

June 23, 2015
MWEA – 90th Annual Meeting

COMPREHENSIVE INSPECTION AND CONDITION ASSESSMENT OF DUCTILE IRON FORCE MAIN PIPES

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT



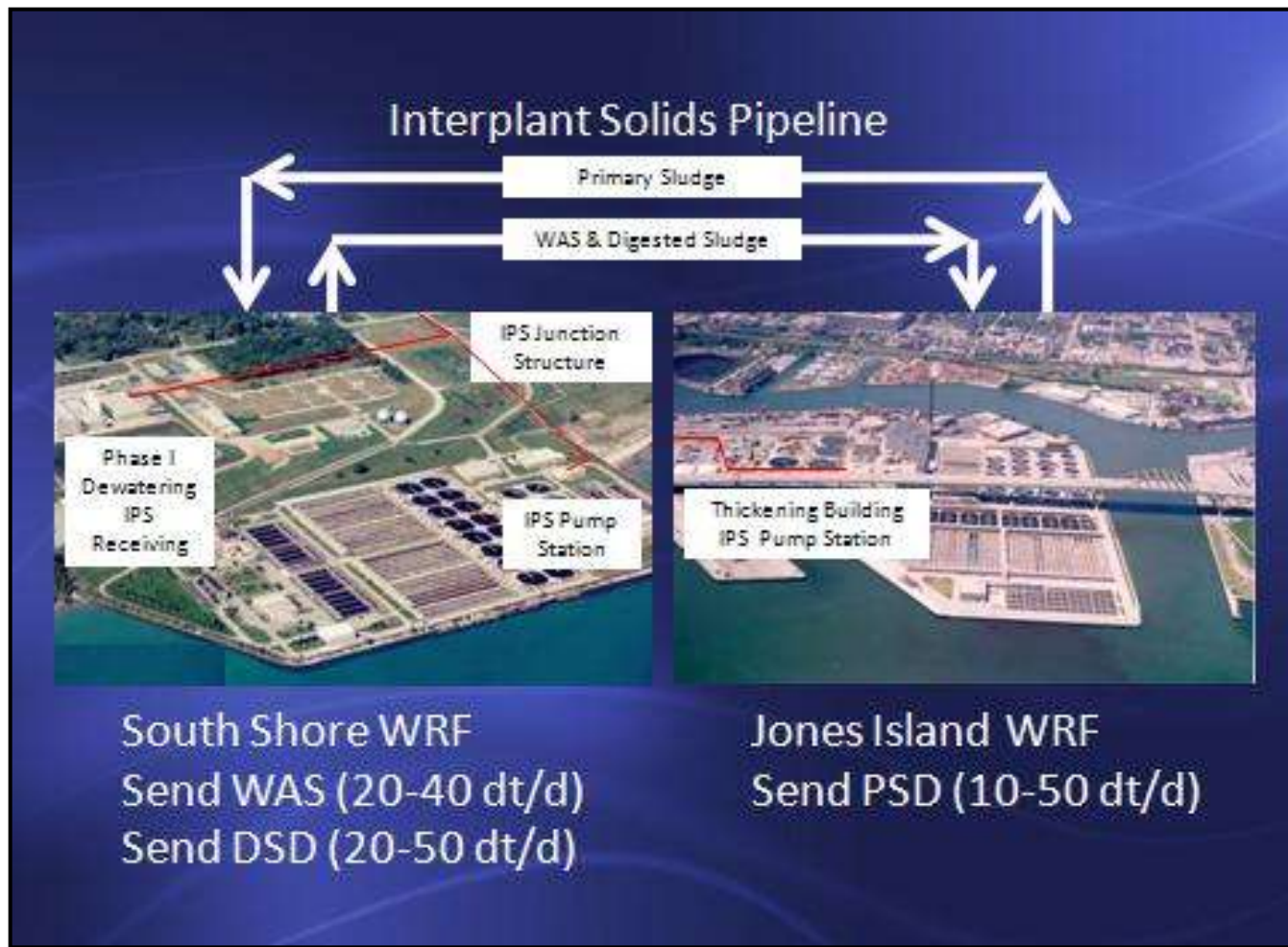
Team

- MMSD / Owner - set goals for risk vulnerability assessment and capital planning
- Corrosion Engineer – Corrosion Control Technologies
- Pipeline Inspection and Condition Analysis Corp. (PICA) – Pipe Condition Inspection and Assessment with RFT
- Flo-more – Pipeline PIG Cleaning
- National Power Rodding – Pipe STI
- Local Mechanical Contractor – Access to the Pipe
- Owner's O&M staff – work around pipe outages
- Donohue & Associates – Engineer, coordination of team members and activities

