OUR HIGHLY CRITICAL ASSETS – WHAT IS UNDER THE BONNET?

Aidan Crimp and Rob Blakemore (Wellington Water)

ABSTRACT

The failure of a number of highly critical assets in Wellington placed political and media attention on the lack of knowledge of the condition of assets that are managed by Wellington Water. There has been a realisation at political level that increased capital expenditure for asset renewals is needed across the region to reduce reactive maintenance expenditure. But renewals prioritization must be evidence based. A commitment has been made by Wellington Water to lift the level of knowledge that is retained on asset condition.

The ability to collect useful asset condition data has been historically inhibited by the shortage of operational funds to implement comprehensive and structured condition assessment programmes. The allocation of funding from the Government Stimulus funding package has allowed Wellington Water to commit to a project that will generate health assessment for all of the very high critical assets – below and above ground stormwater, wastewater and water supply assets.

Using a criticality framework that is linked to service outcomes, a long list of over 9000 very high criticality assets were included in the programme for assessment. This list consists of 229 km of wastewater pipe, 165 km of stormwater pipe, 77 km of water supply pipe, 79 pump stations, 139 reservoirs and numerous other assets within the portfolio that Wellington Water manage.

This paper presents the background, methodologies and findings of this project and discusses how outputs will be used to prioritise future renewals and maintenance programmes.

It describes how methodologies were determined for the wide range of assets to be assessed, as well as the scale and breadth of expertise needed to conduct the fieldwork and interpretation of new and older data. It also discusses how innovation was enabled and the challenges that were encountered when undertaking a project of such significant scale in a short timeframe.

KEYWORDS
Criticality, condition assessment, health assessment

INTRODUCTION

Wellington Water has embarked on a major project towards understanding the condition of the very high criticality assets that it manages. Very high criticality assets are assets which create unacceptable consequences to communities and the environment should they fail. Wellington Water has a gap in knowledge on the condition of these assets which has meant that the remaining life of this asset portfolio could not confidently be predicted. This project was not intended to be a "one off" exercise, but form part of a long term rolling programme of condition assessment.

