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Water Transmission Main Condition Assessment

March 6, 2024

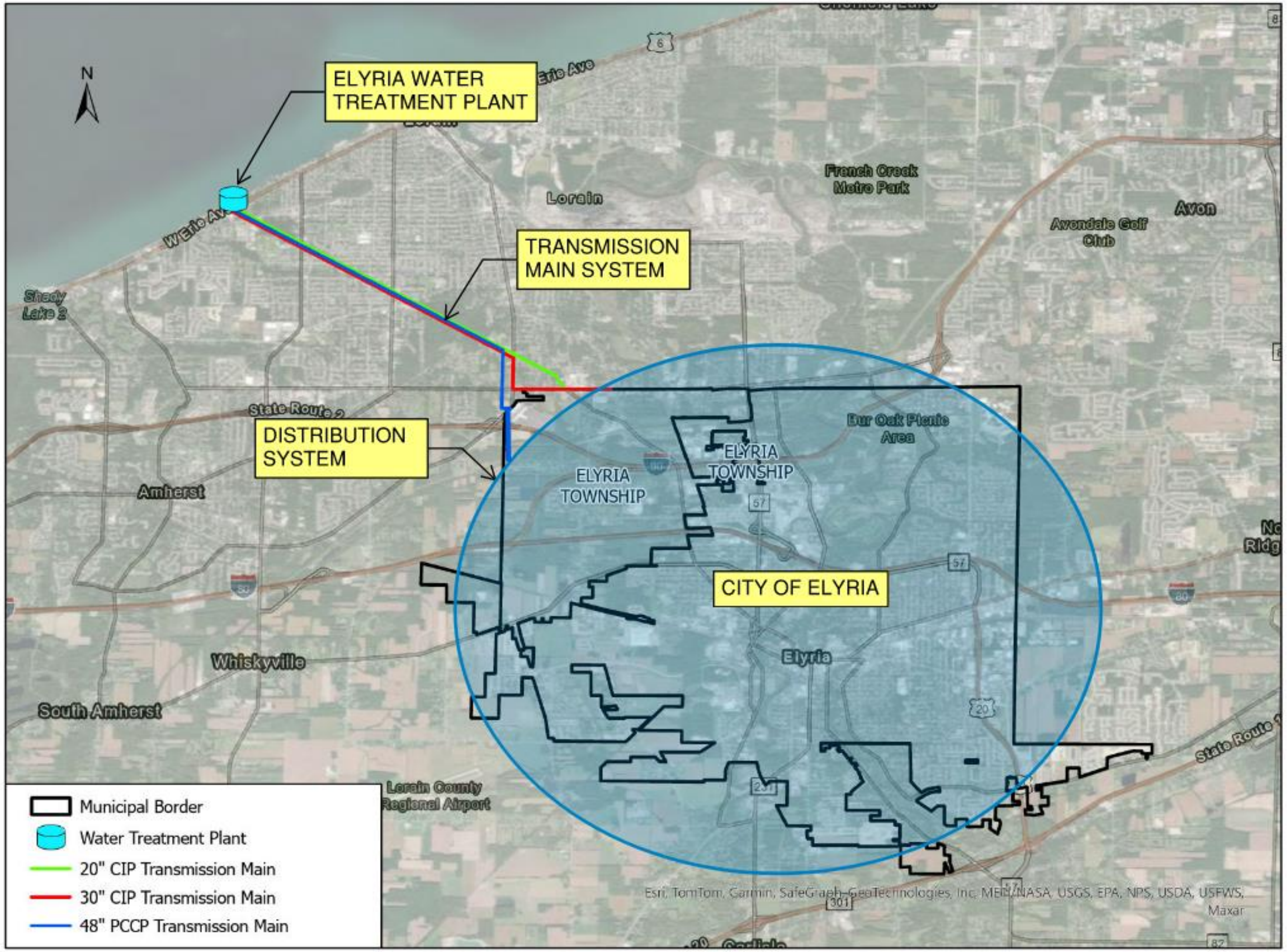
CITY OF ELYRIA

Environmental OTCO Training Center Since 1964

Agenda

- Project Background & Objectives
- Inspection Technology Selection
- Valve Assessments
- Cast Iron Pipe Leak Detection
- PCCP Inspection
- Overall Transmission Main System Recommendations

City of Elyria Water System



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Transmission Mains

21,700LF of 1902 20" Cast iron pipe

26,000 LF of 1945 30" Cast iron pipe

20,500 LF of 1958 48" Prestressed concrete cylinder pipe (PCCP)

Cast Iron Pipe Failure & Leaks

PCCP Failure

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Keys To Success

JUDICIOUS TECHNOLOGY SELECTION

SUCCESSFUL PLANNING & EXECUTION

TRANSFORM DATA INTO AN ACTIONABLE CIP

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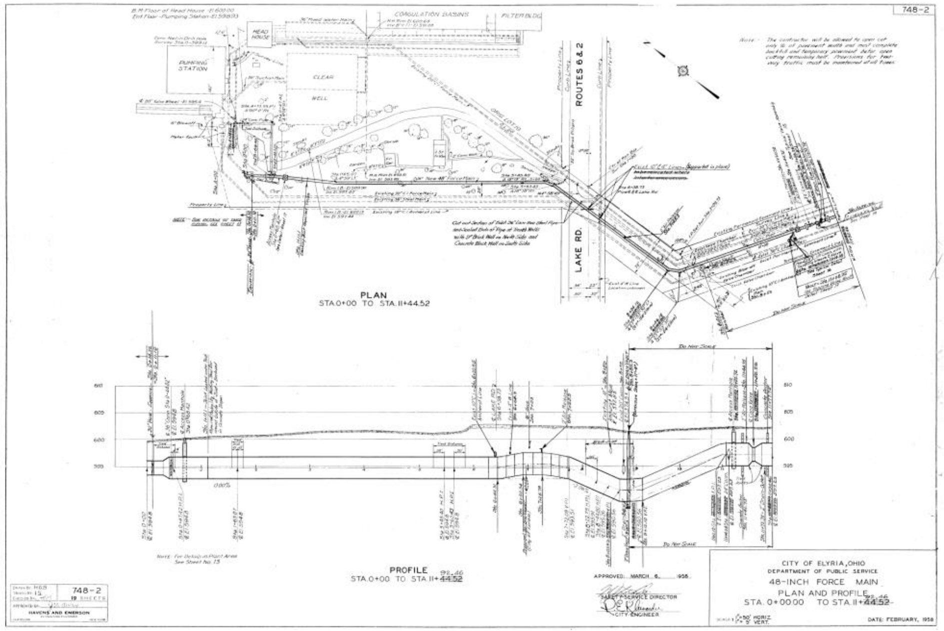
Inspection Technology Selection

Data Collection & Failure History

<u>Limited Data Available on Transmission Main System</u>

- Transmission Main System Record Plans
- Soil Corrosivity Study
- Limited GIS Data
- High Service Pressure & Flow Data
- City institutional knowledge of system