MMSD System

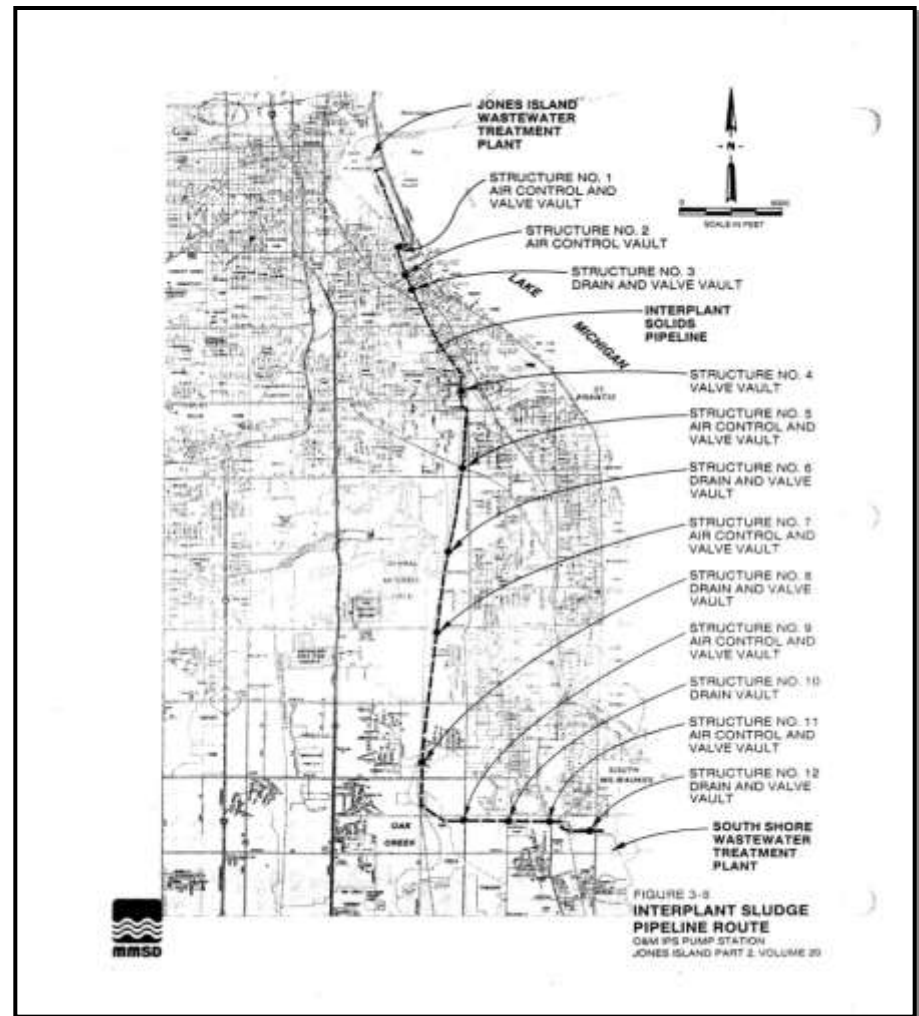
- MMSD provides wastewater services for 28 municipalities in the Milwaukee area.
- MMSD recognized for innovation in resource recovery, energy, green infrastructure, and overflow reduction.
- The MMSD conveyance system includes 54 miles of pressure sewers including force mains and siphons.
- MMSD is conducting a pressure sewer condition assessment master plan.

Interplant Biosolids Pipeline



Interplant Biosolids Transfer Pipeline

- 12 mile pipeline
- Commissioned 1990
- Two 12-inch pipes
- Two 14-inch pipes
- Heavy class 54 DIP
- Cathodic protection for most of the pipe
- Three failures on plant site in the past 5 years



Greenfield Park Force Main

- 1/2 mile force main provides for wet weather flow transfer to a higher capacity interceptor system.
- One 24-inch DIP with poly wrap coating
- Pipe joints bonded but no cathodic protection
- Operates 20-50 days per year



Pipe Assessment Goals

- Reduce the likelihood and consequence of force main pipe failures, avoid unplanned emergencies
- Establish programs and procedures to monitor force main pipes condition
- Provide information for infrastructure capital planning and budgeting
- Quantify the pipe condition
- Target repairs to specific pipe locations or conditions
- Identify cost effective repairs to extend the pipe service life and reduce life cycle costs

