Protecting Our Assets: Water Main Condition Assessment

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Agenda

• Project Background
• Assessment Procedure
• Conclusions From Data Analysis
• Lessons Learned
City of Lynchburg, Virginia Water Treatment System

- Two Water Treatment Plants
  - College Hill Filtration Plant (14 mgd)
  - Abert Filtration Plant (12 mgd)

- Raw Water Sources
  - Primary – Pedlar Reservoir (95% of Raw Water)
  - Secondary – James River PS at Abert WTP (5% of Raw Water)
  - Secondary – James River PS Downtown (rarely used)

- Approximately 90,000 Customers (Residents & Surrounding Counties)
Lynchburg Raw Water Supply & Treatment System

PEDLAR DAM AND RESERVOIR (PRIMARY RAW WATER SUPPLY)

PEDLAR TRANSMISSION MAIN

12 miles

JAMES RIVER

(SECONDARY RAW WATER SUPPLY)

JAMES RIVER PUMPING STATION (ABERT)

ABERT FILTRATION PLANT

DISTRIBUTION SYSTEM

PEDLAR TRANSMISSION MAIN

8 miles

JAMES RIVER PUMPING STATION (DOWNTOWN)

JAMES RIVER FILTRATION PLANT

College Hill Filtration Plant

DISTRIBUTION SYSTEM
Pedlar Dam

Height increased to 89 feet in 1964
Pedlar Reservoir

125 Acres, 33 Square Mile Watershed All within the George Washington National Forest, Full Time Caretaker
College Hill Filtration Plant
College Hill – The Upside-Down Water Plant

- Pedlar Dam – 163 Feet Higher than Filters on 7th Floor
- Water Flows Through the Plant and into Downtown Distribution System Without Pumping, Saving $1,000 per Day of Electricity
Pedlar Pipeline

3 Pipeline Tunnels

1933 Pipe Installation

Pedlar Reservoir

Pedlar Pipeline

Abert Water Plant

Pedlar Pipeline

College Hill
Pedlar Pipeline

- Key Asset in City’s Water Supply System
- Helps Ensure Safe, Clean Drinking Water
- Pedlar Reservoir Preferred Source of High Quality Drinking Water
- Enables City to Provide High Quality Drinking Water at One of the Lowest Water Rates in Virginia
Pedlar Pipeline

- 1903 Redwood Pipeline Completed Between Pedlar Dam & City
- 1933 Redwood Pipe Replaced with Cast Iron Pipe
- 36-Inch & 30-Inch Diameter Unlined Cast Iron Pipe
- Approximately 20 Miles Long (8 Miles Lower Reach, 12 miles Upper Reach)
Pedlar Pipeline

- Significant Features
  - Three Tunnels
  - Ten Crossings of Pedlar River
  - Crossing of James River

- Highest Working Pressure 176 psi Approximately

- Average Working Pressure
  - Amherst County 50 psi
  - Bedford County & City of Lynchburg 80 psi
Pedlar Pipeline

- Estimated Replacement Cost of Pipeline

  Construction Cost \(^{(1)}\) $38,900,000
  Project Costs (35%) 13,700,000
  Total Project Cost $52,600,000

\(^{(1)}\) ENR 8805, does not include land acquisition
Overall Pedlar Program

• Readily Available Information (First Phase)
  – Break Repair History
  – Comparison of Metering Information
  – Hydraulic Evaluations

• Condition Assessments (Second Phase)
  – Pipeline Excavations
  – Pipeline Inspections at Accessible Locations
  – Metallurgical Analysis
Overall Pedlar Program

- Sophisticated Condition Assessments (Third Phase)
  - Determine Assessment Methods After Completion of First & Second Phases
- Evaluation of Alternative Pipeline Rehabilitation & Replacement Approaches
Condition Assessment Program

- Readily Available Information
  - Break & Repair History
  - Comparison of Metering Information
  - Hydraulic Evaluations
Readily Available Assessment Information

• **Break & Repair History**
  – City Maintained 50 Years of Repair History
  – 25 Failures Reported at Project Initiation
  – 22 Joint Failures
  – 1 Failure of Blow Off Valve
  – 2 Failures Due to Split Pipe
  – Additional Failure After History Compiled at James River

• **Failure Locations**
  – 7 Upper Reach (above James River crossing)
  – 18 Lower Reach (below James River crossing)
  – 1 within James River

• **No Pattern of Increasing Failure Rate in Recent Decades**
Readily Available Assessment Information

• Comparison of Flow Meter Data
  – No Significant Loss of Water Between Upstream & Downstream Meters

• Hydraulic Evaluations
  – C Value of 110 Calculated for 80-year Old Unlined Cast Iron Pipe
  – Calculated Roughness Measurements for 80-year Old Pipe Comparable to New Pipe
Readily Available Assessment Summary

