FLINT’S PATH TO DISTRIBUTION SYSTEM OPTIMIZATION

A.J. Brooks, PE
Rebecca Slabaugh, PE, ENV SP

NYSAWWA
Edwin C. Tifft Jr. Water Supply Symposium
September 20, 2018
Agenda

- System Background
- Distribution System Optimization Approach
- Gap Analysis
- Asset Management Program
- Ongoing Efforts
Agenda

System Background

Distribution System Optimization Approach

Gap Analysis

Asset Management Program

Ongoing Efforts
Flint Water System (Pre-Crisis)

- **Source & Treatment**
  - Purchase treated water from Detroit Water & Sewerage Department (DWSD)
  - 2 MG elevated and 20 MG ground storage tanks onsite

- **Distribution**
  - 580 miles of pipe, mostly unlined cast iron
  - 3 pump stations
  - 2 ground storage reservoirs (12 MG and 20 MG)
  - 1 pressure zone
Flint Crisis in a Nutshell

- City switched to Flint River in April 2014
- Changed corrosion treatment
- Flint River water quality highly variable
- Water treatment plant challenges
- Water quality issues

Boil water notice due to *E. Coli*

Colored water complaints

- TTHM MCL exceedance
- First reported lead issues
Remedial Actions

- **October 2015** – City switches back to Detroit water (now operating as Great Lakes Water Authority, GLWA) and begins boosting chlorine, orthophosphate, and if needed, pH at point of entry
- **January 2016** – MDEQ and USEPA begin extensive testing program
- **September 2016** – Arcadis team hired to develop Distribution System Optimization Plan
- **October 2017** – Decision made to stay on GLWA water
Agenda

System Background

Distribution System Optimization Approach

Gap Analysis

Asset Management Program

Ongoing Efforts
Overall Project Approach

1. Gap Analysis
   • Assess existing data, practices and procedures as compared to industry best practices
   • Identify gaps and opportunities for improvement

2. Resource Needs Assessment

3. Optimization Plan

Community Outreach
Industry Best Practices based Largely on Partnership for Safe Water

Distribution system optimization focuses on three categories:

- **Hydraulic Integrity**
  - Pressure Control
  - Water Loss Control
  - Storage
  - Main Breaks
  - Internal/External Corrosion
  - Pipeline Rehab/Replacement

- **Physical Integrity**
  - Main Breaks
  - Hydrant/Valve Maintenance
  - Energy Mgmt
  - Storage

- **Water Quality Integrity**
  - Disinfectant Residual
  - TCR/Sampling
  - Nitrification
  - Inorganics Accum.
  - Internal Corrosion
  - Storage
  - DBP Compliance
  - Customer Complaints
  - Flushing and Main Cleaning
  - Water Age

- **Main Breaks**
  - Water Loss Control
  - Main Installations and Repairs
  - Internal/External Corrosion

- **Water Age**
  - Flushing and Main Cleaning
  - Main Installations and Repairs

- **Customer Complaints**
  - DBP Compliance
  - Storage
  - Main Installations and Repairs
Distribution System Topics Assessed

- Administrative Policies
- **Asset Management**
- Cross Connection Control
- Customer Complaint Tracking & Response
- **Disinfectant Residual**
- Disinfection Byproduct Compliance
- Flushing
- Funding
- Hydraulic Modeling
- Internal Corrosion Control
- Main Breaks
- Online Monitoring
- **Pipeline Rehab and Replacement**
- Post Precipitation Control
- Pressure Control
- Pump Station Operation & Maintenance
- Security, Emergency Management
- **Staffing**
- Storage Facility Operation & Maintenance
- Valves and Hydrants
- Water Age Management
- Water Loss Control
- Water Quality Sampling & Response

![Distribution System Topics Evaluation Scale](image_url)
Agenda

System Background

Distribution System Optimization Approach

Gap Analysis

Asset Management Program

Ongoing Efforts
Water Quality Integrity

- TCR/Sampling
- DBP Compliance
- Internal Corrosion
- Flushing and Main Cleaning
- Storage
- Inorganics Accumulation
- Customer Complaints
- Water Age
- Nitrification
- Main Installations and Repairs
Monthly Chlorine Levels

Before Switch to Flint River

Flint River Operational Period

Return to Detroit Water

95th percentile chlorine level

5th percentile chlorine level

Partnership Goal (≥0.2 mg/L in 95% of monthly samples)

Flint Interim Goal (≥0.5 mg/L in 95% of monthly samples)

Chlorine stability has improved, but is still more variable than before switch
Disinfection Byproducts Have Returned to Pre-Flint River Levels
Orthophosphate Residuals
(Jan 2016 – May 2017)
Maximum Lead Level Measured at Locations with Paired Data
(# of Samples)

Winter 2016 (82)
Spring 2016 (82)
Action Level

Winter 2016 90\textsuperscript{th} percentile lead at 100 µg/L
Spring 2016 did not show any real improvement in lead levels
Nobody was Using Water

- Water demand into houses very low
- High water age in system
- Orthophosphate not getting into the lead service lines and homes

In May 2016, the City of Flint and MDEQ called for FLUSH FOR FLINT
Winter 2016 (82) • Summer 2016 90th percentile lead dropped to 25 µg/L
Fall 2016 (82) • Fall 2016 showed improvement at lower and in peak lead levels
Winter 2017 (82) • Winter 2017 90th percentile lead at 15 µg/L
Spring 2017 (82) • Spring 2017 90th percentile lead down to 9 µg/L

- Maximum Lead Level Measured at Locations with Paired Data (No of Samples)
- Percent of Observations less than Value
- Lead Concentration (µg/L)
Physical Integrity