Pipe Failure Modes

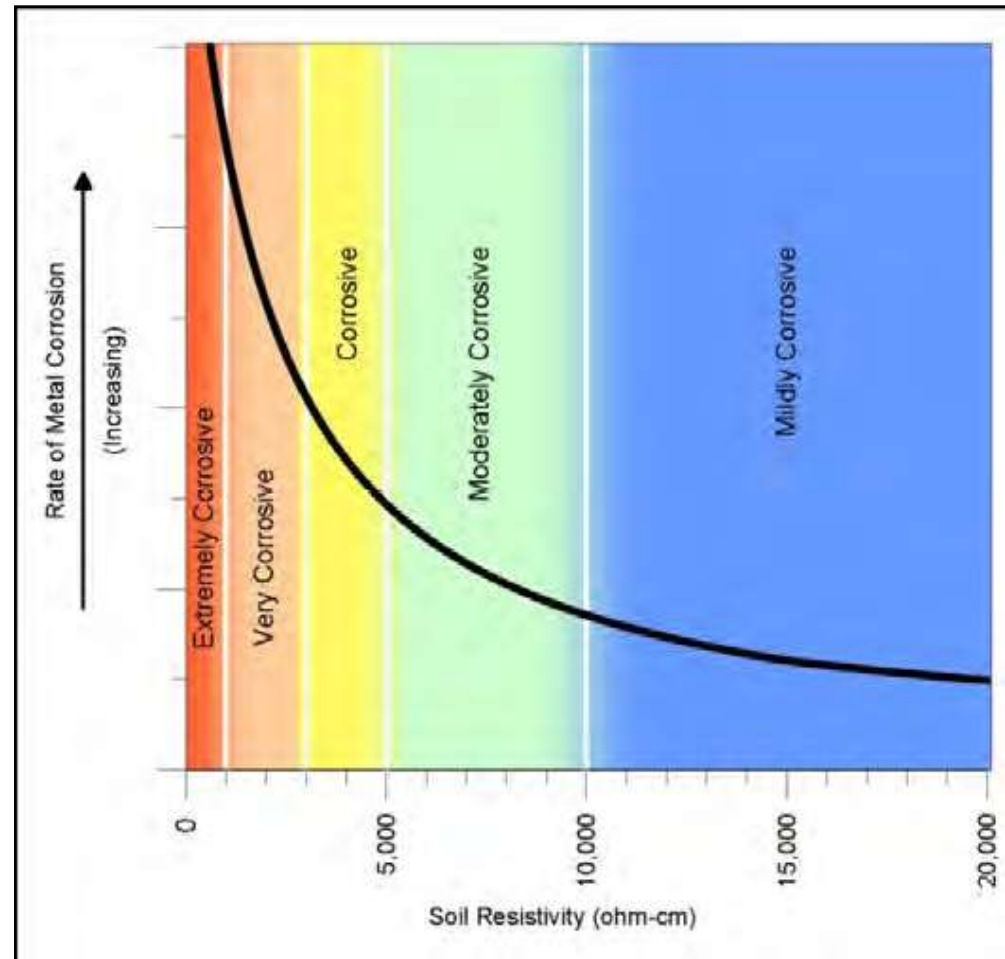
- Blockage / Restriction
- **External Corrosion Leak**
- Internal Corrosion Leak
- Structural Failure / Collapse
- Service Life Expired



