Singapore International Water Week (SIWW) Water Convention 2022
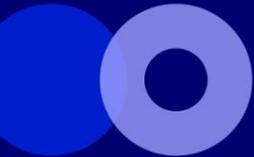
Sensing and managing system performance to minimise leaks and breaks.

20 April 2022

UTS
UNIVERSITY OF TECHNOLOGY SYDNEY

Sydney
WATER

Acknowledgement of Country

Sydney Water respectfully acknowledges the traditional custodians of the land and waters on which we work, live and learn. We pay respect to Elders past and present.

Context

Sydney Water

- Supplies 5 million people
- Serves an area of 12,700 km2
- 21,000km of water pipes and 26,000km of waste water pipes
- Largest utility in the southern hemisphere

What do leaks and breaks mean for Sydney Water?

- Sydney Water experiences around 5,500 breaks and leaks annually
- <8% of water losses
- 60%–70% of the leaks in distribution pipes
- 165 - 175 breaks on critical water mains
- $80 million spent on renewals and maintenance.

How does the water industry traditionally handle leaks and breaks?

- We rely on our customers and staff to report leaks and breaks
- Reactive repairs for leaks and breaks instead of proactive maintenance.

Minimising unaccounted water (SW Water Loss Improvement Program)

Existing

Active Leak Detection (ALD)

Smart Ball Insertion

Sahara Insertion Tool

Innovative Deployment

Using Internal ICATTS

Predictive Analytics & MNF Assessment

ALD+ Acoustic Sensing

Leak Web Portal

Acoustic Sensing

K9 (Canine)

DMA Pressure Management

Spray Lining Inhibiting Leaks

Intelligent Pressure Management

120 ML/day ↓ 90 ML/day (in 5-10 years)

Next Generation

Lidar on a Drone

Quantum Sensing

Dark Fibre

Photonics

Future

Distributed Fibre Optic Sensing

Distribution Insertion
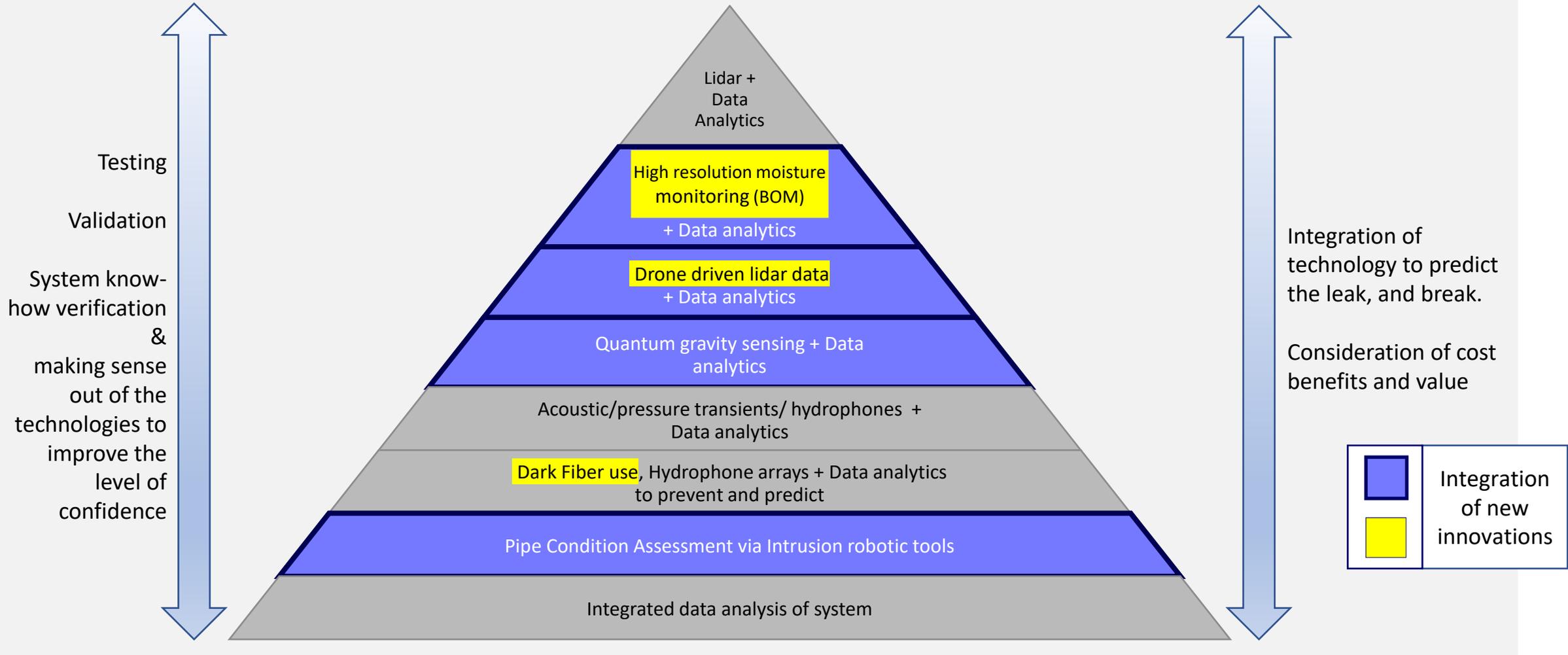
Electro Scan

Satellite Imaging

IOT Integration Intelligent Networks

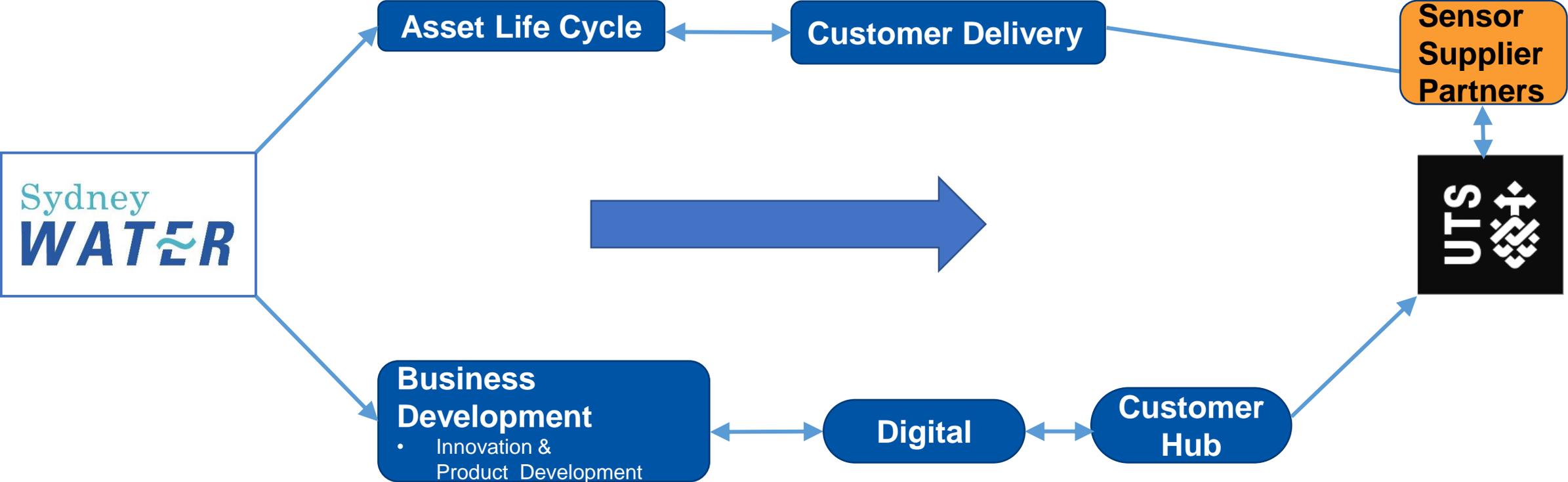# Tool kits to Prevent Leaks and Breaks
(Existing and innovations)

