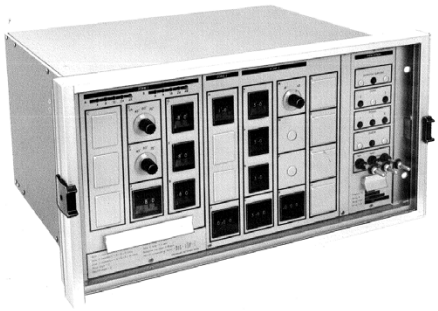

SUBSTATION PROTECTION RELAY REFURBISHMENT

Program PS008 Business Case 2017/18 – 2018/19

Prepared by Strategy and Network Planning

April 2017

Endeavour Energy

REVIEW AND APPROVAL SCHEDULE

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1.0 EXECUTIVE SUMMARY

This business case seeks approval for the expenditure to replace protection relays in zone and transmission substations throughout the network as the next stage of the ongoing relay replacement program PS008. This business case was initiated by a Statement of Asset Need from Asset Standards and Design which identified relays that are experiencing an increasing number of failures which is evidence of them reaching the end of their life.

Relays that increasingly operate inappropriately place a greater reliance on the backup protection schemes that are in place and/or cause unnecessary outages to customers and may attract penalties for the company under the Service Target Performance Incentive Scheme.

This business case includes the replacement of 239 protection relays at 42 transmission and zone substations over the two year period from 2017/18 – 2018/19.

The total cost of the works is $5.60 million in real terms and $5.71 million in nominal terms. A further risk based contingency of $0.40 million being 7% of the estimated project cost is proposed to allow for unforeseen cost increases due to the works being conducted in aged substations which contain hazardous materials such as asbestos.

The Portfolio Investment Plan (v8.2) includes a provision for $4.12 million under program PS008 over this period. Further funding will be provided in the 2018/19 PIP to provide for the works in the 2018/19 year.

Accordingly, it is recommended that:

- A capital expenditure of $5.71 million to replace 239 protection relays at 42 transmission and zone substations throughout the network over the period of 2017/18 – 2018/19 as detailed in this business case be approved;
- A contingency sum of $0.40 million, representing approximately 7% of the estimated cost of the project to cover unforseen events be approved;

The project estimate, including the contingency sum, totals $6.11 million

2.0 INTRODUCTION

2.1 PURPOSE

This business case seeks endorsement for an increase in future expenditure under this program and approval for the expenditure to replace protection relays which have reached the end of their life in zone and transmission substations throughout the network during 2017/18 – 2018/19. It is in response to a Statement of Asset Need (SAN) provided by Asset Standards & Design which identified relays which are experiencing an increasing number of failures, indicating that they are reaching the end of their life and requiring renewal in the short term. Refer to Appendix A for further detail of the SAN documents.

A further SAN is attached as Appendix B. This document outlines the long term strategy for relay replacement and the levels of expenditure that are needed to support this approach. This strategy has been adopted by the Company and has been funded through the Portfolio Investment Plan (PIP).

2.2 BACKGROUND

Within Endeavour Energy's zone and transmission substations there are currently over 18,000 protection relays in service which are covered by this program, PS008.

The function of these relays is to interpret signals from measurement devices such as instrument transformers to identify faults in the network. Once a fault has been detected they signal a circuit breaker to clear the fault. It is important that this process occurs reliably to reduce the risk of exposure of network faults to the public as well as workers and to minimise damage to the network caused by the passage of fault current.

It is also important that a relay does not suffer from spurious mal-operations (i.e. they should not operate when a network fault is not present) as this may cause unnecessary outages to customers and attract penalties for the company under the Service Target Performance Incentive Scheme (STPIS).

In Endeavour Energy's network there are a number of generations of protection relays in service reflecting the age and development of the network over time. These include:

- Electromechanical relays;
- Electronic relays;
- Numerical relays.

An age profile for relays in Endeavour Energy's network based on commissioning dates recorded in the Ellipse database is shown in Figure 1 below.

2.2.1 ELECTROMECHANICAL RELAYS

Between the 1950s and 1980s electromechanical relays were installed in the network. These relays rely on induction coils and moving parts which react to signals from instrument transformers. These relays are mechanically complex but have limited functionality and settings which do not provide flexibility to adjust to changes in the protection requirements of the network.

The life expectancy of electromechanical relays varies from 30 to more than 60 years depending on the type of relay and the level of maintenance carried out. Therefore many are currently approaching the end of their service life.

