Benefits of Formalizing Condition Assessment Programs and Optimizing Pipe Renewal Through Identification of Degraded Sections

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AGENDA

01 **Water Network Challenges**

02 **Condition Assessment for Pipe Renewal Program**

03 **Acoustic Pipe Condition Assessment**

04 **Case Studies**

Your Pipe Condition and Pipe Replacement Challenges

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Challenges - Many pipes are reaching or have passed design life

Materials	Pipe Length	% of network
Asbestos Cement (AC)	39,752	28.7%
Mild Steel (MS)	37,204	26.8%
Ductile Iron (DI)	9,701	7%
Plastic (PE/uPVC)	46,511	33.5%
Others	5,418	3.9%

Source: SPAN Water and Sewerage Fact Book 2023

- As pipes age, they deteriorate at **varying rates** depending on many factors
- Replacing pipe based on age or prior breaks need supporting data to optimize investment in pipe replacement

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Overcoming Challenges

Ageing infrastructure

- Urban areas – difficult to access, high replacement costs per km, high impact of failure
- Rural areas – low customer density, high replacement cost per customer
- Asset condition varies significantly across networks

Financial Limitations

- Significant investment needed to improve / maintain supply
- Balance of asset management and network management
- Efficient return on investment needed

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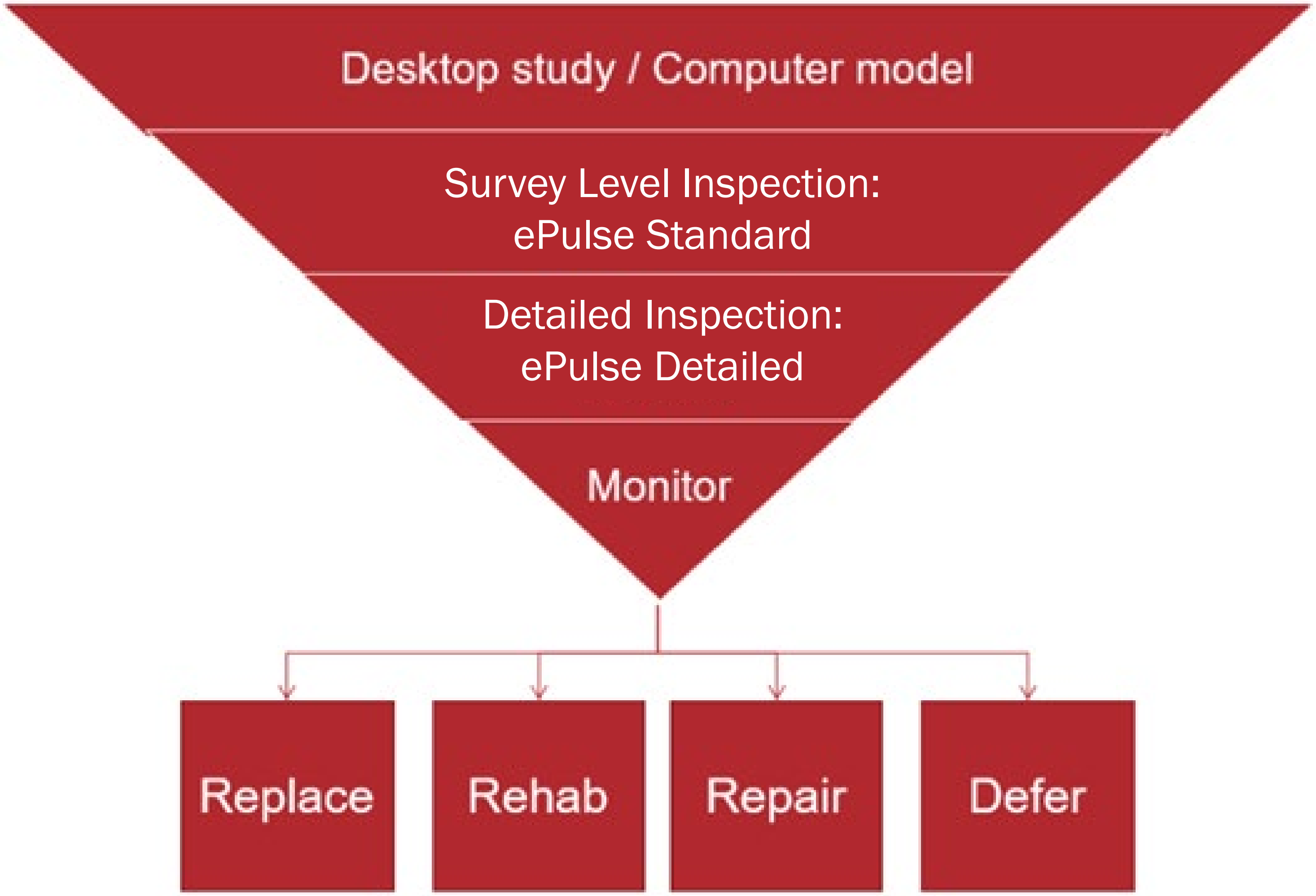
"Replacing good pipe is like digging up money…
…and then throwing it away."

Fred Pfeifer
Water Network Asset Strategy Manager
Washington Suburban Sanitary Commission

