PWC Asset Class Management Plan

Distribution substations

January 2023

PowerWater

Version control

This document has been approved in accordance with the Delegation of Authority (DoA) as evidenced by signatures and dates contained herein.

Rev	Date	Description	Author	Endorsed	Approved
1	17/01/2023	Revised and moved to new template	M Van Doornik Asset Engineer	B Kaye Manager Asset Strategy and Risk	S Eassie Senior Manager Asset Management

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1. Introduction

ISO 55000 defines an Asset Management Plan (AMP) as documented information that specifies the activities, resources and timescales required for an individual asset, or a grouping of assets, to achieve the organisation's asset management objectives.

1.1 Purpose and context

The purpose of this Asset Management Plan (AMP) is aligned to the requirements specified in ISO 55000. This AMP:

- Defines what is included and excluded from its scope
- Describes the asset class being managed
- Defines how this asset class will contribute to achieving the Asset Management Objectives that are defined in the Strategic Asset Management Plan (SAMP)
- Identifies the challenges we are expecting to encounter over the AMP planning horizon
- Sets out the projects and programs that we will invest in to ensure we achieve the AM Objectives and address the identified challenges
- Quantifies the risk posed by this asset class with and without the proposed projects and programs of work.

By reviewing this AMP and reassessing asset performance on an annual basis, we will ensure that any emerging issues are identified and can be addressed prior to becoming a significant risk. The outcome of the annual review will support the annual update of the Statement of Corporate Intent (SCI) and provide an input into the annual Transmission and Distribution Annual Planning Report (TDAPR).

1.2 Scope of the AMP

This AMP covers distribution substations, including pole-mounted, ground and package substations.

The AMP excludes:

- Non-regulated or Indigenous Essential Services (IES) assets, nothing that the emerging challenges and risks are similar across the different populations and improvement plans are also applicable.

This AMP will avoid, as far as practicable, repeating information that is contained in other documentation. Instead, it will provide a reference to the relevant document or data source.

1.3 Timeframe of the AMP

This AMP is focused on a 10-year planning horizon, with respect to expenditure forecasts, that aligns with the requirements of the SCI and TDAPR. However, when assessing future challenges and emerging trends we may consider longer timeframes and will comment by exception if any longer-term issues are expected to arise.

1.4 Asset management framework

Power and Water has a Strategic Asset Management System[1] which sets out the framework for asset management and the hierarchy of documents. This provides line of sight from the corporate objectives through to the asset objectives and how management of this asset class will contribute to achieving those objectives. Figure 1 highlights how the AMP fits in with the overall asset management system.

