Enhancing Your Asset Management Strategy

Innovative Approaches in Stormwater Asset Collection and Evaluation

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Presentation Outline

• Why manage stormwater assets?
• Considerations in developing an AM initiative
• Technology and Tools
• Summary and Conclusions
Why manage stormwater assets?

**Flood Risk**
- ‘Built’ infrastructure can contribute/govern overall flood risk
- Often most prominent in urban areas “upstream” of the floodplain

**Public Safety**
- Public interacts with assets without knowing
- Assets can fail unexpectedly during non-disaster conditions

**Budgetary Concerns**
- Maintenance vs. Replacement
- Ownership
Considerations in developing an AM initiative

- **Mission / Scope**
  - Level (extents) of service (LOS)
  - Probability and consequence of failure (PoF and CoF) thresholds
  - Funding

- **Strategy**
  - Simple vs. Sophisticated
  - Proactive vs. Reactive
  - Extend life (repair) vs. Replace

- **How to Start**
  - Data
  - Assessment
  - Life-Cycle Management
• Asset Management can be a daunting task
  • Costs, resources, expertise, etc.

• There are a number of out-of-the-box solutions that can jumpstart or streamline asset management efforts

• Can also leverage wealth of available data that can system evaluation and planning
  • “Think outside the asset”
Building Blocks of AM

• **Inventory** *(Identify/Locate the Asset)*
  - What do we have?
  - Where is it?

• **Field Condition Assessment** *(Assess the Asset)*
  - What condition is it in?

• **System Evaluation** *(Assess the Asset System)*
  - What deficiencies do I have in my system?
  - What current and projected needs do I have to meet level of service?

• **Maintenance and Life-Cycle Management** *(Manage the Asset System)*
  - What are most effective short- and long-term strategies managing system?
Inventory

• System inventory is most fundamental building block of not only AM, but also stormwater management
  • Need to know what you have, where it is
  • Even if you don’t “do” asset management, still need to know where water goes for about any SWM application

• Common methods for developing inventory
  • As-Builts/Design Drawings
  • GPS Collection
  • Full Surveys

• In practice inventory often combination of methods
  • Piece-meal compilation of separate individual efforts in which mindset collection of individual features rather collection of system
  • Can save on “re-collection” costs, but may have data integrity/usability challenges
Inventory

- Common challenges with municipal inventories:
  - Non-Uniform/Inconsistent nomenclature
  - Lack of system connectivity – have the trees missing the forest
  - Not enough, or in some cases too much information
  - Data storage and usability
If You Don’t Have Any Inventory

• Check again – you probably do have something
  • Review business processes, check with other departments – chances are data is being captured by someone for some purpose
  • Figure out what is available, what condition it is in, and who collects/maintains it
  • NPDES compliance, street improvements/maintenance, etc

• Figure out what you need and what resources/expertise you have to dedicate to this
  • Be practical – avoid the temptation to go “big” just for sake of going big

• Leverage existing tools/technology
  • Existing Data Templates/Models (ESRI, other municipalities, etc.)
  • Integrated mobile collection (e.g. Arc Collector)
What You Think You Need

What Your Budget is Based On

Where You Can Get with Some Ingenuity
Inventory – Tips and and Tricks

Data / Framework Solutions

• ESRI has data models and tools specific to SW inventory as part of “Local Government” Solutions that can be downloaded. See http://solutions.arcgis.com/

• Ask the “community” – leverage ideas other municipalities or organizations that have gone through same discovery process
  • Google, ArcGIS Online, Web Services
Overview
Mapping for Small Stormwater Systems turns ArcGIS Online into a cloud-based GIS and mapping platform for stormwater utilities.

Deploying the Small Stormwater configuration gives your organization access to a preconfigured set of apps that support common stormwater mapping and GIS workflows including the following:

- Asset inventory
- Asset inspection
- System mapping
- Reporting
- External information sharing
- And more

After deploying Small Stormwater, your organization can immediately begin to map your stormwater system digitally.
Field Collection

- ESRI has suite of integrated “field mobility” mobile apps that can be used directly collect data in field
  - Arc Collector and Survey123 are primary
  - Requires organizational account
    
    https://www.esri.com/en-us/arcgis/field-mobility/overview

- There are a number of open source data collection app and GIS software with surprising functionality
  - QGIS / QField:  https://qgis.org
  - GRASS
  - Others...