DISCUSSION

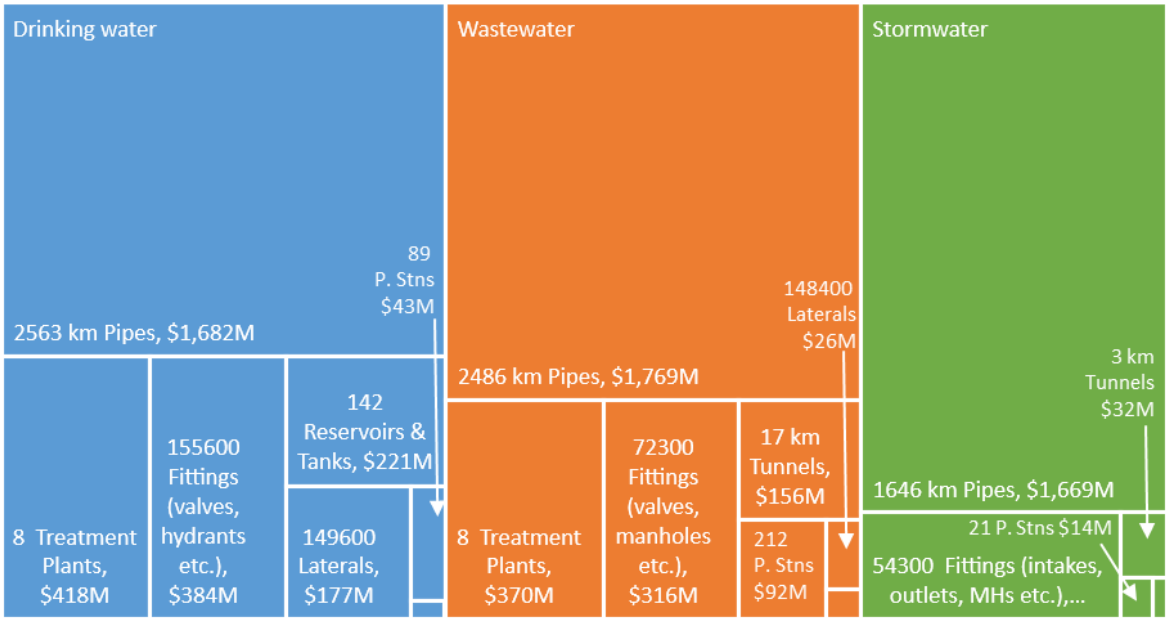
BACKGROUND

Our Assets and Services

Wellington Water provides drinking water, wastewater and stormwater services to customers throughout the greater Wellington region. These three waters services are provided on behalf of our shareholding councils: Greater Wellington Regional Council (GWRC), Hutt City Council (HCC), Porirua City Council (PCC), South Wairarapa District Council (SWDC), Upper Hutt City Council (UHCC) and Wellington City Council (WCC). Wellington Water are responsible for the maintenance, upgrade, renewal and development of the three waters infrastructure through the asset's entire lifecycle.

The regional three waters networks comprise approximately 6,700 km of pipelines, 16 treatment plants, 145 water storage facilities (primarily treated water reservoirs), 322 pump stations, 29 km of tunnels and various other assets. The networks generally serve areas within the region's cities and operate within defined hydraulic catchments or supply zones. Figure 1 shows the breakdown of each three water's assets by replacement value and quantity.

Figure 1: Replacement value of three waters assets managed by Wellington Water

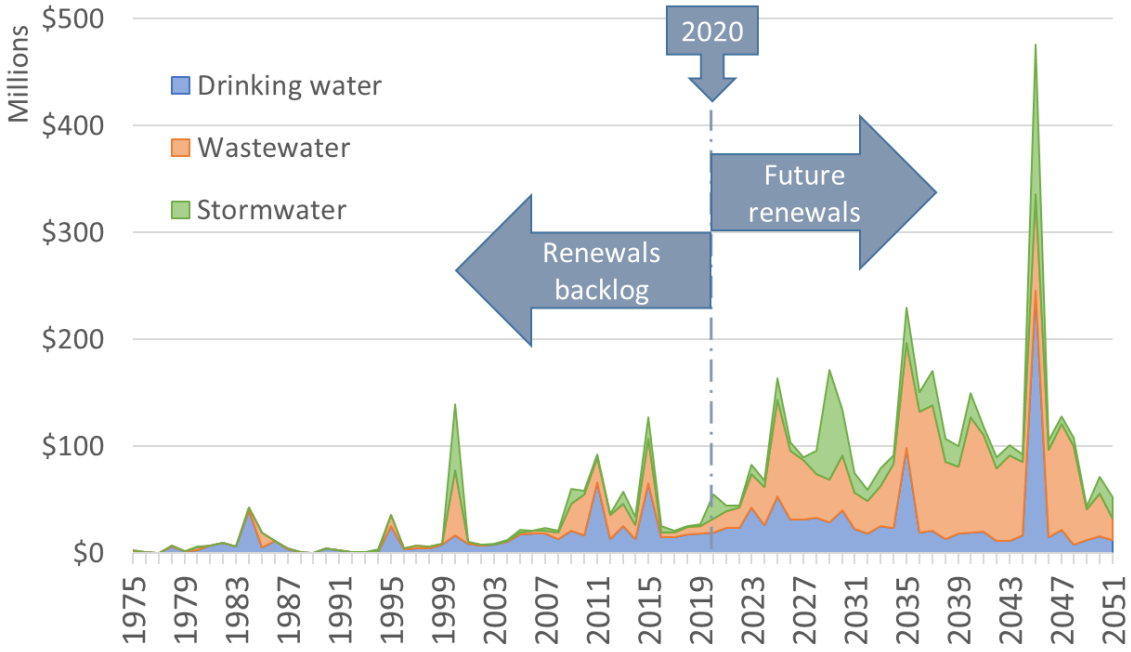


Challenges Faced

Since its inception, Wellington Water has been confronted by multiple significant challenges relating to management of its asset base. These include:

- An ageing asset network across water supply, wastewater and stormwater.
- Inconsistent asset condition knowledge of these assets.
- Inconsistent investment planning approaches, making it difficult to provide a unified approach to prioritising investment.
- Significant renewals liabilities, requiring significantly increased investment over the next 30 years, as demonstrated in Figure 2.

Figure 2: Wellington Water three waters network and utilities renewals profile across all Councils



- Constrained funding for three waters infrastructure upgrades.

In assessing these challenges, it became clear that a robust evidence-based prioritization approach that minimised asset failure risks was required to operate within an environment where funding was constrained.

