Evidence-based Investment Decision Making for 3 Waters Networks (Pipe Renewals)

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water NEW ZEALAND
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Version Control

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Table of Contents

Executive Summary

The *Evidence Based Investment Decision Making for 3 Water Pipe Network Programme* (Pipe Renewals Guidelines Programme) initiated by Quake Centre, IPWEA and Water New Zealand (Water NZ) will develop guidance documents and tools to assist New Zealand's water organisations to make nationally consistent, evidenced-based decisions relating to the management and renewal of their 3 Water Pipe Networks. The programme covers inspection, maintenance and renewal strategies for pipework in potable water, wastewater and stormwater systems.

The tools and guidance documents developed through these initiatives will form a framework that can be used in conjunction with the International Infrastructure Management Manual (IIMM) and the New Zealand Asset Metadata Standards project to implement advanced asset management processes to produce investment strategies that optimise cost, risk and level of service. They will enable organisations to assess the implications of adopting alternative investment strategies and select the strategy that best suits the needs of their community.

Benefits of this programme include:

- Better performing assets and higher returns on investment
- Potentially large cost savings in renewals budgets
- A better understanding of risks and contingent liabilities
- Improved transparency in the decision-making process

This document presents 46 project initiatives that comprise the overall programme and one integrating decision support theme. Of these projects a number have been prioritised such that they could be implemented over the next 3-5 years. A steering group rationalised the number of projects based on level of importance and ease to the following areas:

- Integrated decision making framework
- Condition
- Repairs and Maintenance
- Service Performance
- Resilience
- Design Performance
- Financial Performance

An implementation plan has been developed to determine level of priority for each project based on three measures; ease, level of importance and level of impact. To support the delivery and funding of projects these projects have been grouped into work packages.

The initial literature search identified a series of available polices, guidelines and documentation which will support the early implementation of part of the pipe renewals framework. Based on existing knowledge and priority it is recommended the following projects are progressed first:

- Decision making support tool
- Pipe data management
- Pipe inspection and condition framework
- National Pipe Database
- Pipe sample recovery
- Useful life deterioration curves
- Definition of pipe failure and National Pipe Failure Database
- Pipe performance measures

This version 2.0 report will be updated as projects are undertaken and new information becomes available.

Introduction

The Pipe Renewals Guidelines Programme initiated by UC Quake Centre, IPWEA and Water New Zealand (Water NZ) will develop guidance documents and tools to enable New Zealand's water organisations to make nationally consistent, evidence-based decisions in regards to pipe network operational and capital expenditure. The programme covers inspection, maintenance and renewal strategies for pipework in potable water, wastewater and storm water systems.

Building on the framework developed at a workshop at the University of Canterbury in February 2016, the ***'Pipe Renewals Guidelines Literature Search – Schedule of Works'*** *July-2016 report* produced by Opus International Consultants (Opus) set out a framework which is aligned to the New Zealand Metadata Standards, taking into account existing knowledge and practices, and presents a roadmap for implementing improvements in knowledge and practice.

The roadmap presents 46 project initiatives that could be implemented over the coming years, as shown in Figure 1. A description of each initiative was provided outlining what is required, why it is necessary and the recommended approach for developing the initiative.

A workshop was held with the Governance and Technical Oversight committees (The Committee) to provide feedback on the Pipe Renewal Guidelines Report and the way forward. The implementation plan was considered comprehensive but too large at this stage and would need rationalising in order to allow funding to be assigned and the overall framework delivered.

The group identified the need to rationalise the number of projects, thus prioritising the order of implementation based on level of importance and ease. The key themes identified for prioritisation were based around:

- Integrated decision making framework
- Condition
- Repairs and Maintenance
- Service Performance
- Resilience
- Design Performance
- Financial Performance

MBIE & LINZ are implementing a project to explore the implementation of shared data standards (Metadata Standards) for water infrastructure, roads and built assets (buildings). Metadata standards will provide data consistency. They will enable data to be shared, aggregated and analysed in more detail than is currently possible in a standardised and harmonised manner.

Figure 2 shows the global metadata schemata and how the standards sit in context with the wider asset management framework. Each layer has a role in the development of an integrated, learning asset management environment. Volumes 1 & 2 are being drafted under the Metadata project. The Pipeline Renewals Programme will contribute to Volumes 3, 4 & 5 as discussed in the following section of this report.

The Pipe Renewals Guidelines framework will concentrate on the analysis of data to improve the understanding of the behaviour of pipe networks, the development of analytics to predict future situations and the development of an asset management framework specifically tailored to water pipelines. The programme will integrate with the LINZ Metadata programme and existing asset management practices such as the International Infrastructure Management Manual and ISO55000.

Figure 1 presents the Implementation plan and the prioritised projects identified in the workshop, these have been grouped as work packages for delivery.

