New Zealand Asset Metadata Standard – Potable Water

Volume 2
Asset Management and Performance

New Zealand Treasury – National Infrastructure Unit

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METADATA STANDARD	New Zealand Asset Metadata Standard Potable Water Volume 2 Asset Management and Performance
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A group of experts has developed and produced this standard. The disciplines include product engineers, process engineers, design engineers, CAD/BIM experts, engineering scientists, 3 water engineers, hydraulic engineers, builders, construction specialists, metadata specialists, data experts, asset software systems specialists, asset owners, asset managers, network repair and maintenance specialists, network operations specialists, network refurbishment specialists, financial analysts, data scientists and portfolio or network managers. Combined, this extensive body of knowledge and experience in 3-water management and investment practice has been sought from central government agencies, local government authorities and private sector partners, and has informed the data requirements within this document, on behalf of all NZ Inc.

This standard has been prepared for the National Infrastructure Unit as part of its work to promote improved infrastructure outcomes by providing expert technical input on infrastructure issues across New Zealand. The New Zealand Treasury National Infrastructure Unit also specifically acknowledges this contribution and the role of GISSA International in facilitating and producing these standards.

Individual public sector agencies and authorities will determine their response to this standard following consideration of their legislative or administrative arrangements, available funding, as well as local circumstances and priorities.

Licence for New Zealand Asset Metadata Standards – (Licence)

Abstract

The metadata standard for potable water assets provides asset managers, and their suppliers, with a specification for asset data that supports data creation, collection, storage and analytical capabilities to make evidence-based investment decisions. This applies to both capital and operating environments. The standard establishes a common understanding of the meaning of asset data, and it ensures all stakeholders use and interpret the data correctly and properly. The standard recognises various levels of sophistication in the data and provides relevant guidance on data attributes in this regard. Accordingly, the standard will benefit any potable water asset manager who uses data for analytics to inform funding and investment priorities; research and research investment; policy development and national, regional or local reforms; national, regional or local reporting and benchmarking; shared services and inter-organisational collaborations.

KEYWORDS metadata; standards; assets; potable water

Executive Summary

Introduction

The potable water metadata standard[1] is one in a suite of asset standards used by asset managers and others to manage public infrastructure assets. The objective for asset managers is to maximise the service delivery outcomes envisaged when investments are made in public assets. Evidence-based decision-making is the only sustainable way those with public asset stewardship and custodianship responsibilities can successfully continue to deliver public value.

To achieve these types of investment decisions (both capital and operating), data and information must be standardised (within datasets) and harmonised (across datasets). This should also be done nationally, for the maximum value to be extracted across disciplines, agencies, authorities, sectors and regions. These standards provide a foundation to enable this.

In developing these standards, it was recognised the ***lifecycle of asset data*** is intrinsic to the *whole of life* management of assets, as are the *lifecycles of assets* themselves. For this reason, these specifications have been developed with two purposes in mind. First, they ensure a geospatially digital data standard for any newly constructed asset is captured at source, immediately after construction is completed (Volume 1). Second, these standards ensure that any asset management interventions (or works) undertaken to maintain the asset have a parallel approach. That is, the required information for all of the interventions is collected simultaneously . This process will enable asset managers and others to manage assets through the life of the asset at source and in a common and harmonised way for the asset's whole life (Volume 2).

Another objective of this standard is to streamline the transfer of digital data when managing potable water assets with consideration of the specific asset types – as each is different. This objective must be shared by all those who support potable water asset owners in delivering the outcomes specified by the asset owners. This will extend to several processes, including creating, storing, capturing and/or analysing data. Adopting these standards will increase the efficiency of information access and result in greater customer satisfaction when dealing with inquiries from engineering consultants, surveyors, developers and asset managers by:

- **eliminating duplication of effort** – significant duplication exists in the digitising of as-constructed / as-built information. This duplication occurs between the private sector (which captures as-constructed / as-built information) and council, utility and water authority staff (who may digitise that information from paper plans)
- **improving process efficiency** in the process of accepting and processing lodgements, and in checking existing data against design criteria and/or design plans
- **improving customer service** to both internal and external customers of asset information
- **improving the quality** of potable water information held in council, utility and water authority systems for audit and financial requirements, as well as operational and business requirements

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[1] Alongside potable water, standards are in place for residential housing and light commercial buildings, wastewater, stormwater and roading.

- **providing a structure** for the consistent recording of all council, utility and water authority owned assets, including those created through internal programmes such as capital works and renewals
- **managing assets better** to reduce the need for capital works and/or to reduce ongoing maintenance costs.

Potable water data is characterised as having an infrastructure role by:

- functioning as reference data – which means other kinds of information can and will be linked to the core data
- being of interest for many different kinds of applications (and being a common denominator and integrator between different data suppliers and product and service providers)
- containing information of specific interest for the public sector in its role in supporting asset management, efficient transportation, traffic safety, to handle environmental and social planning, and so on
- having a structure that is stable over time (even if parts of the data content change because of user input)
- having specific interest for cross-border (across local, national or international boundaries) applications.

Use of the Specifications

Volume 1 of this standard is for all who undertake potable water development or capital works (new and renewal or replacement) activities for or on behalf of all asset owners of public potable water assets. Volume 2 is for all who undertake work on the network and who require the exchange of data to update current information about an asset as a result of that work. This also extends to any intervention undertaken for or on behalf of all asset owners of public potable water assets.

This document includes the metadata schemas required for asset management and performance. Each schema comprises a set of specific attributes. This document specifies the attributes that comprise each schema as well as the format and rules by which attributes are collected and stored.

In Summary

The main objective of this standard specification is to provide information to the consultants who will be dealing with any public asset owner. This document outlines the specific requirements for the submission of all digital data that relates to asset management and performance of potable water assets as defined by asset managers in New Zealand.

While all care has been taken with the preparation of this document, it is the responsibility of the consultants to confirm that all details are current and relevant and they are responsible for ensuring they are using the relevant current metadata standard specification.

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1 Introduction

1.1 Purpose of this Document

This standard is designed to capture asset information in a consistent and repeatable format so it can be analysed rigorously and provide intelligence to inform decision-making on asset replacement, augmentation, operation and maintenance.

The document brings together content developed by technical experts and practitioners, and outlines the asset schemas that form part of this standard and the attribute categories relevant to each schema. Details are provided in the attribute tables for each attribute category in the following sections.

This metadata standard covers infrastructure for the provision of drinking water to communities by network reticulation. It does not cover infrastructure for the collection and treatment of water, except in the case of wells, which are sources of potable water, or infrastructure to treat water.

Table 1 shows the asset categories covered by this document, as selected in consultation with technical experts and practitioners.

Table 1: Asset Categories Covered by this Document

• Civil structure	• Fitting	• Instruments
• Containment structure	• Pipe	• Cathodic protection
• Embankment	• Pump station	• Electrical equipment
• Retaining structure	• Tunnel	• Supply meter
• Retaining wall	• Mechanical equipment	
• Well	• Pump	
• Access chamber	• Valve	
• Channel	• Cabling	

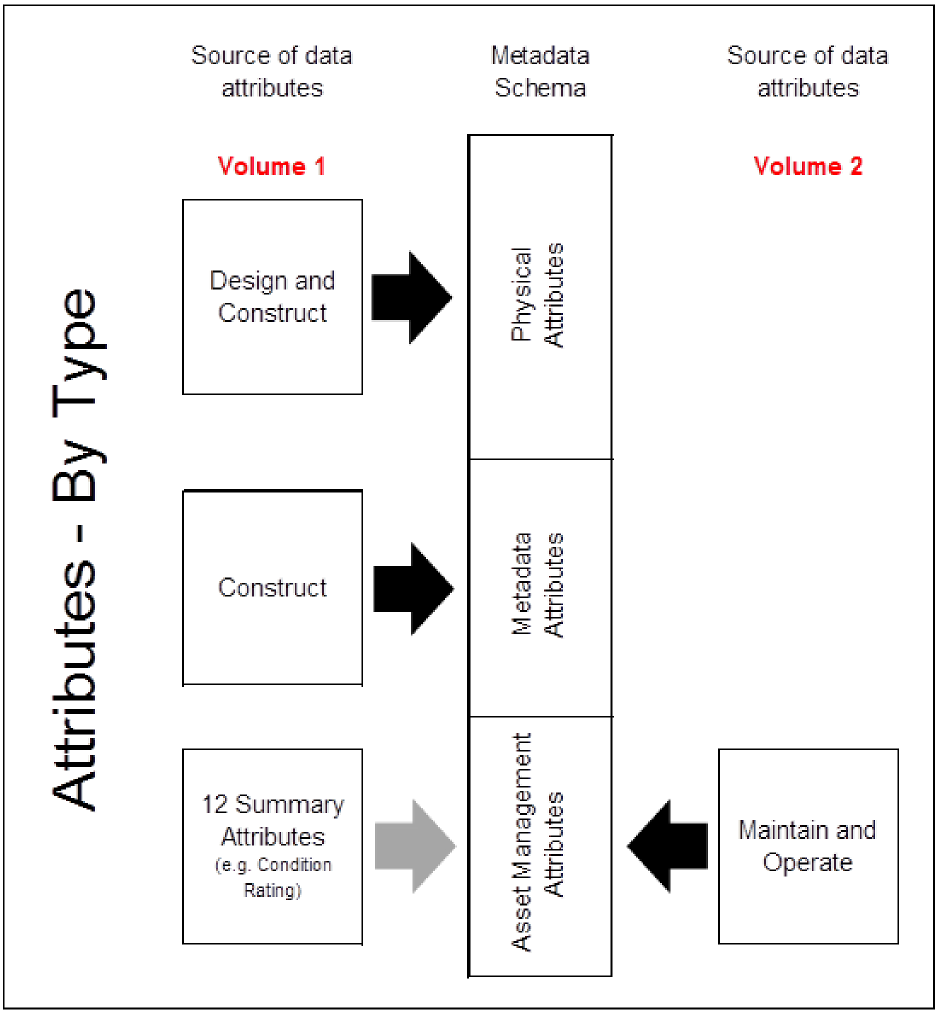
The relationship between Volume 1 (As-constructed / As-built) and Volume 2 (Asset Management and Performance) is both implicit and explicit in nature. It is implicit in that the data required to manage assets requires an appropriate level of knowledge about the asset itself, in a digital sense. Volume 1 specifically defines the description of assets for this first digital environment.

Volume 2 is more explicit in that stewards of assets also know it is as much about the asset's environment and services provided that requires monitoring and management as it is about the assets themselves. Volume 2 specifically defines the assets for the second digital environment.

These two volumes connected by the inclusion of calculable fields defined in Volume 2 into Volume 1 (for example condition or criticality). Each of the 12 decision elements defined in Volume 2 has these ‘digital keys’. In order for a digital environment to capture these important pieces of information, it is necessary to recognise they require a place in the data stored about the asset.

These fields have therefore been included in the tables of Volume 1. This provides the required foundations for interoperability analytics.

Figure 1: Relationship of attributes in metadata schema – Volume 1 and 2



1.2 Objective of Potable Water Supply Service

The objective of providing a potable water supply service is to facilitate public health and enhance the quality of life of customers through the supply of water.

1.2.1 Service Attributes

This objective can be further described using the water supply service attributes listed in Table 2.

Table 2: Water Supply Service Attributes

Water supply attributes	Description
Customer	
Provision of service	
Provision	Service is provided to customers where deemed appropriate by the organisation. Service continues to be provided to those customers.
Quantity	Customers receive water at the flow and pressure deemed appropriate by the organisation. Fire hydrants are provided in accordance with regulations and supply water at specified flows and pressures.
Quality	The system provides water with an appearance, taste and smell that are attractive to customers.
Health and safety	
Public health	Potable water supplied through the system is safe to drink.
Safety	Assets are operated and managed in a manner that is safe for network operators and suppliers who maintain the network, as well as the community who use or consume the water.
Cultural	
Heritage	Our heritage and taonga (treasured resources) are not adversely affected by the operation and maintenance of assets.
Culture	The system operates in a manner that respects the beliefs of our people and does not negatively affect their ability to participate in cultural practices.
Resilience	
Resilience	The ability of an asset to recover from disruption to deliver the service as intended in its design.

Water supply attributes	Description
Organisational	
Financial	
Financial sustainability	The assets enable the service to be provided in a financially sustainable manner for both the present and the future.
Financial impact on stakeholder	Providing service in a manner that does not have a negative financial impact on stakeholders.
Environmental	
Environmental impact	The asset enables the system to be operated in a manner that minimises environmental impact and nuisance to the community.
Governance	
Reputation	The asset enables the system to be operated in a manner that enables the organisation to maintain a good reputation within the community.
Compliance	Assets are operated and managed in a manner that complies with legislation and regulations.

1.3 Structure of Standard

This standard is structured to allow assets to be assessed in terms of the total number of measurable attributes. These include:

- condition
- repairs, maintenance and operations
- utilisation
- demand
- vulnerability
- criticality
- risk
- resilience
- design performance
- financial performance
- service performance.

1.3.1 Asset Hierarchy

An asset hierarchy is a framework for segmenting an asset base into appropriate classifications. It can be based on asset function; asset type or a combination of the two. In these standards, the hierarchy is based on asset type. Not all components are necessarily defined at each layer within the hierarchy (see the 'Example 2' column in Table 3).

Table 3: Asset Hierarchy Framework

Asset hierarchy	Defined as	Example 1	Example 2
Asset Group	Group of classes	3 waters	3 waters
Asset Class	Group of sub-classes	Potable water	Potable water
Asset Sub-class	Group of elements	Pump station	Pipe
Asset Element	Group of sub-elements	Electrical	Civil
Asset Sub-element	Group of components	Pump	n/a
Asset Component	Group of sub-components	Motor	Pipe section
Asset Sub-component	Type of sub-component	Coil	n/a

1.3.2 Structure of Attribute Data Tables

The structure of the attribute tables used in this volume is based on that used in Volume 1 "As-constructed / As-built". Similar tables are also used in the New Zealand Asset Metadata Standards for wastewater, stormwater, residential housing and light commercial buildings. An international search for best practice with data table structure provides further support to this structure. Table 4 outlines the table attribute fields used in this volume. Table 5 lists the data type code to be used for assessing an attribute.

Table 4: Metadata Definitions

Metadata Element Name	Definition
Attribute Name - Abbreviated	An abbreviated name for the attribute field adopting the "underscore_case" structure, e.g. *"Unique_ID"*. Note sometimes this will include the name of the class to differentiate it from other similar names with different definitions. The field name is limited to 10 characters to enable the delivery of data in ESRI Shape file format if required.
Attribute Name – Full	A meaningful name adopting "upper and lower case" structure for the attribute field, e.g. *"Unique Identifier".* Note sometimes this will include the name of the class to differentiate it from other similar names with different definitions.
Data Type	Defines the type of data the field is to hold, for example *"Alpha / Numeric"* Please refer to Section 2.1.5 Data Type Definition.
Unit of Measure	Where relevant the unit of measure for the attribute field is provided, for example *"Metres", "Time",* and *"Millimetres".*
Max Length	Where relevant the maximum length of the Data Type is provided, for example *"10 chars*" (representing 10 characters).
Comment	Additional information provided to fully describe what the data type will consist of, for example *"2 decimal places"*, *"No commas included"* and *"Yes or No field".*

Metadata Element Name	Definition
Contents	Information to fully describe what the attribute field is for. For example *"The current operational state of the asset"*. Sometimes an example is included as a sample value. *"ABN"* a value from the codelist.
Example	Sometimes an example will be provided as an example of a valid entry.
General Validation Rule	Lists one or more general rules that must be applied, for example the *"Field cannot be empty."* Sometimes a default value will be provided as an example of a valid entry. A blank
Specific Validation Rule	Lists one or more specific rules that must be applied, for example the *"Entry must be from the CODELIST"*. (applicable where a codelist is referenced.)
Codelist Reference	A list of allowable values will be provided for attribute fields where the item must be constrained to one of a particular set of values. The field is limited to 10 characters.

Table 5: Data Type

Name	Technical Specification	Definition
Alpha / Numeric	varchar(m)	[a-z], [A-Z],[0-9],[-] letter and digits where m is the maximum number of characters allowed, e.g. 10 chars could be “Abcdef_123” but not “Abcdef_1234”
Boolean	boolean	a data type with only two possible values: true or false
Boolean using Alpha	varchar(m)	[a-z],[A-Z],[-] Alphabetical (letters only), where m is the maximum number of characters allowed. E.g. 1 char “Y”
Date	date	format DD/MM/YYYY
Decimal	decimal	Please note may be a negative number when dealing with Invert levels of pipes. The precision required is listed, for example “2 decimal places” The total number of digits to be stored is not specified to accommodate different systems.
Integer	integer	Positive whole number (0 to 18,446,744,073,709,551,615)
Time	time	Must be in format hh:mm

1.3.3 Structure of Decision Elements

Volume 1 of the New Zealand Asset Metadata Standards details the suite of attributes that digitally describe an asset on its construction (as-constructed / as-built). Managers who are responsible for assets, networks and/or portfolios of assets consider a number of decision elements identified in this volume during both scope and design, before construction even starts. Figure 2 details how strongly many of the asset management decision elements influence these early phases in asset augmentation. Any design will consider material types (saline environments influence future condition), current and future capacity (population growth meeting current utilisation forecasts and future demand) and design strength (in vulnerable environments or with high criticality).

Figure 2: Optimised Replacement – "As-constructed" as an Influence

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand												
Vulnerability												
Criticality												
Risk												
Resilience												
Design Performance												
Financial Performance												
Service Performance												

1.4 Context of Asset Data and Analytics

These standards describe and define the data required for evidence-based investment decision-making within an asset management environment.

The standards support the professional judgement that comes with experience when making investment decisions: analytics do not remove the responsibility of the decision-maker.

Each standard outlines the underpinning definitions, logic and foundations for the resulting analytics and *standardises and harmonises* the data structure across the asset management disciplines.

The rationale is to create a platform for interoperability. The opportunities available with big data and sophisticated machine learning analytics are endless but are also out of reach for most asset managers, unless a common data platform is created to enable this. The standards provide a platform so stewards of public sector assets have access to common-pool resources (for example, analytics).

Asset management has many layers of complexity, from the condition of an asset component, such as a water pipe, to the National Policy Statement for Freshwater Management that gives national guidance on managing the freshwater environment. They are interrelated.

Figure 3 shows the global metadata schemas and how the standards sit in context with the wider asset management discipline. Each layer has a role in the development of an integrated, learning asset management environment. These layers, and the five volumes of metadata standards, are described below.[2]

1.4.1 Metadata Standard (Volumes 1 and 2)

The metadata standard is presented in two volumes: As-constructed / As-built (Volume 1) and Asset Management and Performance (Volume 2).

As-constructed / As-built (Volume 1)

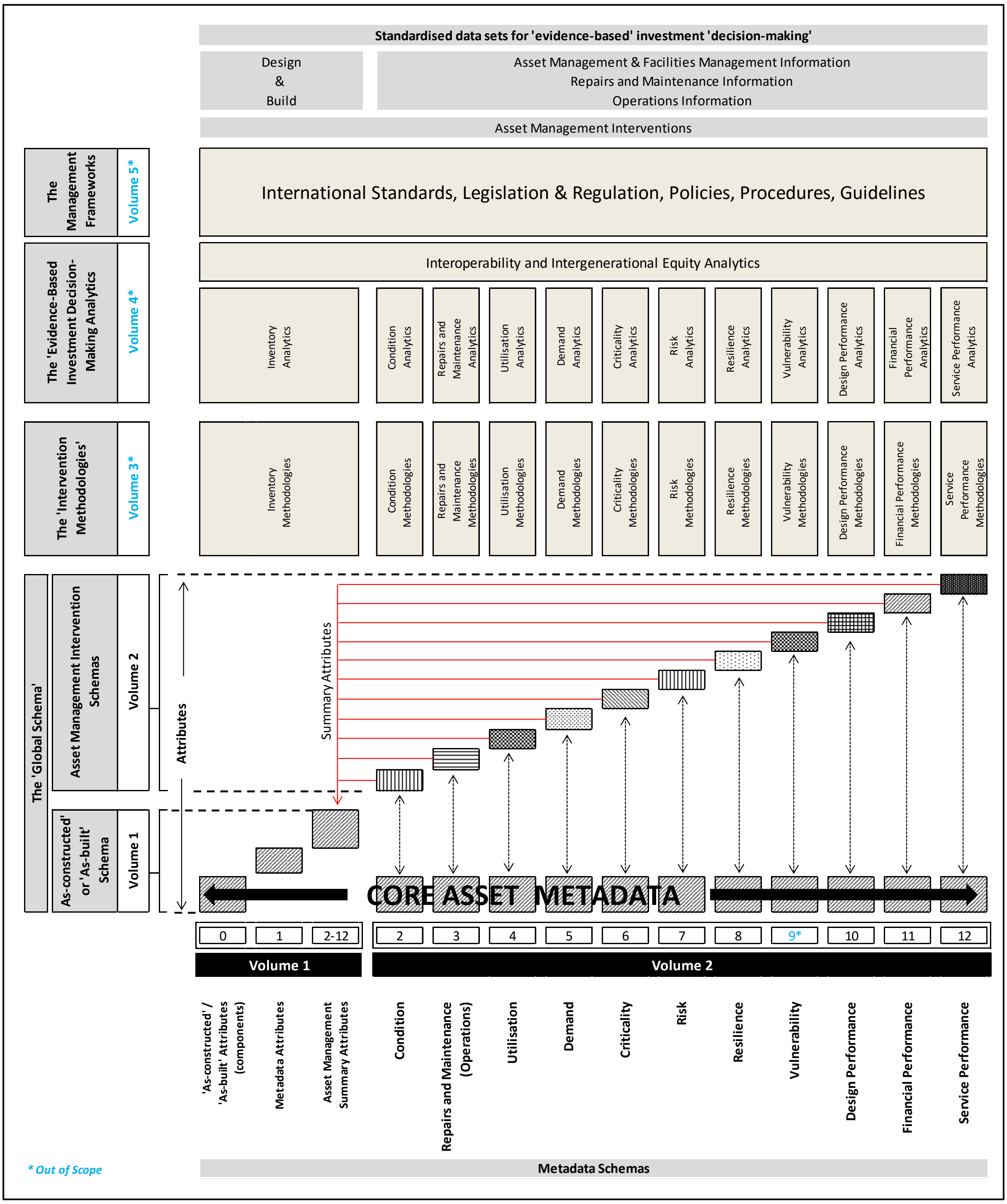
This volume describes the data to be captured on the creation of a new asset at an asset ID (component) level. The data at this level has three attributes that define the characteristics of the asset:

- *physical* (for example, material or diameter)
- *metadata* (for example, date of construction or builder)
- *asset management summary attributes* (for example, condition rating).

Note: These are summary attributes only and are defined with their own metadata schemas in Volume 1. The full schema for each attribute is defined in this volume (Volume 2).

[2] Volumes 3, 4 and 5 are not yet developed but are still an integral part of the goal to have a suite of national standards for managing public assets.

Figure 3: Global Asset Metadata Schema



Asset Management and Performance (Volume 2)

This volume describes the **decision elements** required for making evidence-based investment decisions. The elements are defined as:

- **condition:** the physical state of the asset, which may affect its ability to deliver the service and level of service intended in its design
- **repairs, maintenance and operations:** activities undertaken to ensure the asset continues to deliver the service and level of service intended in its design

- **utilisation:** the proportion being used of an asset's available capacity
- **demand:** the call on an asset's capacity at any given time
- **vulnerability:** the susceptibility or flaw,[3] which in certain events could diminish an asset's ability to deliver the service and level of service intended in its design
- **criticality:** the significance of the removal of any individual component or asset to the ability of any part of a network or portfolio to deliver the service it was designed to perform
- **risk:** the potential to gain or lose something of value, that is, the probability or threat of quantifiable damage, injury, liability, loss, or any other negative occurrence caused by external or internal vulnerabilities, and that may be avoided through pre-emptive action
- **resilience:** the capacity of an asset to absorb disturbance, return from disruption, act effectively in a crisis and adapt to changing conditions over time
- **design performance:** an asset's ability to deliver the service within the functional limits as intended in its design
- **financial performance:** an asset's ability to deliver the service within the financial limits as intended in its design
- **service performance:** an asset's ability to deliver the service within the levels of service limits as intended in its design.

Each element is required to inform investment decisions for public sector assets – whether for operational investment (for example, prioritising a work programme for condition assessments) or a capital investment programme for renewals (for example, the replacement of mains water pipes).

Their use and application will vary significantly, depending on the circumstances of the specific decision and the accessibility of information to help develop supporting analytics. In time, the documents referenced in the Management Frameworks – Volume 5 will describe decision-making best practice (for example, Water New Zealand's Pipe Renewal Guidelines).

Intervention methodologies, Evidence-based investment decision-making analytics and Asset management frameworks – not in scope

The layers referred to in Figure 3 (intervention methodologies; evidence-based investment decision-making analytics; and asset management frameworks) are not yet developed, but for context an explanation is provided for how they fit into an integrated, learning asset management environment.

1.4.2 Intervention Methodologies (Volume 3)

Many interventions are needed to manage the life of an asset. They range from *direct non-invasive* interrogations for condition (for example, visual inspections or CCTV assessments from video footage) to *direct invasive* interventions of materials testing (for example, pipe wall thickness and strength tests in a mains water pipe). They also range from *indirect non-invasive* desktop-type interventions for financial performance (for example, the economic yield of a pipe investment proposal) to *indirect invasive interventions* that hardwire water quality monitoring solutions at a stormwater outfall (for example, sensors measuring turbidity or *Escherichia coli*).

[3] Susceptibility refers to environmental factors, such as liquefaction zone; flaw refers to physical factors, such as material type.

Irrespective of the intervention, each requires its own standard methodology. This includes a metadata schema that collects the requisite data and stores it in a standardised metadata format that can be analysed using standardised algorithms and analytical frameworks.

The intervention methodologies must be repeatable. This maintains the intent of both the standards and supporting analytics; otherwise the logical intent of the metadata standards is reduced to a point where it could be assumed the analytics are not standardised. While the standards recognise we do not work in a perfect world, they also attempt to maintain consistency in the methodologies used to interrogate assets throughout their life.

The standards are silent on which interventions are appropriate to interrogate assets, because that is for the relevant sectors to determine through their own processes.

1.4.3 Evidence-based Investment Decision-making Analytics (Volume 4)

This is sometimes referred to as the ‘engine-room’ of strategic asset management planning. Within it are four levels of analytical complexity that can be considered as having standardised the data.

The first relates to analytical endeavours within any one of the suite of elements (for example, condition). Here, analytics into condition modelling across a water network or building portfolio have the ability to prioritise organisational activities (for example, condition investigation work programmes). These types of analyses, although necessary and extremely useful, are also ‘one dimensional’.

The second level considers asset-specific interoperability (for example, network optimisation analytics). Network optimisation analytics can interrogate pipe capacity, connection frequency and hydraulic competency within the same analysis. It is now easy to mix other decision-making elements (for example, criticality, resilience or risk) into these optimisation analytics to prioritise them (for example, optimising a renewals programme relating to criticality or risk). These ‘two-dimensional’ analytics are relatively unsophisticated but can add substantial value to an asset management environment.

The third level is where the interdisciplinary nature of strategic asset management planning can be demonstrated. Here, core asset data is analysed with other information related to asset management to help other disciplines, such as financial and spatial planning. Spatial planning relies heavily on core infrastructure to enable development. Analytics that uncover economic yield and infrastructure affordability indices for capital widening or capital deepening planning strategies are instrumental in how cities might plan for economic growth. These ‘three-dimensional’ interoperability analytics require highly collaborative approaches across the disciplines.

The fourth level is the most sophisticated. The ‘fourth-dimensional’ element, *time*, allows for analytics that reach not only within and across decision-making elements and disciplines for interoperability, but also across generations. Strategic asset planning has several principles that should be followed in public infrastructure investment decision-making; consideration against the *whole of asset life* is one.[4] Analytics, such as long-life economic yield and intergenerational equity, provide guidance on long-term infrastructural affordability and

[4] Other principles are: do the basics first, make evidence-based decisions, for the whole of an asset’s life, always maximise value and measure real benefits.

sustainability. These analytics also underpin the numerous financial forecasting and predictive analytics being used in demand-type models.

The models: Much discussion occurs about the variety of models used to support strategic asset management planning. These models are defined as static, dynamic and real-time, and the analytics described above exercise themselves over all three.

Static: analytics supporting these models are invariably point solutions and do not contain a temporal element. Sensitivity and scenario analyses often support these models and the evidence being developed for an investment decision. The most sophisticated are also underpinned by stochasticity analytics, which provide levels of confidence in any analysis.

Dynamic: analytics supporting these models include time. They are also able to support both sensitivity and scenario analyses and should be underpinned with stochasticity analytics. The more sophisticated include predictive analytics in forecasts, using what has been recorded in the past to inform decisions in the future.

Real-time: the powerful analytics engines of today and big data analytical capability that comes with these emerging technologies allow data to be collected and analysed in real time. These analytical tools mean networks can respond to real-time circumstances with real-time solutions (for example, demand-driven pressure regulation across a water network).

1.4.4 Asset Management Frameworks (Volume 5)

The asset management frameworks are the systems and processes asset managers use to manage their portfolios. Quite specific legislative requirements are in place that asset managers must adhere to as part of their responsibility for managing these assets (for example, health and safety standards).

1.5 Lifecycle of Asset Data and Analytics

Asset data and the analytics that support asset managers have a lifecycle often regarded as similar to the assets themselves. Advances in analytics show this is not the case. The data used to interrogate an asset must meet the analytical requirements asset managers have when managing an asset throughout its life. The use of a variety of analytical opportunities maximises the value an asset can deliver. These opportunities provide insight both *throughout* (for example, condition) and at a *point of time* in an asset's life (for example, utilisation or demand).

