From Detection to Prevention: Proactive Management of Trunk Mains

25th Annual Leakage Conference

December 2024

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Trunk Mains

- Major pipe failures impact to many customers
- High risks means, High costs
- Small leaks:
  - Major contributor to NRW (non-revenue Water)
  - will eventually lead to failures

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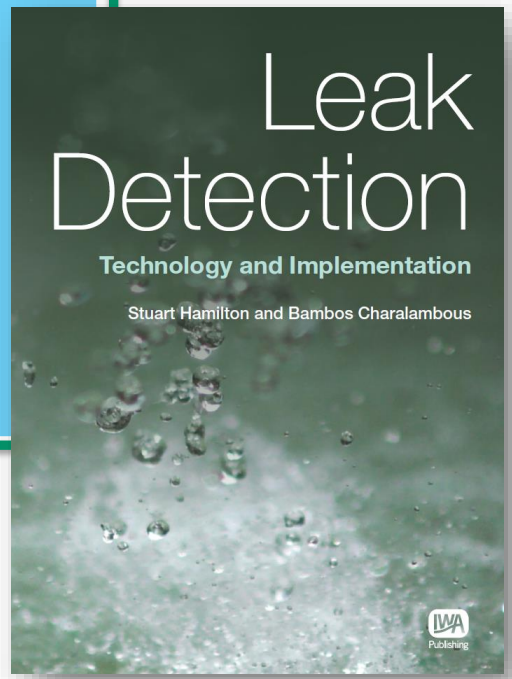
Accepted Pipeline Leak Detection Methods

Diameter	mm	75	100	150	200	250	300	350	400	450	500	600	700	800	900	1000+
	inches	3	4	6	8	10	12	14	16	18	20	24	28	32	36	40+
Material																
Metallic all		A,B, C,D, F,G	A,B, C,D, F,G	A,B, C,D, F,G	A,B, C,D, F,G	A,B, C,D, F,G	A,C, D,E, F,G	A,C, D,E, F,G	A,C, D, E	C,D, E	C,D,E	D,E	D,E	E	E	E
Concrete all		A,C,D	A,C,D	A,C,D	A,C,D	A,D	A,D,E	A,D,E	A,D,E	E	E	E	E	E	E	E
Asbestos Cement		A,C,D	A,C,D	A,C,D	A,C,D	A,D	A,D,E	A,D,E	A,D,E	E	E	E	E	E	E	E
GRP		A,D	A,D	A,D	A,D	A,D	A,D,E	A,D,E	A,D,E	E	E	E	E	E	E	E
PVC		A,D	A,D	A,D	A,D	A,D	A,D,E	A,D,E	A,D,E	E	E	E	E	E	E	E
Polyethylene all		A,D	A,D	A,D	A,D	A,D	A,D,E	A,D,E	A,D,E	E	E	E	E	E	E	E

Method A Gas Injection
Method B Traditional Techniques with Manual Listening Stick
Method C Non-Intrusive Acoustic Techniques that is Standard Correlator, Correlating Noise Loggers (Accelerometers)
Method D Intrusive Acoustic Techniques that is Standard Correlator or Correlating Noise Loggers (Hydrophones)
Method E Inline Inspection Techniques (Tethered & Free-swimming)
Method F Noise Loggers (Non-Correlating), Non-Intrusive Magnetic Connection
Method G Electronic Amplified Listening Ground Microphone



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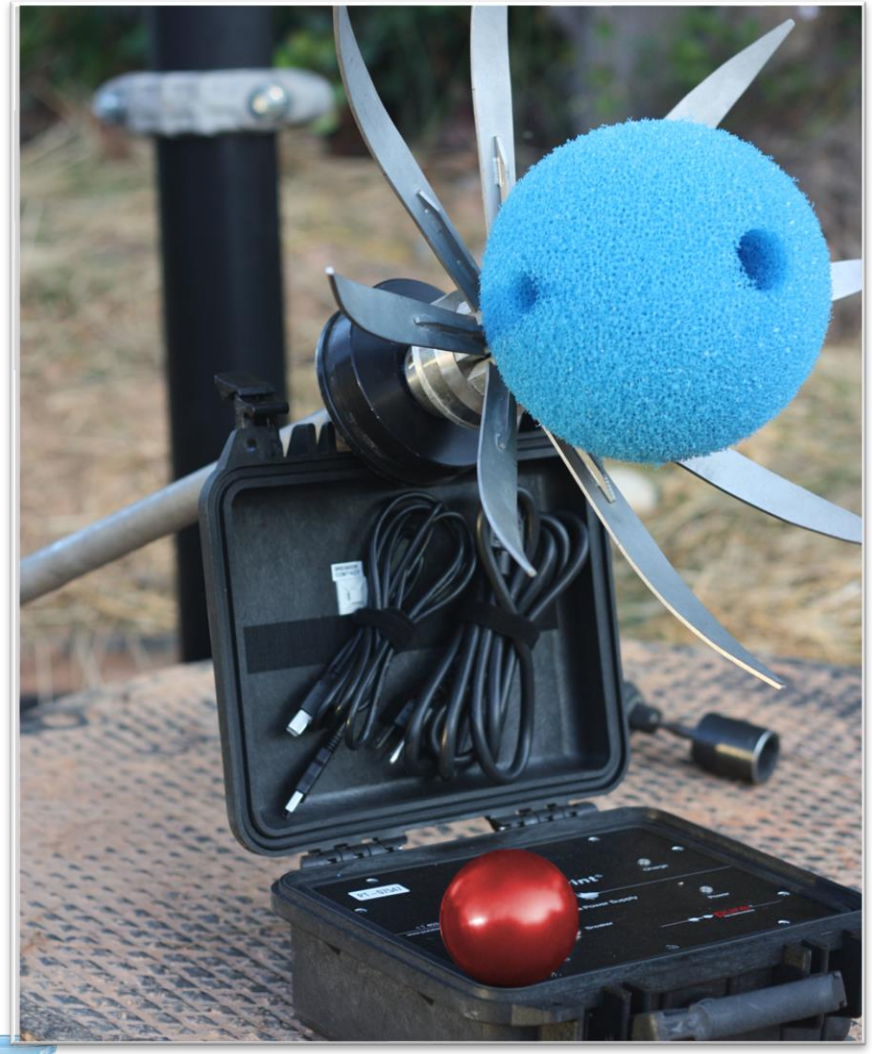
SmartBall – Inline Free-Swimming Inspection Platform