<u>Failure History</u>

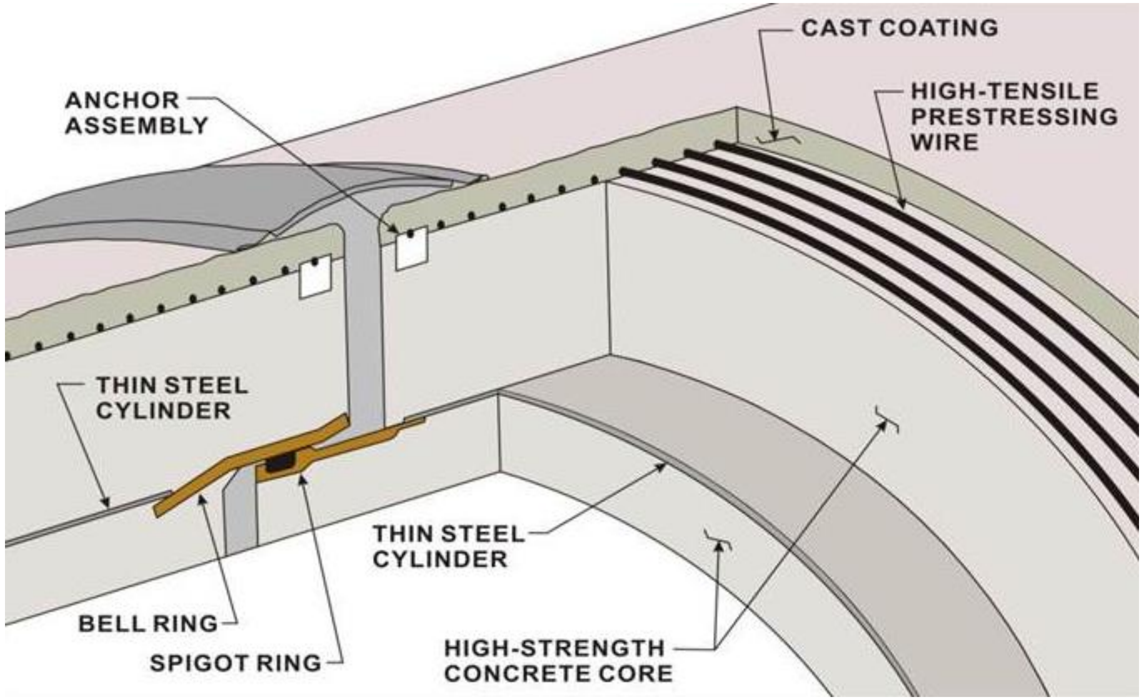
- 20" CIP - 1 Failure & History of Joint Leaks/Repairs
- 30" CIP – No Failures, History of Joint Leaks
- 48" PCCP – No Failure History
- Valve Conditions – Largely Unknown, City did not regularly exercise transmission main valves


20-inch CIP Failure

PCCP Technology Selection

PCCP Design

- Composite pipe product
  - Internal mortar or concrete lining
  - Steel Cylinder
  - Concrete Core(s)
  - **High Strength Prestressed Wires**
  - Exterior Mortar Coating
- No lay sheets available for Elyria's PCCP transmission main



Let Failure Mode Dictate Technology Selection

WIRE BREAKS

CYLINDER CORROSION

MORTAR DAMAGE

Reduced Compression in Concrete Core

Concrete Core in Tension
Concrete Core Cracks

PIPE FAILS

Failure Mode

Technology Selection

PCCP failures begin with wire breaks

ELECTROMAGNETIC INSPECTION

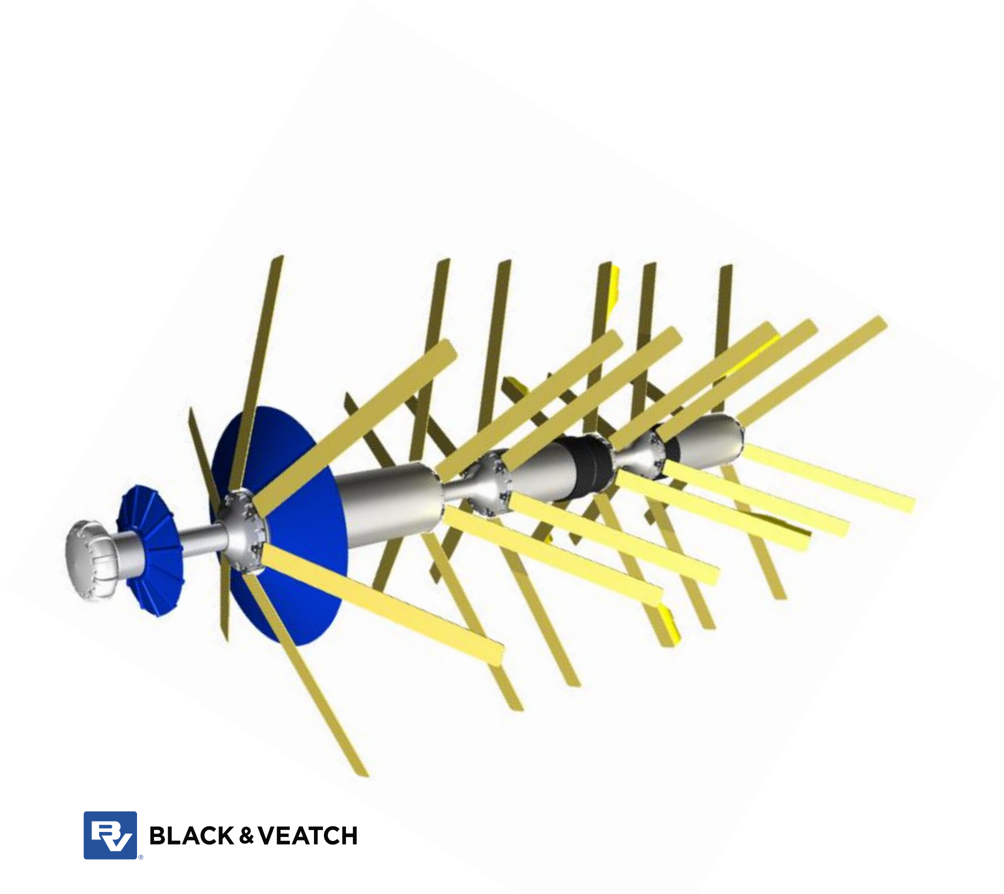
Technology & Platform Comparison for this Project

Technique or Technology	Platforms	Information Obtained	Deployment/ Extraction Requirements	Operating Environment	Viable for this Project?
Internal Electromagnetic Inspection	Pure PipeDiver	▪ Location and quantity of wire breaks ▪ Identifies cracking, spalling, and joint damage from onboard camera	▪ Hand or insertion tube ▪ >=16-inch outlet	▪ In service ▪ Partially Isolated	YES ★
	Pure Robotics	▪ Location and quantity of wire breaks ▪ Identifies cracking, spalling, and joint damage from CCTV	▪ Hand ▪ >=16-inch outlet	▪ Partially Dewatered ▪ Fully Isolated	YES
Visual and Sounding Inspection	Manned Entry	▪ Identify hollows, cracking, spalling, and joint damage	▪ Manned entry though >=20-inch outlet	▪ **Dewater main**	NO
Acoustic Fiber Optic Monitoring	Fiber Optic Cable	▪ Real time location and quantity of wire breaks	▪ Installation requires **dewatering of the pipeline**	▪ Normal operating conditions	NO
Stress Wave Analysis	Echologics Epulse	▪ Provides an indirect estimate of prestress loss ▪ **Does NOT find wire breaks**	▪ Requires external sensors spaced ~100 feet	▪ Normal operating conditions	NO
Leak Detection & Visual Inspection	Pure Sahara	▪ Identify and locate leaks ▪ Identifies cracking, spalling, and joint damage ▪ **Does NOT find wire breaks**	▪ Insertion tube ▪ >=2-inch outlet	▪ Inservice	NO