Utility Decision Making Framework

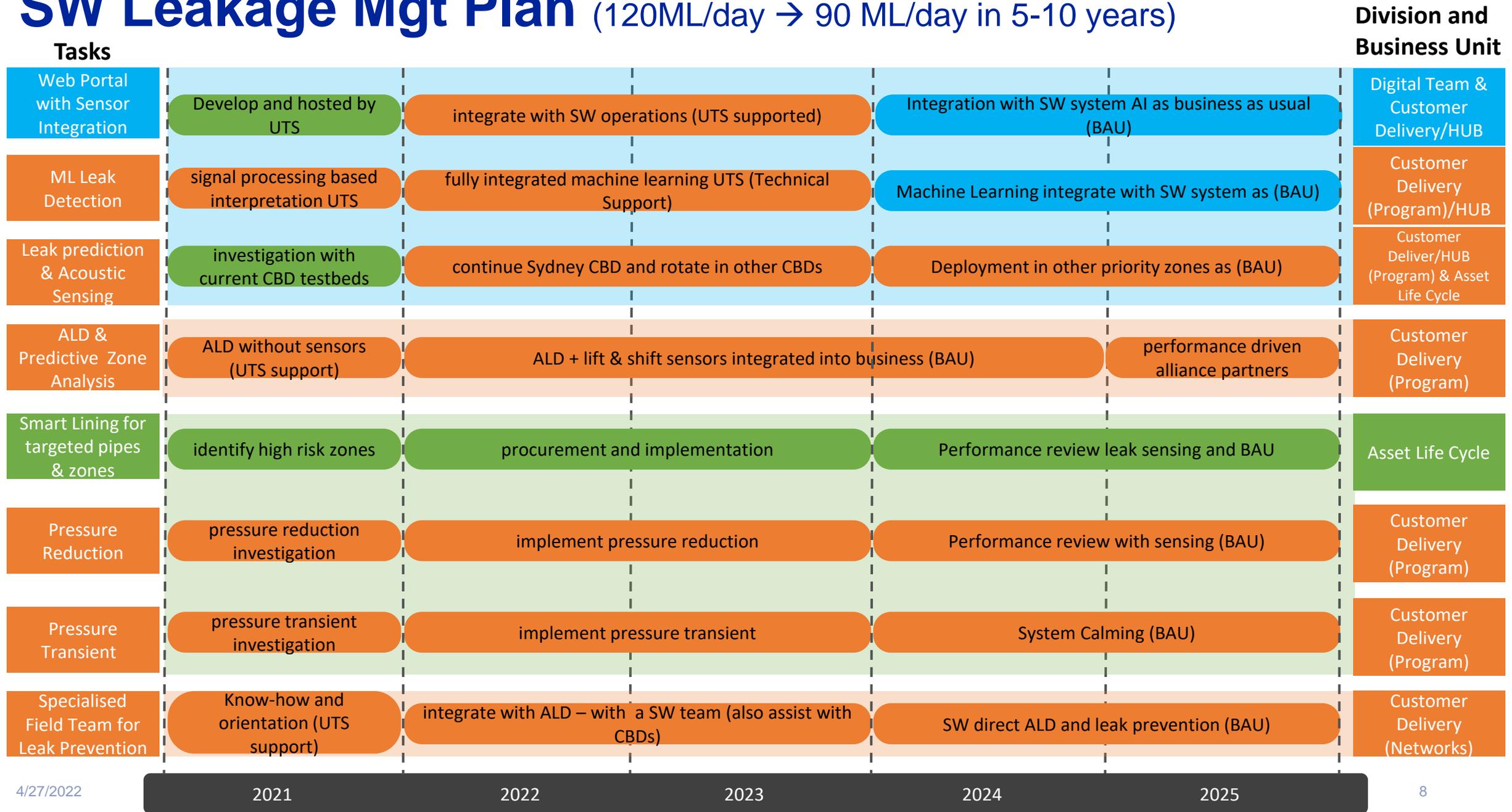Testing

Validation

System know-how verification & making sense out of the technologies to improve the level of confidence

Lidar + Data Analytics

High resolution moisture monitoring (BOM)
+ Data analytics

Drone driven lidar data
+ Data analytics

Quantum gravity sensing + Data analytics

Acoustic/pressure transients/ hydrophones + Data analytics

Dark Fiber use, Hydrophone arrays + Data analytics to prevent and predict

Pipe Condition Assessment via Intrusion robotic tools

Integrated data analysis of system

Integration of technology to predict the leak, and break.