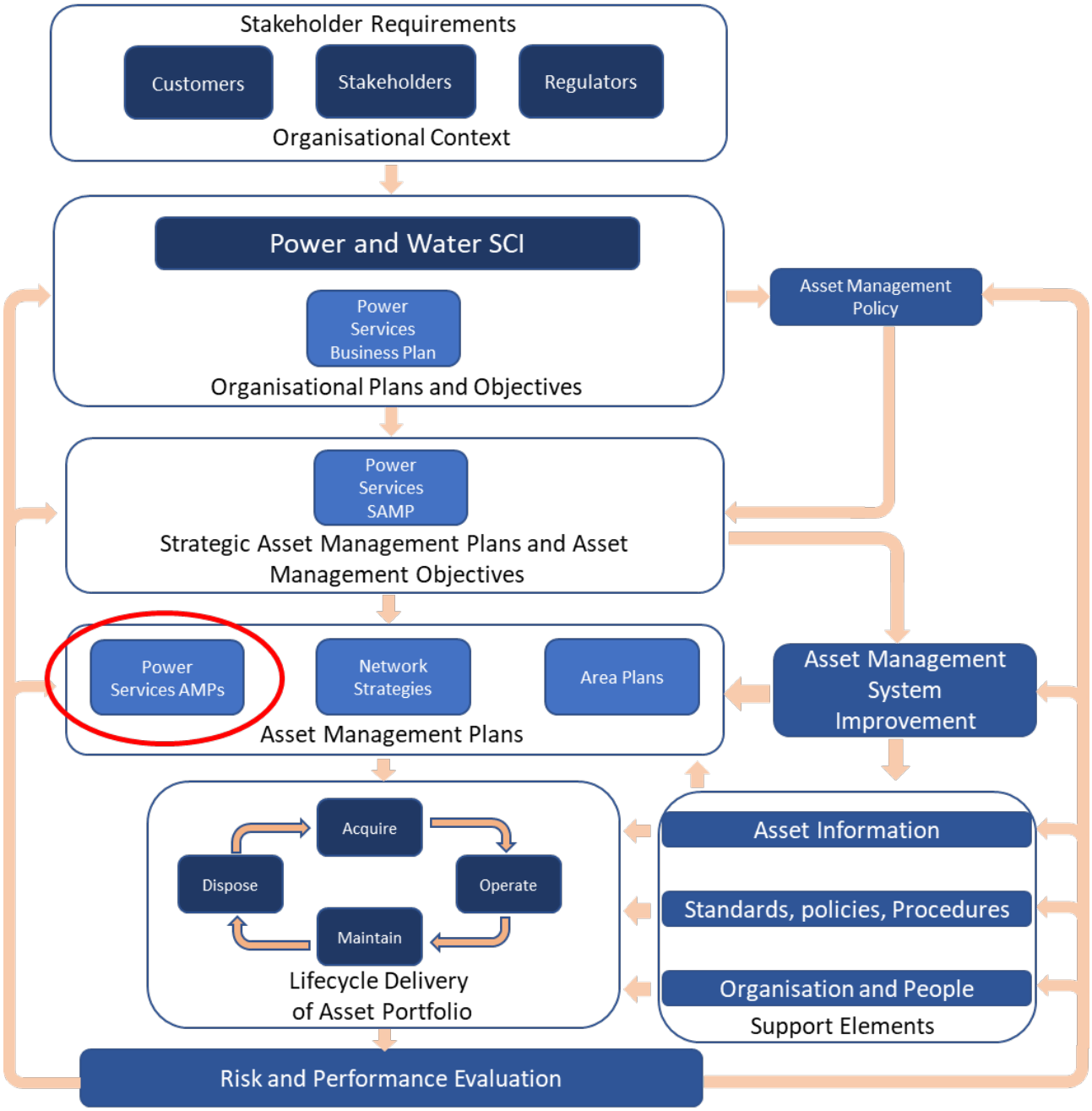

Figure 1: The AMP within the context of the Asset Management System

[1] CONTROL0548

1.5 Document structure

This document has been structured to align with the Power and Water Asset Management Standard and fits under the SAMP in the hierarchy of documentation. The document has been designed to be concise and provide the outcomes of detailed analysis with references, and not repeat the analysis in this document.

The purpose of each section is described below:

- **Asset profile** provides an overview of what the asset is to provide context to the reader of the asset's role in the electricity transmission and distribution network. It provides a breakdown by asset characteristics and volumes as well as the age profile which is an important input to asset management.
- **Asset objectives and performance** sets out the asset objectives and how they apply to this asset class. Any gaps or emerging trends are identified and linked to a project or program, if relevant, to address the issue and ensure the asset objectives are achieved.
- **Asset challenges and emerging issues** outlines any existing or emerging challenges that may impact the performance of the asset class or may otherwise impact the management of, or need for, the asset class.
- **Implementation plan** sets out the project and programs with expenditure per year for the 10-year planning horizon. This is a point in time assessment that is updated periodically so it may not align fully to the SCI and TDAPR if additional analysis has been completed subsequent to the AMP update.
- **Risk quantification and mitigation** describes the approach to risk-based investment decision-making and demonstrates the risk mitigated by the proposed implementation plan.
- **Asset lifecycle management** describes the asset management approach at each stage in the asset lifecycle.
- **Continuous Improvement** outlines the improvement plans related to the asset class.