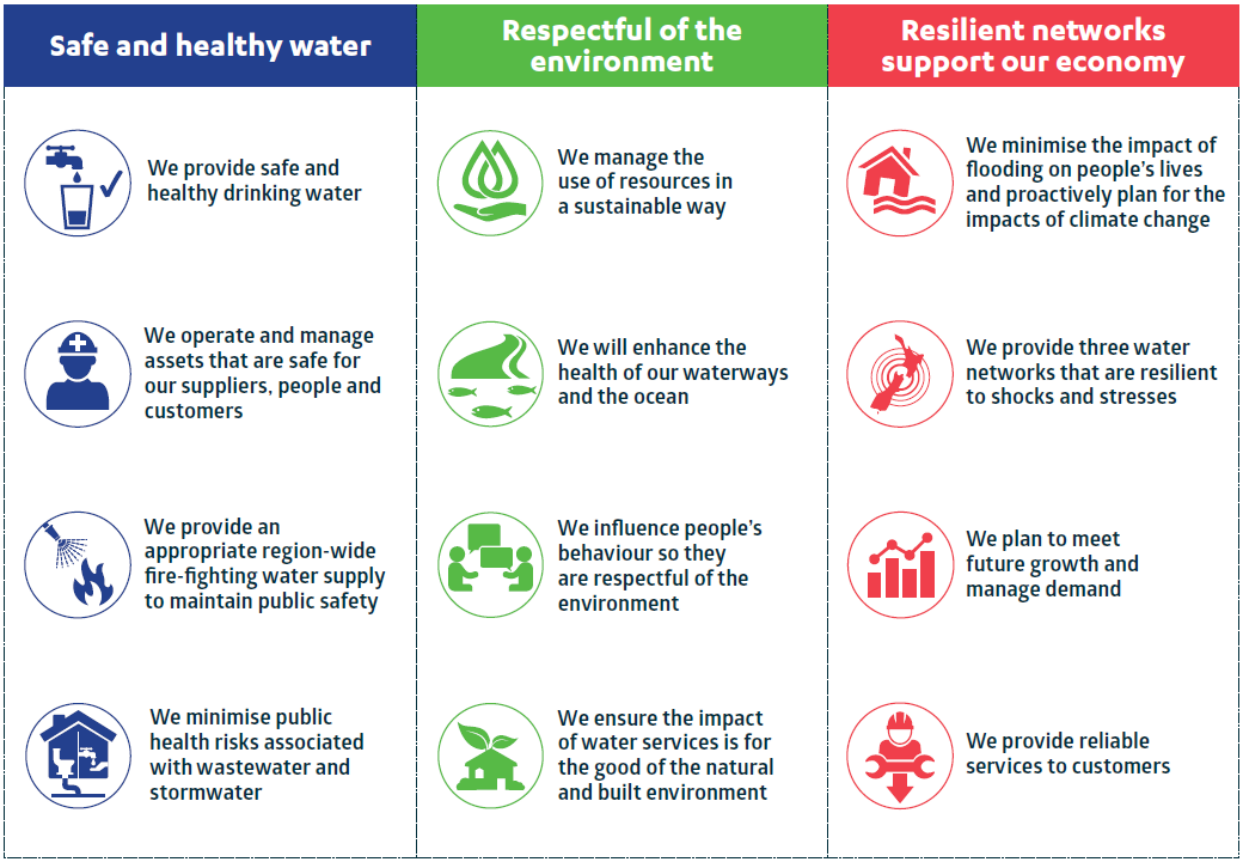
ASSET MANAGEMENT APPROACH

Performance Goals

To get consistency of approach to future planning, Wellington Water needed to have frameworks for asset management that could be built upon a sound strategically driven platform of performance goals. These goals needed to be agnostic to the type of water service (i.e. water supply, wastewater and stormwater).

More than five years ago Wellington Water set three outcomes and twelve service goals that were to drive all expenditure (capital and opex). These are displayed in Figure 3.

