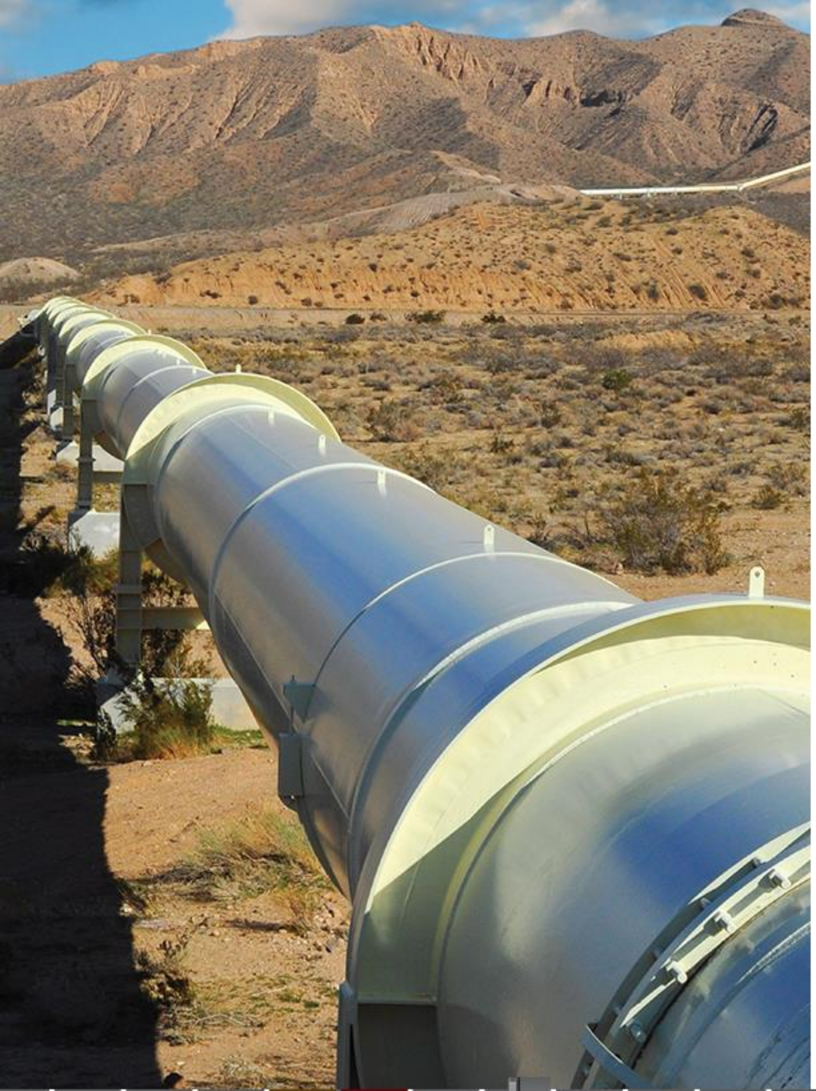

p-CAT™

Pipeline Condition Assessment Technology

Presented by: Paul Schumi

cwea
Chesapeake Water Environment Association

Collection Systems Fall Seminar
December 1, 2016

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Advanced Water, Wastewater and Gas Data Collection

understand the present | **protect the future**

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water

Asset Management
- Pipeline Assessment
- Hydrant Assessment
- Valve Assessment
- Leak Detection
- Flushing & UDF

Advanced Solutions
- Utilis Satellite Leak Detection
- p-CAT Pipeline Condition Assessment
- ArcServer Operations Dashboard

gas
- Cross Bore Elimination
- Condition Assessment

sewer
- CCTV Condition Assessment
- Manhole Inspection
- Smoke Testing

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Pipeline Condition Assessment using Inverse Transient Pressure Waves

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THE UNIVERSITY of ADELAIDE

Pipeline Condition Assessment Manager / PCAT Team Leader

Detection Services

Director

DS INSIGHT

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The pipeline condition assessment challenge

Current technologies for assessing pipeline condition are often:

- Highly invasive
- Time consuming
- Disruptive
- Costly
- May not give a representative picture of pipe wall condition (average condition over long pipe lengths ≤ 300+ ft.)

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Average Condition vs. Sub-Sectional Condition

The average wall thickness measurement method is simply the average wall condition between two test points.

Sub-Sectional wall thickness (p-CAT) measurement separates the pipe into multiple sections between the two test points into smaller sections (approx. 30 ft. sub-sections).