2. Asset profile

Power and Water owns and maintains a portfolio of 4,898 distribution substations across the four regions of Alice Springs, Darwin, Katherine and Tennant Creek, with the largest population in the Darwin Region.

The distribution substations function across the different network voltage levels including LV (400V) and HV (6.35kV, 11kV, 22kV). The asset class for distribution substations can be broken down into four types:

- Ground substations (installed within a building or fenced enclosure)
- Package substations (enclosed unit, usually housing HV and LV switchgear)
- Pole mounted substations
- Single phase substations (similar to package substations but treated separately due to unique issues)

Distribution substations convert distribution voltages to 230/400V for consumers to use. They are located close to consumers since low voltages cannot be distributed over long distances due to the resulting voltage drop.

2.1 Fleet characteristics

In-scope assets include Power and Water's distribution substations which include the four main subclasses. Table 1 provides an overview of the asset class**.**

Asset type[1]	Quantity	Average age	Nominal lifespan
Ground Substation	342	21 years	45 years
Package Substation	1,297	20 years	45 years
Pole Substation	2,936	17 years	45 years
Single Phase Substation	323	35 years	45 years
Total	**4,898**	-	-

Table 1 - Overview of in-scope assets

2.2 Age profile

The age profiles provide an early indication of expected asset condition and potential life extension or renewal investment requirements. The asset age profile for distribution substations is shown in Figure 2.