2.2.2 ELECTRIC RELAYS

During the 1990s electronic relays were beginning to be installed in the network. These relays use electronic components to simulate the characteristics of the earlier electromechanical

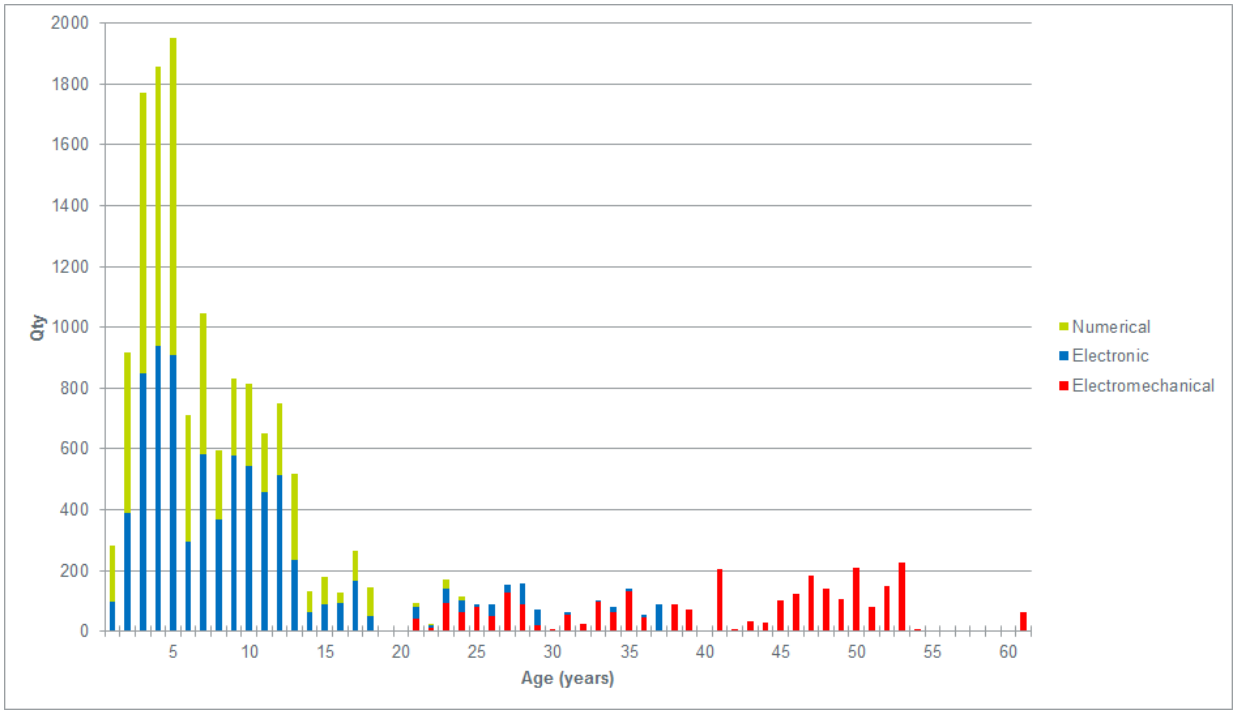
relays and have the same limited functionality and settings. These relays have proven to be robust and reliable with life expectancy of 15 to 30 years depending on the make and model.

2.2.3 NUMEREICAL RELAYS

Over the last 15 or so years numerical relays have been installed in Endeavour Energy's network. These relays use microprocessors to provide greater flexibility, accuracy, performance and functionality than what could be provided by electromechanical or electronic relays.

The life expectancy of numerical relays is 10 to 30 years. This is shorter than their predecessors due to the complex microprocessor based electronics used. Therefore, many of the older numerical relays in the network are already approaching the end of their life.

FIGURE 1 – RELAY AGE PROFILE



2.3 RENEWAL STRATERGY

Endeavour Energy has in place a strategy of replacing individual protection relays or complete protection schemes with numerical relay schemes based on an assessment of the risks posed by these relays and schemes taking into consideration:

- The failure history and probability of failure of that relay;
- The impacts of the type of failure considering the location the relays are installed;
- The level of backup protection provided by other relays;
- Whether or not the relay has watchdog supervision and a failure alarm;

Refer to the SAN in Appendix A for further detail of the risks posed by each relay and the primary and secondary benefits provided by their replacement.

2.3.1 PROBABILITY OF FAILURE

The probability of failure for a particular type of relay increases as it ages. This probability is calculated based on historical failures recorded in the Ellipse database.

2.3.2 IMPACT OF FAILURE

The impact of failure depends on the part of the network that the relay protects and the consequence of the relay failing to operate.