- Failure Rate Approximately 1 every 2 years
- Majority of Failures Joint Failures
- Majority of Failures in Lower Reach
- Insignificant Leakage
- Interior Roughness Comparable to New Pipe
Condition Assessment Program

• Pipeline Excavations
  – Soils Investigations to Identify Corrosion Hot Spots
  – Use of Break History, Soils Information, & Proximity to Other Utilities to Identify Potential Excavation Sites
  – Detailed Corrosion Surveys of Potential Excavation Sites to Identify Specific Excavation Sites
  – Ultrasonic Wall Thickness Measurements of Excavated Pipe
  – Corrosion Engineer Assessments
  – Geotechnical Engineering Assessments of Soils
Condition Assessment Program

• Pipeline Inspections at Accessible Locations
  – Accessible Locations Include Exposed Pipe & Buried Vaults
  – Ultrasonic Wall Thickness Measurements
  – Visual Condition Assessment

• Metallurgical Analysis (James River break pipe)
  – Chemical Analysis, Mechanical Properties,
Pipeline Excavations – Test Site 1

- Site Chosen Due to Previous Failure Nearby

- Corrosion Field Survey
  - In-situ Soil Resistivity: 94,792 ohms/cm (Mildly Corrosive)
  - pH: 7.4 (Negligible)
  - External Surface: Very Good Condition, Minor Pitting

- Wall Thickness Measurements
  - Average Thickness Reduction: 0.07”
Pipeline Excavations – Test Site 2

- Location Perpendicular Crossing of Liquid Fuel Line
- Corrosion Field Survey
  - In-situ Soil Resistivity: 7,899 ohms/cm (Moderately Corrosive)
  - pH: 7.5 (Negligible)
  - Scaling Around Bell
- Wall Thickness Measurements
  - Average Thickness Reduction: None Measurable
Site Chosen Due to a Previous Break & Joint Failures

Corrosion Field Survey

- In-situ Soil Resistivity: 13,000 ohms/cm (Mildly Corrosive)
- pH: 7.4 (Negligible)
- External Surface: Excellent Condition

Wall Thickness Measurements

- Average Thickness Reduction: None Measurable
Pipeline Excavations – Test Site 4

- **Corrosion Field Survey**
  - In-situ Soil Resistivity: 59,173 ohms/cm (Mildly Corrosive)
  - pH: 7.4 (Negligible)
  - External Surface: Excellent Condition

- **Wall Thickness Measurements**
  - Average Thickness Reduction: None Measurable

- **Parallel 36” Finished Water Pipeline** Also No Sign of Corrosion
Pipeline Inspections at Accessible Locations

- Eight Sites Inspected
- Six Sites had Measurable Thickness Loss Assuming Pipe Manufactured to Average Thickness
- All Losses were Minor
- Only One Site (#13) had Significant Visual Corrosion
Pipeline Inspections at Accessible Locations

Site 6

Site 7

Site 8

Site 9

Site 12

Site 13

Site 13

Site 13
Metallurgical Analysis

- Metallurgical Analysis Performed on Pipeline Removed for Repair
- Analysis Findings
  - Cast Iron Chemistry within Expected Parameters Except for Silicon
  - No Measurable Graphitic Corrosion
  - Minor Corrosion Products
  - Large Quantity of Phase Called “Steadite”
  - Leadite Joint Compound
Condition Assessment Findings

- After Eighty Years of Continuous Service, Pedlar Main is Expected to Continue to Serve the City
- Majority of Failures Result from Leadite Joints
- Leakage Insignificant
- Interior Roughness Comparable to New Pipe
- Minor Exterior Corrosion
- Thickness Reductions Insignificant
- Iron Structure Stable
Leadite Joint Failures

- Majority of Failures Result From Leadite Joints
- Metallurgical Analysis Confirmed Presence of Leadite Joints
- Leadite: Plasticized Sulfur Cement Compound
- Joint Repair By Annual Contractor
- Repair Consists of Lead Wool Packing Combined with External Bell Clamp
Results From Condition Assessment Report

- Sophisticated Assessment Techniques Anticipated as Part of Study Deferred
- Evaluation of Alternative Pipeline Rehabilitation & Replacement Approaches Included in Report Scope Deferred With City’s Concurrence
- Joint Repair Alternatives Evaluated
  - No Plan for Immediate Implementation
  - Only Planning Level Costs Developed
Lessons Learned

- Readily Available Information (Break History, Friction Coefficients) Valuable for Assessment Program
- Age is not an Indicator of Condition
- Record Information on Your Assets
- Prior to Implementation of Costly Replacement Programs, Perform Condition Assessments
Questions?

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