- This method provides the average for much smaller sections and finding faults that the average wall thickness technique cannot.

Average Condition vs. Sub-Sectional Condition

Often less than 2% of a pipeline is affected by serious corrosion or defects.

Example:

1,500 ft. long section where 1,470 ft. of the pipeline is **85%** of its original condition

- And, the remaining 30 ft. is severely corroded to **30%** of its original condition

The acoustic method's average wall condition would provide an average of **83.5%** and report the pipeline as "good".

Yet the pipe could still experience a catastrophic failure at any time.

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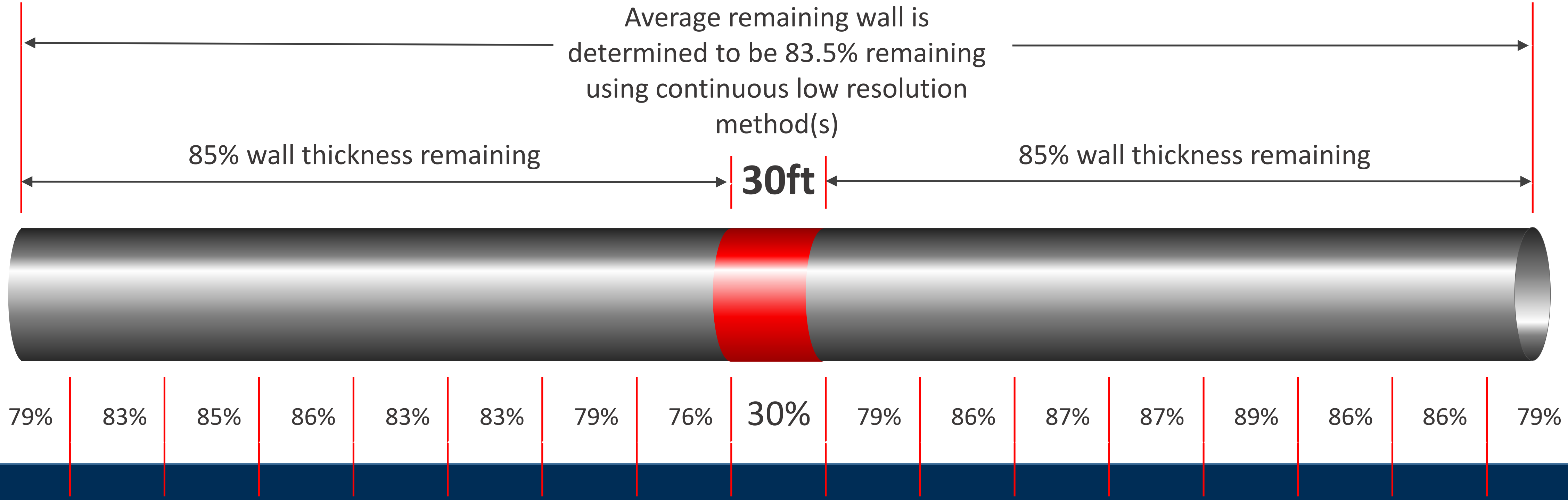
Average Condition vs. Sub-Sectional Condition

The *p*-CAT method could identify this corroded section from within the 1500 ft, allowing for targeted repair or replacement and minimising risk while saving considerable cost.

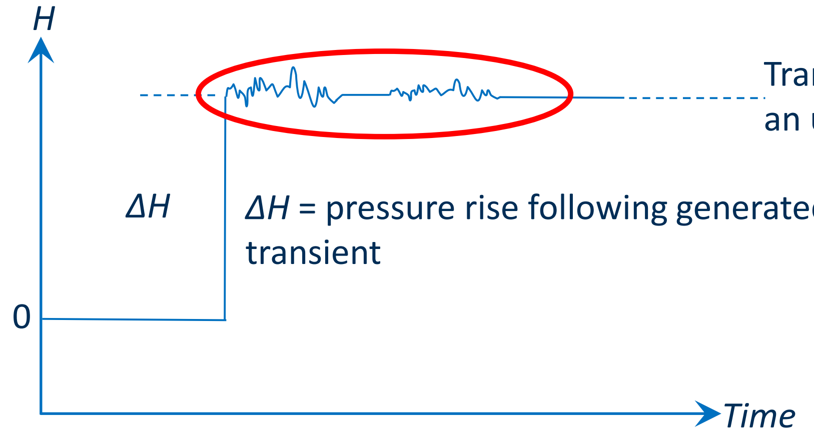


p-CAT™ pipeline condition assessment

Play Video

Fundamental Physical Mechanisms

There is a correlation between changes in the thickness of metal and cement mortar lining forming a pipeline wall and the speed with which a wavefront from a hydraulic transient propagates along the pipeline.