- Other commercial solutions – Trimble, etc.
Mobile Inventory Collection Tools
Inventory – Tips and Tricks

If You Do Have Inventory (or once you get inventory)

• Perform data review and needs assessment
  • Take the time to clean/standardize data if need to
  • Figure out why it is not being used as would be envisioned

• Look for relatively simple things that you can do to enhance data that are not time/resource intensive
  • Enhanced attribution
  • Geometric enhancements

• Leverage existing tool/technology with data and “smarts”
  • Existing Data Templates/Models (ESRI, other municipalities, etc.)
  • Integrated mobile collection (e.g. Arc Collector)
Example Inventory Enhancements

Geometric
• Feature snapping
• Flow direction enforcement
• Connectivity / Geometric networks

Attribution (Automated / Psuedo-Automated)
• Sensible ID Scheme
• Location (Watershed, Address, Grid Schemes)
• Feature-Level metadata (data source, update history, etc.)
• Connectivity and connection valency (#feature connections to structures)
• LiDAR-Based elevation and 3D characteristics (slope, volume, etc.)
• Ownership
• Drainage area
• Attachments (photos, documents)
• Relates (Inspections, maintenance history, etc)
Longitudinal XS and Automated Volume Determination of Dry Detention from LiDAR

Automated Drainage Area Enabled Drainage Network

LAS Dataset Plan/Profile and Feature Elevation Extraction
Network Tracking and Analysis

and Enhanced Attributes Example
Condition Assessment

• Similar to inventory, there are a number of good tools/resources for conditions assessments

Framework

• Methodology depends on level of sophistication
• NASSCO PACP is a robust scoring system for pipelines that can be applied to stormwater systems

Field Assessments

• In addition to mobile apps and software, there are a number of field instruments that facilitate/enhance assessments (e.g. pole cameras)
PACP Assessment Scheme

Section 5 — Operation and Maintenance

Spike Phone Attachment for Phone Measurements

Section 6 — Construction Features

PACP Assessment Scheme

Section 7 — Miscellaneous Features

QuickView Pole Camera

Dioptra Mobile App for Annotated Pictures
System Evaluation

- This is step where leveraging data and smarts can greatly enhance system evaluation.

- Evaluations can be largely automated or pseudo-automated. Degree depends on availability and accuracy of data.

Example 1: Age Susceptibility Assessment (Pre-Field Assessment)

Objective: Identify timeline for pipe life-cycle replacement needs

Steps:
- Extract “year built” from parcels and categorize in to generalized “year developed” categories
- Associate generalized year developed with inventory
- Update records of known improvements, as-builts, etc. (if available)
- Compare estimate age of inventory with pipe material life expectancy, and flag systems where age exceeds life expectancy
- Compute preliminary system replacement needs by age
Example Age Analysis and Replacement Assessment
Simplified Pipe Outfall Capacity Assessment

**Objective:** Assess capacity of closed pipe systems at outfalls and determine preliminary upsizing requirements

**Steps:**
- Extract pipe system outfall pipes with target threshold drainage area (DA) using terrain generated DA-enabled drainage network
- Calculate simplified peak flow based on Rational method with DA-based rainfall intensity estimates and estimated C coefficient values
- Calculate Manning’s based pipe capacity (based on size, material, slope)
- For pipes not meeting capacity, back calculate required pipe size
- Identify outfall pipes that may not be meeting capacity and further investigate
Psuedo-Automated Outfall System Capacity Check

30" Outfall Pipe
DA = 22 acres (drainage raster)
Q = 55 cfs (psuedo-automated Rational)
Capacity = cfs (automated Mannings)
Pipe Check = FAIL
Required Size = 42"

- Circular Section -

Slope (ft./ft.) 0.008
Mannings 'n' 0.013
Hydraulic Radius 0.68
Area 9.52 sq ft
Capacity 89.9 cfs
Velocity 3.35 ft/sec
Critical Depth 3.12 ft
Culvert Sufficiency Check

Objective: Identify culverts that do not meet HW/D requirements and determine preliminary upsizing requirements

Steps:
• Extract culverts from inventory
• Calculate simplified peak flow based on Rational method for smaller drainage areas and Regression flows for larger DAs
  – Can leverage both DA rasters and impervious weighted rasters
• Extract estimate culvert inverts from LiDAR (lowest point proximity)
• Extract top of road from LiDAR
• Compute HW/D from culvert shape, size, material, flow, and inlet type using FHWA nomograph equations
• Identify culverts not meeting HW/D (max 1.2) criteria
• Compare HW vs road SAG to identify potential road overtopping
• For pipes not meeting requirements back adequate size
### CHART 1B