- Pressure Control
- Water Loss Control
- Internal/External Corrosion
- Storage
- Pipeline Rehab/Replacement
- Hydrant/Valve Maintenance
- Main Installations and Repairs
- Main Breaks
Main Break Summary

Partnership Goal ≤ 15 breaks per 100 miles of pipe per year

Breaks per 100 miles

Year


© Arcadis 2018 20
Main Breaks Closely Related to Temperature

The graph shows the number of main breaks per month and the temperature in degrees Fahrenheit for Flint River, Water Main Breaks, and Temperature. The data is represented from January 2013 to October 2016.}

© Arcadis 2018
Main Rehabilitation and Replacement Program Status

• Typical R&R program targets 1% of system per year to maintain age < 100 years

• ~362 miles (62%) of Flint pipes installed between 1900-1930

• To meet goal of 1% by 2030, would need to replace 28 miles (~5%) per year from 2017-2030

Recommendation to develop and implement a risk-based R&R program
Hydraulic Integrity

- Main Breaks
- Cross-Connection Control
- Water Loss Control
- Energy Mgmt
- Pipeline Rehab/Replacement
- Flushing
- Storage
Hydraulic Modeling Background

- Created in 2000 with updates in 2015
  - 17,873 pipes
  - 15,922 nodes
  - 5 tanks
  - 14 pumps
  - 7 valves
  - 2 sources/reservoirs (River & Detroit)
  - 14, 18, 22 MGD Scenarios

- USEPA/Citilogics began updates in 2016
  - Updates to infrastructure, operations (pump status, valve positions), customer demands
  - Real-time modeling platform
  - Field studies (pressure loggers, fire low tests) to support calibration

Source: USEPA (2016)
Hydraulic Modeling Field Work & Calibration

- Is HGL degradation consistent throughout the system or localized?
- Large System Wide Pressure Survey
- Fire flow testing and pipe interior roughness testing

Model Calibration Adjustments:
- C-factors
- Pipe Diameters
- Valve Status
- Relationship w/ GIS
- Coordinate & Vertices Updates
Agenda

- System Background
- Distribution System Optimization Approach
- Gap Analysis
- Asset Management Program
- Ongoing Efforts
## Asset Management and Capital Planning

### Tasks
- Update/revise existing AM report to meet MDEQ requirements
- Establish distribution improvements capital plan
- Lay groundwork for future water system asset management program

### AM Program Objectives
1. Asset inventory and condition assessment
2. Level of service and key performance indicators determinations
3. Asset criticality
4. Life-cycle financial planning
5. Distribution system capital improvement plan
6. Enterprise AM software procurement assistance
Inventory in GIS

- Primary Attributes
  - Diameter
  - Length
  - Material
  - Install Year (not populated)
    - Hydrant casting year used as estimate of pipe age
    - Conducted additional survey to capture all hydrants
- Coordinated GIS with Hydraulic Model so both have the latest data
Risk-based Approach to Asset Management

Probability of Failure
• Based on asset condition and performance standards

Consequence of Failure
• Based on Triple Bottom Line principles:
  – Economic
  – Environmental
  – Social

\[
\text{Probability} \times \text{Consequence} \times \text{Redundancy/Mitigation} = \text{Asset Risk Score}
\]
Consequence of Failure Results
Likelihood of Failure Criteria and Results

- Model Pipe C-Factor
- Model Head Loss Gradient
- Break Rate
- Actual Breaks
Current System-Wide Risk: CoF X LoF
Agenda

- System Background
- Distribution System Optimization Approach
- Gap Analysis
- Asset Management Program

Ongoing Efforts
Human Resources and Funding Needs

*Identified Resource Needs to Implement Best Practices Among All Optimization Topics*

---

Recommendations to be tailored to Flint system and prioritized
Human Resources Challenges

Water Department staffing: 64 budgeted / ~ 45 filled
Distribution O&M staffing: 39 budgeted / ~ 27 filled

<table>
<thead>
<tr>
<th></th>
<th>Customer Accounts per Employee</th>
<th>MGD Delivered per Employee</th>
<th>Training Hours per Employee</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th Percentile</td>
<td>400</td>
<td>0.17</td>
<td>32</td>
</tr>
<tr>
<td>Median</td>
<td>500</td>
<td>0.25</td>
<td>20</td>
</tr>
<tr>
<td>75th Percentile</td>
<td>700</td>
<td>0.36</td>
<td>12</td>
</tr>
<tr>
<td>Flint (Budgeted/Actual)</td>
<td>808/1167</td>
<td>0.33/0.48</td>
<td>0/0</td>
</tr>
</tbody>
</table>

Source: AWWA Benchmarking survey, 2007

Bottom line… more Water Department Staff and more training are needed
Funding Considerations

Challenges

• Reduced demands
• High water rates → inability or willingness for customers to pay bills
• Significant water loss
• Historically no distribution system capital budget

Potential Options

Cash Funding
• Grants
• Consumer assistance programs
• Cost sharing
• Property taxes

Debt Financing
• Low interest loans (SRF, WIFIA)
• Tax exempt municipal bonds

Other
• Improved revenue collection rates
• Operational efficiencies
Additional Activities

Optimization Plan and SOP Development

Public Education and Outreach

Operator Training
Contact Information

A.J. BROOKS, PE
Project Engineer, Arcadis U.S.

- 518 250 7300
- a.j.brooks@arcadis.com

REBECCA SLABAUGH, PE, ENV SP
Drinking Water Treatment Practice Technical Lead, Arcadis U.S.

- 317 231 6500
- rebecca.slabaugh@arcadis.com