Consideration of cost benefits and value

Integration of new innovations

Leakage Road Map

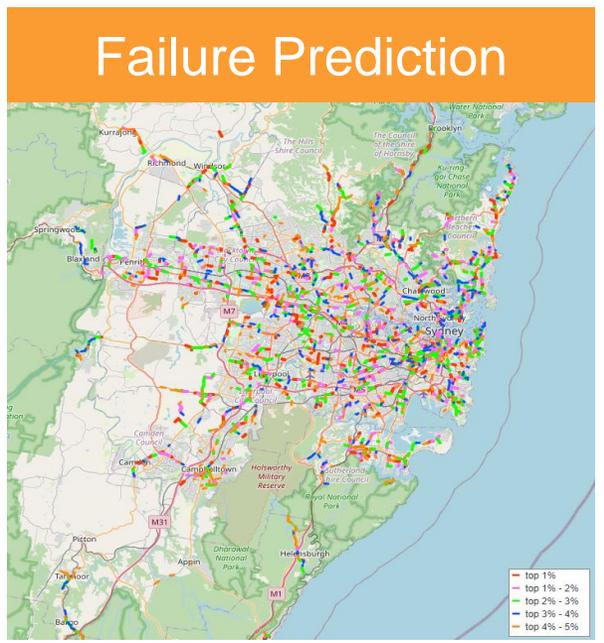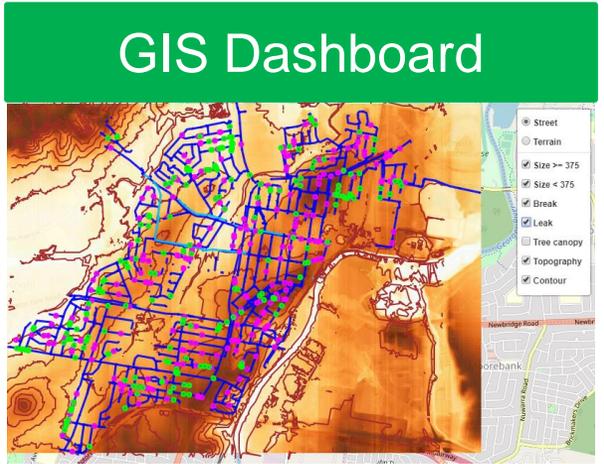| Asset Class	Technology	Detection Limit	Year 1	Year 2	Year 3	Year 4
Critical + Distribution	Data driven pipe leak/break prediction $0.5/m	predicts 80% leaks and breaks within 200m	Operationalised			
C+D	Lidar and Lidar on a drone on nature strips $1/m	only on nature strips wet areas	Validated Trials	Operationalised		
C	BOM Moisture and Soil Analysis $20/m	available wetness	Concept improvement	Operationalised		
C+D	Quantum Sensing $20/m	leak patch within 5m of the leak	Validating real leaks	Operationalisation		
C+D	Acoustic Sensing $25/m	>=0.01 Lit/sec	Business as usual			
C	In pipe distributed fibre sensing $30/m	~0.6 Lit/sec	Concept	Validated Trials	Operationalised	
C+D	Dark Fibre Sensing $5/m	>0.6 Lit/sec	Concept	Validated Trials	Operationalised	
C	Smart in pipe sensing $5/m	0.005 Lit/sec limited length	Concept	Validated Trials	Operationalised	
D	Distribution in pipe <$5/m	0.005 Lit/sec part of DMA	Concept		Validated Trials	Operationalised

How we worked as one team and with our partners

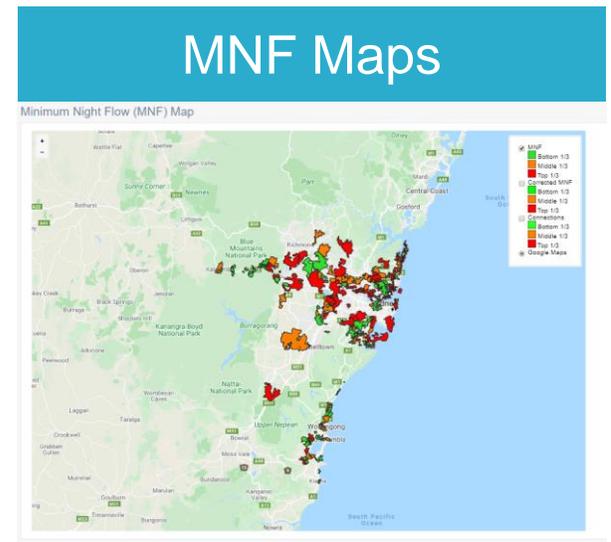# SW Leakage Mgt Plan (120ML/day → 90 ML/day in 5-10 years)

Tasks

Division and Business Unit

Task	2021	2022	2023	2024	2025	Division and Business Unit
Web Portal with Sensor Integration	Develop and hosted by UTS	integrate with SW operations (UTS supported)		Integration with SW system AI as business as usual (BAU)		Digital Team & Customer Delivery/HUB
ML Leak Detection	signal processing based interpretation UTS	fully integrated machine learning UTS (Technical Support)		Machine Learning integrate with SW system as (BAU)		Customer Delivery (Program)/HUB
Leak prediction & Acoustic Sensing	investigation with current CBD testbeds	continue Sydney CBD and rotate in other CBDs		Deployment in other priority zones as (BAU)		Customer Deliver/HUB (Program) & Asset Life Cycle
ALD & Predictive Zone Analysis	ALD without sensors (UTS support)	ALD + lift & shift sensors integrated into business (BAU)			performance driven alliance partners	Customer Delivery (Program)
Smart Lining for targeted pipes & zones	identify high risk zones	procurement and implementation		Performance review leak sensing and BAU		Asset Life Cycle
Pressure Reduction	pressure reduction investigation	implement pressure reduction		Performance review with sensing (BAU)		Customer Delivery (Program)
Pressure Transient	pressure transient investigation	implement pressure transient		System Calming (BAU)		Customer Delivery (Program)
Specialised Field Team for Leak Prevention	Know-how and orientation (UTS support)	integrate with ALD – with a SW team (also assist with CBDs)		SW direct ALD and leak prevention (BAU)		Customer Delivery (Networks)

Predictive Analytics Tool

Water Pipe Failure Prediction

Data used:

- Break locations up to Jan 2021

- Size >= 250 mm

The distribution of distance between the actual failures to predicted locations (middle point of the pipe):
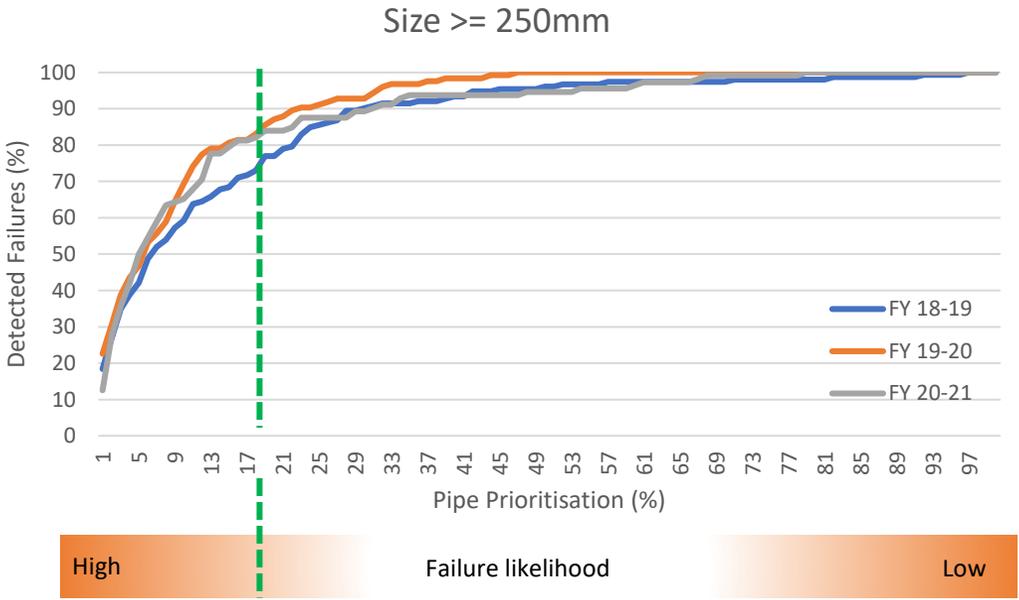