Understanding the data requirements for particular analytics is important, as is recognising when these analytics should be applied. It is about having the right information at the right time when making investment decisions. The asset data and analytical lifecycle schematic provide context to help stewards of assets ensure demands are planned (Figure 4). Without this context, evidence-based investment decision-making will become problematic.

The data and analytical requirements to manage assets fall into three broad phases:

- those applied on the augmentation of a new asset to meet the demands of growth or changes in services or levels of service (for example, new subdivisions)
- those applied to existing assets throughout their life that determine their current state (for example, condition) for future interventions

- those applied at the end of an asset's life when the analytics for evidence-based investment decisions inform asset renewal, replacement or disposal (for example, criticality or risk).

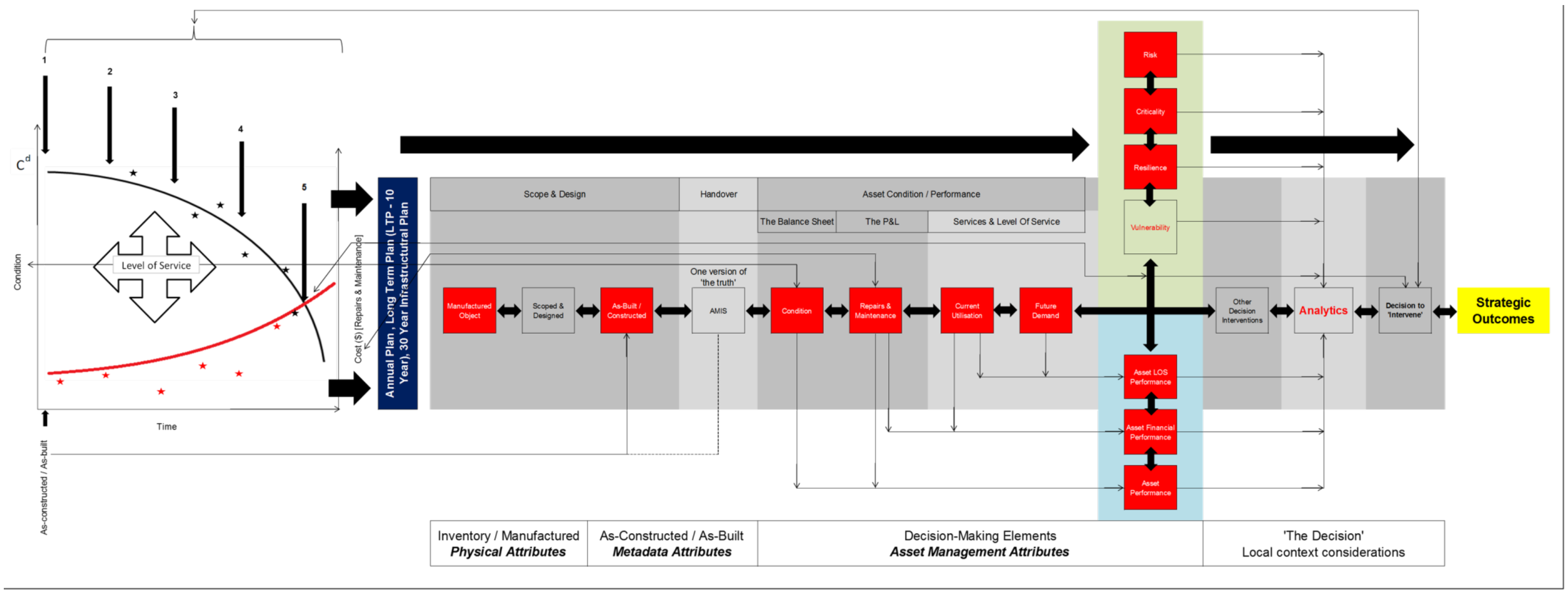
Asset augmentation investment decisions: asset managers require two sets of data from this phase.

First, data and analytics are needed to inform business cases to invest. Often data and analytics that support decisions to invest in new assets have no 'history'. Moreover, asset data required for the development of asset augmentation proposals will often rely heavily on data, analytics and analysis derived from information about similar current assets. Datasets and analytics for utilisation and demand, or financial or service performance, are good examples. Several other asset analytical outcomes (for example, financing costs) can also be derived from current asset information. When combined, these analytics provide a sound *evidence-base* to inform decision-making.

Second, as-constructed / as-built data is required to manage an asset through its life. This describes the asset's physical attributes (for example, material) and the metadata attributes (for example, builder). This is essential for ensuring ongoing asset management success. The importance of collecting the right data after completing construction has only recently become better understood, as has the opportunity cost of not collecting the information at this time. It is becoming untenable to retrospectively collect the data. It is extremely costly and, for practical reasons, is almost impossible to collect.

Asset managers require data and data integrity to manage assets at the level of competency commensurate with the importance and value of their public asset portfolios.

Figure 4: Evidence-based Decision-making in Asset Investment Decisions



Note: AMIS = Asset Management Information System; LOS = Levels of Service; P&L = Profit and Loss.

'Current state' for future investment decisions is equivalent to investments in the operating environments that maximise the future potential in the capital environment. Datasets and analytics in this phase are mostly about interrogating current state to ensure the asset is delivering the value as intended in design (for example, design performance). They also assess when interventions are needed to replace assets so they are not compromised in their ability to deliver the service at the level of service intended in design (for example, condition or utilisation).

As described above, several elements inform evidence-based investment decisions (condition, repairs, maintenance and operations, utilisation, demand, criticality, risk, resilience, vulnerability, design performance, financial performance and service performance). However, not all are used to determine an asset's current state. Those used include: condition, repairs, maintenance and operations, utilisation, demand, design performance, financial performance and service performance. In reality, the balance of the elements (vulnerability, criticality, risk and resilience) is essential in helping prioritise interventions when resources are scarce and/or information is unavailable on a significant percentage of the network or portfolio.

It is likely that insufficient funding will require prioritisation of the investments to ensure the right interventions are undertaken at the right time. This creates complexity and necessitates the use of the same decision elements required in capital investment decisions (for example, renewals) as those used in the operating environment (for example, inspection work programmes).

By combining these elements, asset managers ensure the operating interventions (for example, assessments of asset utilisation) are being undertaken in the most efficient and effective way. This creates the lowest *risk* and, with regard to the *critical* assets, improves *resilience* in the networks as a priority, if, when and where appropriate.

Evidence-based investment decision-making considers all asset-related decision elements, including asset centric and non-asset specific elements and those that consider the circumstances in which investment decisions are being made (for example, affordability and sustainability). The political and democratic environments where these decisions are often made are another influence.

Finally, the sophistication in asset management information systems, the analytical tools and big data analytical capabilities will only increase the requirements on asset data and subsequent analytical opportunities. Interoperability and intergenerational equity analytics are examples of the types of interdisciplinary considerations asset managers and senior executives alike are seeking.

1.6 Analytical Hierarchy and Maturity

A natural order exists in the development of data, analytics and the analysis frameworks that support evidence-based investment decisions. This is best demonstrated by evidence that shows some datasets are prerequisites to others, while others can be developed concurrently (Figure 5).

Adopt asset metadata standards and establish services and levels of service: two foundations must be developed before an analytical framework can be applied. The first is data standards. These can take any form, but their rationale is to standardise and harmonise datasets across all public assets. The second is defining the services and levels of service an asset provides. This forms the analytical platform for future diagnostic opportunities and sets the information system configurations for how asset information can be created, stored, collected and analysed.

Establish actual asset condition and optimising operations and maintenance plans: once the data definitions and analytical foundations are set, an asset manager's first task is to establish the condition of the network or portfolio. It is not possible to manage the statement of performance (balance sheet) unless the condition underpinning the statement of position (profit and loss) is understood. Once condition is established, many opportunities exist to optimise operations and maintenance plans (for example, inspection work programmes). However, if the condition is not defined in a standardised way, any results and interventions resulting from the analytics could possibly undermine any proposed solution.

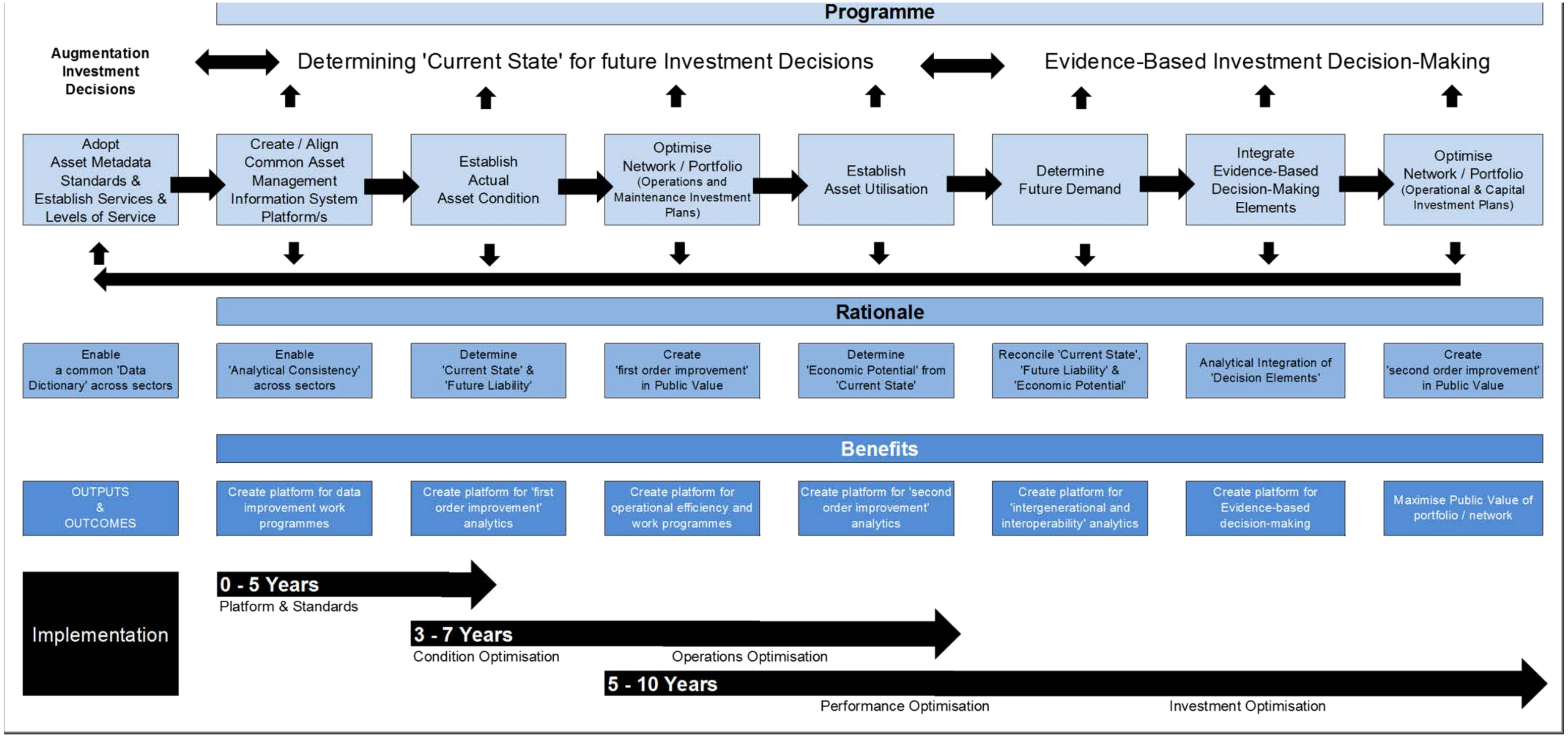
Establish asset utilisation and determine future demand: asset utilisation is a fundamental but as yet undiscovered element that maximises the value of public assets. It also sets the foundation for advanced evidence-based investment decision-making analytics (for example, economic yield and hedonic pricing models for town planning provisions). Alongside these benefits, strategic asset planning also requires an understanding of future growth, and the analytical capabilities described by asset utilisation and demand enable this.

Optimise network and/or portfolio capital investment plans: outside of optimising the operating environments for the operation, repair and maintenance of assets, capital investment plans provide the basis for asset managers to deliver the services assets are pledged to supply. These include augmentation plans (new assets) and renewal plans (assets towards the end of their lives requiring replacement – often installed many generations ago). The importance of this cannot be overstated.

Many public asset networks and portfolios have been developed on principles that do not apply today. This means the decisions to shift networks and portfolios to meet the demands of the 21st century are proving to be difficult.

The advanced strategic asset management analytical engine used to optimise large asset networks or portfolios is yet to reach a maturity that corresponds with the demands of the sophisticated analytical environment being suggested here. These types of analytics (for example, interoperability and intergenerational equity) are at the apex of strategic asset management analytical capabilities. They are also where the most important opportunities for long-term sustainability and affordability outcomes are likely to be achieved.

Figure 5: Asset Management Evidence-based Decision-making Dashboard – Strategic and Tactical Overview



1.7 Where Strategic Asset Management Meets Analytics

The final piece of the data and analytical puzzle is the relationship between the analytics that inform the evidence-based decision-making and the organisational and community outcomes being sought (Figure 6). The standard provides guidance on the types of analytics that can be considered by asset managers and when it will be possible to undertake these. It also gives guidance on how these analytics fit into the wider decision-making environment where work done supports the organisational and community outcomes and the public value it provides.

Figure 6: Strategic Asset Management Planning Decision Scheme

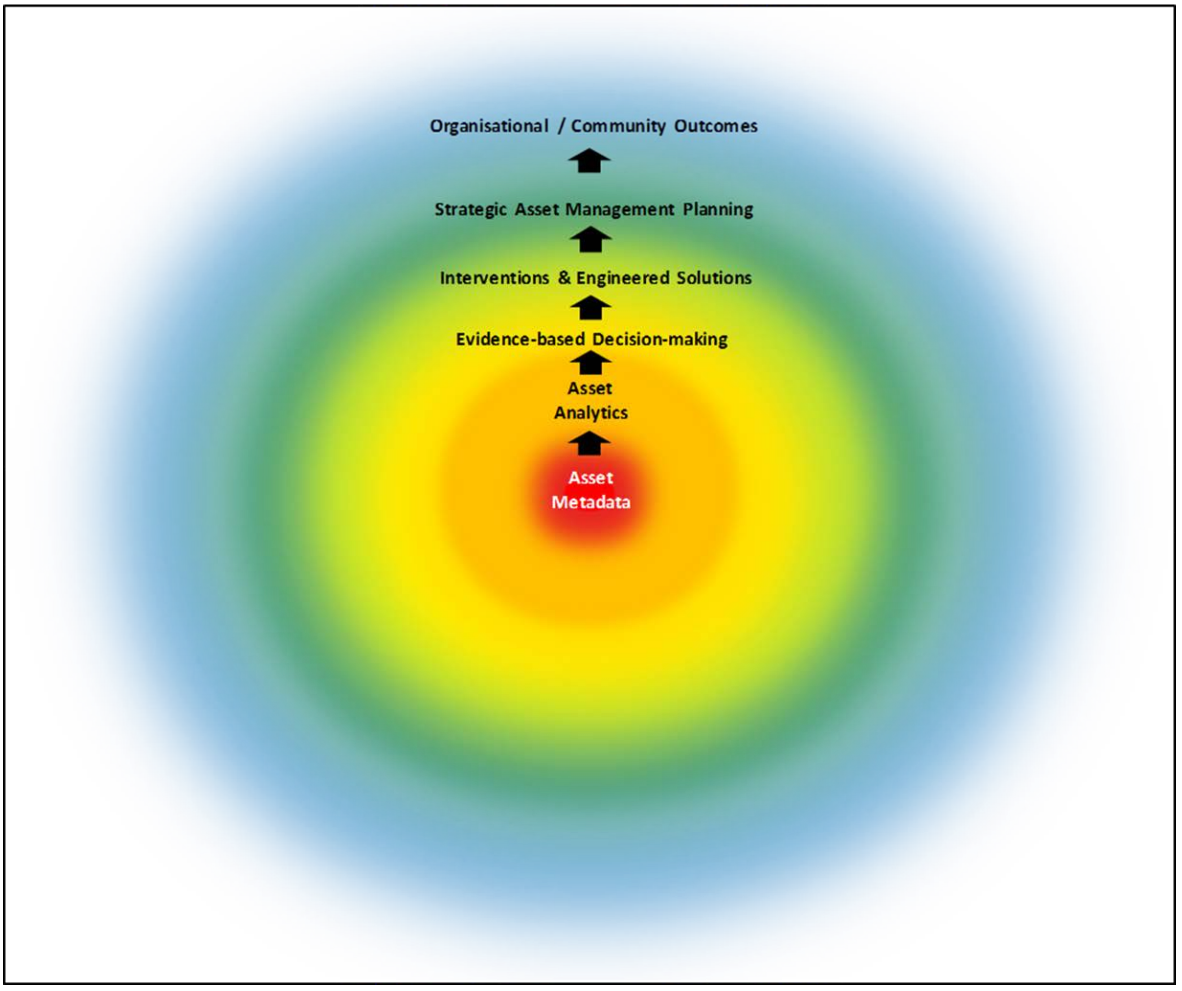
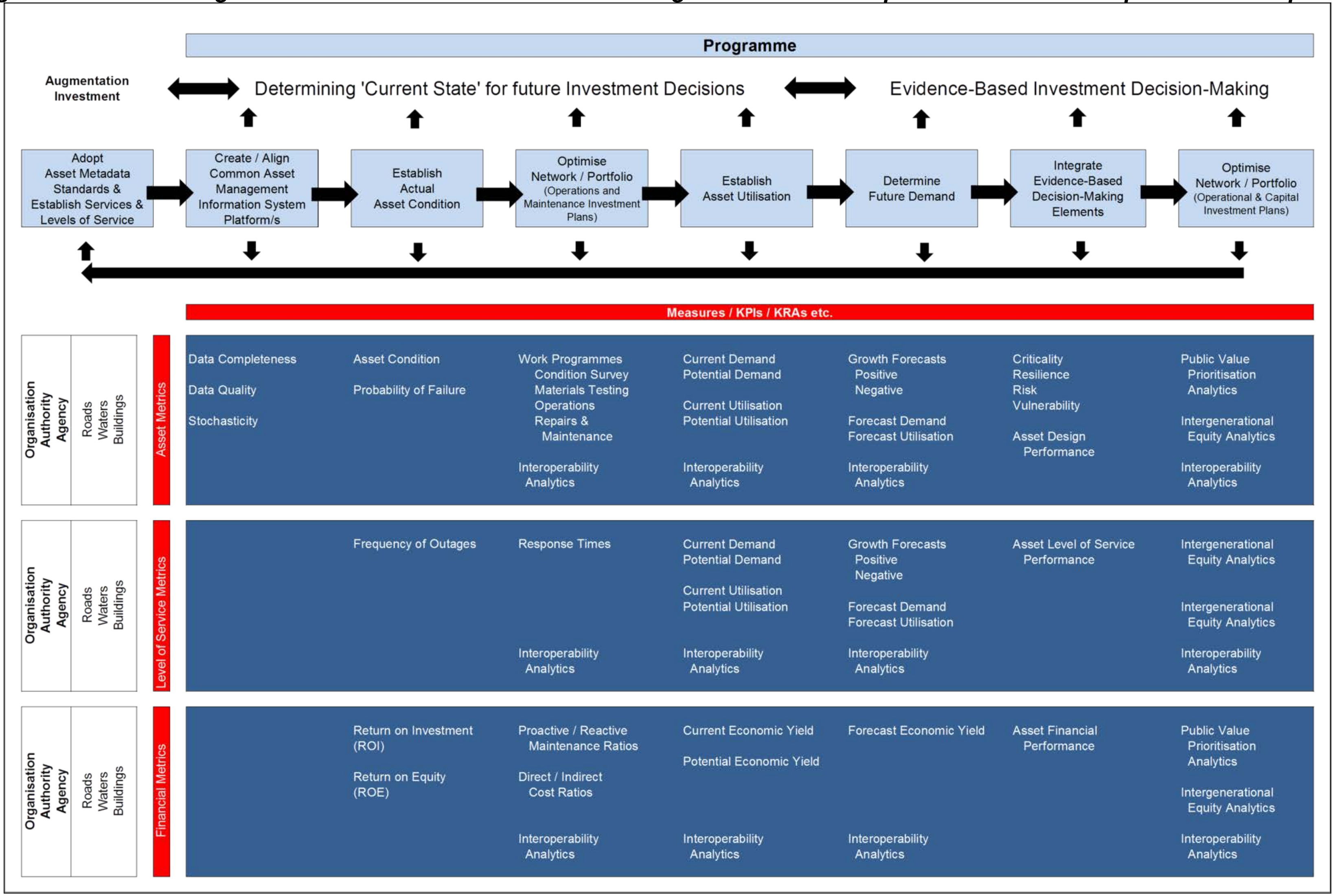


Figure 7 provides examples of the specific types of analytics available to stewards of public assets. Many more exist. It also gives insight into the types of analytics that can be achieved relatively early in the development of an evidence-based decision-making environment. It is possible to achieve substantial gains in operating and capital efficiency through the use of these types of analytics early in the programme, depending on the local circumstance.

Figure 7: Asset Management Evidence-based Decision-making Dashboard – Proposed Tactical and Operational Response



Note: KPIs = key performance indicators; KRAs = key result areas

1.8 Theory and Practice of Asset Analytics – Principles

Metadata standards and metadata-rich datasets do not actually provide public value. Real value is created when the stewards of public assets access the analytical engines that analyse the datasets to gain information to underpin evidence-based investment decisions.

This analytical capability ultimately delivers a series of analytical outputs (for example, graphical visualisations). These outputs are an unspecified series of standard analytics that take each decision element and analyse it relevant to the context of the environment.

Fundamental elements need to be considered in the development of the analytics, to gain the value being sought from these metadata standards (for example, a fiscal imperative is involved in every investment decision). Alongside these fundamentals are first principles. These define how each decision element relates to an analytic and how the interoperability opportunities are enabled between decision elements (for example, *condition* is one of several triggers for capital renewal investment consideration; others include *vulnerability, criticality*, *risk* and *resilience*).

To follow are examples of the types of analytics that underpin evidence-based decision-making and the practical applications asset managers can expect from the use of metadata-rich datasets.

1.8.1 Condition Curve Schematic

The condition curve schematic (Figure 8) represents the measurement and record of any intervention undertaken to determine the *residual life* of an asset.

Figure 8: Condition Curve

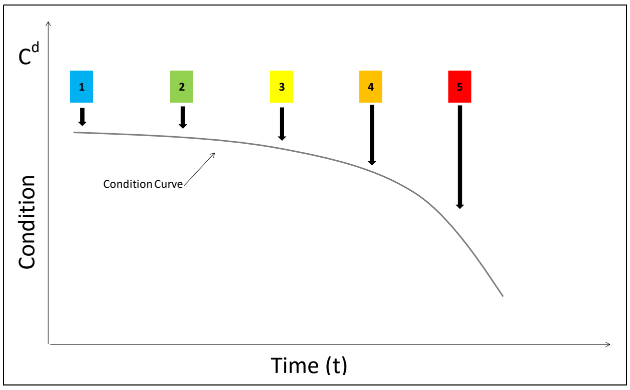
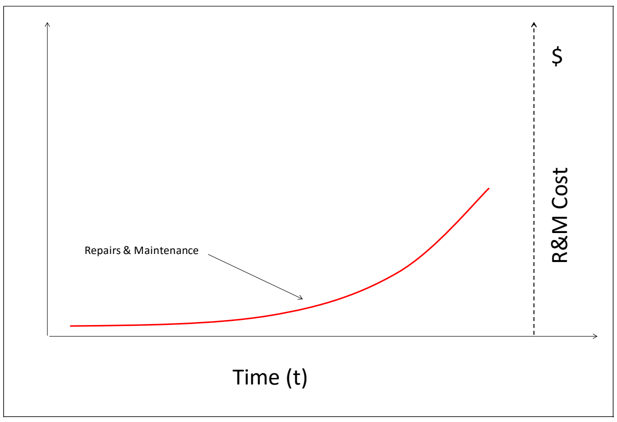


Figure 8 shows the principle that, as time passes, the condition of an asset will deteriorate. It is important to note that the shape of the curve will vary significantly with regard to the type and specific attributes of an asset (for example, material type), as well as the circumstances the asset is subject to (for example, physical environment).

1.8.2 Repairs and Maintenance Curve Schematic

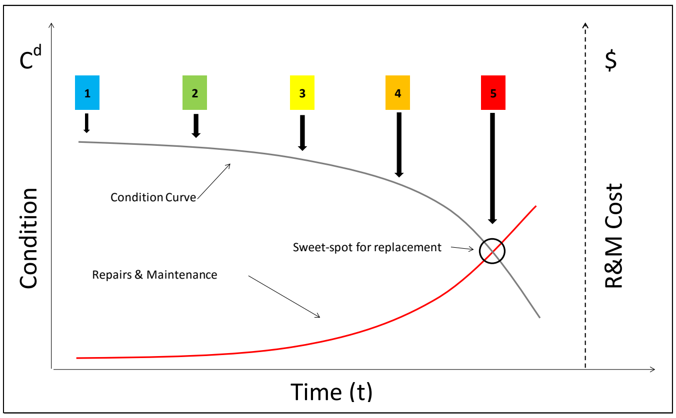
The repairs and maintenance curve schematic (Figure 9) represents the measurement and record of the costs of any intervention undertaken to *maintain the functionality of an asset.*

Figure 9: Repairs and Maintenance Curve



1.8.3 *Optimised* Replacement Schematic

Figure 10: Optimised Replacement



The *optimised* replacement schematic (Figure 10) represents the relationship between the condition curve (Figure 8) and the repairs and maintenance curve (Figure 9).

The relationship between these curves is important because it defines the first principle, the financial metric, for determining when an asset should be replaced. This is when the annualised cost of the capital renewal of an asset (including principle, interest and depreciation) is less than the annual cost to repair and maintain the functionality of an asset (it makes little sense to replace it otherwise).

1.8.4 Optimised Replacement Schematic – *Criticality* as an Influence

Figure 11: Optimised Replacement – Criticality as an Influence

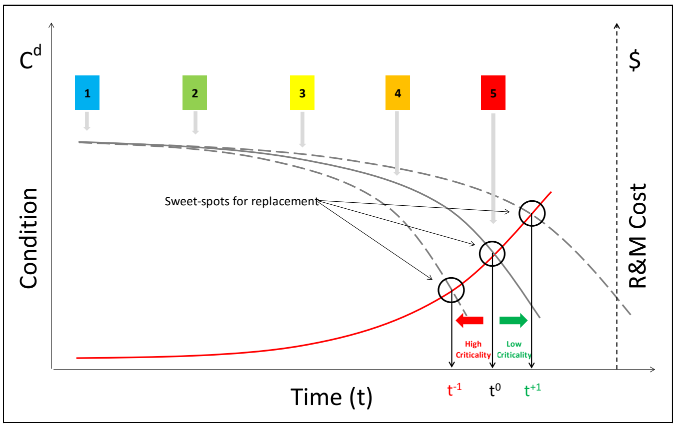


Figure 11 represents how *criticality* influences the optimised replacement (t^0) of an asset using financial metrics as a first principle.

Where a renewal is being proposed on a critical asset, it is possible to graphically illustrate the positive and negative costs and benefits of replacing the asset in advance (t^{-1}) of its optimised replacement (for example, a mains water pipe into a school or hospital). The same can be done when replacing a non-critical asset after (t^{+1}) its optimised replacement (for example, a distribution water pipe to a small number of residences).

Secondary analytics can reconcile the potential financial loss of value as intended in design from replacing an asset in advance with the potential savings in repairs and maintenance. This provides asset managers with a financial metric for the measured costs of 'criticality' in capital replacement plans.

1.8.5 Optimised Replacement Schematic – *Risk* as an Influence

Figure 12: Optimised Replacement – Risk as an Influence

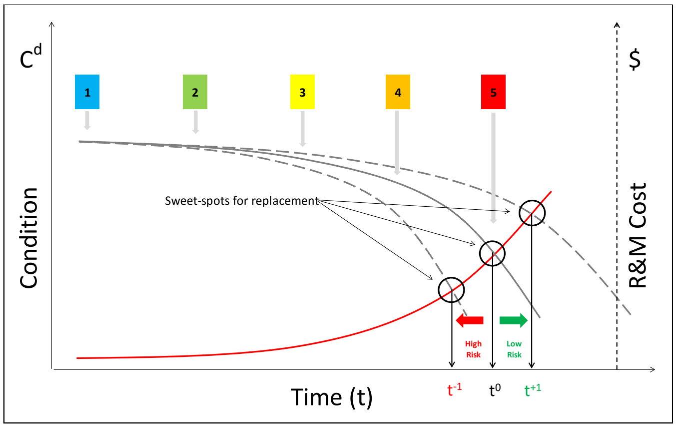


Figure 12 represents how *risk* influences the optimised replacement (t^0) of an asset using financial metrics as a first principle.

Where a renewal assessment is being undertaken on a 'risk-based approach', it is possible to graphically illustrate the positive and negative costs and benefits of replacing the asset in advance (t^{-1}) of its optimised replacement (for example, a mains water pipe into a school or hospital). The same can be done when replacing a non-critical asset after (t^{+1}) its optimised replacement (for example, a distribution water pipe to a small number of residences).

Secondary analytics can reconcile the potential financial loss of value as intended in design from replacing an asset in advance with the potential savings in repairs and maintenance. This provides asset managers with a financial metric for the measured costs of carrying 'risk' in capital replacement plans.