2.3.3 LEVEL OF BACKUP PROTECTION

The greater the degree and reliability of backup protection that is present reduces the reliance the network has on a particular relay. Therefore, this reduces the likelihood of the potential impact from occurring upon failure of the relay.

2.3.4 FAILURE ALARMS

If the relay has watchdog supervision and a failure alarm, system operations will be informed when a relay fails whilst in-service. This will provide an opportunity for the organisation to repair the failed relay before a fault is encountered.

2.3.5 RELAY REPLACEMENT

The decision to replace a relay is reached when its probability of failure has increased so that the risk of the impact occurring outweighs the cost to replace the relay. Refer to Appendix A for further detail and examples of different types of relays.

2.3.6 RELAY TYPES WITH LOW POULATION

It is not practical to assess failure rates of relays where there are only a few of that type in the network. It is recommended that an age based renewal strategy is taken for these relays before they are expected to reach a high risk of failure as shown in Appendix B.

2.4 REPLACEMENT CATEGORIES

Based on the risks shown above certain categories of relays have been identified for renewal. These are summarised below. Refer to Appendix A and Appendix B for further detail.

2.4.1 HIGH FAILURE RATE RELAYS

This group of relays are relays that are displaying an increasing rate of failure in recent years. This has been determined by analysing records of defects and failures of the relays on ellipse entered in the last five years. These relays have a high probability of failure when required to operate and is risk of resulting in an uncleared fault resulting in damage to the network.

2.4.2 RELAYS WITH NO REDUNDANCY

This group of relays are relays that are distribution feeder relays with no backup relay. In the event that these relays fail to clear a fault the upstream transformer circuit breaker is required to operate. However the transformer relay cannot account for the entire length of the feeder and faults on the ends of the feeder will remain uncleared resulting in safety issues and damage to the feeder.

There are 18 relays in the network that fall under this category. All relays are numerical relays which are either approaching 20 years of age or are over 20 years of age. As shown in page 2 in Appendix B, these relays are expected to acquire a high rate of failure in the short term. Given the risks associated with uncleared faults it is recommended that these relays are replaced in the short term.

Relays in this category are required to maintain a very low failure rate and to avoid premature replacement of future relays at these sites it is recommended that these single relay protection schemes are replaced by a duplicated relay protection scheme.

2.4.3 RELAYS FOR 132KV FEEDERS

This group of relays are relays that provide protection for 132kV feeders. All 132kV feeder protection schemes contain duplicate relays and therefore have good levels of backup. However, if the protection scheme fails to clear faults there will be major impacts to large parts of Endeavour Energy's network as well as the networks of other utilities. It has been found that it is not acceptable for these relays to have a failure rate of more than 1% per event.

2.4.4 AGED RELAYS WITH LOW POPULATION

Relays in this category have been nominated for renewal due to their age suggesting they are approaching end of life as detailed in page 2 in Appendix B.

2.5 FURTHER BENEFITS OF REPLACEMENT

Further benefits associated with the replacement of the relays noted above are discussed below.

2.5.1 REDUCED SAFETY RISK

The replacement numerical relays will reduce the risk of slow clearing of faults and therefore the exposure of the public and workers to fault energy and earth potential rise hazards.

2.5.2 REDUCED STPIS PENALTY

Reducing the incidents of protection failure to operate or mal-grading will reduce the impact on the company's reliability indices and hence the exposure to STPIS penalties.

2.5.3 REDUCED DAMAGE TO NETWORK ASSETS

Rapid and reliable clearing of faults will reduce the fault energy to which the network is exposed with reduced cumulative thermal and mechanical wear and damage to the equipment carrying the fault current. This in particular will result in reduced stress on power transformers supplying the fault current and also reduce the likelihood of bonds being burnt off in the overhead distribution network.

2.5.4 IINCREASED PERFORMANCE

Numerical relays provide flexibility, accuracy and performance as well as adding additional functionality and the ability for substantially faster electrical fault clearance times by taking advantage of:

- Multiple programmable characteristic curve shapes;
- A more flexible time shift multiplier;
- A more accurate characteristic (e.g. trip, overshoot and reset times) resulting in the potential for a reduction in coordination margins;
- The ability to use high speed or instantaneous protection at higher fault levels and the ability to change this characteristic by SCADA remote control depending on the circumstances (e.g. during high risk works such as switching and live line work).

2.5.5 INCREASED FUNCTIONALITY

Fault information and response

Immediate remote indication of fault type and fault current which can be provided by numerical relays will enhance critical operational decisions. For example, knowledge of the fault level can assist in determining where on the network the fault is likely to be, leading to faster restoration of supply.