Electromagnetic PCCP Inspection Technology Option 1: Pipe Diver

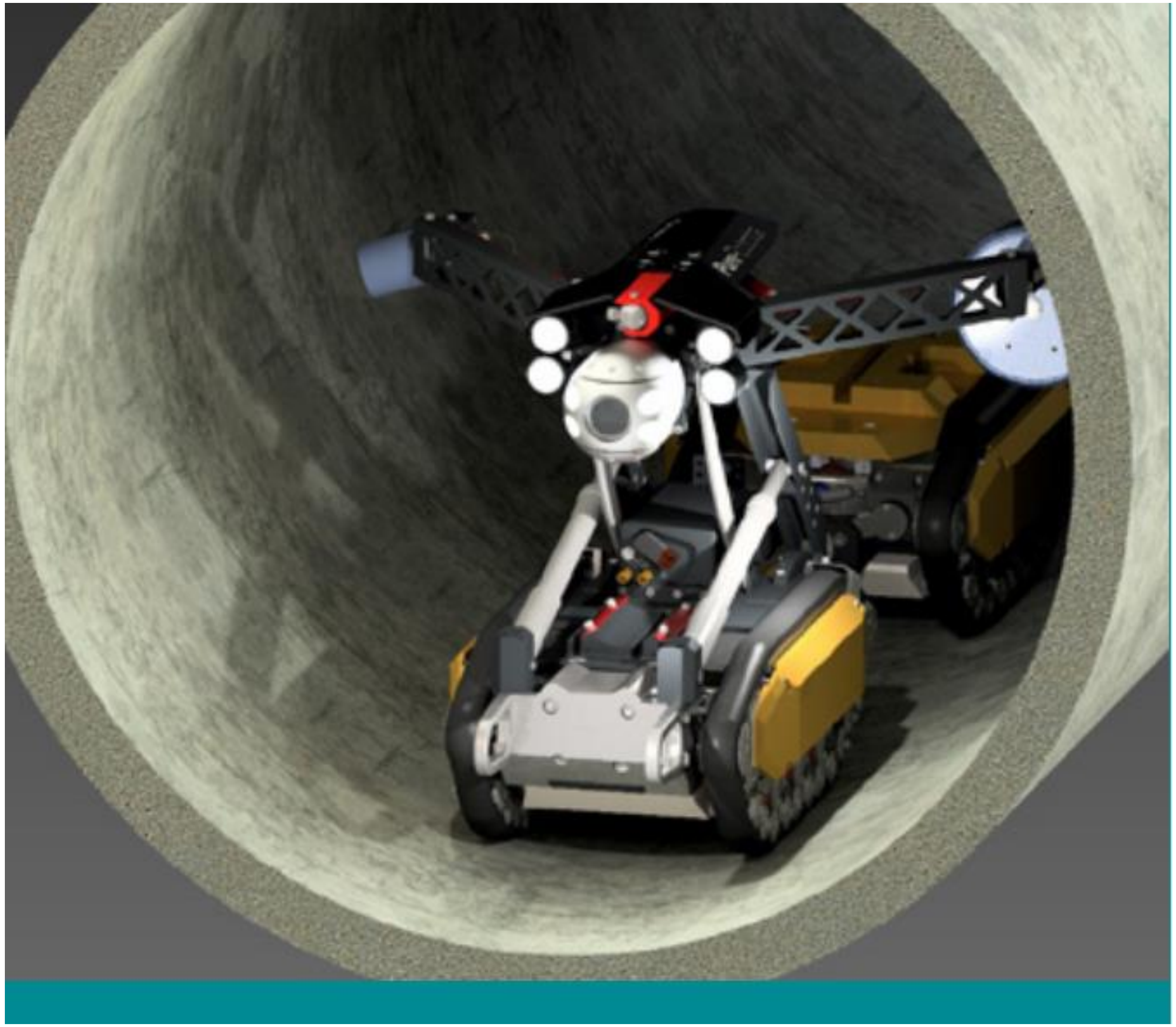
Free swimming condition assessment tool

Data obtained: Wire break data & onboard camera footage



Electromagnetic PCCP Inspection Technology

Option 2: Pure Robotics



Robotic Crawler Inspection Tool

Data obtained: Wire break data & CCTV

Pure Robotics & Pipe Diver Comparison

	PureRobotics CCTV	PipeDiver (Depressurized Entry)
Inspection Duration	5 Days	1 day
Operational Impacts	48" PCCP Offline for 5 Days minimum Full isolation Requires Installation of 5 Pipe Taps	48" PCCP Offline for 1 Day Partial isolation Requires Installation of 2 Pipe Taps
Required Dewatering	Significant dewatering effort. Multiple phases required.	Minimal dewatering required at two locations.
Length Inspected	20,247 LF	20,066 LF
Information Obtained	High-resolution electromagnetic data Wire break location & quantity Cracking, spalling and joint damage (Depending on CCTV Video Quality)	Medium-resolution electromagnetic data Wire break location & quantity Cracking, spalling and joint damage (Depending on onboard Video Quality)
Cost Estimate	$1,500,000	$1,000,000
Schedule	Requires multiple contracts, longest duration	Requires single contract, shortest duration

CIP Technology Selection

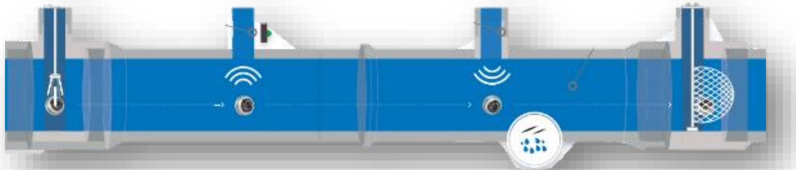
Let Failure Mode Dictate Technology Selection