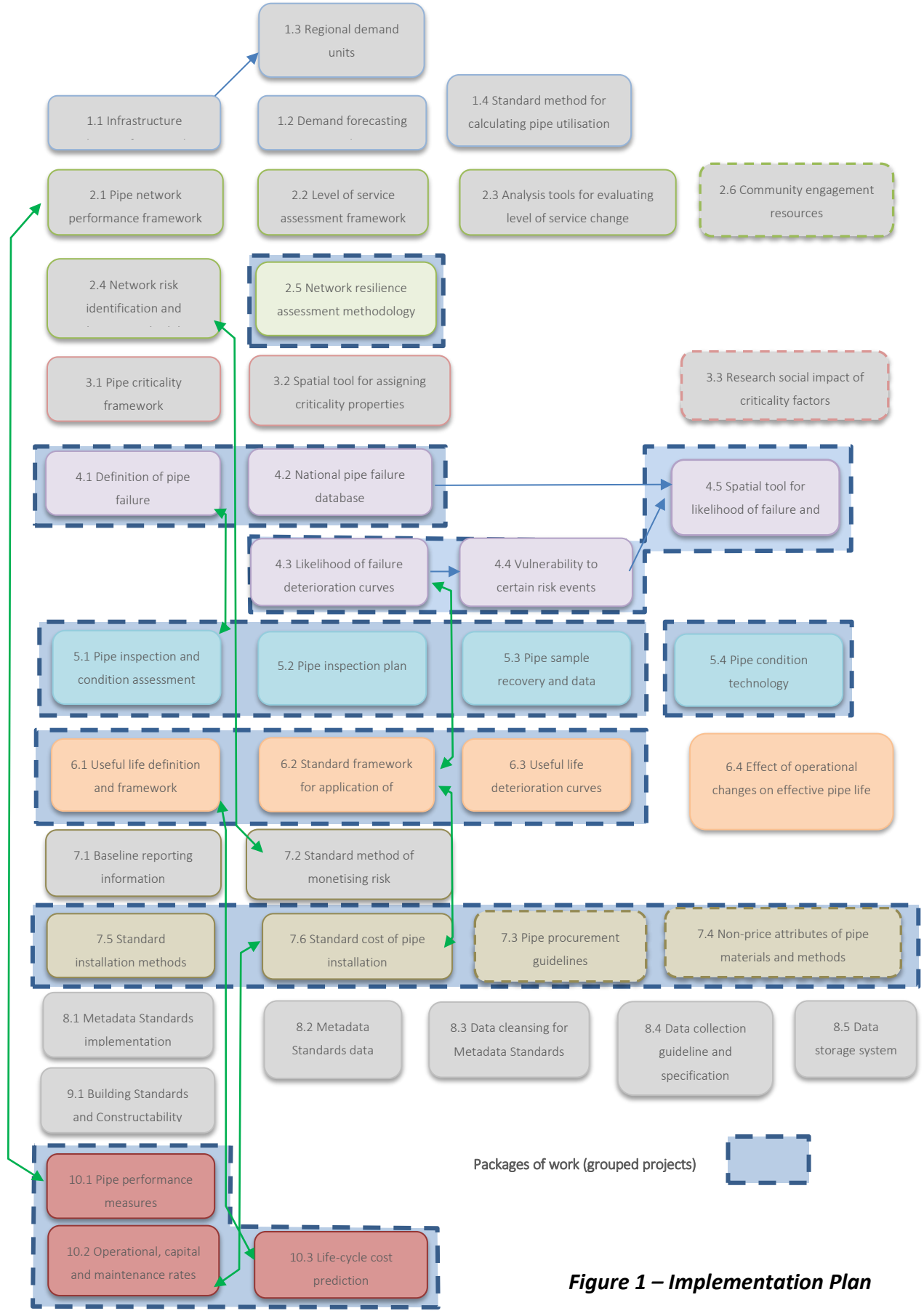

Figure 1 – Implementation Plan

A Framework for Decision Making

Figure 1 demonstrates the interdependencies of various themes. In addition to this there is a need for a central cross-theme decision support tool to integrate the outputs from the various themes. This will provide a dashboard approach to inform investment decision-making as well as:

- Defining the information output requirements from each theme
- Defining a methodology for integrating that information
- Allowing sensitivity analysis in respect to the information
- Providing a guide to the prioritisation of the future work streams.

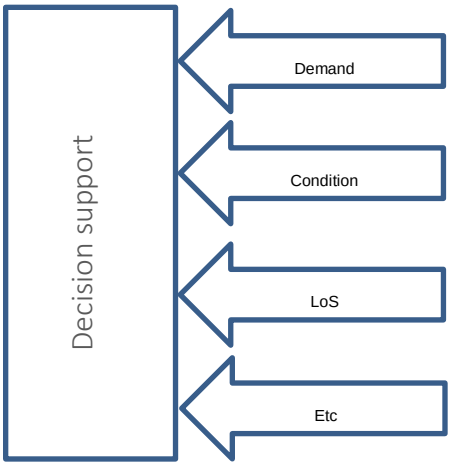

Figure 2 – Decision support as a central theme

Project Prioritisation

The Committee at the review workshop discussed the first draft of the *'Pipe Renewals Guidelines Literature Search – Schedule of Works'* report, and highlighted the need to prioritise projects, as the proposed implementation plan was considered too extensive. The committee identified the following projects for prioritisation as a first pass, these are listed below:

- Condition:
  - Pipe Inspection and Condition Assessment Framework
  - Pipe Inspection PlanPipe Sample Recovery and Data Management
  - Pipe Condition Technology
  - Likelihood of failure deterioration curves
  - Definition of Useful Life
  - Standard framework for application of remaining useful life
  - Useful life deterioration curves
- Repairs and Maintenance (Operations):
  - Definition of pipe failure
  - National pipe failure database
- Non-price attributes of pipe materials and methods

- Service Performance:
  - Pipe performance measures
- Resilience:
  - Network resilience assessment methodology and improvement opportunities
- Vulnerability (Could be classified with Risk):
  - Vulnerability to certain risk events
  - Spatial tool for assigning vulnerability and likelihood of failure
- Design Performance:
  - Standard Installation Methods
- Financial Performance:
  - Pipe procurement guidelines
  - Standard cost of pipe installation
  - Operational and maintenance rates
  - Lifecycle cost prediction

A separate business case has been submitted for the implementation of the ***Metadata Standards Project***, therefore at this time no metadata standard projects have been identified as priority projects for the development of pipe renewals guidelines.

Each of the identified projects listed above are presented in more detail in the following section of this report, highlighting what is required, the benefits and recommended approach. An assessment on where New Zealand is in relation to the Metadata Standard Schema is presented in Figure 3, showing the current knowledge and gaps against volume 3 and volume 4 of the metadata standards.

Volume 3 will describe intervention methodologies to determine the current state and performance of assets. For example Volume 3 will describe methodologies for determining the condition of pipelines. Whereas volume 4 will include analytical methods to predict the condition and performance of assets, to determine when and where to undertake the interventions described in Volume 3 and to assess the implications of adopting alternative investment strategies with regard to cost, risk and level of service.

Using a traffic light system, Figure 3 gives the approximate status for each schema, such as condition. The green indicates what documentation exists and could be used right now with some minor amendments. Yellow represents the projects likely to be delivered as a priority, and red those projects which should be implemented in the future.

A first cut of the priority projects has been undertaken to rank projects based on:

- Ease – Is it reliant on other projects, does it require a significant amount of work to produce
- Level of importance – Value it will provide such as better use of data or decision making
- Level of impact – How quickly will it provide results or a direct benefit

A scoring system of 1 to 3 has been applied to each of the three categories with:

- 1 being relatively straight forward to implement or high importance/impact
- 2 some work required and reliant on other projects, or medium importance/impact; and
- 3 reliant on more than one project, or low importance/impact

A second cut of priorities is required based on the highest value inputs to the Cost, Risk and Level of Service Decision Support Process. Projects categorised as future are not included within the main body of this report and are located in Appendix A for reference.

Project summaries in Appendix A are limited in scope and reference documents. However the information provided is sufficient to commence reviews of prioritisation. As each project is implemented it will be further reviewed and the scope expanded to a full project summary suitable for tendering with an associated update to the version number. This document will remain live and as each project is scoped this document will be updated and a version number applied to each theme.

Impacts of operational decisions

Operational decisions and conditions can have a significant impact upon the effective life and Level of Service delivered by an asset. Operational parameters are not considered in this iteration of the programme. However, changes to asset operation should be considered alongside the decision making process of maintenace and renewals. A place-holder theme of: *Operational Impacts on Effective Pipe Life* has been included in this document for later consideration.