Condition based maintenance

Fault level data transmitted to SCADA presents opportunities to improve condition based maintenance practices. For example, circuit breaker maintenance can be scheduled based on actual wear and tear based on accurate knowledge of actual fault levels experienced by the circuit breaker and by knowing which phases were involved in each fault, compared to the existing practice which assumes a maximum fault level and all three phases exposed for each fault operation.

Forensic analysis of network incidents

Detailed fault records from numerical protection relays connected to the SCADA system assists with the investigation of fault incidents, providing a better understanding of the events and the performance of the network during incidents. This leads to more efficient remedial action resulting in enhanced safety and reliability of the network at lower cost.

3.0 PROPOSED REPLACEMENT PROGRAM

3.1 SCOPE OF WORKS

The proposed replacement works include:

- Replace single relays with new duplicate relays;
- Like for like replacement of all other relays with new numerical relays;
- Wiring and marshalling replacement works, including the wiring of additional circuits to trip coils, circuit breaker failure circuits etc. to connect the new relays to the existing protection and control systems and SCADA systems;
- Modification of protection panels to accommodate the new relays;
- Replacement of associated ancillary relays such as multi-trip and supervision relays, where required.

3.2 RELAYS TO REPLACE

During 2017/18 - 2018/19 it is proposed that 239 relays will be replaced. Table 1 below shows the summary of these relays and the associated costs.

TABLE 1 – RELAY REPLACEMENTS

Relay Type	Scheme	Number of relays	Estimated Cost ($)
Electromechanical	11kV Feeder	3	30,000
	11kV frame leakage	6	37,500
	33kV/66kV feeder	36	1,500,800
	132kV Busbar protection	24	420,000
	33kV Busbar protection	16	400,000
	TX protection	2	12,500
Total electromechanical		**87**	**$2,400,800**
Electronic	11kV Feeder	35	483,500
	11kV busbar	1	10,000
	33kV/66kV feeder	3	76,000
	66kV busbar	1	10,000

Relay Type	Scheme	Number of relays	Estimated Cost ($)
	132kV feeder	3	121,000
	TX Protection	4	130,000
		47	**$730,500**
Numerical	11kV/22kV feeder	48	1,017,000
	33kV/66kV feeder	9	362,500
	33kV busbar	2	57,000
	132kV feeder	5	162,500
	TX protection	41	753,000
Numerical total		**105**	**$2,352,000**
Total (rounded to nearest $10,000)		**239**	**$5,580,000**

Refer to Appendix D for a list of all relays to be replaced under this program and the estimated cost of each scheme. Note that typical current replacement relays for each protection scheme in this business case are shown. The exact model of the replacement relay will be selected during the design phase of each part of the project.

3.3 REPLACEMENT PROGRAM DETAIL AND COST

Table 2 shows the cost of replacing the 239 protection relays as proposed in this business case. Details of the relays are shown in the SAN attached as Appendix A. The relays are located in 42 zone and transmission substations and it is proposed that the works should be carried out over the two year period from 2017/18 – 2018/19. The costs are in real 2017/18 terms and in nominal terms as indicated. Refer to Appendix C for further detail including a breakdown of the costs.

The total base cost of the works is $5.85 million including an allocation for project definitions and project management works.

TABLE 2 – RELAY REPLACEMENT COSTS

Estimated Cost	2017/18	2018/19	Totals
Relay Replacements	1,330,000	4,250,000	**5,580,000**
PD costs	20,000	-	**20,000**
Estimated total cost (real) ($)	1,350,000	4,250,000	**5,600,000**
Estimated total cost (nominal) ($)	1,350,000	4,360,000	**5,710,000**

3.4 CONTINGENCY

A contingency amount of $400,000 (representing 7% of the estimated project base cost) is proposed to allow for unforeseen cost increases due to the works being conducted in aged protection panels in aged substations. These risks are shown in Table 3 below.

TABLE 3 - CONTINGENCY PROVISIONS ($ REAL 2017/18)

Item	Amount ($)
Addition costs associated with working in panels which contain asbestos and or removal of the asbestos.	300,000
Additional wiring and panel works required due to wiring and or panels being in inadequate condition	100,000
Total	**400,000**

3.5 PROJECT FUNDING

This project falls within SARP program PS008 – *Substation protection relay refurbishment*. The program summary in the Portfolio Investment Plan (PIP) v8.2 is shown in Table 4 and reflects the risk level and priority of the program.