Progressive condition assessment enhances capital investment

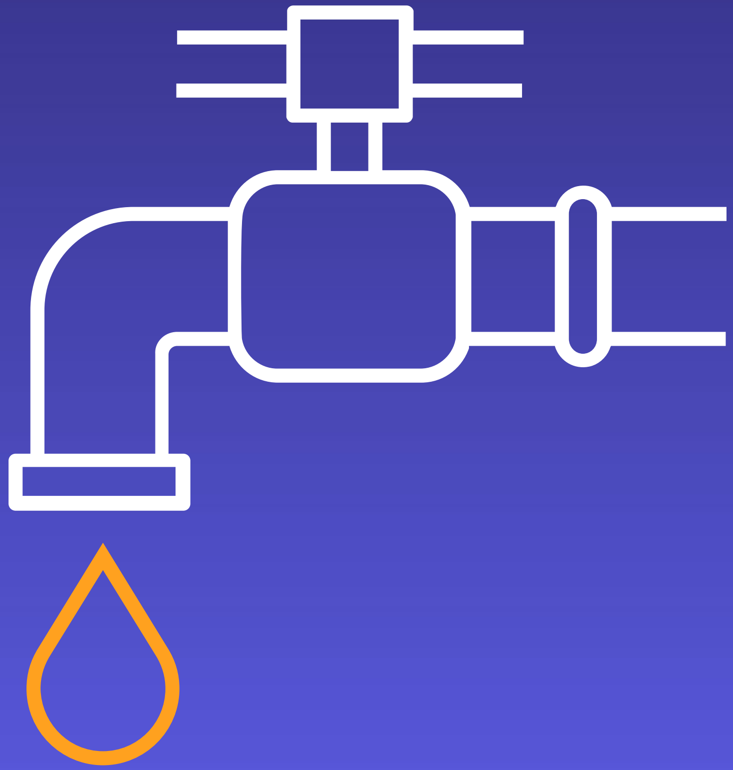


Acoustic Pipe Condition Assessment

Non-invasive

Non-Destructive

Non-Disruptive



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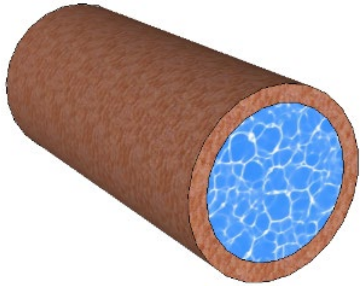
The science

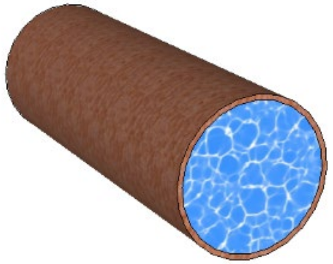
Leaks or induced noises cause the pipe to vibrate, which creates an acoustic-pressure waves that alternately compress and decompress the water molecules as the sound wave travels along the pipe.

New Pipe – full pipe thickness and more rigid



Acoustic wave moves faster

Degraded Pipe – lost some of its wall thickness and is less rigid



Acoustic wave moves slower

- In 1878, D.J. Korteweg's defined the equation for the speed of propagation of sound in tubes.
- By collecting and measuring the components of this equation, Echologics uses this principle to determine the current wall thickness of pipes, *h*

$$c = \frac{c_o}{\sqrt{1 + \frac{K}{E} \cdot \frac{D}{h}}}$$

c = Propagation velocity of sound through pipe wall
c_o = Propagation velocity of sound in water
D = Internal diameter of pipe
h = Thickness of pipe wall
K = Bulk modulus of elasticity of water
E = Young's modulus of elasticity of pipe material

ePulse® Standard

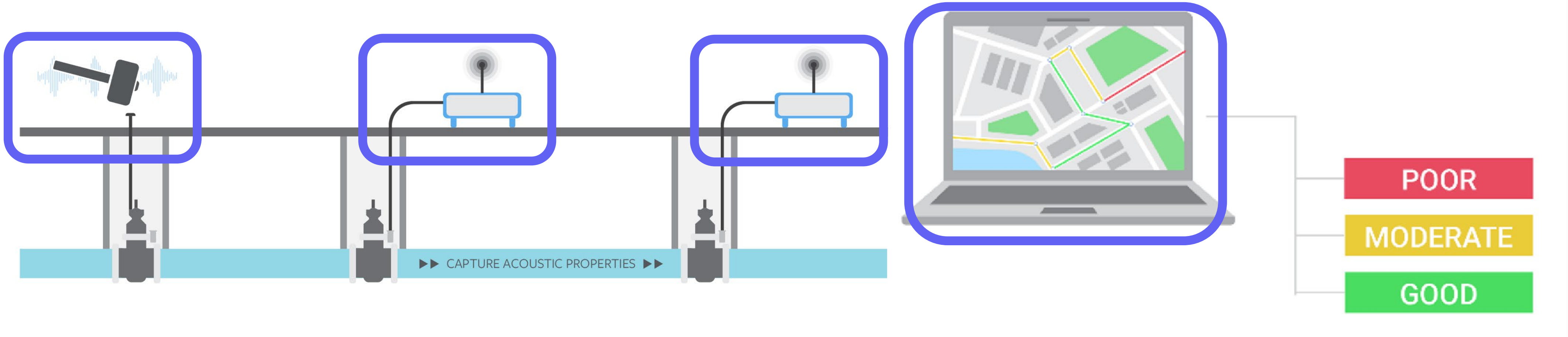
Measures Average Remaining pipe wall thickness (80-200m segments)

Non-invasive	Non-disruptive	Non-destructive	Leave Detection

2. Excite pipe

1. Install acoustic sensors

3. Analytics



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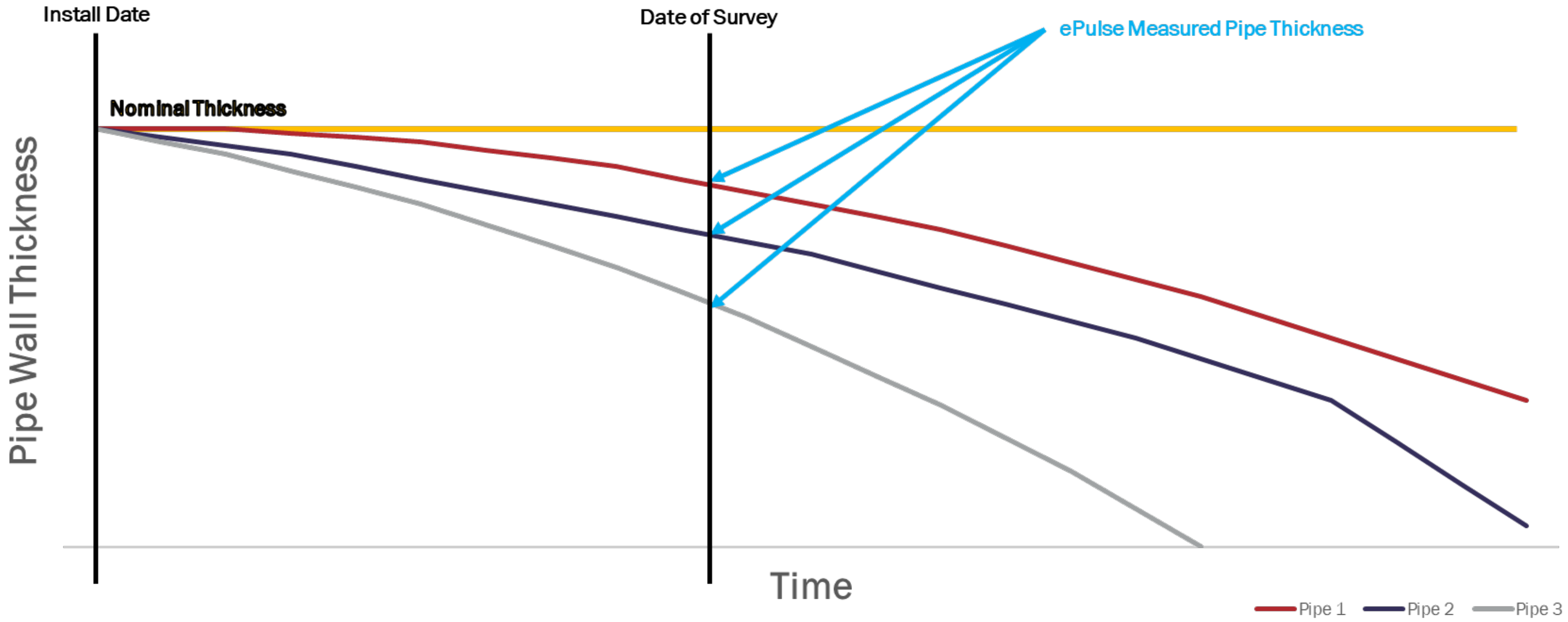
ePulse only measures the remaining structural wall thickness