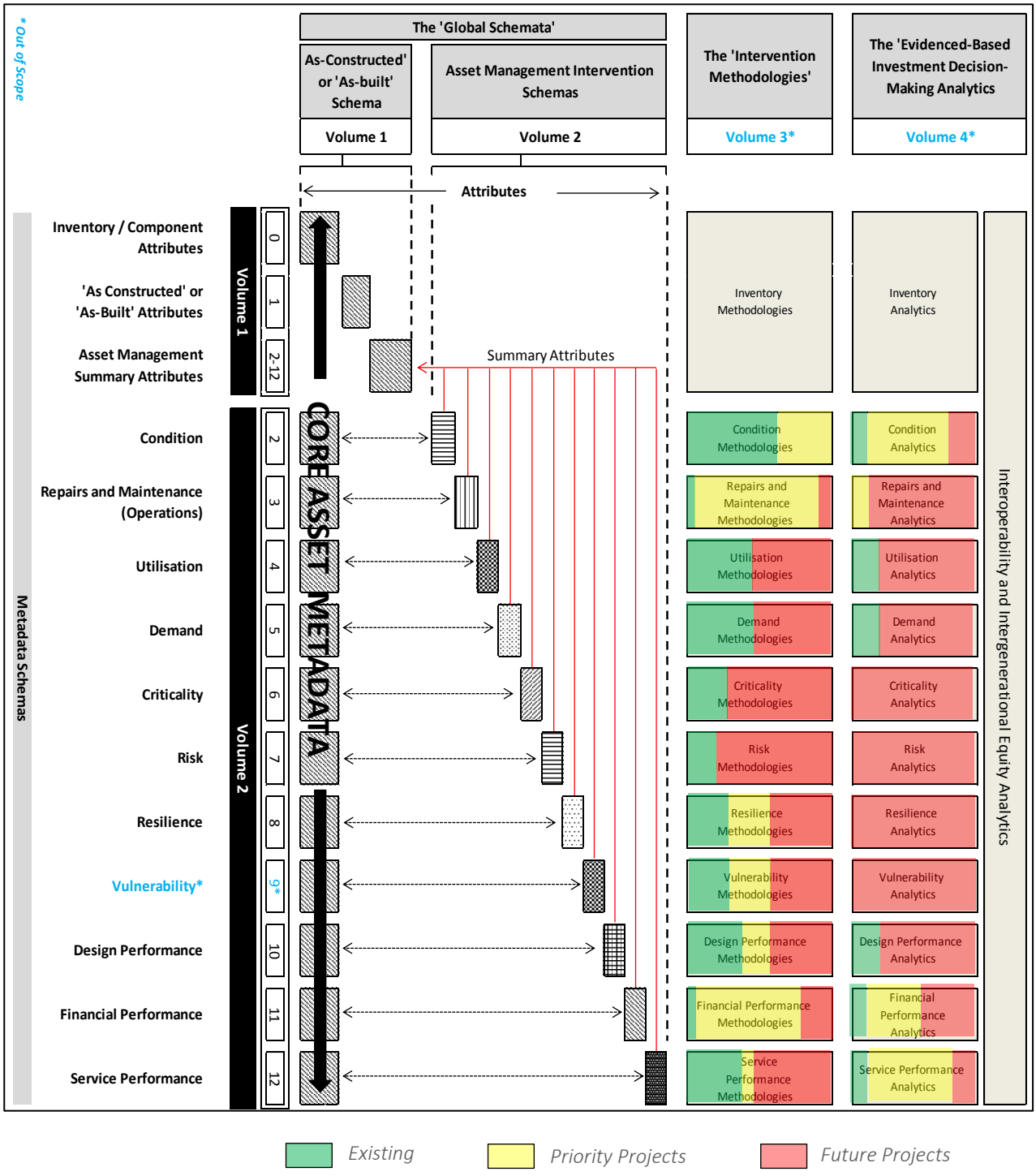

Figure 3 - Global Asset Metadata Schema – Documentation and Project Alignment

Breakdown of Work Packages and Associated Literature

Decision support (Version1.0)

Current Status / Knowledge

PROJECT	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
Metadata Standards Volume 1 and 2	LINZ			Provides data standards/requirements Intervention methodology and Evidence based decsions to be developed as part of stage 3 and 4
dTIMS Water – Optimised renewal and maintenance programmes for 3waters	Infrastructure Decision Support (IDS) / IPWEA		✓	Predicts number of expected break rates and likelihood of failure. Deterioration curves applied which need testing on a wider dataset and refined to allow for other factors such as ground conditions, pipe size/material.
IIMM	NAMS / IPWEA	✓	✓	Provides asset management framework consistent with ISO 55000 suite

Priority Projects

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	

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			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
0.1_v1	*Decision support process for pipe renewals planning*	*Evidence Based Decision*	✓	✓	✓				
What	To develop: • The process for integrating the themes from the Pipe Renewals Framework to support evidence based decision making for 30-Year Infrastructure Strategies and Asset Management Plans (AMPs) • A user tool to undertake and visualise the outputs								
Why	• To provide a nationally consistent approach to: • Improving the level of confidence in 30-Year Infrastructure Strategies and AMPs • Prioritise the intervention stratgies/options, including ops changes • Test key assumptions • Prioritise future development of the framework and associated research needs								
Approach	• Assess suitability of other international tools and standards • Develop a strawman process • Workshop with key industry stakeholders • Beta develop spreadsheet based version zero • Test, present, feedback for update • Scope out open scourced closed based solution								

D

Condition (Version 1.0)

Metadata definition - The physical state of the asset, which may or may not affect its ability to deliver the service designed to perform.

Current Status / Knowledge

	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
Pipe Inspection Manual 3rd Edition (Currently being updated)	Water New Zealand / ProjectMax	✓		Good practice guideline for the investigation of wastewater and stormwater gravity pipelines, using Closed Circuit Television (CCTV).
National Asbestos Cement Pressure Pipe Manual (Currently being updated)	Water New Zealand / Opus	✓		Good practice guideline for determining current pipe condition and likely remaining life of Asbestos Cement (AC) pressure pipelines.
Inspection and test plan preparation for pipeline condition assessment	Opus	✓		Standard approach for the development of an inspection and test plan for water and wastewater pipelines (has been applied to a number of smaller TLAs)
Crush testing pipe for condition assessment purposes	Opus	✓		Good practice guideline for crush testing pipe samples to determine condition and remaining life
Materials Pipe Cohort Tables	Opus (developed for Dunedin CC)	✓		Set of pipeline parameters for standardisation, data cleansing and developing pipe condition assessment programmes.
Risk based approach to assign condition grading	ProjectMax / Opus (developed for Auckland Council)	✓		Developed alternative method of applying condition grading to pipelines, based on likelihood of failure (different to inspection