1.8.6 Optimised Replacement Schematic – *Performance* as an Influence

Figure 13: Optimised Replacement – Performance as an Influence

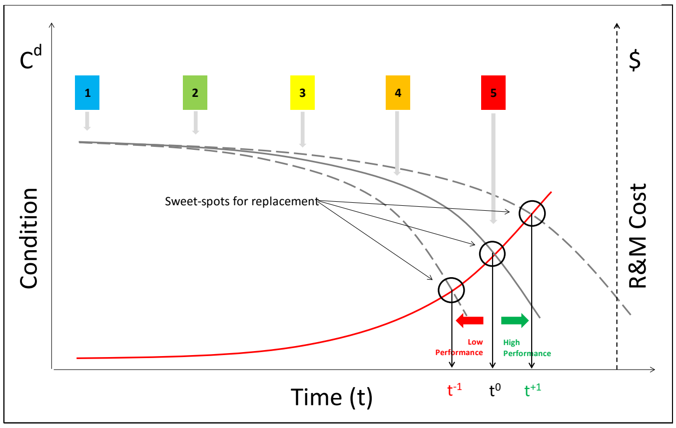


Figure 13 represents how asset *performance* (design, financial and service) influences the optimised replacement (t^0) of an asset using financial metrics as a first principle.

Where a renewal assessment is being undertaken on a 'performance-based approach', it is possible to graphically recognise and measure the opportunity cost and benefit (positive and negative) of replacing an asset in advance (t^{-1}) of its optimised replacement. This might be to mitigate poor performance (for example, water pressure), or replacing an asset after (t^{+1}) its optimised replacement to accept poor performance.

Secondary analytics can reconcile the potential financial loss of value as intended in design from replacing an asset in advance with potential savings in repairs and maintenance. This provides asset managers with a financial metric for the measured costs of 'performance', both positive and negative, in capital replacement plans.

1.8.7 Probability of Failure

Figure 14: Probability to Failure (High Confidence – Normal Failure Distribution)

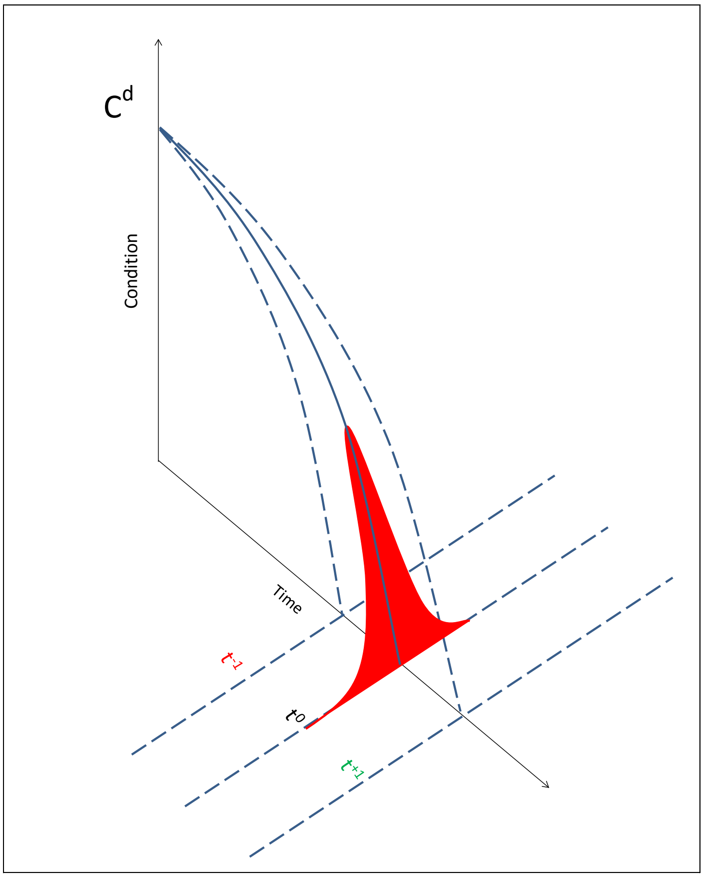
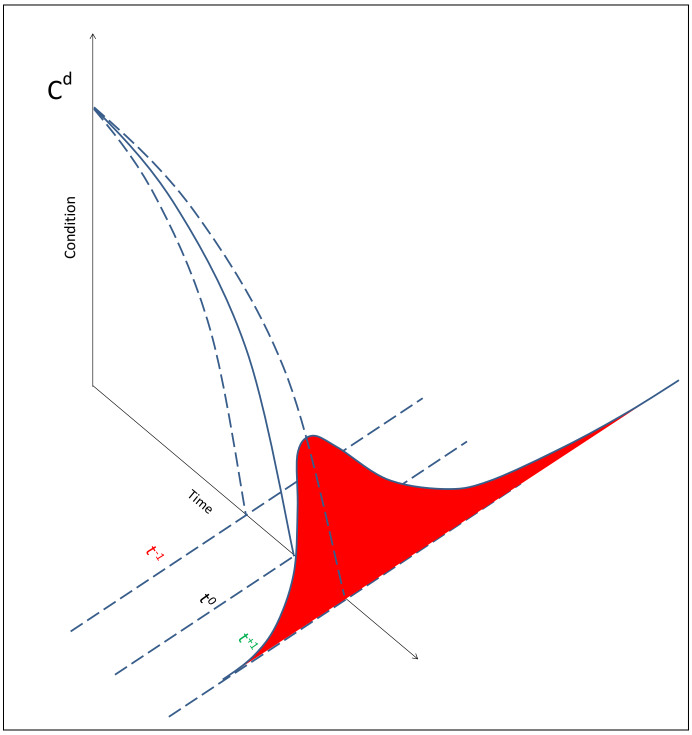


Figure 15: Probability to Failure (Low Confidence – Positively Skewed with Kurtosis Failure Distribution)



Among the challenges facing an asset manager, the greatest is knowing when it is the right time to replace an asset – considering all available information.

The important analytical tool that gives asset managers confidence in this decision is being able to determine the probability of failure. In other words how confident is an asset manager that the investment in replacing an asset is timed appropriately to consider those elements that maintain services at the appropriate levels of risk and cost as intended in the asset's design?

In some instances the probability of failure is relatively easy to determine (Figure 14), and is underpinned by significant records of failure (for example, asbestos concrete pipes). In other circumstances it is more difficult to give direction to asset managers of probable failure (Figure 15). Low confidence is mirrored by the often scant records of failure (for example, materials testing).

These measures of stochasticity are sophisticated analytical tools the asset manager can use to develop a financial metric for the measured costs of 'criticality, risk and performance', both positive and negative, in capital replacement plans. In applied practice, confidence intervals are typically stated at the 95% confidence level. However, when presented graphically, confidence intervals can be shown at several confidence levels, for example, 90%, 95% and 99%.

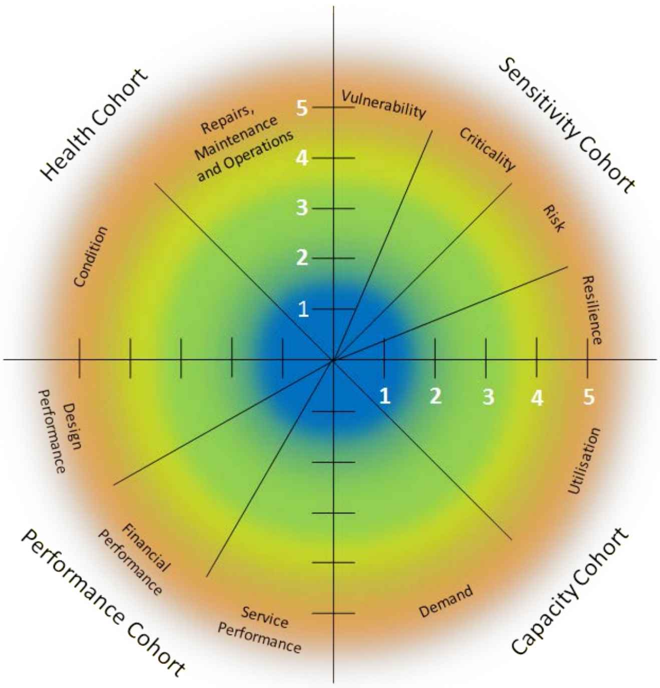
1.9 Asset Management Cohorts

The NZAMS suite of decision elements contains four cohorts. It is the combination of these cohorts and the elements within them that define the asset management environment in which evidence-based decisions are made. The asset management cohorts are:

1. the **health** of the network or portfolio, as described by two elements: condition; and repairs, maintenance and operations (section 2)
2. the **capacity** of the network or portfolio, as described by two elements: utilisation and demand (section 3)
3. the **sensitivity** cohort, as described by four elements: criticality, vulnerability, risk and resilience (section 4)
4. the **performance** cohort, as described by three elements: design performance, financial performance and service performance (section 5).

Given these cohorts are made up of elements that inform evidence-based investment decision-making, it is important to understand the relationships between them in order to progress the analytical environment for which they have been defined (Figure 16).

Figure 16: Decision-making Cohorts and Elements



The elements within each of the four cohorts (for example, the capacity cohort elements utilisation and demand) are tightly coupled in a first-order relationship. The relationship between the four cohorts themselves, for example between the **health** of a network or portfolio and its **performance**, is less tightly coupled but no less important. Evidence-based investment decision-making relies on this relationship. More detailed analysis of data and information that support each of the elements within each cohort may be able to identify a root cause investment driver, for example criticality. However, in the majority of investment decisions, the evidence will be a combination of attributable elements in the complex asset management environment that asset managers know well.

1.10 Code Lists

Code List 1: Asset Elements

Code	Description
CIV	Civil
STR	Structural
ELE	Electrical
MEC	Mechanical

Code List 2: Units of Measurement

Code	Description
GJ	Gigajoules
ha	Hectare
l	Litre
kg	Kilogram
kN	Kilonewton
kW	Kilowatt
m	Metre
m2	Square metre
m3	Cubic metre
mm	Millimetre
t	Tonne
NO.	Number

Code List 3: Confidence Rating

Code	Description	Comment
1	Very High	Measured / Tested
2	High	Modelled (calibrated)
3	Medium	Modelled (uncalibrated)
4	Low	Estimated (interpolated)
5	Very Low	Estimated (Inferred)

Code List 4: Location – Coordinate System

Code	Description
A	WGS84
B	NZTM Grid 2000

Code List 5: Recurrence Cycle Unit

Code	Description
d	Days
h	Hours
m	Months
w	Weeks
y	Years
n/a	Not a recurring activity

Code List 6: Bases of Cost

Code	Description
A	Actual
B	Budget
E	Estimated
N	No cost information

Code List 7: Remaining Useful Life (Asset Cycle)

Code	Description	Comment
1	55% or more	For example: remaining life for an asset with a 40-year life expectancy would be more than 18 years
2	54–36%	For example: remaining life for an asset with a 40-year life expectancy would be 18 years to 14 years
3	53–26%	For example: remaining life for an asset with a 40-year life expectancy would be 14 years to 10 years
4	25–11%	For example: remaining life for an asset with a 40-year life expectancy would be 10 years to 4 years
5	10–0%	For example: remaining life for an asset with a 40-year life expectancy would be less than 4 years

Code List 8: Remaining Useful Life (Planning Cycle)

Code	Description	Comment
1	50+ years	Outside 30 year Infrastructure Planning Cycle
2	30–50 years	Outside 30 year Infrastructure Planning Cycle
3	11–30 years	Inside 30 year Planning Cycle, but outside Long Term Plan (LTP) 3 year planning cycle
4	4–10 years	Inside 10 year Planning Cycle, but outside Long Term Plan (LTP) 3 year planning cycle
5	1–3 years	Inside Long Term Plan (LTP) 3 year Planning Cycle

Code List 9: Event Type

Code	Description
A	Fire
B	Lightning
C	Water damage – internal
D	Flood and inundation
E	Extreme weather – storm, cyclone, typhoon, tempest, tornado
F	Impact damage – hail etc.
G	Malicious damage, vandalism
H	Subsidence, landslide
I	Explosion, implosion
J	Terrorism
K	Earthquake
L	Wild/bush fire
M	Pandemic
N	Cyber attack
O	Economic or financial
P	Social or political unrest

Code List 10: Minor Event Significance Rating [5]

Code	Description	Comment
1	Very Low	10 year return period (10%AEP)
2	Low	1 year return period (100%AEP)
3	Medium	1 month return period (%AEP – N/A)
4	High	1 week return period (%AEP – N/A)
5	Very High	1 day return period (%AEP – N/A)

5 Predominantly used for real-time analytics

Code List 11: Major Event Significance Rating

Code	Description	Comment
1	Very Low	1 year return period (100%AEP)
2	Low	10 year return period (10%AEP)
3	Medium	50 year return period (2%AEP)
4	High	100 year return period (1%AEP)
5	Very High	500 year return period (0.5%AEP)

Code List 12: Residential Population Rating

Code	Description	Small Population (< 20,000 people)	Medium Population (<100,000 people)	Large Population (>100,000 people)
1	Very Low	0–50	0–50	0–50
2	Low	51–100	51–250	51–500
3	Medium	101–1,000	251–2,500	501–5,000
4	High	1,001–5,000	2,501–10,000	5,001–50,000
5	Very High	5,001–10,000+	10,001–50,000+	50,001–250,000+

Code List 13: Facility Importance Rating

Code	Description	Comment
1	Very Low	Examples include: • Machinery storage sheds • Garages • Glasshouses • Residential properties
2	Low	Examples include: • Public toilets & changing rooms • Arts facilities/ community halls/ centres • Sports clubrooms
3	Medium	Examples include: • Primary schools, colleges or adult education facilities • Health care facilities, e.g. with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities • Airport terminals, principal railway stations e.g. a capacity greater than 250 • Correctional institutions • Emergency medical and other emergency facilities not designated as post-disaster • Power-generating facilities, water treatment and wastewater treatment facilities and other public utilities not designated as post-disaster

Code	Description	Comment
4	High	Examples include: • Facilities designated as essential facilities • Facilities with special post-disaster function • Medical emergency or surgical facilities • Emergency service facilities such as fire, police stations and emergency vehicles garages • Utilities or emergency supplies or installations required as backup facilities for post-disaster response • Designated emergency shelters, designated emergency centres and ancillary facilities
5	Very High	Examples include: • Special facilities are facilities above and beyond category 4, such as munition storage and critical data centres

Code List 14: Obsolescence Rating

Code	Description	Comment
1	The asset is current technology with no foreseeable change	
2	Unknown	There is no information or evidence available to determine the ongoing or future viability of the asset
3	Replacement parts or similar assets are unobtainable	

Code List 15: Geographic Units

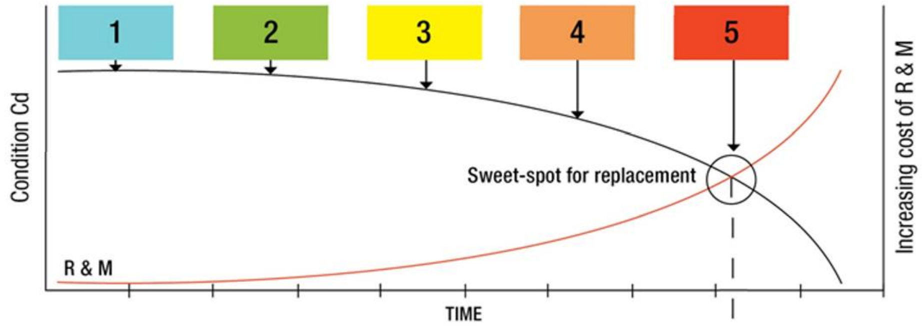
Code	Description	Comment
1	Land	E.g. Parcel, Property, Address
2	Infrastructure	E.g. 3-Waters, Roads, Telecoms, Buildings, Energy
3	Development	E.g. Developers
4	Consenting	E.g. Resource and Building
5	Events and Activities	E.g. Community Events
6	Planning	Unitary / District / Regional Plan
7	Social	Heath, Education, Justice
8	Environmental	E.g. Air, Water
9	Cultural	E.g. Iwi Rohe
10	Economic	E.g. GDP, Rating Income

2 Condition and Repairs, Maintenance and Operations

2.1 Introduction

The heath cohort of an asset, network or portfolio is described by its current condition and to some extent the cost to maintain the service and level of service as intended in its design. The capital and operating environments are strongly influenced by the condition of assets (the condition of the balance sheet). The costs to maintain an asset and the analytics of this relationship with condition provide the first insights for managers to inform evidence-based investment decisions. It is important to note that this is the first of many considerations, as the notes under Figure 17 highlight.

Figure 17: Optimised Replacement – Relationship between Condition and Repairs and Maintenance



Asset Management is defined as 'Activities' undertaken to ***determine*** the ***residual life*** of an asset (and therefore establishing condition)

Facilities Management is defined as 'Activities' undertaken to ***maintain*** the ***functionality*** of an asset (and therefore establishing cost of repairs & maintenance)

An asset's ***sweet-spot for replacement*** is defined as where the *annualised cost of the capital renewal of an asset* (incl. principle, interest and depreciation) ***is less than*** the *annual cost of to repair and maintain the functionality of an asset*. NB: There is a natural dependency / relationship between these two disciplines which will influence the whole of life and whole of life cost of an asset. A significant dependency on the timing of replacement is demand and criticality.

2.2 Condition Schema

2.2.1 Definition of Condition

Condition is the physical state of the asset, which may affect its ability to deliver the service and level of service intended in its design.

2.2.2 Purpose of Schema

The condition of an asset is how asset managers assess its physical state. Condition alone provides only limited value, unless it is defined with an estimated 'remaining useful life'. The challenge is comparing the liability posed by the asset's remaining useful life with the subsequent demands on the organisation's finances when planning to renew an asset. An additional challenge for asset managers is that assets have different lives. This schema's purpose is to:

- measure condition in a consistent way, irrespective of methodology
- establish a forecast 'end of life' when the asset is no longer able to provide the service or level of service for which it was designed[6]
- reconcile the condition of assets with substantially different 'design lives' and be able to normalise a variety of assets at an asset, portfolio or network level
- determine, in a financial sense, the optimised replacement point of an asset with its analytical counterpart – repairs and maintenance
- determine, as well as can be assessed, when the financial liability for replacement is expected to fall.

2.2.3 Interface with Other Schemas

Condition may be used, together with other factors, to infer likelihood and risk of failure, future maintenance costs or remaining service life. Condition, when combined with other decision-making elements, forms the factual basis to inform decisions on asset intervention and/or replacement.

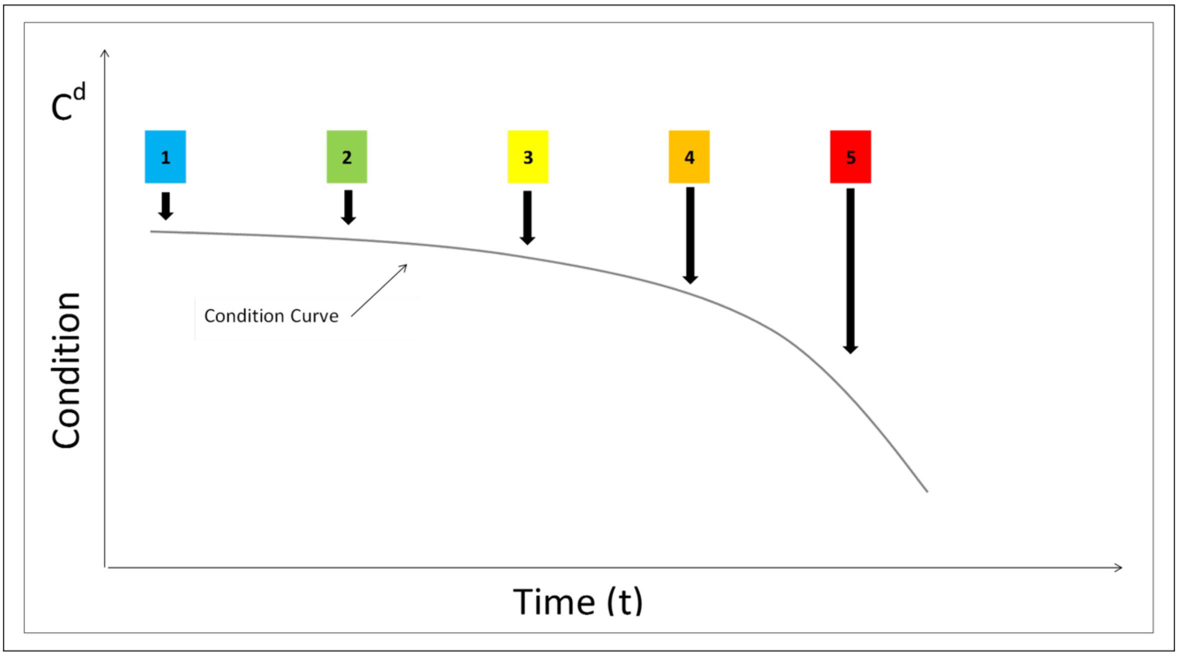
Table 6 identifies the other schemas that condition interfaces with. Figure 18 shows the optimal replacement point based on condition and cost.

[6] At times, the original design of an asset may no longer be its 'current use'. For the purposes of this standard, if and when an asset's intended use in its design is different from its current use, then forecast 'end of life' is when the asset is unable to provide the service or level of service for its currently intended use.

Table 6: Condition – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed	■											
Condition	✓	■	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Repairs, Maint & Ops			■									
Utilisation				■								
Demand					■							
Vulnerability						■						
Criticality							■					
Risk								■				
Resilience									■			
Design Performance										■		
Financial Performance											■	
Service Performance												■

Figure 18: Optimised Replacement – Condition as an Influence



Numerous analytics highlight the interoperability of harmonised asset data and the relationships between the decision elements managers used to inform evidence-based investment decisions. The figures that follow show how these are optimised for asset performance versus vulnerability (Figure 19) and asset performance versus criticality (Figure 20).

Figure 19: Replacement Curve – Based on Asset Performance versus Vulnerability

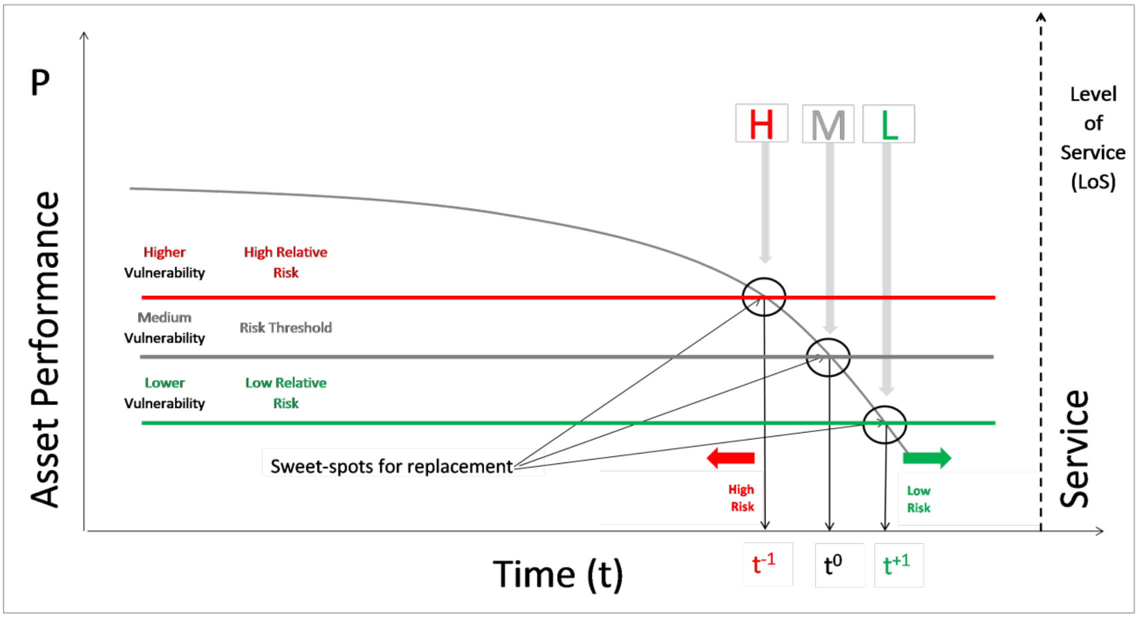
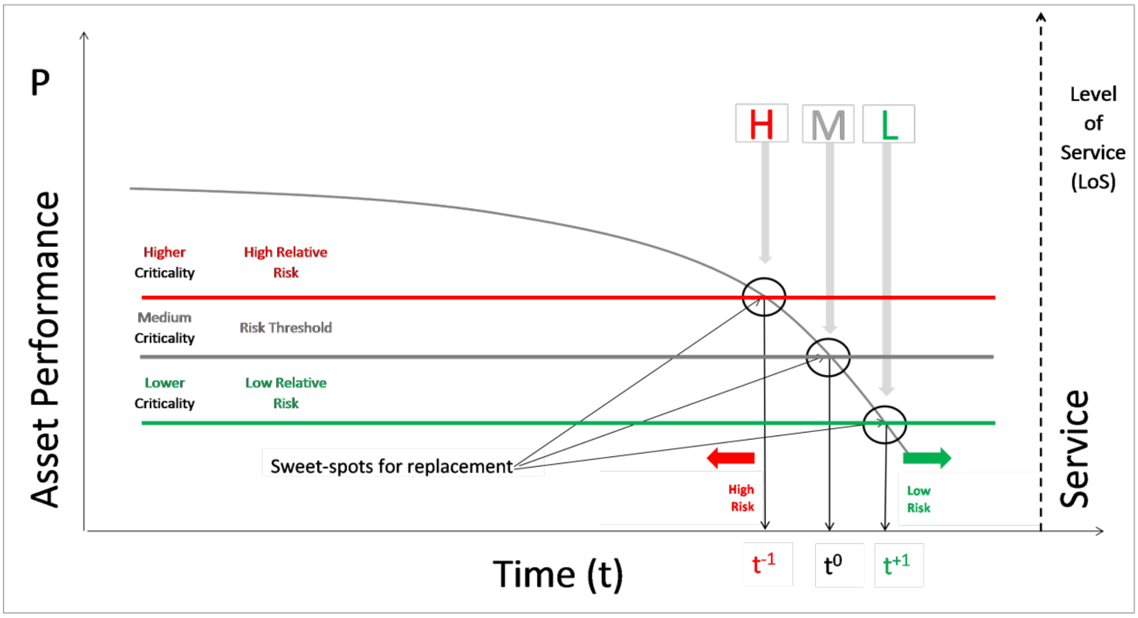


Figure 20: Replacement Curve – Based on Asset Performance versus Criticality



2.2.4 Assessing Condition

The main output of this schema is the condition rating based on a 1 to 5 scale. Users are able to select the method of assessment.

An assessment may consider several different observations. Organisations may elect not to collect data at observation level, but if they choose to undertake this process, the attributes to be collected are shown in Data Table 1.

Data Table 1: Condition Attributes

Attribute Name - Abbreviated	Attribute Name - Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Cdn_rating	Condition Rating	Integer		n/a	Whole number	A 1 to 5 scale where 1 is considered to be very good condition and 5 is considered very poor condition	1	Field can be empty if no assessment	Entry must be from CODELIST	Condition Rating
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor	John Smith	Field cannot be empty		
Assess_D	Assessment Date	Date		n/a	n/a	The date that the assessment took place	6/25/2016	Field cannot be empty		
Con_Gra_Ty	Condition Grade Type	Alpha / Numeric		10	No commas included	The condition grade type the value relates to	Peak	Field can be empty if no assessment	Entry must be from CODELIST	Condition Rating
Con_As_Mtd	Condition Assessment Methodology	Alpha / Numeric		50	n/a	The assessment methodology used	PIPMAN	Field can be empty if no assessment	Entry must be from CODELIST	Condition Rating - Methodology
Assess_T	Assessment Type	Alpha / Numeric		10	No commas included	The method used for assessing the condition	VISINS	Field can be empty if no assessment	Entry must be from CODELIST	Condition Rating - Methodology
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	A link to any documents that add useful information to the assessment	User manual. Document ref 5896	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
RUL_U	Remaining useful life max *	Integer		n/a	Whole number	A calculation of the minimum amount of an asset	60	Field can be empty if no assessment	Entry must be from CODELIST	Remaining Useful Life
Con_Pa_Ty	Condition Parameter Type	Alpha / Numeric		10	No commas included	Parameter being measured	MINWALL	Field can be empty if no assessment	Entry must be from CODELIST	Condition Parameter Type
Con_Pa_Va	Condition Parameter Value	Alpha / Numeric		100	No commas included	The measured value dependant on parameter	5	Field cannot be empty		
Con_Pa_Un	Condition Parameter Unit	Alpha / Numeric		10	No commas included	The unit of measure used for Condition Parameter	mm	Field can be empty if no assessment	Entry must be from CODELIST	Units of Measurement
Mea_Dat	Measurement Date *	Date		n/a	n/a	Date measurement was taken	3/12/2000	Field cannot be empty		
Mea_Mtd	Measurement Methodology	Alpha / Numeric		10	No commas included	The methodology followed when taking measurements	PIPMAN	Field can be empty if no assessment	Entry must be from CODELIST	Measurement Methodology
Mea_Ty	Measurement Type	Alpha / Numeric		10	No commas included	Measurement Type	MEA	Field can be empty if no assessment	Entry must be from CODELIST	Measurement Type

2.2.5 Code Lists

The following code lists define the options that can be used to populate the attributes within the condition schema.