Failure Mode → Technology Selection

CAST IRON

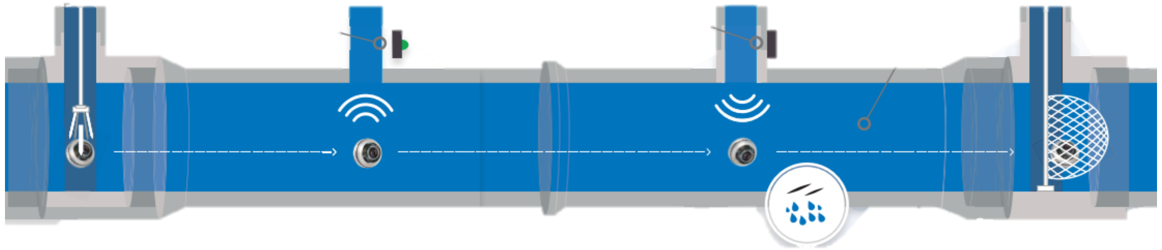
Cast Iron leaks before it fails

LEAK DETECTION INSPECTION

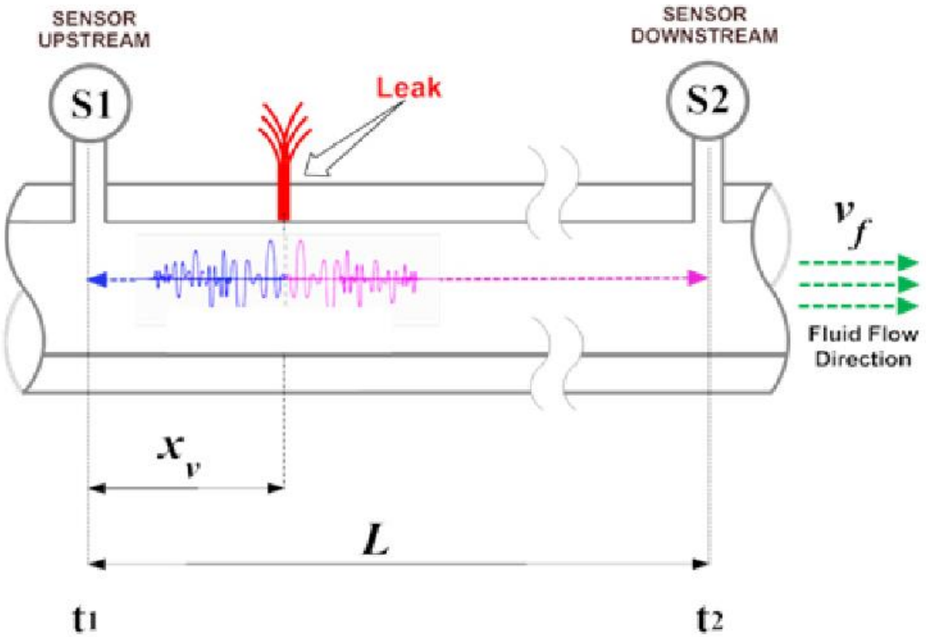


Leak Detection Platforms

- In-pipe acoustic probe
  - Pressure and flow requirements
  - **Tethered**: Can couple to CCTV
  - **Free-flowing**: Requires excavation for sensor installation; may get lost



- External acoustic correlators
  - Easy installation on existing appurtances (hydrants, valves, sampling ports)
  - Pressure requirements; not ideal near noisy areas (high traffic, pump stations)



Leak Detection Selection

External leak detection is recommended for Elyria's 20 & 30-inch CIP Transmission Mains

- Minimal operational impact
- Minimal city support

Why not internal?

- Risk of losing tool in service connections or cross connections
- Risk of tool getting caught on tuberculation
- Significant pipeline modifications
- Major system operational impacts (Dewatering, Isolation, etc.)

Valve Assessment

Valve Assessment Objectives

1. Ensure that valves required for pipeline inspection function and identify any valve replacements that may be required.

2. Gather information on existing valves for the condition assessment.

Valve Assessment Overview

48" PCCP Main – Mainline Cone Valves

20" & 30" CIP Main – Mainline Gate Valves

Valve Assessment Overview

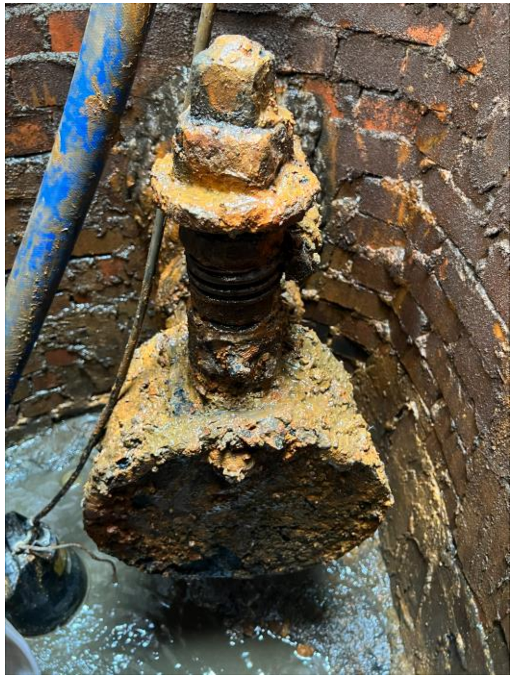
48” PCCP to 30” CIP Cross Connection Gate Valves

20” CIP to 30” CIP Cross Connection Gate Valves

PCCP Cone Valves & Cross Connection Valves

All cone valves operated very well and were in great condition.

48 – 30-inch Cross-connection gate valves also operated well



PCCP Cone Valves & Cross Connection Valves Results

Short Term Recommendations

- **No action needed prior to inspection**

Long Term Recommendations

- Continue to monitor performance of valves and exercise valves on a scheduled program.

Table 2: Condition Summary of 48-inch PCCP System Valves

Valve Type	Total Valves Inspected	Operable Valves	Inoperable Valves	High Risk Valves	Medium Risk Valves	Low Risk Valves
Water Treatment Plant Gate Valves	2	2	0	0	1	1
30-inch Cone Valves	6	6	0	0	0	6
24-inch Cross Connection Valves	6	6	0	0	0	6
Downstream Gate Valves to Distribution System	2	1	0	1	0	0
Total	**16**	**15***	**0**	**1**	**1**	**13**

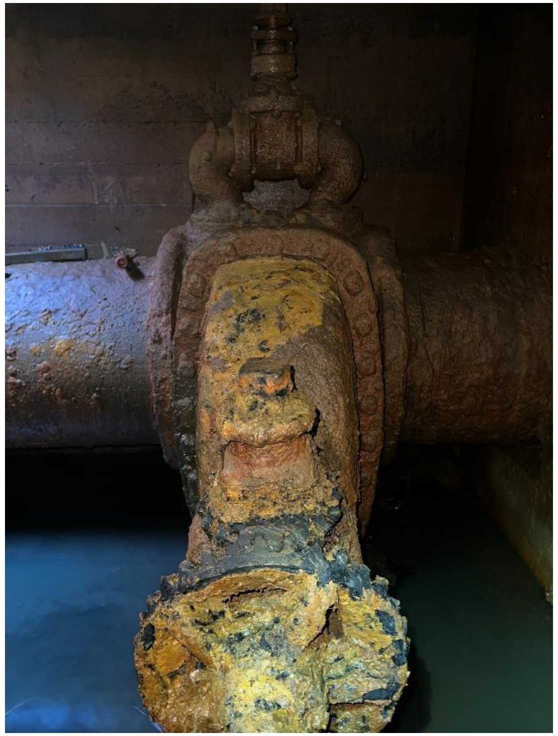
**This Quantity does not include the 36-inch gave valve which is yet to be exercised*

30-inch & 20-inch CIP Mainline & Cross Connection Valves

Valves were very corroded

Valves struggled to exercise 25% often

Some exposed gear boxes on the 20-inch CIP valves in very poor condition – did not exercise



20-inch & 30-inch CIP Valves Reults

Short Term Recommendations

- No action needed prior to inspection.

Long Term Recommendations

- Continue to exercise valves in operable condition
- Avoid exercising high risk valves identified in TM
- Replace all valves including air valves and drain valves during pipeline rehabilitation project or within 10 years.