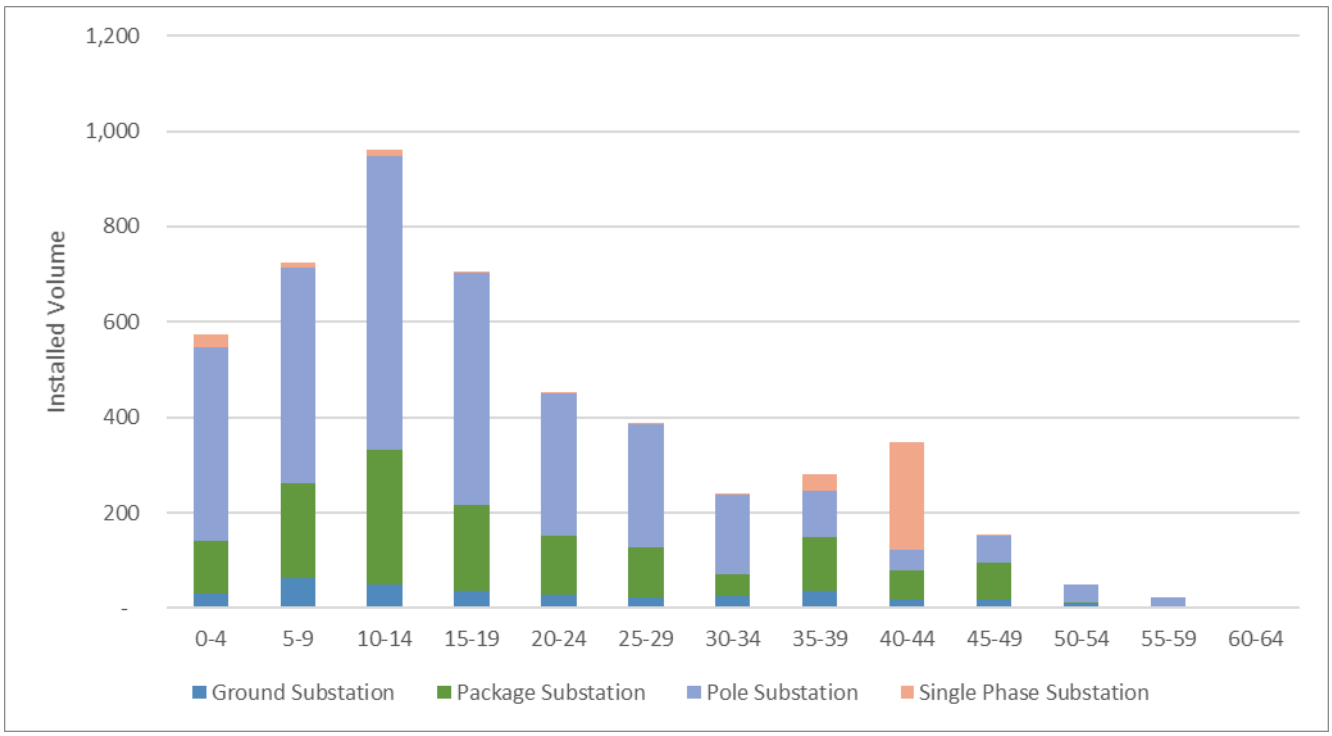

Figure 2 – Age profile by substation type

The age profile shows a young asset group, with relatively few assets currently exceeding the nominal life of 45 years. The majority of single-phase substations are approaching end of life, and this is discussed further in section 4.

2.3 Criticality

Power and Water has established a Risk Quantification Procedure for Investment Decision Making to assess the overall risk posed by the asset fleet. However, when undertaking detailed scheduling and prioritisation of assets within the fleet for specific tasks, such as testing and inspection or replacement, we consider the localised characteristics of individual assets to account for relative criticality within the fleet.

The criticality assessment considers the diversity of the network including impact on public safety, service disruption (reliability) or environmental incidents. The location of an asset has a significant impact on the likelihood and severity of the consequences.

Details of the criticality assessment approach can be found in our Health and Criticality Method (D2018/72550).

3. Asset objectives and performance

The Strategic Asset Management Plan (SAMP) defines the Asset Objectives and how they support Power and Water achieving the corporate objectives. This section shows how the Asset Objectives are supported by this asset class by establishing the measures and targets to assess if the Asset Objectives are being achieved, and any gap in performance that needs to be addressed.

Table 2 states the asset management objectives from the SAMP, identifies whether they are relevant to this asset class, and defines the measures of success, targets and performance gaps. This provides a 'line of sight' between the discrete asset targets and Power and Water corporate Key Result Areas.

The performance shown here represents the historical performance of the asset class to date. It is expected that benefits from investments proposed in the next regulatory period will manifest as benefits in these key objectives.

Objectives	Measures	Targets	Performance
Ensure appropriately skilled and qualified staff are employed to meet the current and future needs of the network. Embed a fit for purpose Asset Management System across the business that is consistent across Regulated, Non-Regulated and IES.	A capability development plan will include the requirements to ensure each asset class has defined capability requirements to enable effective management and performance. The development of our Capital and Operational Works Plan (COWP) will define capacity requirements across different capabilities to achieve asset management objectives.		
Maintain the safety of customers, community and staff demonstrated by reducing worker and public safety incidents and implementing public incident reporting metrics into asset plans.	Public injuries	0	0
	Worker injuries	0	0
Reduce by 50% the number of feeders and communities exceeding performance targets by more than 100% by 2025. Enable greater visibility of planned and unplanned interruptions to customers through improved online services for all networks and improve accuracy and transparency of	SAIDI and SAIFI targets.	Target by feeder type as set by the Utilities Commission.	Targets achieved. Refer to section 3.2

reliability performance metrics for isolated remote communities.			
Implement risk quantification for all regulated network (system) capital investment decisions by Jan 2023, and extend for remote generation and networks by 2025.	Implementation of risk quantification for decision making.	Use of Risk Quantification to assess investment needs for all aspects of the asset fleet.	Achieved.
Implement by EOFY 2023 asset criticality process to support granular prioritisation of corrective works based on public safety, reliability, security and other factors, and implement in the AMS and supporting systems by 2025	A quantitative criticality assessment criterion that can be integrated into defect management processes and supported by our ICT systems to be developed for all asset classes.		
Preparing our network and systems to be ready for the future, including building in flexibility for future uncertainty, maximising hosting capacity for customer DERs and enabling the energy transition to reviewable energy according to the governments targets.	Development of specific capability requirements for various asset classes is a key focus of our Future Networks Strategy to support increased utilisation of DER while maintaining safety and reliability performance.		