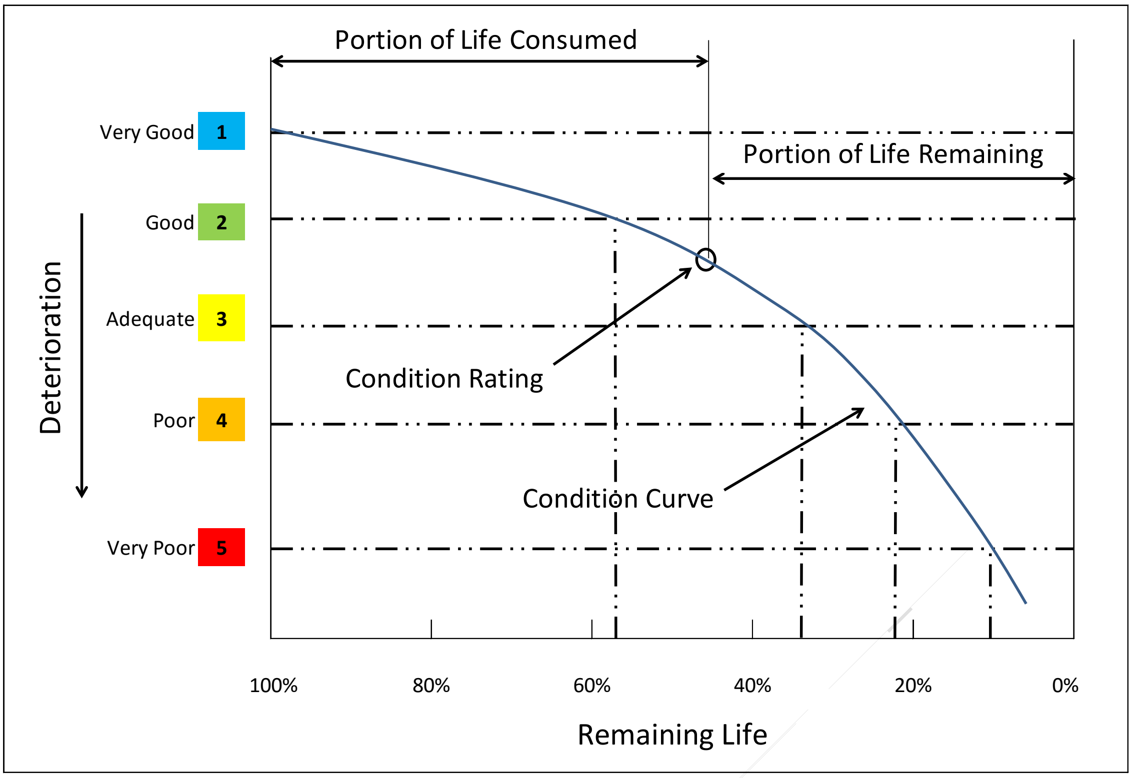
Code List 16: Condition Rating

Code	Description	Comment
General		
1	Very High	No observable defects or deterioration
2	High	No defects evident that if worsened would result in asset failure
3	Medium	Defects evident that if worsened could result in asset failure
4	Low	Significant defects and/or serious deterioration affecting an asset's structural integrity evident
5	Very Low	If the asset has not already failed it could fail at any time

Code List 17: Condition Rating – Methodology

Code	Description	Comment
EST1	Estimated	Expert Opinion
EST2	Estimated	Interpolated Electronically
MODEL1	Modelled	uncalibrated
MODEL2	Modelled	calibrated
MEASURE1	Measured	Measured Electronically
MEASURE2	Measured	On site
TESTED1	Tested	E.g. Material, Chemical, Mechanical

Figure 21: Condition Rating versus Time



Source: Based on *International Infrastructure Management Manual* 2015 edition, section 2.5, Table 2.5.10.

2.3 Repairs, Maintenance and Operations Schema

2.3.1 Definition of Repairs, Maintenance and Operations

Repairs, maintenance and operations are the activities undertaken to ensure the asset continues to deliver the service and level of service intended in its design.

2.3.2 Purpose of Schema

The repairs, maintenance and operations schema provides data to enable asset managers to assess the actual costs of repairing, maintaining and operating an asset. This schema's purpose is to:

- record repairs, maintenance and operations in a consistent way, irrespective of activity, with each asset as appropriate
- ensure operating expenditure items are separated from capital items for each International Financial Reporting Standard (IFRS)
- ensure the two operating expenditure items (repairs and maintenance; and operations) are separated to determine operating efficiency indices where appropriate
- provide guidance on the selection of the most appropriate intervention at the most appropriate time
- provide a platform to establish whole of life costs when evaluating options for asset augmentation
- help to inform (determine), in a financial sense, the optimised replacement point of an asset with its analytical counterparts – condition, criticality, risk, demand, utilisation, financial performance and service performance.

2.3.3 Interface with Other Schemas

Repairs, maintenance and operations, together with asset performance and condition, form the factual basis to inform decisions on asset intervention and/or replacement.

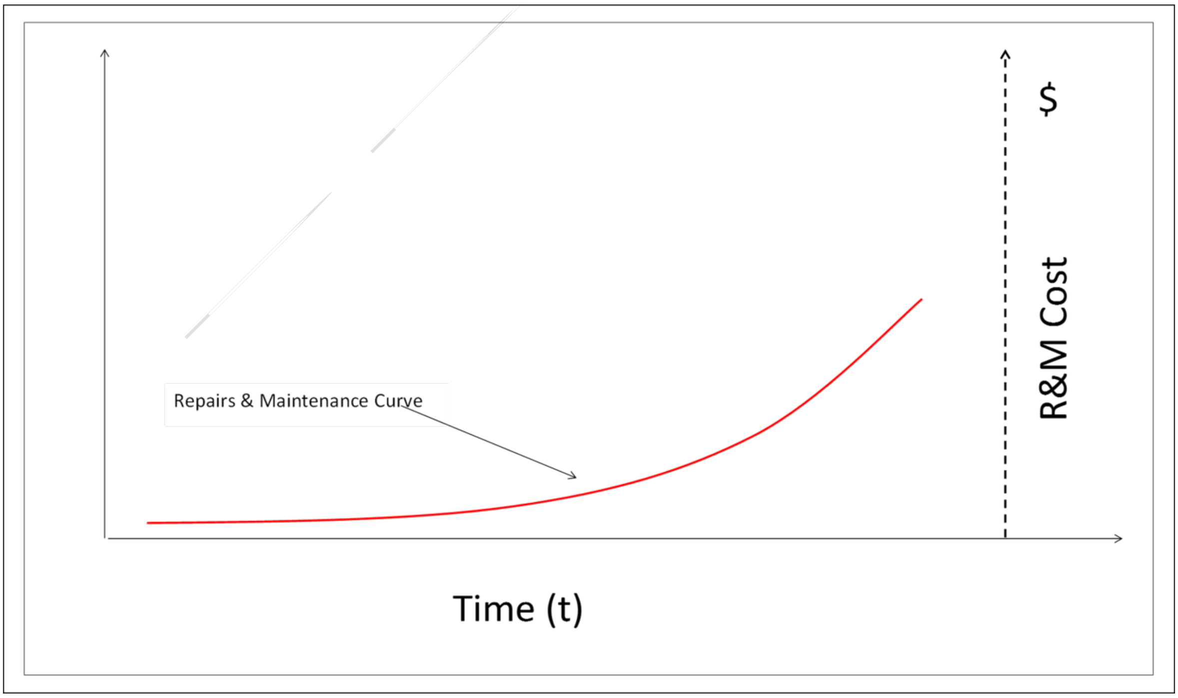
Table 7 identifies the other schemas that repairs, maintenance and operations interface with.

Repairs, maintenance and operations, and condition are the factual basis to inform decisions on asset intervention and/or replacement. Figure 22 shows the optimal replacement point based on repairs and maintenance and cost.

Table 7: Repairs, Maintenance and Operations – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops	✓	✓		✓	✓					✓	✓	✓
Utilisation												
Demand												
Vulnerability												
Criticality												
Risk												
Resilience												
Design Performance												
Financial Performance												
Service Performance												

Figure 22: Optimised Replacement – Repairs and Maintenance as an Influence



2.3.4 Components of Repairs, Maintenance and Operations

In this schema, all activities undertaken on an asset are categorised into four broad ‘Event Types’ as defined below:

- investigation: activities undertaken to gather information on the asset
- maintenance: all actions necessary for retaining an asset as near as practicable to its original condition, but excluding rehabilitation or renewal (IPWEA, 2015)
- repair: action to restore an asset to its previous condition after failure or damage (IPWEA, 2015)
- operations: the active process of using as asset that will consume resources, such as manpower, energy, chemicals and materials (IPWEA, 2015).

Each activity (excluding operations) has an ‘Activity Type’ that defines the asset management approach adopted to determine the timing of the activity. This schema uses the Activity Types defined below:

- scheduled: activities that are regular and/or routine and carried out regardless of condition and/or performance of an asset
- unscheduled: activities that occur in response to an event or circumstance
- proactive: activities that are undertaken before the performance of an asset is impaired
- reactive: activities that are undertaken after the impairment of the performance of an asset.

Note: Complaints related to an asset are captured separately.

Data Table 2 lists the attributes used to categorise all activities or interventions in this schema that are undertaken on an asset to maintain the service and the service level intended in design.

Data Table 2: Repairs, Maintenance and Operations Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Eve_Type	Event Type	Alpha / Numeric		10	No commas included	Event Type	INV	Field can be empty if no assessment	Entry must be from CODELIST	Event Type
Act_Type	Type of activity	Alpha / Numeric		10	No commas included	Type of activity	PRO	Field can be empty if no assessment	Entry must be from CODELIST	Workflow Type
Start_date	Start date	Date		n/a	n/a	Start date of activity	1/05/2016	Field cannot be empty		
Start_time	Start time	Time		n/a	n/a	Start time of activity	11:45	Field cannot be empty		
End_date	End Date	Date		n/a	n/a	End date of activity	2/06/2016	Field cannot be empty		
End_time	End Time	Time		n/a	n/a	End time of activity	13:45	Field cannot be empty		
Loc_Add	Location - Address	Alpha / Numeric		100	No commas included	The address corresponding to the geographical location of where the activity was undertaken	123 Abc Road	Field cannot be empty		
Loc_GPS	Location - GPS	Decimal		n/a	n/a	The geographic coordinate of the location where the activity was undertaken	36.8485	Field cannot be empty		
Loc_GPS_Sy	Location - Coordinate System	Alpha / Numeric		10	No commas included	The system used to obtain coordinates	WGS84	Field can be empty if no assessment	Entry must be from CODELIST	Location - Coordinate System
Request_ID	Service Request Identifier	Alpha / Numeric		15	No commas included	The ID number used by the organisation to manage service request from customers and stakeholders	5489ff2	Field cannot be empty		
JobNr_ID	Job Number Identifier	Alpha / Numeric		15	No commas included	The ID number used by the organisations to manage particular activity carried out on an asset	6688L	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the activity carried out on asset	5989612	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	Sediment sump vacuumed	Field cannot be empty		
Comp_Type	Component Type	Alpha / Numeric		10	No commas included	The particular component of the asset on which the activity was carried out	Sump	Field can be empty if no assessment	Entry must be from CODELIST	Component
Fail_Mode	Fail Mode	Alpha / Numeric		10	No commas included	The issue that the activity is required to address (mandatory only for repair activities)	Overflow	Field can be empty if no assessment	Entry must be from CODELIST	Failure Mode - Type
Cause_Iss	Cause Issue	Alpha / Numeric		10	No commas included	What caused the issue (mandatory only for repair activities)	Sediment accumulation	Field can be empty if no assessment	Entry must be from CODELIST	Failure Mode - Cause
Activity	Specific Activity Undertaken *	Alpha / Numeric		10	No commas included	The specific activity undertaken on the asset	Sediment removal	Field can be empty if no assessment	Entry must be from CODELIST	Workflow Activity
Outage_Dur	Outage Duration	Time		n/a	n/a	The duration of which the service was not available as a result of activities carried out on asset	36:30:00	Field cannot be empty		
Outage_No	Outage Number	Integer		n/a	Whole number	Number of people affected by the unplanned interruption	1	Field cannot be empty		
Quantity	Quantity	Decimal		10	2	A quantitative measure of the activity carried out on the asset or findings from investigation. (Mandatory only for Investigation and Maintenance)	1	Field cannot be empty		
Unit	Unit of Measurement *	Alpha / Numeric		10	No commas included	Unit of measurement the quantity value is representing	kg	Field can be empty if no assessment	Entry must be from CODELIST	Units of Measurement
Has_def	Has been deferred	Boolean		n/a	n/a	Is the undertaken activity required as a result of past deferred maintenance	No	Field cannot be empty		
Is_def	Is deferred	Boolean		n/a	n/a	Has the required activity been deferred (i.e. the work has not been carried out and will now be required in the future)	No	Field cannot be empty		
Recur	Recurring *	Boolean		n/a	n/a	Whether the activity/cost type is recurring	No	Field cannot be empty		
Recur_Cyc	Recurrence Cycle *	Integer		n/a	Whole number	Where the activity requires undertaking on a routine bases the cyclical time between activities. (enter 0 where there is no recurrence)		Field cannot be empty		
Rec_Cyc_U	Recurrence Cycle Unit *	Alpha / Numeric		10	No commas included	Unit used for describing recurrence cycle period	n/a	Field can be empty if no assessment	Entry must be from CODELIST	Recurrence Cycle Unit

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Cos_Pla	Cost of Plant	Decimal		10	2	The cost of plant incurred by the organisation to carry out the activity	75	Field cannot be empty		
Cos_Lab	Cost of Labour	Decimal		10	2	The total cost of labour incurred by the organisation to carry out the activity	75	Field cannot be empty		
Cos_Con	Cost of Consumables	Decimal		10	2	The total cost of material and energy incurred by the organisation to carry out the activity	75	Field cannot be empty		
Base_Cost	Base of Cost	Alpha / Numeric		10	No commas included	An indicator as to whether the data is based on an estimate or actual data	e	Field can be empty if no assessment	Entry must be from CODELIST	Bases of Cost
Date_Cost	Date of Incurred Cost *	Date		n/a	n/a	The date in which the cost was incurred	1/05/2016	Field cannot be empty		
Date_Paid	Date Paid	Date		n/a	n/a	The date in which the cost was paid	1/05/2016	Field cannot be empty		

Data Table 2a: Complaints Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Comp_Da	Complaint Date	Date		n/a	n/a	Date on which complaint was made	1/05/2016	Field cannot be empty		
Comp_Na	Complainant Name	Alpha / Numeric		100	n/a	Name of the person making the complaint	John Smith	Field cannot be empty		
Comp_Ad	Complainant Address	Alpha / Numeric		100	n/a	The address that the complainant occupies	123 AAA Street	Field cannot be empty		
Comp_Ty	Complaint Type	Alpha / Numeric		10	No commas included	The issue that the complaint refers to	TASTE	Field can be empty if no assessment	Entry must be from CODELIST	Complaint Type

2.3.5 Code Lists

The following code lists define the options that can be used to populate the attributes within the repairs, maintenance and operations schema.

Code List 18: Repairs, Maintenance and Operations Intervention Type – Workflow Type

Code	Description
INV	Investigation
MAIN	Maintenance
OPER	Operate
REP	Repair

Code List 19: Repairs, Maintenance and Operations Intervention – Workflow Response Type

Code	Description
PRO	Proactive
REAC	Reactive
SCHED	Scheduled

Code List 20: Repairs, Maintenance and Operations – Workflow Activity

Code	Description	Comment
1	Asset Base Data Collection	The collection of base inventory data for any individual asset of grouped asset. (What,where,species, type, model No, other attributes as required)
2	Asset Install	New asset installed
3	Asset Partial Removal	Removal of a component of an asset but not the whole!
4	Asset Removal	Existing asset removed (Not replaced)
5	Asset Replacement	Removal and replacement with similar asset as single operation
6	Audit	Audit carried out as part of contractual requirements
7	Blockage Clearage	Regular Maintenance
8	Cancelled Maintenance	Any work which has been requested that during implimentation is cancelled due to unforeseen circumstances

Code	Description	Comment
9	CCTV Inspection	CCTV inspection of a conduit to assess flow, damage and condition of the asset.
10	Certification and Compliance	All work associated with an operation to ensure that the assets involved meet the legal requirements to achieve the appropriate certification or appropriate compliances.
11	Chlorination Dosing	Application of Chlorine to the Water supply network in order to maintain required water quality standards.
12	Cleaning	Clensing for hygene/aesthetics. Includes polishing surfaces, cleaning chatells, walls and floors, disinfecting surfaces and chatells, also covers minor waste removal collected during the cleaning process
13	Condition Assessment	Provision of assessments of the condition rating of an asset(s)
14	De-watering	The removal of excess water from a trench or other excavation in order to prevent inundation of ground water where it is a requirement to identify this as a separate activity within the task being underataken
15	Electricity	Provision of Electricity supplies to enable an asset to carry out its desired function(s)
16	Estimator	All work associated with carrying out a cost and quantative estimation for any activity to satisfy the provision of a quote for the works being estimated where their will be a cost submitted for the provision of the estimate.
17	Excavation	The excavation of any trench or hole where it is a requirement to identify this as a separate activity within the task being underataken
18	Flushing	The cleansing of pipe networks, storage tanks and reserviors etc by through put of a liquid (water) to remove debris which ensures cleanliness of the asset.
19	Fuel	Provision of fuel supplies to enable an asset to carry out its desired function(s)
20	Servicing	General work usually over 30 minutes in

Code	Description	Comment
		duration that cannot be easily classified as a singular maintenance activity type but can be linked to an asset or asset group.
21	Graffiti Removal	Maintenance to clean / cover / remove Graffitti
22	Inspection	Visit to an asset to assess an issue prior to carrying out any maintenance actions. May include the provision of costs and quantities.
23	Investigation	All activities associated with researching a suspected issue / defect using specified criteria in order to determine an appropriate action & record findings of this investigation.(ie, Contaminent, Odour, Noise complaint) THIS IS NOT A REPORT CREATION ACTIVITY
24	Leek Detection	All work associated with the detection of leeks in the potable water supply network, where it is a requirement to identify this as a separate activity within the task being underataken
25	Megger Test	Megger Testing
26	Mowing	Mowing of any turf or lawn area
27	Painting	Painting of any asset
28	Performance Testing	All work associated with Performance Testing of an asset
29	ph Dosing	Application of a chemical agent that affects the Ph levels of the substance being treated
30	Pruning Formative	Pruning to create or encourage desired growth characteristics (Shaping and Form) of a tree, shrub or hedge or pruning to maintain an asset at contractual standards
31	Remove Inorganic Waste	Works which deal with Litter, Domestic waste, Industrial waste etc of a non organic nature
32	Remove Organic Waste	Works which deal with green waste materials (Garden organic waste, Industrial green waste, Domestic organic waste materials)
33	Repair (Permanent)	The permanent repair of an asset /

Code	Description	Comment
		equipment that is damaged to restore the asset(s) to full functionality
34	Repair (Temporary)	The temporary repair (patching up / short term fix) of an asset / equipment that is damaged in order to maintain function until permanent repairs can be implimented
35	Report Provision	Provision of all reports on asset(s)
36	Rewind	This is the rewind of a motor winding mechanism
37	Rework	The repetition of an activity that has already previously been completed (And paid for) to below accepted criteria / failed audit to ensure the desired quality is achieved. This work is carried out at no cost to the Council.
38	Road Marking	The application any kind of device or material that is used on a road surface in order to convey official information (ie, white and yellow lines, STOP commands, delination of parking bays etc)
39	Root Clearing	The removal of roots that have infiltrated a conduit and are impairing flow
40	Root Spraying	The chemical treatment of roots that have infiltrated a conduit and are impairing flow in order to control the issue.
41	Sampling	All activities associated with taking samples of a physical asset or the contents of an asset which are to be tested for specified criteria.
42	Security	Provision of security services to ensure a safe crime free environment is achieved
43	Sterilisation	All activities associated with ensuring the steralisation of an asset
44	Survey	Collecting quantitative information about items in a population, Locating of structures relative to a reference line, Collection of data used to document land ownership, The systematic collection of geophysical data for spatial studies etc.
45	Cleaning	The implimentation of a comprehensive inspection and maintenance regime

Code	Description	Comment
		which includes replacement of multiple worn or time bounded parts (valves, seals, lubricants etc) to ensure asset is achieving its full performance.
46	Overhaul	The servicing of an asset to replenish & replace consumables and ensure asset is carring out it operational requirements. This is regular cyclic work to ensure lubricant & coolant levels etc are maintained and minor maintenance is undertaken ie, replacing fuel filters & oil on a machine, toiletries & consumables in a building etc.
47	Thermal Imaging	All work associated with Thermal Imaging of an asset
48	Traffic Management	All work associated with the implimentation of traffic management and control of traffic associated with a worksite, where it is a requirement to identify this as a separate activity within the task being underataken
49	Undefined Maintenance	Jobs completed under 30 minutes that cannot be associated to an Asset or Asset Group
50	Vibration Analysis	All work associated with Vibration Analysis of an asset
51	Weeding-Mechanical/Hand	Weeding out of unwanted plants for aesthetic purposes in garden etc. Through the use of hand tools or small plant equipment. No chemical use involved in this activity.

Code List 21: Repairs, Maintenance and Operations Failure Mode – Type

Code	Description
BANKOV	Bank overflow
BLOCK	Blockage
BROCOM	Faulty broken components
BROKE	Broken/Collapsed Asset
BYLAW	Non-compliance to Bylaw
CAPEXC	Capacity Exceeded
CCTVDEF	CCTV minor defects

Code	Description
CCTVFA	CCTV fail
COVBRO	Cover broken/ missing
CRACKS	Cracks in Asset
DISP	Displacement in Asset
DUCKS	Dead ducks, botulism, pond level risen
EROS	Erosion
JOINT	Pipe Joint Problem
OTHER	Defect Other
OVER	Overflow
POP	Surcharged/Popped manhole
STAG	Stagnant, smelly water, stream level risen

Code List 22: Repairs, Maintenance and Operations Failure Mode – Cause

Code	Description
AGE	Age related deterioration/Normal wear and tear
BEAR	Bearing capacity exceeded
CHEM	Chemical attack
DEBR	Debris
FLOOD	Flooding Damage
GREA	Grease/Fats
SEDI	Sediment
SETT	Settlement
SIES	Seismic Damage
THIRDP	Third Party Damage or broken
VANDAL	Vandalism
VEGE	Vegetation
WILD	Wildlife

3 Utilisation and Demand

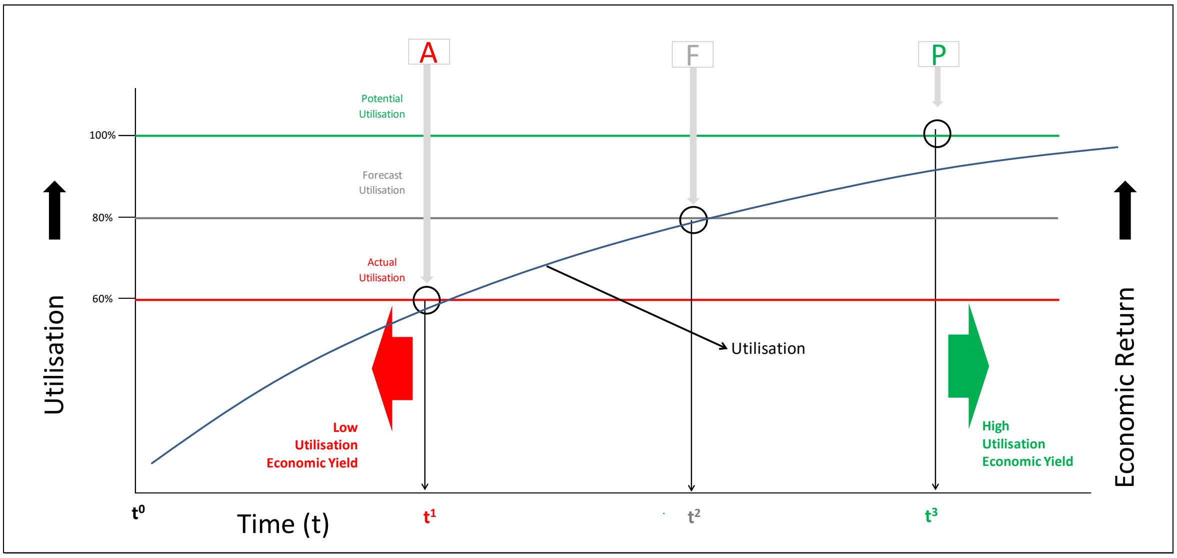
3.1 Introduction

Managers use the capacity cohort of utilisation and demand to analyse a number of important metrics in the service design envelope – that is, the extent and the quantity of services that can be provided at the level of service intended at that time.

Utilisation in this standard considers three layers.

- The first is the potential utilisation (Figure 23). This is the theoretical maximum number of service units any network or portfolio might provide. For example, the maximum number of connections per pipe in a potable water network is designed for 1,000 connections.
- The second layer is actual utilisation – the total in the network or portfolio being analysed. In the example in Figure 23, the measured number of connections is just 600.
- The final layer is forecast utilisation. Numerous constraints within a network or portfolio work against maximising the utilisation of a network or portfolio. Spatial planning constraints are one type of such constraints (due to density, height and so on). In the example above, it is possible to design networks or portfolios with the economic potential of 1,000 connections. It is also possible that it will take many years to reach this potential; developments can take decades so the actual connections invariably lag behind. What has been less clear historically is how planning constraints influence this economic potential and what their economic implications are. Planning densities in this example might only allow for a forecast utilisation of 800 connections. The economic loss is significant, and it is these analytics from this cohort that track this potential.

Figure 23: Layers of Utilisation – Potential, Actual and Forecast

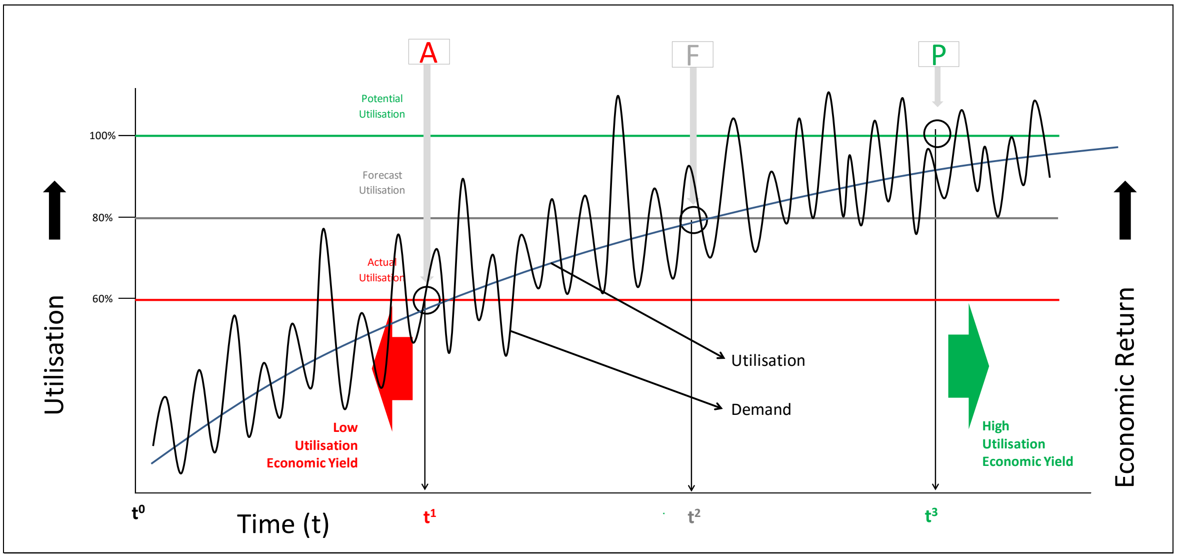


The importance of these metrics cannot be overstated. A manager's ability to analyse potential, actual and forecast utilisation is an essential ingredient in maximising the economic benefit of any investment in infrastructure. If the first cohort measures the 'health of the balance sheet', it could be reliably referred to as the 'wealth of the balance sheet'.

Demand is the chronological dimension of utilisation that allows managers to consider the ebbs and flows of services. The level of detail by which time is measured is crucial. In some instances, measuring the average demand annually is sufficient to achieve the intended purposes. In many instances, even daily averages (for example, of pressure) do not meet requirements to provide services at the level the service providers and their customers, clients or stakeholders are seeking.

As for the utilisation potential, actual demand and forecast demand are essential metrics providing insights into the network or portfolio, which managers must consider to maximise the economic return of any infrastructure investment (Figure 24).

Figure 24: Utilisation and Demand (Actual, Forecast, Potential)



The capacity of a network or portfolio is then defined as the maximum number of service units that can utilise the network while meeting the variability of demand of that utility at any given time. Residual or latent capacities are forms of unused capacity. Significant ongoing capacities of this nature would suggest overcapitalisation (the economic equivalent of a lazy balance sheet). These circumstances offer significant opportunities to improve network or portfolio economic performance (for example, economic yield).

The data tables in this section provide the analytical detail for capturing the attributes that provide additional information on a network or portfolio that is part of the suite of considerations required for an evidence-based investment decision.

3.2 Utilisation Schema

3.2.1 Definition of Utilisation

Utilisation is the proportion being used of an asset's available capacity.

3.2.2 Purpose of Schema

The utilisation of an asset is how asset managers assess the asset's effective use. This schema's purpose is to:

- identify the essential attributes that can be measured to assess availability and, hence, utilisation
- create the opportunity to measure utilisation in a consistent way, in respect to an asset.

Utilisation of an asset can be measured in three substantive ways as defined below:

- current utilisation: utilisation measured as at today
- potential utilisation: the theoretical maximum utilisation as intended in the asset's design
- forecast utilisation: the planned utilisation subject to known constraints (for example, population).

3.2.3 Interface with Other Schemas

Utilisation is one of a suite of elements that determines the effectiveness of investments in the past and how well these have been utilised. Utilisation is also an important consideration for future demand (for example, population growth) and any ability to meet this demand with current infrastructure capacity envelope.