Over 18+ years and 16,250 kilometers of experience

Single Deployment

Acoustic: Locate hidden leaks and gas pockets with high accuracy

Contributing current inspection data to engineering analysis used for capital planning

Metallic: Identify and locate potential undocumented features and joint

Gyroscope: Mapping capabilities to confirm alignment, change in direction

Pressure: identify partial blockages and confirm pipeline elevations

Live tracking

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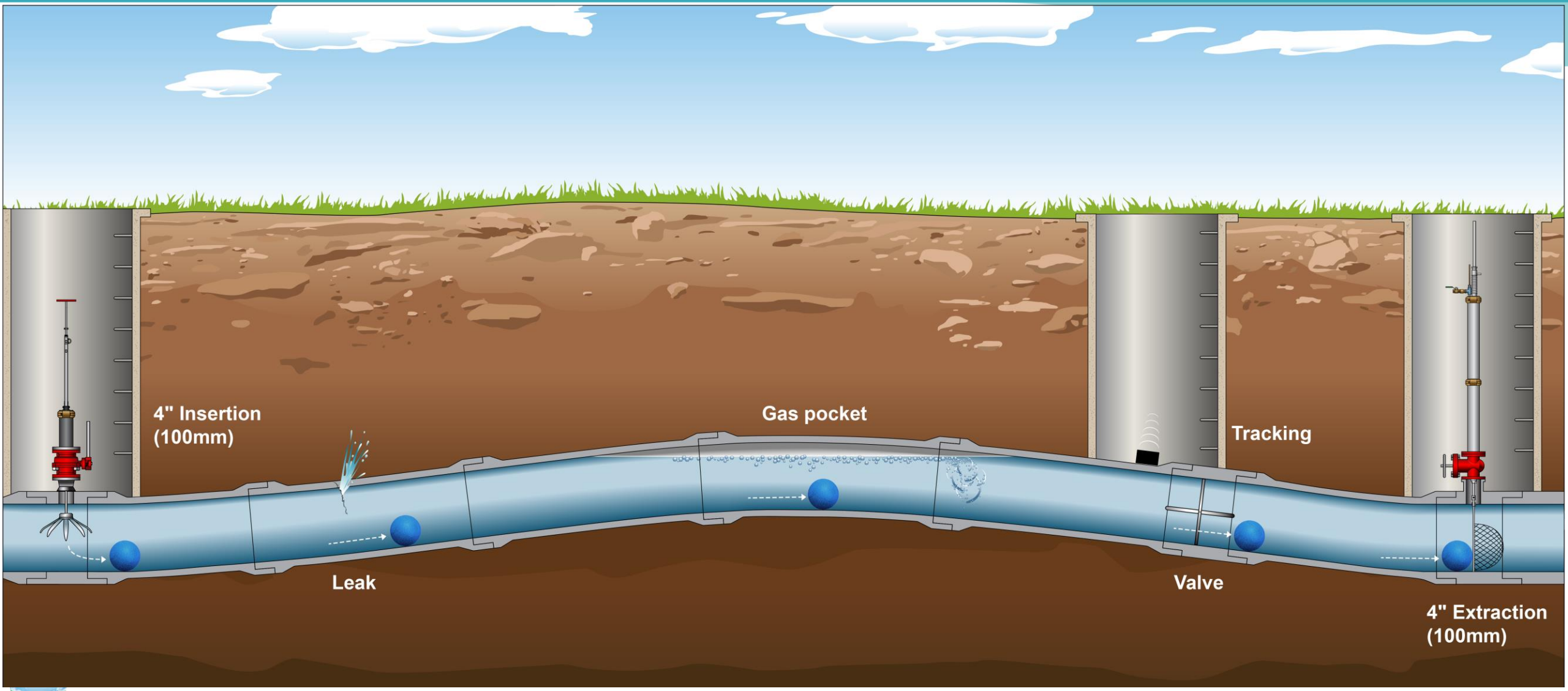