Table 2 - Asset Management Objectives

3.1 Reliability performance

The Utilities Commission requires Power and Water to report performance against targets for SAIDI and SAIFI, by feeder category and network region. We do not disaggregate the feeder category targets by asset class. Instead, we assess the performance of each asset class to identify trends that require further analysis, and to determine if a specific program of works is required to support achievement of our targets at the feeder category level.

From a whole of system perspective, Power and Water has continued to improve its performance, although there has been mixed performance in each feeder category and region. These trends are discussed in the SAMP and are the subject of the network reliability performance improvement strategy.

Figure 3 shows the historical and forecast performance of the distribution substations asset class. The data shows that the average duration of interruptions experienced by customers due to substation failures has

decreased steadily over time. However, there has been a noticeable increase in SAIDI between FY19 and FY21. These failures were mostly due to age-related deterioration and lightning events. Although the failure of a single transformer does not impact many customers, if an upstream protection device trips due to a transformer or EDO fault, it can affect many customers and take significant time to locate and restore, resulting in a high SAIDI contribution.

Although there is some year-to-year variation, the SAIDI contribution of distribution substations appears to have stabilised at around 4 SAIDI minutes since FY15. This can be partially attributed to our ongoing feeder improvement programs which aim to target the worst performing feeders with reliability improvements such as increased network automation, segregation and new HV feeder ties.