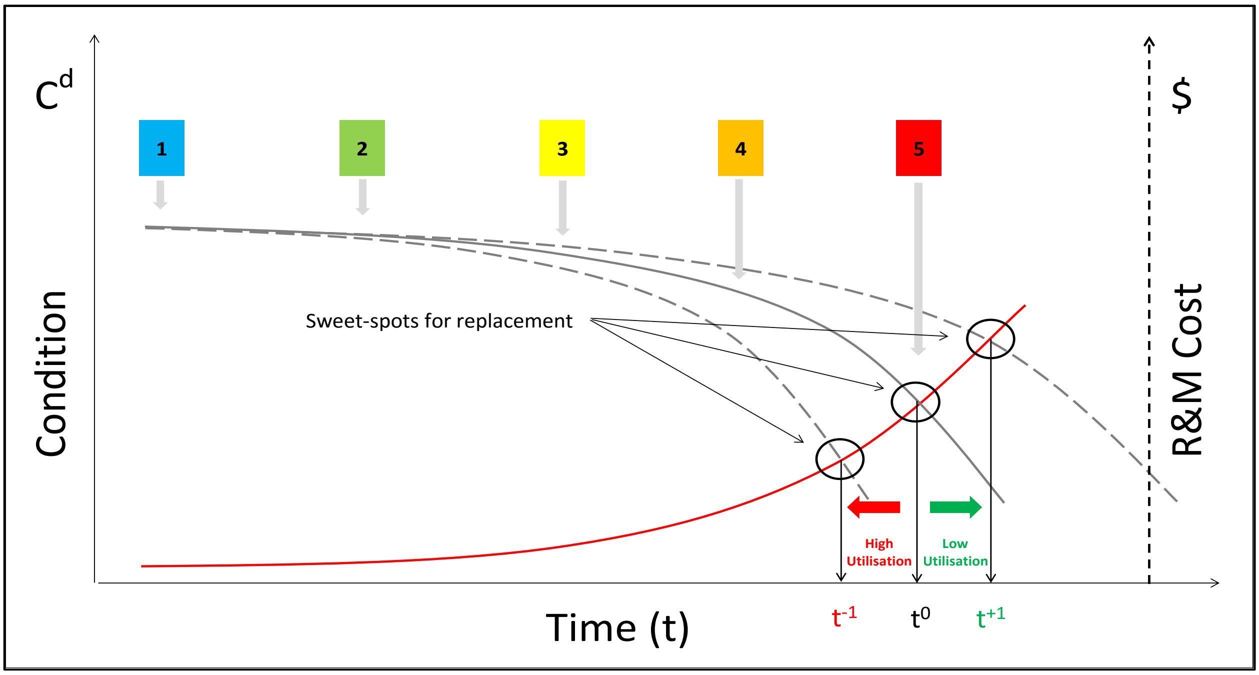
When combined with other schemas (for example, condition), utilisation can provide further insight into determining 'end of life' for design performance and service performance.

Table 8 identifies the other schemas that utilisation interfaces with. Figure 25 shows the optimal replacement point based on utilisation and cost.

Table 8: Utilisation – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed	■											
Condition		■										
Repairs, Maint & Ops			■									
Utilisation	✓	✓		■	✓					✓	✓	✓
Demand					■							
Vulnerability						■						
Criticality							■					
Risk								■				
Resilience									■			
Design Performance										■		
Financial Performance											■	
Service Performance												■

Figure 25: Optimised Replacement – Utilisation as an Influence



3.2.4 Calculating Utilisation

Utilisation is calculated by recording the actual use of an asset and comparing this with the asset's capacity as recorded in the service performance schema. The result is expressed as a percentage. Capacity is generally measured in terms of:

- flow rate
- pump run time.

Multiple capacity measures are included to account for temporal variations in current demand.

Data Table 3: Utilisation Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Util_Sce	Utilisation Scenario	Alpha / Numeric		10	No commas included	Utilisation scenario to which values apply	CURR	Field can be empty if no assessment	Entry must be from CODELIST	Utilisation - State
Util_Unit	Utilisation Unit	Alpha / Numeric		10	No commas included	The unit of measure used for capacity	FLOW	Field can be empty if no assessment	Entry must be from CODELIST	Utilisation – Capacity Unit of Measure
Ut_ Av_d	Utilisation Average Day	Decimal		10	2	Percentage of the available capacity being used on an average day	75.5	Field cannot be empty		
Ut_Pk_H	Utilisation Peak Hour	Decimal		10	2	Percentage of the available capacity being used during the peak hour	75.5	Field cannot be empty		
Ut_Pk_D	Utilisation	Decimal		10	2	Percentage of the available capacity being used during the peak day	75.5	Field cannot be empty		
Ut_Pk_W	Utilisation Peak Week	Decimal		10	2	Percentage of the available capacity being used during the peak week	75.5	Field cannot be empty		
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor and organisation working for	John Smith	Field cannot be empty		
Assess_D	Assessment Date	Date		n/a	n/a	The date that the assessment took place	6/25/2016	Field cannot be empty		
Supp_doc	Supporting documents	Alpha / Numeric		100	n/a	A link to any documents that add useful information to the assessment	User manual. Document ref 5896	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	Demand expected to increase in 2018	Field cannot be empty		

3.2.5 Code Lists

The following code lists define the options that can be used to populate the attributes within the utilisation schema.

Code List 23: Utilisation – Capacity

Code	Description
ACTCAP	Actual Capacity
FORECAP	Forecast Capacity
POTCAP	Potential Capacity

Code List 24: Utilisation – Unit of Measure

Code	Description	Comment
1	Very Low	< 50%
2	Low	> 50% – < 68%
3	Medium	> 68% – < 80%
4	High	> 80% – < 95%
5	Very High	>95%

Code List 25: Utilisation – Capacity Unit of Measure

Code	Description	Comment
A	Run time per hour	Duty Cycle
B	Litres per hour	Flow Rate
C	Litres	Redundancy
D	Connections Per Pipe	Yield

Code List 26: Utilisation – State

Code	Description	Comment
CURRUTI	Current Utilisation	Actual utilisation
POTUTI	Potential Utilisation	Future utilisation without constraints
FOREUTI	Forecast Utilisation	Future utilisation with constraints

Code List 27: Utilisation – Measurement Type

Code	Description	Comment
PERCEN	Percentage	0%–100%
CONN	Connections	Number of connections to network
PARCELS	Forecast Utilisation	Number of parcels to network
FLOW1	lmin	litres per minute
FLOW2	lsc	Litres per second per 1000 connections

Code List 28: Utilisation – Measure

Code	Description	Comment
1	Very Low	< 50%
2	Low	> 50% – < 68%
3	Medium	> 68% – < 80%
4	High	> 80% – < 95%
5	Very High	>95%

Code List 29: Utilisation – Measure Methodology

Code	Description	Comment
EST1	Estimated	Expert Opinion
EST2	Estimated	Interpolated Electronically
MODEL1	Modelled	uncalibrated
MODEL2	Modelled	calibrated
MEASURE1	Measured	Measured Electronically
MEASURE2	Measured	On site
TESTED1	Tested	E.g. Material, Chemical, Mechanical

3.3 Demand Schema

3.3.1 Definition of Demand

The demand for or on an asset is the call on an asset's capacity at any given time.

3.3.2 Purpose of Schema

The demand on an asset is how asset managers assess if the asset has enough capacity to meet the capacity intended in its design. This schema's purpose is to:

- identify the essential attributes that define an asset's specific utility
- create the opportunity to measure demand in a consistent way, with respect to an asset.

The data collected in this schema can be used in preliminary investigations to identify shortfalls in capacity within a network. It is envisaged, however, that this data will be supplemented with site-specific information before any works are carried out.

Demand on an asset can be measured in three substantive scenarios, as defined below:

- current demand: the demand measured as at today
- potential demand: the theoretical maximum demand as intended in the asset's design
- forecast demand: the planned demand subject to known constraints (for example, planning regulations that specify population density).

Demand varies over a given time; therefore, peak demand and average demand are considered separately and defined below:

- peak demand: demand measured at the period of greatest load and/or use (for example, maximum daily demand)
- average demand: demand measured over a period of time (for example, average daily demand).

3.3.3 Interface with Other Schemas

Demand, together with utilisation, supports evidence-based decision-making about maximising the investment potential and the economic yield that the initial investment should enable.

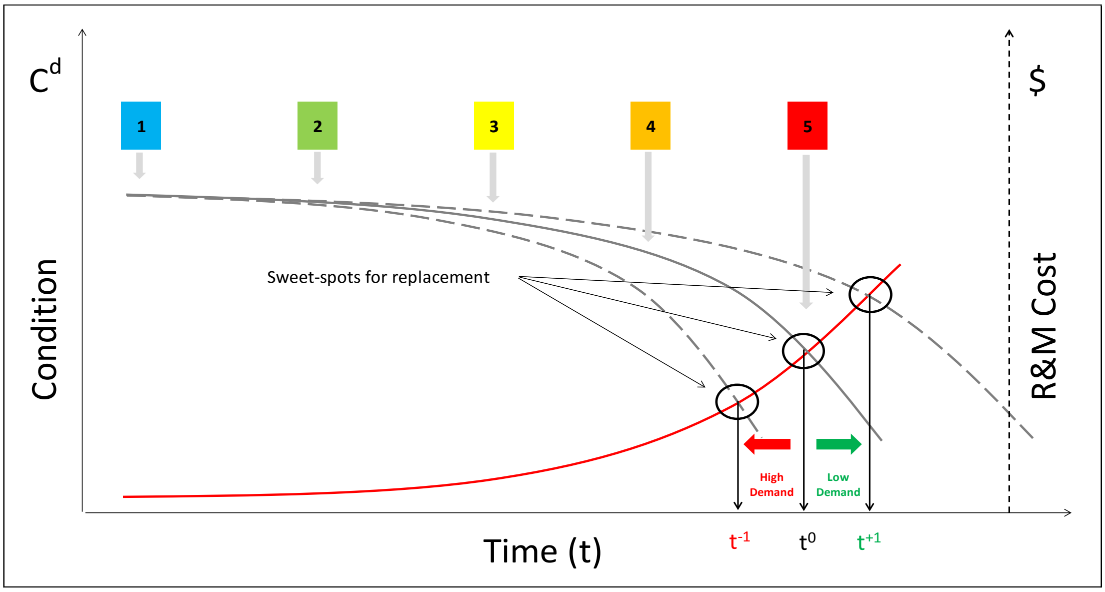
When combined with other schemas (for example, condition), demand can provide further insight into how to determine reinvestment opportunities that will maximise future potential return on the economic yield of any one investment.

Table 9 identifies the other schemas that demand interfaces with. Figure 26 shows the optimal replacement point based on demand and cost.

Table 9: Demand – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand	✓	✓		✓						✓	✓	✓
Vulnerability												
Criticality												
Risk												
Resilience												
Design Performance												
Financial Performance												
Service Performance												

Figure 26: Optimised Replacement – Demand as an Influence



3.3.4 Calculating Demand

Demand on an asset may be measured, interpolated from measured data, or estimated by aggregating the usage requirements values as specified in design standards.

Data Table 4: Demand Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Dem_Sce	Demand Scenario	Alpha / Numeric		10	No commas included	Demand scenario to which values apply	Current	Field can be empty if no assessment	Entry must be from CODELIST	Demand - State
De_Av_Hr	Average Hourly Demand *	Integer		n/a	Whole number	Average hourly demand on asset	10	Field cannot be empty		
De_Av_Da	Average Daily Demand *	Integer		n/a	Whole number	Average daily demand on asset	10	Field cannot be empty		
De _Pk_Hr	Average Hourly Demand *	Integer		n/a	Whole number	Peak hourly demand on asset	20	Field cannot be empty		
De _Pk_Da	Average Daily Demand *	Integer		n/a	Whole number	Peak daily demand on asset	20	Field cannot be empty		
Dem_Fl_Un	Unit of measurement for demand *	Alpha / Numeric		10	No commas included	Unit of measurement for demand on asset	l/s	Field can be empty if no assessment	Entry must be from CODELIST	Units of Measurement
Total_Conn	Total Connections	Integer		n/a	Whole number	Total number of connections serviced by asset	500	Field cannot be empty		
Fl_Met	Flow Method	Alpha / Numeric		10	No commas included	The method used to determine demand	MEA	Field can be empty if no assessment	Entry must be from CODELIST	Units of Measurement

3.3.5 Code Lists

The following code lists define the options that can be used to populate the attributes within the demand schema.

Code List 30: Demand – Capacity

Code	Description	Comment
1	Very Low	< 50%
2	Low	> 50% – < 68%
3	Medium	> 68% – < 80%
4	High	> 80% – < 95%
5	Very High	>95%

Code List 31: Demand – Capacity Unit of Measure

Code	Description
BPUMRUN	Pump run time
FLOW	Flow Rate
STORAGE	Storage

Code List 32: Demand – State

Code	Description	Comment
CURRDEM	Current Demand	Actual Demand
POTDEM	Potential Demand	Future Demand without constraints
FOREDEM	Forecast Demand	Future Demand with constraints

Code List 33: Demand – Measure

Code	**Description**	**Comment**
PERCEN	Percentage	0%–100%
CONN	Connections	Number of connections to network
PARCELS	Forecast Utilisation	Number of parcels connected to network
FLOW1	Lmin	litres per minute
FLOW2	Lsc	Litres per second per 1000 connections

Code List 34: Demand – Measure Methodology

Code	**Description**	**Comment**
EST1	Estimated	Expert Opinion
EST2	Estimated	Interpolated Electronically
MODEL1	Modelled	uncalibrated
MODEL2	Modelled	calibrated
MEASURE1	Measured	Measured Electronically
MEASURE2	Measured	On site
TESTED1	Tested	E.g. Material, Chemical, Mechanical

4 Vulnerability, Criticality, Risk and Resilience

4.1 Introduction

Understanding the sensitivity of an asset (alongside its network or portfolio) for evidence-based investment decisions involves understanding the complex relationship between vulnerability, criticality, risk and resilience. In each instance, information about the asset, the event, the scale of the event, the level of disruption and the period of reinstatement will be required to make an evidence-based investment decision. Collectively these different aspects are described as the **sensitivity** of an asset to its surrounds and any event that will affect the delivery of the service at the levels intended in its design (where an event is something that has occurred to create quantifiable loss, for example, a storm or flood).

Vulnerability is the asset's predisposed state and its ability to withstand an event of a certain nature and type – the threat. Within the same network, individual assets can differ in their vulnerability to the same event (for example, a pipe in a liquefaction zone compared with one that is not). Similarly an asset may differ in its vulnerability to different events (for example, the pipe in the liquefaction zone may be less vulnerable in a 500-year return period flood than it is in an earthquake with a similar return period).

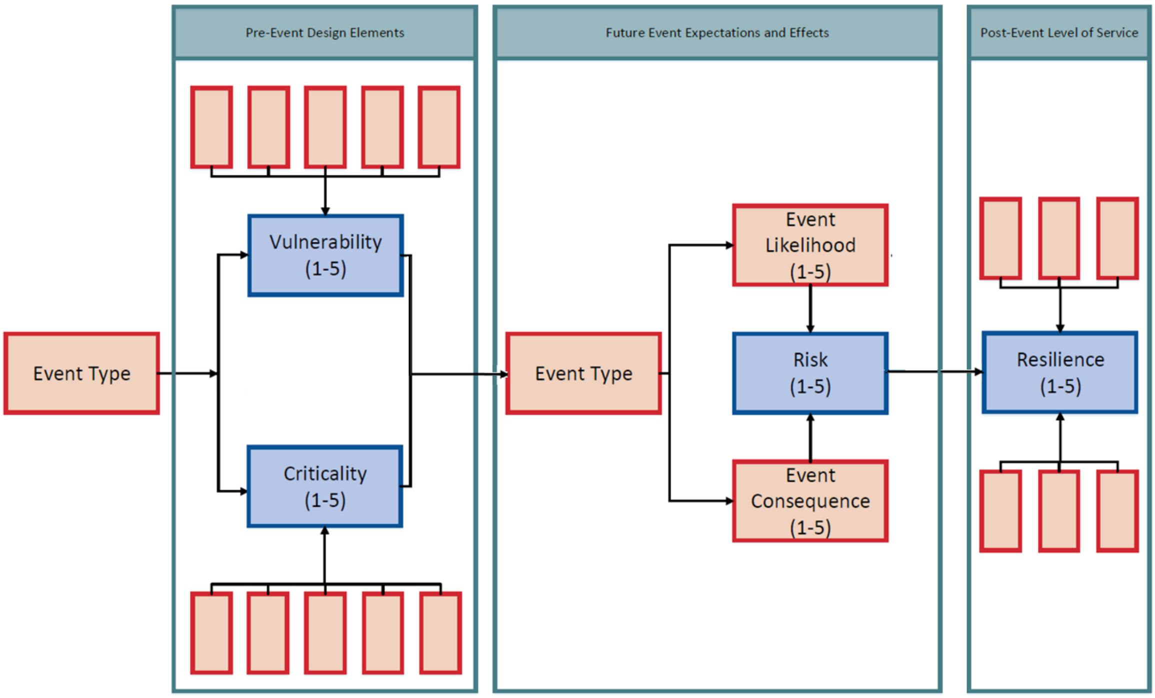
Criticality considers the vulnerabilities and risks associated with any event in the context of an asset's importance to a network or system for delivering a service at an agreed level as intended in its design. End-users will vary in importance, with priority users such as hospitals influencing this assessment. Critical assets will have higher risks based on those vulnerabilities and the importance of each asset's role in delivering essential services to the communities as intended in its design.

Risk in the first instance considers an event's likelihood and its possible consequences. Considering the vulnerabilities and criticalities of an asset at the time an event occurs is essential. Events will naturally vary by type (for example, natural hazards, social and political events, wilful damage and terrorism, population growth and climate change). The risks are expressed in terms of their likelihood: for natural hazards, this is an average return period or probability of occurrence in any given year; although social and political events are harder to predict, a similar approach is used for them. The long-term processes such as population growth and climate change are also difficult to accurately predict. The consequences of a given event are determined by the type of event (for example, destructive events such as earthquakes and non-destructive events such as flooding) and the scale of an event (for example, the difference between ground movements during magnitude 6.0 and 8.0 earthquakes). Consequences can be common across threat types.

Resilience of an asset is assessed in the context of a post-event service and level of service subject to that event. Vulnerability, criticality, and risk are considered in regard to estimates of the likelihood for damage to occur during an event, the expected post-event service and level of service, and the time to restore an asset, network or portfolio to the level of service as was intended before the event. Reinstatement could include a service or level of service different to what was experienced before an event and what is expected after the event.

Figure 27 summarises the relationships between these different elements before, during and after an event.

Figure 27: Relationships between the Elements of Sensitivity Before, During and After an Event



4.2 Vulnerability Schema

4.2.1 Definition of Vulnerability

Vulnerability is the susceptibility or flaw,[7] which in certain events could diminish an asset's ability to deliver the service and level of service intended in its design.

4.2.2 Purpose of Schema

The schema's purpose is to:

- explore how assets respond when threat events affect the delivery of services that the asset is required to provide
- assess how the asset's construction, structure and materials affect its susceptibility to threat events
- take account of the level of maintenance in assessing as an asset's response to threat events
- allow for the overall condition of the asset to be considered in determining susceptibility to threat events
- take account of the location of the asset, which may have a strong influence on its susceptibility to threat events.

4.2.3 Interface with Other Schemas

Vulnerability, together with criticality, risk and resilience, provides intelligence to:

- inform investment decisions to minimise the impact on a community if a service interruption (asset failure) occurs
- provide information on the factors that will affect how susceptible the asset is to a range of foreseeable threats
- inform management protocols in preparedness for an event
- inform management protocols after an event.

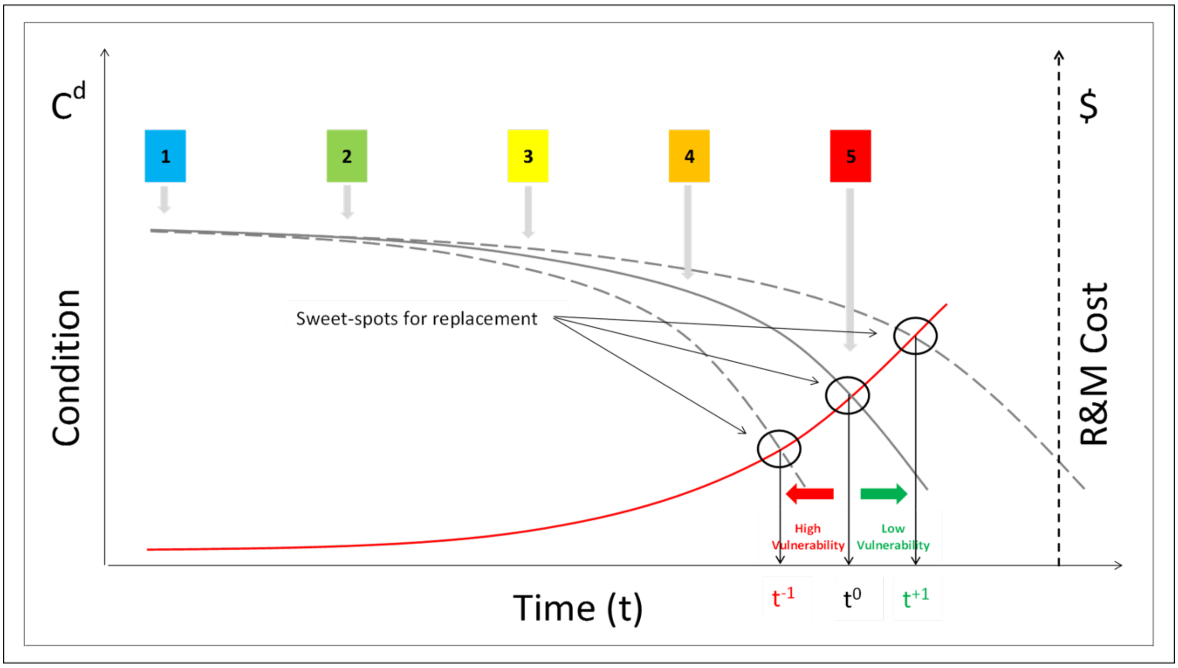
Table 10 identifies the other schemas that vulnerability interfaces with. Figure 28 shows the optimal replacement point based on vulnerability and cost.

[7] Susceptibility refers to environmental factors, such as liquefaction zone; flaw refers to physical factors, such as material type.

Table 10: Vulnerability – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	**Vulnerability**	Criticality	Risk	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand												
Vulnerability	✓	✓	✓				✓	✓	✓	✓	✓	
Criticality												
Risk												
Resilience												
Design Performance												
Financial Performance												
Service Performance												

Figure 28: Optimised Replacement – Vulnerability as an Influence



4.2.4 Components of Vulnerability

This schema describes how susceptible assets are to threats that might materialise as events limiting or preventing the asset from providing the required service. It does not describe vulnerabilities arising from the performance of organisations. For example, this schema covers how susceptible an asset is to an earthquake, but does not describe the vulnerabilities that may be created by staff behaviour during such an event.

Vulnerability can be described in terms of:

- the adaptability of an asset to handle changes – either sudden or gradual – in the operating environment
- the construction of an asset and how the standard it is built to or materials it is made of affect its performance during an event
- how an asset's performance during an event is affected by its condition compared with its "as-new" performance
- how an asset's performance during an event is affected by its level of maintenance
- how the asset responds to the different event types.

4.2.5 Calculating Vulnerability

This schema describes vulnerability from the perspective of how the asset is anticipated to perform during an event that is likely to affect service. The ability of the organisation to prepare for or respond to an event is not covered.

The threats that the asset may be exposed to are identified and assessed in the risk schema (section 4.4).

A threat event may be:

- a crisis or shock type of event such as a natural disaster
- conditions that change over time, such as asset deterioration or climate change.

Code List 35 provides 1 to 5 criteria for each element being considered under the vulnerability schema.

To assess a score for vulnerability, score each element in Code List 36.

After completing the column (1 to 5), average the scores to create the vulnerability score.

Data Table 5: Vulnerability Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Vul_Rating	Vulnerability Rating	Integer		n/a	Whole number	Vulnerability Rating – rating based on the outcome of Code List 29. Use Code List 28 to fill out Code List 29.	2	Field can be empty if no assessment	Entry must be from CODELIST	Global Vulnerability Rating
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor	John Smith	Field cannot be empty		
Assessor_O	Assessor Organisation	Alpha / Numeric		100	No commas included	Organisation of the Assessor	Wellington City Council	Field cannot be empty		
Assessor_Q	Assessor Qualification	Alpha / Numeric		100	No commas included	Relevant qualification of the assessor expected for the task being undertaken.	Geotechnical Engineering degree	Field cannot be empty		
Assessor_E	Assessor Experience	Integer		n/a	Whole number	Number of years	10	Field cannot be empty		
Assess_D	Assessment Date	Date		n/a	n/a	The date that the assessment took place	6/25/2016	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_doc	Supporting documents	Alpha / Numeric		100	n/a	A link to any documents that add useful information to the assessment	User manual. Document ref 5896	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	Action not required	Field cannot be empty		

4.2.6 Code Lists

The following code lists define the options that can be used to populate the attributes within the vulnerability schema.

Code List 35: Global Vulnerability Rating

Code	Description	Comment
1	Very Low	Average of the ratings from Adaptability, Asset Condition, Level of Maintenance, Material, Physical Condition and Structural Design Scores Score = 1–3
2	Low	Average of the ratings from Adaptability, Asset Condition, Level of Maintenance, Material, Physical Condition and Structural Design Scores Score = 4–6
3	Medium	Average of the ratings from Adaptability, Asset Condition, Level of Maintenance, Material, Physical Condition and Structural Design Scores Score = 8–10
4	High	Average of the ratings from Adaptability, Asset Condition, Level of Maintenance, Material, Physical Condition and Structural Design Scores Score = 12–16
5	Very High	Average of the ratings from Adaptability, Asset Condition, Level of Maintenance, Material, Physical Condition and Structural Design Scores Score = 20–25

Code List 36: Global Vulnerability Rating Elements

Code	Description	Comment
Vulnerability Rating – Adaptability		
1	Very Low	Can be operated without skilled staff
2	Low	Can be operated with minimal training
3	Medium	Can be operated by trained staff on site
4	High	Requires specialist expertise to operate, locally available
5	Very High	Requires specialist expertise to operate , not locally available
Vulnerability Rating – Asset Condition (From condition schema)		

Code	Description	Comment
1	Very Low	55% or more residual life
2	Low	54–36% or more residual life
3	Medium	53–26% or more residual life
4	High	25–11% or more residual life
5	Very High	10–0% or more residual life
Vulnerability Rating – Level of Maintenance		
1	Very Low	Audited annual inspection process for critical assets and corrective maintenance completed when required
2	Low	Non-audited annual inspection process for critical assets and corrective maintenance completed when required
3	Medium	Ad hoc inspections or corrective maintenance completed, but with delays/backlog.
4	High	No inspections or corrective maintenance not completed.
5	Very High	No inspections or corrective maintenance not completed. Backlog of deferred maintenance.
Vulnerability Rating – Material		
1	Very Low	Ideal material
2	Low	Good material
3	Medium	Material no longer industry preferred
4	High	Material no longer used and difficult to repair
5	Very High	Worst material normally used
Vulnerability Rating – Physical Location		
1	Very Low	Asset has no known exposure to hazards
2	Low	Asset has some exposure to one known hazard
3	Medium	Asset has exposure to one known hazard
4	High	Asset is exposed to more than one hazard (liquefiable soil, rock fall, volcanic, fault line, rising sea levels, flooding)
5	Very High	Asset is exposed to more than three hazards (liquefiable soil, rock fall, volcanic, fault line, rising sea levels, flooding)
Vulnerability Rating – Structural Design		
1	Very Low	Over 100% NBS
2	Low	From 100% to 67% NBS
3	Medium	From 67% to 34% NBS
4	High	Less than 34% NBS
5	Very High	Earthquake prone with key structural weakness

4.3 Criticality Schema

4.3.1 Definition of Criticality

Criticality is the significance of the removal of any individual component or asset to the ability of a network or facility to deliver the service it was designed to perform.

4.3.2 Purpose of Schema

The criticality of an asset is how asset managers assess the importance of any component or asset and the effect that loss of function is likely to have on service delivery. This schema's purpose is to:

- identify the essential attributes that define an asset's criticality specific to how it is measured
- measure criticality in a consistent way, irrespective of component, system, network or facility.

4.3.3 Interface with Other Schemas

Criticality, together with vulnerability, risk and resilience, provides intelligence to:

- inform investment decisions to minimise the impact on a community if a service interruption (asset failure) occurs
- inform management protocols in preparedness for a service interruption
- inform management protocols if a service interruption occurs.

All other schemas, including condition, repairs, maintenance and operations, utilisation, demand, design performance, financial performance and service performance, provide additional intelligence that can be used to inform decisions on the maintenance or replacement of the asset.

Table 11 identifies the other schemas that criticality interfaces with.

Figure 29 shows the optimal replacement point based on criticality and cost.

