Innovative Methods to Assess Sewer Pipe Risk and Improve Replacement Planning Decisions

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Presentation Topics

- The Infrastructure Challenge
- The Risk Based Approach for Doing More with Less
- Risk Based Planning Case Studies
AWWA and USEPA Studies 2001-12
$1 Trillion Needed Over 25 years
Funding is Short. The List is Long. Utilities Must “Do More With Less”
“Doing More With Less” Results From Making “Risk Based” Decisions
Risk = Probability * Consequence
Consequence of Failure: Evaluate by Triple Bottom Line (TBL) Analysis

Economic
Social
Environmental

Triple Bottom Line
Sustainability
Probability of Failure: Evaluate By Condition Assessment

- Performance
- Failure Modes
- Remaining Life
Buried Infrastructure Has Always Been The Greatest Challenge
Recent Publications: New Best Practices For Pipeline Inspections

- Condition Assessment of Wastewater Collection Systems (EPA May 2009)
- Condition Assessment of Ferrous Water Mains (EPA June 2009)
- Inspection Guidelines for Wastewater Force Mains (WERF March 2010)
- Condition Assessment Technologies for Water Transmission and Distribution Systems (EPA March 2012)
Evolving Best Practices For Utility Infrastructure Asset Management

- Condition Assessment
- Risk-Based Planning
- Predictive Models
- Program Efficiency

- Smart Data
- Right Projects
- Lowest Cost
- Best Performance
Two Types of Predictive Models - Failure or Condition Data

LEYP = Linear Extended Yule Process

GompitZ = Markov Chain

GompitZ Input Data Fields:
- Install Date
- Material
- Diameter
- Inspection Date
- Condition Grade

Predicted probability a Pipe will be at a given condition in any year

Predicted Break Number (PBN) for every pipe and for each year

Uses Historic Failure Data (water main breaks)

Uses Historic Condition Data (sewer pipes)
Case Study

Innovative technologies lead the way.
Metropolitan Sewer District of Greater Cincinnati

Force Main Assessment

- **Force Main:** 6,945 LF, 24-inch diameter, steel and ductile iron, 40 years old

- **Challenges:**
  - High traffic area
  - I-275 crossing
  - Deep sections with many high points
  - No redundancy
Force Main Ranks Highest For Consequence of Failure (COF)

- I-275 Crossing
- Congested Residential Area
- High Flows

Economic
Social
Environmental
Progressive Inspection Makes The Most Use Of Each Technology

Cathodic Protection & ARV Evaluation
SAHARA Leak Detection
BEM Wall Thickness

Each inspection informs the next inspection
SAHARA® For Leak Detection, Air Pockets and Pipe Bends

Internal – Minimally Invasive – Water or Wastewater – Any Pipe Material
SAHARA® Inspection Required Five Insertion Points for 6,500 Feet
BEM = Broadband Electromagnetic: Real-Time Pipe Wall Thickness

BEM Test Grid around full pipe

Signal is received at laptop

Real-Time data on thickness
BEM Full versus CAP® Options
Provide Data Collection Flexibility

Full Pipe Option
BEM grid wraps complete pipe

CAP Option
Pipe Crown from 11:00 to 1:00
BEM Inspection Gives Remaining Pipe Life for Replacement Planning

<table>
<thead>
<tr>
<th>Site</th>
<th>Range of BEM Wall Thickness (in)</th>
<th>Average BEM Wall Thickness (in)</th>
<th>Annual Wall Loss (in/yr)</th>
<th>Total Remaining Life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.176 to 0.213</td>
<td>0.200</td>
<td>0.0044</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>0.205 to 0.254</td>
<td>0.228</td>
<td>0.0026</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>0.162 to 0.210</td>
<td>0.186</td>
<td>0.0052</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>0.208 to 0.239</td>
<td>0.227</td>
<td>0.0025</td>
<td>44</td>
</tr>
<tr>
<td>5</td>
<td>0.220 to 0.247</td>
<td>0.237</td>
<td>0.0018</td>
<td>68</td>
</tr>
</tbody>
</table>

Number of Measurements vs. Wall Thickness, inches
Recommendations – Optimize Replacement – Save Money

- 150 feet of force main near pump station within 2 to 3 years
- 450 feet of force main north of I-275 casing within 3 to 5 years
- Total Savings = $2.5M
**Columbus, OH Collection System Risk Assessment**

- **Collection System:**
  - 4,600 miles

- **Challenges:**
  - Limited inspection data

- **Objectives:**
  - Verify affordability assumptions
  - Support consent order renegotiation
  - Plan inspection program
Steps To A Risk-Based Collection System Investment Strategy

1. Consequence of Failure with GIS.
2. Apply available inspection data for Probability of Failure.
3. Estimate pipe life.
4. Define thresholds for “repair, rehabilitate and replace”.
5. Configure GIS R&R Planning Tool
6. Develop investment scenarios.
7. Verify against rates and affordability.
Sewer Consequence of Failure
Using Triple Bottom Line in GIS

**Economic Criteria**

<table>
<thead>
<tr>
<th>Diameter</th>
<th>COF Score</th>
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<tbody>
<tr>
<td>&lt;=8-inch</td>
<td>1</td>
</tr>
<tr>
<td>&gt;8 to &lt;=18</td>
<td>2</td>
</tr>
<tr>
<td>&gt;18 to &lt;30</td>
<td>3</td>
</tr>
<tr>
<td>&gt;=30 to &lt;=36</td>
<td>4</td>
</tr>
<tr>
<td>&gt;36</td>
<td>5</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Depth</th>
<th>COF Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;8 feet</td>
<td>1</td>
</tr>
<tr>
<td>&gt;=8 to &lt;12</td>
<td>2</td>
</tr>
<tr>
<td>&gt;=12 to &lt;20</td>
<td>3</td>
</tr>
<tr>
<td>&gt;=20 to &lt;30</td>
<td>4</td>
</tr>
<tr>
<td>&gt;=30</td>
<td>5</td>
</tr>
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**Social and Environmental Criteria**