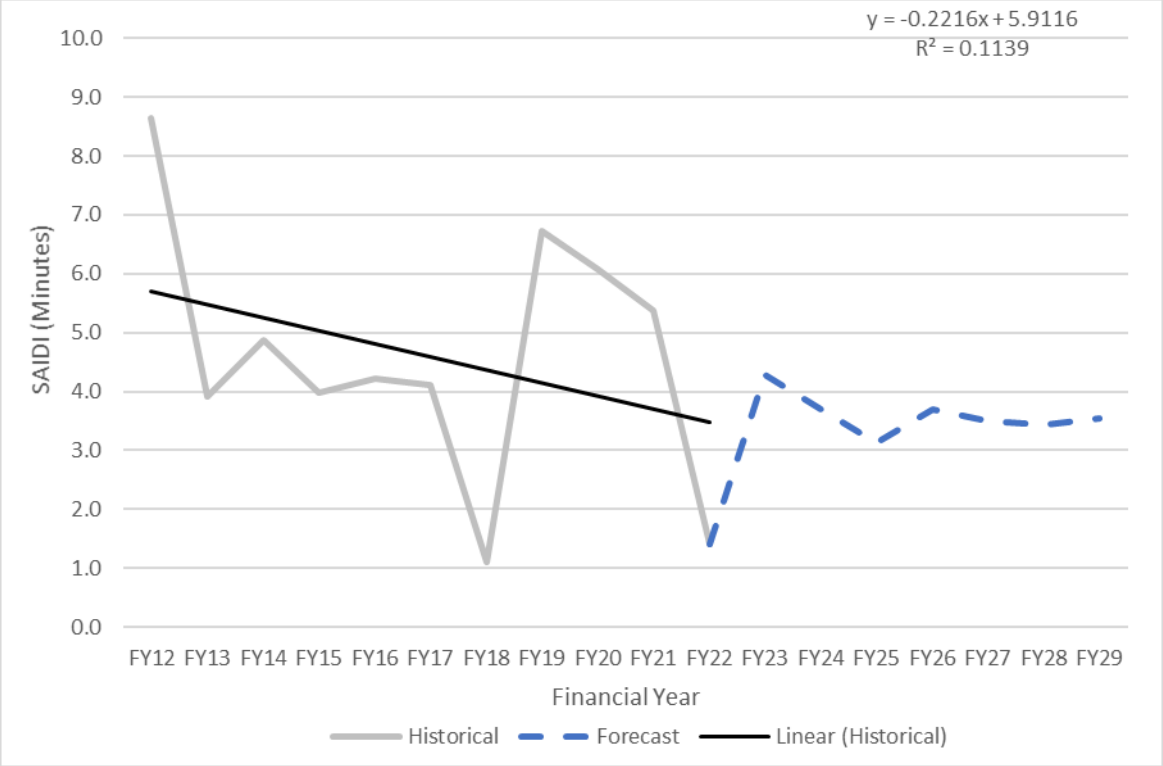

Figure 3 - SAIDI performance of the distribution substation asset class

3.2 Asset safety

Single phase substation condition is a key public safety concern. The substations are typically located in the front yards of residential properties and subject to watering and build-up of dirt and leaves, and the likelihood of people being present during a failure event is elevated. We have implemented a program of replacement and refurbishment to address this issue, as discussed in section 4.1.

The number of safety related events associated with distribution substations for the past 10 years are documented in Table 3.

Category	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	Total
Exposed	-	1	1	-	-	3	1	1	-	-	**7**
Vehicle / impact damage	2	8	6	7	25	19	10	6	1	3	**87**

Table 3 - Safety incidents in the last 10 years

The “exposed” category refers to instances where a package substation has been found to be improperly locked or secured, resulting in the potential for access by members of the public. In response we are planning a review and replacement of package substation locks and locking mechanisms to prevent unauthorised access to the assets.

4. Asset Challenges and emerging issues

4.1 Single phase substation refurbishment program

The single-phase underground substation network includes 323 substations in Darwin's urban area. The majority of the substations were installed over a four-year period from 1980 to 1983 and the portfolio has an average age of 35 years.

Corrosion at the bottom of transformer tanks is the most common failure mode. The substations are typically located in the front yards of residential properties and subject to watering and build-up of dirt, leaves, etc. These installation and environmental conditions maintain moisture beneath the tank and accelerate the corrosion of the base of the substation. As the corrosion is not visible, oil leaks develop over time, contaminating soil around the substation and, if undetected, ultimately lead to internal flashover.

Electrical failure due to loss of insulating oil places people in proximity to the substation at risk. Containment of fault energy cannot be guaranteed and being a residential area, the likelihood of people being present during a failure event is elevated.

There is no ability to transfer loads between single phase substations so generators are required to maintain supply to customers in the event of a faults or corrective work. As a result, faults and defects result in an excessive performance and cost impact.

A targeted replacement and refurbishment program to rectify corrosion defects and bring high risk substations back to acceptable design standards is proposed – refer to section 5 for more information.

4.2 Power quality compliance program

Power and Water is required under Australian Standards and the Network Technical Code to comply with prescribed network performance standards. The performance standards apply to power system frequency, power quality, electromagnetic interference, and stability. The power quality standards principally concern voltage management to enable customer's electrical equipment to function as designed and without damage or reduction in expected service life. A key driver of this program is the significant increase in rooftop solar throughout the Northern Territory, in a network that was designed for monodirectional power flow.

A power quality program has been established to address these non-compliance issues. The issues are analysed to identify the most efficient solution to address voltage issues and may require a new or upgraded distribution substation.

5. Implementation plan

The following set of projects and programs have been developed to address the gaps in asset performance compared to the asset objectives and our long-term view to start planning for forthcoming asset challenges.

5.1 Replacement expenditure

Replacement expenditure is defined as work to replace an asset with its modern equivalent where the asset has reached the end of its useful life. Capex has a primary driver of replacement expenditure if the factor determining the expenditure is the existing asset's inability to efficiently maintain its service performance requirement.

The identified projects and programs are listed below. The indicative cost (real FY22) of the project or program for the 10-year horizon is provided and includes the entire project, not only the distribution substation component:

- All regions condition and failure-based replacement program ($ 55.6 million)
- Single phase substation refurbishment program ($6.5 million)

5.2 Augmentation expenditure

Augmentation expenditure is defined as work to enlarge the system or to increase its capacity to transmit or distribute electricity. It also includes work relating to improving the quality of the network, for example, to meet regulatory obligations.

