
<td>16.5</td>
<td>100.0</td>
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</tbody>
</table>
Performance Checklists

- Condensed version of manual
- Developed for each section of the manual
- Reduce maintenance activities to a summary
- Eliminate photos
- Identify key performance indicators
  - monitoring and reporting
Key Performance Indicators (KPI’s)

- Determine LOS achieved for swales
- Provides an overall reporting score for high level management
- Indicators help identify
  - successes
  - areas of improvement
  - failures for each system
## NDS KPI Reporting Form
### USM Urban Watersheds

<table>
<thead>
<tr>
<th>Project Location</th>
<th>Drainage area (sq ft)</th>
<th>Hardscape maintained to:</th>
<th>Vegetation maintained to:</th>
<th>Infiltration Failure</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Target</td>
<td>Actual</td>
<td>Target</td>
<td>Actual</td>
</tr>
<tr>
<td>Carkeek Cascade at NW 110th</td>
<td>4,730</td>
<td>B</td>
<td>17,130</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Achievement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadview Green Grid - Carkeek Cascades at NW107th</td>
<td>8,240</td>
<td>B</td>
<td>29,330</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Achievement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinheur St Green Grid</td>
<td>16,941</td>
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<td>50,000</td>
<td>B</td>
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<tr>
<td>10th Avenue NE</td>
<td>3,170</td>
<td>B</td>
<td>16,850</td>
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<td>20th Avenue NE</td>
<td>5,396</td>
<td>B</td>
<td>17,830</td>
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<tr>
<td>23rd Avenue NE</td>
<td>5,710</td>
<td>B</td>
<td>18,100</td>
<td>B</td>
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<td>NE 117th Street</td>
<td>2,240</td>
<td>B</td>
<td>6,420</td>
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<tr>
<td>NE 113th Street</td>
<td>2,320</td>
<td>B</td>
<td>7,870</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>26th Ave NE</td>
<td>330</td>
<td>B</td>
<td>??</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Achievement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Point</td>
<td>B</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Comments</td>
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<tr>
<td>Project Achievement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadview Green Grid - SEA Streets</td>
<td>8,470</td>
<td>B</td>
<td>63,040</td>
<td>B</td>
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<tr>
<td>Pinney Ave N SEA Street</td>
<td>2,000</td>
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<td>16,700</td>
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<td>Palatine Ave N SEA Street</td>
<td>9,840</td>
<td>B</td>
<td>18,960</td>
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<td>1st Ave NW SEA Street</td>
<td>2,040</td>
<td>B</td>
<td>12,130</td>
<td>B</td>
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</tr>
<tr>
<td>2nd Ave NW SEA Street</td>
<td>2,870</td>
<td>B</td>
<td>16,730</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>
Key Performance Indicators (KPI’s)

- Data includes
  - Project location
  - Drainage area
  - Maintenance target
  - Reporting of maintenance LOS achieved
- Provides
  - Accountability
  - Reporting method
- Excellent asset management tool for management
Appendix D - Facility Operations and Maintenance Requirements

This appendix outlines inspection, maintenance, and record keeping requirements for stormwater management facilities in the City of Seattle. In addition, this appendix includes basic information about the common types of drainage systems used to detain and treat urban runoff, how they function, and how well they perform in removing stormwater pollutants. The types of drainage systems covered in this appendix include:

- Catch basins, maintenance nodes, and storm drain inlets
- Vaults, tanks, and pipes
- Chlorine feeders
- Media filters
- Biofilters (swales, wet swales, and filter strips)
- Infiltration trenches and basins
- Ponds and constructed wetlands
- Bioretention (swales and planters)
- Pervious pavement
- Vegetated roofs
- Chlorination
- Compost amended soil

The appendix is designed to serve as both a summary of maintenance requirements as well as an inspection checklist for facility owners. The tables presented below describe each type of drainage system and list the inspection and maintenance requirements for each system. The inspection and maintenance requirements include information about what features to inspect at each facility, when and how often these systems should be inspected, and how to identify specific defects that warrant corrective action. Corrective actions are described that should be taken to maintain system performance.

In addition, the tables contain checklists to assist owners of drainage systems in conducting inspections and to aid in inspection documentation. Recordkeeping is an important and often required component of any maintenance program. It is necessary to ensure that inspections and maintenance operations are completed as scheduled and also to track the level of maintenance required at individual facilities and structures.
O&M Estimating Database Tool - Vegetation

- Inputs:
  - Level of Service
  - sq footage
  - discount rate
  - establishment time
  - Life of project
  - replacement frequency
O&M Estimating Database Tool
Vegetation

• Output Costs
  – Mowing for grass lined swales
  – Plant maintenance inspection including litter and minor weed removal
  – Watering
  – Mulching *above ordinary high water mark*
  – Debris removal/dry vactor of sedimentation
  – Replacement cost (15yr)

• Hardscape database developed for LOS B
## Vegetation Estimated O&M Costs

<table>
<thead>
<tr>
<th>LOS B – 47,290 SQ FT</th>
<th>Total Present Value</th>
<th>Annual Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial 3 year Landscape Establishment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>assuming 0% community participation</td>
<td>$177,614</td>
<td>$65,221</td>
</tr>
<tr>
<td><strong>Established (starting year 4)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0% community participation</td>
<td>$562,228</td>
<td>$28,615</td>
</tr>
<tr>
<td>25% community participation</td>
<td>$421,671</td>
<td>$21,461</td>
</tr>
<tr>
<td>50% community participation</td>
<td>$281,114</td>
<td>$14,308</td>
</tr>
<tr>
<td>75% community participation</td>
<td>$140,557</td>
<td>$7,154</td>
</tr>
<tr>
<td>90% community participation</td>
<td>$56,223</td>
<td>$2,862</td>
</tr>
<tr>
<td><strong>Soil Replacement (every 15yrs)</strong></td>
<td>$466,952</td>
<td>$23,527</td>
</tr>
</tbody>
</table>
Estimation Data Base vs. Invoiced Costs

- Watering methods
- Initial Landscape – 3 years
  - Estimator: $1.38
  - SPU cost: $2.47 to $2.89
- Established Landscape
  - Estimator: $0.61
  - SPU cost: $2.44
- Replacement costs
- Estimator $0.50 per sq. ft.
Life Cycle Costs - Pinehurst

- Present value of O&M + construction costs
- LCC for Pinehurst (47,290 ft$^2$)
  - $1.2M + $5.2M = $6.4M
- Initial estimates
  - $4.8 million construction cost
- Comparable project to retrofit $8.9 million
- Total project cost 453K for 660 ft blk
  - Includes all design, project management, const. cost
- Present value of O&M costs compared to traditional systems is significantly less
Risks
Questions?

www.seattle.gov/util/naturalsystems