	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
				manual)
Risk based approach for predicting likelihood of failure of Stormwater assets	Opus (developed for Auckland Council)		✓	Developed likelihood of failure for Auckland Council Stormwater gravity pipelines, predicts when to intervene using risk based approach and the likelihood to failure.
dTIMS Water – Optimised renewal and maintenance programmes for 3waters	Infrastructure Decision Support (IDS) / IPWEA		✓	Predicts number of expected break rates and likelihood of failure. Deterioration curves applied which need testing on a wider dataset and refined to allow for other factors such as ground conditions, pipe size/material.
Sewer Rising Main & Risk Management Manual	WSAA, Australia	✓	✓	Provides guidance on condition assessment and risk management strategies being applied within Australia. Improved analytical and predictive tools.
Condition Assessment Guidelines Stage 1 & 2	WSAA, CSIRO, WERF, WRf (Australia – Lead)	✓		Review of condition assessment techniques in the Australian urban water industry and international case studies (UK & US)

Priority Projects

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
5.1_v1	*Pipe Inspection and Condition Assessment Framework*	*Intervention Methodology*	1	1	1	Pipe condition and inspection experts / water engineer			500
What	A framework to outline the recommended pipe inspection methods for assessing condition / remaining useful life with basic principles and guidance on setting condition parameters for different pipe material and genre. The framework will clearly set-out pipe inspection techniques used for different pipe materials (advantages, limitations and sensitivity), where best to apply them and how to interpret the results and allocate a condition grade in accordance with the Metadata Standards definitions.								
Why	Enables the asset owner to make an informed decision on the preferred method of pipe condition assessment for piped asset(s) and understand the level of the results likely to be achieved (e.g. specific to a pipe sample or an average for a pipeline etc.). Supports implementation of the metadata standards project.								
Approach	• Literature search and review of available research to verify and validate current pipe inspection/ condition assessment techniques, advantages, limitations and outputs/results • Develop a national guideline for the application of pipe inspection methods across different pipe materials detailing where and how to apply them • Guide for assigning pipe condition rating in accordance with metadata standard definitions, based on inspection method and the interpreting of results.								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	

5.2_v2	*Pipe Inspection Manual*	*Intervention Methodology*	1	1	2	Pipe condition and inspection experts / material scientist/ asset planner			300
What	Good practice guidelines on the development and implementation of a pipe inspection and test planning process and quantities. Includes typical inspection test plans for small, medium and large pipe networks.								
Why	Enables the asset owner understand the advantages, limitations and costs of the two methods, opportunistic and planned pipe inspections. To better understand the type and quality of pipe data likely to be generated for the different pipe materials and where best to use each method within their network (for both condition assessment and pipe data improvement).								
Approach	• Procedure for establishing a pipe inspection programme based on network type size and materials • Set our rules / guidance for number of samples based on network type/size considering performance/risk/criticality/vulnerability/etc. • Provide costs for type of condition assessment i.e. $/m to allow financial budgets to be set								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
5.3_v1	*Pipe Sample Recovery and Data Management*	*Intervention Methodology*	1	1	1	Pipe condition and inspection experts / Material scientist/ geotechnical specialist			450
What	A standard procedure to be followed for the removal of pipe samples and soil samples associated with pipe networks. The procedure is to be used by those								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
	involved in either opportunistic removal of pipe samples or removal of selected pipe samples in support of a renewal programme.								
Why	The aim of the procedure is to standardise the requirements of the pipe sample removal and data capture process throughout to ensure that a consistent system of controlling and managing the data is developed and maintained.								
Approach	• Data cleansing tools – standard cohorts table for all material types • Identify areas for data collection for improved confidence for decision making activities • Procedures and work instructions for pipe sample recovery method to Define planned and opportunistic pipe data collection processes include: o Health and Safety procedures / Permit to work o Cutting and removing pipe samples (i.e. AC Pipe Watermain Manual) o Wrapping and tagging • A standard for the recording of Operational and Management fault data, including the collection, storage (Asset Management Information Systems) and reporting to allow estimates to be made of future expenditure that will be required to maintain and upgrade the asset condition								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
5.4_v1	*Pipe Condition Technology*	*Intervention Methodology*	2	1	2	Consultant / Industry/ Water NZ technical group			400

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
What	Register of pipe inspection methods to capture existing and new technology, detailing level of confidence, accuracy and recommended use i.e. pipe material								
Why	To ensure new technology is captured and regulated to ensure users are informed of the what is approved technology and its capabilities								
Approach	• Establish a New Zealand Technical Committee responsible for managing new technology and innovation • Establish links and work with other organisations to share experience with technology and innovation i.e. Universities, AWWA, UKWIR • Set up a Water NZ site listing recommended technology – status approved, not approved, not tested etc. • List of recommended contractors and suppliers that can provide pipe condition assessment								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
4.3_v1	*Likelihood of failure deterioration curves*	*Evidence Based Decision*	2	1	1	Consultants / Manufacturers / Contractors /Researchers / statistician			1000
What	Creation of deterioration curves that predict the likelihood of various pipe failures. This work is closely related to deterioration curves of other tasks that predict remaining useful life, physical pipe performance, financial performance, and level of service performance								
Why	Knowledge of pipe failure likelihood will inform all predictive analysis and planning for pipe renewals								
Approach	• Create a set of curves to be used and tested in the first instance based on available international literature and practice • Determine the most influential factors that affect the likelihood of pipe failure • Further research into the relationships to determine relationships between the most influential factors and pipe failure rates • Update curves based on the further research findings								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
6.1_v1	*Definition of*	*Intervention*	1	1	1	Consultant/ Manufacturer/ Asset			80

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
	useful life	*Methodology*				manager			
What	Develop a definition of useful life for each of the 3 waters to account for the financial impact of operating a pipe with poor performance vs the cost of renewal or rehabilitation. Also to take into account risk profiles								
Why	To provide a common understanding of useful life that subsequent tasks are founded on the same definitions								
Approach	• Review international literature and practices relevant to useful asset life, especially for pipes • Develop a definition of useful pipe life that is complete and relevant for 3 waters pipes								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
6.2_v1	*Standard framework for application of remaining useful life*	*Intervention Methodology*	2	1	1	Financial/ asset management / researchers			400
What	A standard process for how pipe network authorities should plan activities based on useful life pipe data. The development of guidelines that recommend intervention points (eg when to inspect, budget for replacement and take action) for pipes depending on remaining useful life and cost/benefit scenarios								
Why	To provide a financially sound process for intervention points that are evidence based and associated with remaining pipe useful life								
Approach	• Develop a theoretical framework for intervention points based on international literature and practice • Financial research into best practice and standard methods for monetising pipe risk profiles • Financial research project on the cost benefit of intervention points for 3 waters pipes to determine optimal timing • Update framework based on financial research								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
6.3_v1	*Useful life deterioration curves*	*Evidence Based Decision*	2	1	1	Consultants / Manufacturers / Contractors /Researchers / statistician			1000
What	Creation of deterioration curves that predict the useful life of various pipe failures. This work is closely related to deterioration curves of other tasks that predict likelihood of failure, physical pipe performance, financial performance, and level of service performance								
Why	Knowledge of pipe useful life will inform all predictive analysis and planning for pipe renewals								
Approach	• Create a set of curves to be used and tested in the first instance based on available international literature and practice • Determine the most influential factors that affect pipe useful life • Further research into the relationships to determine relationships between the most influential factors and pipe useful life • Update curves based on the further research findings								