Remaining Service Life (RSL)

Why RSL

- Provides additional context to ePulse results to support integration into asset management plans and justify capital improvement plans
- Estimation that can be used to prioritize pipe rehabilitation or replacement
  - Utility specific risk tolerance can be factored into RSL determination
- RSL Estimate can be provided for all pipes tested by ePulse



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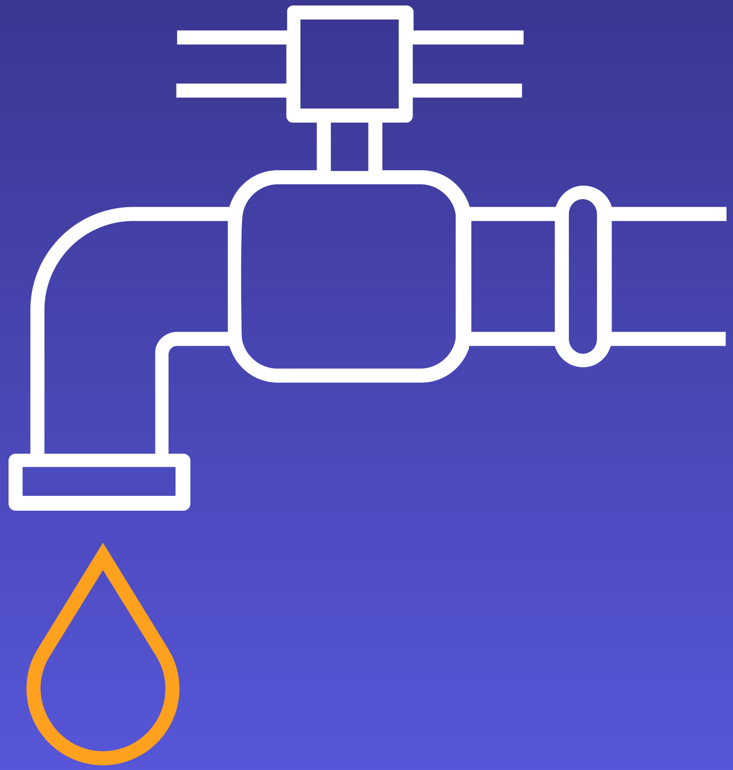
High Resolution Acoustic Pipe Condition Assessment

Non-invasive

Non-Destructive

Non-Disruptive



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ePulse Detailed

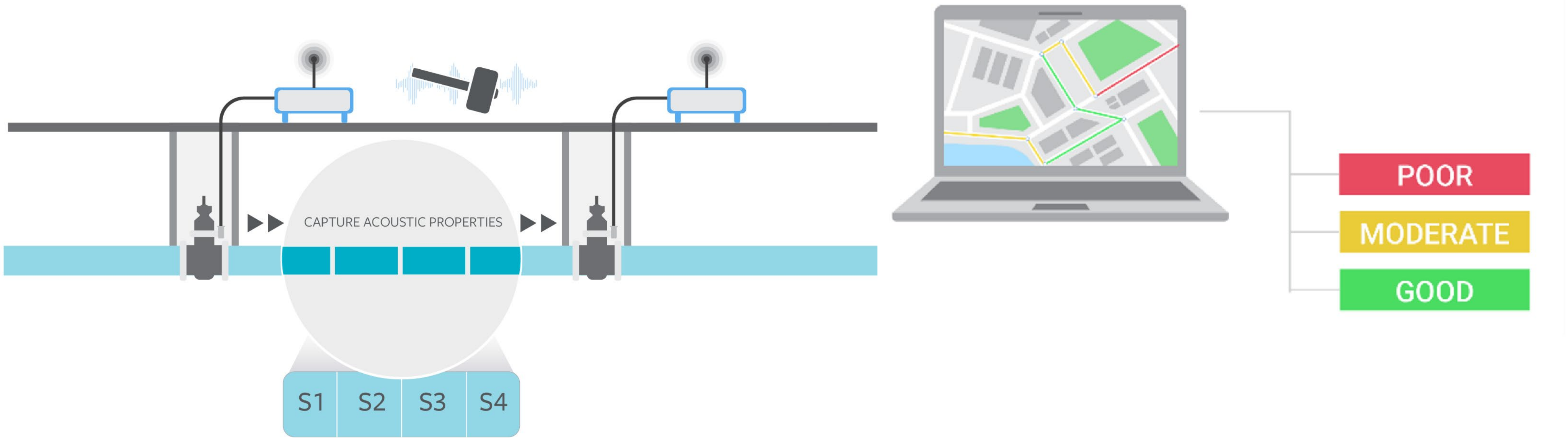
Measures Average Remaining pipe wall thickness (10-30m sections)