Distance of predictions to actual failure locations (m)
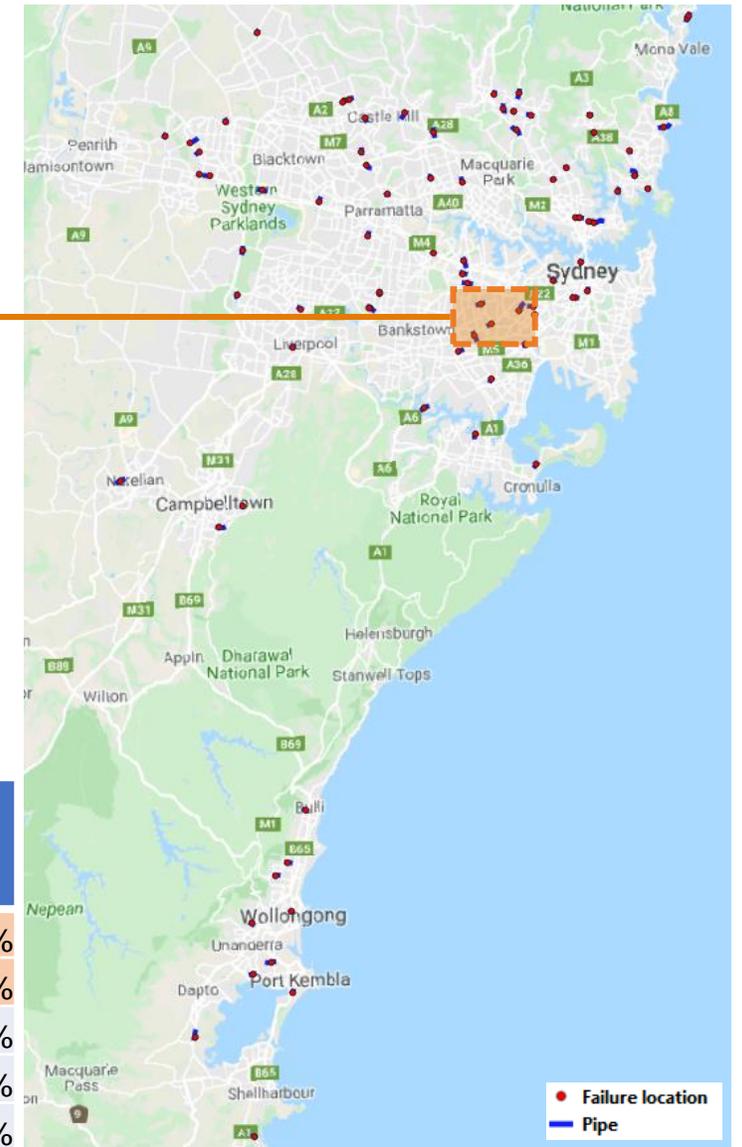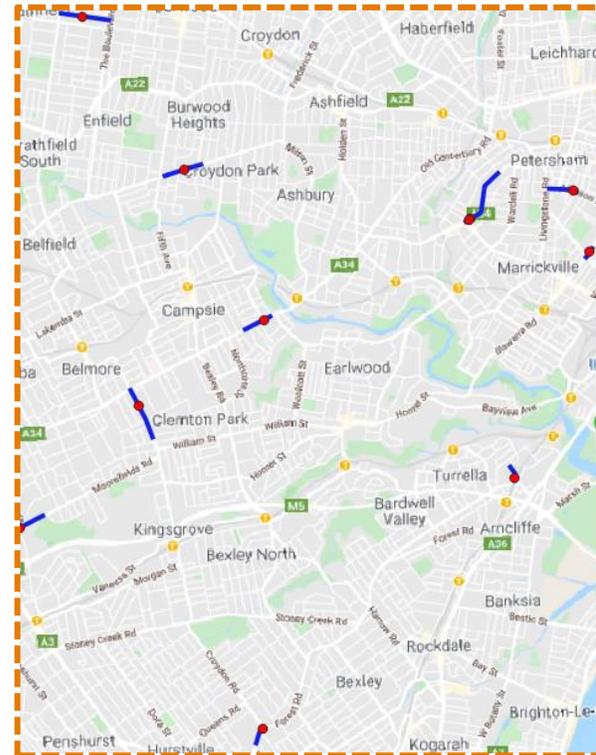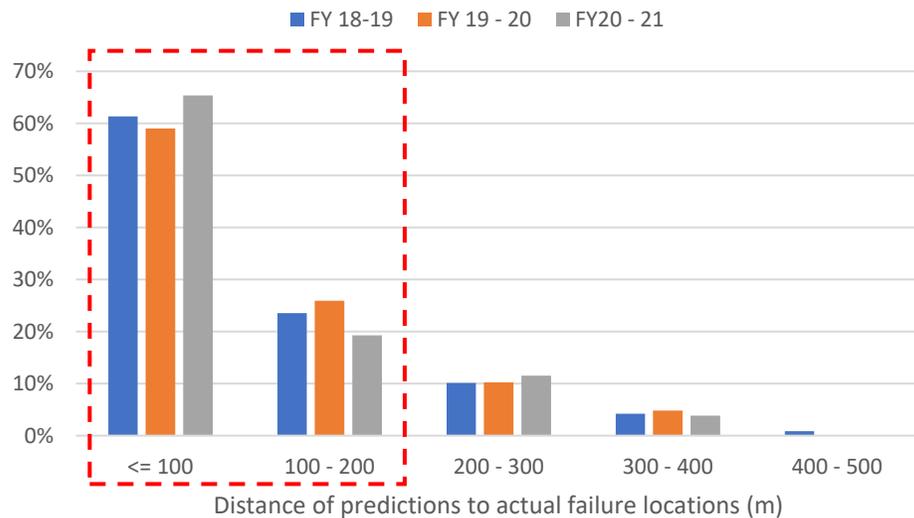
Distance to failure location (m)	FY 18-19	FY 19-20	FY 20-21
<= 100	61.34%	59.04%	65.38%
100 - 200	23.53%	25.90%	19.23%
200 - 300	10.08%	10.24%	11.54%
300 - 400	4.20%	4.82%	3.85%
> 400	0.84%	0.00%	0.00%