Pipe Corrosion Considerations

➤ External Corrosion – Soil and Water Conditions

- DIPRA 10-point soil corrosivity index used

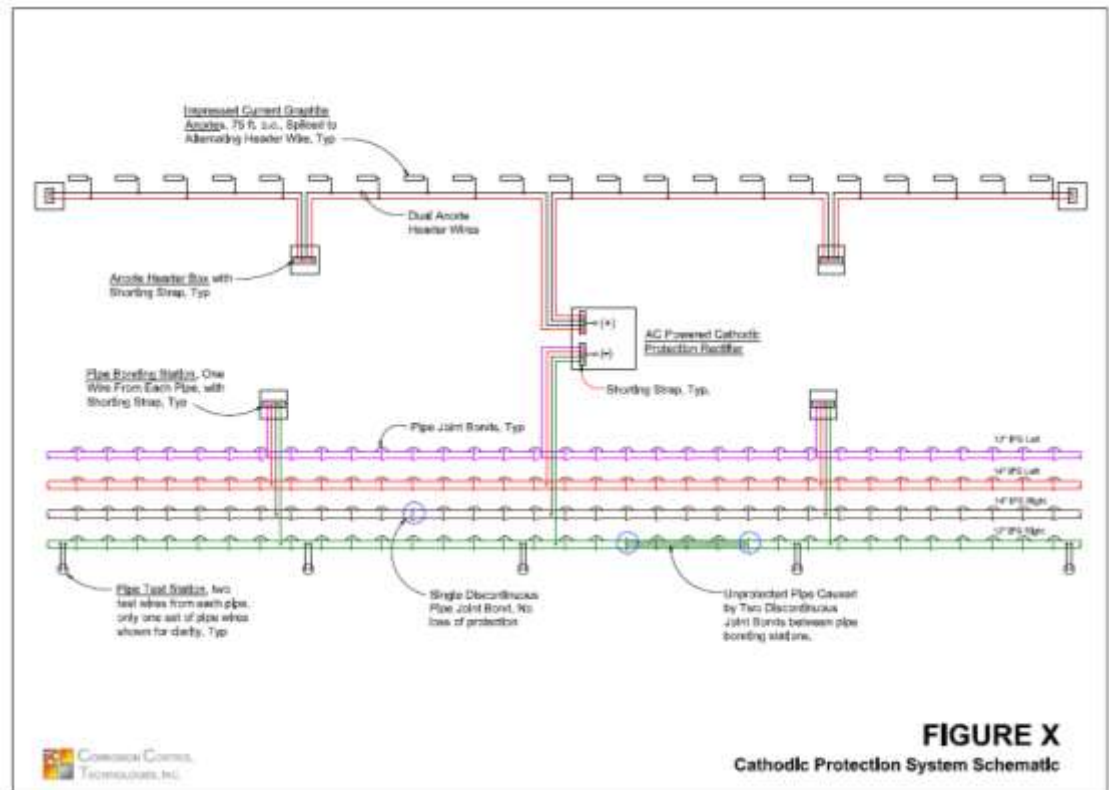


Pipe Corrosion Considerations

- Internal Corrosion – H₂S and Bacteria Conditions
 - Can be an issue for force main not flowing full due to uneven grade, unvented high points, corrosion occurs at pipe crown/soffit
- Corrosivity of the soils
- Cathodic Protection or Not
- Pipe Coating System
 - Bonded (paint)
 - Un-bonded (polyethylene encasement, baggy)

Pipe Corrosion Considerations

- Cathodic Protection System
- Impressed current system to provide high current required to protect under polyethylene encased pipe.
- Redundancy for system components

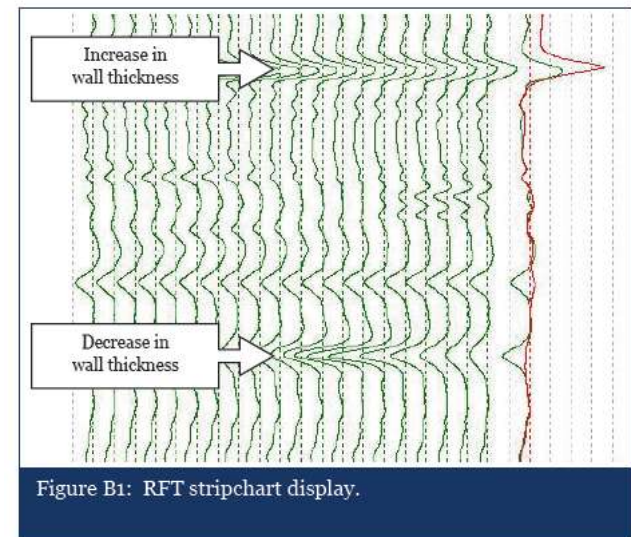
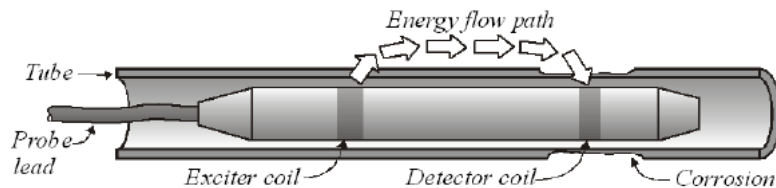


Pipe Inspection Alternatives

- Failure history – (date, location, type/cause)
- Inspection via pipe excavation
 - Select locations (corrosive soils, high points, failures)
 - Visual with sandblast to remove graphitization
 - Ultrasonic thickness testing at observed corrosion sites
- CCTV
 - Internal condition visual (blockages, cracks, leaks), not wall thickness or corrosion degradation
- Acoustic sensing
 - Identifies existing leaks and air pockets, may identify H₂S