Repairs and Maintenance (Operations) (Version 1.0)

Metadata definition - Activities undertaken to ensure the asset continues to deliver its intended design performance.

Current Status / Knowledge

PROJECT	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
Earthquake demand to pipelines (white Paper)	Opus	✓		Looks at examples of pipe failure modes on different pipe materials following the Christchurch earthquakes
Pipe Damage Assessment Tool	SCIRT	✓		Tool developed to enable quick and efficient assessment of actions required on assets.
Overseas experience	LA Water/ San Francisco/ Japan et.			

Priority Projects

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
4.1_v1	*Definition of pipe failure*	*Intervention Methodology*	1	1	1	Consultant			60
What	Develop a definition of pipe failure for each of the 3 waters to account for different mechanisms that each constitute "failure" e.g. pipe break, collapse, blockage								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
Why	To provide a common understanding for pipe failure so that subsequent tasks are founded on the same definitions								
Approach	• Review international literature and practices relevant to pipe failure definitions • Develop a definition of pipe failure that is complete for all failure modes and for each of the 3 waters								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
4.2_v1	*National pipe failure database*	*Intervention Methodology*	2	1	1	Industry / Research / Consultant / Asset owners			800
What	A single source database for storing pipe failure information for all New Zealand pipe network authorities								
Why	To provide a common database where pipe failure rates and trends can be investigating using data from all of New Zealand. The database will allow pipe failure rates to be analysed for pipes of varying physical states and will inform analytics within other related schemas. Provides a common standard for reporting and describing failures.								
Approach	• Create a database for NZ wide failure reporting • Pilot test database through importing legacy failure records where available								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
	• Develop a standard method for reporting and describing failures • Roll out to pipe network authorities with supporting software								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
7.4_v1	*Non-price attributes of pipe materials and methods*	*Intervention Methodology*	2	1	1	Research			400
What	Research the whole of life cost impact of choosing different pipe materials or construction methods in comparison to the lowest conforming price materials and method								
Why	To quantify the economic benefit of using materials and methods that may not be the lowest outturn cost or are less common								
Approach	• Research of life cycle costing between alternative materials and methods including ability to maintaiin and repair • Publish a guideline document available to industry that sets out the benefits, issues and appropriateness of various alternative materials and methods • Will require updating as new information flows from analysis of pipe failure database								

Operations (Version 0.0)

Metadata definition – Not currently defined in metadata schema

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
6.4_v1	*Effect of operational changes on effective pipe life*	*Intervention Methodology*							
What	Understanding the opportunities, risks, Levels of Service change and costs of changes to operations to improve the useful life of an asset.								
Why	Significant cost savings may be made to both Opex and Capex through changing the operationg conditions to which a pipe is subjected								
Approach	• Curation of a library of operational changes that can effect pipe performance • Publish a guideline document available to industry that sets out the benefits, issues and appropriateness of various operational changes • Will require updating as new information flows from analysis of pipe failure database								

Resilience (Version 1.0)

Metadata definition – The potential disruption of an asset to deliver the service as was intended upon design.

Current Status / Knowledge

PROJECT	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
Liquefaction Impacts on Pipe Networks	UC Cicil & Natural Resources Engineering			Presents the outcomes of Short Term Recovery Projects (STRP), impacts if liquefaction on pipe networks, which focused on the impacts of liquestaction on the potable water and wastewater systems of Christchurch.
Earthquake demand to pipelines (white Paper)	Opus	✓		Looks at examples of pipe failure modes on different pipe materials following the Christchurch earthquakes
International Infrastructure Management Manual	IPWEA			Guidance on Assessing Infrastructure Resilience (3.2.8)

Priority Projects

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
2.5_v1	*Network Resilience Assessment Methodology and Improvement Opportunities*	*Intervention Methodology*	2	1	1	Consultant / Research / Industry			750
What	Develop a methodology for assessing the degree of resilience of a pipe network and identifying potential improvements along with associated costs and benefits								
Why	To promote wider understanding of network resilience and the costs and benefits of potential strategies for improving the resilience of pipe networks, to inform pipe network intervention strategies								
Approach	• Define 'resilience' in the context of three waters services • Research and engage with communities to understand expectations around network resilience and service delivery • Identify key factors underlying the provision of resilient pipe network infrastructure • Establish and test assessment methodologies that can be used to provide a measure of network resilience • Research and identify current strategies for improving pipe asset resilience and evaluate potential costs and benefits								

Vulnerability (Version 1.0)

Metadata definition – To be confirmed

Priority Projects

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
4.4_v1	*Vulnerability to certain risk events*	*Intervention Methodology*	2	1	1	Research			800
What	Determine how vulnerable pipes of varying conditions are to a range of expected risk events								
Why	This research provides the key link between condition and performance for a range of events as defined under the Metadata standards risk schema								
Approach	• Determine which events are most important to investigation, e.g. earthquake, rain events • Develop a number of relationships between condition and performance for each of the events in the first instance based on available international literature and practice • Further NZ specific research into the relationships to determine relationships between events and pipe failure rates • Provide equations/tables/methods to determine vulnerability rates for each of the events researched								

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			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	

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			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
4.5_v1	*Spatial tools for assigning vulnerability and likelihood of failure*	*Intervention Methodology*	2	1	1	Consultant			400
What	Developing a spatial tool to assign vulnerability and likelihood of failure to pipes based on spatial features								
Why	A spatial tool allows vulnerability and likelihood to be assigned automatically and provides efficiencies particularly for large networks								
Approach	• Determine the factors that will be linked to vulnerability and likelihood in the spatial tool • Develop the tool and test over a number of different networks								

Design Performance (Version 1.0)

Metadata definition - The ability of the asset to deliver the service within the functional limits as was intended upon design.