TABLE 4 – PIP SUMMARY

PIP element	PIP rating
Project ID	PS008
Principal driver	Renewal
Weighted ranking	3,600
Percentage	53.44%

The PIPv8.2 includes an allocation of $4.11 million over the two year period of 2017/18 - 2018/19 for PS008 which included a gradual ramp-up to an annual expenditure level of around $3 million. This business case, based on the SAN, provides for a more rapid ramping up of expenditure to address imminent renewal needs and therefore there is a shortfall in the PIP allocation across FY18 and FY19. In this business case the expenditure has been spread such that the FY18 expenditure aligns with the PIP allocation but additional funding will be required in FY19. This will be included in the FY19 SARP and PIP. However, delivery of the program may follow a different pattern which will be addressed through the Gate 3 change control process as required.

A nominal split of the expenditure over the two years, including contingency and the allocations currently made for this program in the PIP (in nominal terms) is shown in Table 5 below.

TABLE 5 – PROJECT EXPENDITURE SPREAD

Estimated Cost	2017/18	2018/19	Totals
PIP 8.2 provision ($, nominal)	1,350,000	2,770,000	**4,120,000**
Estimated project cost ($, nominal)	1,350,000	4,360,000	**5,710,000**
Contingency ($)			**400,000**
Project Total ($)			**6,110,000**

4.0 RECOMMENDATIONS

It is recommended that:

- A capital expenditure of $5.71 million to replace 239 protection relays at 42 transmission and zone substations throughout the network during 2017/18 – 2018/19 as detailed in this business case be approved;
- A contingency sum of $0.40 million representing approximately 7% of the estimated cost of the project to cover unforseen events.

The project estimate, including the base costs and the contingency sum, totals $6.11 million.

5.0 APPENDICES

APPENDIX A - Statement of Asset Need - *Protection Relay Renewal*
APPENDIX B - Statement of Asset Need – *Protection Scheme Renewal Need (PS008 & PS011)*
APPENDIX C – Cost Estimate
APPENDIX D – Relay Replacements

6.0 REFERENCES

1. GRM 0003 – Risk Management, 29 July 2014

APPENDIX A - STATEMENT OF ASSET NEED - *PROTECTION RELAY RENEWAL*

Refer to the attached Appendix A – Statement of Asset Need – *Protection Scheme Renewal 2017-2019, March 2017*

STATEMENT OF ASSET NEED

PROTECTION RELAY RENEWAL 2017-2019

SARP PS008

March 2017

Harshul Dalal

Protection Engineer - Secondary Systems

Endeavour Energy

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1.0 EXECUTIVE SUMMARY

This Statement of Asset Need has been written to detail the selection of the replacement of protection relays under the PS008 program for the 2017/18 and 2018/19 years. The primary aim of protection scheme refurbishment is to identify and replace protection equipment which creates an excessive risk to the safety impact or reliability of the network in relation to the cost of replacement.

The cost of the program is estimated to be $5.435 million (plus contingency) over the 2017/18 and 2018/19 financial years and will replace 244 relays across 51 zone and transmission substation sites.

1.1 Primary benefits

The primary benefits of this program include:

- Reducing the risk of incorrect operations leading to outages
- Reducing the risk of non-operation or slow operation for faults leading to excessive equipment damage, public risk as well as the potential for unwanted outages.
- Meeting our obligations in regards to the National Electricity Rules (5.2.3 (e1) and 5.7.4 (a1)) requirement to maintain protection systems in good working order.

1.2 Secondary benefits

In addition to the primary benefits there are secondary benefits associated with the installation of newer modern protection systems which are outlined below:

- Remote indication of fault type, fault current and distance to fault in sub-transmission relays with voltage inputs. This can assist in the assessment of risk and the locating of permanent faults on the network, thus potentially reducing outage times.
- The opportunity to reduce maintenance costs of circuit breakers by basing the maintenance schedule on the actual fault currents and phases involved in the fault.
- Provides detailed fault records, assisting with the investigation of incidents and helping to permit a better understanding of events which can lead to appropriate choice of remedial actions and can help enhance safety and reliability in the future.
- An improvement in power quality (reduced dip times). This has the potential to reduce impacts on and reduce complaints from sensitive customers.
- Decreased maintenance/fault and emergency works and costs

2.0 RISK CONTEXT

2.1 Introduction

Protection relays and their associated equipment are critical to the safety and reliability of the electrical network. Not only do they have to be reliable (that is, they have to operate when called upon), but they also have to be secure (that is, they need to not operate when not called upon). Redundancy is generally designed into the system by way of having multiple protection systems for the one item of plant, so the prevailing impact of protection relay malfunction is insecurity and unintended tripping of plant which commonly results in unnecessary outages.