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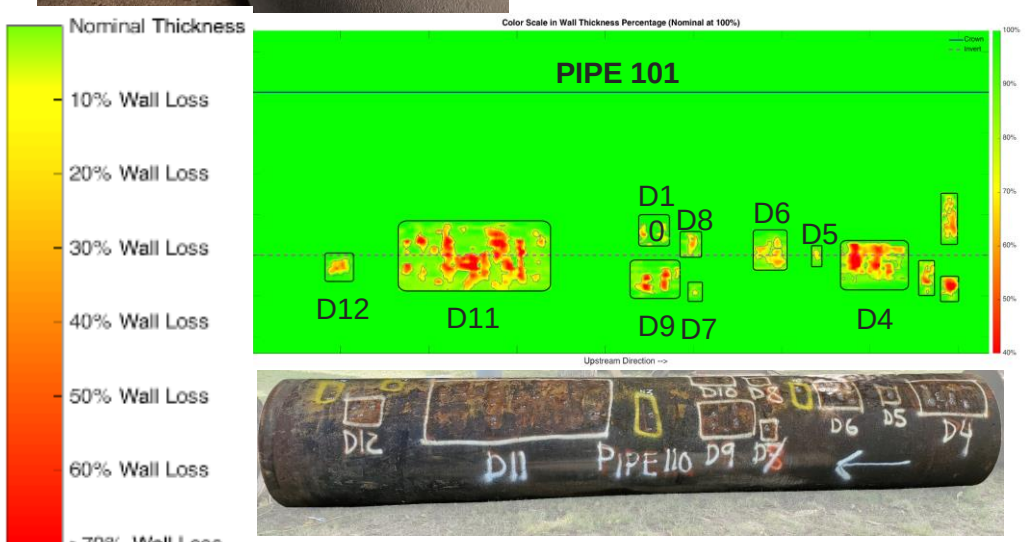
PipeDiver – Inline Free-Swimming Inspection Platform

- Advanced pipeline condition assessment tool
- Accurately pinpoints areas of pipe wall distress using ultrasonic and electromagnetic technologies.
- Effectively inspects metallic and concrete pressure pipe in both water and wastewater pipelines
- Ideal for inspecting critical, large-diameter mains that cannot be removed from service
- Provides accurate, detailed pipe wall condition data to inform proactive repair and replacement decisions
- Easy to operate while the pipeline remains in service
- Avoid dewatering costs − up to £40,000/km
- No excavations or extensive civil work



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What is a Condition Assessment?

PREDICTIVE MODELLING

PRN	US joint sta, m	DS joint sta, m	BWW
10001	136	141	0
10002	141	146	0
10003	146	151	0
10004	151	156	0
10005	156	160	0
10006	160	165	0
10007	165	170	0
10008	170	175	0
10009	175	180	0
10010	180	185	0
10011	185	190	0
10012	190	195	5
10013	195	199	0
10014	199	204	0
10015	204	209	0
10016	209	214	0
10017	214	219	0
10018	219	224	0
10019	224	229	0
10020	229	234	0
10021	234	236	0
10022	236	241	0
10024	246	251	25

INSPECTION RESULTS

PipeDiver (wires, wall loss)
SmartBall (leaks)

- Review of pipe specifications
- Review of applicable standards
- Loading conditions

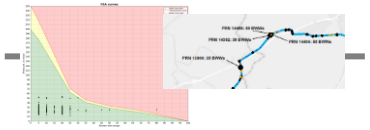
Profile drawings

TPM data

- **Design checks**
- **Finite element analysis**

- Pipe by pipe pressure distribution
- Pipe by pipe wall loss or broken bars

Data visualisation

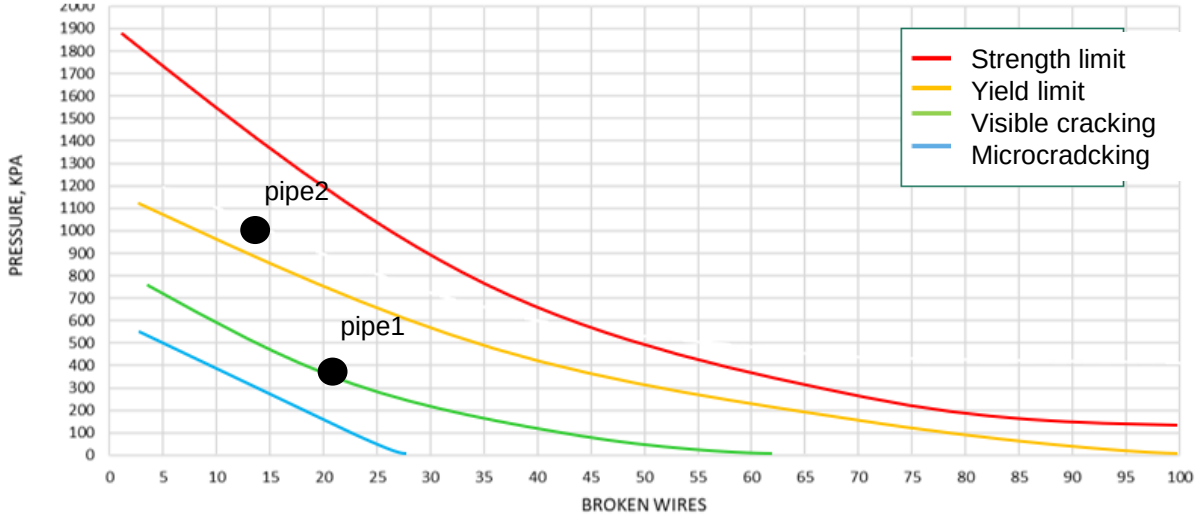


Pipeline Management Strategy

- Identification of **critical assets**
- Identification of **clusters** of defects
- **Priorisation** of repairs, replacements or recommended monitoring
- Further recommendations
- Reinspection interval
- Next steps

RUL Remaining Useful Life modelling combines historical industry data with inspection results to get a pipe-by-pipe end-of-life forecast for pipeline assets.