Failure location
Pipe

Latest Pipe Failure Prediction

Latest evaluation

Size >= 250mm

	FY 18-19	FY 19-20	FY 20-21
1%	18.42%	22.58%	12.50%
5%	42.11%	46.77%	41.96%
10%	59.21%	69.35%	65.18%
20%	76.97%	87.10%	83.93%

Priority Map for FY 20-21
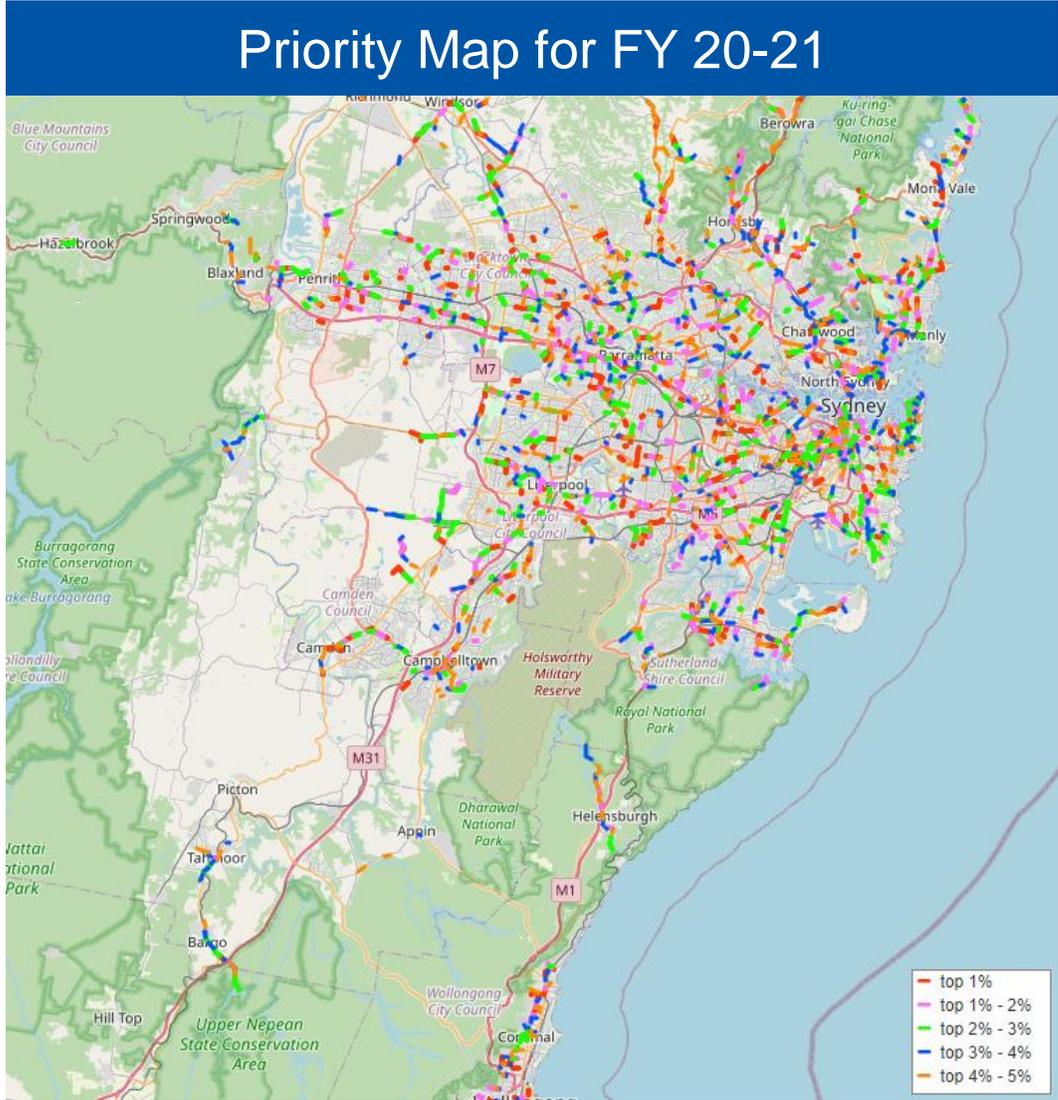
Acoustic Sensor Deployment

Semi-permanent Loggers:
125 leaks raised with SW
88 leaks confirmed by SW
~70% Hidden Leaks

Leaks found
Hydrant ~30%
Valves ~20%
Main tap ~22%
Private ~11%
Service ~12%
Main break ~2.5%
Meter tap ~2.5%

270 Loggers:
38 Primayer Enigma3m
40(/64) Sebalog N-3
168 HWM PermaNET+/SU

Lift and Shift Loggers:
52 leaks confirmed by SW
~70% Hidden Leaks

Types of leaks found
Hydrant: ~37%
Meter tap/coupling: ~13%
Valves: ~13%
Mains to meter/service: ~19%
Main leak: ~8%
Main break: ~8%
Other: ~2%

Penrith [finished]
20 HWM PermaNET+

Wahroonga Reduced 8 [finished]
40 Primayer Enigma

Terrey Hills Elevated [finished]
40 Primayer Enigma

Paramatta [current]
38 Primayer Enigma3m
17 Von Roll Ortomat

Hermitage Reduced 5 [finished]
40 Primayer Enigma

Bantry Bay Reduced 2 [finished]
70 HWM PCorr+

Holroyd Reduced 1 [finished]
100 Gutermann ZoneScan 820
70 HWM PCorr+

Chatswood [finished]
40 Primayer Enigma3m

Chatswood Reduced 7 [finished]
40 Primayer Enigma

Liverpool [current]
23 SebaKMT Sebalog N-3

Sydney CBD [current]
41 SebaKMT Sebalog N-3
130 HWM PermaNET SU
38 HWM PermaNET+

Bankstown [finished]
20 VonRoll Ortomat
20 HWM PermaNET+

Loftus Reduced 3 [finished]
40 Primayer Enigma

Semi-Permanent Acoustic Sensors

Leaks detected December 2019 – 2022
(Updated 21st February '22)

