Assessment of a Leaky Transmission Main

ASSESSING AND DEVELOPING OPTIONS TO REDUCE VULNERABILITY OF AGING CRITICAL INFRASTRUCTURE

CITY OF Salem AT YOUR SERVICE

MSA

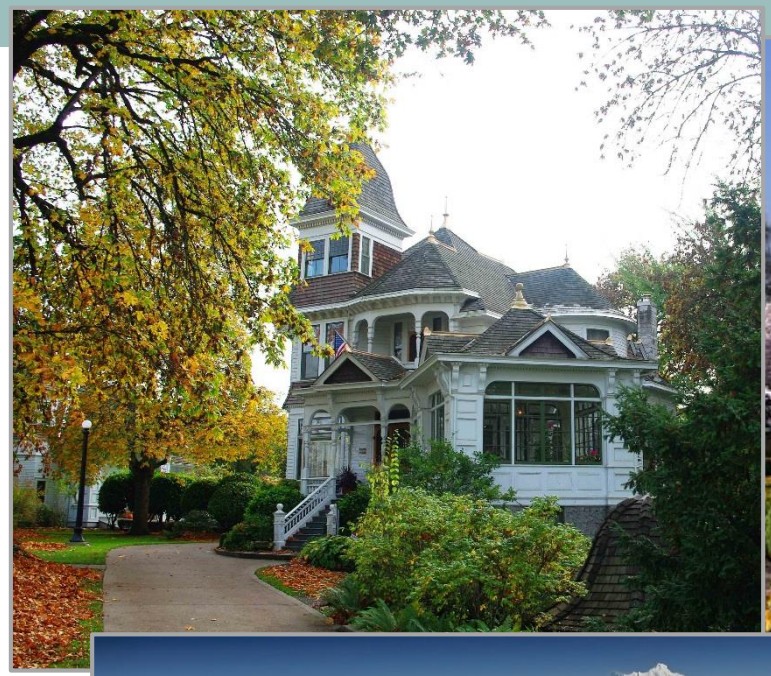
Presented by
Jeff Jones, PE

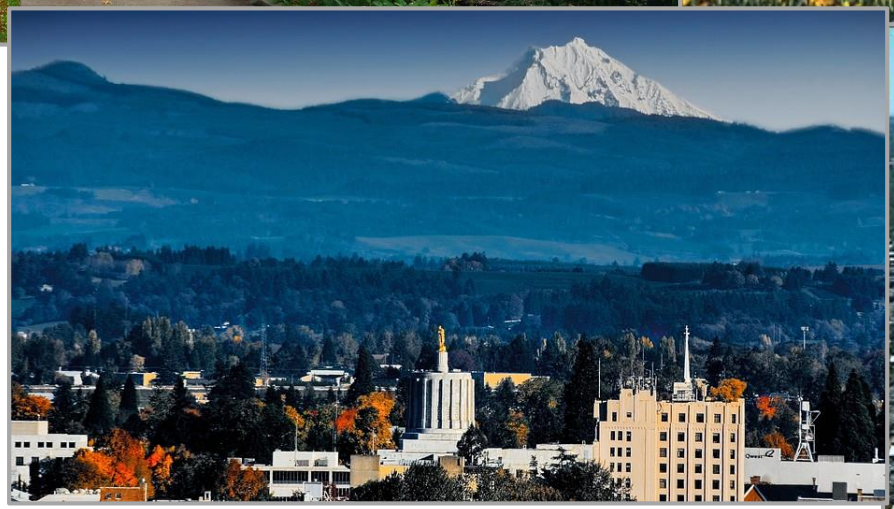
American Water Works Association
Pacific Northwest Section

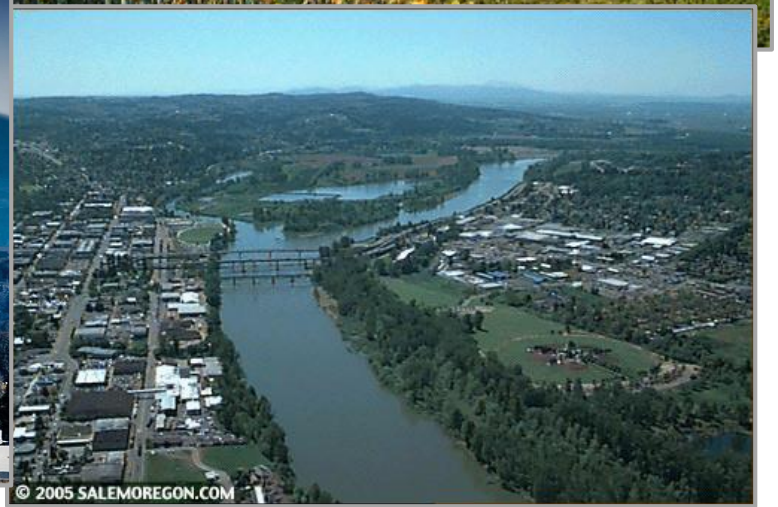
PROBLEM STATEMENT:

- **Problem:**
  - City of Salem's Line 1, a 80 year old transmission main, leaks and has a reoccurring need to repair leaking pipe joints.
- **Wanted:**
  - Inspect and evaluate Line 1.
  - Recommend improvement/replacement options.
  - Prioritize sections of transmission main to rehabilitate.

SALEM, THE "CHERRY CITY" AND OREGON'S CAPITOL







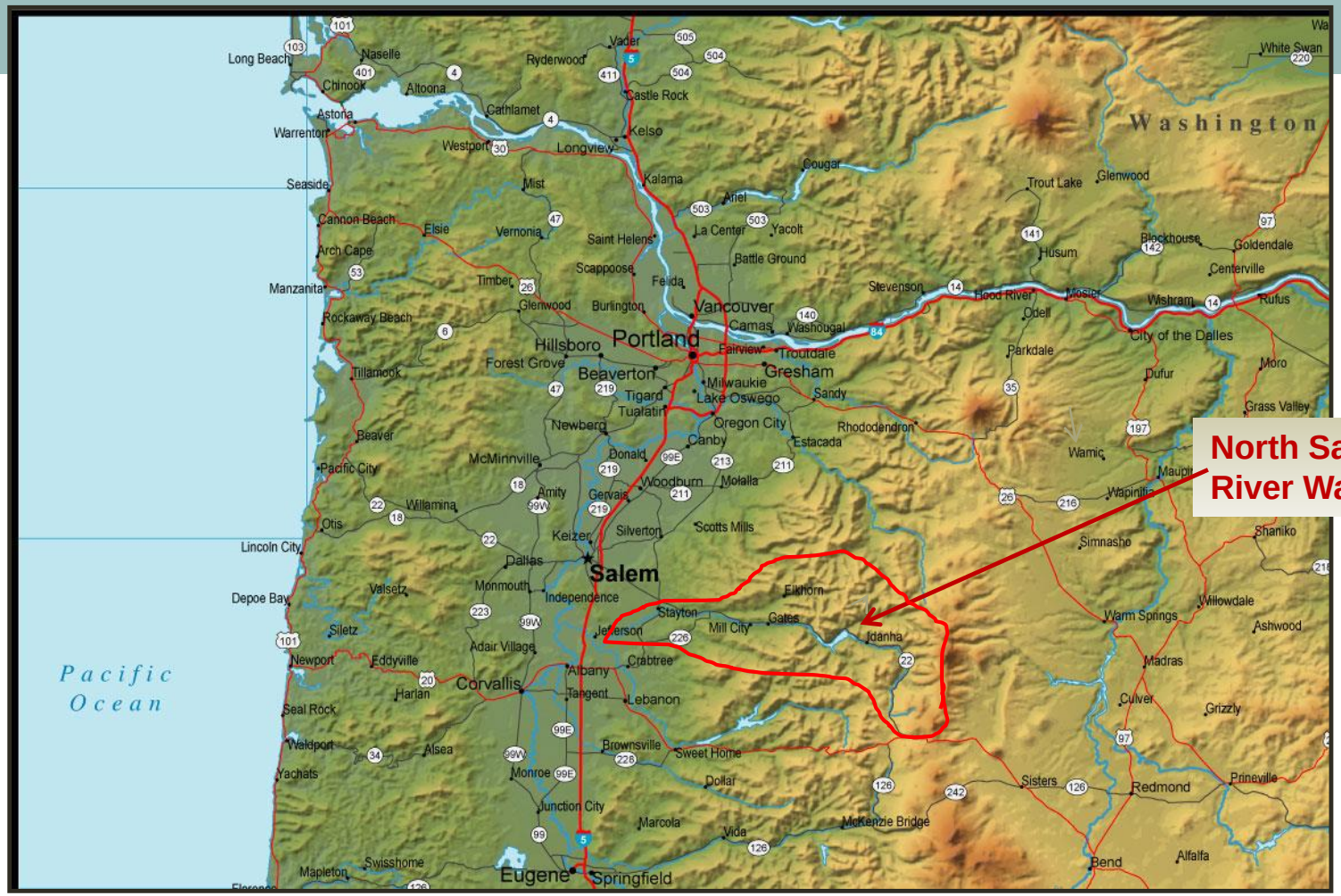
Where Does Salem's Water Come From?