Example: pipe 2 has fewer broken wires than pipe 1, but is more critical (passed yield limit)



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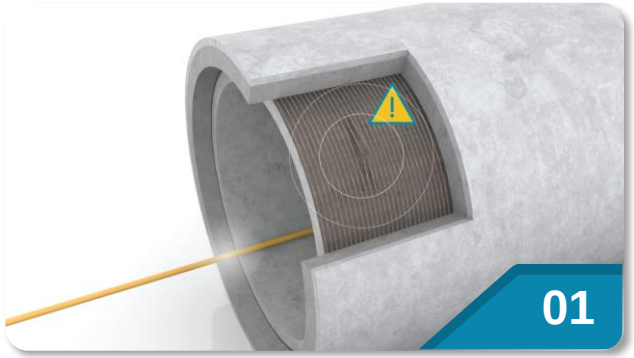
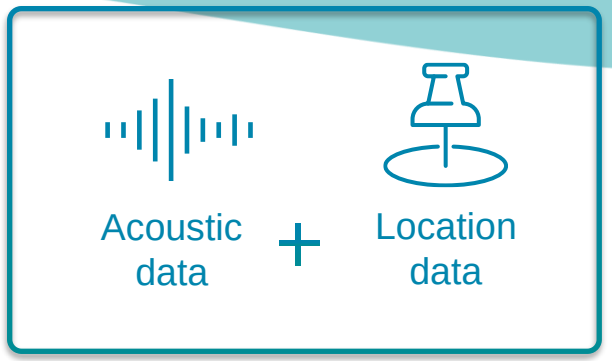
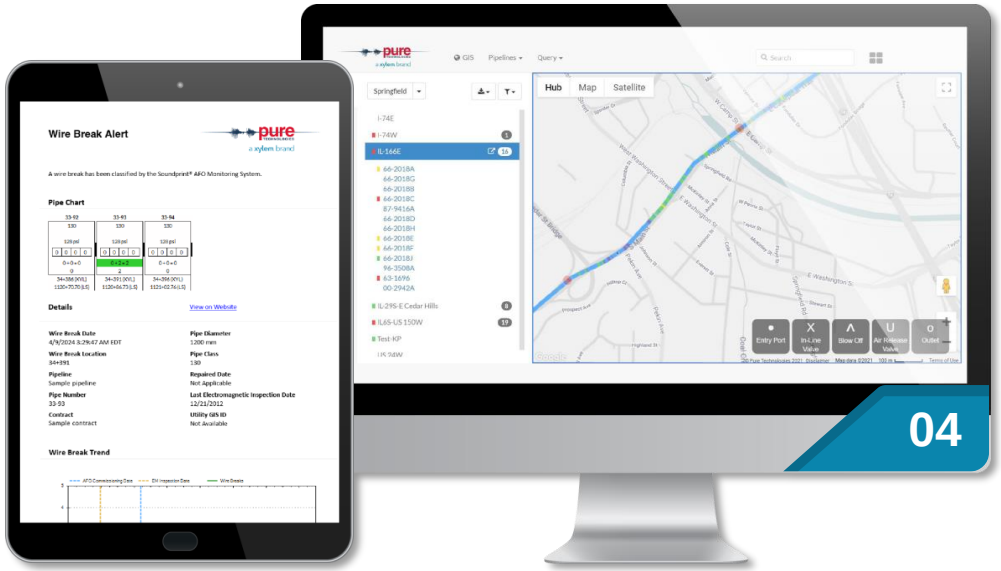
SoundPrint AFO - Continuous Monitoring

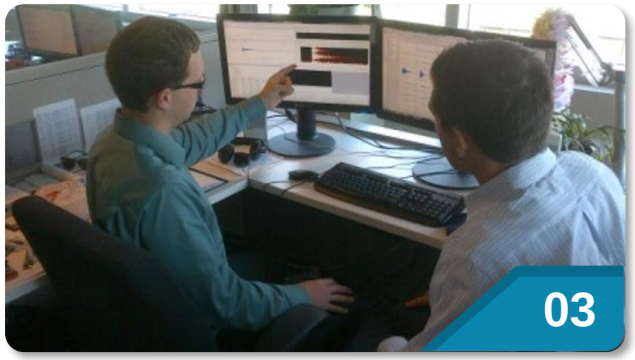


AFO cable detects one or more wire breaks

DAQ captures and sends acoustic and location data







AI + Analysts review data and map events to the pipe

Data available via alerts and an online portal

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SW Risk Appetite

Adoption of Management Approach (MA) methodology based on asset groups

Threshold levels for intervention are determined based on risk appetite

Likelihood of failure scores based on asset condition (inspection data is critical)