**Circular Culvert Calcs Equations and Notes**

*Heroes Project - Phase 2*

*July 2018*

<table>
<thead>
<tr>
<th>Column</th>
<th>Parameter</th>
<th>Equation</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Culvert Shape</td>
<td></td>
<td>Can select between Circular, Box, Horizontal and Vertical Elliptical culvert shape</td>
</tr>
<tr>
<td>Material</td>
<td>Culvert Material</td>
<td></td>
<td>Can select between Concrete, CMP, PVC and HDPE</td>
</tr>
<tr>
<td>Headwall Type</td>
<td>Inlet Type</td>
<td></td>
<td>Can Select between Projecting - Groove Edge, Headwall - Square Edge, Headwall - Groove Edge, Headwall - Square Edge, Mitered and Projecting</td>
</tr>
<tr>
<td>Diameter (in)</td>
<td>Inlet Diameter</td>
<td></td>
<td>Hard coded value. Diameter of a circular culvert in inches.</td>
</tr>
<tr>
<td>Q (cfs)</td>
<td>Flow</td>
<td></td>
<td>Flow through the culvert. This number is inserted manually</td>
</tr>
<tr>
<td>S</td>
<td>Slope</td>
<td></td>
<td>Culvert Slope. It is not relevant to the equation calculations.</td>
</tr>
<tr>
<td>g</td>
<td>gravity (ft/s^2)</td>
<td>32.174</td>
<td>Gravitational Acceleration</td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
<td>Coefficient for unsubmerged inlet control equation</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td></td>
<td>Exponent in unsubmerged inlet control equation</td>
</tr>
<tr>
<td>c</td>
<td></td>
<td></td>
<td>Coefficient for submerged inlet control equation</td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
<td>Additive term in submerged inlet control equation</td>
</tr>
<tr>
<td>ks</td>
<td>Slope correction</td>
<td>0.7 or -0.5</td>
<td>0.7 for mitered inlets and -0.5 for nonmitered inlets</td>
</tr>
<tr>
<td>A (ft^2)</td>
<td>Culvert Area</td>
<td>(D/12)^2 * 2 * π *</td>
<td>Area of the circular culvert in square feet</td>
</tr>
<tr>
<td>Q/B</td>
<td></td>
<td></td>
<td>Ratio of Discharge to Width</td>
</tr>
<tr>
<td>T/LIM</td>
<td>Inlet condition criteria</td>
<td>Q/(AD^0.5 * g^0.5)</td>
<td>An approximate limiting value to determine inlet condition. Unsubmerged if T/LIM &lt;= 0.62, Submerged if T/LIM &gt; 0.7 and Transition if 0.62 &lt;= T/LIM &lt;= 0.7.</td>
</tr>
<tr>
<td>yc</td>
<td>Critical Depth</td>
<td>1.01 * (Q^2 / (g * D)) ^ 0.25</td>
<td>Critical Depth for partial flow conditions</td>
</tr>
<tr>
<td>θ</td>
<td></td>
<td>2 * π - 2 * arccos((2yc/D-1))</td>
<td>Value used to calculate Velocity at Critical Depth</td>
</tr>
<tr>
<td>Vc</td>
<td>Critical Velocity</td>
<td>8 * Q / ((9 - sin(θ) * D) ^ 2)</td>
<td>Velocity at critical depth, ft/s (m/s)</td>
</tr>
<tr>
<td>HW/D</td>
<td></td>
<td></td>
<td>Headwater Depth for pipe culverts with inlet control.</td>
</tr>
</tbody>
</table>

**HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL**

<table>
<thead>
<tr>
<th>Head for Concrete Pipe Culverts</th>
<th>Flowing Full</th>
<th>n = 0.012</th>
</tr>
</thead>
</table>

**BUREAU OF PUBLIC ROADS JAN 1963**

**REVISED MAY 1964**
Example Interactive HW/D Calculator
Summary and Conclusions

- Asset management helps you manage your system proactively vs. reactively

- Asset management can be done in a wide spectrum of level of sophistication/complexity

- There are a lot of data, technologies, tools, and “tips” that can enhance your AM strategy – regardless of where you are at now