Current Status / Knowledge

PROJECT	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
Approved Code of Practice for Excavations and Shafts for Foundations	WorkSafe NZ			
AS/NZS Pipe installation standards	Various standards			including but not limited to: 2566 Buried flexible pipes 3725 Design and installation of buried concrete pipes 2032 Installation of PVC pipe systems 2033 installation of polyethylene pipe systems 3690 Installation of ABS pipe systems 2041 Buried corrugated metal structuresNZS 7643 Code of practice for the installation of unplasticized PVC pipe systems
SCIRT pipelining specification	SCIRT, NZ			

Priority Projects

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
7.5_v1	*Standard Installation Methods*	*Intervention Methodology*	1	2	1	Consultant / Industry			400
What	Provide a standard pipe installation method for various pipe materials and ground conditions								
Why	Seeking efficiencies by standardising construction methods. Improves quality assurance of installation methods by standardising approaches.								
Approach	• Research current methods of installation • Publish a pipe installation standard document to industry								

Financial Performance (Version 1.0)

Metadata definition - The ability of the asset to deliver the service within the financial limits as was intended upon design.

Current Status / Knowledge

PROJECT	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
Gold Coast Water – Unit rates review 2008	Gold Coast City Council	✓		Cost estimates for the delivery of water and wastewater infrastructure based on a set of unit rates for pre-defined asset types, with an allowance for variations in cost affecting factors such as soil type. These rates are typically used in a wide range of cost estimation applications, including infrastructure planning and income modelling requirements.

Priority Projects

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
7.3_v1	*Pipe Procurement Guidelines and Standard Specifications*	*Intervention Methodology*	2	1	2	Industry/ TAs/ MBIE			400
What	Production of a guideline on different procurement methods with commentary on when and why to use each different method								
Why	To provide a single source of wisdom for pipe procurement methods to give opportunities for different procurement models to be adopted where appropriate so that efficiencies can be achieved								
Approach	• Research of international literature and practices for different pipe procurement models to determine which models may be appropriate for NZ • Further research into the benefits and issues with the possible procurement models • Publish a guideline document available to industry that sets out the benefits, issues and appropriateness of various procurement models (as well as presenting findings to industry groups, councils, conferences etc) • Coordinate manufacturers and territorila authorities to develop a national specification								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
7.6_v1	*Standard cost of pipe installation*	*Intervention Methodology*	2	1	2	Consultant / Industry			400
What	Provide a standard costing regime for pipe installation								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
Why	Reduce variance in pipe installation costs. Reduce variance in the calculation of replacement costs of pipes.								
Approach	• Research current methods of pipe costing • Publish a pipe installation costing guideline document to industry								

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
10.2_v1	*Operational, Capital and Maintenance Rates*	*Intervention Methodology*	2	1	1	Research			700
What	Unit rate guide for operational and maintenance actions and capital expenditure for pipe renewals and rehabilitation methods.								
Why	To provide robust and quality data for whole life cycle costing								
Approach	• Review OPEX and CAPEX methods and cost rates across New Zealand • Develop a standard rate for typical O&M procedures (jobs) • Develop cost rate for intervention options consisting of opex and capex solutions								

PROJECT	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY	WHO	TIMING	PROJECT HOURS

NO.			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
10.3_v1	*Life-Cycle Cost Prediction*	*Evidence Based Decision*	2	1	1	Consultant			700
What	A procedure which seeks to identify the most appropriate solution to network problems by considering various types of intervention options mainly consisting of opex and capex solutions.								
Why	Cost effective approaches can be utilised to determine the most appropriate least whole life cost option								
Approach	• Literature search to identify what tools/approaches are available for assessing expenditure based on intervention methods i.e. IDS approach • Develop financial tool to predict opex /capex methods								

Service Performance (Version 1.0)

Metadata definition - The ability of the asset to deliver the service within the levels of service limits as was intended upon design.

Current Status / Knowledge

PROJECT	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
Non-Financial Performance Measures Rules 2013	Dept Internal Affairs			Establishes a set of mandatory performance measures for local authorities to use when reporting to their communities. Comment (PC) Measures adopted for reporting may not be complete/or appropriate for use in the context of assessing investment decisions with respect to community outcomes and level of service.
National Performance Review	Water New Zealand			Annual performance review and benchmarking of local authority delivery of 3 waters services. Aligned with Non-Financial Performance Measures Rules 2013
International Infrastructure Management Manual (2015)	IPWEA / NAMS			A foundation document for asset management practice as generally adopted/promoted in NZ. Section 2.2 Covers Establishing Levels of Service and includes case studies.
Levels of Service & Community Engagement	IPWEA			Levels of Service are the building blocks for infrastructure asset management. Proper understanding about the levels of service is a basic requirement to effectively provide services from infrastructure. The best results are when the

PROJECT	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
				community understands their infrastructure needs, delivered at affordable levels.
Level of Service Performance Measures for Seismic Resilience of Three Waters Network Delivery	Quake Centre	✓		The Levels of Service Performance Measures for the Seismic Resilience of 3 Waters Network Delivery provides a framework which may be used by engineers and asset managers to define the current or potential operating stage of any part, or parts, of a 3 waters network in the event of, or planning for, a significant earthquake.
Asset & Asset Performance Data	WSAA	✓		This project delivers a Reference Manual which documents asset data required by water utility asset managers to undertake effective asset management. The information will assist water utilities to identify what information they need to manage their assets including reporting against asset based regulated and business KPIs and analysis of asset performance.
Developing Levels of Service & Performance Management Guide	NAMS			
Water Utility Service Performance and Benchmarking	Opus			
Water NZ National Bench Marking	Water NZ			
Life Cycle Analysis of Water Networks	CSIRO			

PROJECT	ORGANISATION	INTERVENTION METHODOLOGY	EVIDENCE BASED DECISION	DETAIL
Design Guidelines 43	SCIRT	✓		Capital rationing process based on level of service / asset performance

Priority Projects

PROJECT NO.	TITLE	PROJECT TYPE	IMPLEMENTATION PRIORITY			WHO	TIMING		PROJECT HOURS ESTIMATE
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		DURATION	START-DATE	
10.1_v1	*Pipe Performance Measures*	*Evidence Based Decision*	1	1	1	Consultant			800
What	A specification that sets out pipe performance measures and how they should be applied and used to provide justification for investment decisions								
Why	Optimised total expenditure by providing the appropriate actions at the right time								
Approach	• Review pipe failures data within New Zealand and Internationally to identify key indicators for assessing performance with a LoS/Community and financial focus • Develop a specification for key performance indicators (KPIs) and parameter definitions (Condition Type – burst frequency, blockages) (Performance Type – Water quality failures, customer complaints, environmental impact) • Provide provisional weightings for each parameter and test i.e. burst frequency (15%), blockages (30%), Overflows (50%) • Develop a pipe performance grading system as a measure of the performance of the asset and its ability to maintain adequate levels of service								

The Implementation Plan

The implementation plan has been developed to determine level of priority based on the three measures discussed previously; ease, level of importance and level of impact, as presented in Table 1.