Non-invasive

Non-disruptive

Non-destructive

Leak Detection



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ePulse Standard vs ePulse Detailed

ePulse Standard	ePulse Detailed
Segment length: 80-200 metres	Segment length: 80-200 metres Section length: 10-130 metres
Method: Out of bracket pipe excitation	Method: Out of bracket & in-bracket pipe excitation
Tools: Rubber Mallet and Metal Hammer	Tools: Rubber mallet, metal hammer and ground excitation device

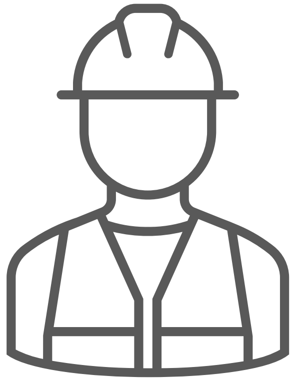
Use cases for ePulse Detailed

High resolution condition data

Critical crossings

Material transitions

Diameter transitions



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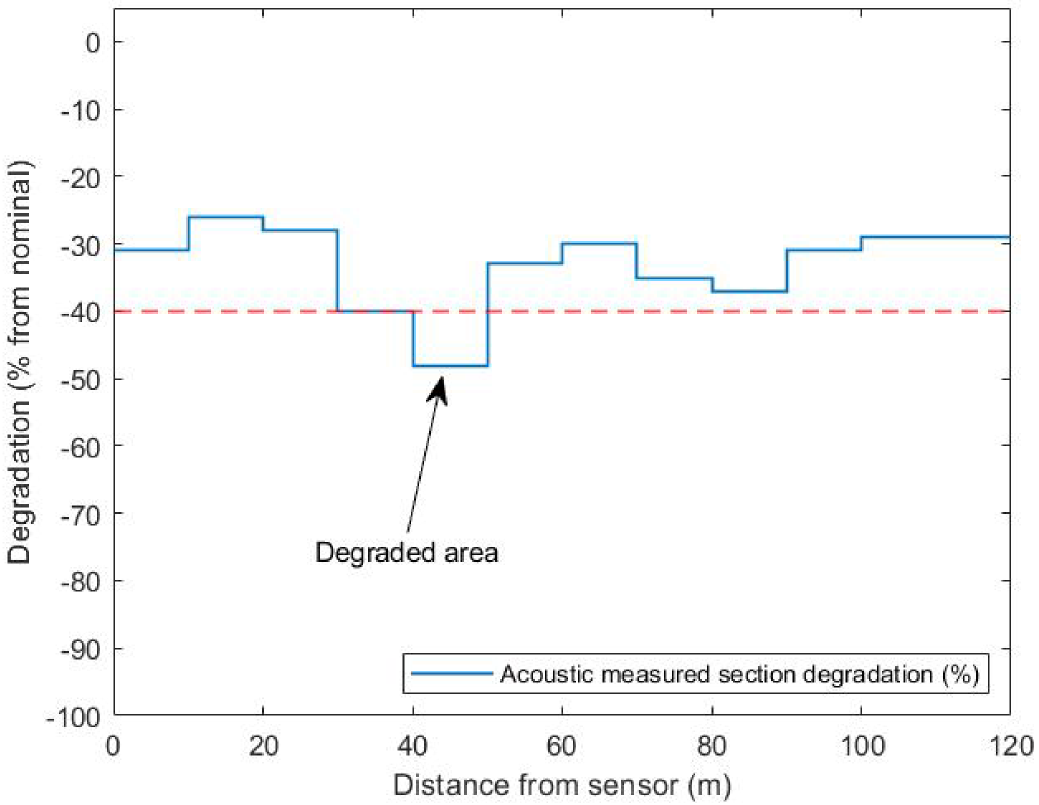
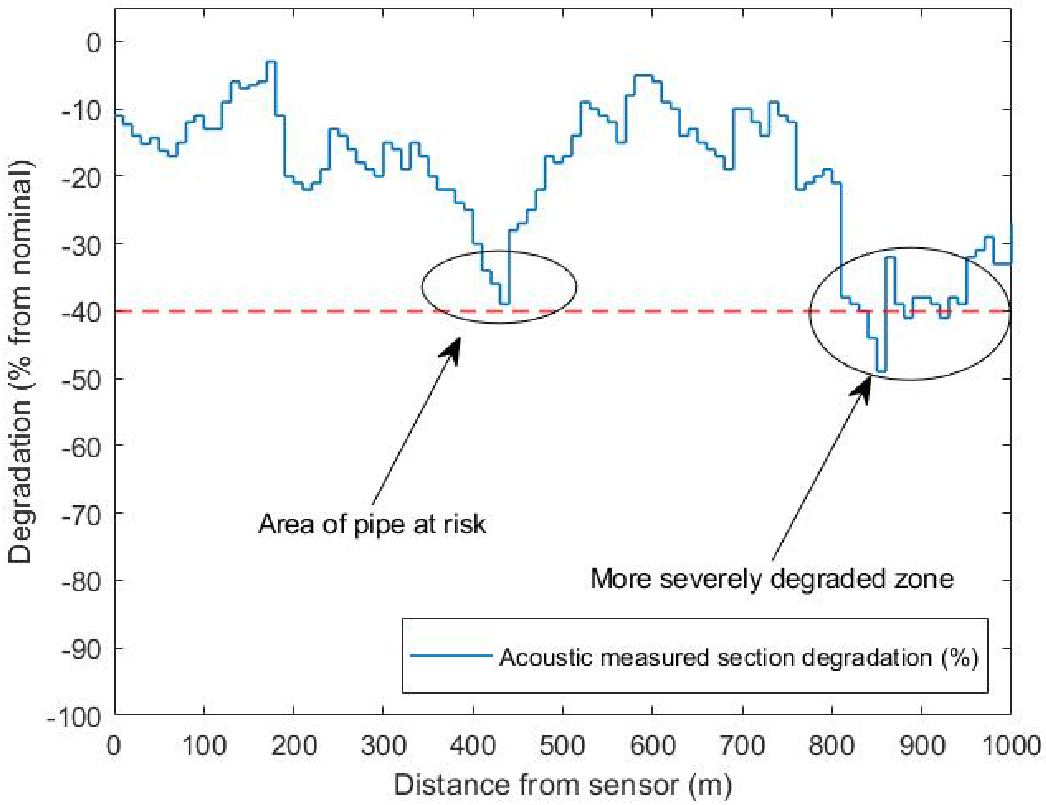
Example of condition profile at high resolution



Several segments (1 km long pipe)