Pipe Inspection Alternatives

- Laser profile
 - Internal blockages or deformities
- Electromagnetic
 - Measure pipe wall thickness
 - Identify and locate deep corrosion pits



Pipe Inspection Constraints

- Force main has no redundancy
- Force main must be operated routinely
- Access to the force main is limited (pump station pipe access, PIG station?, force main route is below street)
- Force main distance makes bypass pumping impractical
- Can flow diversions temporarily reduce need for force main?
- Can the inspection device be sent via pumped wastewater?

Biosolids Transfer Pipeline

- The inspection program included:
 - Two excavations with external visual inspections covering cathodic protected and unprotected sections
 - Electro-magnetic inspection of ½ mile section covering cathodic protection and non-cathodic protection sections
 - Two excavations with external visual inspection in severe duty area (variable ground water, salt storage, damaged cathodic protection system)

Biosolids Transfer Pipeline

➤ Excavation to access pipe



➤ Poly Wrap Pipe Coating System



Biosolids Pipeline Visual Inspections

- Visual Inspection Poly Wrap Pipe, No Cathodic Protection



- Visual Inspection Poly Wrap Pipe with Cathodic Protection



Biosolids Pipeline Visual Inspections

- Visual Inspection – Poly Wrap, No Cathodic Protection, Pre Sand Blast



- Visual Inspection – Poly Wrap, No Cathodic Protection, Post Sand Blast



Biosolids Pipeline Visual Inspections

- Visual Inspection – Bonded (Paint) Coating, Cathodic Protection, Pre Sand Blast



- Visual Inspection – Bonded (Paint) Coating, Cathodic Protection, Post Sand Blast



Biosolids Pipeline PICA Inspection

- The Electro-Magnetic inspection program included:
 - PICA requires assurance of clear pipeline
 - PIG cleaning to confirm no obstructions
 - Install temporary PIG launch and catch stations, (long enough to also accept the PICA See-Snake)
 - Use the pipeline pump system with flush water to PIG clean and to slowly pump the See-Snake
 - Restore the pipe at the temporary PIG stations

Biosolids Pipeline PICA Inspection

- Pipeline Inspection and Condition Analysis Corp. provides electromagnetic inspection of pipe wall thickness
- Pipe must be verified to have no restrictions – PIG Cleaning Station
- PICA See-Snake Inspection Tool pumped through the pipeline.