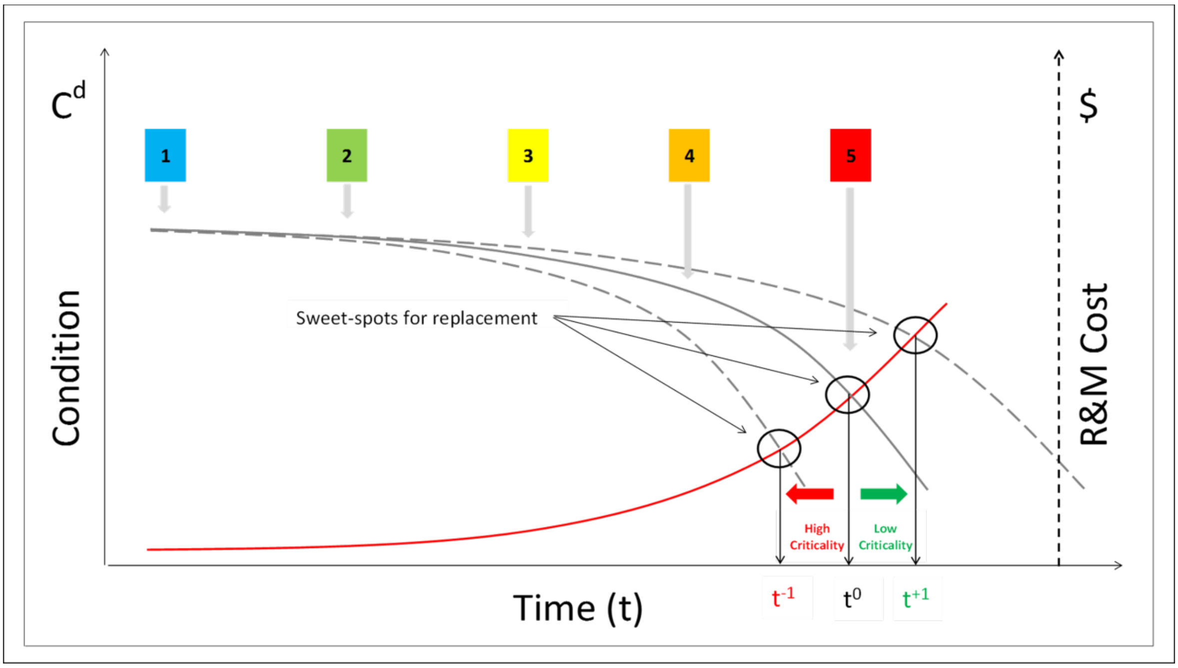
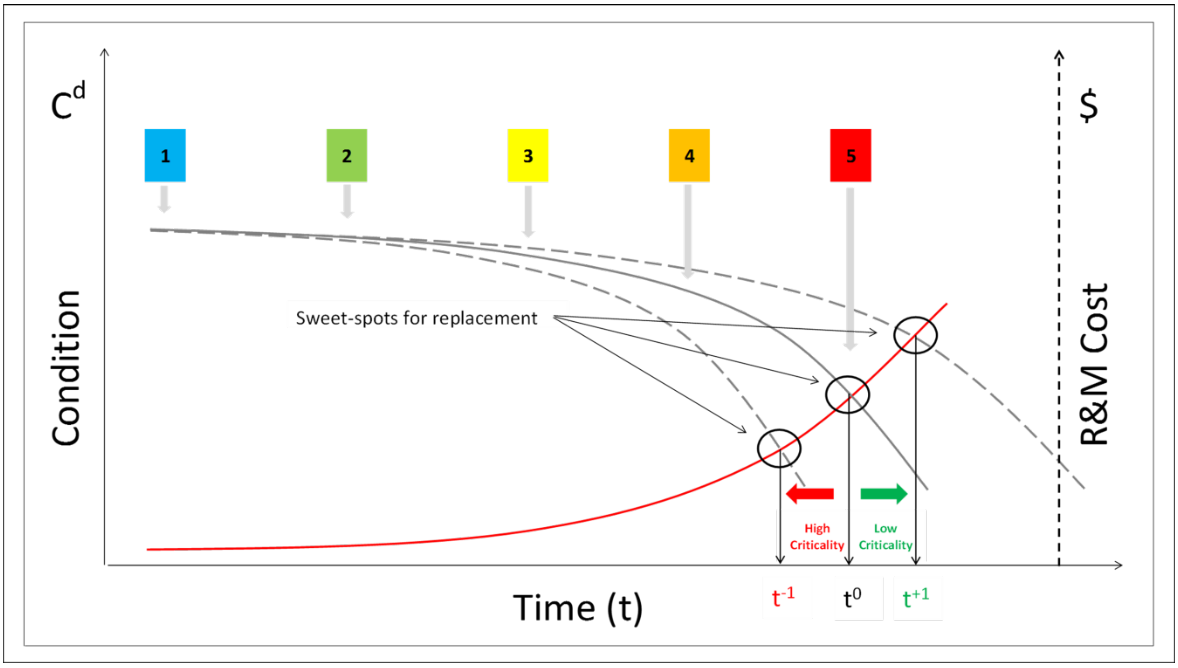


Table 11: Criticality – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand												
Vulnerability												
Criticality	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
Risk												
Resilience												
Design Performance												
Financial Performance												
Service Performance												

Figure 29: Optimised Replacement – Criticality as an Influence



4.3.4 Calculating Criticality

This schema considers the following elements in determining a criticality rating:

- facility importance rating: the importance of facilities based on the role they play in enabling the community to function, as shown in Code List 13. The facility with the highest importance that is affected by the removal of the asset determines this value
- residential population rating: the number of people affected by the removal of the asset, as shown in Code List 12.

The highest rating from the above two elements is used as the ‘Criticality Rating’.

Data Table 6: Criticality Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Fac_Rtng	Facility Importance Rating	Integer		n/a	Whole number	The importance rating of the facility to determine the impact of lost service	2	Field can be empty if no assessment	Entry must be from CODELIST	Facility Importance Rating
Res_Pop_Rt	Residential Population Rating	Integer		n/a	Whole number	population served by asset	1	Field can be empty if no assessment	Entry must be from CODELIST	Residential Population Rating
Crit	Criticality rating	Integer		n/a	Whole number	determined by the highest of facility importance or number of residents affected	1	Field can be empty if no assessment	Entry must be from CODELIST	Global Criticality Rating
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor and organisation working for	John Smith	Field cannot be empty		
Assess_D	Assessment Date	Date		n/a	n/a	The date that the value was measured or predicted	6/25/2016	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	Reference to any documents that add useful information to the assessment	Report ref: R001	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	Ground levels reduced after earthquake	Field cannot be empty		

4.3.5 Code List

The following code list defines the options that can be used to populate the attributes within the criticality schema.

Code List 37: Global Criticality Rating

Code	Description	Comment
1	Very Low	Derived from the ratings from both Facility Importance Rating (Code List 13) Residential Population Rating (Code List 12) Score = 1–3
2	Low	Derived from the ratings from both Facility Importance Rating (Code List 13) Residential Population Rating (Code List 12) Score = 4–6
3	Medium	Derived from the ratings from both Facility Importance Rating (Code List 13) Residential Population Rating (Code List 12) Score = 8–10
4	High	Derived from the ratings from both Facility Importance Rating (Code List 13) Residential Population Rating (Code List 12) Score = 12–16
5	Very High	Derived from the ratings from both Facility Importance Rating (Code List 13) Residential Population Rating (Code List 12) Score = 20–25

4.4 Risk Schema

4.4.1 Definition of Risk

Risk is the potential to gain or lose something of value, that is, the probability or threat of quantifiable damage, injury, liability, loss, or any other negative occurrence caused by external or internal vulnerabilities, and that may be avoided through pre-emptive action.

The potential to gain something of value is excluded from this standard.

4.4.2 Purpose of Schema

Determining the risk of an asset is how asset managers assess its probability or threat of quantifiable loss. This schema's purpose is to:

- identify the essential attributes that define an asset's risk
- create the opportunity to measure risk in a consistent way, with respect to an asset
- define the appropriate level of detail to consider when measuring the risk associated with an asset
- define the components of risk to measure asset risk, whether at the network, facility or asset level.

Determining the risk of an asset helps asset managers to:

- decide on current levels of risk
- predict future levels of risk
- highlight areas of unacceptable risk or areas where risk is managed to a point that is as low as reasonably practicable (ALARP)
- evaluate the impact on risk levels with a range of potential intervention investments.

4.4.3 Interface with Other Schemas

Risk, together with vulnerability, resilience and criticality, provides intelligence to:

- inform investment decisions to minimise the impact on a community if a service interruption (asset failure) occurs
- inform management protocols in preparedness for an event
- inform management protocols after an event.

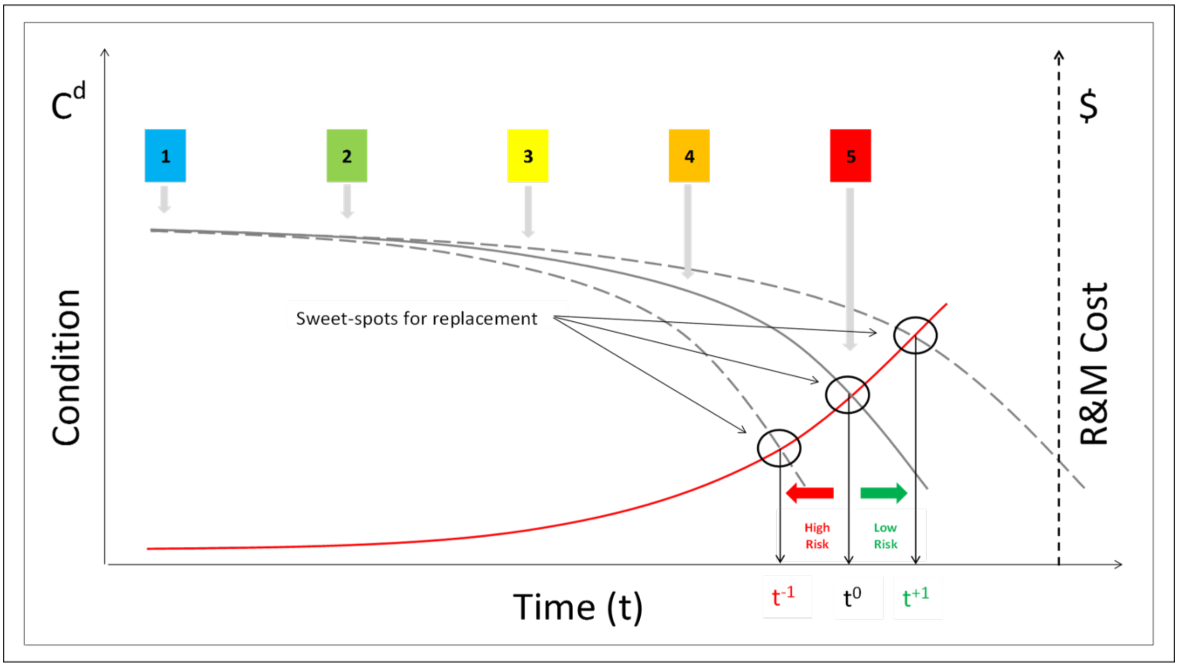
All the other schemas, including condition, repairs, maintenance and operations, utilisation, demand, design performance, financial performance and service performance, provide additional intelligence that can be used to inform decisions on maintenance or replacement of the asset to maintain or improve network integrity as per the service performance agreed.

Table 12 identifies the other schemas that risk interfaces with. Figure 30 shows the optimal replacement point based on risk and cost.

Table 12: Risk – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	**Risk**	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand												
Vulnerability												
Criticality												
Risk	✓	✓		✓		✓	✓		✓			✓
Resilience												
Design Performance												
Financial Performance												
Service Performance												

Figure 30: Optimised Replacement – Risk as an Influence



4.4.4 Components of Risk

This schema describes the risks arising from the performance of assets. It does not describe risks arising from the performance of organisations. For example, the schema covers health and safety risks arising from the failure of an asset, but it does not describe the health and safety risks arising from staff maintaining the asset.

Risk can be described in terms of:

- type: defined as something that has the potential to give rise to quantifiable loss (for example, financial or environmental risk)
- event: defined as something that has the potential to create quantifiable loss (for example, a storm or flood).

Risk[8] is quantified in terms of the likelihood of failure and the consequence of failure:

- likelihood: defined as the chance of something happening
- consequence: defined as the outcome of an event.

Likelihood of failure is a product of:

- the probability of an event occurring in terms of return periods (refer Code List 39).

Consequence of failure can be observed through several categories:

- health and safety: an asset's ability to deliver the service within the public health and safety limits as intended in its design
- socio-cultural: assets enable the system to be operated in a manner that contributes to the social, economic and cultural wellbeing of the community and provides a competitive advantage for businesses and industries; an asset's ability to deliver the service at the levels of service as intended in its design
- financial: an asset's ability to deliver the service at the levels of service as intended in its design
- environmental: an asset's ability to deliver the service within the environmental limits as intended in its design
- governance: an asset's ability to deliver the service within the reputational limits and within the legislation as intended in its design.

4.4.5 Calculating Risk

The schema uses a consequence and likelihood matrix to produce a risk rating (score). The approach involves:

- identifying the sources of risk that may lead to the failure of an asset
- identifying the consequences of an event occurring and assigning a consequence score for each of the consequence categories affected. Assign an overall consequence score based on the highest consequence score assigned to each of the individual categories
- predicting the likelihood of the event occurring and assigning a likelihood score for each of the consequence categories affected. Assign an overall likelihood score based on the highest likelihood score assigned to each of the individual categories
- assigning a risk score based on the consequence and likelihood scores assigned.

[8] See AS/NZS ISO 31000:2009 Risk Management – Principles and guidelines.

Data Table 7: Risk Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Risk_Rt_Ov	Risk Rating Overall	Integer		n/a	Whole number	Overall risk rating identified by likelihood and consequence	1	Field can be empty if no assessment	Entry must be from CODELIST	Likelihood Rating
Like_Rt_Ov	Overall Likelihood Rating	Integer		n/a	Whole number	Overall likelihood rating considering how often the hazard is likely to occur	1	Field can be empty if no assessment	Entry must be from CODELIST	Likelihood Rating
Con_Rat_Ov	Consequence Rating Overall	Integer		n/a	Whole number	The overall consequence rating considering the impact of asset failure across the predefined list of stakeholders and organisational objectives	1	Field can be empty if no assessment	Entry must be from CODELIST	Consequence Rating
Con_Rat_HS	Consequence Rating Health and Safety	Integer		n/a	Whole number	The health and safety consequence rating considering the impact of asset failure across the predefined list of stakeholders and organisational health and safety objectives	1	Field can be empty if no assessment	Entry must be from CODELIST	Consequence Rating
Con_Rat_SC	Consequence Rating Socio Cultural	Integer		n/a	Whole number	The socio-cultural consequence rating considering the impact of asset failure across the predefined list of stakeholders and organisational socio-cultural objectives	1	Field can be empty if no assessment	Entry must be from CODELIST	Consequence Rating
Con_Rat_Fi	Consequence Rating Financial	Integer		n/a	Whole number	The financial consequence rating considering the impact of asset failure across the predefined list of stakeholders and organisational financial objectives	1	Field can be empty if no assessment	Entry must be from CODELIST	Consequence Rating
Con_Rat_En	Consequence Rating Overall	Integer		n/a	Whole number	The environmental consequence rating considering the impact of asset failure across the predefined list of stakeholders and organisational environmental objectives	1	Field can be empty if no assessment	Entry must be from CODELIST	Consequence Rating
Cons_Gr_Go	Consequence Rating Governance	Integer		n/a	Whole number	The governance consequence rating considering the impact of asset failure across the predefined list of stakeholders and organisational governance objectives	1	Field can be empty if no assessment	Entry must be from CODELIST	Consequence Rating
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor	John Smith	Field cannot be empty		
Assess_D	Assessment Date	Date		n/a	n/a	The date that the value was measured or predicted	6/25/2016	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	Reference to any documents that add useful information to the assessment	Report ref: R001	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	Action not required	Field cannot be empty		

4.4.6 Code Lists

The following code lists define the options that can be used to populate the attributes within the risk schema.

Code List 38: Risk Rating[9]

Code	Description	Comment
1	Very Low	Sum of the ratings from both Likelihood Rating (Code List 39) Consequence Rating (Code List 40) Score = 1–4
2	Low	Sum of the ratings from both Likelihood Rating (Code List 39) Consequence Rating (Code List 40) Score = 4–6
3	Medium	Sum of the ratings from both Likelihood Rating (Code List 39) Consequence Rating (Code List 40) Score = 8–10
4	High	Sum of the ratings from both Likelihood Rating (Code List 39) Consequence Rating (Code List 40) Score = 12–16
5	Very High	Sum of the ratings from both Likelihood Rating (Code List 39) Consequence Rating (Code List 40) Score = 20–25

[9] The likelihood assessment code list is based on Table C4 of SA/SNA HEB 436:2013, Risk management guidelines – Companion to AS/NZS ISO 31000:2009.

Code List 39: Likelihood Rating[10]

Code	Description	Comment
1	Very Low	The event has not been known to occur Indicative probability (over the time frame or activity of interest) <0.03 Indicative return period* Greater than 100 years
2	Low	The event does occur somewhere from time to time Indicative probability (over the time frame or activity of interest) >0.03,<0.1 Indicative return period* Every 30 years
3	Medium	The event might occur once in your career Indicative probability (over the time frame or activity of interest) >0.1, <0.3 Indicative return period* Every ten years
4	High	The event has occurred several time or more in your career Indicative probability (over the time frame or activity of interest) >0.3, <0.9 Indicative return period* Every three years
5	Very High	The consequence expected to occur on an annual basis Indicative probability (over the time frame or activity of interest) >0.9 Indicative return period* Every year or more frequently

* Return period is an estimate of the likelihood of an outcome occurring. It is also known as a recurrence interval.

The consequence assessment (Code List 40) considers the following factors:

- the number of people potentially affected by the event
- whether the consequence has a temporary or permanent effect.

[10] The likelihood assessment code list is based on Table C4 of SA/SNA HEB 436:2013, Risk management guidelines – Companion to AS/NZS ISO 31000:2009.

Code List 40: Consequence Rating

Code	Description	Comment
1	Very Low	The event has not been known to occur Indicative probability (over the time frame or activity of interest) <0.03 Indicative return period* Greater than 100 years
2	Low	The event does occur somewhere from time to time Indicative probability (over the time frame or activity of interest) >0.03,<0.1 Indicative return period* Every 30 years
3	Medium	The event might occur once in your career Indicative probability (over the time frame or activity of interest) >0.1, <0.3 Indicative return period* Every ten years
4	High	The event has occurred several time or more in your career Indicative probability (over the time frame or activity of interest) >0.3, <0.9 Indicative return period* Every three years
5	Very High	The consequence expected to occur on an annual basis Indicative probability (over the time frame or activity of interest) >0.9 Indicative return period* Every year or more frequently
	Consequence Rating – Governance	
Objective	Assets enable the system to be operated in a manner that permits the organisation to maintain a good reputation within the community. Assets are operated and managed in a manner that complies with legislation and regulations.	
1	Very Low	The event generates minor interest within the organisation. External interest is confined to just a few individuals. Non-compliance with legal or regulatory requirements is minor and not expected to result in investigation, comment or censure from regulatory government authorities. Manage within normal delegations.
2	Low	The event generates minor community interest. Reported in local media. Non-compliance with legal or regulatory requirements could result in investigation comment or censure or warning from regulatory or government authority. Manage within normal delegations and inform executives.
3	Medium	The event generates community and regional media discussion. Non-compliance with legal or regulatory requirements results in a fine or legal action of up to $100,000. Senior leadership and Chief Executive are actively engaged in managing risk.
4	High	The event generates national media coverage. Some sections

Code	Description	Comment
		of the community lose confidence in the organisation. Non-compliance with legal or regulatory requirements results in a fine or legal action greater than $100,000. Supervision is provided by external regulator or Crown advisory.
5	Very High	The event generates international media coverage, and widespread and sustained loss of confidence in the organisation. Crown managerial intervention could result in loss of licence to operate service or a Ministerial Enquiry. Non-compliance with legal or regulatory requirements results in criminal prosecution, punishable by imprisonment. organisation loses its licence to operate service.
Consequence Rating – Health and Safety		
Objective	Assets are operated and managed in a manner that is safe for people in terms of the following: • failure of an asset or its components does not cause health issues or injury to people • stormwater is managed in a manner that does not result in harm to people from ground saturation, flooding or contaminated water.	
1	Very Low	Potential injury or impact on health is limited to individuals. Basic medical intervention, such as a doctor's visit, may be required but individual is fully recovered after days or weeks.
2	Low	Some individuals may require medical intervention, but fully recover after days or weeks.
3	Medium	Localised significant impact. Individuals may potentially suffer permanent harm from the event. The impact on the health of some individuals is potentially widespread.
4	High	Localised major impact. Individuals could potentially be exposed to circumstances that cause fatalities.
5	Very High	Widespread major impact. Multiple fatalities might occur.
Consequence Rating – Financial		
Objective	Assets enable service to be provided in a financially sustainable manner for both the present and future. Assets enable service to be provided in a manner that that does not have a negative financial impact on customers and stakeholders	
1	Very Low	Financial impact is accommodated within annual reactive works budget. Financial impact on individual customers and stakeholders is negligible.
2	Low	Financial impact cannot be accommodated within annual reactive works budget. Requires funds to be diverted from other work areas but expenditure can be accommodated within the organisation's overall annual budget. Multiple customers or stakeholders experience negligible financial impact.
3	Medium	The financial impact of the event cannot be accommodated

Code	Description	Comment
		within the organisation's annual budget. Financial loss to multiple stakeholders is more than negligible but does not impact on the sustainability of financially stable businesses.
4	High	The organisation's overall budget is affected by the event for several years. Multiple customers or stakeholders experience financial losses, which may affect the financial sustainability of some businesses.
5	Very High	The organisation's long-term financial sustainability is threatened. Local stakeholders and customers are unable to continue to operate due to financial impact of the event.
Consequence Rating – Environmental		
Objective	Assets enable the system to be operated in a manner that minimises environmental impact.	
1	Very Low	Localised area experiences a negligible environmental impact, which is reversible within days, weeks or months.
2	Low	Localised areas experience environmental impacts, which are fully reversible within months to a year.
3	Medium	Localised areas experience environmental impacts, which are fully reversible within months to a year.
4	High	The environment is significantly damaged and may take decades to recover.
5	Very High	The environment is seriously damaged. Long-term impacts may not be fully reversible.
Consequence Rating – Social and Cultural		
Objective	Assets enable the system to be operated in a manner that contributes to the social, economic and cultural wellbeing of the community and provides a competitive advantage for businesses and industries. The system operates in a manner that respects the beliefs of our people and does not negatively affect their ability to participate in social and cultural practices. Our heritage and taonga are not adversely affected by the operation and maintenance of assets.	
1	Very Low	-10% - 15% agreed Outcome
2	Low	- 5% - 10% agreed Outcome
3	Medium	+/- 5% agreed Outcome
4	High	+ 5% - 10% agreed Outcome
5	Very High	+10% - 15% agreed Outcome

4.5 Resilience Schema

4.5.1 Definition of Resilience

Resilience is the capacity of an asset to absorb disturbance, return from disruption, act effectively in a crisis and adapt to changing conditions over time.

4.5.2 Purpose of Schema

The schema's purpose is to:

- measure resilience within a set of agreed assumptions
- enable asset managers to establish the resilience of an asset, or a network or portfolio
- inform investment decisions that consider resilience and enable asset managers to prioritise investments to improve resilience as and where required
- provide data that describes the ability of an asset to recover from an event to deliver the services and levels of service as intended in its design so as to assist asset managers preparing contingency plans for responding to events.

4.5.3 Interface with Other Schemas

Resilience, together with risk, vulnerability and criticality, provides intelligence to:

- inform investment decisions to minimise impact on community if an event occurs (asset failure)
- identify the factors that will affect when or if an asset can start delivering the required service(s) again
- inform management protocols in preparedness for an event

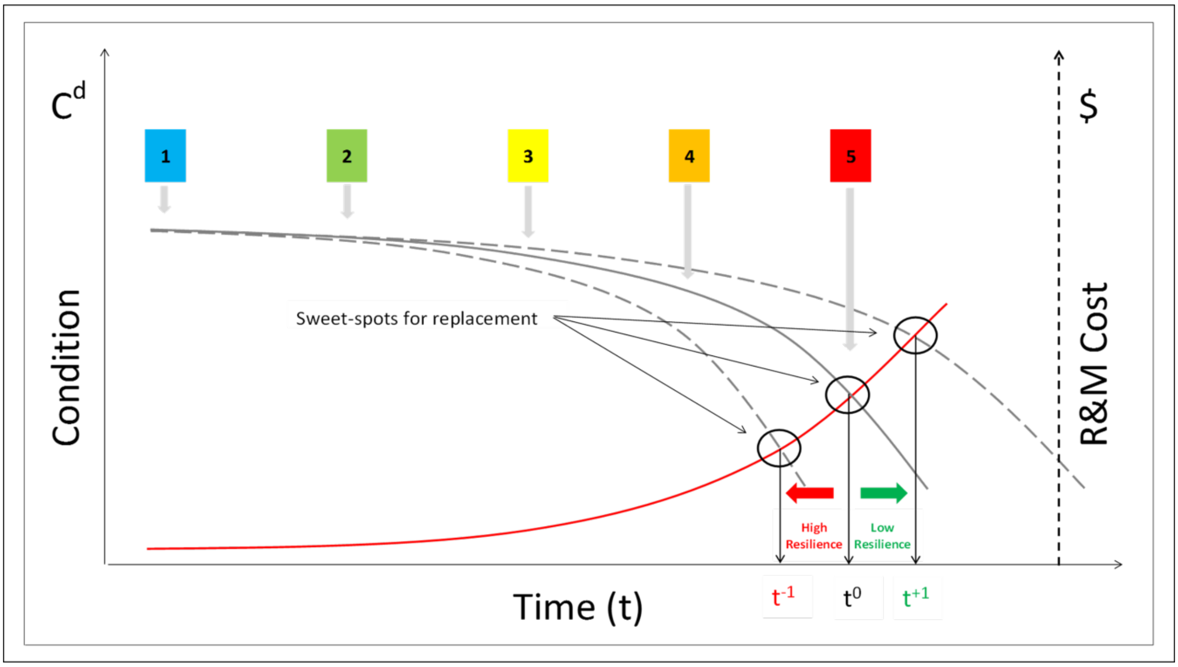
inform management protocols when an event occurs.

Table 13 identifies the other schemas that resilience interfaces with. Figure 31 shows the optimal replacement point based on resilience and cost.

Table 13: Resilience – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	**Resilience**	Design Performance	Financial Performance	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand												
Vulnerability												
Criticality												
Risk												
Resilience	✓	✓		✓		✓	✓	✓		✓		✓
Design Performance												
Financial Performance												
Service Performance												

Figure 31: Optimised Replacement – Resilience as an Influence



4.5.4 Components of Resilience

Many building component assets do not have readily measurable resilience criteria. However, elements that affect the resilience of an asset include:

- redundancy – is there a back-up or alternative asset that can provide the required service?
- alternative servicing options – for example, for utilities, is the asset serviced from multiple locations that may reduce the time needed to restore key services to the asset after disruption?
- recovery time – can the asset be restored to working order quickly?
- extent of service failure – how many customers who are expecting service experience the service failure and for how long?

Asset resilience assessment may not be applicable to many asset elements and therefore is considered an optional attribute only.

4.5.5 Calculating Resilience

This schema describes resilience from the perspective of the performance of assets after an event has affected service delivery. The ability of the organisation to prepare for or respond to an event is not covered.

The threats that the asset may be exposed to are identified and assessed in the risk schema (section 4.4).

An event may be:

- a crisis or shock type of event, such as a natural disaster or
- conditions that change over time, such as asset deterioration or climate change.

Code List 42 provides 1 to 5 criteria for each element being considered under the resilience schema.

To assess a score for resilience, score each element listed in Code List 42.

After completing the column (1 to 5), average the scores to create the resilience score.

Data Table 8: Resilience Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Res_Rating	Resilience Rating	Integer		n/a	Whole number	Resilience Rating – resilience rating based on the outcome of Code List 37. Use Code List 36 to fill out Code List 37.	2	Field can be empty if no assessment	Entry must be from CODELIST	Global Resilience Rating
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor	John Smith	Field cannot be empty		
Assessor_O	Assessor Organisation	Alpha / Numeric		100	No commas included	Organisation of the Assessor	Wellington City Council	Field cannot be empty		
Assessor_Q	Assessor Qualification	Alpha / Numeric		100	No commas included	Relevant qualification of the assessor expected for the task being undertaken.	Geotechnical Engineering degree	Field cannot be empty		
Assessor_E	Assessor Experience	Integer		n/a	Whole number	Number of years	10	Field cannot be empty		
Assess_D	Assessment Date	Date		n/a	n/a	The date that the assessment took place	6/25/2016	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_doc	Supporting documents	Alpha / Numeric		100	n/a	A link to any documents that add useful information to the assessment	User manual. Document ref 5896	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	Action not required	Field cannot be empty		

4.5.6 Code Lists

The following code lists define the options that can be used to populate the attributes within the resilience schema.