Figure 3: Wellington Waters service goals



Criticality Framework

The adoption of these goals has enabled integrated planning in Wellington Water. One important development has been the formalisation of a criticality framework. As a controlled document it allows the organisation to:

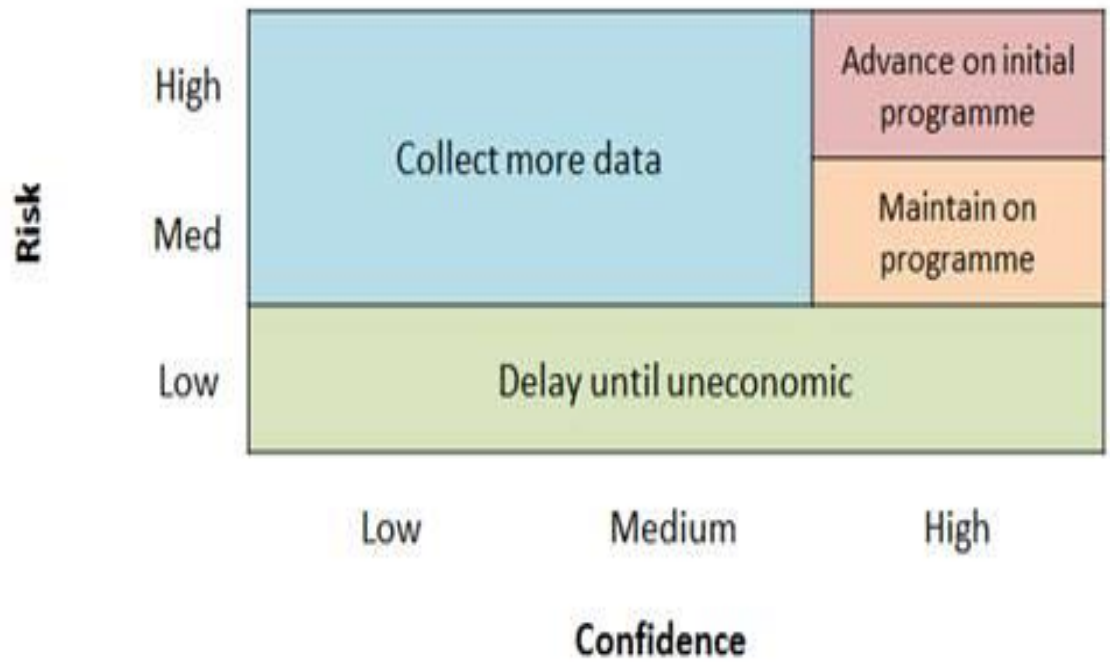
- Assign importance to individual water network assets,
- Help determine the relative risk of significant assets failing in normal everyday service, and
- Measure the consequence of an asset failing to deliver its expected contribution towards Wellington Water service goals.

For each of the service goals relevant to the asset this document explains how to assign scores linked to four factors should the asset fail in its worst conceivable failure mode. These factors are:

- Exposure of the loss of service,
- Time to restore service,
- Whether there is a contingency for the loss of service, and
- Severity of impact.

These measures have allowed for an improved investment planning process to be adopted within Wellington Water. Figure 4 summarises this investment approach, relating to risk posed by asset failure against the confidence in asset condition data.

Figure 4: Risk-confidence decision table utilised by Wellington Water



Intervention Guides

A further step on the asset management maturity path is to progress the writing of asset intervention guides. Wellington Water plans to prepare guides for every asset type under its management.

Asset intervention guides describe the intervention required at various stages of an assets lifecycle, and how to use analysis outputs to decide when to take intervention activities i.e. programmed condition-based maintenance, refurbishment or renewal.

The guides support operation, maintenance, and renewals planning. They are a reference to help determine appropriate maintenance activities, to describe different failure modes with respect to our service goals, and to decide timing and methods for condition assessment.

THE VERY HIGH CRITICALITY ASSET HEALTH ASSESSMENTS

High profile asset failures

In the latter part of 2019 and in 2020, there was considerable publicity generated following the failure of critical wastewater assets in Wellington city, such as the Dixon St adit that connects to the Central Interceptor and the Mt Albert Tunnel Sludge Pipeline. In addition, funding had to be diverted to refurbish a section of the Central Interceptor close to Moa Pt when condition assessment identified a rapid deterioration of this asset. These failures attracted significant political commentary about Wellington Water's performance. Since then there have been other high-profile failures within the Wellington CBD – a sewer rising main failure and a collapsed stormwater pipe, both causing significant disruption.

At a May 2020 meeting of the Wellington Water Board, a commitment was made to "target the completion of the initial health assessments for all very high criticality assets by the end of the 2020/21 financial year."

One outcome of these failures was a commitment at mayoral level in Wellington City and Hutt City to provide additional funding to support the Board target. However, the additional funding was still going to be insufficient to get an

understanding of the condition of all very high criticality assets in the regions three waters networks.