Salem's Water System

Serving a population of 189,000 daily from the North Santiam River Watershed

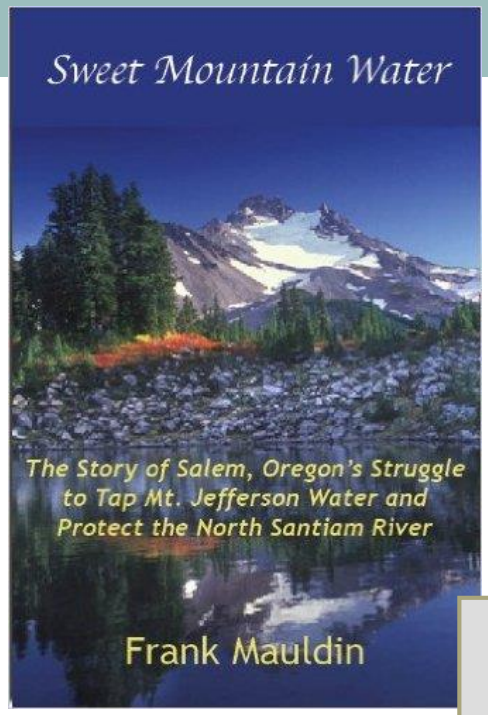
- North Santiam River is Salem's Drinking Water Source
- Intake and Treatment Plant Located on Geren Island near Stayton.
- Water is conveyed by gravity approximately 11 miles from plant to Franzen Reservoir
- Transmission system consists of 69-inch, 54-inch and 36-inch supply transmission mains with 75 MGD capacity.

BACKGROUND: DRINKING WATER SOURCE

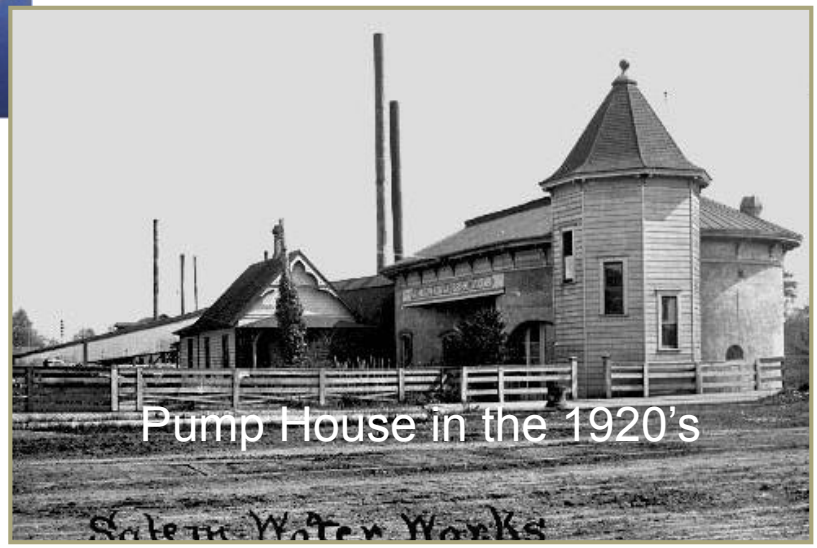


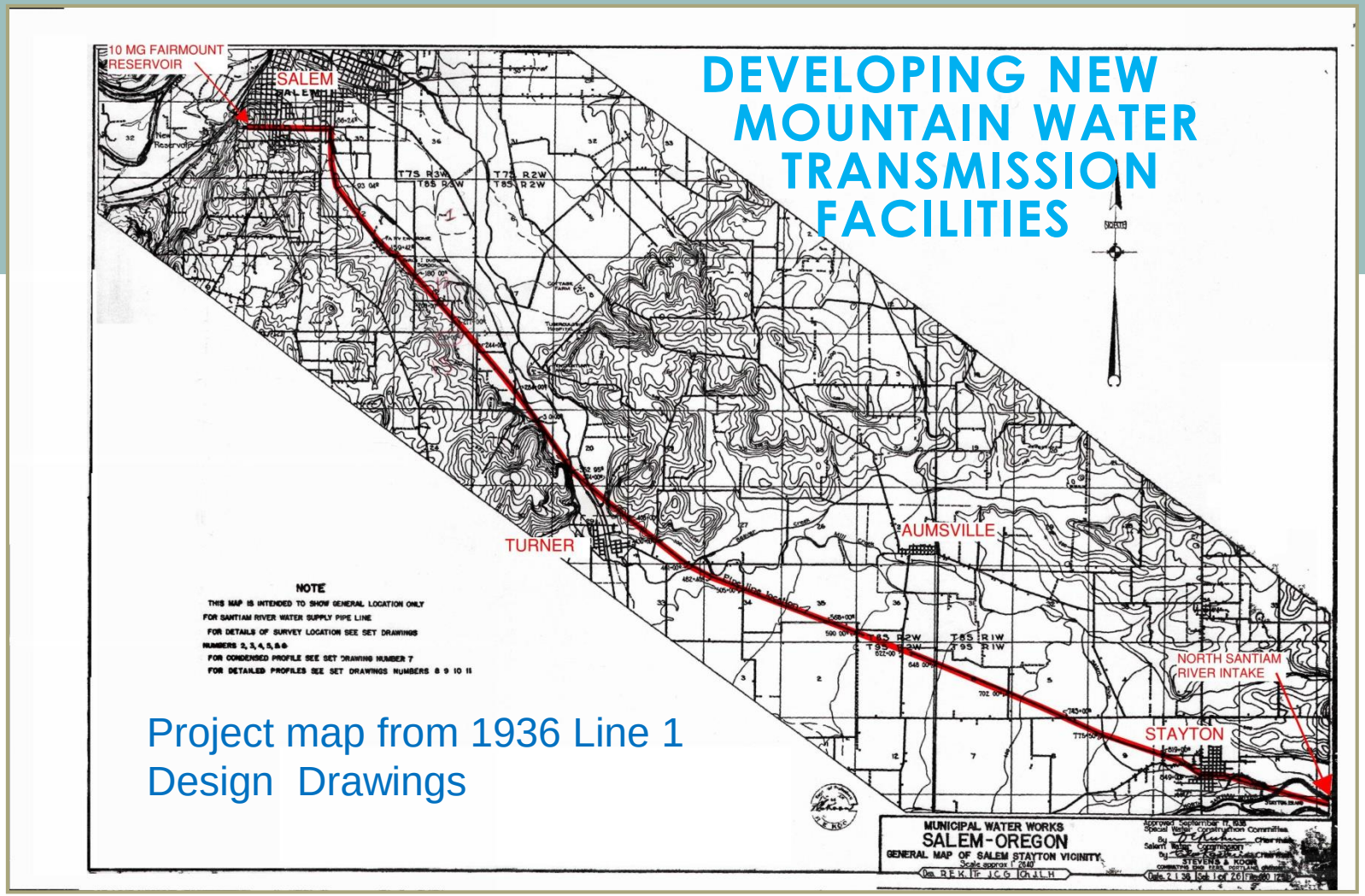
- South Santiam River is a Tributary of the Willamette River