Examples of impacts to follow

Investment Prioritisation Category		Impact Score			
		1	2	3	4
Likelihood Score	1	P4	P4	P4	P4
	2	P4	P4	P4	P3
	3	P4	P3	P3	P2
	4	P3	P2	P2	P1
	5	P0	P0	P0	P0

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Trunk Main Failures

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Trunk Main Repair

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Siphon Bursts 2003 & 2021

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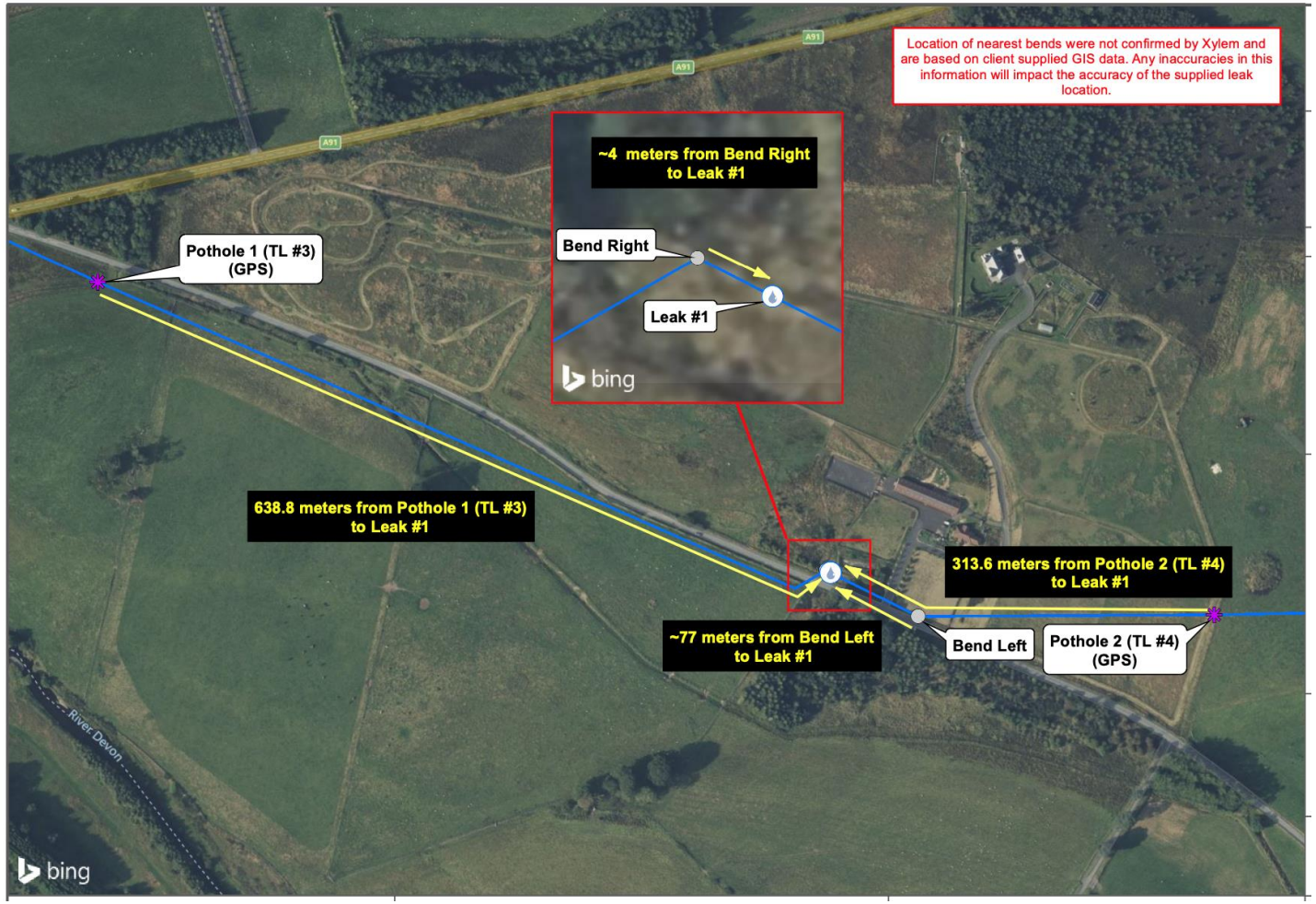
Preventing Failures



The acoustic intensity of each event detected by the SmartBall technology is presented in Figure 2.4 - Figure 2.6.