Commitment of Funding and Use of Government Stimulus Funding

The announcement of the government three waters stimulus in July 2020 provided Wellington Water the funding it required to complete the condition assessment of very high criticality assets.

The workstream was to be managed as a standalone project - one of several projects within the $47.3M stimulus funding programme for Wellington Water

Assets Identified for Assessment

Before assessment could begin, the full scope of very high criticality assets managed by Wellington Water needed to be evaluated. This required incorporation of the criticality framework into the asset data, and an analysis of the impact of failure of all assets on each of the service goals as displayed in Figure 3. This selection criteria varied for each of the different asset classes.

Three waters pipes

Predictive analytics and modelling were used to score the impact of the worst possible failure mode of each pipe asset on service outcomes. Those rated above a determined score threshold were selected as very high criticality assets. The most significant factors affecting a pipes selection included:

- Size, which broadly measured the population serviced,
- Location, whether underneath a major road carriageway or near a sensitive receiving environment
- Redundancy, whether service could be maintained through other parts of the network, and
- Repair timeframe, whether there was a method available to restore service within a short timeframe.

Three waters pump stations

In a similar fashion to pipes, the impact of a significant outage of a pump station on the service outcomes was measured. A score threshold was again used to select pump stations as very high criticality assets. Factors influencing pump station selection included:

- Wet well storage for wastewater pump stations, measuring time until overflow and corresponding environmental impacts,
- Power output, broadly measuring the population served,
- The presence of redundancy within the network or within the pump station itself, and whether service could be maintained using other assets in the event of a significant failure,
- For water pump stations, presence of sufficient reservoir storage to account for a water pump station outage.

Reservoirs

Failure mode analysis of reservoirs concluded that all reservoirs should be included as very high criticality assets. The reasoning for this was the potential impact of failure through contamination of any reservoir was above the "very high" threshold as defined within the criticality framework.

Water Treatment Plants

Detailed analysis of process and instrumentation diagrams for each plant and comparison with the values highlighted in the criticality framework enabled selection of the very high criticality assets for our Water Treatment Plants.

Factors considered in this selection included:

- Whether contamination at any stage of the process could be mitigated through downstream processes (such as other treatment processes or run to waste systems),
- Whether redundancy of a particular component was present in the system, and
- What impact failure of a particular asset would have on the overall volume of water delivered.

A summary of the assets selected across the region is presented in Table 1.

Table 1: List of very high criticality assets managed by Wellington Water

Asset	**Total distance/no. assets**
Wastewater Pipes	**229 km**
Stormwater Pipes	**165 km**
Water Pipes	**77 km**
Pump Stations	**79**
Reservoirs	**139**
Water Treatment Plant assets	**612**

Methodologies for Assessment

Once the assets had been selected, methodologies for condition assessment of these assets needed to be identified. These methodologies heavily referenced the intervention strategies previously developed by Wellington Water, however had several key areas of focus:

- The methodology needed to focus primarily on the worst possible failure mode for each asset. For example, in pump stations a leaking pump may not cause a significant service interruption as there may be standby pumps available – however, a fire in the electrical cabinet would cause the entire pump station to be offline for a number of days, and so needed special attention.
- Due to the volume of pipe assets selected as very high criticality, physical inspections of all pipes by the end of June 2021 target was not going to be possible. The methodologies would need to incorporate pre-existing health information where possible and utilise results from completed inspections to provide best estimates of the remaining network condition. Additionally, institutional knowledge from experienced Wellington Water staff would need to be utilised. This information would be reviewed within "peer-to-peer" workshops made up of a collection of experts and determine what conclusions could be made about the health of assets not inspected within the first year of the project.

- The methodologies needed to consider how data gathered from the different inspection techniques would be used to inform on health assessments for each asset.
- The methodology needed to consider how data gathered from the assessments would flow into Wellington Water's asset management systems.
- Where primary inspection techniques were not available/applicable, secondary techniques would need to be selected.

The primary methodology selected for assessment of each different asset type are displayed in Table 2.