- Pipe excited every 10 m with no excavation to the ground or pipe
- High resolution condition data can identify sections at risk along the pipeline

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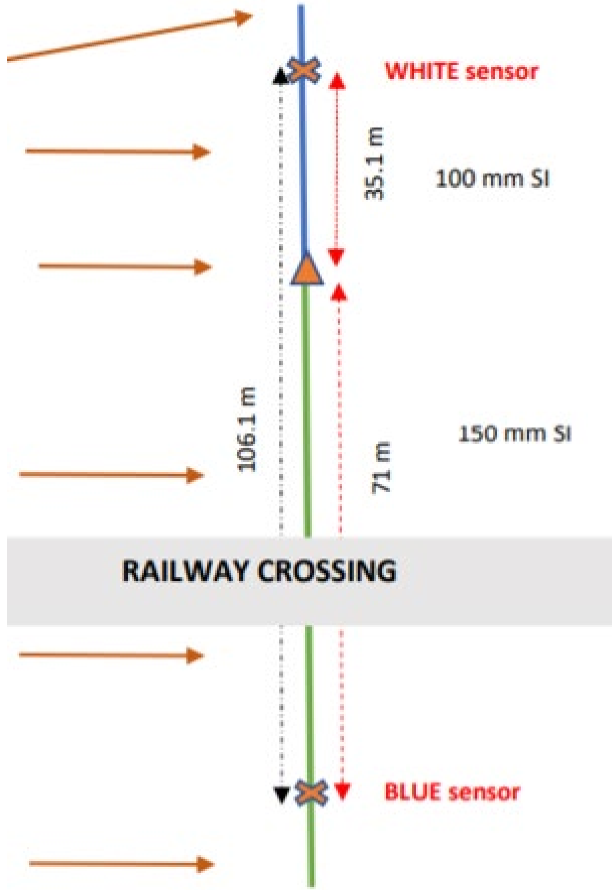
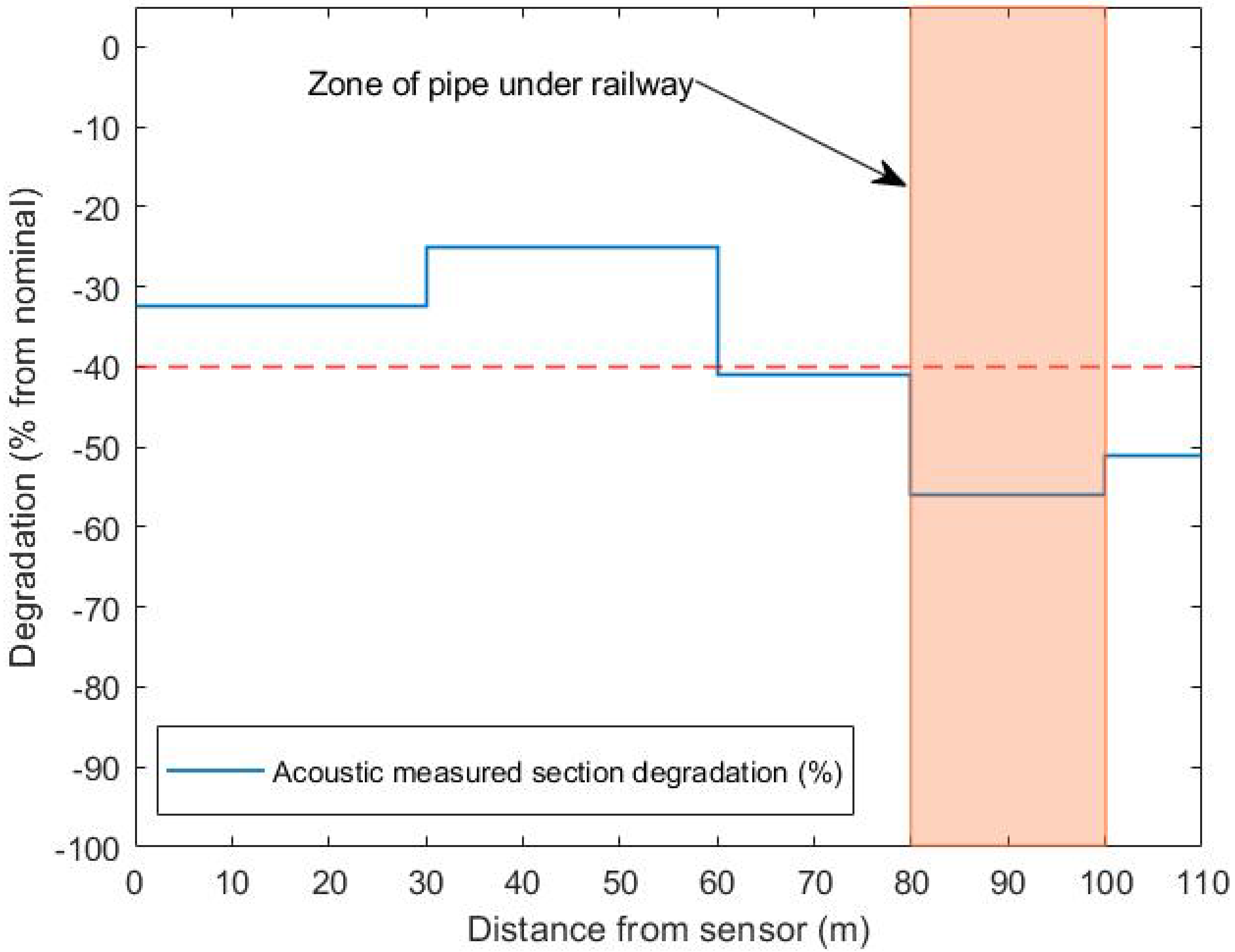
Section of a watermain under critical infrastructure