Most of the leaks are hidden but delays in validating the confirmed leaks results in a lower hidden rate of 70%

CBD area	Deployment Status	Potential leaks raised w/ SW	Confirmed leaks (SW)	To be investigated	Awaiting repair
Penrith	Finished (moved to Sydney CBD)	6	6	0	0
Bankstown	Finished (moved to Sydney CBD)	17	15	0	0
Chatswood	Finished (moved to Parramatta)	5	3	0	0
Liverpool	Current	10	9	0	1
Sydney CBD	Current	76	48	8	3
Parramatta	Current	11	7	0	0

Lift & Shift Acoustic Sensors

Leaks detected June 2020 – February 2022
(Updated 21st February 2022)

Most of the leaks are hidden but delays in validating the confirmed leaks – cause majority of leaks to surface

Pressure Zone	Loggers Deployed	Deployment Status	Potential leaks raised w/ SW	Confirmed leaks (SW)	Awaiting repair
Holroyd Reduced 1	Gutermann ZoneScan 820, HWM PCorr+	Finished	7	3	0
Bantry Reduced 2	HWM PCorr+	Finished	9	9	0
Wahroonga Reduced 8	Primayer Enigma	Finished	7	6	1
Chatswood Reduced 7		Finished	7	5 + 1 network issue (DV)	0
Loftus Reduced 3		Current (1 location requires re-visit)	6	1 + 1 network issue (DV)	1
Hermitage Reduced 5		Finished	7	5	0
Terrey Hills Elevated		Finished	22	21	0