Table 2: Primary inspection technique for each asset class

Asset	**Primary Inspection Technique**
Wastewater Gravity Pipes	Multi Sensor Inspection (CCTV, Laser & Sonar)
Wastewater Pressure Pipes	P-Cat
Stormwater Pipes	Multi Sensor Inspection (CCTV, Laser & Sonar)
Water Pipes	P-Cat
Pump Stations	Visual Inspection
Reservoirs	Visual Inspection
Water Treatment Plants	Visual Inspection

Procurement

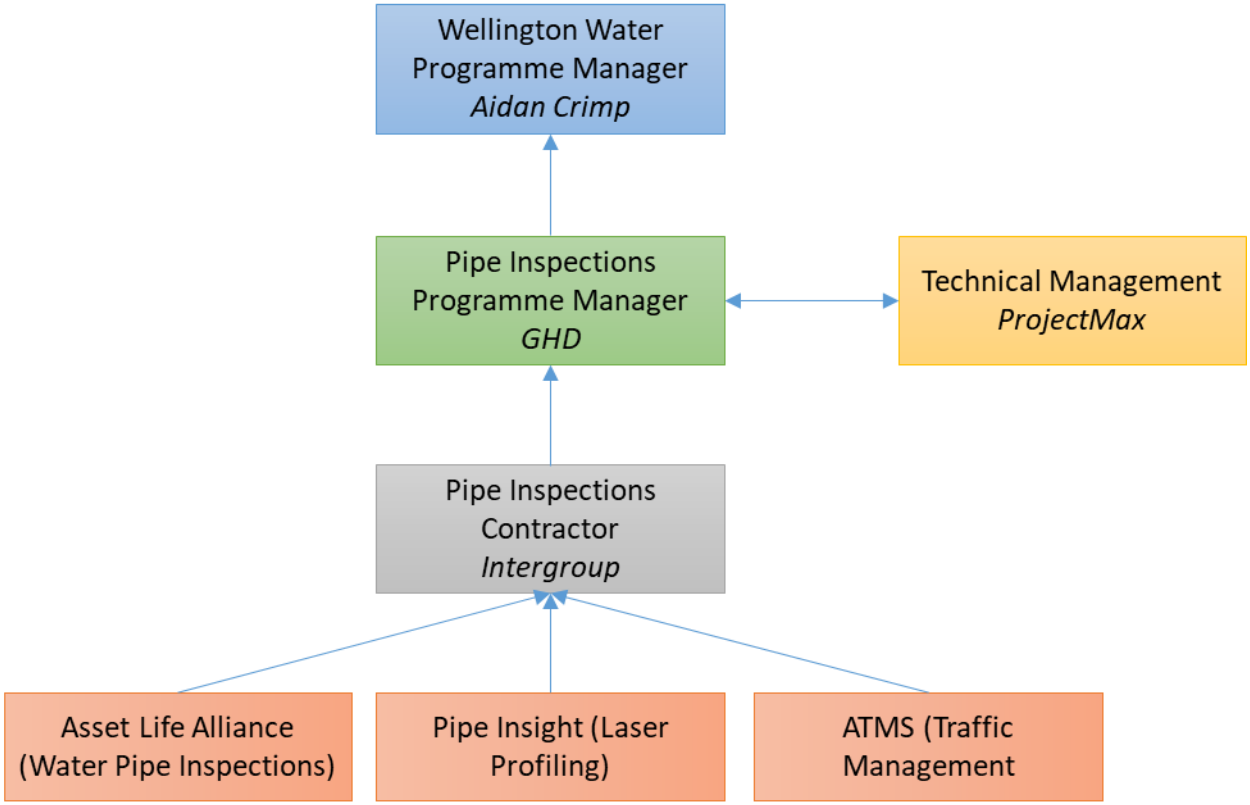
Two different procurement models were used to procure suppliers to complete the inspections.

Pipe inspections

Physical inspections of wastewater gravity pipes, wastewater pressure pipes, stormwater pipes and water pipes all required specialist equipment and contractor resource to manage and deliver. For this reason, it was determined that a lead contractor would be procured via open tender. This was awarded to Intergroup Ltd. Management of this contract would be carried out by GHD as engineer to contract, with ProjectMax Ltd providing quality assurance and production of

condition assessments from the data gathered. This structure is displayed in Figure 5.