To support the delivery and funding of projects they have been grouped into work packages, centred on a common theme or where projects are linked together to provide a combined outcome i.e. pipe inspection.

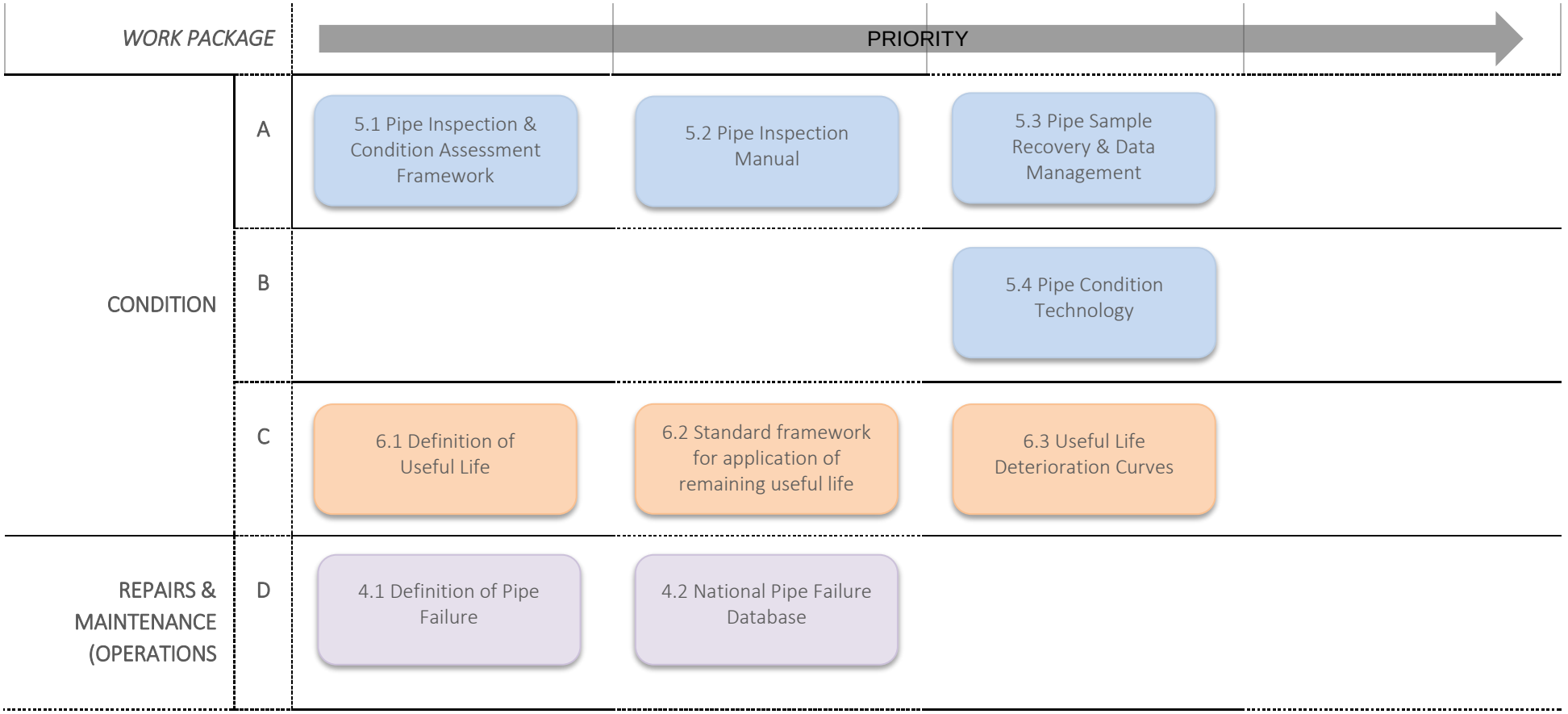
Table 1 – Project Implementation Plan

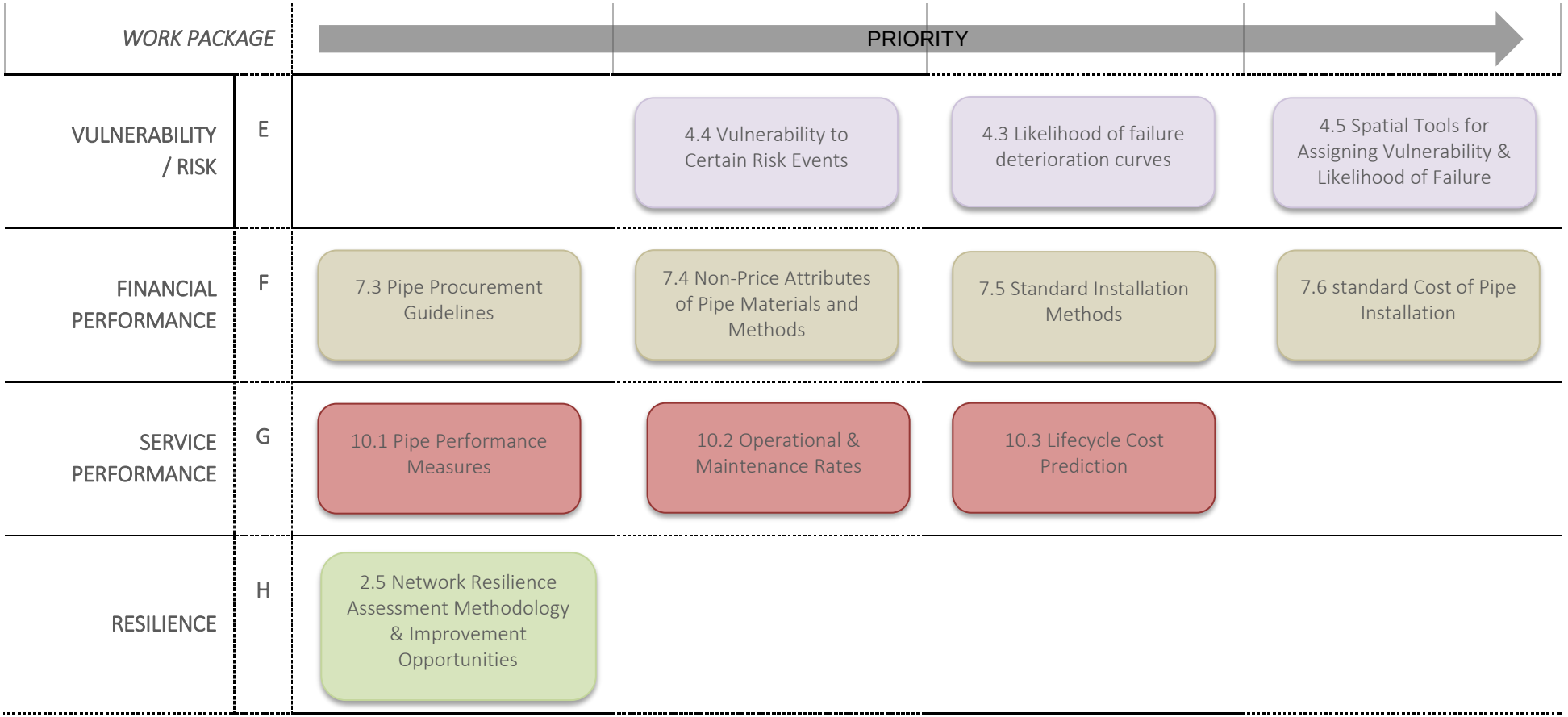
PROJECT NO.	PROJECT	TYPE	IMPLEMENTATION PRIORITY			WORK PACKAGE	PROJECT PRIORITY
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		
5.1	Pipe inspection and condition assessment framework	Intervention Methodology	1	1	1	A	1
5.3	Pipe sample recovery and data management	Intervention Methodology	1	1	1	A	1
5.2	Pipe inspection manual	Intervention Methodology	1	1	2	A	2
5.4	Pipe condition technology	Intervention Methodology	2	1	2	B	2
6.1	Definition of useful life	Intervention Methodology	1	1	1	C	1
6.2	Standard framework for application of remaining useful life	Intervention Methodology	2	1	1	C	1
6.3	Useful life deterioration curves	Evidence Based Decision	2	1	1	C	1
4.1	Definition of pipe failure	Intervention Methodology	1	1	1	D	1
4.2	National pipe failure database	Intervention Methodology	2	1	1	D	1
4.4	Vulnerability to certain risk events	Intervention Methodology	2	1	1	E	1
4.3	Likelihood of failure deterioration curves	Evidence Based Decision	2	1	1	E	1
4.5	Spatial tools for assigning	Intervention	2	1	1	E	2