Signal Processing + Machine Learning for Accurate & Reliable Leak Alarms

Raw Audio Signals
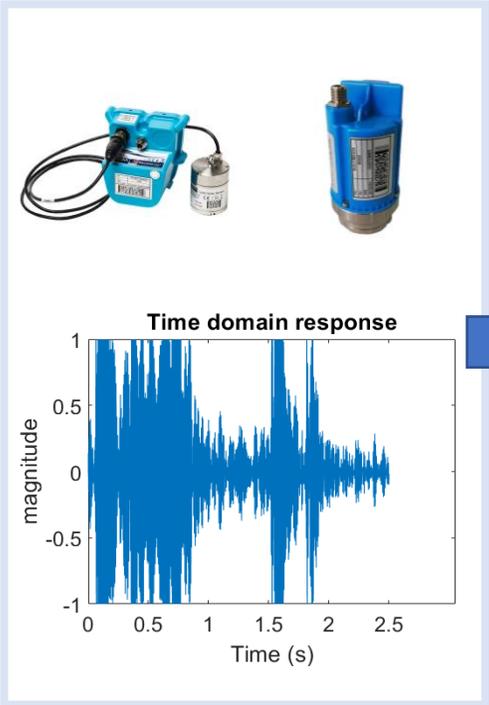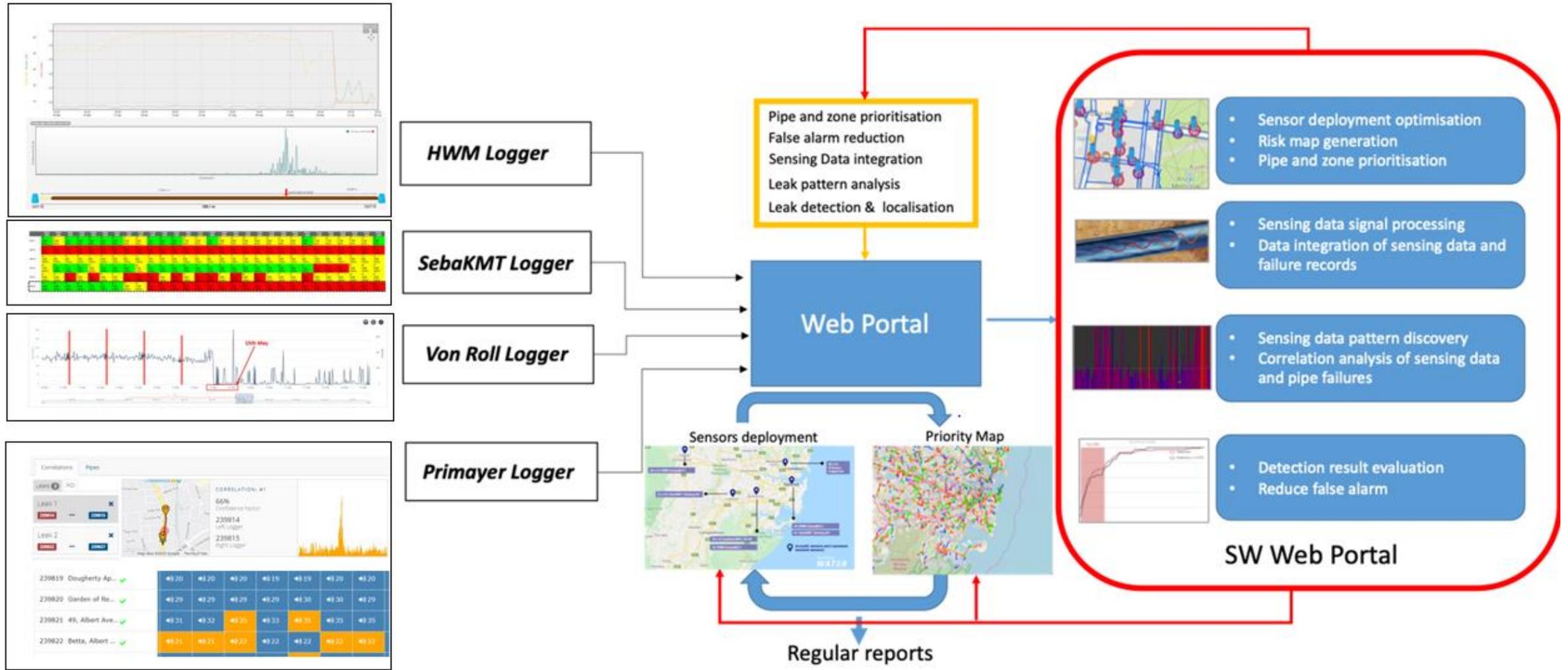
Processed Signals + Field Validation
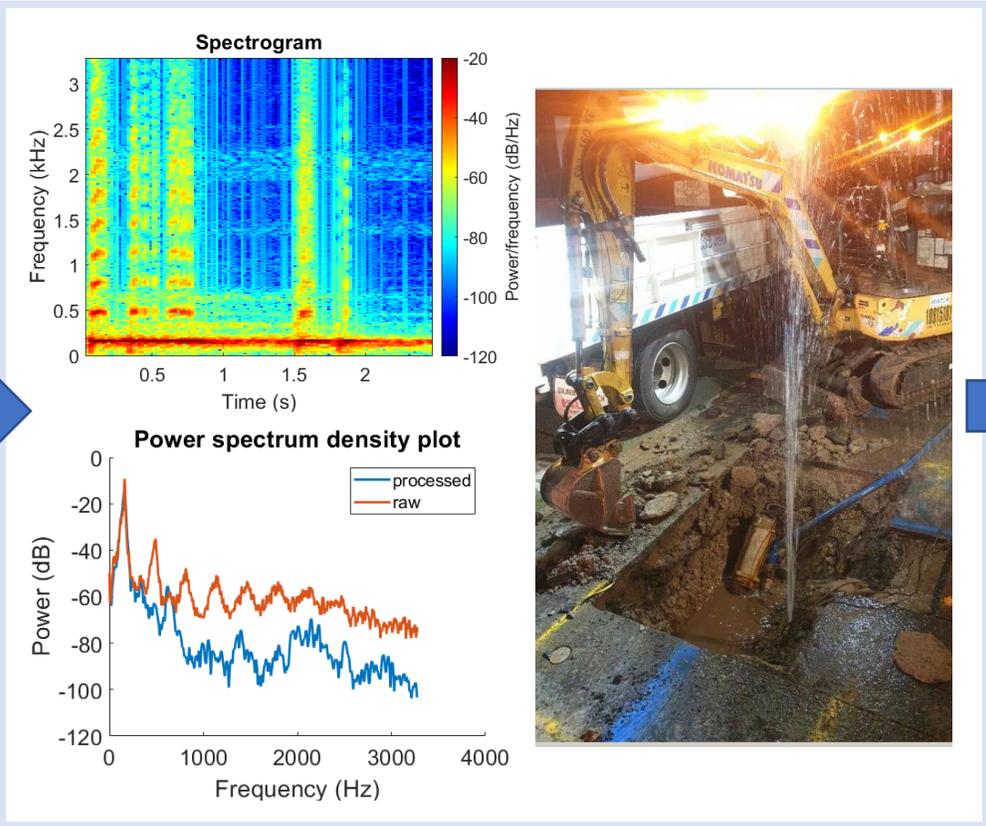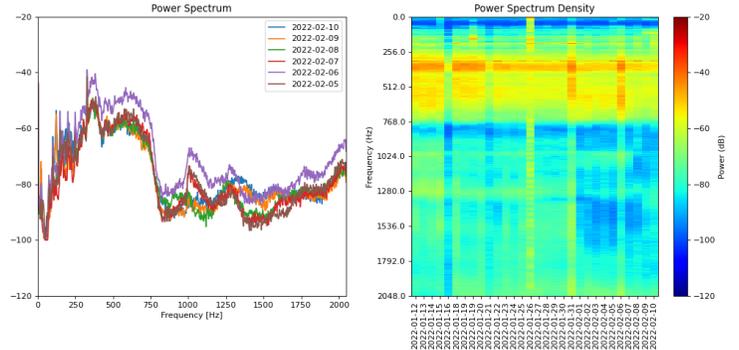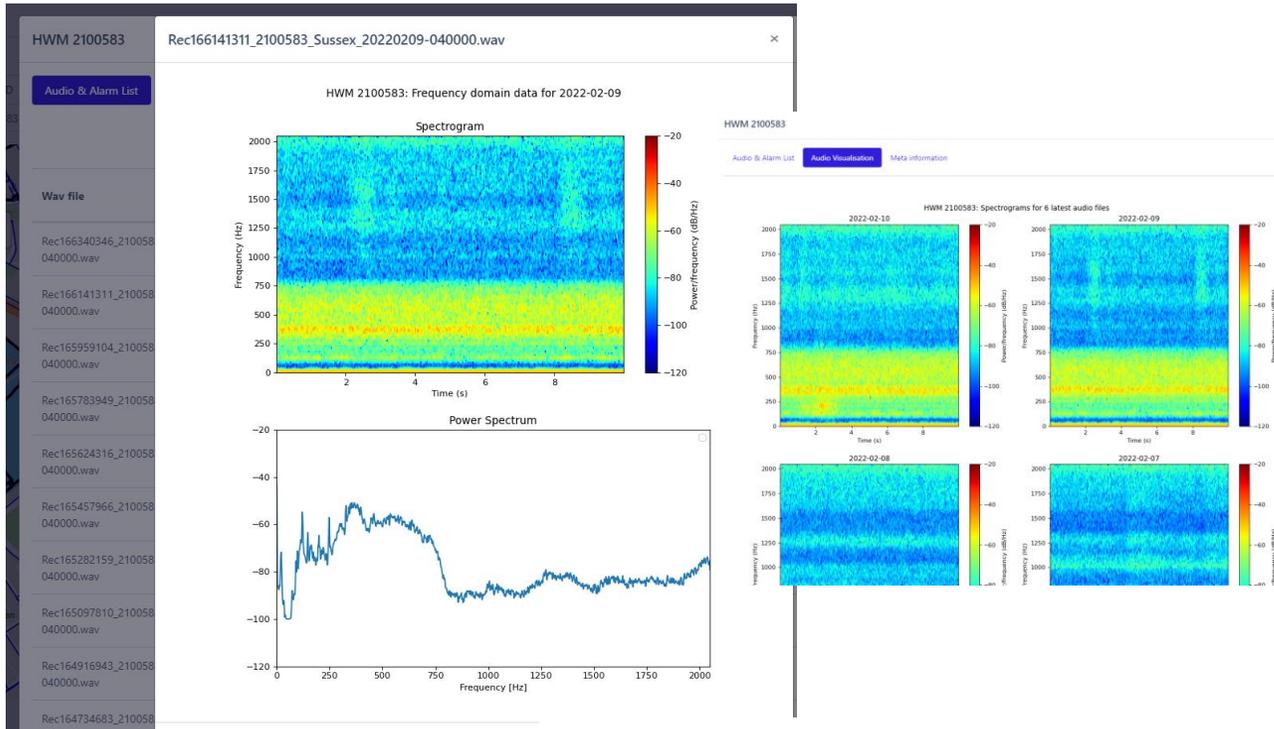
Machine Learning Classifier

Leak Alarms

Time domain response

Spectrogram

Power spectrum density plot
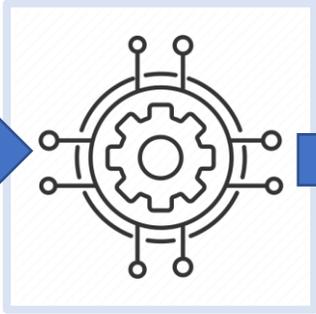
Leak
No Leak