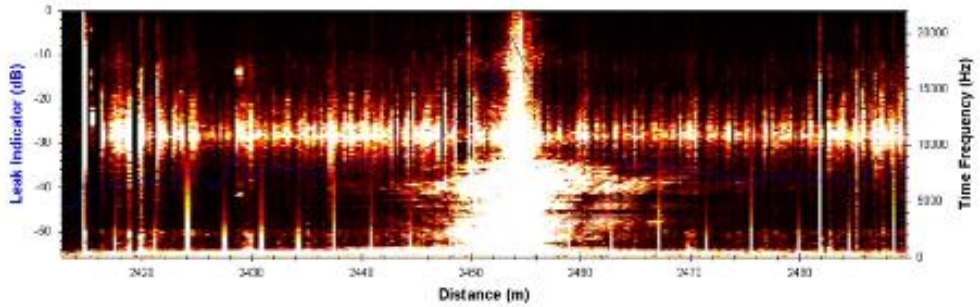


Figure 2.4: Acoustic Intensity of Leak #1

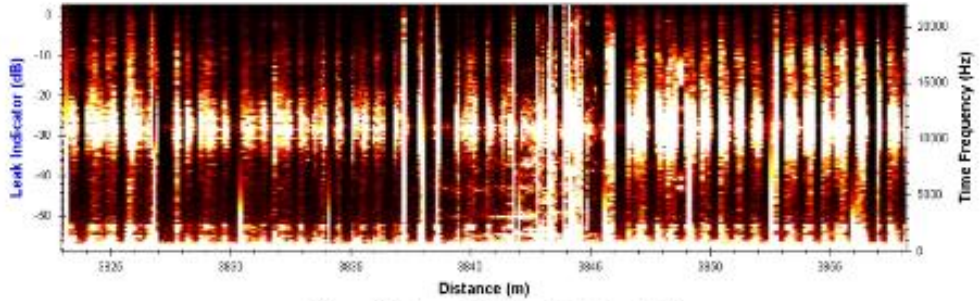


Figure 2.5: Acoustic Intensity of Leak #2

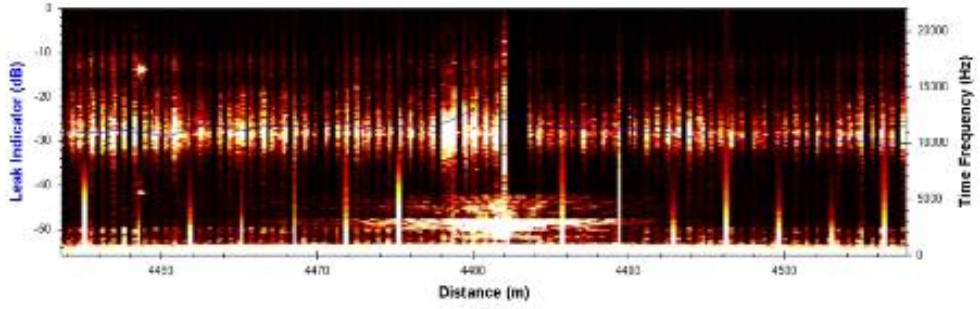
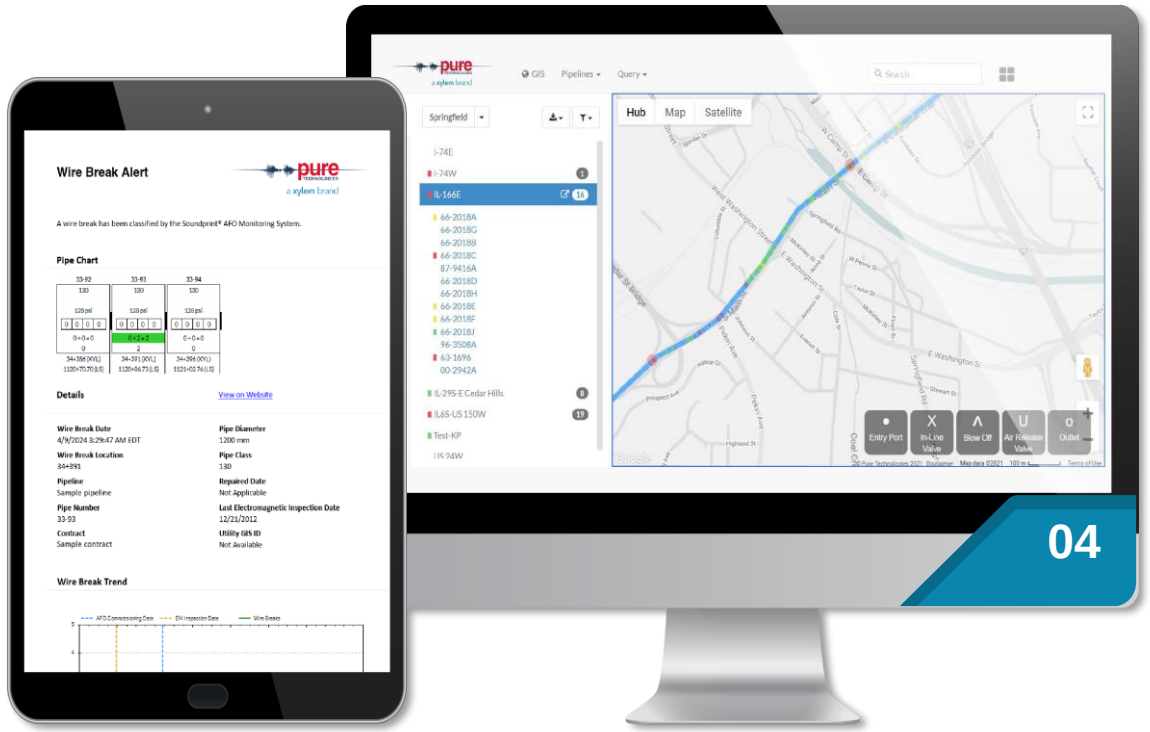


Figure 2.6: Acoustic Intensity of Acoustic Anomaly #1

Blairlinnans Survey Summary

- SmartBall and PipeDiver surveys completed for the full length (16km)
- Unexpected challenges overcome
- Partnership between Scottish Water, WRc, Xylem, Fastflow (contractor) ensured ultimate success
- Survey data analysed by Xylem
- Analysis allowed targeted plan for the next steps.