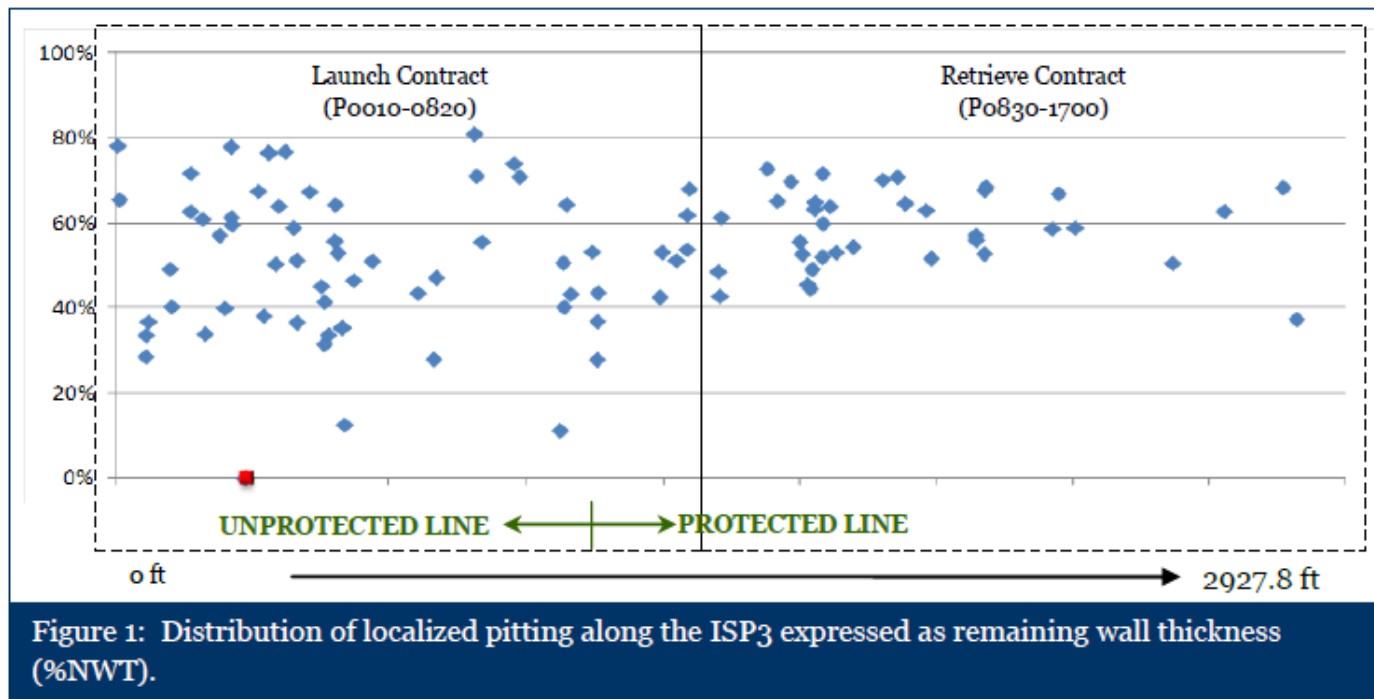
Biosolids Pipeline PICA Inspection

- PICA inspected 2,928 feet of 12-inch force main, (total length >50,000 ft).
- Plant site pipe does not have cathodic protection
- Off plant site pipe does have cathodic protection
- PICA inspection tool pumped with flush water from on-site excavation to off-site excavation



Biosolids Pipeline PICA Inspection

- The PICA inspection showed a significant difference in the number and depth of corrosion pits between the CP protected section and the non-protected section



Biosolids Pipeline PICA Inspection

- Although the average pipe wall thickness is nearly 90%, there are numerous corrosion pits including 3 pits of 0% - 10% remaining wall thickness

Table 1 summarizes the RFT inspection results for the 12-in wastewater pipeline.

Table 1: Feature Indication Summary			
	Launch Contract	Retrieve Contract	Total
Inspected length (ft)	1424.9	1404.5	2927.8
Number of pipe sections:	82	88	170
Number of analysed pipe sections:	71	83	154
Number of push-on joints:	71	63	135
Number of flanged connections:	1	0	1
Number of restrained joints:	0	22	22
Number of Vertical Bends/Elbows:	6	0	6
Number of Horizontal Bends/Elbows:	6	0	6
Number of Tees	2	0	2
Number of Unidentified Features	0	3	3
Average Wall Thickness (%NWT):	89.3%	92.3%	90.9%
Number of pipes without localized wall loss indications:	37	57	94
Number of pipes with localized wall loss indications:	36	25	61
Number of pipes with Through Hole (TH) indications:	1	0	1

Biosolids Pipeline

Conclusions & Recommendations

- Cathodic protected section of pipeline in good to very good condition, with 50 years or more of remaining service life.
- Implement repairs to the cathodic protection system, monitor its operation and performance
- The non-cathodic protected section of the pipeline on the SSWRF plant site will be repaired:
 - Use PICA “Dig Sheet” to locate and repair the 3 deep corrosion pits
 - Install cathodic protection system on the pipeline to mitigate further corrosion

Wet Weather Force Main

- The inspection program included:
 - No excavations, entire pipeline length was inspected by PICA's See-Snake
 - Assure clear pipeline with visual inspection by sewer televising
 - Use cable and winch system to send See-Snake through the pipe
 - Schedule activities with a minimum 3 day clear weather forecast

Wet Weather Force Main

- Sewer televising selected for pre-inspection
 - The 2,800 foot length was just within STI capability of National Power Rodding (up to 3,300 feet). This length cannot be met by most STI contractors.
 - STI camera tractor installs 5/8" rope (mule tape) as it is pulled back following the inspection
 - Rope used to pull through PICA winch cable
 - STI crew was just able to traverse the full length, camera tractor was struggling near the end

Wet Weather Force Main PICA Inspection

- Pump Sta. discharge pipe disassembled for inspection access



- PICA See-Snake Inspection Tool staged for winch pull through the pipe.