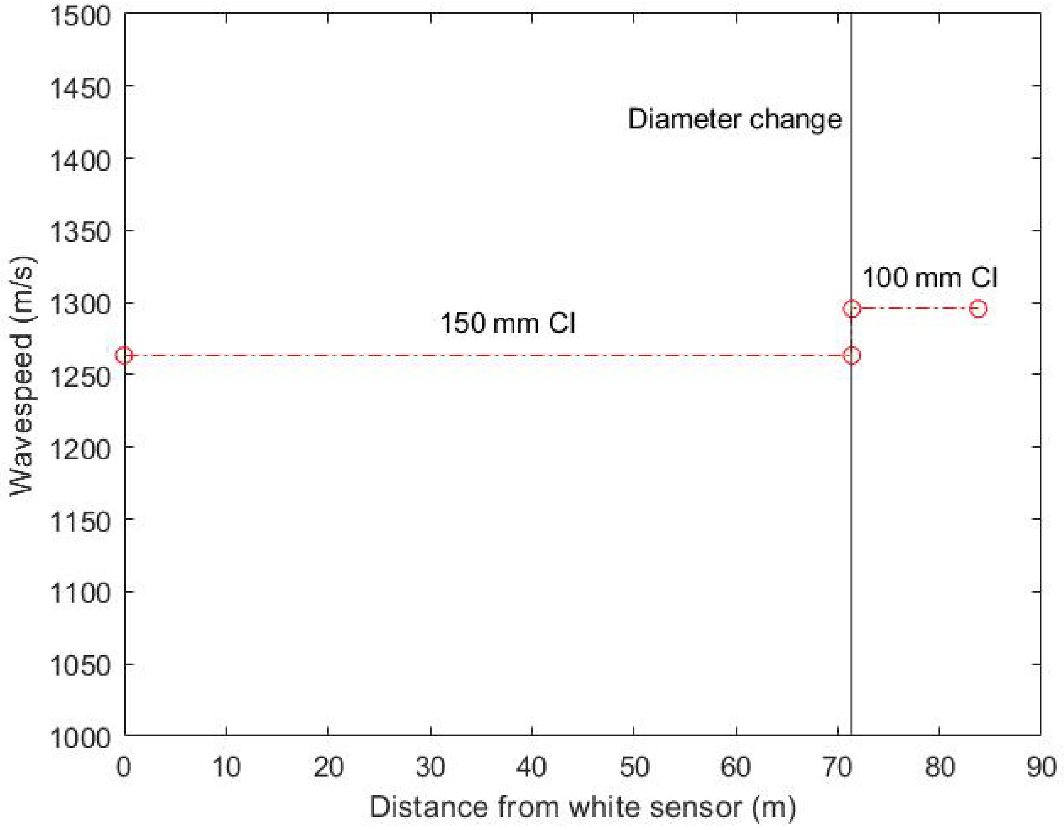
- A section under a rail crossing is isolated and shown to be in worse condition compared to the rest of the main

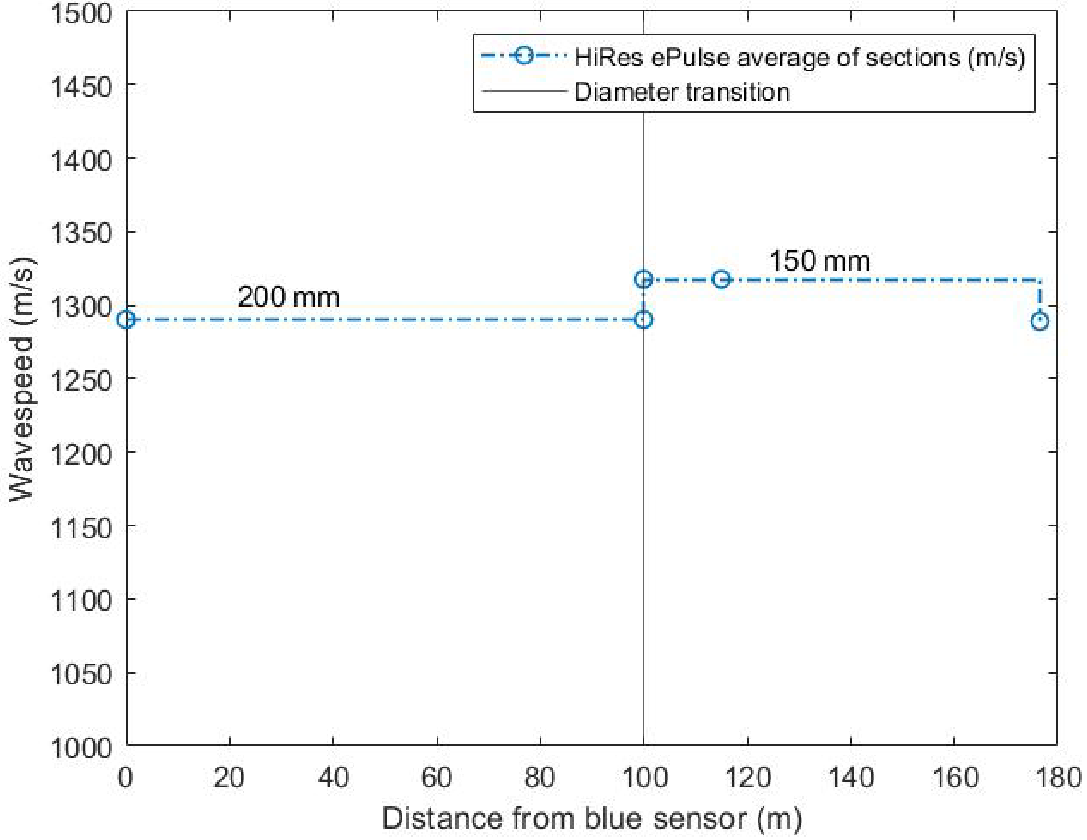




Changes in diameter or pipe material

- Location of change in pipe specification is unknown
- Change in wavespeed indicates the location of a transition in diameter or pipe material