Data available via alerts and an online portal

Engineering Analysis Deliverables

Hydraulic analysis

- Static and dynamic pressures
- Pipe-by-pipe pressure distribution

Design check

- Material, class, forces
- External vs internal

Finite element analysis

- Build 3D model using mechanical properties
- Structural performance curve

Remaining useful life analysis

- Current level of distress, intervention level
- Probability curve

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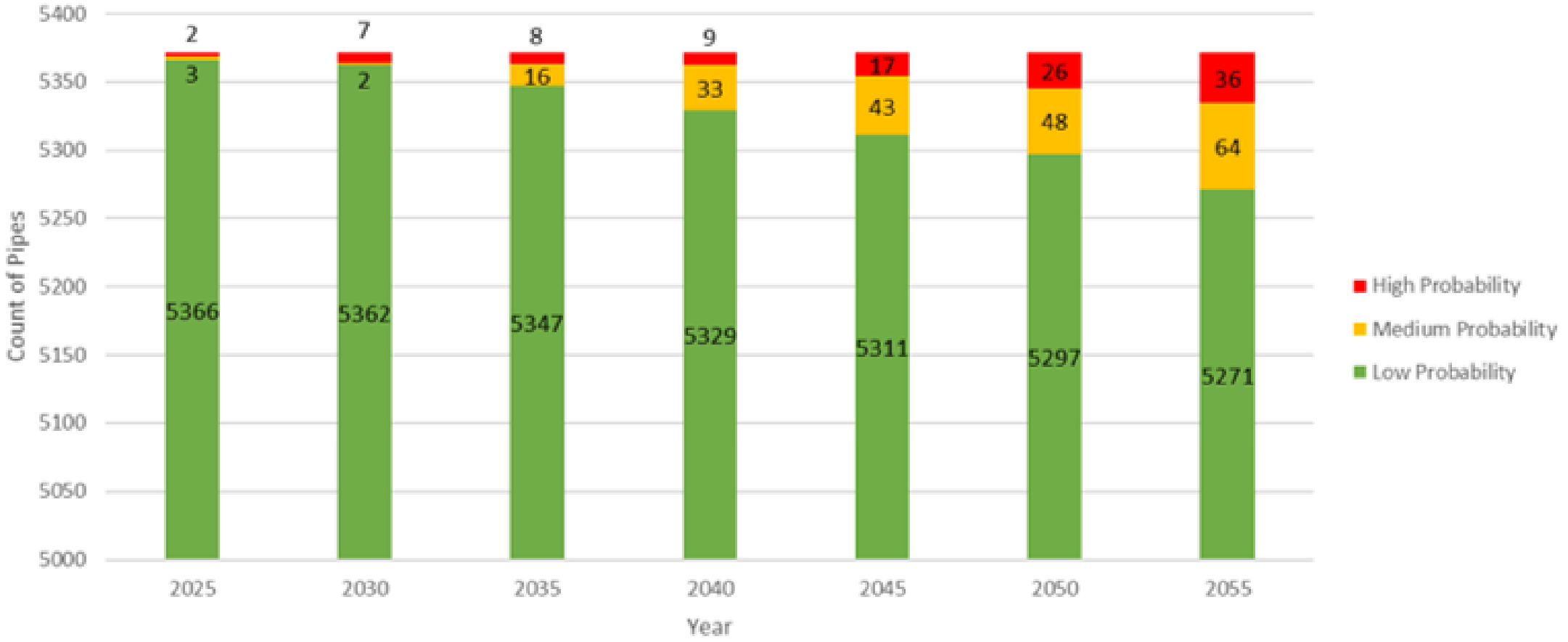
Remaining Useful Life (RUL) Analysis