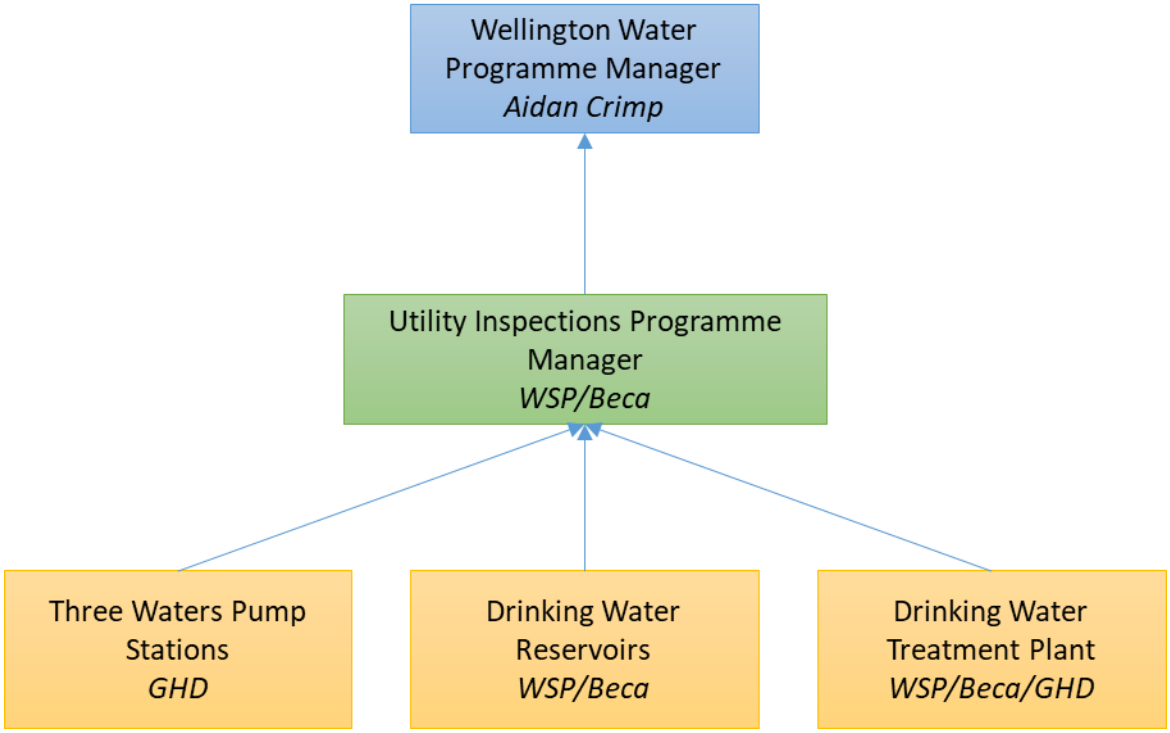
Figure 5: Pipe inspections programme structure



Utilities Inspections

As condition assessment of water treatment plants, reservoirs and pump stations was to be primarily carried out through visual inspection, it was decided to utilise resource from Wellington Water's consultancy panel to carry out these inspections. This arrangement is displayed in Figure 6 below.

Figure 6: Management of utilities inspection delivery

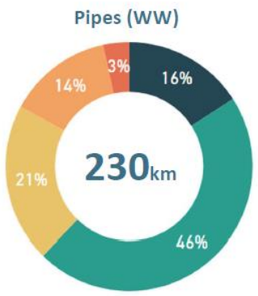
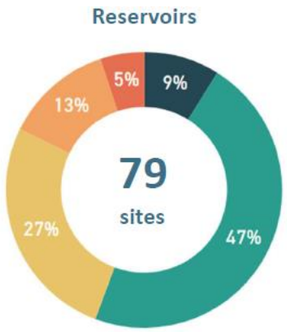
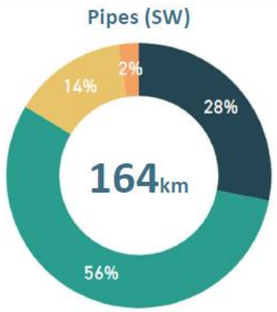
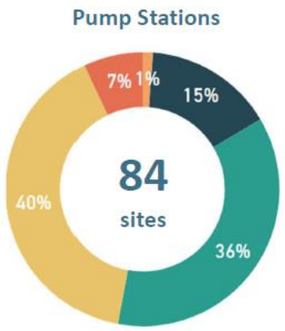
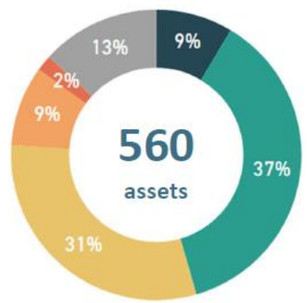


Results to Date

Interim assessments for all very high criticality assets were presented at the end of June 2021. While the results were heavily based on pre-existing health data, it represented the first time that Wellington Water had formally reported the health of its very high criticality assets. The data was presented with the caveat that inspections scheduled for the 21/22 financial year would likely result in changes to the overall health of the assets.