Potential consequences of incorrect protection operation include:

- Electrocution
- Bushfire ignition
- Excessive plant damage and fire
- Excess arc flash burns consequences
- Loss of system stability and widespread loss of supply
- Lower scale loss of supply, but still with an indicative value of $10k to $5m per event

The primary aim of protection scheme refurbishment is to identify and replace protection equipment which creates an excessive risk regarding risk associated with these consequences.

2.2 Business risks

Protection systems are a key control for the following business risks:

Ref	Category	Description	Residual risk	ALARP status
BR1.1	Safety	Uncontrolled discharge of electricity	High	Non-ALARP
BR2.1	Network	Performance of the network does not meet customers supply expectations	Medium	ALARP
BR2.3	Network	Major fire caused by the network or network activity	High	Non-ALARP
BR2.4	Network	Loss of upstream supply (major reliability event)	Medium	ALARP
BR4.2	Compliance	Non-compliance with legislation or licence conditions	Medium	ALARP

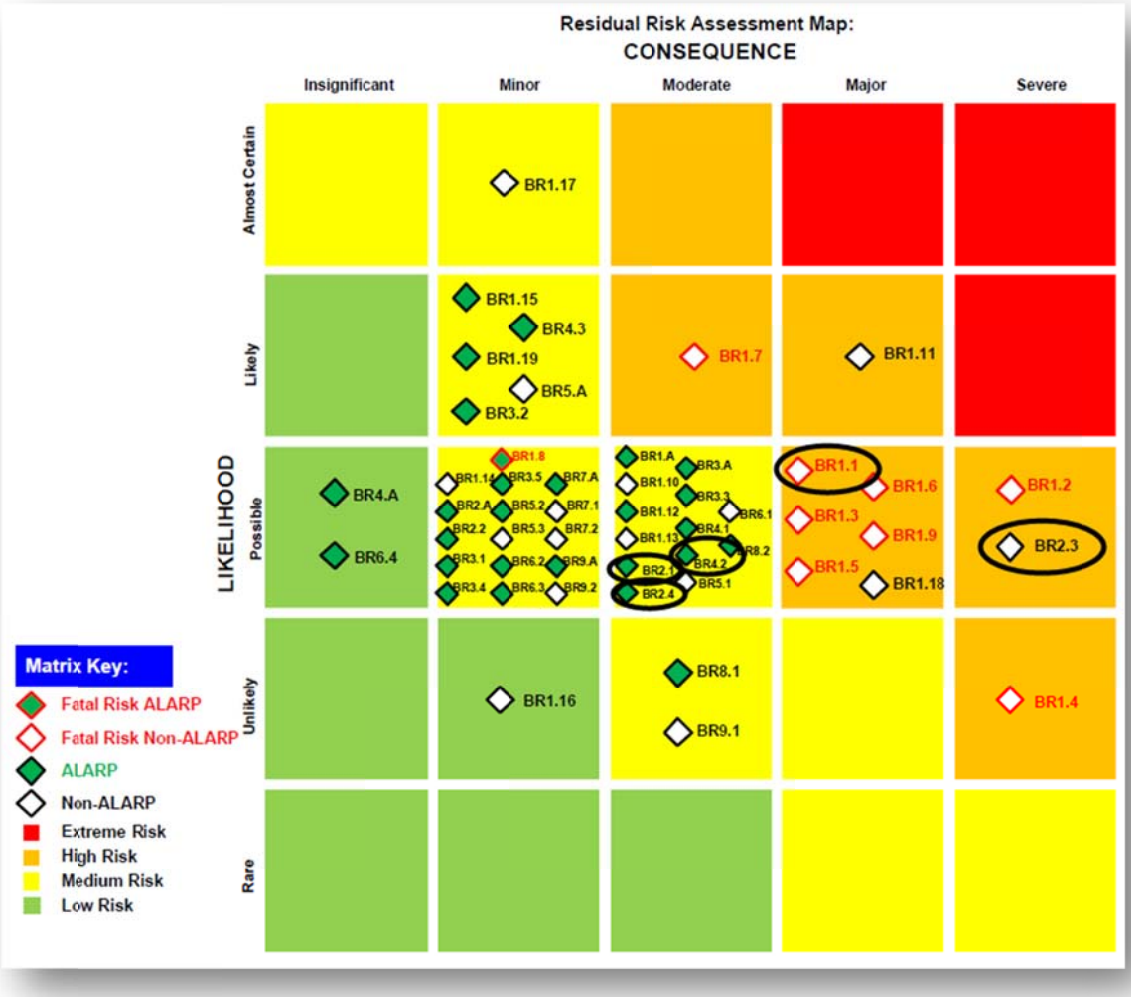

Figure 1 – Business risk – residual risk levels

3.0 ASSET PROFILE

