Evaluation of Consequence of Failure for Water Pipelines Using Surface Water Modelling

AMIN GANJIDOOST, PHD / INFRASTRUCTURE ASSET MANAGER
CRAIG DALY, PE / SENIOR PROGRAM MANAGER
KARL SAN LUIS, CAP / TECHNICAL TEAM LEAD
• Amin Ganjidoost, PhD
• Pure Technologies, a Xylem brand
• Toronto, ON
• Ph.D. in Civil Engineering, University of Waterloo
• +7 years experience in data analytics and developing decision-support systems for financially-sustainable management of urban water infrastructure, as well as identifying and evaluating mitigation strategies to reduce the risk of asset failure.
**Advanced Infrastructure Analytics (AIA)** provides an **integrated** suite of state-of-the-art **data acquisition, analytics, and management tools** that give decision makers comprehensive and precise information backed up by **consultancy** to optimize **water utility** management.

<table>
<thead>
<tr>
<th><strong>Data Acquisition</strong></th>
<th><strong>Software Suite</strong></th>
<th><strong>Consultancy</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve assessment</td>
<td>Pressure management</td>
<td>Implementing solutions</td>
</tr>
<tr>
<td>Hydrant/appurtenance assessment</td>
<td>Hidden revenue</td>
<td>State of the art knowledge</td>
</tr>
<tr>
<td>Distribution monitoring</td>
<td>NRW management</td>
<td>Data → Actionable information</td>
</tr>
<tr>
<td>Meter data</td>
<td>Condition management</td>
<td>World class project management</td>
</tr>
<tr>
<td>Condition assessment</td>
<td>Water quality modeling</td>
<td></td>
</tr>
<tr>
<td>SCADA Data</td>
<td>Remaining useful life</td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Background
2. Methodology
3. Results and Conclusion
Background
Identifying High Risk Pipes For Integrity Plan

- Stroke
- Heart Attack
- Aneurysm

No water!
Typical Industry Approach

- Qualitative & Semi-Qualitative

Consequence of Failure (CoF)  Likelihood of Failure (LoF)

<table>
<thead>
<tr>
<th>Asset A</th>
<th>Weight</th>
<th>CoF</th>
<th>Weighted CoF</th>
<th>Weight</th>
<th>LoF</th>
<th>Weighted LoF</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>50%</td>
<td>5</td>
<td>2.5</td>
<td></td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>B</td>
<td>10%</td>
<td>5</td>
<td>0.5</td>
<td></td>
<td>3</td>
<td>0.3</td>
</tr>
<tr>
<td>C</td>
<td>5%</td>
<td>1</td>
<td>0.1</td>
<td></td>
<td>5</td>
<td>0.3</td>
</tr>
<tr>
<td>D</td>
<td>15%</td>
<td>2</td>
<td>0.3</td>
<td></td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>E</td>
<td>20%</td>
<td>4</td>
<td>0.8</td>
<td></td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Total CoF =</strong></td>
<td><strong>4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{Total CoF} \times \text{Total LoF} = \text{LOF} \]
Tale of the Tape: Two Pipes with Score of 8

Low estimated probability (2) but can impact 80% of the city (4)

400,000 people

High estimated probability (4) but impacts only 5% of the city (2)

2,500 people
Flooding Effects of Water Main Break

Water main break in Morena leaves businesses flooded

SAN DIEGO (NEWS 8) - At least four businesses in Morena were flooded Friday when an eight-inch pipe burst, causing a big mess for people who work in the neighborhood.

According to the city officials, an eight-inch concrete water main broke sending water down West Morena Boulevard and Dorcas Street like a river.

Water main break in Cambridge floods neighbors, shuts street

A water main break in Cambridge damaged a road, flooded houses, and knocked out power for some residents early Sunday morning, according to Cambridge police.

Crews responded to the break on Craigie Street near Concord Avenue at about 2:45 a.m., according to Jeremy Warnick, a spokesman. The water main was under control by about 5 a.m. he said in an e-mail.

“This was a significant break” in a 20-inch main line, he said.
Monetary Quantification of Damage
Summary of Steps

Data Gathering

| Pipe GIS | Pipe Flow Data | Land Use | Elevation Data |

Quantifying the Properties Affected Across the Pipe Network

Quantifying the Monetary Impact for Each Property

Assigning the Monetary Impact to Each Pipe
Data Gathering

- Utilize available data from water utility and publicly available data of customers

Water Network Data

Elevation

Land Use
What happens during a water main break?

1. Water utility gets alerted with the water main break
2. Utility mobilizes a team on site to assess the situation
3. Utility isolates the line to stop water from leaking/bursting by closing the valves*. This triggers the water meters to have no water
4. Utility works 24/7 to repair** the line and bring back the water service.

*Analysis assumes that valves in the model are 100% working. In practice, this is not always true.
**Analysis assumes that repairs work smoothly. In practice, this is not always true.
Surface Water Modelling: How it was performed

Selection of Pipe Burst Points

• Selected surface modelling points in the system were chosen as representative leak points instead of simulating for each spot
• Selection of points were performed based on flow and geographic area
• Flood simulation points chosen to represent the potential flood impacts of a water main break

Intensity of Pipe Burst

• Peak pipe burst discharge were quantified based on the pipe’s typical flow rate, material and size
• Hydrograph was assumed based on the pipe flow and emergency response time of shutting the pipe
Quantifying the Properties Affected Across the Pipe Network

- Flood results were produced
- Total simulation time was 24 hours
- Maximum flood depth across the timeframe was considered for quantifying the damage

Flood depth resolution was 150 meters
Customers are quantified across the flood range based on the surface water modelling simulation.
Cost of damage for each affected establishment was based on flood depth, type of establishment and the land area. Consider the structure damages and contents damages of a property depending on the establishment type.
Assigning the Monetary Impact to Each Pipe

Linking Pipe Burst Points

- Pipes which did not have any dedicated simulation points were linked up:
  - to the closest flood simulation point,
  - within a specific flow range
Results and Conclusion
Surface Water Modelling for Quantifying Risk Damage

Most critical water mains in the system is reflected in the model

Highest consequence water mains are thousands of times more consequential than the average mains!
Surface Water Modelling for Estimating Risk Damage

This gives emphasis on which pipes the water utility can’t afford to have a “heart attack” and should spend money on to avoid failure.
Surface Water Modelling Reflects The **Real** Consequence of Failure

- Surface water modelling aids in quantifying consequences of water main break
- Estimated damage reflects a different distribution compared to qualitative
- Allows for dollar-for-dollar comparison in preparing asset management plans