A LITTLE HISTORY OF SALEM WATER

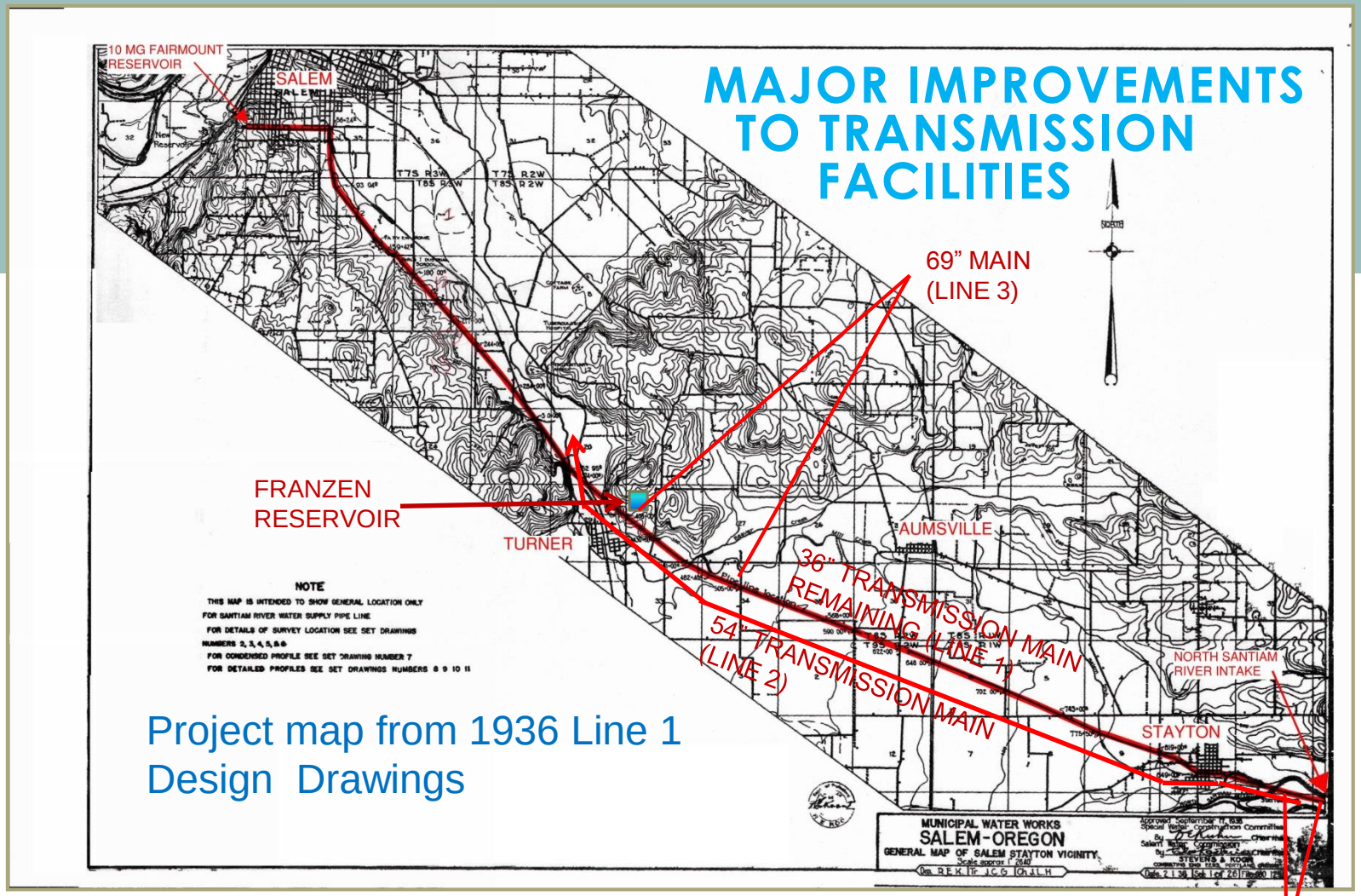


- Prior to the 1930's, Salem's drinking water source was the Willamette River
- Early 1930's City takes over private water system
- 1936 City developed plans to tap "Mountain Water" from the North Santiam River



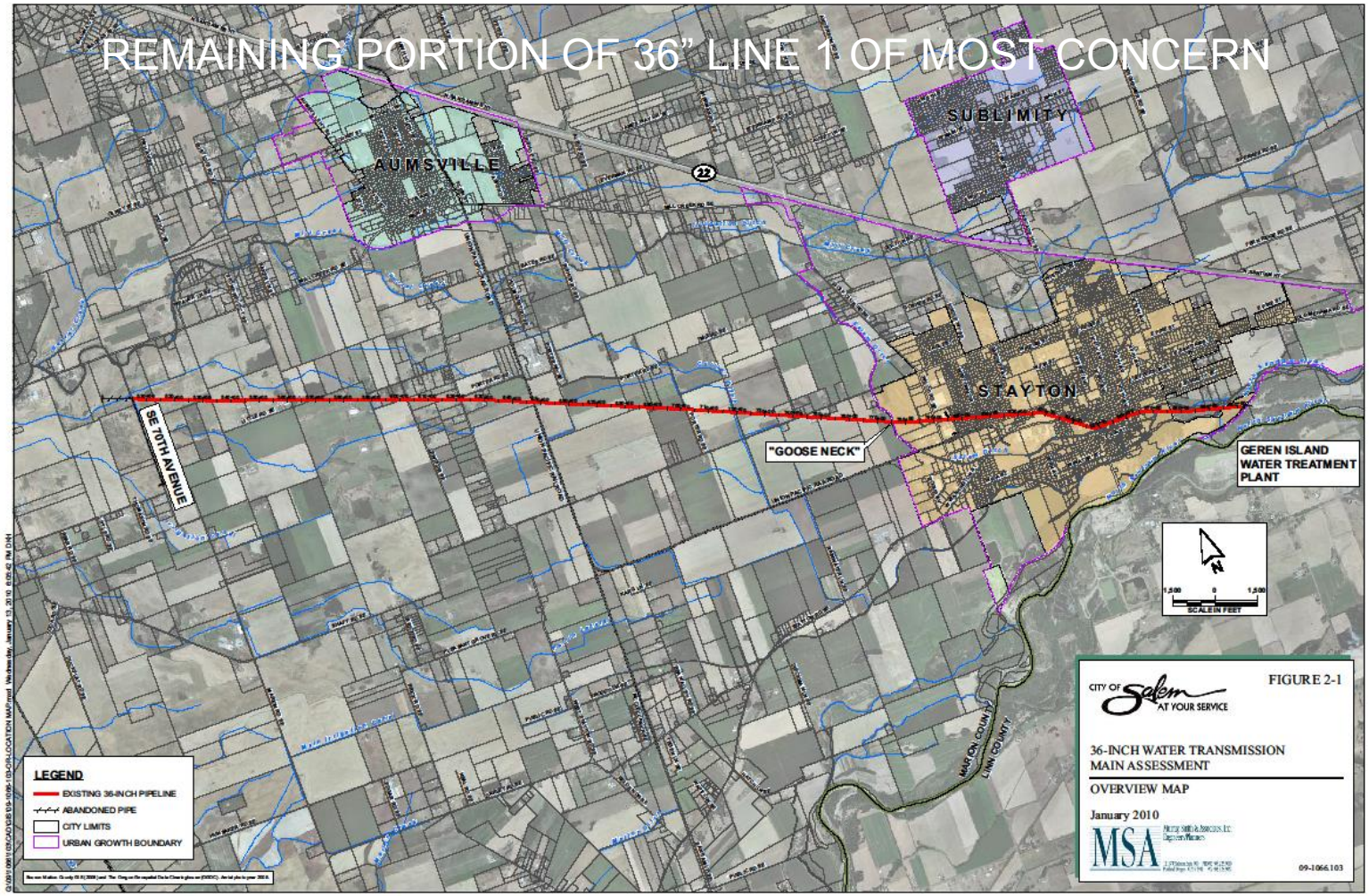


- Approximately 16 miles of Line 1 constructed in 1937



- 100 MG Franzen Reservoir near Turner in 1952 with a control valve station
- 54-inch diameter Line 2 was constructed in 1958
- Portions of Line 1 replaced with 69-inch diameter pipeline in phases starting in 2003

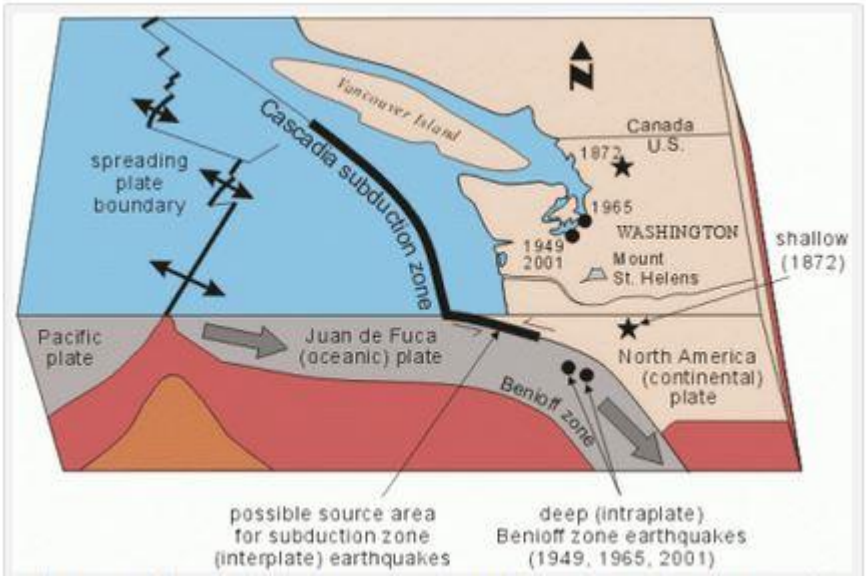
REMAINING PORTION OF 36" LINE 1 OF MOST CONCERN



- Due to water right and funding issues, remaining phases of 69-inch transmission main on hold.
- City concerned about reliability of remaining 7.5 miles of Line 1.