Graph showing transient pressure response when wall is damaged

Changes in this thickness give rise to reflections which can be theoretically interpreted to obtain a distribution of damage in the pipe.

Fundamental Physical Mechanisms

This theory has been developed into a non-invasive technique which can determine:

- The interior and exterior condition of pipelines including corrosion and cement mortar lining spalling
- Wall loss
- Locations of leaks, air pockets and blockages
- The sealing status of valves, closed valves and cross-connections

Fundamental Physical Mechanisms

$$a = \sqrt{\frac{K/\rho_W}{1 + \left(K/E_m\right)\left(ID/e_{eq}\right)\psi}}$$

a = speed of propagation of hydraulic transient pressure wave

K = bulk modulus of water

ρ = density of water

E = Young's modulus of elasticity of the pipeline wall material

D = internal diameter of the pipeline

e_{eq} = wall thickness of a single material pipe
or
the total equivalent wall thickness of the composite material pipe

ψ = pipeline restraint factor.

$$e_{eq} = e_m + e_c \times \frac{E_c}{E_m}$$

e_{eq} = wall thickness of a single material pipe
or
the total equivalent wall thickness of the composite material pipe

e_m = thickness of the metal wall component

e_c = thickness of the cement lining wall component

E_m = Young's modulus of elasticity of the metal

E_c = Young's modulus of elasticity of the cement lining

Fundamental Physical Mechanisms

Properties of steel, cement and water at 15°C

E_s = 210 GPa

E_c = 25 GPa

K = 2.14 GPa

ρ_w = 999.1 kg/m^3

ρ_s = 7850 kg/m^3

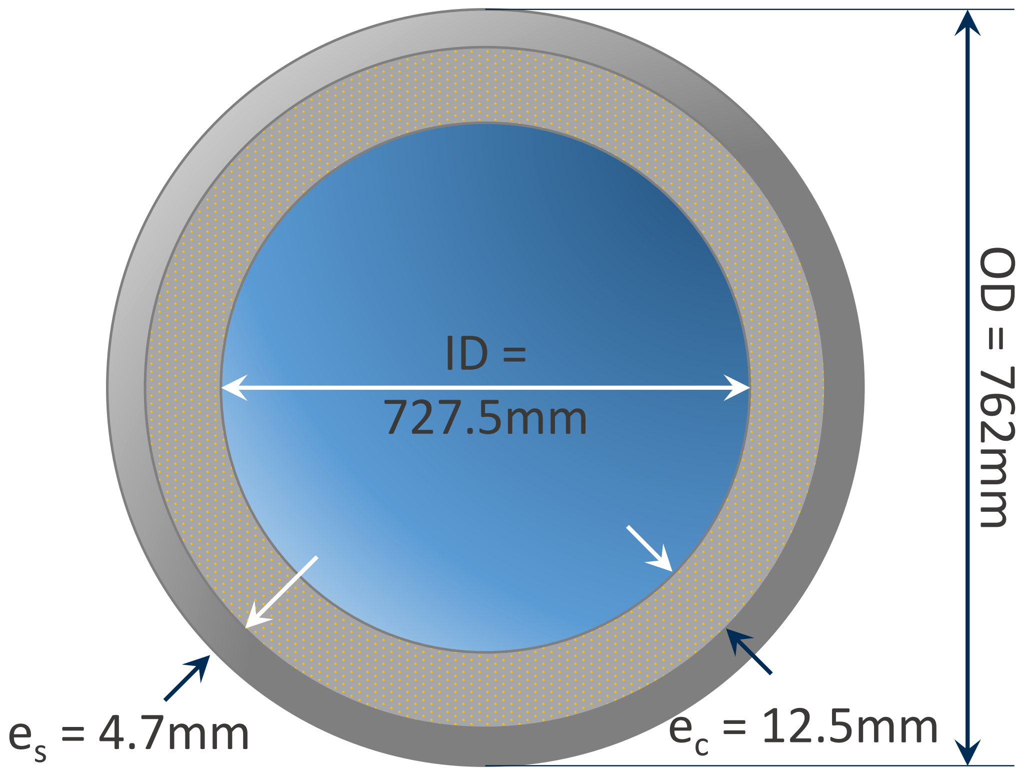
γ_w = 9.8 kN/m^3

γ_s = 77.0 kN/m^3

γ_c = 23.0 kN/m^3

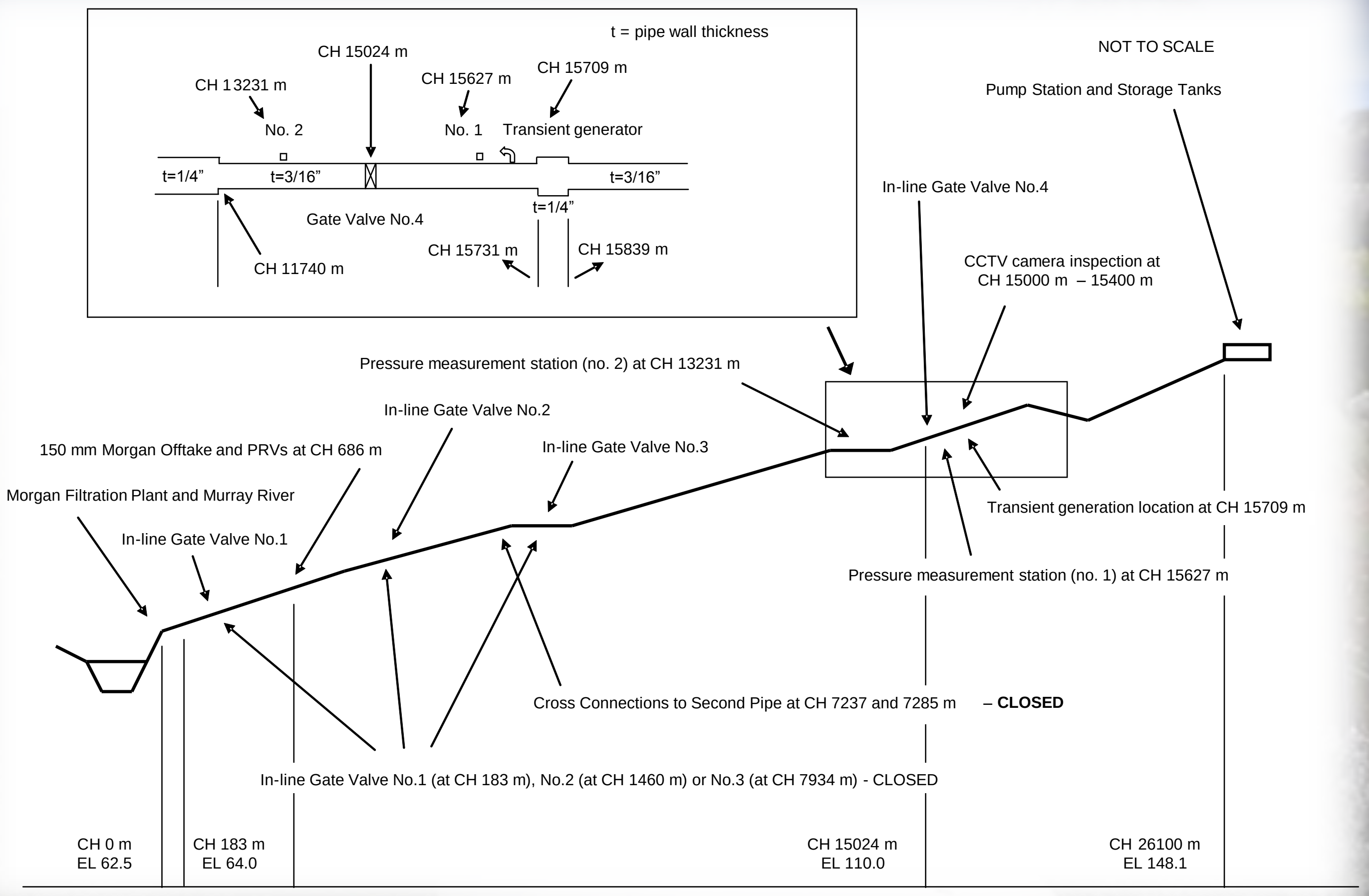
ν_s = 0.30

ν_c = 0.15

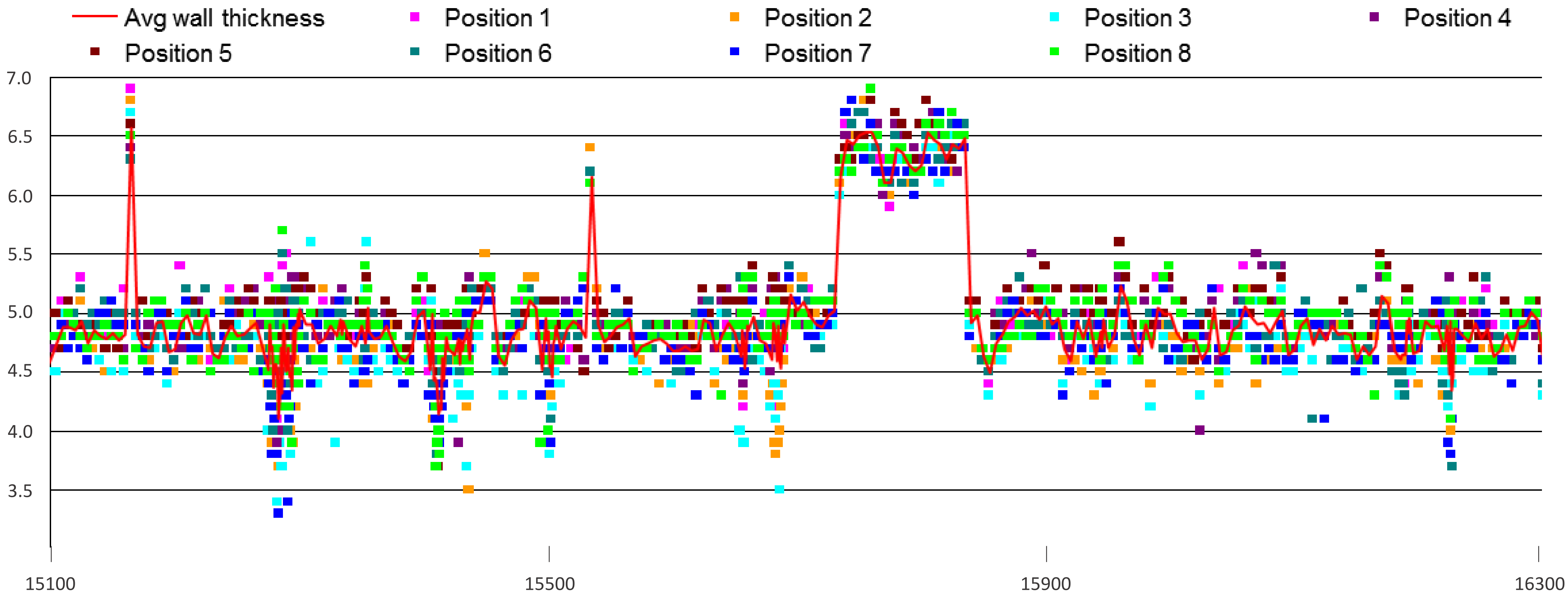


Morgan – Whyalla pipeline testing example

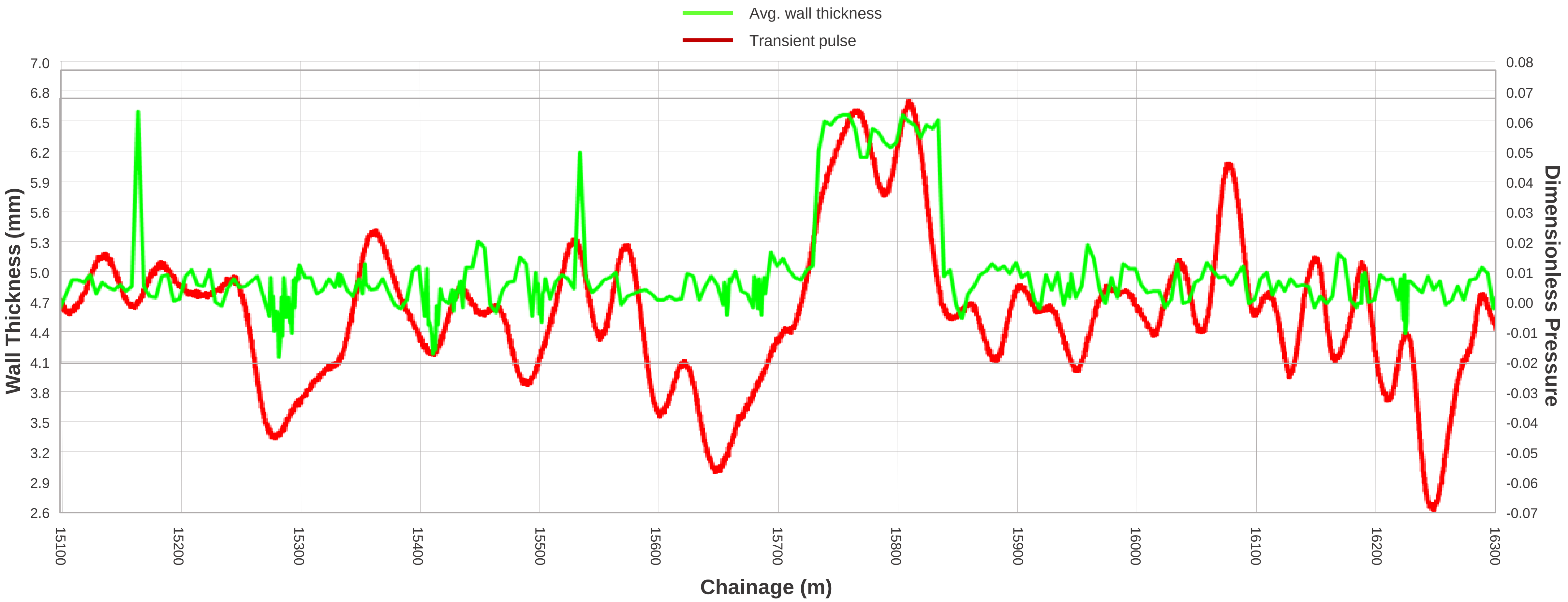
Morgan – Whyalla pipeline testing example