Wet Weather Force Main PICA Inspection

- Force main discharge manhole, PICA winch pulling See-Snake

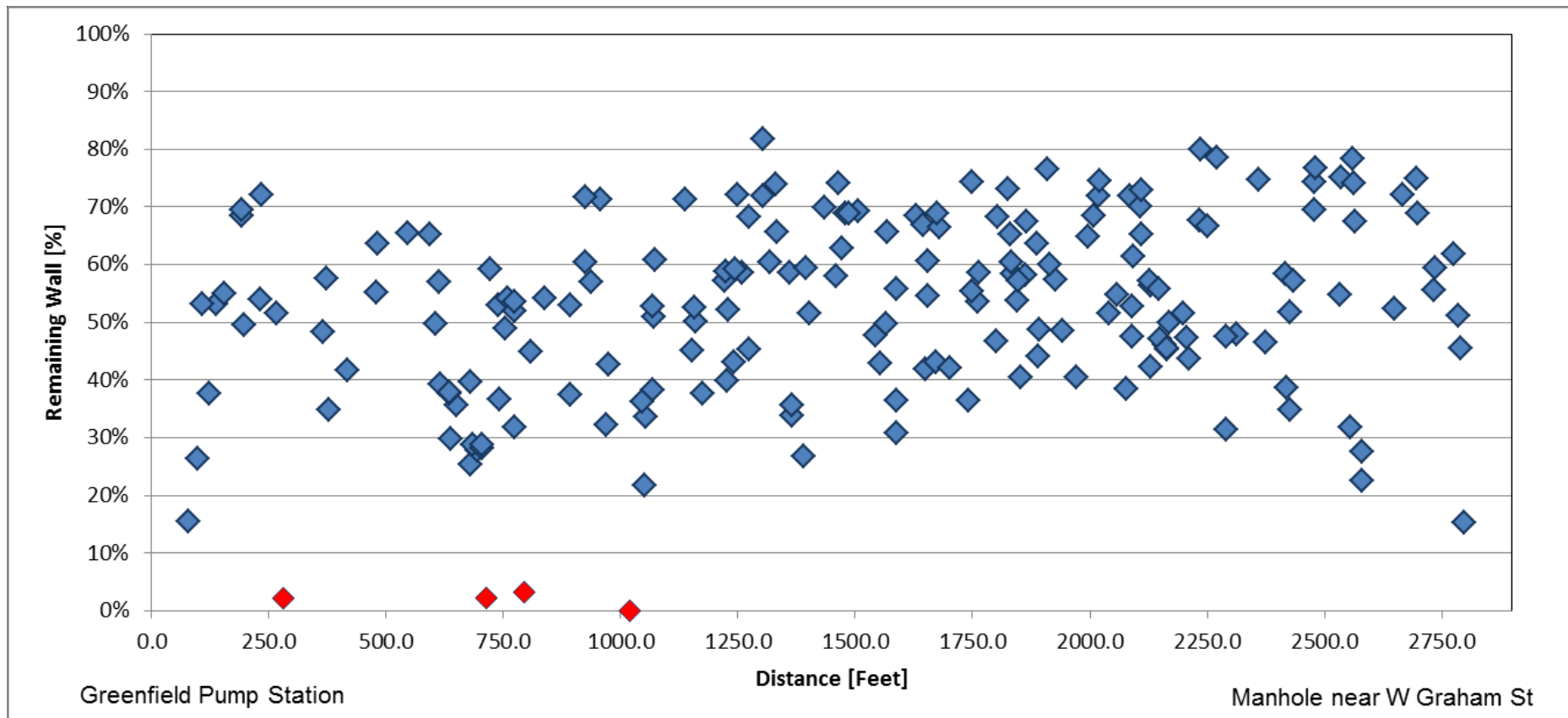


- See-Snake Inspection Tool pulled out of the force main manhole.