SO, CRITICAL TRANSMISSION MAIN WITH LEAKING JOINTS AND THEN THERE IS THE FORECASTED SUBDUCTION ZONE EVENT

Growing concern about the Cascadia subduction zone



- In the 1980's, geologists identified the Cascadia subduction zone as an active fault that poses a major geological hazard to Oregon
- Oregon's building codes were updated significantly in 1994 with subsequent updates to address this threat to the built environment
- Majority of the Northwest's infrastructure was constructed prior to 1994

MSA PROJECT TEAM AUTHORIZED IN AUGUST 2009 TO PERFORM EVALUATION OF LINE 1

MSA LINE 1 EVALUATION TEAM:

- Murray, Smith & Associates, Inc. (MSA)
- Cascade Corrosion Consulting Services, Inc. (CCCS)
- Bravo Environmental

LINE 1 ASSESSEMENT PROJECT SCOPE

- Review and evaluate existing info
- Excavate select areas
- Corrosion assessment of steel pipe sections
- Internal Pipeline Inspection using video
- Leakage testing using City SCADA system
- Localized leak testing using ground microphone
- Improvement Recommendations and prioritization
- Pipeline Assessment Report

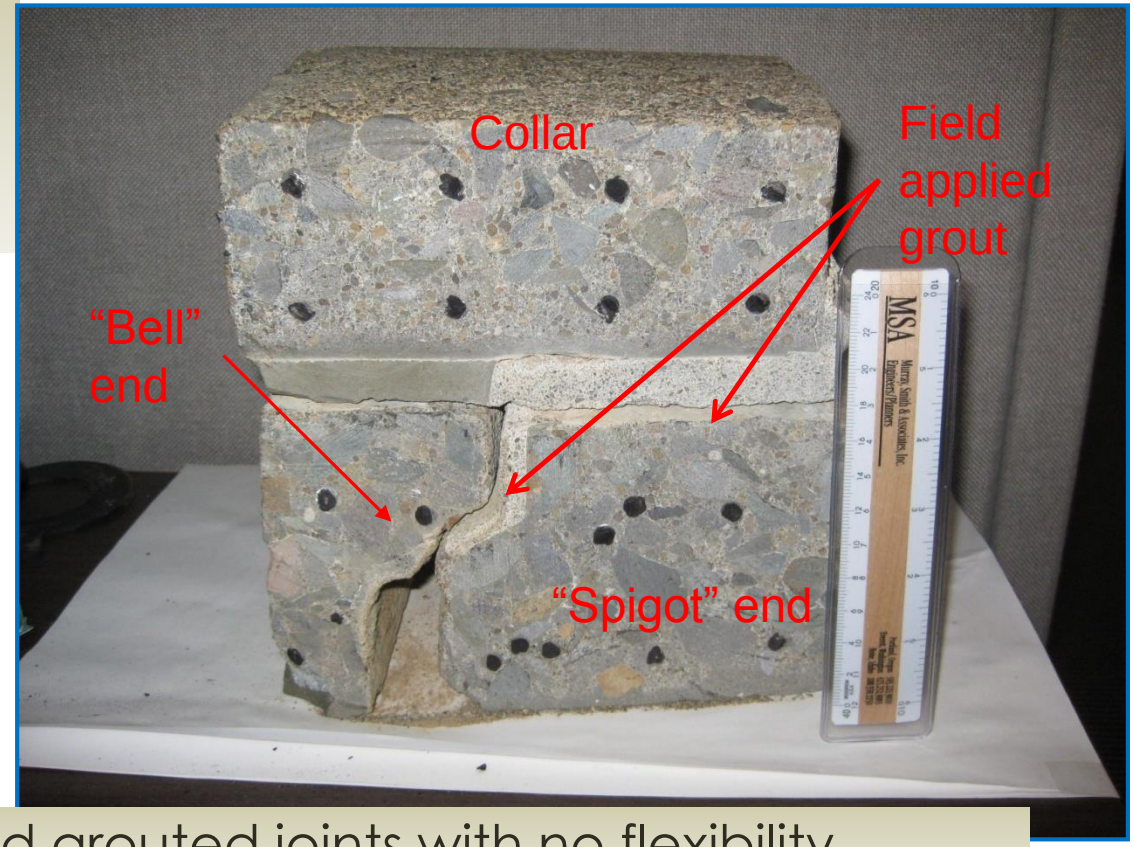
APPROXIMATELY 75% OF LINE 1 IS CONCRETE

36-inch Diameter / Reinforced Concrete Pressure Pipe / 8-foot lengths

Exterior appears sound / no exposed steel reinforcement / no spalling or cracking

EXTERNAL CONCRETE PIPE ASSESSMENT:
UNUSUAL CONCRETE PIPE JOINT CONFIGURATION

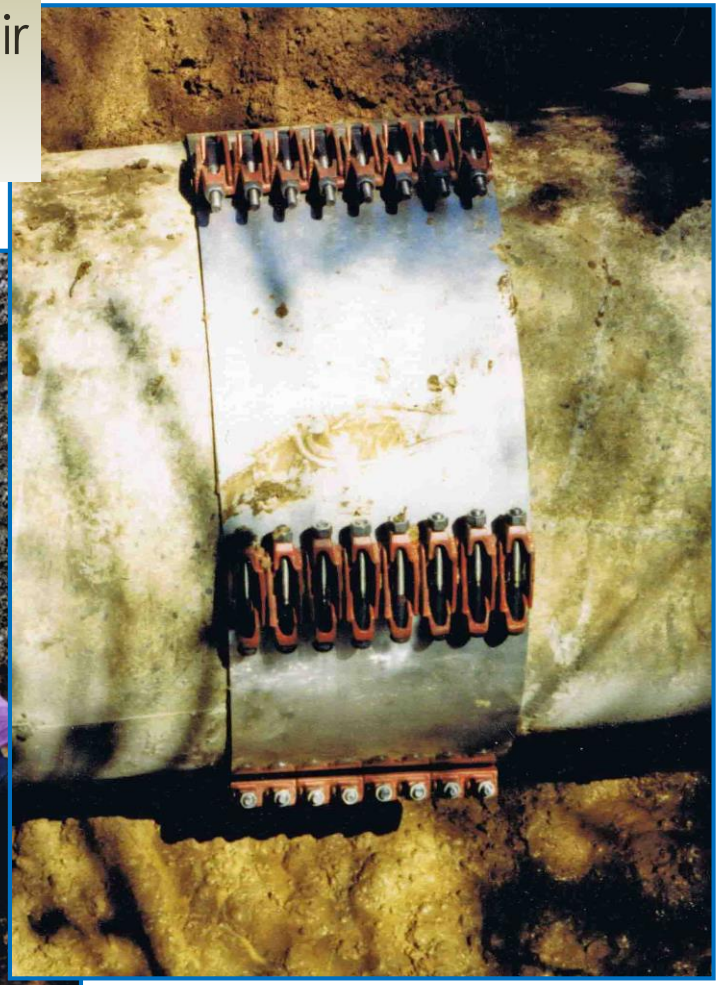
Factory installed collars to form a "bell end".



Hardened grouted joints with no flexibility.

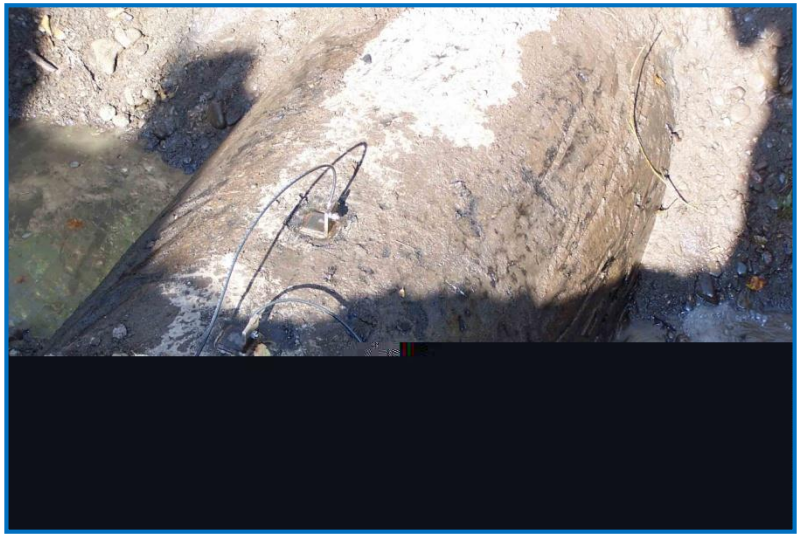
EXTERNAL CONCRETE PIPE ASSESSMENT: CONCRETE PIPE JOINTS CONSTANTLY NEED REPAIRING

City crews keep stainless steel repair sleeves on hand



25% OF LINE 1 IS WELDED STEEL

36-inch diameter / ¼-inch thick steel



Buried coated with wrapped asphaltic coal tar

Above grade coated with red primer/alkyd coating

CORROSION ASSESSMENT :
TEST STATIONS INSTALLED

Salem crews assisted in installing six test stations

George Richards of CCCS / thickness of coating and pipe walls / measuring soil properties

CORROSION ASSESSMENT OF STEEL PIPE: CORROSION TESTING

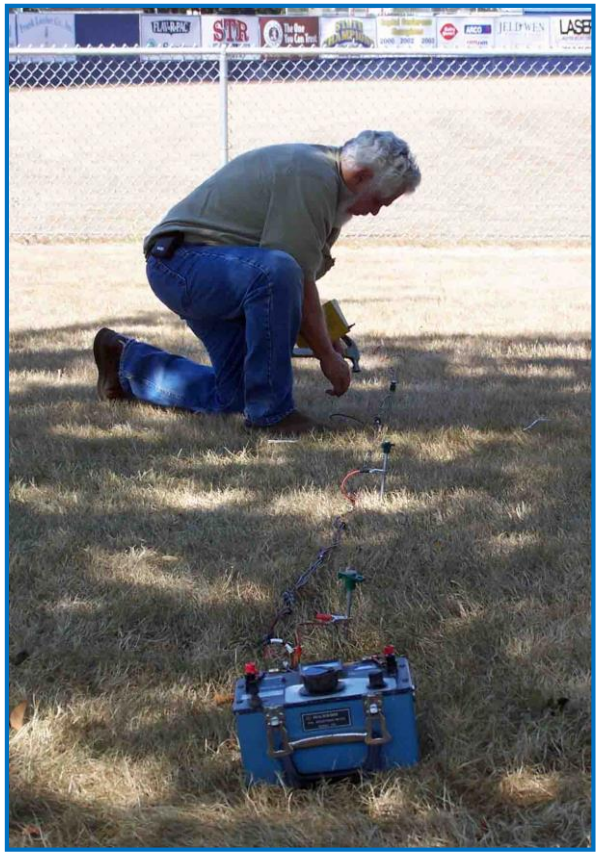
At each test station excavation, perform inspections:

- Evaluate coating
- Evaluate condition of the pipe and measure steel thickness
- Measure pipe to soil potential
- Measure Soil pH and Redox, to be used in determining soil resistivity

CORROSION ASSESSMENT OF STEEL PIPE: CORROSION TESTING

Using the test stations, CCCS performed corrosion tests:

- Pipe Continuity
- Over-the-line potential measurements to determine areas of highest corrosion



INTERNAL PIPELINE INSPECTION:
PIPE INTERIOR SURFACES FROM SECTIONS OF ABANDONED LINE 1.