<table>
<thead>
<tr>
<th>Adjacency</th>
<th>Score=5</th>
<th>Score=4</th>
<th>Score=3</th>
<th>Score=2</th>
<th>Score=1</th>
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<tbody>
<tr>
<td>Railways</td>
<td>Intersecting</td>
<td>w/in 50’</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Water Bodies</td>
<td>Intersecting</td>
<td>w/in 50’</td>
<td>w/in 200’</td>
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<td>NA</td>
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<tr>
<td>Interstates</td>
<td>Intersecting</td>
<td>w/in 50’</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>State Routes</td>
<td>NA</td>
<td>Intersecting</td>
<td>w/in 50’</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>U.S. Roads</td>
<td>NA</td>
<td>NA</td>
<td>Intersecting</td>
<td>w/in 50’</td>
<td>NA</td>
</tr>
</tbody>
</table>
Use Available Inspection Data for System Wide Probability of Failure

Data Summary:

- 11% System Inspected
- Applied to 42% similar pipe
- 58% no inspection data
Develop Initial Pipe Life Estimates Using Available Data

Example: 8” VCP from 1930’s with average age = 75 years

<table>
<thead>
<tr>
<th>Material</th>
<th>Diameter</th>
<th>Decade Installed</th>
<th>Structural Score</th>
<th>Length Ft</th>
<th>L x Score</th>
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<tbody>
<tr>
<td>VCP</td>
<td>8</td>
<td>1930</td>
<td>5</td>
<td>439</td>
<td>2195</td>
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<tr>
<td>VCP</td>
<td>8</td>
<td>1930</td>
<td>45</td>
<td>55</td>
<td>2475</td>
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<tr>
<td>VCP</td>
<td>8</td>
<td>1930</td>
<td>65</td>
<td>422</td>
<td>27,430</td>
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<tr>
<td>VCP</td>
<td>8</td>
<td>1930</td>
<td>70</td>
<td>195</td>
<td>13,650</td>
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<tr>
<td>VCP</td>
<td>8</td>
<td>1930</td>
<td>75</td>
<td>215</td>
<td>16,125</td>
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<tr>
<td>VCP</td>
<td>8</td>
<td>1930</td>
<td>80</td>
<td>151</td>
<td>12,080</td>
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<tr>
<td>VCP</td>
<td>8</td>
<td>1930</td>
<td>95</td>
<td>909</td>
<td>86,355</td>
</tr>
</tbody>
</table>

**Totals** 2386 16,0310

**Weighted Score** 67

**Calculate Age at Failure Score = 80**

\[
\frac{75}{67} = \frac{X}{80}
\]

Pipe Life = X = 90 years
Define Thresholds for Interventions “Repair, Rehabilitate or Replace”

<table>
<thead>
<tr>
<th>Pipe Consequence Of Failure</th>
<th>Replace</th>
<th>Rehabilitate</th>
<th>Repair</th>
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<tbody>
<tr>
<td>&gt;= 1 and &lt; 2</td>
<td>&gt;= 95 and &lt;= 100</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>&gt;= 2 and &lt; 3</td>
<td>&gt;= 95 and &lt;= 100</td>
<td>&gt;= 80 and &lt; 95</td>
<td>NO</td>
</tr>
<tr>
<td>&gt;= 3 and &lt; 4</td>
<td>&gt;= 95 and &lt;= 100</td>
<td>&gt;= 80 and &lt; 95</td>
<td>&gt;= 70 and &lt; 80</td>
</tr>
<tr>
<td>&gt;= 4 and &lt;= 5</td>
<td>&gt;= 80 and &lt;= 100</td>
<td>&gt;= 70 and &lt; 80</td>
<td>&gt;= 60 and &lt; 70</td>
</tr>
</tbody>
</table>
Configure GIS R&R Planning Tool and Create Investment Scenarios
Determine Current System Risk Baseline By Pipe COF

<table>
<thead>
<tr>
<th>COF</th>
<th>% of System</th>
<th>Average Condition</th>
<th>Average Risk</th>
<th>% Max Risk*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.9%</td>
<td>48.4</td>
<td>48.4</td>
<td>48%</td>
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<tr>
<td>2</td>
<td>30.8%</td>
<td>51.5</td>
<td>102.9</td>
<td>51%</td>
</tr>
<tr>
<td>3</td>
<td>50.9%</td>
<td>38.5</td>
<td>115.6</td>
<td>38%</td>
</tr>
<tr>
<td>4</td>
<td>10.5%</td>
<td>32.6</td>
<td>130.6</td>
<td>33%</td>
</tr>
<tr>
<td>5</td>
<td>1.9%</td>
<td>31.1</td>
<td>155.7</td>
<td>31%</td>
</tr>
<tr>
<td>System</td>
<td>100%</td>
<td>41.1</td>
<td>111.1</td>
<td>41%</td>
</tr>
</tbody>
</table>

*Note: System Wide Max Risk Score = 271.5
$3-5 Million Budget Scenario

$3-5M Budget over 50 Years

$3-5M over 50 Years
Questions/Discussion