The identified projects and programs are listed below. The indicative cost (real FY22) of the project or program for the 10-year horizon is provided and includes the entire project, not only the distribution substation component:

- Power quality compliance program ($6.8 million)
- Protective security program ($1.75 million)

5.3 Operational expenditure

The forecast annual expenditure on maintenance activities is outlined in Table 4 below.

Maintenance Type	All Assets	Distribution Substations
Routine Maintenance	$7.0	$0.3
Non-Routine Maintenance	$7.7	$1.6
Emergency Response	$7.6	$1.1
Total	**$22.3**	**$3.0**

Table 4 - Forecast annual maintenance expenditure ($ Million FY22)

5.4 Delivery plan

There have been a number of challenges during the current regulatory period that have resulted in under-delivery of capital plans. We have undertaken a detailed analysis of our internal processes and activities to identify the causes and compiled a detailed plan to address this issue. The analysis and resulting plan to enable delivery of the proposed program of works is described in our Capital Delivery Plan.

6. Risk quantification and mitigation

Power and Water has established a Risk Quantification Procedure for Investment Decision Making to assess the overall risk posed by the asset fleet. Our procedure considers the asset's condition and failure modes, the likely risks of failure on safety, security and reliability of services to customers, and the relative maintenance and capital costs. In some cases, our decision making will be influenced by demand growth or customer upgrade requirements. Essentially, our decision making is based on an economic assessment of risks, costs, and benefits.

Figure 4 below shows our forecast of risk on the network that is contributed by the distribution substation asset fleet. The unmitigated risk shows increasing risk cost if no actions are taken to address known issues. The mitigated risk shows the risk cost increases slightly but is largely maintained if the suite of proposed programs is implemented. The current risk level provides a reference to the current level of risk.

The risk is driven by the general condition of the asset fleet as well as the specific issues that have been identified with single phase distribution substations. By addressing the known defects and continuing with our approach of replacement at functional failure, we can largely maintain network risk for this asset class. Our risk based economic analysis demonstrates that implementing the proposed replacement programs and reducing the contribution of risk cost is efficient and has a net benefit to our customers.

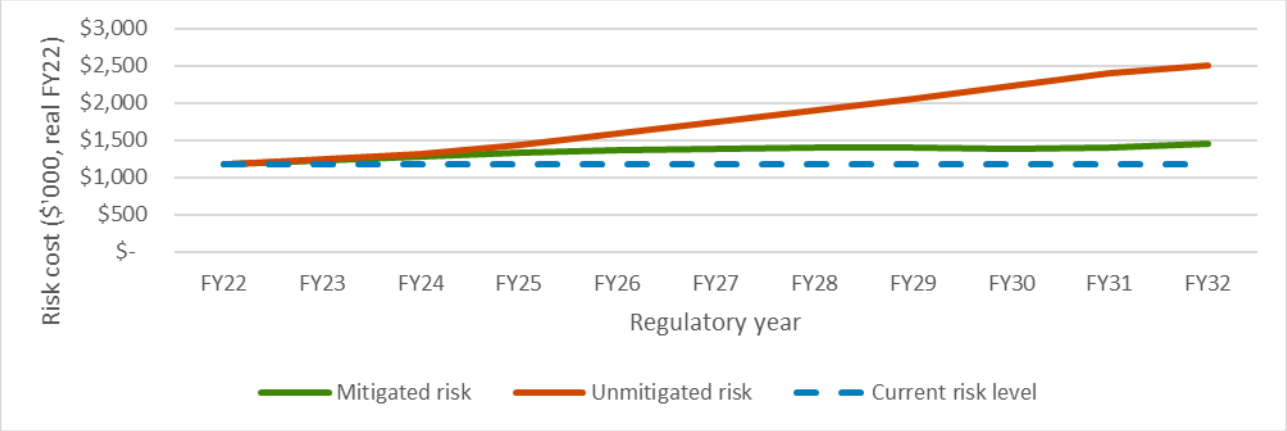

Figure 4 - Forecast total unmitigated and mitigated risk compared to the current risk level

7. Lifecycle asset management

Power and Water's asset management approach considers the entire asset lifecycle. This approach supports prudent asset management decision making to effectively balance risk, cost and performance over the life of the asset. The intended outcomes of a lifecycle approach are to:

- Maximise asset utilisation
- Minimise asset lifecycle costs
- Keep asset risk as low as reasonably practical
- Review and continuously improve asset management practices

The following sections detail Power and Water's lifecycle management activities.