PROJECT NO.	PROJECT	TYPE	IMPLEMENTATION PRIORITY			WORK PACKAGE	PROJECT PRIORITY
			EASE	LEVEL OF IMPORTANCE	LEVEL OF IMPACT		
	vulnerability and likelihood of failure	Methodology					
7.3	Pipe procurement guidelines	Intervention Methodology	2	2	2	F	2
7.4	Non-price attributes of pipe materials and methods	Intervention Methodology	2	1	1	F	2
7.5	Standard installation methods	Intervention Methodology	1	2	1	F	2
7.6	Standard cost of pipe installation	Intervention Methodology	2	1	2	F	2
10.1	Pipe Performance Measures	Evidence Based Decision	1	1	1	G	1
10.2	Operational and maintenance Rates	Intervention Methodology	2	1	1	G	1
10.3	Life-cycle cost prediction	Evidence Based Decision	2	1	1	G	1
2.5	Network resilience assessment methodology and improvement opportunities	Intervention Methodology	2	1	1	H	2

Work Package

The packages of work have been aligned to the metadata schema and present the order each project should be carried out in.




WORK PACKAGE
PRIORITY
VULNERABILITY / RISK
E
4.4 Vulnerability to Certain Risk Events
4.3 Likelihood of failure deterioration curves
4.5 Spatial Tools for Assigning Vulnerability & Likelihood of Failure
FINANCIAL PERFORMANCE
F
7.3 Pipe Procurement Guidelines
7.4 Non-Price Attributes of Pipe Materials and Methods
7.5 Standard Installation Methods
7.6 standard Cost of Pipe Installation
SERVICE PERFORMANCE
G
10.1 Pipe Performance Measures
10.2 Operational & Maintenance Rates
10.3 Lifecycle Cost Prediction
RESILIENCE
H
2.5 Network Resilience Assessment Methodology & Improvement Opportunities

Quick Wins

The initial literature search identified a series of available polices, guidelines and documentation which will support the early implementation of part of the pipe renewals framework. This existing knowledge can be captured, tailored and developed to support the immediate phasing of some of the priority projects, as listed below:

- Pipe Inspection and condition framework – There is currently a high level of understanding of AC and gravity pipelines based on the availability of documentation, such as the '*Pipe Inspection Manual 3rd Edition'* and the *'National AC Pressure Pipe Manual'* both currently in the process of being updated. There are also trusted condition assessment practices being used within New Zealand such as Pipe CT scanning to determine remaining useful life.

- Pipe sample recovery and data management – Practices and training for contractors in the water industry have been developed to recover samples in a safe and consistent manner. Data management tools are also available for data cleansing and data collection.

- Useful life deterioration curves – Data exists in the form of the national pipe sample database predicting remaining life based on individual pipe samples. A materials cohorts table also exists for a range of 3 water pipe materials, this could be developed further to include expected life.

- Definition of pipe failure and National pipe failure database – Similar databases exist in the UK and the US which could be used and/or developed to suit the needs of the NZ water industry. This international knowledge could also be used to support the development of deterioration curves and standard useful life.

- Pipe performance measures – A series of documents are available within NZ and internationally on performance measures. The knowledge is extensive varying from national performance measures, to levels of service and community engagement guidelines, and research with the seismic resilience of three waters network delivery, following the Canterbury earthquake.

Financial Performance – There is an opportunity to run this project stream in parallel to other projects, as the resources (contractor led) required are separate and do not affect the delivery of other projects.

Summary

This Pipe Renewals report sets out a framework which is aligned to the New Zealand Metadata Standards, taking into account existing knowledge and practices, and presents a roadmap for implementing improvements in knowledge and practice.

The roadmap presents 46 project initiatives and one integrating decision support framework that could be implemented over the next three years. The Committee discussed the first draft of the Pipe Renewals framework and highlighted the need to prioritise projects, as the proposed implementation plan was considered to extensive. Completion of the integrating decision support framework will allow this ongoing.

An implementation plan has been developed to determine level of priority for each project based on three measures; ease, level of importance and level of impact. To support the delivery and funding of projects these projects have been grouped into work packages.

The initial literature search identified a series of available polices, guidelines and documentation which will support the early implementation of part of the pipe renewals framework. Based on existing knowledge and priority it is recommended the following projects are progressed first:

- Decision Support Framework
- Resilience
- Pipe Inspection and condition framework
- National Pipe Database
- Pipe sample recovery and data management
- Useful life deterioration curves
- Definition of pipe failure and
- Pipe performance measures