Code List 41: Global Resilience Rating

Code	Description	Comment
1	Very High	Mean Sum of the ratings from Event Significance Rating (Code List 10 and Code List 11) Service Performance Rating (Code List 50) Residential Population Rating (Code List 12) Reinstatement Time Rating (Code List 5) Score = 1–3
2	High	Mean Sum of the ratings from Event Significance Rating (Code List 10 and Code List 11) Service Performance Rating (Code List 50) Residential Population Rating (Code List 12) Reinstatement Time Rating (Code List 5) Score = 4–6
3	Medium	Mean Sum of the ratings from Event Significance Rating (Code List 10 and Code List 11) Service Performance Rating (Code List 50) Residential Population Rating (Code List 12) Reinstatement Time Rating (Code List 5) Score = 8–10
4	Low	Mean Sum of the ratings from Event Significance Rating (Code List 10 and Code List 11) Service Performance Rating (Code List 50) Residential Population Rating (Code List 12) Reinstatement Time Rating (Code List 5) Score = 12–16
5	Very Low	Mean Sum of the ratings from Event Significance Rating (Code List 10 and Code List 11) Service Performance Rating (Code List 50) Residential Population Rating (Code List 12) Reinstatement Time Rating (Code List 5) Score = 20–25

Code List 42: Global Resilience Rating Elements

Code	Description	Comment
Resilience Rating – Adaptability/Operability		
1	Very High	Can be operated without skilled staff
2	High	Can be operated with minimal training
3	Medium	Can be operated by trained staff on site
4	Low	Requires specialist expertise to operate, locally available
5	Very Low	Requires specialist expertise to operate, not locally available
Resilience Rating – Alternative Servicing Options (e.g. power, water)		
1	Very High	Asset can be re-serviced within hours
2	High	Asset can be re-serviced within days
3	Medium	Asset can be re-serviced within weeks
4	Low	Asset can be re-serviced within months
5	Very Low	Asset can be re-serviced within years
Resilience Rating – Cost to Recover		
1	Very High	>100% asset value
2	High	51%–100% asset value
3	Medium	11%–50% asset value
4	Low	1%–10% asset value
5	Very Low	less than 1% of asset value
Resilience Rating – Critical Spares Availability		
1	Very High	Spares available within hours
2	High	Spares available within days
3	Medium	Spares available within weeks
4	Low	Spares available within months
5	Very Low	Spares available within years

Code	Description	Comment
Resilience Rating – Recovery Time		
1	Very High	Asset function can be restored within hours
2	High	Asset function can be restored within days
3	Medium	Asset function can be restored within weeks
4	Low	Asset function can be restored within months
5	Very Low	Asset function can be restored within years
Resilience Rating – Redundancy		
1	Very High	Asset is fully backed up (100%)
2	High	Majority of asset has back-up (75%)
3	Medium	Asset is partially backed up (50%)
4	Low	Only essential services are backed up (25%)
5	Very Low	Asset has no standby capacity (0%)

5 Design, Financial and Service Performance

5.1 Introduction

The performance cohort contains three decision elements: design performance, financial performance and service performance. Managers use these elements to:

- analyse a myriad of important metrics that consider the service design envelope or the extent and the quality of services able to be provided within that envelope
- measure the level of service intended at the time of design and through the life of an asset to determine if it maintains that performance.

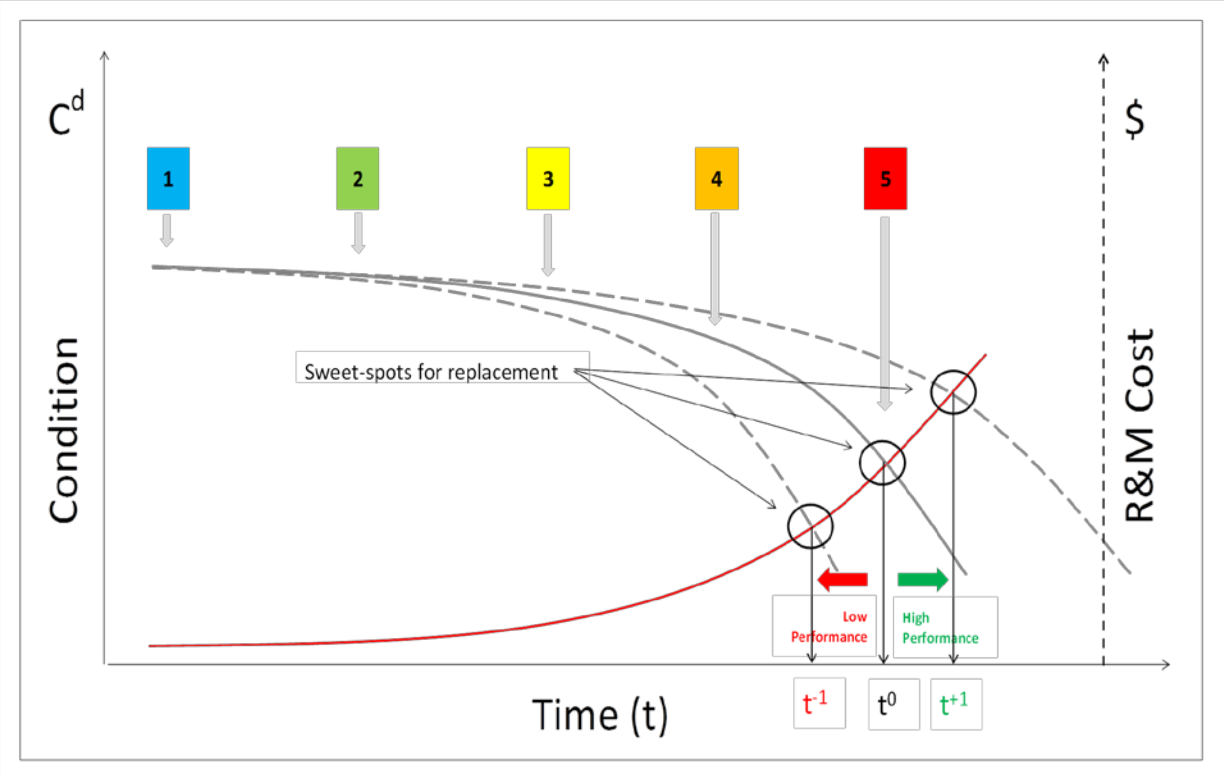
What sets this cohort apart from others is that it enables managers to reconcile outputs and outcomes in the asset management environment with agreed community expectations, which were the basis on which the infrastructure investments were initially made.

Like the capacity cohort, the performance cohort considers three layers of performance within each of the three elements identified: potential performance, actual performance and forecast performance. It is also has an inherent temporal element. Potential performance is determined at the time of design, for the life of the investment in the asset. Actual performance is equivalent to a current performance – at some point in time (albeit at any time through the life of the asset). Constraints on development on assets that can in some circumstances provide services for a century or more are difficult to manage – forecast performance requires careful monitoring to ensure the value proposition being designed for is in fact created. These different layers have a natural relationship.

Potential performance is the theoretical measurable maximum performance any asset, network or portfolio might provide – in relation to any metric that defines the performance being measured and analysed (Figure 32 and Figure 33). It is illustrated by the following examples, drawn from some of the countless performance metrics available.

- Example 1: Design capacity. The theoretical maximum capacity could be designed to accommodate 1,000 connections in a potable water network solution. Reaching maximum capacity, as intended in design, can take years and in some cases decades.
- Example 2: Maintenance costs. The theoretical maximum maintenance costs could be designed at an annual operational commitment to 5 percent of capital value of a potable water network.
- Example 3: Service design flow. The maximum design flow could be designed at 20 litres per minute for a potable water network.

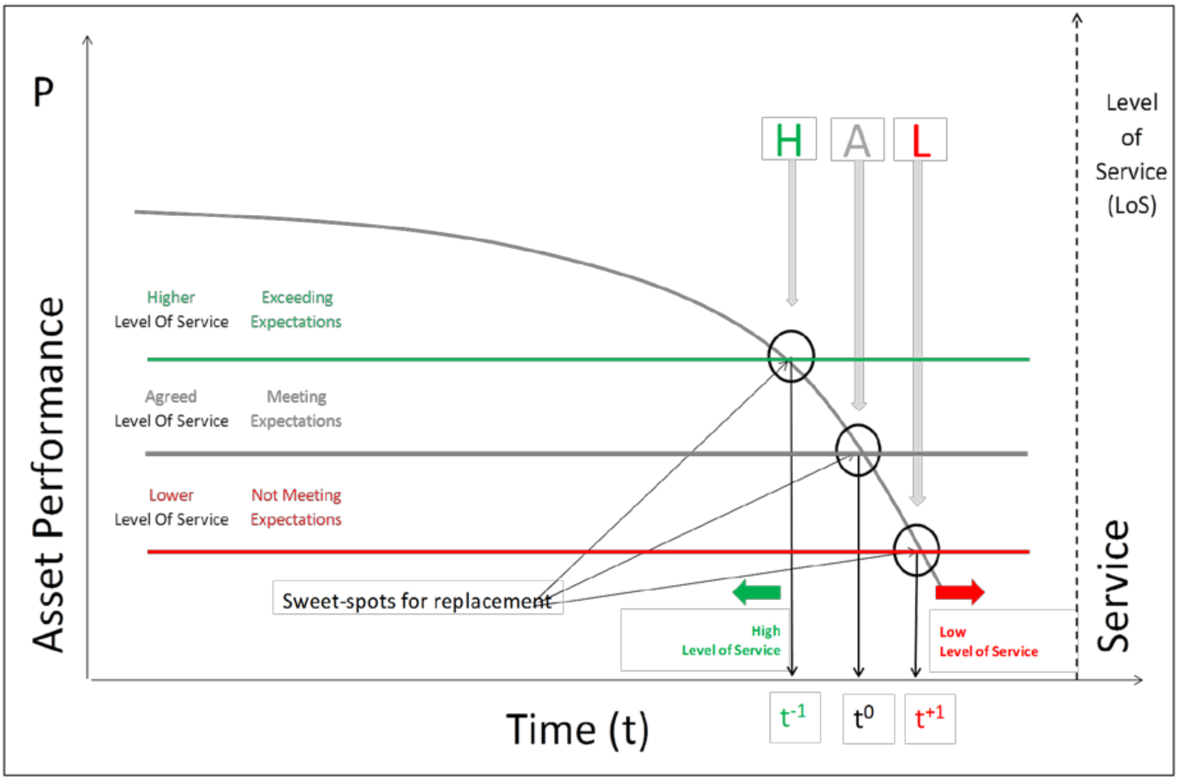
Figure 32: Replacement Curve – Based on Asset Performance (Design, Financial, Service) versus Condition



Actual performance is the actual measurable maximum performance of any asset, network or portfolio being provided – in relation to any metric that defines the performance being measured and analysed. It is illustrated following on from the three examples described for potential performance above.

- Example 1: Design capacity: The actual maximum capacity designed may only be able to accommodate 500 connections in a potable water network solution. Reaching maximum capacity, as intended in design, can take years or even generations; in some cases it may never be reached. One possible reason for this situation may be that the proposed development potential is yet to be realised.
- Example 2: Maintenance costs. The actual maximum maintenance costs may be resulting in 2 percent of capital value of the potable water network annually.
- Example 3: Service design flow. The actual design flow may only be providing 15 litres per minute in a potable water network.

Figure 33: Replacement Curve – Based on Asset Performance (Design, Financial, and Service) versus Service and/or Level of Service



Forecast performance is the forecast measurable maximum performance any asset, network or portfolio might provide, considered with any known constraints that limit potential performance – again in relation to any metric that defines the performance being measured and analysed. One such constraint might be on planning provisions specified in a district plan (for example, through planning rules on building heights or densities).

Forecast performance is illustrated following on from the design capacity examples described for potential performance and actual performance above. In this example, the forecast maximum capacity designed may only be able to accommodate 700 connections in a potable water network solution. Maximum capacity may never be reached unless planning rules (for example, height or density rules in the district plan) can be changed to address the constraints identified. Until such changes are made, the potential performance may never be reached.

The potential, actual and forecast performance elements that define the quantity of investment outcomes give a broad insight into the management effectiveness and efficiency of assets, networks and portfolios. The quality of the service provision is a more nuanced level of service that can be even more difficult to measure, and doing so invariably requires other techniques (for example, customer surveys).

The data tables in this section provide the analytical detail needed to capture the attributes to interrogate these networks and portfolios, providing a further lens in the range of considerations required for an evidence-based investment decision. The ultimate goal is to be able to determine the relationship between service performance and cost and, more specifically, between level of service performance and cost. This is the equivalent of asset management's 'Holy Grail'.

5.2 Design Performance Schema

5.2.1 Definition of Design Performance

Design performance is an asset's ability to deliver the service within the functional limits as intended in its design.

5.2.2 Purpose of Schema

This schema provides data to enable asset managers to assess the actual or engineered design performance of an asset. This schema's purpose is to:

- compare the actual performance with the main design outputs for each asset, obtained from the as-constructed schema
- inform decisions requiring operational interventions as and when required
- create an opportunity to interrogate the performance of an asset to meet the comparative analytical demands of new opportunities (for example, technology)
- examine the potential obsolescence of an asset, which may affect its ability to perform in the future.

5.2.3 Interface with Other Schemas

Design performance, financial performance and service performance provide intelligence to:

- inform decisions on how well the asset is delivering the services it was designed to provide
- inform investment decisions to minimise the impact if a service interruption (asset failure) occurs.

All other schemas, including condition, repairs, maintenance and operations, utilisation, demand, vulnerability, criticality, risk and resilience, provide additional intelligence that can be used to inform decisions on the maintenance or replacement of the asset.

Table 14 identifies the other schemas that design performance interfaces with. Numerous analytics highlight the interoperability of harmonised asset data and the relationships between the decision elements managers used to inform evidence-based investment decisions. The figures that follow show how these are optimised for asset performance versus condition (Figure 34) and asset performance versus service and level of service (Figure 35).

Table 14: Design Performance – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	**Design Performance**	Financial Performance	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand												
Vulnerability												
Criticality												
Risk												
Resilience												
Design Performance	✓	✓		✓	✓	✓	✓		✓		✓	✓
Financial Performance												
Service Performance												

Figure 34: Replacement Curve – Based on Asset Performance (Design, Financial, Service) versus Condition

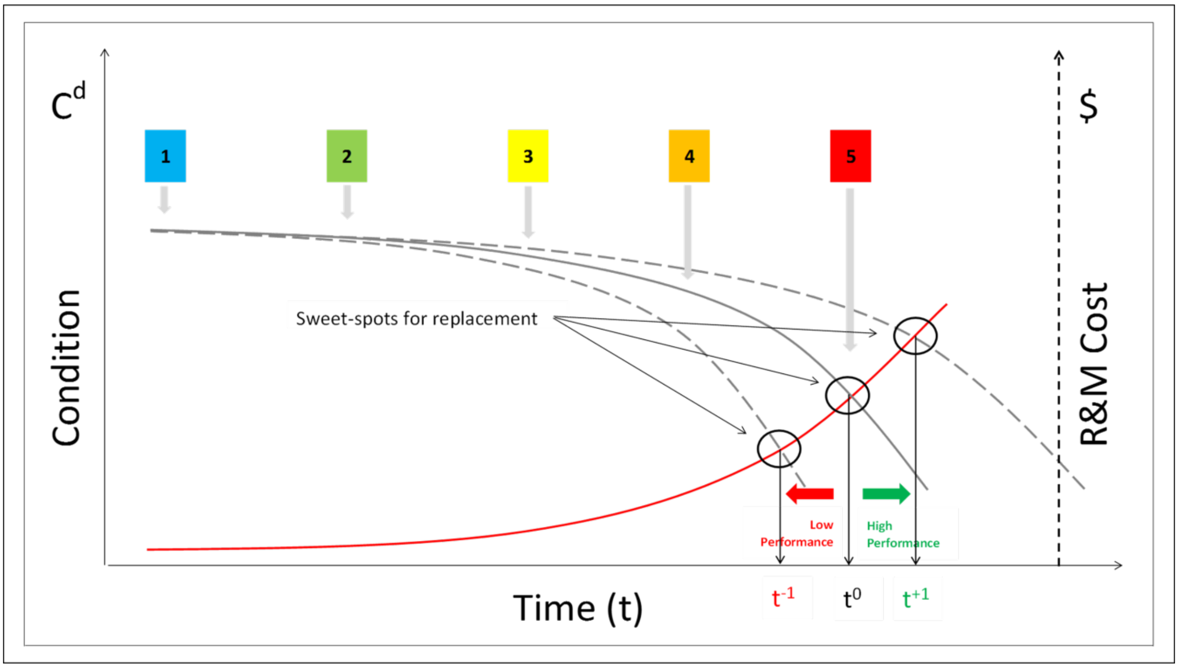
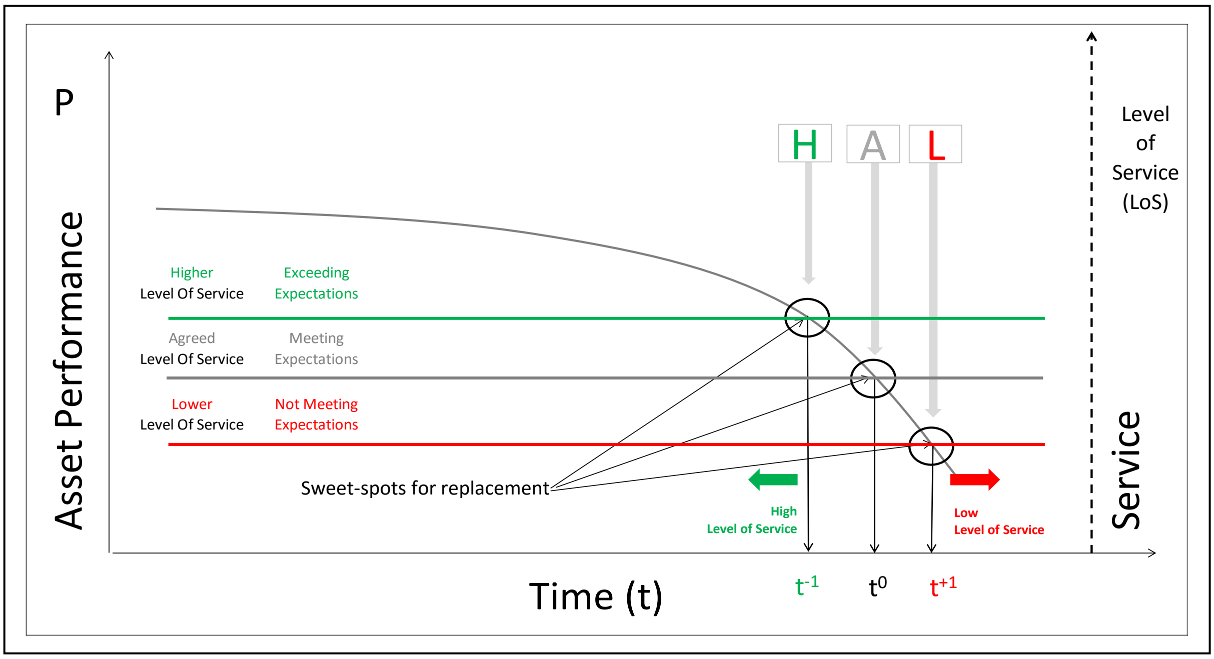


Figure 35: Replacement Curve – Based on Asset Performance (Design, Financial, Service) versus Service and Level of Service



5.2.4 Limitations of Performance Measurement

It is expected that design performance data should be available from the as-constructed schema. Asset performance is, therefore, an optional attribute and is applicable where criteria are available as a comparative measure.

5.2.5 Examples of Design Performance

Table 15 provides examples of design performance.

Table 15: Design Performance Examples

Asset	Design performance and/or capacity	Design performance measure	Measurable in the field
Pipe	Yes	L/sec	Yes
Pipe	Yes	KPa	Yes
Pump	Yes	L/sec	Yes
Pump	Yes	KPa	Yes

5.2.6 Measuring Design Performance

Measurement of performance will normally require specialist instrumentation or reporting. Results should be compared with a performance figure captured under the as-constructed schema. The result will be expressed as a percentage, in line with Code List 44.

Without any formal measurement, the level of confidence in an assessment will be lower and this will be reflected in the 1 to 5 score entered against accuracy and/or confidence in line with Code List 3.

Obsolescence is scored on a 1 to 3 scale in line with Code List 14.

Data Table 9: Design Performance Attributes

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Per_Dsg_PM	Design Performance Primary Measurement *	Decimal		15	3	Design performance from as constructed Primary Measurement	5	Field cannot be empty		
Per_Deg_PU	Design Performance Primary Unit of Measurement *	Alpha / Numeric		10	No commas included	Unit of Measurement	L/s	Field can be empty if no assessment	Entry must be from CODELIST	Description of Design Performance – Engineering Unit of Measure
Per_Dsg_SM	Design Performance Secondary Measurement *	Decimal		15	3	Design performance from as constructed Secondary Measurement	2	Field cannot be empty		
Per_Deg_SU	Design Performance Secondary Unit of Measurement *	Alpha / Numeric		10	No commas included	Unit of Measurement	KPa	Field can be empty if no assessment	Entry must be from CODELIST	Description of Design Performance – Engineering Unit of Measure
Des_Act_PM	Actual Performance from AC Primary Measurement *	Decimal				Actual performance from as constructed Primary Measurement	5	Field cannot be empty		
Per_Act_PU	Actual Performancefrom AC Primary Unit of Measurement *	Alpha / Numeric		10	No commas included	Unit of Measurement	L/S	Field can be empty if no assessment	Entry must be from CODELIST	Description of Design Performance – Engineering Unit of Measure
Per_Act_SM	Actual Performancefrom AC Secondary Measurement *	Decimal		15	3	Actual performance from as constructed Secondary Measurement	2	Field cannot be empty		
Per_Act_SU	Actual Performancefrom AC Secondary Unit of Measurement *	Alpha / Numeric		10	No commas included	Unit of Measurement	KPa	Field can be empty if no assessment	Entry must be from CODELIST	Description of Design Performance – Engineering Unit of Measure
Per_Rating	Performance Rating *	Decimal		7	2	Performance rating of the asset based upon the design criteria from As-Constructed or the current requirement from the asset. Expressed in %	50.2	Field can be empty if no assessment	Entry must be from CODELIST	Description of Design Performance Rating
Conf	Accuracy / Confidence	Integer		n/a	Whole number	The certainty that can be placed on the assessment as undertaken	4	Field can be empty if no assessment	Entry must be from CODELIST	Confidence Rating
Obsoles	Obsolescence	Integer		n/a	Whole number	The current or future issues affecting the viability of retaining the asset	2	Field can be empty if no assessment	Entry must be from CODELIST	Obsolescence Rating
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor and organisation working for	John Smith	Field cannot be empty		
Assess_D	Assessment Date	Date		n/a	n/a	The date that the value was measured or predicted	6/25/2016	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	Reference to any documents that add useful information to the assessment	Report ref: R001	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	Action not required	Field cannot be empty		

5.2.7 Code Lists

The following code lists define the options that can be used to populate the attributes within the design performance schema.

Code List 43: Description of Design Performance – Engineering Unit of Measure

Code	Description
A	L/sec
B	kPa metered
C	kPa unmetered
D	mm/hour
E	Load
F	kW
G	kg/Hr steam
H	m^3/Hr Gas
I	kPa
J	Amps
K	Voltage
L	W/m^2
M	°C
N	NC or NR Rating
O	R Rating.
P	Slip Resistance
Q	Noise Reduction Coefficient
R	m – Conductor spacing
S	STC Rating
T	kg
U	m/sec
V	Persons/Hr
W	m/s rated speed
X	Lux @ height
Y	Ohms – Earth Resistance

Code List 44: Description of Design Performance Rating

Code	Description	Comment
1	Very Low	< 50%
2	Low	> 50% – < 68%
3	Medium	> 68% – < 80%
4	High	> 80% – < 95%
5	Very High	>95%

Code List 45: Description of Design Performance Elements

Code	Description
CIV	Civil
STR	Structural
ELE	Electrical
MEC	Mechanical

5.3 Financial Performance Schema

5.3.1 Definition of Financial Performance

Financial performance is an asset's ability to deliver the service within the financial limits as intended in its design.

5.3.2 Purpose of Schema

The financial performance of an asset is how asset managers assess the asset's ability to deliver its intended service within given financial constraints, and how the asset's lifecycle is managed in a manner that is financially sustainable for the asset owner. This schema's purpose is to:

- enable the financial implications of asset investment decisions to be reliably measured and assessed
- provide historical data that allows better prediction of future asset financial performance
- allow asset lifecycle costs to be modelled and predicted
- satisfy regulatory obligations for external reporting and taxation purposes
- quantify financial exposure that may arise following an insurance event.

This schema is concerned primarily with revenues, liabilities and valuations associated with a particular asset. Generally, all other expenses associated with a particular asset are included in the repairs, maintenance and operations schema.

5.3.3 Interface with Other Schemas

Financial performance, together with design performance and service performance, provides intelligence to:

- inform decisions on how well the asset is delivering the services it was designed to provide
- inform investment decisions to minimise the impact if a service interruption (asset failure) occurs.

Some financial performance measures rely on information collected in other schemas. In particular, information on expenses relating to an asset is contained within the repairs, maintenance and operations schema, and information on historical cost is contained within the as-constructed schema.

All other schemas, including condition, repairs, maintenance and operations, utilisation, demand, criticality, risk and resilience, provide additional intelligence that can be used to inform decisions on the maintenance or replacement of the asset.

Table 16 identifies the other schemas that financial performance interfaces with. Numerous analytics highlight the interoperability of harmonised asset data and the relationships between the decision elements managers used to inform evidence-based investment decisions. The figures that follow show how these are optimised for asset performance versus condition (Figure 36) and asset performance versus service and level of service (Figure 37).

Table 16: Financial Performance – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	Design Performance	**Financial Performance**	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand												
Vulnerability												
Criticality												
Risk												
Resilience												
Design Performance												
Financial Performance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Service Performance												

Figure 36: Replacement Curve – Based on Asset Performance (Design, Financial, Service) versus Condition

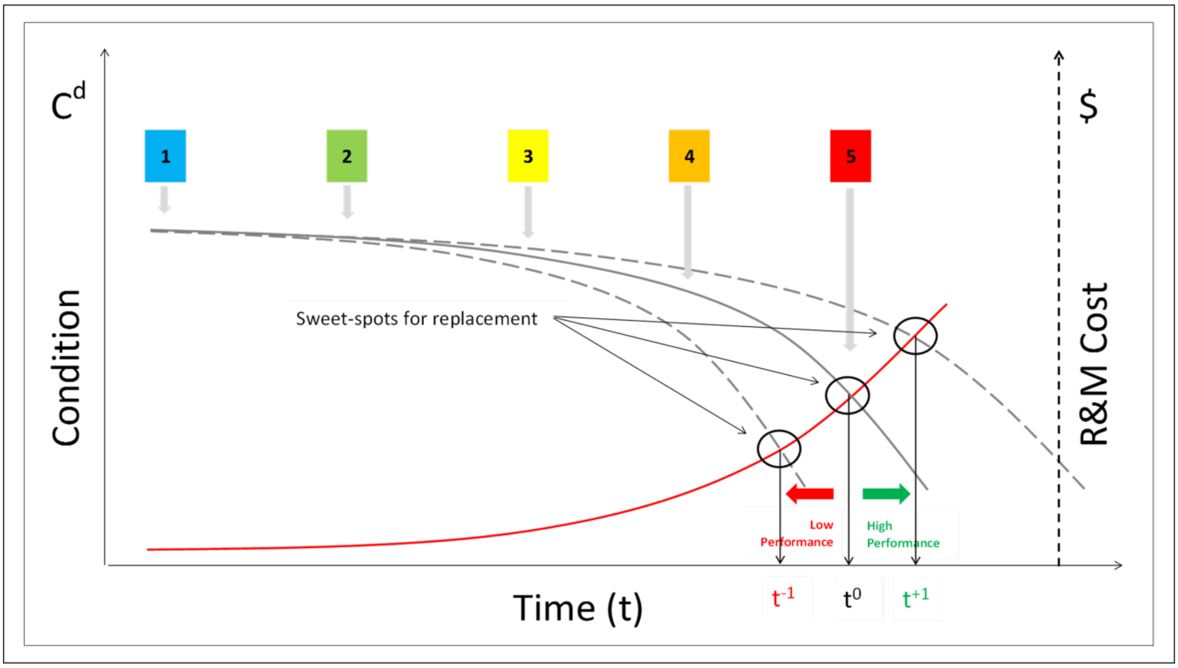
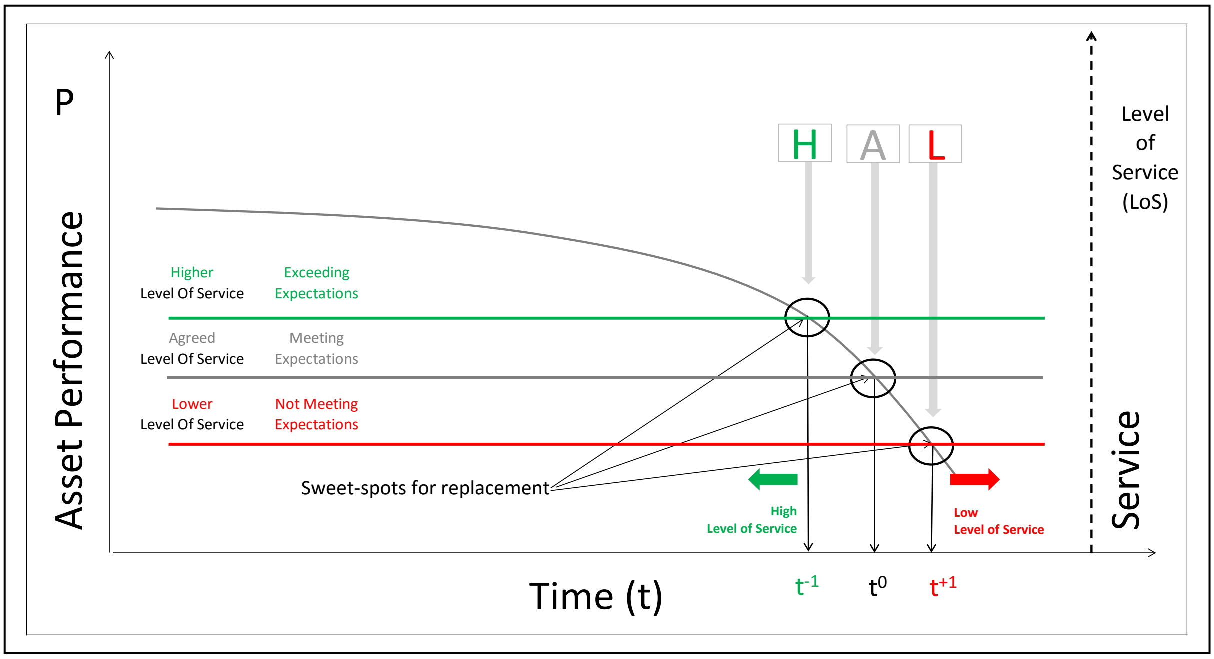


Figure 37: Replacement Curve – Based on Asset Performance (Design, Financial, Service) versus Service and Level of Service



5.3.4 Measuring Financial Performance

Measurement of the financial performance of an asset relies on the use of various financial ratios and metrics and will depend on the aspect of financial performance that is being measured.