Concrete pipe lining appears to be a skim coat of some kind

Steel pipe interior asphaltic coal tar lining with signs of deterioration and corrosion

6 PIPELINE ACCESS PORTS FOR VIDEO INSPECTION WITH WATERLINE DRAINED

Two new 24-inch access ports

Four existing 18-inch ports

INTERNAL PIPELINE INSPECTION
COMPLETED BY BRAVO ENVIRONMENTAL

Video cam mounted on a "Storm Drain Tractor".

Tight fit for the 18-inch access ports

INTERNAL PIPELINE INSPECTION

Locals took an interest in the operation

INTERNAL PIPELINE INSPECTION

APPROXIMATELY 14,000 FEET OF 40,000 FEET LONG MAIN WAS VIDEO INSPECTED

Steel Pipe

Concrete Pipe

INTERNAL PIPELINE INSPECTION
CONCRETE PIPING

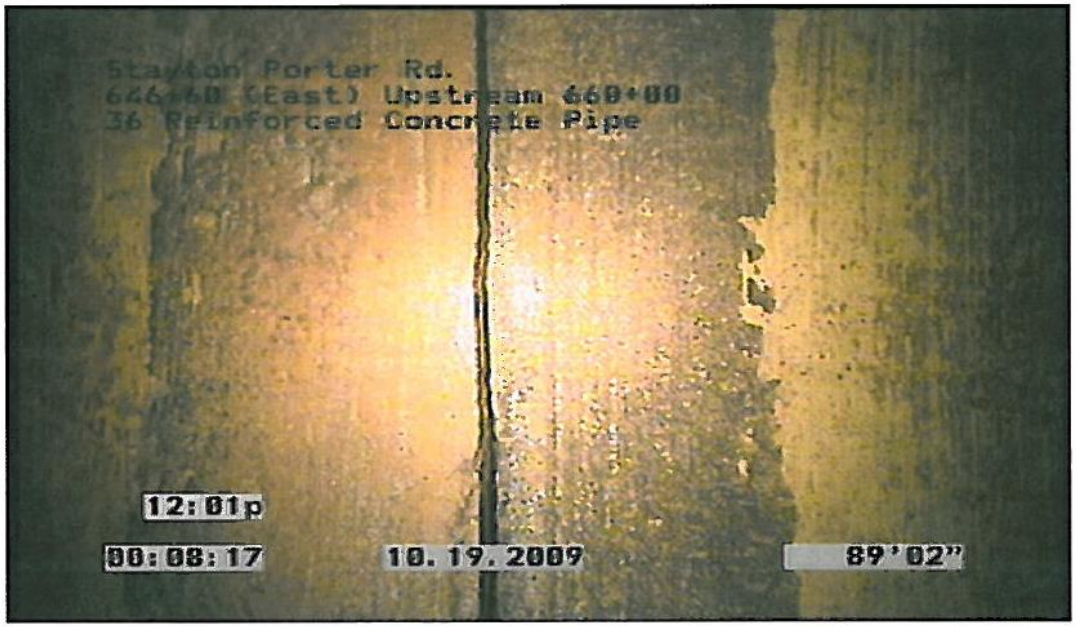


Photo: 660+00_646+60 (East)_101909_120115_A.JPG, VCR #: 10.19.09
89.06FT, Joint Separated Medium

Concrete joint separating

INTERNAL PIPELINE INSPECTION
STEEL PIPING

Photo: 570+00_560+00 (East)_102009_084320_A.JPG, VCR #: 10.19.09
166.35FT, Lining Failure Blistered, from 11 to 01 o'clock, within 8 inches of joint: YES

Lining in steel pipe at this location is failing

PIPELINE LEAK TESTING AND DETECTION

Leakage Testing

- SCADA system showed average loss of 0.94 MGD over 19 day period

Leak Detection

- American Leak Detection / concrete pipe alignment
- Ground microphones
- Surface water along the pipe alignment was tested for chlorine

ANALYSIS, FINDINGS, REHAB OPTIONS, RECOMMENDATIONS, AND PRIORITIES

36-INCH WATER TRANSMISSION MAIN ASSESSMENT
PHASE I

FOR

CITY OF SALEM

JANUARY 2010

REGISTERED PROFESSIONAL ENGINEER 16589 OREGON JULY 20, 1995 TROY L. BOWERS
EXPIRES: 12/31/11

REGISTERED PROFESSIONAL ENGINEER 18542 OREGON JULY 10, 1992 JEFFREY S. JONES
RENEWS: 6.30.2011

REGISTERED PROFESSIONAL ENGINEER 72619 OREGON JUNE 11, 2008 TAMARA S. CONNOLLY
RENEWS: 12-31-2011

Prepared by:

MURRAY, SMITH & ASSOCIATES, INC.
Engineers/Planners
121 SW Salmon, Suite 900
Portland, Oregon 97204

09-1066.103

CITY OF Salem AT YOUR SERVICE

City of Salem

36-INCH WATER TRANSMISSION MAIN ASSESSMENT – PHASE I




MSA
Murray, Smith & Associates, Inc.
Engineers/Planners

January 2010

SUMMARY OF FINDINGS: CONCRETE

- Structurally in good condition
- Pipe joints cracked and failing grout
- Ground water infiltrating
- Chlorine detected in road ditches indicating chronic leakage
- Many leaking concrete pipe joints appear at roadway and railroad crossings

SUMMARY OF FINDINGS: STEEL

- Exterior appeared to be in good condition
- Buried coal tar coating appears intact
- Minor damage from tree roots, irrigation piping, or previous excavation
- Interior surface has moderate to extensive corrosion
- Corrosive soil conditions throughout the pipe sections surveyed.

SUMMARY OF CORROSION ASSESSMENT

- **Pipe Continuity:** Confirmed through most of the steel portions except at Geren Island
- **Pipe-to-Soil Potential**:
  - Analysis showed areas of high probability of corrosion to occur
  - Western section of steel piping showed 90% probability of corrosion activity
- **Soil Resistivity, pH and Redox:** Western section of steel piping susceptible to failure due to seasonal soil corrosion or oxidation reduction corrosion

CONCLUSIONS AND RECOMMENDATIONS

- ✓ The City of Salem's 80 year old 36-inch diameter Line 1 appears to have reached the end of its service life.
- ✓ Line 1 is vulnerable to failure during a seismic event, due primarily to the grouted, non flexible, concrete pipe joints.
- ✓ Installation of an external corrosion protection system to preserve the steel pipe is recommended.
- ✓ Pipeline rehabilitation is recommended to include a combination of trenchless pipe rehabilitation systems and pipe replacement.
- ✓ Rehabilitation methods to be further evaluated during pipe rehabilitation design.