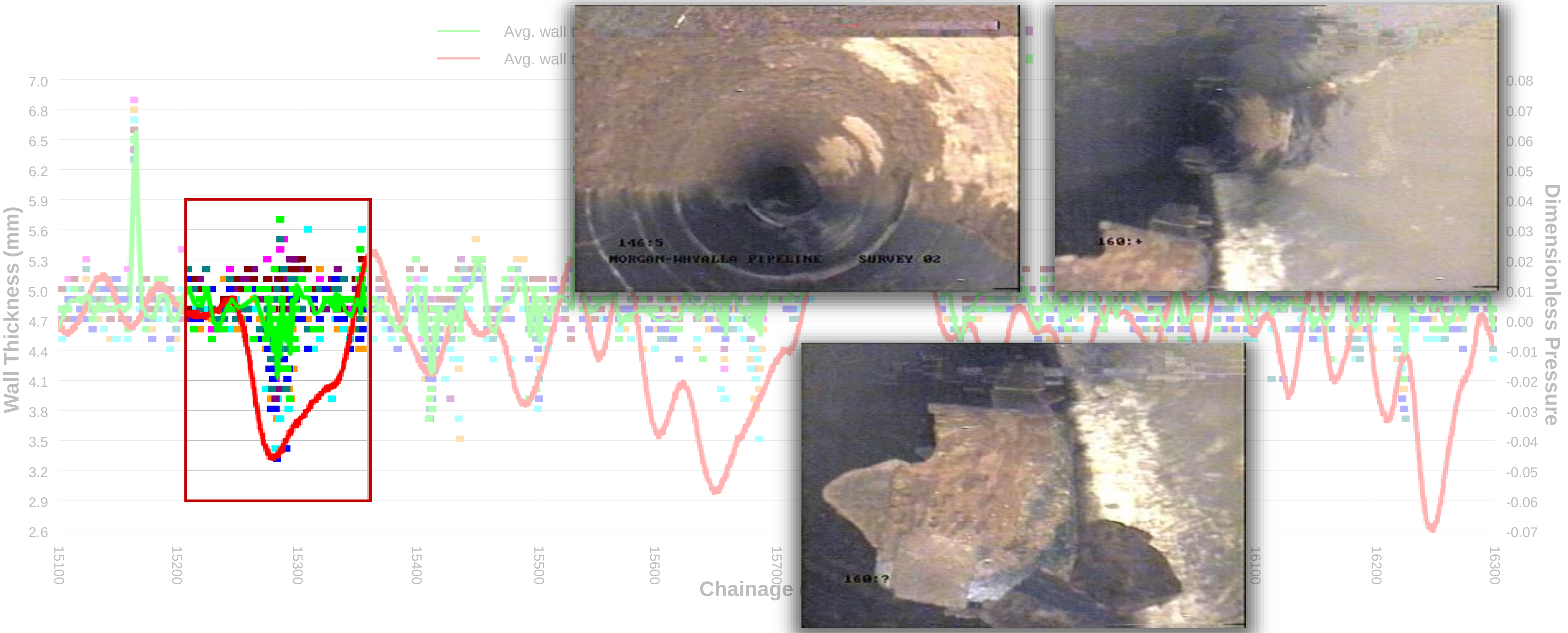
Ultrasonic wall thickness measurements



Transient reflections vs. Ultrasonic



Transient reflections vs. Ultrasonic

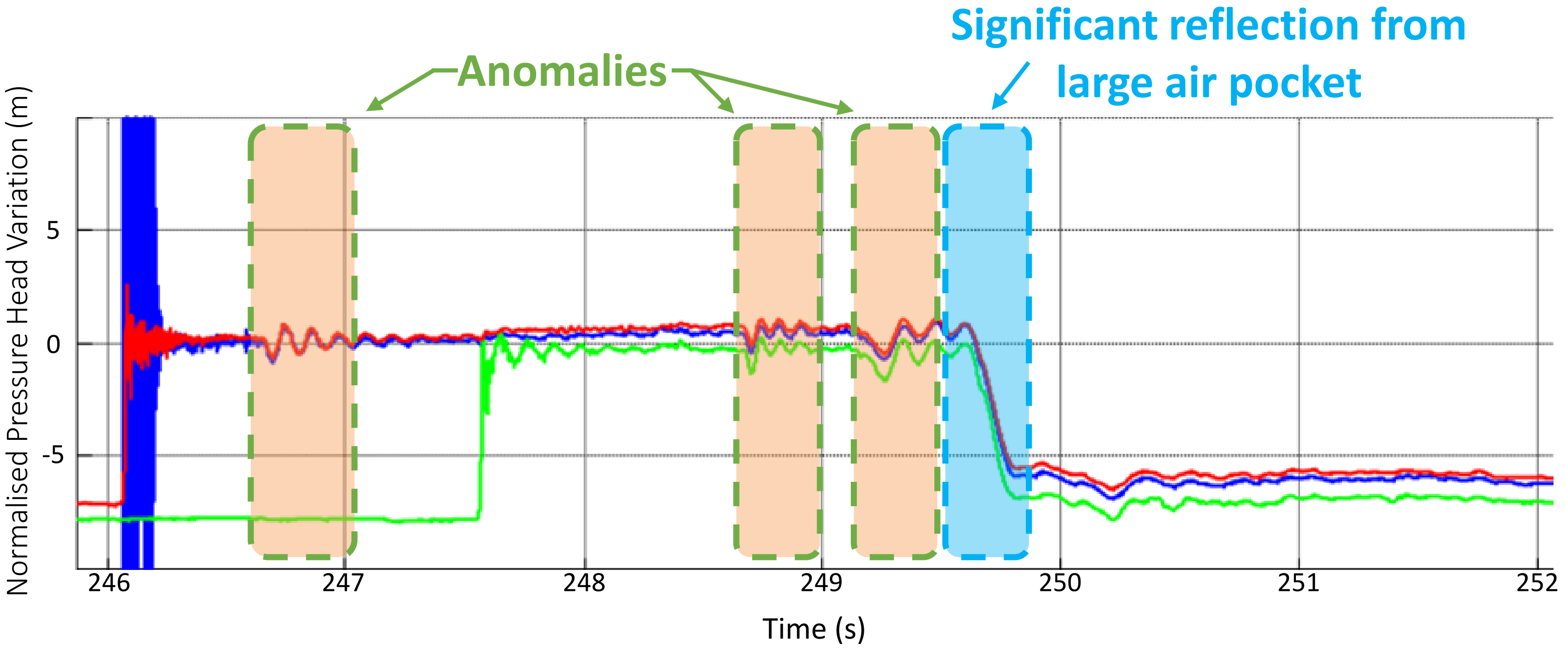


Transient reflections vs. Ultrasonic

Identification of Anomalies

Signal Analysis Overview

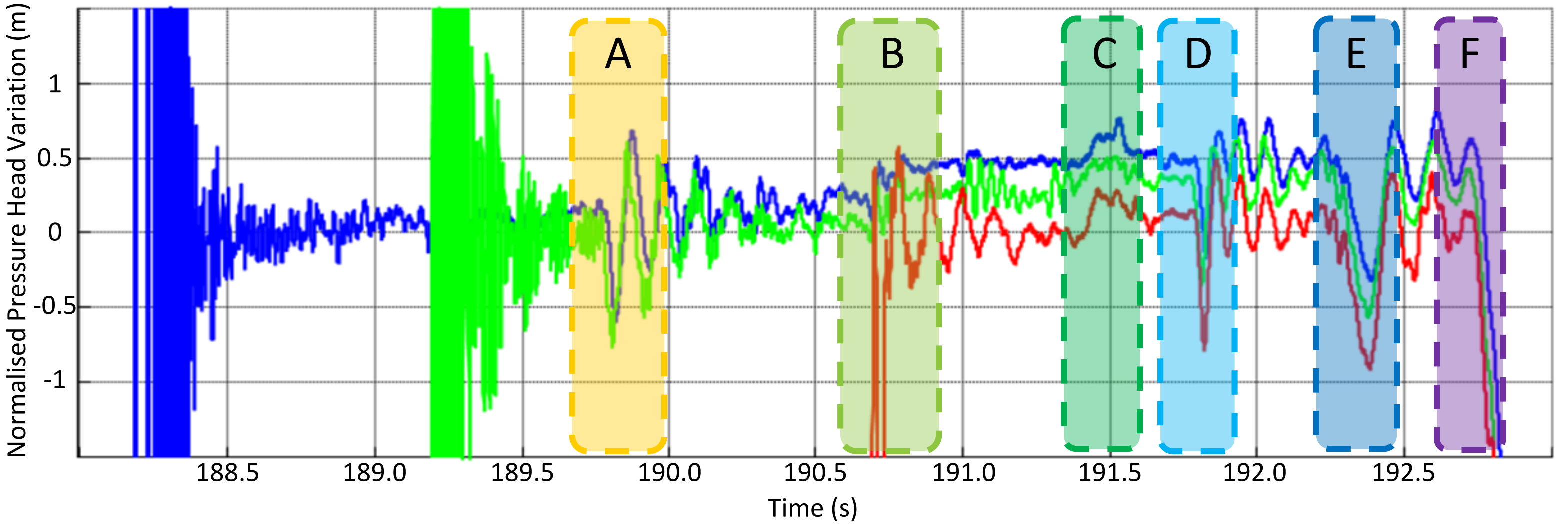
- The key benefit of p-CAT is the identification of pipeline anomalies (localised pipeline faults) with approx. 10 m spatial accuracy along a pipeline.



Identification of Anomalies

Detailed Signal Analysis

- Anomalies A to F are described in the next table.



Identification of Anomalies

Example summary of anomalies detected in previous plot segment

Anomaly Identifier	Approx. Location	Interpretation	Priority	Recommended Action