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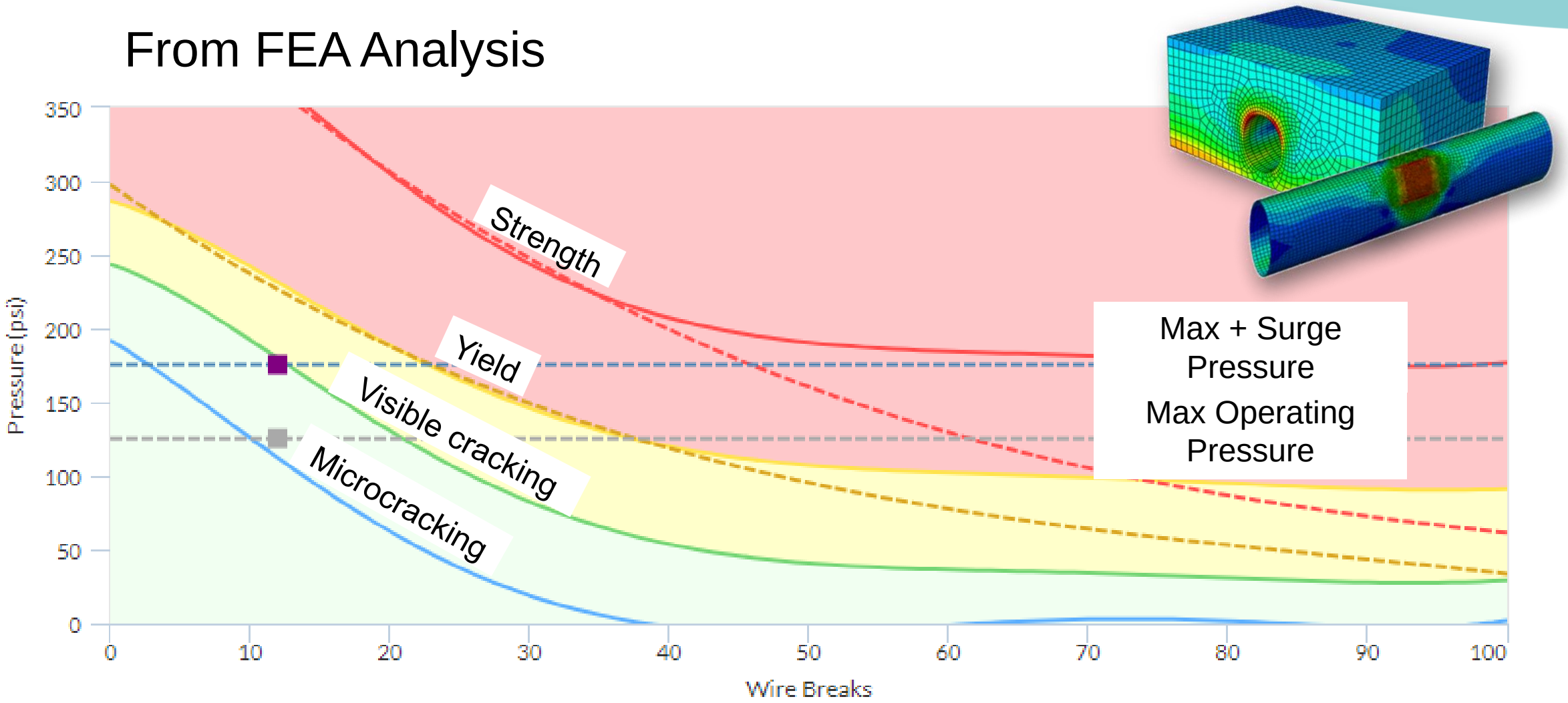
Structural Performance Curve

From FEA Analysis



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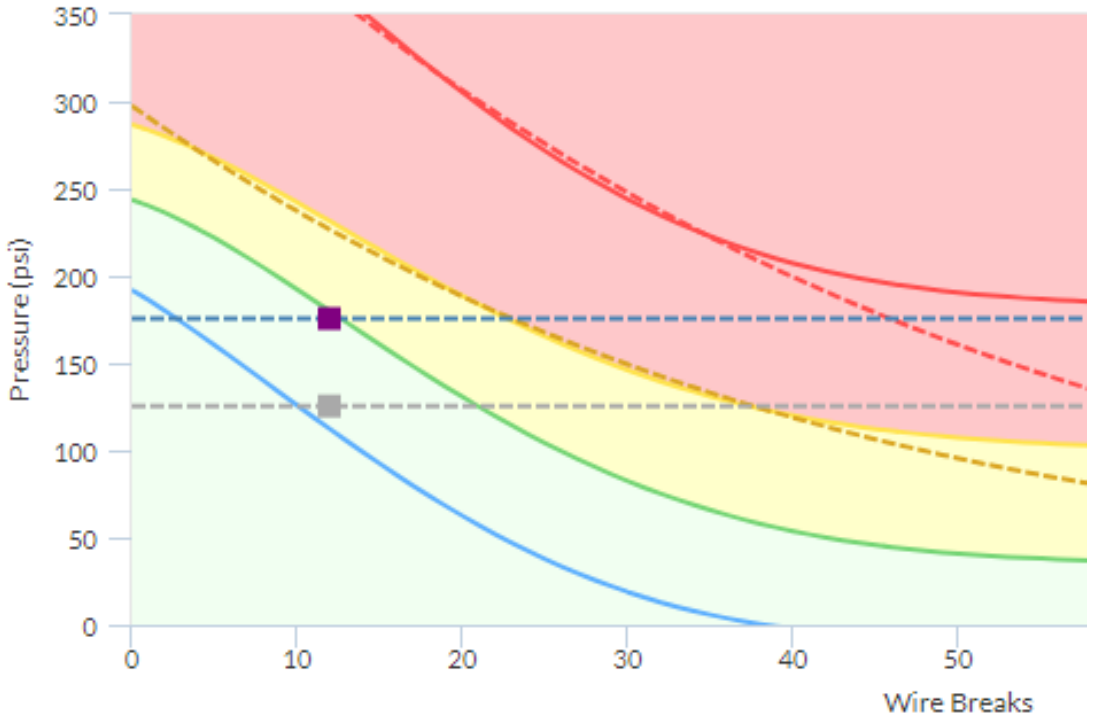
Ongoing Monitoring

- Team mailbox receives wire break alerts
- FEA based condition curves for each pipe stick
- Threshold intervention levels based on FEA values with agreed outputs
- Intelligent Control Centre reaction plan for catastrophic events



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Thank you

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