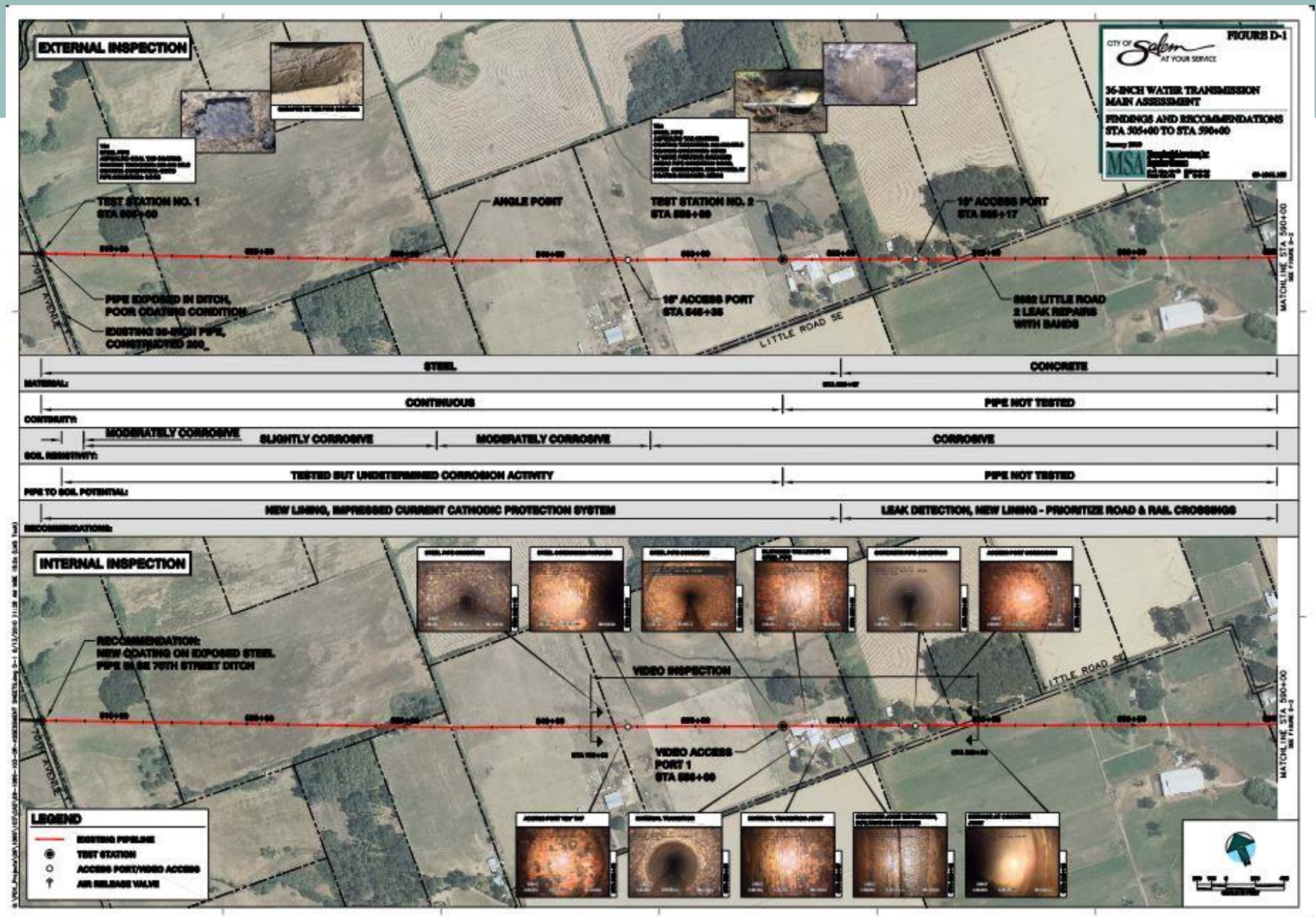
PIPE REHABILITATION OPTIONS:

- **NSF Structural Lining Technology:**
  - Sliplining methods with PVC, HDPE, or FRP
  - InsituMain by Insituform, installed similar to cured-in-place pipe (CIPP)systems
  - InsituGuard by Insituform, installed similar to sliplining methods
  - Fiber Reinforced Polymer (FRP) systems such as QuakeWrap, applied by hand

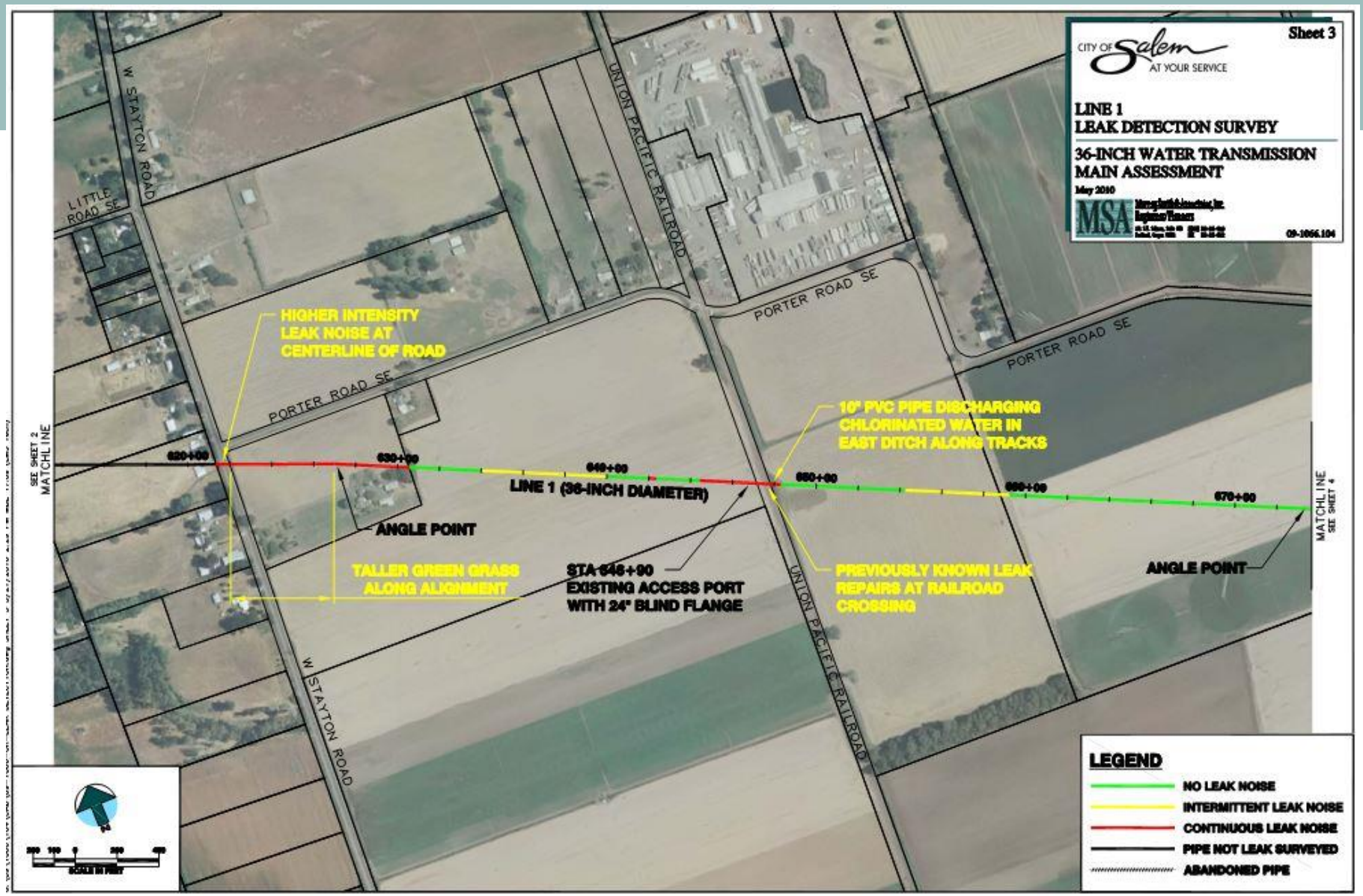
PIPE REHABILITATION OPTIONS (CONT.)

- **Non-Structural Lining:**
  - Conventional cured-in-place pipe (CIPP).
  - Cement Mortar and Epoxy Lining
- **Pipe Replacement/Realignment:**
  - Pipe replacement through long stretches of agricultural land potentially less costly than trenchless rehabilitation
  - Reroute Line 1 through the City of Stayton, locating it within the public right-of-way