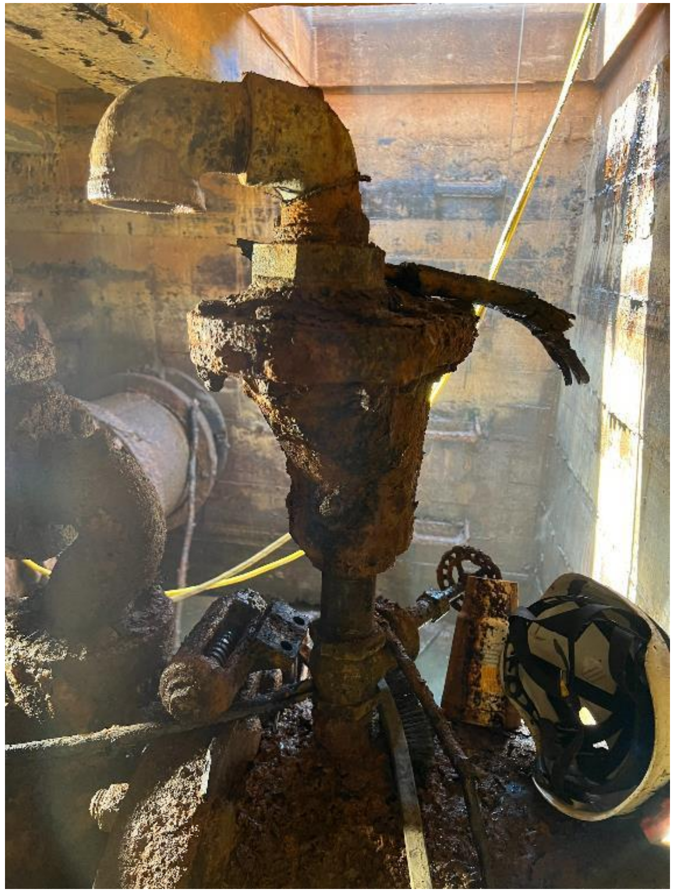
Table 3: Condition Summary of 30-inch and 20-inch CIP System Valves

Transmission Main	Total Valves Inspected	Operable Valves	Inoperable Valves	High Risk Valves	Medium Risk Valves	Low Risk Valves
30-inch CIP Main Line	17	15	2	7	10	0
20-inch CIP Main Line	11	9	2	4	6	1
30 - 20-inch Cross Connection	5	4	1	1	4	0
Total	**33**	**28**	**5**	**12**	**20**	**1**

30-inch & 20-inch CIP Air Valves

Air Valves were very corroded and in poor condition

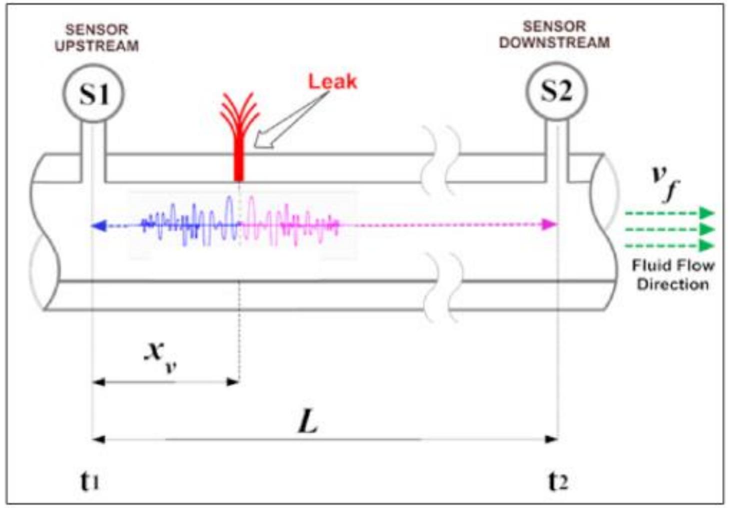
Did not operate or exercise air valves



CIP Leak Detection

CIP Leak Detection Overview

- Utilize correlator data to recommend any necessary improvements to transmission main system
- Correlators can detect acoustic leak noise at a relative location between sensors
- Sensors can be mounted on surface of pipe, appurtenances, or threaded into hydrants or air valves (hydrophone)
- General approach was to space sensors at ~1000 ft
- Utilized potholing when 1000 ft spacing between valves, hydrants, etc. could not be achieved



CIP Leak Detection Photos

CIP Leak Detection Overview: 20-inch CIP Transmission Main

23 Phases Completed ~22,000 LF Inspected

FIGURE 1: 23,000-LF, 20-inch Phase

26 Phases Completed ~26,000 LF Inspected

FIGURE 2: 25,000-LF, 30-inch Phase

Water Valve
Test Hole
Hydrant

CIP Leak Detection Results Overview

FIGURE 1: 23,000-LF, 20-inch Phase

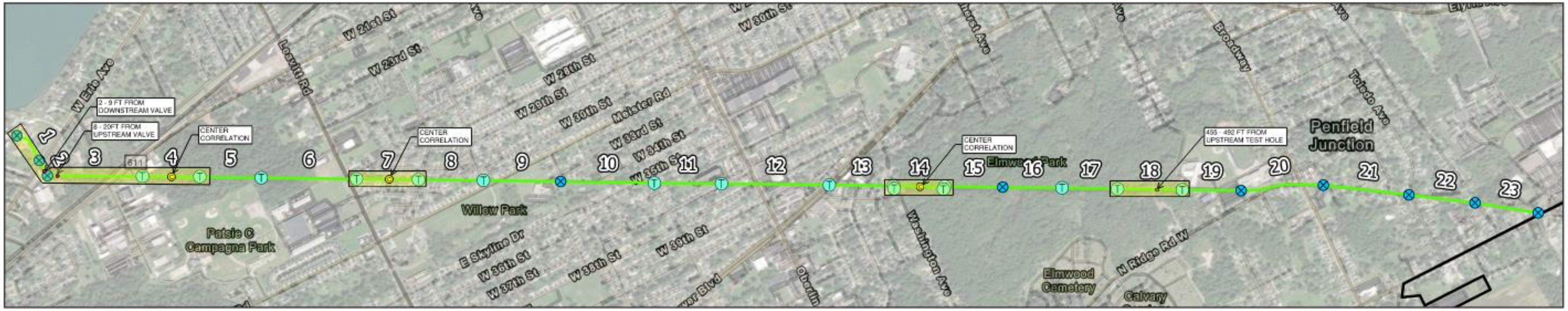
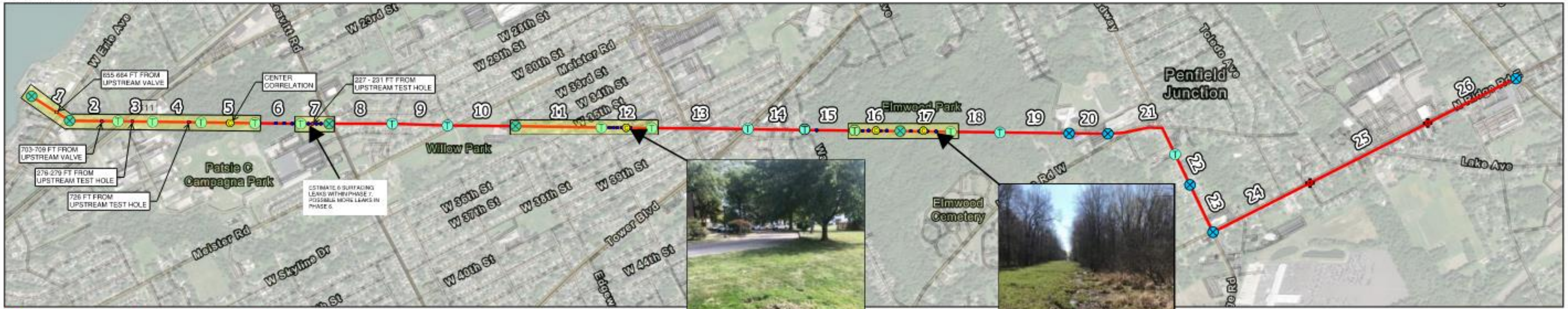


FIGURE 2: 25,000-LF, 30-inch Phase



SURFACING WATER OR SOFT WET SPOTS APPEARING EVERY 18 FEET IN THIS AREA. ESTIMATE OF 12 SURFACING LEAKS NEAR OBERLIN MANOR IN PHASE 11. NO EVIDENCE OF SURFACING LEAKS IN PHASE 12.