A	340m from FP2 towards FP3	Unknown structural component or air pocket	**Medium**	Check records to determine if repair has occurred
B	SV4	Change in pipe wall thickness	Low	None, known feature.
C	153m from SV5 towards FH9	Concrete encasement	Low	None, known feature.
D	402m from FP10 towards SCV2	Unknown structural component or air pocket	**Medium**	Check records to determine if repair has occurred
E	18m from SCV2 towards SV5	Unknown structural component or air pocket	**Medium**	Check records to determine if repair has occurred
F	13m from FP11 towards FH12	Discrete large air pocket	**HIGH**	**Check valve operation at pit and check air valves.**

Valve Sealing

- The status of in-line isolation valves is important for operational effectiveness
- Closed valves in network systems can seriously compromise hydraulic efficiency
- Knowing if a cross-connection between potable and recycled water systems occurs is also important

Corroded valve

Evaluation of transient techniques undertaken at Iron Knob

p-CAT™ - Benefits / Advantages

- Non-Invasive
- Not disruptive
- Minimal or no civil costs required
- Generally minimal or no site preparation required
- Use existing assets to test from (hydrants, air-valves, etc.)
- Distance between fittings can be 3000 ft. or more

2006 – 2016 Field Program

For **27** different clients –

- Such as water utilities, councils, contractors and mining companies

For over **70** different pipeline systems

For over **700km / 450 miles** of pipeline

p-CAT™ - Suitability

- Potable water
- Force Mains

Materials:

- CI, CICL, DI, DICL, steel, AC, concrete
- PCCP, theoretically, yes but untested to date

Thank You!

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