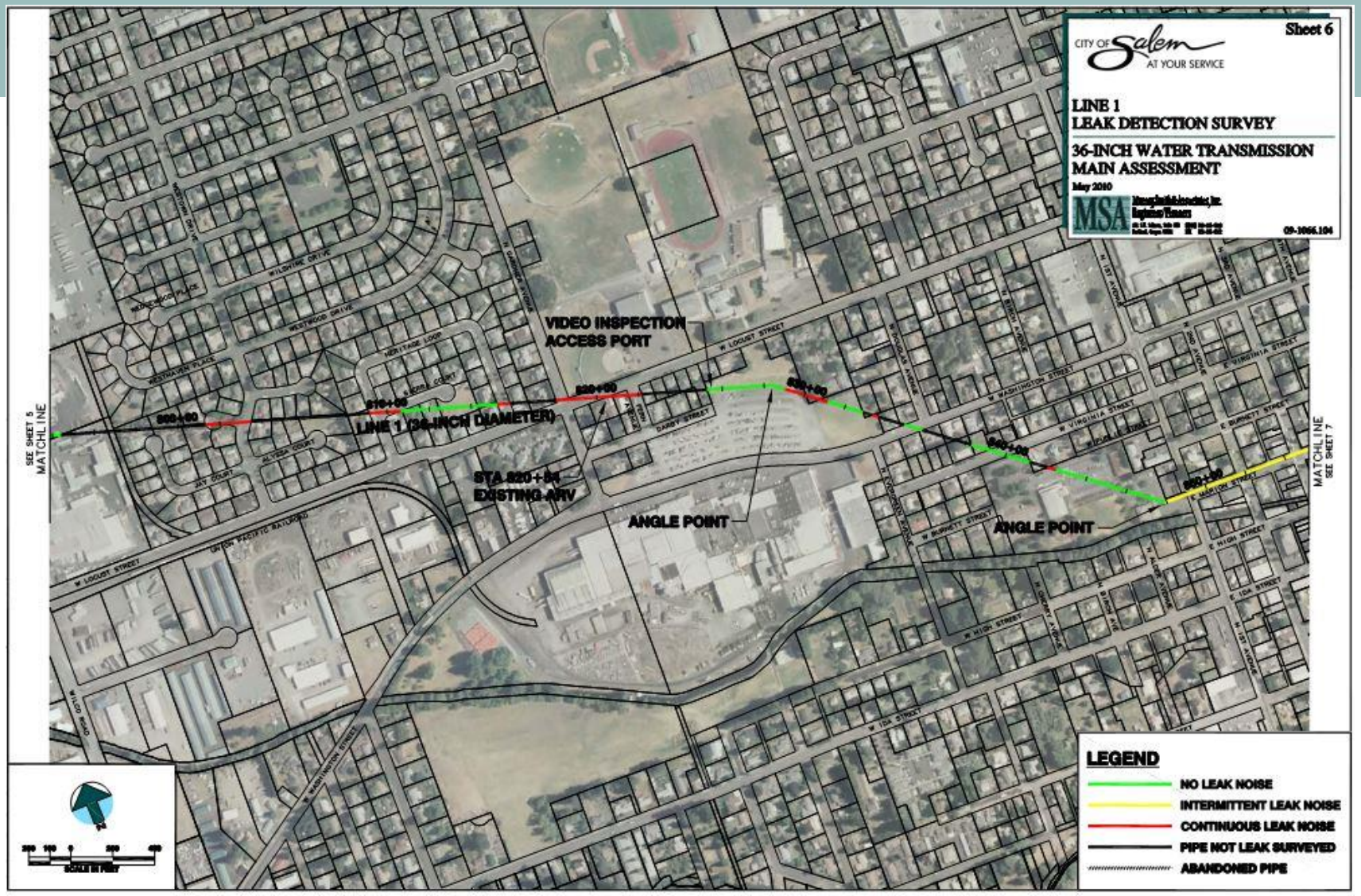
SUMMARY GRAPHICS OF TRANSMISSION MAIN ASSESSMENT AND RECOMMENDATIONS



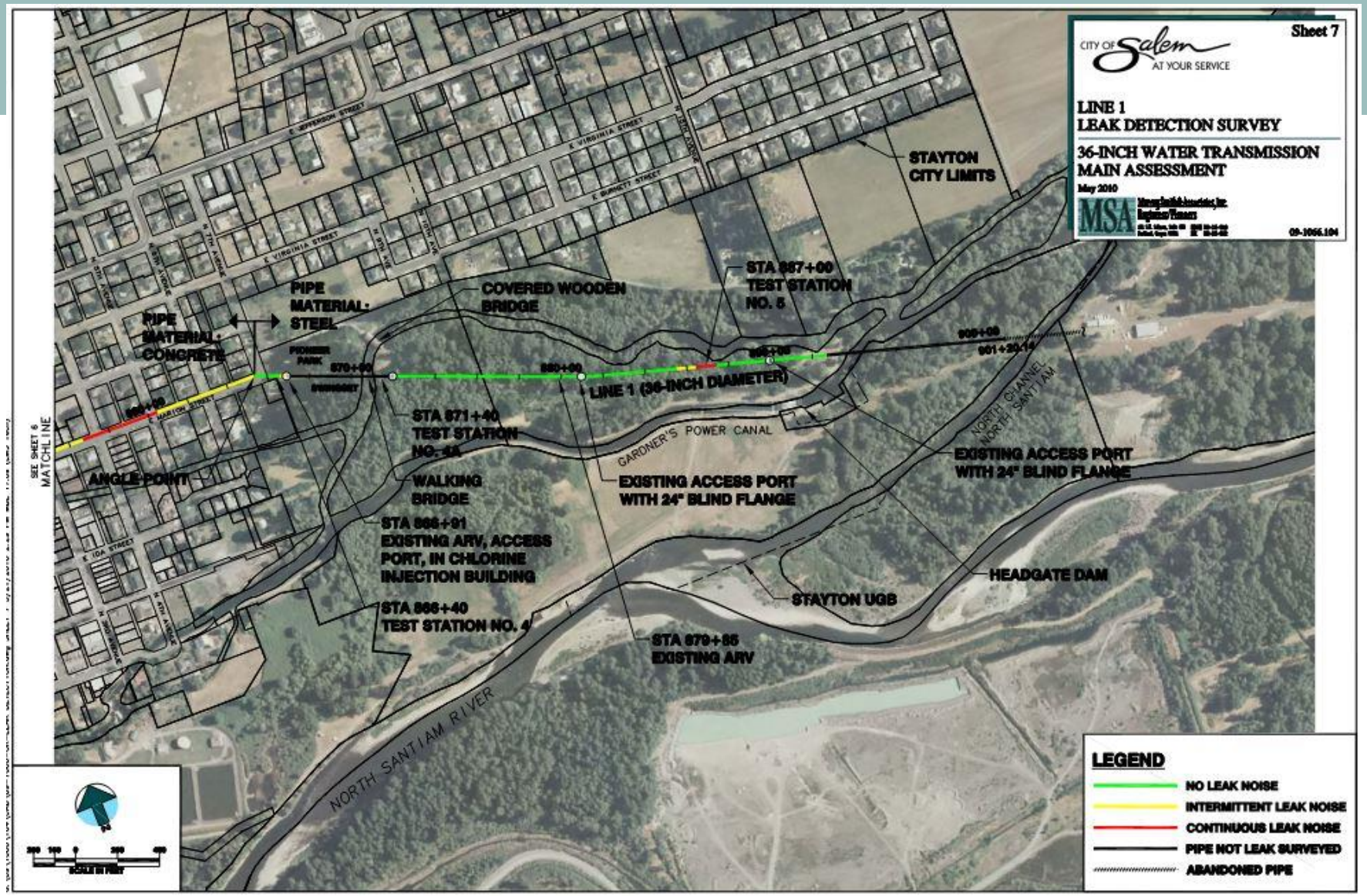
LEAK DETECTION GRAPHIC: RURAL FARM LAND



LEAK DETECTION GRAPHIC: CITY OF STAYTON



LEAK DETECTION GRAPHIC: STAYTON AND GEREN ISLAND



PIPELINE REHABILITATION PRIORITIZATION METHODOLOGY

Five criteria used for determining priority areas of pipeline rehabilitation

Relative Weight	Fixed Weight	Description
10	5	Risk to Life
9	5	Risk to Property
6	5	High Leakage Rate
6	5	Impact to Public: Economic, Traffic Disruption, etc.
5	5	Good Accessibility for Pipe Rehabilitation Work