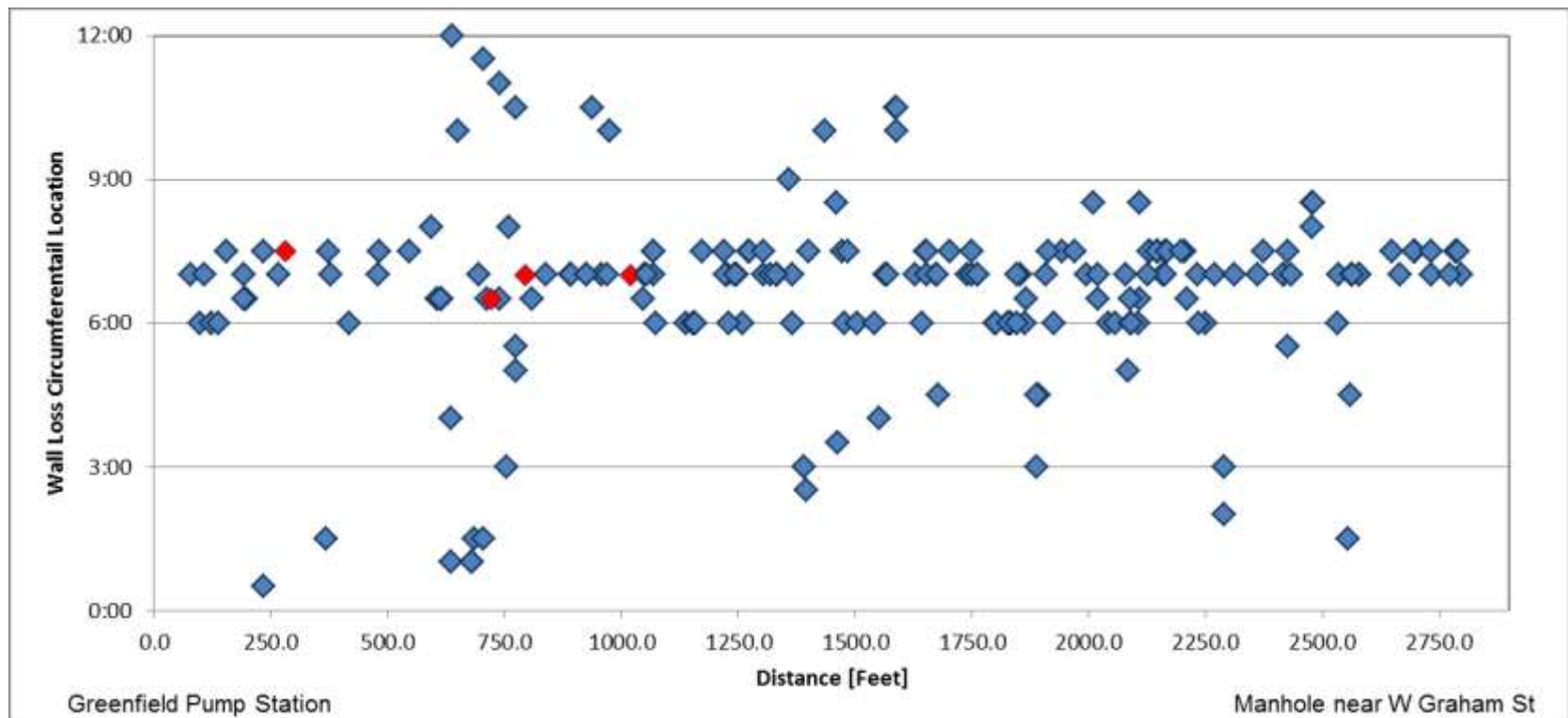
Wet Weather Force Main PICA Inspection

- The PICA inspection showed several corrosion pits of 20% or less remaining wall thickness



Wet Weather Force Main PICA Inspection

- This force main operates intermittently and residual solids lay in the bottom of the pipe. There is a high concentration of corrosion pits at the pipe invert.



Wet Weather Force Main Condition

Conclusions & Recommendations

- The higher concentration of deep corrosion pits closer to the pump station suggest galvanic corrosion (pipe was not constructed with electrical isolation from the pump station).
- Corrosion pits at the pipe invert could be from microbiologically influenced corrosion (MIC) or from tears in the polywrap at the pipe invert due to careless installation.
- Root cause of corrosion cannot be determined without visual inspection.

Wet Weather Force Main Condition

Conclusions & Recommendations

- Several deep corrosion pits significantly raise the risk for pipeline leak
- Repair options include:
 - Use PICA “Dig Sheet” to locate and repair the deep corrosion pits or replace pipe segments
 - Electrically isolate the pipe from the pump station
 - Install cathodic protection system on the pipeline to mitigate further corrosion
 - Install CIPP liner system or slip lining

Wet Weather Force Main Condition Conclusions & Recommendations

- If MIC corrosion, solution is pipe lining or pipe replacement (\$1.4M - \$1.9M).
- If external / galvanic corrosion, solution is spot repairs + electrical isolation + cathodic protection system (\$0.4M).
- Conduct excavation(s) with visual inspections to confirm the corrosion root cause.
- Design the pipe remediation based on the root cause.

- Assess aged force main pipes for vulnerability and risk mitigation

- Force main assessments are challenging



- Avoiding will lead to unplanned emergencies

- Fit the inspection methods to the force main constraints

- Ductile iron force mains will have a long service life if well installed and well maintained

- Make a plan and follow it through