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Case Studies

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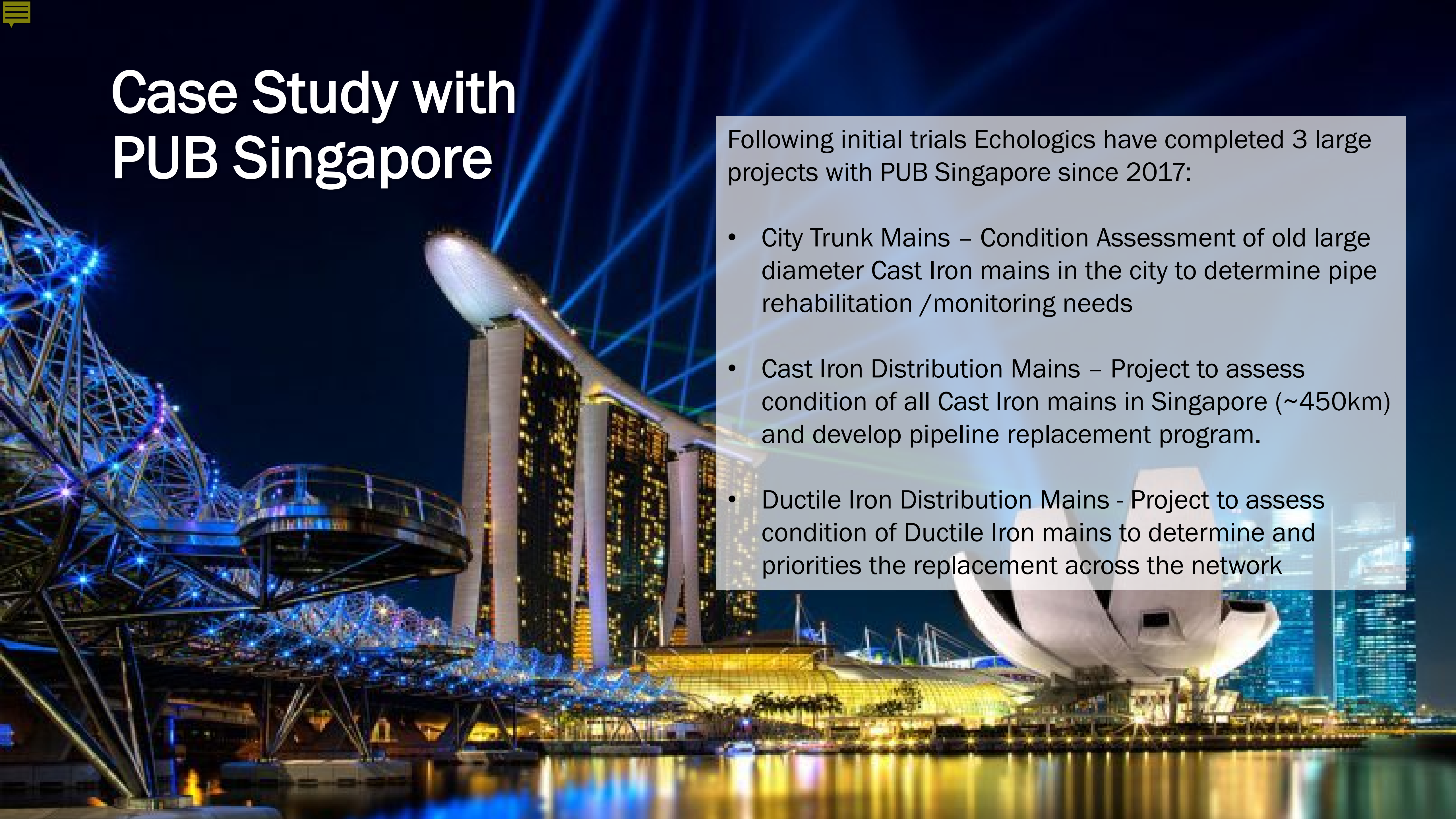

Case Study with PUB Singapore

Following initial trials Echologics have completed 3 large projects with PUB Singapore since 2017:

- City Trunk Mains – Condition Assessment of old large diameter Cast Iron mains in the city to determine pipe rehabilitation /monitoring needs
- Cast Iron Distribution Mains – Project to assess condition of all Cast Iron mains in Singapore (~450km) and develop pipeline replacement program.
- Ductile Iron Distribution Mains - Project to assess condition of Ductile Iron mains to determine and priorities the replacement across the network

Case Study 1– ePulse Standard on Cast Iron Mains

To prioritise the replacement works of all Cast Iron mains under 400 millimetres in diameter

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Situation

- PUB Singapore world renowned for high level of service
- Ageing cast iron distribution mains experiencing higher likelihood of failure
- Plan to replace over a 10-year period
- Develop a strategy to identify and prioritise high risk pipes for replacement

Case Study 1– ePulse Standard on Cast Iron Mains

Results

- 80km ePulse testing with RSL on Cast Iron pipe, extrapolated to rest of network
  - Results are based on the average wall thickness per sections (80-200m/section)
  - More than half of pipes with more than 30% thickness loss
  - However, remaining service life of the pipes shows some of those pipes can be deferred and some pipes with less loss should be prioritized.

- Significant savings and performance improvements predicted from optimisation of program
  - 271km of pipes to be replaced by PUB over 5 years.
  - 161 km of the mains (40% of the target network) can be deferred and remain into service for more than 10 years.
  - **Approximately $70M CAPEX savings compared to a scenario of 100% CI pipes renewal in the next 10 years.**
  - This capital could be redirected to other replacement programs

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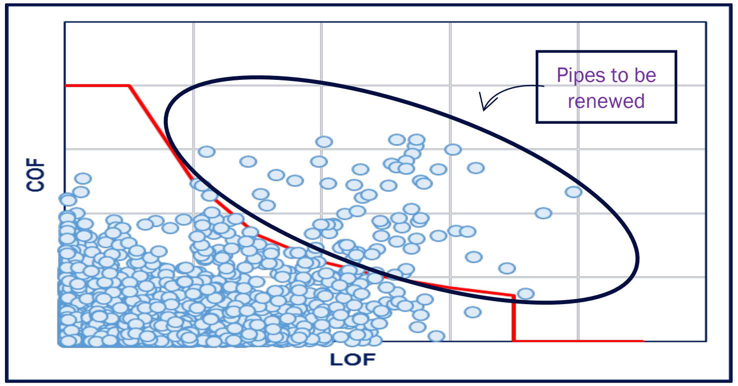
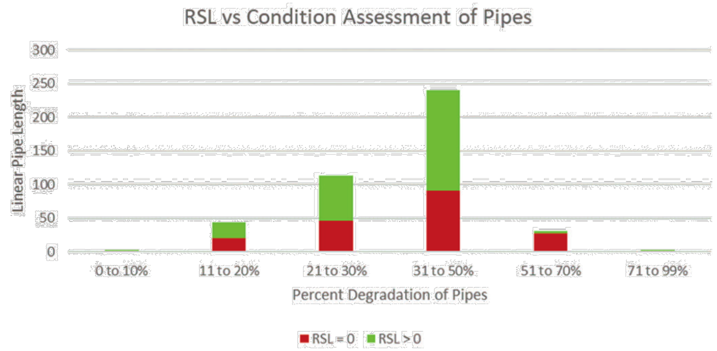
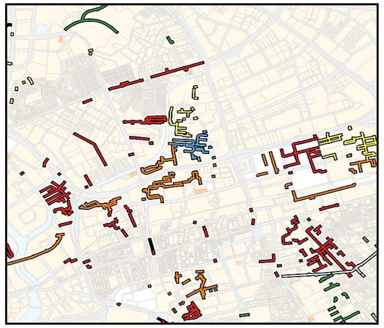
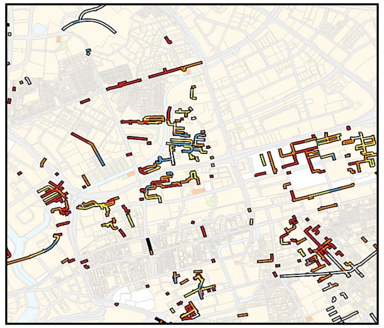