While each asset owner will likely have their own preferred set of financial ratios and metrics, examples of metrics that may be useful to asset managers are provided below:

- Net Present Value – to assess the whole of life cost of alternative investment options
- Reactive versus Routine Maintenance Ratio – a proxy for the measurement of asset condition and management of maintenance budget
- Costs per unit – to allow better benchmarking of asset performance, may be indicative of asset condition or level of maintenance
- Revenue per unit – financial proxy for asset demand and utilisation
- Renewals and/or Depreciation – portfolio level measurement of the management of the renewals programme, this should trend towards 100 percent over time
- Actual maintenance and/or Planned maintenance – indicative of maintenance backlogs
- Depreciated value and/or Replacement cost – across the portfolio indicates the average amount of remaining utility in asset stock.

Data Table 10: Revenue Attributes (Collected on Space Level)

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Revenue_A	Revenue Amount *	Decimal		10	2	The amount of annual revenue (excl GST) that is able to be derived from utilisation of the asset	6,789.56	Field cannot be empty		
Revenue_T	Revenue Type *	Alpha / Numeric		100	n/a	A descriptor of the type of revenue that is derived from utilisation of the asset. E.g Rent, User Charges, External Grants etc	rent	Field cannot be empty		
Recurrence	Recurrence	Boolean		n/a	n/a	Whether the revenue type is recurring (yes) or one-off (No)?	Yes	Field cannot be empty		
Base	Base - Estimate or Actual *	Alpha / Numeric		10	No commas included	An indicator as to whether the data is based on an estimate or actual data	E	Field can be empty if no assessment	Entry must be from CODELIST	Base of Cost
Date_E	Date revenue derived *	Date		n/a	n/a	The financial year in which the revenue was derived	4/05/2016	Field cannot be empty		
Date_R	Date revenue received *	Date		n/a	n/a	The financial year in which the revenue was received	5/10/2016	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	Reference to any documents that add useful information to the assessment	Report ref: R001	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	Late payment	Field cannot be empty		

Data Table 10a: Depreciation Attributes (Collected on Asset ID Level)

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Dep_Meth	Depreciation Method	Alpha / Numeric		25	n/a	The method used for calculating the depreciation expense of an asset (e.g. Straight line or diminishing value)	Straight Line	Field cannot be empty		
Resid_Val	Residual value	Decimal		15	2	The value of the asset at the end of its useful life (this could be zero, the assets scrap value, or the assets value in use)	9,586,520.23	Field cannot be empty		
RUL	Remaining useful life	Integer		n/a	Whole number	The period over which it is expected that economic benefits are still able to be derived from the asset. From Asset Condition Schema	25	Field cannot be empty		
TDM	Tax Depreciation Method	Alpha / Numeric		25	No commas included	The depreciation method adopted for tax purposes (could be Straight line or Diminishing value)	Diminishing Value	Field cannot be empty		
TDL	Tax depreciation loading	Boolean		n/a	n/a	Indication as to whether the asset is being depreciated using the additional 20% loading rate	Yes	Field cannot be empty		
TDR	Tax Depreciation Rate	Decimal		n/a	2	The rate of depreciation used for taxation purposes	5	Field cannot be empty		
TAT	Tax Asset Type	Alpha / Numeric		50	No commas included	The purpose for which the asset has been held by the organisation (e.g. inventory, investment property, capital asset)	Investment	Field cannot be empty		
TAC	Tax Asset Category	Alpha / Numeric		50	No commas included	The type of asset for tax purposes. Refer Inland Revenue Depreciation tables	Fit out	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	Reference to any documents that add useful information to the assessment	Report ref: R001	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	General comment	Field cannot be empty		

Data Table 10b: Liability Attributes Type

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Lia_Amm	liability amount	Decimal		15	2	The value of any potential future liabilities (or financial obligations) that arise as a result of ownership of the asset	6,985.65	Field cannot be empty		
Lia_Type	Liability Type	Alpha / Numeric		50	n/a	A descriptor of the type of liability that may be incurred in the future	deferred taxation liability aftercare cost disposal cost make-good provision decontamination cost	Field cannot be empty		
Lia_VD	Liability Valuation Date	Date		n/a	n/a	The date on which the value of the liability was determined	4/05/2016	Field cannot be empty		
Lia_Date	Liability Date	Date		n/a	n/a	The date upon which it is expected that the liability will become due	6/25/2016	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	Reference to any documents that add useful information to the assessment	Report ref: R001	Field cannot be empty		

Data Table 10c: Valuation Attributes Details

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Val_Amm	Valuation amount	Decimal		15	2	The value of the asset, as determined by the relevant valuation method. Normally done at building level	6,985.65	Field cannot be empty		
Val_Type	Valuation type	Alpha / Numeric		50	n/a	Selection of the measurement base used for determining the gross carrying value of the asset for financial reporting purposes	Market value Replacement cost Optimised replacement cost Historical cost Insured amount	Field cannot be empty		
Val_Date	Valuation date	Date		n/a	n/a	The date that the last revaluation was carried out for the asset.	6/25/2016	Field cannot be empty		
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor and organisation working for	John Smith	Field cannot be empty		
Assessor_O	Assessor Organisation	Alpha / Numeric		100	No commas included	Organisation of the Assessor	Wellington City Council	Field cannot be empty		
Assessor_Q	Assessor Qualification	Alpha / Numeric		100	No commas included	Relevant qualification of the assessor expected for the task being undertaken.	Geotechnical Engineering degree	Field cannot be empty		
Assessor_E	Assessor Experience *	Integer		n/a	Whole number	Number of years	10	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the activity carried out on asset	5989612	Field cannot be empty		
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	Reference to any documents that add useful information to the valuation	Report ref: R001	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	General comment	Field cannot be empty		

Data Table 10d: As-constructed Attributes

Name	**Description**	**Example**
Unique_ID	Unique ID of the asset	ID567541
Cost	The amount incurred to acquire the asset and install it	6,985.65
Cost_Type	A descriptor of the type of cost that was incurred to acquire the asset	Materials cost Construction cost Installation cost Consent fees Total cost
Dev_Cont	Development Contribution – identification as to whether the asset was acquired directly or as part of a development contribution	Yes
Cap_Date	Capitalisation Date – the date on which the asset was capitalised	25/6/2016
New_asset	New Asset or Renewal – select whether the asset is new (“Yes”) or a replacement or upgrade of an existing asset (“No”)	Yes
Image_ID	ID of an image related to the asset	5989612
Supp_Doc	Supporting Documents – reference to any documents that add useful information	Report ref: R001
Comments	Comments that cannot be captured in the attributes	General comment

5.3.5 Code Lists

The following code lists define the options that can be used to populate the attributes within the financial performance schema.

Code List 46: Financial Performance Metrics

Code	Description	Comment
NZD	NZD	New Zealand Dollars ($)
ODRC	ODRC	Optimised Depreciated Replacement Cost
ORC	ORC	Optimised Replacement Cost
RC	RC	Replacement Cost
ROI	Return on Investment	
ROE	Return on Equity	

Code List 47: Description of Financial Performance Rating

Code	Description	Comment
1	Very Low	< 50%
2	Low	> 50% – < 68%
3	Medium	> 68% – < 80%
4	High	> 80% – < 95%
5	Very High	>95%

Code List 48: Description of Financial Performance Element

Code	Description
OPEX	Operational Expenditure
CAPEX	Capital Expenditure
INT	Interest
DEP	Depreciation

Code List 49: Description of Financial Performance Funding Element

Code	Description
TRATE	Targeted Rate
GRATE	General Rate
SPRATE	Special Purpose Rate
LOAN	Loan Funded
DEVCON	Development Contributions
FINCAN	Financial Contributions
SUBSIDY	Subsidies
FEE	Fees and Charges
GRANT	Grants

5.4 Service Performance Schema

5.4.1 Definition of Service Performance

Service performance is an asset's ability to deliver the service within the levels of service limits as intended in its design.

5.4.2 Purpose of Schema

The service performance schema provides data to enable asset managers to assess the actual service and service performance (with regard to the agreed levels of service within the services) that an asset provides. This schema's purpose is to:

- describe the service an asset provides across a range of main service attributes
- measure the main service attributes in a consistent way
- identify the data that is considered necessary to measure service performance
- report on the current service performance in relation to an asset
- provide information in an agreed framework that allows joint planning opportunities and benchmarking outcomes.

5.4.3 Interface with Other Schemas

Service performance, together with financial performance, provides intelligence to:

- inform asset managers at a management level, enabling them to make sound investment decisions
- inform asset managers whether an adequate and sustainable service is being provided to stakeholders over time.

All the other schemas, including as-constructed, design performance, repairs, maintenance and operations, risk, demand, financial performance and resilience, provide additional intelligence to inform decisions on the service that is delivered by an asset.

Where data is not readily available, high-level qualitative assessments are used for some non-traditional attributes, such as cultural significance.

Table 17 identifies the other schemas that service performance interfaces with. Numerous analytics highlight the interoperability of harmonised asset data and the relationships between the decision elements managers used to inform evidence-based investment decisions. The figures that follow show how these are optimised for asset performance versus condition (Figure 38) and asset performance versus service and level of service (Figure 39).

Table 17: Service Performance – Interface with Other Schemas

Schema	As Constructed	Condition	Repairs, Maint & Ops	Utilisation	Demand	Vulnerability	Criticality	Risk	Resilience	Design Performance	Financial Performance	Service Performance
As Constructed												
Condition												
Repairs, Maint & Ops												
Utilisation												
Demand												
Vulnerability												
Criticality												
Risk												
Resilience												
Design Performance												
Financial Performance												
Service Performance	✓	✓	✓	✓	✓					✓	✓	

Figure 38: Replacement Curve – Based on Asset Performance (Design, Financial, Service) versus Condition

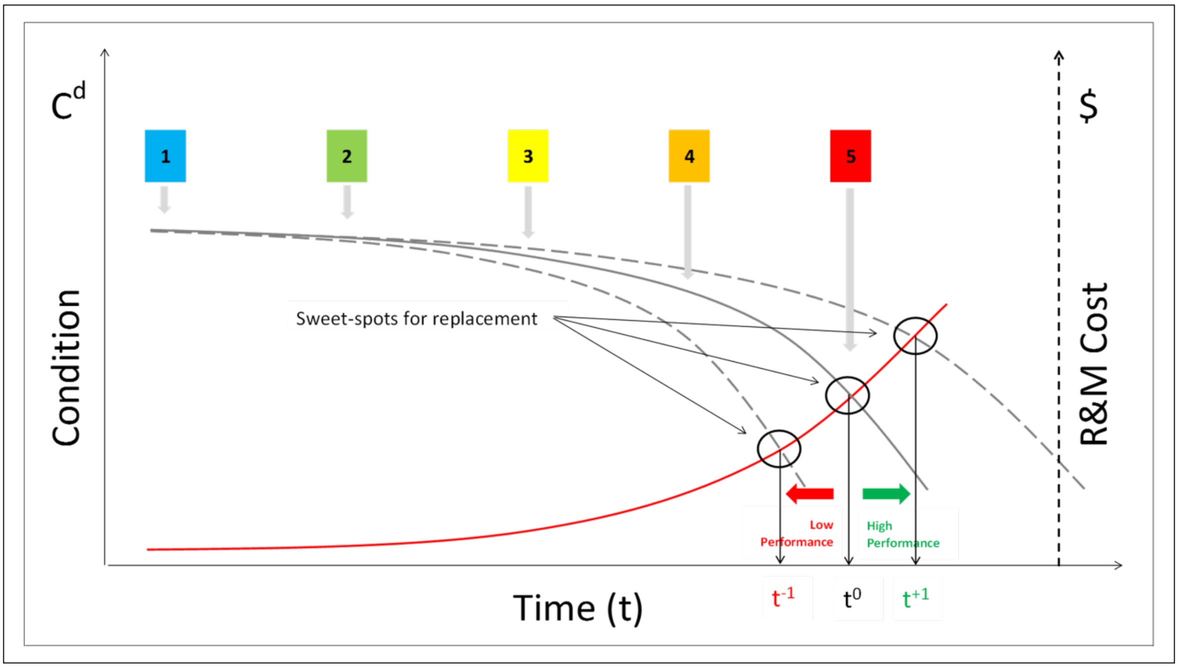
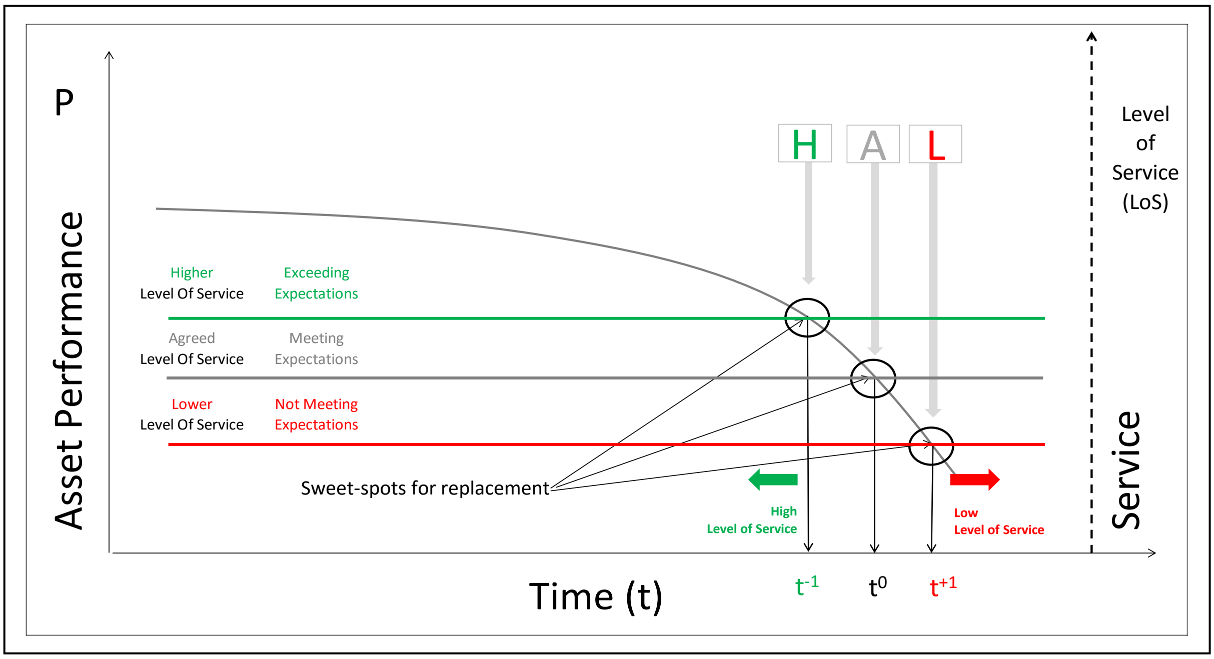


Figure 39: Replacement Curve – Based on Asset Performance (Design, Financial, Service) versus Service and Level of Service



5.4.4 Potable Water Service Definition

The main service expectations have been deliberately kept at a high level for potable water and as agnostic as possible across the other water groups (stormwater and wastewater). The potable water service is defined as "reliable supply of safe water to meet community needs today and into the future".

5.4.5 Measuring Service Performance

Data Table 11 provides the description and required attributes under the service performance schema. The cultural attribute considers three elements using Code List 51.

5.4.6 Service Performance Components

Table 18 shows how the data attributes collected in this schema inform the various components of potable water service performance.

Data Table 11: Service Performance Attributes – Functional

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Unique_ID	Unique Identifier	Alpha / Numeric		20	No commas included	Unique ID of the asset	ID567541	Field cannot be empty		
Cult_Rate	Cultural significance rating	Integer		n/a	Whole number	Cultural significance rating based on the elements to consider under Code List 41	2	Field can be empty if no assessment	Entry must be from CODELIST	Cultural Significance Outcomes Rating
Unpl_Dur	Unplanned Interruption Duration	Integer		n/a	Whole number	Duration of unplanned interruptions to service (hours) from the Repairs and Maintenance (Operations) Schema (excluding interruptions caused by third party damage)	5	Field cannot be empty		
Unp_Int_No	Unplanned Interruption Number	Integer		n/a	Whole number	Number of unplanned interruptions to service from the Repairs and Maintenance (Operations) Schema (excluding interruptions caused by third party damage)	2	Field cannot be empty		
Conn_Aff	Connections Affected	Integer		n/a	Whole number	Number of connections affected by unplanned interruption to service from the Repairs and Maintenance (Operations) Schema (excluding interruptions caused by third party damage)	10	Field cannot be empty		
Unp_Int_Re	Repeat Unplanned Interruption Number	Integer		n/a	Whole number	Number of repeat unplanned interruptions to service (defined as more than 3 in a given six month period) from the Repairs and Maintenance (Operations) Schema(excluding interruptions caused by third party damage) (Note that the Stakeholder Group is to give feedback on suitable threshold)	2	Field cannot be empty		
Fi_Pre_AC	Fire Hydrant Pressure Test	Integer		n/a	Whole number	Fire hydrant pressure test results from the As Constructed and Repairs and Maintenance (Operations) Schemas (actual results and not the 1 to 3 grading)	8	Field cannot be empty		
Fi_Pre_DP	Fire hydrant pressure test	Integer		n/a	Whole number	Fire hydrant pressure test results from the NZ Fire Service from the Design Performance Schema (actual results and not the 1 to 3 grading)	10	Field cannot be empty		
Res_Sto	Reservoir Storage	Integer		n/a	Whole number	The average days of treated water storage calculated as reservoir storage capacity/average daily use from the Demand Schema (Note - Opus to confirm this data is being collected as only wastewater was drafted in version 3 document)	24	Field cannot be empty		
MoH_Gra	MoH Grading	TBC		TBC	TBC	Latest Ministry of Health grading for reticulation from the Repairs and Maintenance (Operations) Schema (For discussion with Stakeholders Group on inclusion; WSL have included it for treatment only)	TBC	Field can be empty if no assessment	Entry must be from CODELIST	TBC
HS_Ass	Health and Safety Assessment	Boolean		n/a	n/a	Has a health and safety risk assessment of this water facility been completed from the Design Performance Schema with yes/ no (or NA) (For discussion with Stakeholders Group on inclusion; WSL have included it for treatment only)	No	Field cannot be empty		
Bac_Prev	Backflow Prevention	Boolean		n/a	n/a	Whether there is an adequate backflow prevention programme in place from the Repairs and Maintenance (Operations) Schema with yes/ no (or NA) (Suggested by Water NZ post workshop; need definition of adequate) (For discussion with Stakeholders Group on inclusion; WSL have included it for treatment only)	No	Field cannot be empty		
Com_Cla	Water Clarity Complaints	Integer		n/a	Whole number	The number of complaints received per 1,000 connections by the local authority about drinking water clarity from the Repairs and Maintenance (Operations) Schema	8	Field cannot be empty		
Com_Tas	Water Taste Complaints	Integer		n/a	Whole number	The number of complaints received per 1,000 connections by the local authority about drinking water taste from the Repairs and Maintenance (Operations) Schema	7	Field cannot be empty		
Com_Odo	Odour Complaints	Integer		n/a	Whole number	The number of complaints received per 1,000 connections by the local authority about drinking water odour from the Repairs and Maintenance (Operations) Schema	4	Field cannot be empty		
Wat_Eff	Water efficiency	TBC		TBC	TBC	Water efficiency assessed using the Infrastructure Leakage Index (ILI) (Note this is the water industry	TBC	Field can be empty if no assessment	Entry must be from CODELIST	TBC
Res_De	Residential Water Demand *	Integer		n/a	Whole number	Residential water demand (litres / person/ day) consumption from the Demand Schema	300	Field cannot be empty		
Con_Com	Consent Compliance	Boolean		n/a	n/a	Is the peak day demand (ML / day) in a given year within the resource consent requirements from the Demand Schema (actual demand for a given period) with yes/ no (or NA)	No	Field cannot be empty		
Con_Com_P	Consent Compliance Percentage	Decimal		7	2	Percentage of actual annual water take for drinking water against consented take from the Demand and Utilisation Schemas	50.2	Field cannot be empty		
No_Prop	Number Serviced Properties *	Integer		n/a	Whole number	Number of serviced properties from the Demand Schema (Discuss if this remains as removed from Buildings Schema)	300	Field cannot be empty		

Attribute Name – Abbreviated	Attribute Name – Full	Data Type	Units of Measure	Max Length	Comments	Contents	Example	General Validation Rule	Specific Validation Rule	CODELIST Reference
Perc_Pop	Percentage of Population *	Decimal		7	2	Percentage of population connected to system from the Demand Schema (Discuss if this remains as removed from Buildings Schema)	50.2	Field cannot be empty		
Res_Cha	Residential Charges	Decimal		10	2	Calculated as charges per residential customer (use 200m3 where usage based). User charges revenue is from the Financial Performance Schema and average household income is from Statistics NZ published data (Discuss if this remains as removed from Buildings Schema)	6,789.56	Field cannot be empty		
Cul_Con	Cultural Considerations	Boolean		n/a	n/a	Are there cultural considerations in this network / zone with yes/ no (or NA)? Take into account the elements for the significance of the water in relation to iwi from Code list 1 based on contribution to:Life force, Spiritual, and Sustenance	No	Field cannot be empty		
Assessor_N	Assessor Name	Alpha / Numeric		100	No commas included	Name of the assessor and organisation working for	John Smith	Field cannot be empty		
Image_ID	Image Identifier	Alpha / Numeric		100	No commas included	ID of an Image related to the asset	5989612	Field cannot be empty		
Supp_Doc	Supporting documents	Alpha / Numeric		100	n/a	Reference to any documents that add useful information to the asset	Report ref: R001	Field cannot be empty		
Comments	Comments	Alpha / Numeric		250	No commas included	Comments which cannot be captured in the attributes	General comment	Field cannot be empty		

Table 18: Service Performance Attributes – Strategic

Attribute	Description	Measure level	Required attribute	Data type	Attribute level	Optional/ mandatory
Reliable	Service is continuously provided to customers	Network; zone; water facility; asset ID	Duration of unplanned interruptions to service (hours) from the repairs, maintenance and operations schema (excluding interruptions caused by third party damage)	Integer	Network; zone; water facility; asset ID	Mandatory
			Number of unplanned interruptions to service from the repairs, maintenance and operations schema (excluding interruptions caused by third party damage)	Integer	Network; zone; water facility; asset ID	
			Number of connections affected by unplanned interruption to service from the repairs, maintenance and operations schema (excluding interruptions caused by third party damage)	Integer	Network; zone; water facility; asset ID	
			Number of repeat unplanned interruptions to service (defined as *more than three in a given six-month period*) from the repairs, maintenance and operations schema (excluding interruptions caused by third party damage)	Integer	Asset ID	

Attribute	Description	Measure level	Required attribute	Data type	Attribute level	Optional/ mandatory
	Customers receive water at the flow and pressure deemed appropriate by the organisation	Zone; water facility; asset ID	The number of complaints received per 1,000 connections by the local authority about drinking water pressure or flow from the repairs, maintenance and operations schema	Integer	Network; zone; water facility; asset ID; addresses	Mandatory
			Fire hydrant pressure test results from the as-constructed and repairs, maintenance and operations schemas *(actual results and not the 1 to 3 grading)*	Integer	Asset ID	Mandatory
			Fire hydrant pressure test results from the New Zealand Fire Service and design performance schema *(actual results and not the 1 to 3 grading)*	Integer	Asset ID	
	Service is continued to be provided to those customers	Network; zone	The average days of treated water storage calculated as reservoir storage capacity and/or average daily use from the demand schema	Integer	Water facility	Optional
Safe water	Potable water supplied through the system is safe to drink	Network; zone	Latest Ministry of Health grading for reticulation from the repairs, maintenance and operations schema	Alpha	Network; zone	Optional

Attribute	Description	Measure level	Required attribute	Data type	Attribute level	Optional/ mandatory
	Assets are operated and managed in a manner that is safe for network operators and suppliers who maintain the network, as well as the community who use or consume the water	Water facility	Has a health and safety risk assessment of this water facility been completed from the design performance schema with yes or no (or n/a)?	Alpha	Water facility	Mandatory
		Network	Whether there is an adequate backflow prevention programme in place from the repairs, maintenance and operations schema with yes or no (or n/a)	Alpha	Network	Optional
	The system provides water with an appearance, taste and smell that are attractive to customers	Network; zone	The number of complaints received per 1,000 connections by the local authority about drinking water clarity from the repairs, maintenance and operations schema	Integer	Addresses	Mandatory
			The number of complaints received per 1,000 connections by the local authority about drinking water taste from the repairs, maintenance and operations schema	Integer	Addresses	Mandatory

Attribute	Description	Measure level	Required attribute	Data type	Attribute level	Optional/ mandatory
			The number of complaints received per 1,000 connections by the local authority about drinking water odour from the repairs, maintenance and operations schema	Integer	Addresses	Mandatory
Today and into the future	The assets enable service to be provided in a financially sustainable manner for both the present and future	Network; zone	Water efficiency assessed using the Infrastructure Leakage Index (ILI)	Integer	Network; zone	Optional
		Network; zone	Residential water demand (litres per person per day) consumption from the demand schema	Integer	Network; zone	Mandatory
	Assets are operated and managed in a manner that complies with legislation and regulations	Network; zone	Is the peak day demand (millilitres per day) in a given year within the resource consent requirements from the demand schema (actual demand for a given period) with yes or no (or n/a)?	Alpha	Network; zone	Mandatory
			Is the average day demand in a given year within the resource consent requirements from the demand schema (actual demand for a given period) with yes or no (or n/a)?	Alpha	Network; zone	Mandatory

Attribute	Description	Measure level	Required attribute	Data type	Attribute level	Optional/ mandatory
	Allowance for future demand in the public water supply system to support the local economy	Network; zone	Percentage of actual annual water take for drinking water against consented take from the demand and utilisation schemas	Integer	Network; zone	Optional
Community needs	Service is provided to customers where deemed appropriate by the organisation	Network; zone	Number of serviced properties from the demand schema	Integer	Network; zone; water facility; asset ID; addresses	Optional
			Percentage of population connected to system from the demand schema	Integer	Network; zone; water facility	Optional
	The assets enable service to be provided in a financially sustainable manner for both the present and future	Network	Calculated as charges per residential customer (use 200 cubic metres where usage based). User charges revenue is from the financial performance schema and average household income is from Statistics New Zealand published data	Integer	Network; zone	Mandatory

Attribute	Description	Measure level	Required attribute	Data type	Attribute level	Optional/ mandatory
	The system operates in a manner that respects the beliefs of our people and does not negatively affect their ability to participate in cultural practices	Network; zone	Are there cultural considerations in this network and/or zone with yes or no (or n/a)? Take into account the elements for the significance of the water in relation to iwi from Code List 51 based on contribution to: • life force • spiritual • sustenance.	Alpha	Network; zone	Mandatory

5.4.7 Code Lists

The following code lists define the options that can be used to populate the attributes within the service performance schema.

Code List 50: Description of General Service Performance Rating

Code	Description	Comment
1	Very Low	< 50%
2	Low	> 50% – < 68%
3	Medium	> 68% – < 80%
4	High	> 80% – < 95%
5	Very High	>95%

Code List 51: Cultural Significance Outcomes Rating

Code	Description	Comment
1	Life force	Strong significance for water in relation to its purposes, origins, and life force
2	Spiritual	Strong significance for spiritual to iwi i.e. healing powers, connected to trees etc.
3	Sustenance	Strong significance for sustenance i.e. physical, keeps life going, used for cooking

Code List 52: Environmental Outcomes Rating

Code	Description	Comment
1	Very High	+10% - 15% agreed Outcome
2	High	+ 5% - 10% agreed Outcome
3	Medium	+/- 5% agreed Outcome
4	Low	- 5% - 10% agreed Outcome
5	Very Low	-10% - 15% agreed Outcome

Code List 53: Environmental Outcomes Rating – Potable Water Source Environment

Code	Description	Comment
Environmental Rating – Amenity Outcomes		
1	Very High	+10% - 15% agreed Outcome
2	High	+ 5% - 10% agreed Outcome

Code	Description	Comment
3	Medium	+/- 5% agreed Outcome
4	Low	- 5% - 10% agreed Outcome
5	Very Low	-10% - 15% agreed Outcome
Environmental Rating – Ecology Outcomes		
1	Very High	+10% - 15% agreed Outcome
2	High	+ 5% - 10% agreed Outcome
3	Medium	+/- 5% agreed Outcome
4	Low	- 5% - 10% agreed Outcome
5	Very Low	-10% - 15% agreed Outcome
Environmental Rating – Source Environment Outcomes		
1	Very High	Marine reserve or significant ecological area
2	High	Inner estuary
3	Medium	Streams
4	Low	Lake, Harbour, River
5	Very Low	Ocean or other not listed
Environmental Rating – Restoration Outcomes		
1	Very High	+10% - 15% agreed Outcome
2	High	+ 5% - 10% agreed Outcome
3	Medium	+/- 5% agreed Outcome
4	Low	- 5% - 10% agreed Outcome
5	Very Low	-10% - 15% agreed Outcome
Environmental Rating – Water Quality Improvement Outcomes		
1	Very High	+10% - 15% agreed Outcome
2	High	+ 5% - 10% agreed Outcome
3	Medium	+/- 5% agreed Outcome
4	Low	- 5% - 10% agreed Outcome
5	Very Low	-10% - 15% agreed Outcome