The results gathered as of the 30 June 2021 are presented in Table 3.

Table 3: Health assessments to date for all very high critical assets

Asset Condition Grading	Commentary	Asset Condition Grading	Commentary
	• Wastewater pipes were generally found to be in good or very good condition • Key risks were identified with aging pressure wastewater mains – these were recommended for renewal. • Valves and fittings attached to pressure pipes were also identified as potential risk points – these were recommended for a programme of maintenance and/or replacement.		• Generally, the reservoir structures were in moderate or good condition. • Some issues were identified with the reservoir's ability to prevent contamination due to issues with the water tightness of reservoir roofs. • Chlorine in water lessens this risk and regular testing of the network revealed no contamination. • However, we have recommended a programme of work to address this contamination risk.
	• Stormwater pipes were generally assessed as being in good or very good condition. Less than 1% of assessed stormwater pipes were in very poor condition • Several significant faults were identified through CCTV inspection – these could have caused structural failure of the pipe. • These faults were placed on repair programmes		• Generally, pump station assets were in moderate or good condition. • Some improvements were recommended to pump station access to lessen health and safety risks.
	• Drinking water pipes were generally in moderate condition • Pipes assessed as being in poor or very poor condition were primarily aging asbestos cement or cement lined steel pipes.		• Water treatment plant assets were generally in moderate to good condition • 13% of assets required special equipment or measures (such as shutdowns) to assess – these were programmed for assessment at a later date. • Very poor condition assets were programmed for replacement.

1 – Very Good 2 – Good 3 – Moderate 4 – Poor 5 – Very Poor Not assessed

CONCLUSIONS

While the full programme of physical inspections has still yet to be completed, there are a lot of lessons that can be taken from the work completed to date.

Importance of failure mode analysis

The use of failure mode analysis as defined by the criticality framework was a major success of the study. This allowed for the condition assessment techniques used to focus on the worst case scenario of failure. This was a shift in thinking from previous condition assessment approaches, which have assessed condition relating to likelihood of failure over consequence of failure. While this was an acceptable approach to condition assessment, it meant that there were weak points in the assessments relating to significant modes of failure. The focus of this project meant that all potential "showstoppers" were identified and assessed against.

Network operation for condition assessment

While gravity pipe inspections were relatively easy to carry out, pressure pipe inspections required better network access than what could be provided. Modern pressure condition assessment techniques (such as P-Cat) require direct access to the water column at multiple points in the network – historically, Wellington Water's approach has been to limit access points to the water column to reduce contamination risks and/or corrosion points. Additionally, valves that had not regularly been exercised made isolating sections for installation of such access very difficult.

Asset data

Having asset data in a format that allowed for simple and easy communication of the required assets for assessment was key in ensuring streamlined programmes. Asset data that was inaccurate or hard to come by lead to delays in assessment programmes, and in some cases required manual corrections to make the data useable.

Conversely, development of systems to ensure consistent recording, quality and analysis of incoming condition data provided significant benefits and streamlined the process of reporting on condition results.

Familiarity with the assets

Each of the consultancy panel members working on the utilities programme had previous experience working with the assets that were selected for assessment. This provided significant efficiencies in management of the inspections programme, allowing for more streamlined delivery and better quality of results.

Future Applications

While a test programme in many aspects, this project represented a key step in Wellington Water's journey towards managing assets by criticality. This programme allowed for not just a reset of renewal priorities but also identified future maintenance requirements and allowed them to be programmed for the most critical assets. By tailoring asset management approaches towards assets that are most critical, Wellington Water is aiming to avoid large scale disruption to communities and environmental damage.

ACKNOWLEDGEMENTS

This paper would not be possible without the work done by the entire project team. For pipeline assessments, Michael Syred and Callum Mulligan from GHD, Steven Apeldoorn, Ian Garside and Oliver Modricker from ProjectMax Ltd, and Chris Newton (Reveal) and Adrian Chatfield on behalf of Intergroup Ltd. For utilities assessments, Stephen Molineux and Leanne Charles from WSP, Timbi Poon and Frank Yu from Beca, and Brittany Challis and Austin Clark from GHD.