Prioritisation of Pipe Segments

*Around **50 km/year** of CI pipes replacement*



Prioritisation of Work Packages

*Around **50 km/year** of CI pipes replacement*

Case Study 2 – ePulse Standard and Detailed on Ductile Iron Mains

The Situation

- Over 4,000 km of ageing cast iron and ductile iron pipes
- Implemented rigorous replacement programme to maintain burst rate under 4/100km/year
- Wanted to calculate and localise risk due to bursts, and optimise their replacement strategy
- Ductile iron pipes degrade less uniformly than cast iron pipes, so analysis over long segments may not reflect degradation over smaller sections

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The Challenge

- Asked Echologics to develop a solution to determine pipe wall thickness on much smaller sections

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Example exhumed pipe – 150 mm Ductile Iron

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- Conducted ePulse Standard throughout system to find pipes with greatest degradation
- Utilise ePulse Detailed on degraded DI pipes to see where degradation is most prevalent

Segment (across 112m)	0m to 28m	28m to 56m	56m to 84m	84m to 112m
Lab result (validation)	5.9 mm	5.9 mm	5.9 mm	5.5 mm
ePulse Standard	5.6 mm			
ePulse Detailed	5.9 mm	5.6 mm	5.6 mm	5.4 mm
Error (ePulse Detailed) (%)	0.0 mm (0 %)	0.3 mm (5.1 %)	0.3 mm (5.1 %)	0.1 mm (1.8 %)

Results

- ePulse Standard confirmed average pipe wall thickness of 5.6 mm (measured 5.7mm)
- ePulse Detailed error is only between 0.1% and 5.1% of actual measured wall thickness

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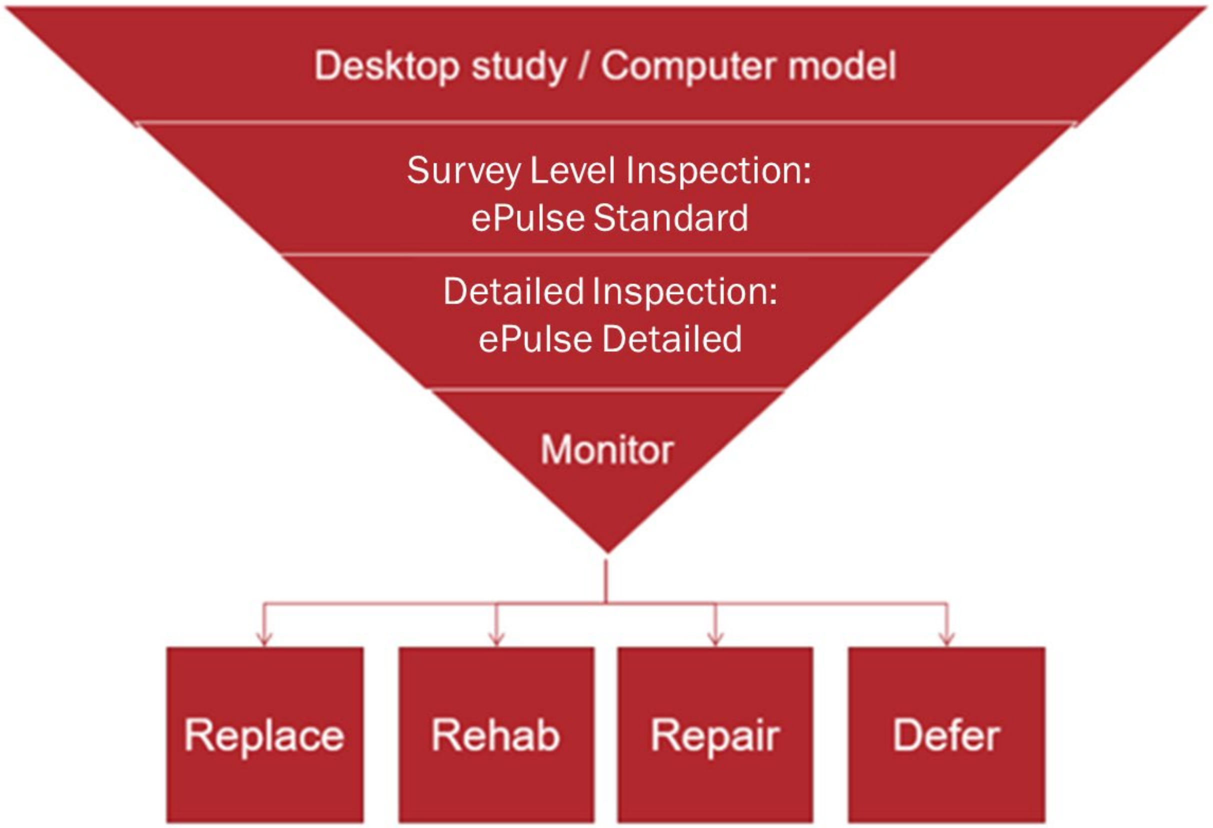
Conclusions



- Pipe replacement program objective is to focus on mitigating risk and maximizing capital investments.
- Survey Level acoustic pipe condition assessment measures accurately (<5% error) the <u>average condition of the whole segment</u> between two access points
- Detailed condition assessment method measures the <u>condition of individual sections</u> with less than 10 % error. *Recommended for:*
    - *Pipes with high consequence of failure*
    - *Critical crossings (railways, major road junctions etc.)*
    - *Where non-uniform degradation is expected*

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