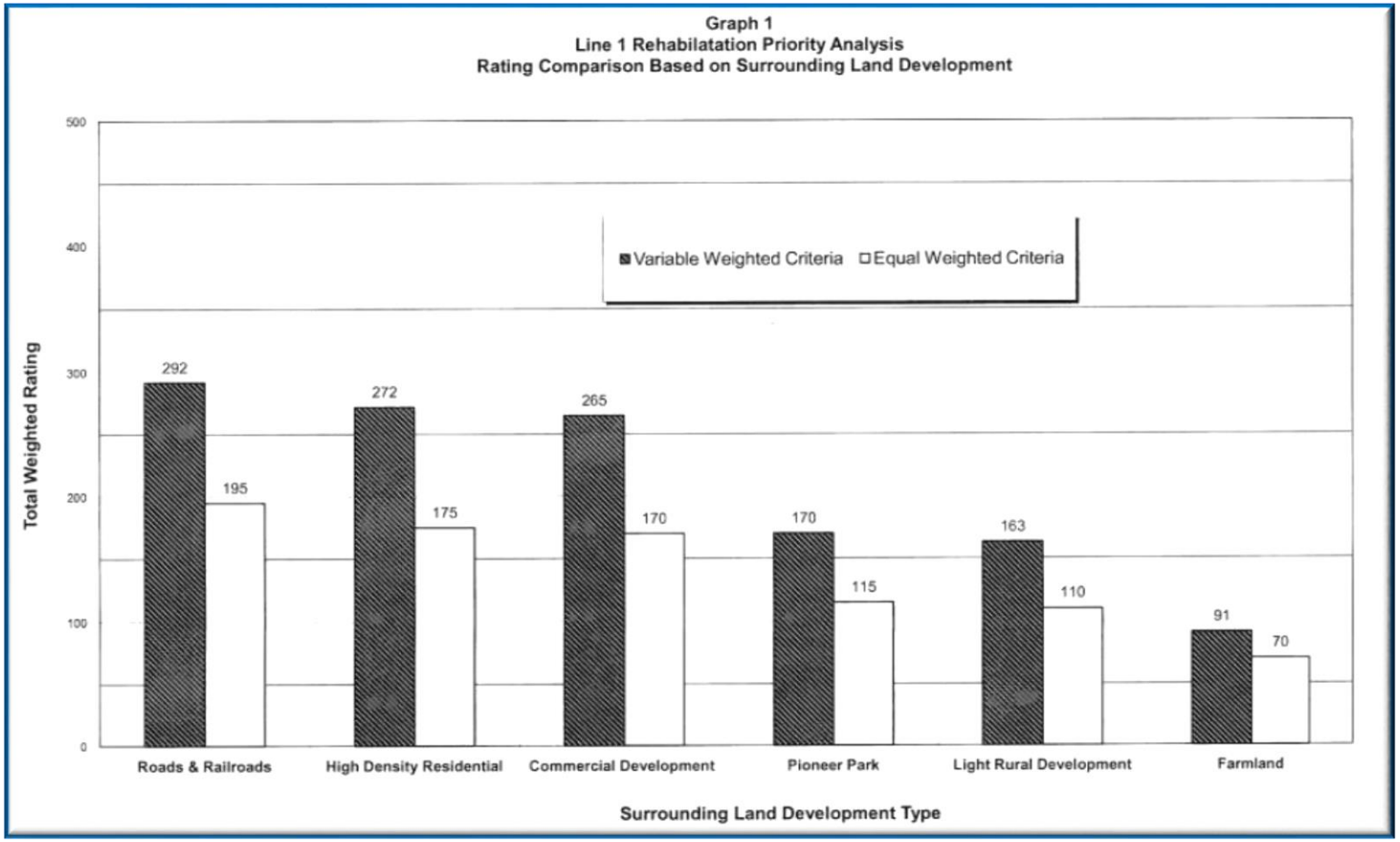
PIPELINE REHABILITATION PRIORITIZATION ANALYSIS

Two screening matrices with variable Rate and Fixed Criteria were used (variable rate matrix shown)

Table 1A
Line 1 Rehabilitation Prioritization Analysis
City of Salem
Initial Screening Matrix with Variable Rated Criteria

		Average Rating Based on Surrounding Land Development											
		Road and Railroad Crossings		High Density Residential (Stayton)		Commercial Development (Stayton)		Pioneer Park (Stayton)		Light Rural Development, Farm Structures		Farmland, Open Fields	
Total Length of Line 1 (feet)		4,665		6,000		1,500		2,640		2,435		21,401	
Number of $250k Projects		8		12		3		6		5		42	
Criteria	Relative Weight	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Risk to Life	10	10	100	10	100	9	90	8	80	7	70	2	20
Risk to Property	9	9	81	9	81	10	90	2	18	3	27	2	18
High leakage rate	6	1	6	1	6	1	6	1	6	1	6	1	6
Impact to Public	6	10	60	10	60	9	54	6	36	5	30	2	12
Good Accessibility	5	9	45	5	25	5	25	6	30	6	30	7	35
TOTAL WEIGHTED RATING			292		272		265		170		163		91

PIPELINE REHABILITATION PRIORITIZATION ANALYSIS RATING COMPARISON



PRIORITIZE LINE 1 REHABILITATION:
Prioritized List of Pipeline Rehabilitation Work

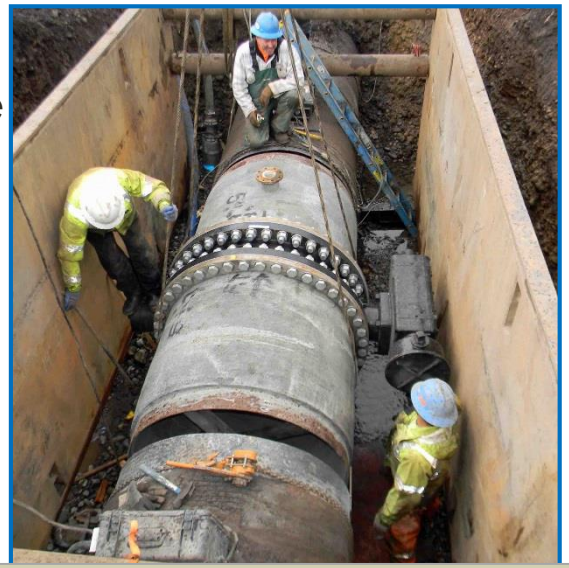
Order of Priority	Proposed Work Components
1	Line concrete pipe located under buildings and homes
2	Line concrete pipe located under roadways and adjacent to railway
3	Line remaining concrete pipe
4	Steel pipe section under railway – Interior lining and exterior cathodic system
5	Exposed steel pipe under waterways – Interior lining and exterior cathodic protection
6	Steel pipe interior lining
7	Steel pipe with coating damage in Pioneer Park (Stayton)- Exterior cathodic protection
8	Western section of steel pipe near dairy farm – Exterior cathodic protection
9	Above ground and remaining steel piping – Exterior corrosion and cathodic protection

SUMMARY

- Assessment provides the City with a thorough understanding of their supply main's condition
- Rehabilitation priorities allow the City to best manage risk, invest limited financial resources, and sustain useful function of Line 1 until City is able to replace it
- Recommended additional assessment work on Line 1 includes further analysis of the steel pipe for cathodic protection
- Recommended further examination of trenchless pipe rehabilitation options applicable to large diameter potable water transmission mains

SUBSEQUENT WORK AND CURRENT STATUS

- In 2013, isolation valves where cut into Line 1 and Line 2.



Cutting in 54-inch butterfly valves

Cutting in 36-inch butterfly valves with custom fabricated transition couplings

- City is considering their rehabilitation and replacement options for Line 1

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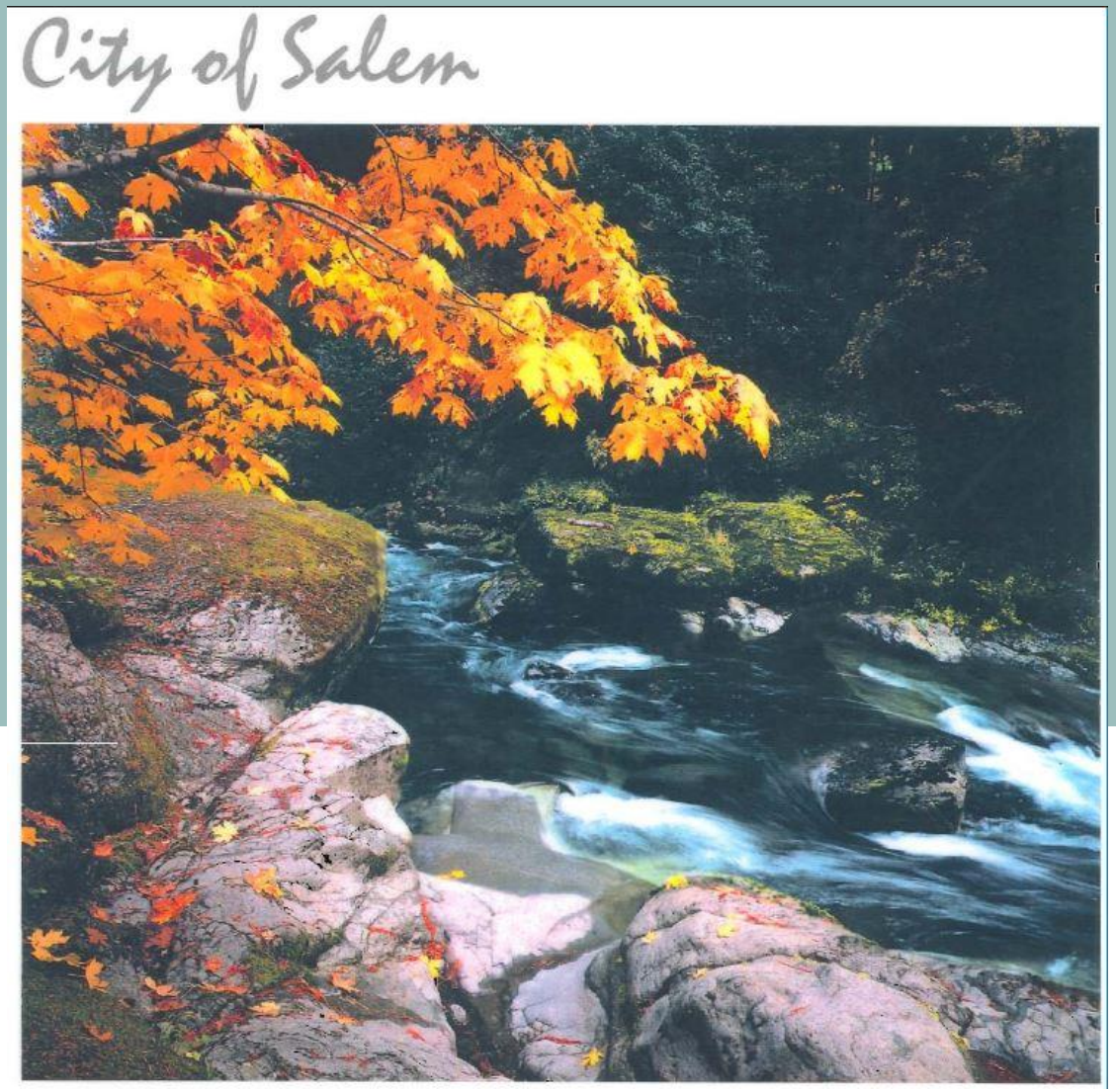
QUESTIONS?



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