TYPICAL SURFACING WATER ABOVE THE 30-INCH IN RIGHT OF WAY NORTHWEST OF CLEARVIEW HIGH SCHOOL. DIFFICULT TO DETERMINE LEAKS VS. SURFACE WATER DUE TO THE GRADE IN THIS AREA. NEED TO TEST FURTER TO GET BETTER IDEA OF QUANTITY OF LEAKS.

Water Valve
Test Hole
Hydrant
PHASES CORRELATORS IDENTIFIED CONTAINING POTENTIAL LEAKS
POTENTIAL SURFACE LEAK
CORRELATOR IDENTIFIED SINGLE LEAK
IDENTIFIED CENTER CORRELATION (>3 LEAKS)

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CIP Leak Detection Data Validation

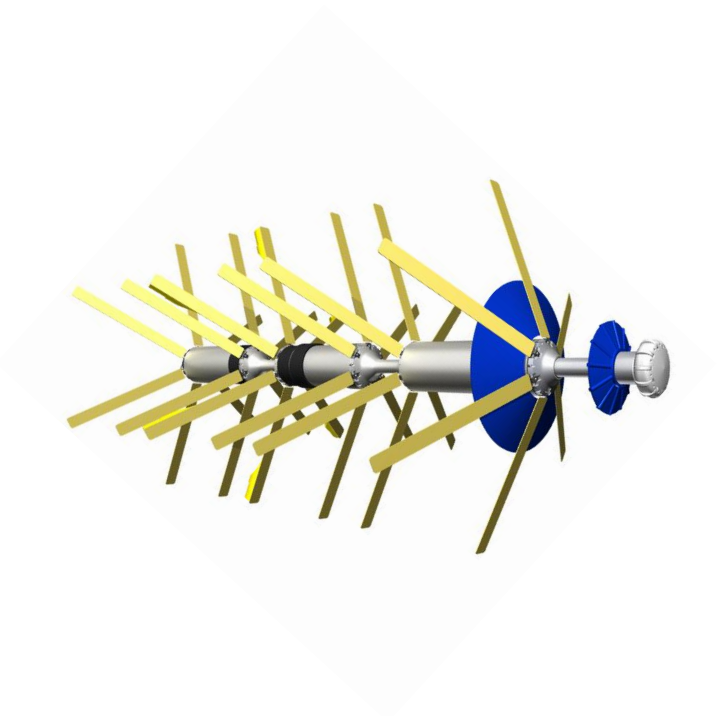
- Utilize ground mics to confirm data that was gathered by leak correlators
- Confirm areas with observed surface leaks are generating leak noise
- Testing surfacing leaks for chlorine content
- Excavation at a few sample leaks to test for chlorine, ultrasonic pipe testing for wall thickness at leak locations

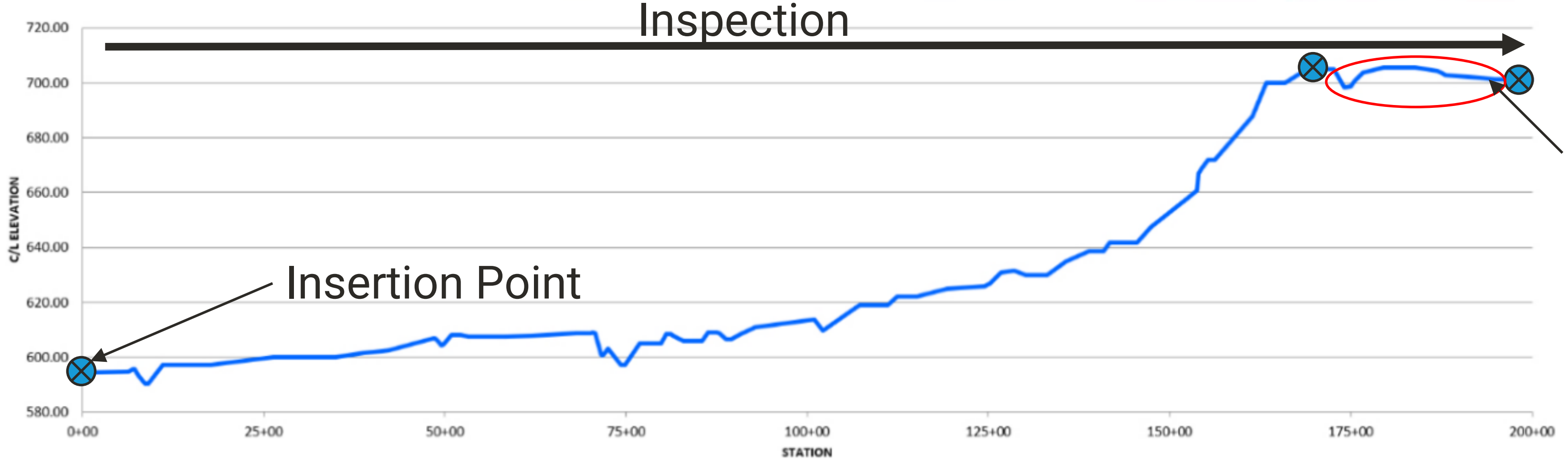
Objective:

Quantify number of leaks and locations for use in condition assessment.

PCCP Inspection

PCCP Inspection Plan Overview





Retrieval Point

Depressurize segment for retrieval

PCCP Inspection Plan Sequence Overview

Maintain supply

- Open Avon Lake Connection
- Proactively Fill Elevated Storage
- Supply water through 30 & 20-inch mains

Install retrieval net

- Isolate southern section (close valves)
- Partially dewater & remove tap blind flange
- Install retrieval device
- Reinstall blind flange, refill main, open valves

Pressurized Insertion of tool & Inspection

- Insert tool into mechanical standpipe
- Hoist & Install standpipe to tapping valve
- Open tap valve
- Release tool into pipeline & track tool at pre installed sensors
- Tool will take ~6 hours to reach the extraction point

Inspection complete & tool extraction

- Isolate southern section (close valves)
- Partially dewater & remove blind flange
- Remove tool & retrieval device
- Reinstall blind flange & refill main, open valves