7.1 Planning

Asset planning identifies the need for an asset, outlines its functional requirements, and identifies the lowest cost solution that maintains risk within tolerable levels. Key planning inputs include asset condition, performance, criticality, and forecast demand.

For distribution substation assets, other planning considerations are site selection, capacity requirements and environmental and cultural heritage constraints.

7.2 Design

The design phase involves the detailed specification of the asset function and physical characteristics.

Power and Water develops and maintains standard designs and technical specifications for most distribution assets, including distribution substations, all new distribution assets installed in the Power and Water network must comply. Standardisation has many benefits, including staff familiarity, asset and component interchangeability, increased production and productivity, and standardisation of construction equipment and processes. This is especially the case for assets with a high volume of installation and replacement.

7.3 Maintenance

Asset maintenance involves the upkeep of assets to ensure they will function to their required capability in a safe and reliable manner from their commissioning through to their disposal. Maintenance requirements can evolve as the condition and performance requirements of the assets change throughout its life.

Maintenance activities can be classified into three distinct areas:

- **Preventative maintenance** involves the activities carried out to reduce the probability of failure or degradation of asset performance. It includes routine inspection and monitoring, upkeep and repair, testing and component replacements. Preventative maintenance requirements are documented in our Asset Strategies Procedure. For distribution substation assets we perform a regular visual inspection, thermographic scans and testing of substation earthing.
- **Corrective maintenance** involves planned activities to repair defects or restore asset condition. Defects are typically identified during preventative maintenance and are prioritised for rectification based on the risk they pose to the network.

- **Unplanned maintenance** involves activities to immediately restore supply or make a site safe in response to asset functional failure.

7.4 Renewal

Asset renewal is the establishment of a new asset in response to an existing asset's condition, or the extension of life of an existing asset. The need for asset renewal is typically identified during maintenance and is verified in the asset planning stage. Asset renewal aims to optimise the utilisation of an asset whilst managing the safety and reliability risk associated with the failure of the asset.

Where it is practical to do so, Power and Water has targeted asset replacement programs which aim to proactively replace assets when the risk of asset failure is higher than the cost of the replacement. In some cases, proactive replacement is not justified, and the asset is replaced upon failure.

Section 5 outlines the implementation plans relevant to distribution substations.

7.5 Disposal

Assets are assessed for potential reuse prior to disposal. Where it is economical to do so, assets may be retained as essential spares or components of the asset salvaged for spare parts. This is particularly the case for legacy assets since like-for-like replacements may not be available. Assets with remaining value are offered for sale prior to disposal.

Power and Water ensures that all assets identified for disposal are disposed of in an environmentally responsible manner. Older distribution substation assets have the potential for PCB contamination in the insulating oil, so assets require testing prior to disposal to ensure compliance with statutory obligations.

8. Continuous improvement

Table 5 below outlines the improvement plans related to the asset class.

Improvement Area	Today	Tomorrow / In Development	Future
Standards	Pole substations standards in place have no requirement for LV fusing	Review LV fusing standards to better understand protection coverage during conductor drops, benchmark industry best practice	Integration with voltage control capability to manage DER impacts
Asset inspection	Visual inspection of substation assets using check sheets	Develop asset inspection manuals and training materials and competencies.	Remote monitoring capability at efficient cost, reducing inspection cost.
Defect prioritisation	Prioritisation using high level risk assessment and staff experience	Systemisation of asset criticality and improved failure codes	Risk based defect prioritisation supported by asset systems

Table 5 - Asset improvement plan

Power and Water Corporation

Senior Manager Asset Management
Power Services
Phone 1800 245 092

powerwater.com.au

PowerWater