Web Portal System Overview

- Pipe and zone prioritisation
- False alarm reduction
- Sensing Data integration
- Leak pattern analysis
- Leak detection & localisation

HWM Logger

SebaKMT Logger

Von Roll Logger

Primayer Logger

Web Portal

Sensors deployment

Priority Map

Regular reports

- Sensor deployment optimisation
- Risk map generation
- Pipe and zone prioritisation

- Sensing data signal processing
- Data integration of sensing data and failure records

- Sensing data pattern discovery
- Correlation analysis of sensing data and pipe failures

- Detection result evaluation
- Reduce false alarm

SW Web Portal

Common Web Portal
Integrated Machine Learning
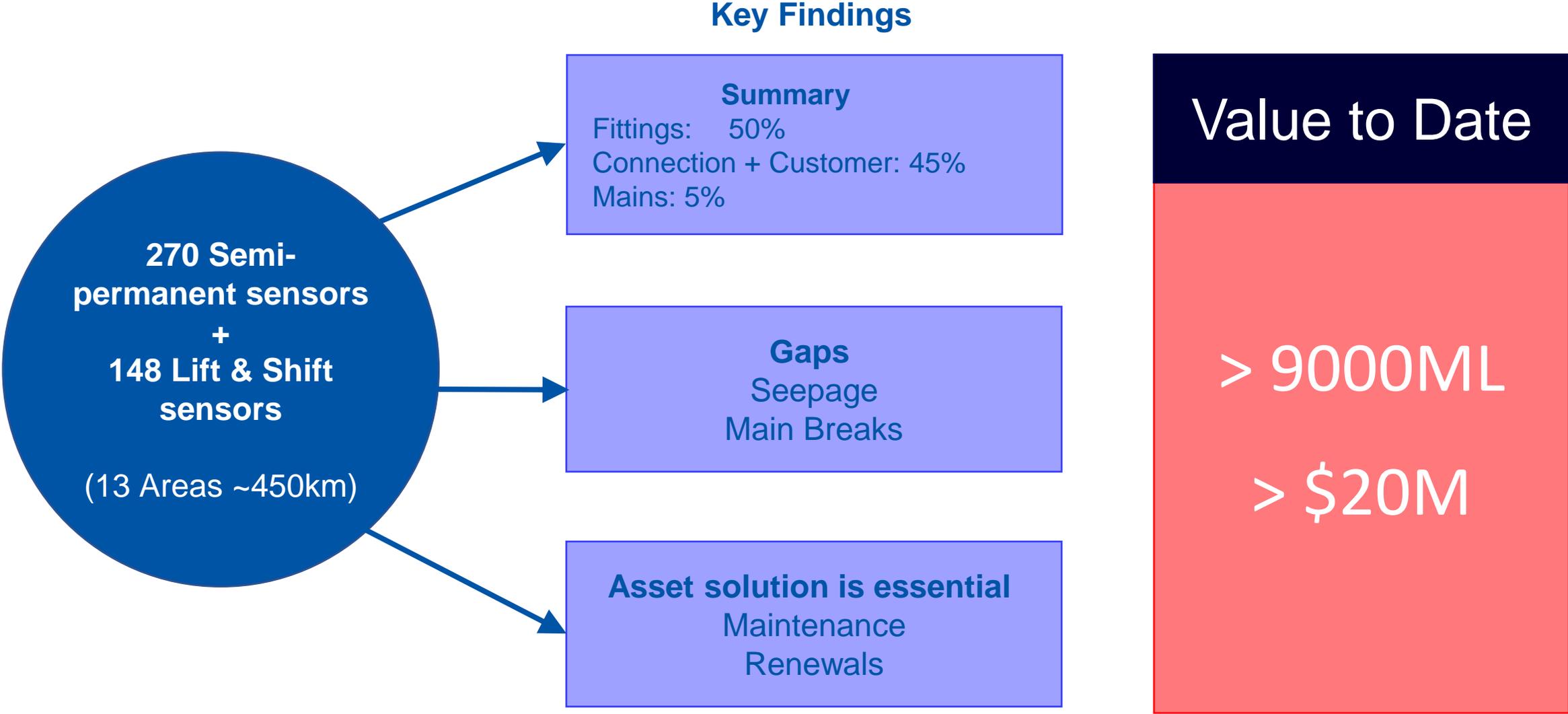
Current Water Loss Estimation

(Updated February 2022)

→ **Water loss up to date:**   **9102.34 ML**
→ **Saving up to date:**   **$21.39 M**

Area	Main Tap Leak	Hydrant Leak	Valve Leak	Customer End Leak	Main leak	Fire Service Leak	Other leaks	*Potential leak*	*Total Leaks	*Water Loss (ML)	*Saving ($ M)
Sydney CBD	6%	12%	9%	4%	1%	1%	6%	62%	125	4117.55	9.68
Bankstown	13%	9%	13%	3%	3%	3%	3%	53%	32	881.43	2.07
Penrith	17%	3%	0%	6%	0%	0%	3%	19%	12	385.26	0.91
Chatswood	13%	6%	0%	0%	0%	0%	0%	16%	8	221.80	0.52
Liverpool	6%	0%	0%	3%	0%	0%	19%	31%	18	507.73	1.19
Parramatta	10%	9%	3%	0%	0%	0%	3%	41%	20	544.52	1.28
P_HOLROYD_RED_1	0%	3%	3%	0%	0%	0%	3%	22%	10	202.88	0.48
P_WAHROONGA_RED_8	0%	0%	9%	9%	0%	0%	0%	22%	13	206.56	0.49
P_BANTRY_RED_2	0%	9%	0%	13%	6%	0%	0%	28%	18	329.55	0.77
P_CHATSWOOD_RED_7	8%	13%	0%	3%	0%	0%	0%	19%	12	257.54	0.61
P_HERMITAGE_RED_5	17%	3%	0%	0%	0%	0%	6%	22%	12	416.80	0.98
P_LOFTUS_RED_3	0%	3%	3%	0%	0%	0%	0%	19%	8	152.42	0.36
P_TERREY_HILLS_EL	2%	28%	6%	0%	19%	6%	3%	69%	43	878.28	2.06

* the calculations include the potential leaks

Key Findings, Value & the Way Forward

Key Findings

270 Semi-permanent sensors
+
148 Lift & Shift sensors

(13 Areas ~450km)

Summary
Fittings: 50%
Connection + Customer: 45%
Mains: 5%

Gaps
Seepage
Main Breaks

Asset solution is essential
Maintenance
Renewals

Value to Date

> 9000ML

> $20M

Thank you … Questions?