Maintain water quality

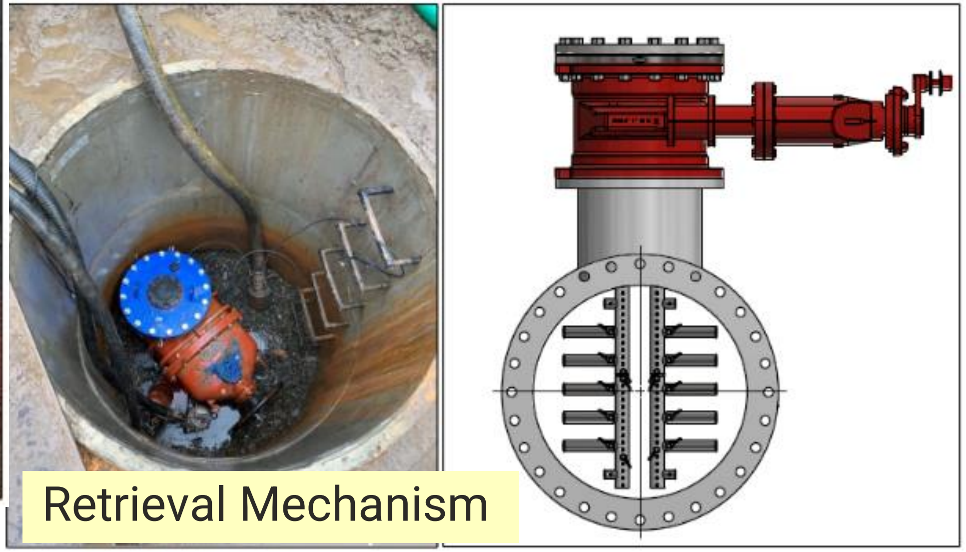
- Flush main & test for turbidity

Insertion & Retrieval of Inspection Tool

- Decided to tap pipeline to create reliable access, reducing risk and operational impact
- Pressurized insertion
- Depressurized retrieval

PCCP Tapping

Pressurized Insertion Standpipe



Retrieval Mechanism

MOPO Overview (Maintenance of Plant Operations)

Step by step procedure for execution of inspection and operational activities broken down into the following:

1. Maintaining Supply
2. Retrieval Mechanism Setup
3. Pressurized Insertion/Inspection of Main
4. Retrieval of Inspection Tool
5. Flushing

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48" PCCP Electromagnetic Inspection
Shutdown & Inspection MOPO

Date MOPO submitted:	1/9/2024
Project Start Date	6/4/2024
Approximate Duration	35 Hours

DRAFT

City of Elyria - 48-inch PCCP Transmission Main		MOPO written by:	Adam Covey (Black & Veatch)
Pipe length/volume:	3.9 miles of 48 inch, 2.0M gallons	Phone:	440-785-8868
Site/Location:	3628 W Erie Ave, Lorain, OH 44053 to Cooper Foster Park Rd, Lorain, OH	**City Project Manager**	**Stephen Canfield**
PROJECT #:	**414869**	Phone:	440-935-3012

Pre-work Items

	Activity	Start Time	Date	City of Elyria / Black & Veatch / Pure Technologies

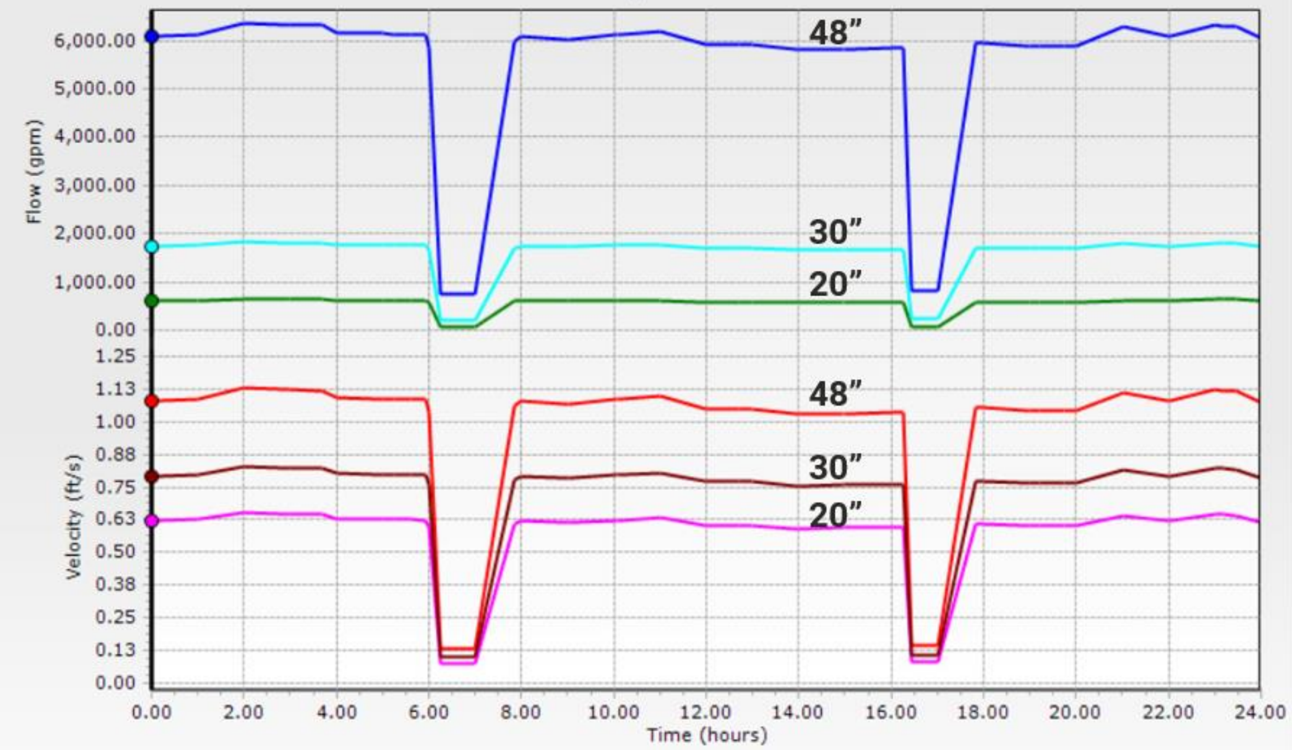
Retrieval Net Set Up

Item	Activity	Start Time	Date	City of Elyria / Black & Veatch / Pure Technologies
1	**To Maintain Supply and Flush a Dead End Main** Begin flushing hydrants on Avon Lake Interconnection	7:00 AM	Tuesday, June 4, 2024	**City of Elyria Crew 1 (Crew Contact Name XXX-XXX-XXXX)**
2	Slowly open 20" and 24" gate valves to open the Avon Lake interconnection line and confirm interconnection is open	7:15 AM	Tuesday, June 4, 2024	**City of Elyria Crew 1 (Crew Contact Name XXX-XXX-XXXX)**
3	Begin flushing hydrant west of W Ridge Rd & Milan Elyria Rd intersection **Completed Maintaining Supply Measures**	7:45 AM	Tuesday, June 4, 2024	**City of Elyria Crew 1 (Crew Contact Name XXX-XXX-XXXX)**
4	**Begin Isolation of Southern Retrieval Section** - Slowly close 36" BFV (Butterfly Valve) at Middle Ridge Rd and Old West Ridge Rd. Allow at least 10 minutes to close	8:00 AM	Tuesday, June 4, 2024	**City of Elyria Crew 2 (Crew Contact Name XXX-XXX-XXXX)**
5	Slowy close 36" gate valve south of Cooper Foster Park Rd. Allow at least 10 minutes to close **Completed Isolation of Southern Retrieval Section**	8:30 AM	Tuesday, June 4, 2024	**City of Elyria Crew 4 (Crew Contact Name XXX-XXX-XXXX)**

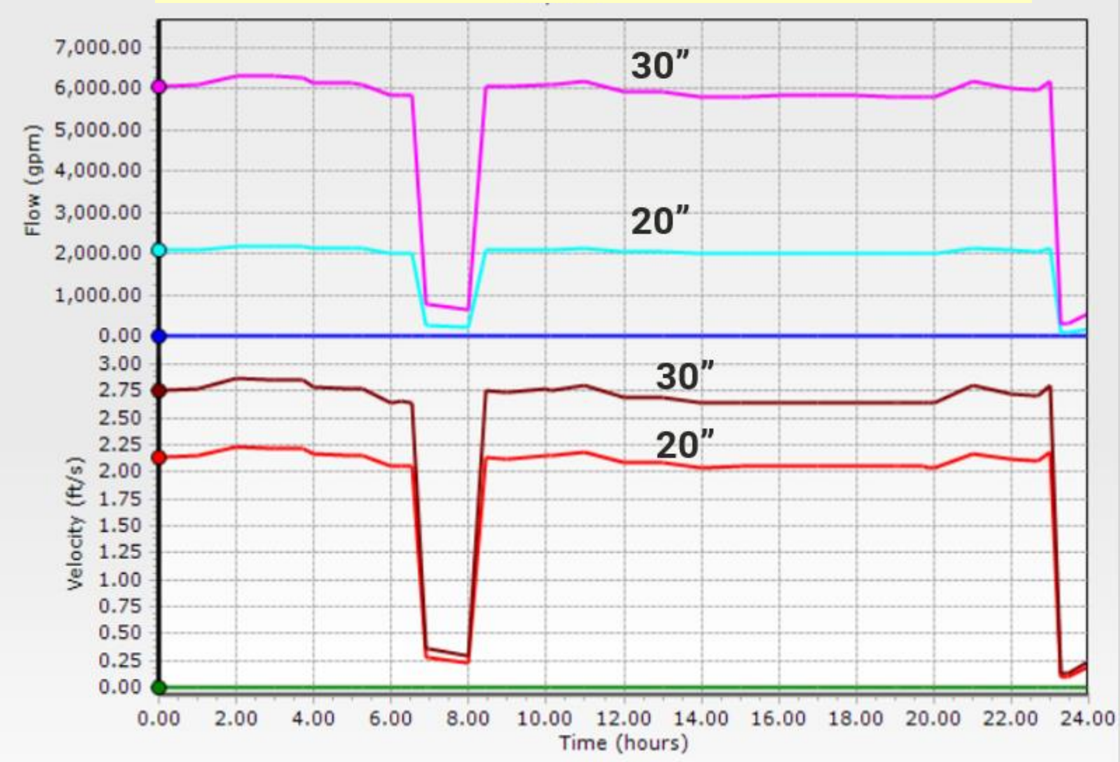
Hydraulic Planning

- Modeling scenarios – Taking 48" PCCP Transmission main offline for 8 – 24 hours
- Desired flow velocity for inspection tool: 1-2 ft/s
- Evaluation of opening interconnection with neighboring city to supplement taking 48" offline temporarily
- Determine min/max achievable flows

Average Demand of Transmission Main System



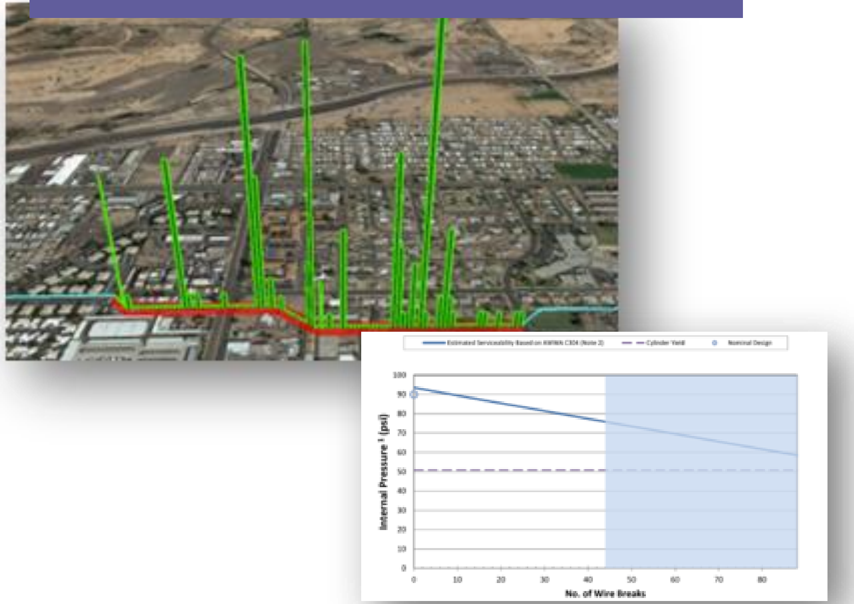
Average Demand w/ 48" Out of Service

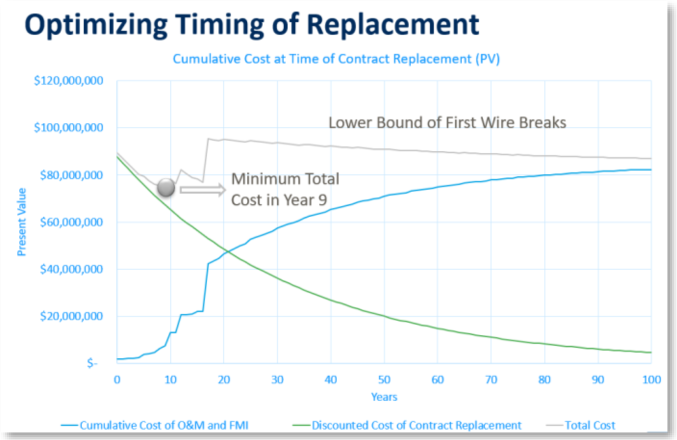


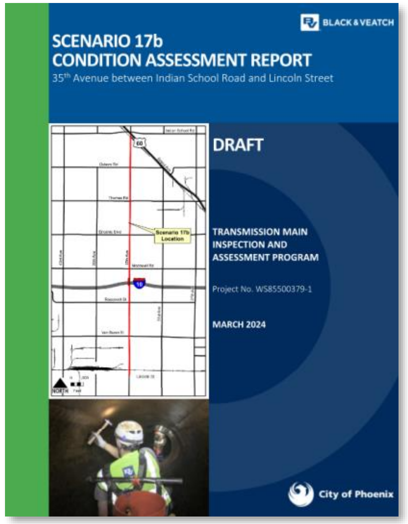
PCCP Inspection Objectives

- Obtain wire break data to complete structural analysis of pipe
- Determine expected useful life of pipeline

DETAILED ANALYSIS ➕ PERFORMANCE MODELING ➡ RECOMMENDATIONS







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Overall Transmission Main System Recommendations

Next Steps:
Overall Transmission Main System Recommendations

- Summarize Inspection Results
- Utilize data collected from:
  - Valve Assessments
  - CIP Leak Detection
  - PCCP Inspection
  - Past Records & Reports
- Provide recommendations for future inspection, repair and maintenance
- Provide alternatives analysis for rehabilitation or replacement
- Provide recommendations for future capital improvement projects

Special Thanks to…

Sam F. Jacob – Water Team Leader
Dave Rothgery – Water Distribution Operations Manager
Sam W. Jacob – Water Distribution
Kathy McKillips – City Engineer
Stephen Canfield – Water Distribution Operator

THANK YOU

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Senior Engineering Manager

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