There are approximately 21,000 relays in the Endeavour Energy network, with 50% of these being electromechanical. Electronic relays started to be installed in significant numbers on the network approximately 20 years ago. Electromechanical relays were generally phased out at that time, however simple electromechanical auxiliary relays are still installed today, for example, multitrip relays and flagging relays.

The commissioning year profile is shown in Figure 2.

Note: For approximately 25% of the relay population the commissioning date has been estimated based on either the commissioning date of the substation they are installed at, the commissioning date of the plant they protect or the date of the earliest setting file.

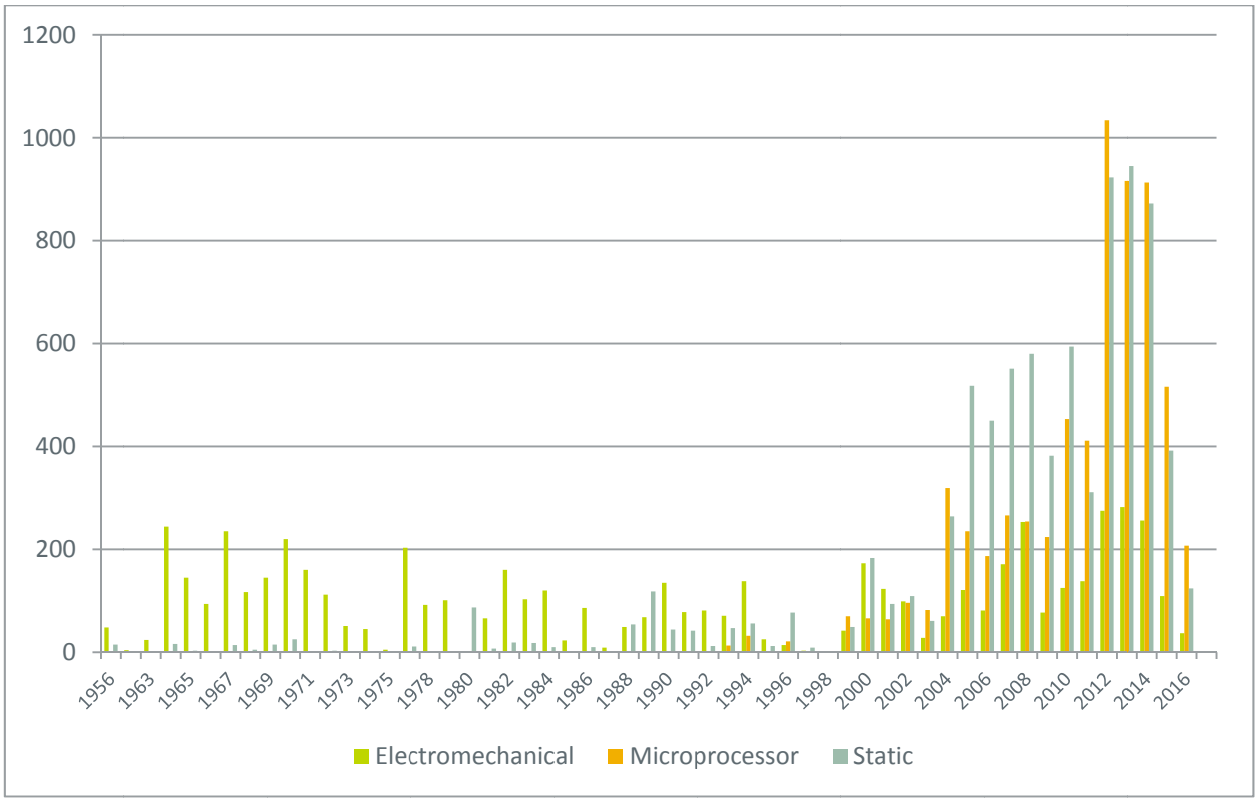

Figure 2 Relay Commissioning Date Profile

3.1 Electromechanical relays

Electromechanical relays work on the principle of a mechanical force causing operation of a relay contact in response to a current and/or voltage stimulus. The mechanical force is generated through current flow in one or more windings on a magnetic core or cores. These relays have few moving parts and are maintainable. The life expectancy of these relays is 30 to 50 years, though many of these relays can still operate reliably beyond 50 years of life when properly maintained. The disadvantages of electromechanical relays include:

Type CAG34 relay

- Reduced accuracy
- Characteristic limitations which can cause unnecessary issues, for example, transformer differential relays have fixed inrush restraint characteristics which can result in a transformer trip when they are energised.
- Fixed characteristic – if a different characteristic is required, the relay must be replaced, for example, the ability to change curve shape or introduce high-set.
- Slower operating speeds
- Some relays are liable to chatter/bounce
- Cannot provide fault information such as:
    - Current levels and faulted phases
    - Distance to fault information
    - Fault records etc.
- Cannot incorporate additional functions such as:
    - CB Failure
    - Check synchronisation
- Physically larger package size than numerical relays

3.2 Electronic relays

The life expectancy of protection relays incorporating electronics is much lower than their electromechanical counterparts, the life expectancy being between 10 and 25 years which is largely dependent on the life of non-serviceable components such as capacitors, resistors and transistors. The design life for protection systems is listed as 10 years in Company Policy 9.2.5, Network Asset Design.

In some models we have already seen elevated unsatisfactory failure rates at between 10 and 15 years after commissioning. Some of these features have resulted in protection mal-operations or the failure to operate and properly clear faults.

For example, the GE SR750 series microprocessor overcurrent relays are now between 10 and 15 years old. We have experienced 43 failures over the last five years. This represents a failure rate of 28% of the population per year. The failures were experienced across multiple sites, and not all failures resulted in relay failure watchdog alarms. One such failure, on the 29 March 2014 resulted in the loss of 2 bus sections at Parklea Zone Substation for nearly an hour, contributing 0.4 minutes of SAIDI with an approximate STPIS impact of $690,714 (if the incident were to occur when STPIS applies).

These failures are not of consistent failure modes. Examples of the failure modes experienced include microprocessor failure, power supply failure, and output contact failure. The manufacturer has been queried and has responded that *“some components are at the end of their life cycle”.*

4.0 BASIS FOR PROPOSED WORKS

4.1 Introduction

The selection of schemes to be replaced is based on both quantitative and qualitative risk assessment and engineering judgement and takes the following into consideration:

- The failure history and probability of failure of that relay or equipment.
- The failure mode.
- The impacts of the type of failure considering the location the relays are installed.
- The level of backup protection provided by other systems.
- Whether or not the relay has watchdog supervision and a failure alarm.
- Maintenance difficulties.
- The availability of spare relays or spare parts.
- The expertise available to properly maintain the scheme in the system.
- The ability to maintain setting software and firmware updates required to properly maintain the relay.
- Deficiencies in the current protection system.
- The overall quantity of the schemes and cost and impact of replacement.
- The enhanced opportunities provided by replacement, for example, new relays installed in feeder positions can be used to send distance to fault information to system operators, thus decreasing the time taken to locate the fault and subsequently reducing outage times.
- Whether there is a sufficient quantity of the relay platform remaining on the network to monitor and manage failure rates, spares, and expertise.

4.2 Benefits

The renewal of protection relays provides both primary and secondary benefits are outlined below.

4.2.1 Primary benefits

4.2.1.1 Maintaining network reliability

Relays that operate inappropriately (either do not operate or operate when they are not supposed to) will result in either unnecessary outages or increases in the size of an outage. New relays would improve network reliability as they would be less like to cause mal-operations. As well as disruption to our customers, the STPIS reliability incentive scheme in operation results in financial costs (penalties or bonuses) for reliability impacts.

4.2.1.2 Achieving network security and compliance

At transmission levels (such as 132kV), the correct operation of protection schemes is imperative to prevent power system instability and large scale loss of supply. The National Electricity Rules requires that we maintain these systems in good working order for this reason.

4.2.1.3 Maintaining safety

Reliable operation of protection schemes is required to achieve intended levels of safety during network faults, which impacts on the safety of both our employees and members of the public, as well as livestock.

4.2.1.4 Limiting asset damage

Reliable operation of protection schemes is required to achieve intended level of protection of our network assets, to prevent costly damage and prevent or limit the extent of uncontained failures such as fires and explosions.

4.2.2 Secondary Benefits

4.2.2.1 Modern technology and fault clearance

Compared to old protection relays, the latest modern microprocessor protection relays improve the flexibility, accuracy and performance of the protection characteristic as well as adding additional functionality. Amongst other benefits, this allows the introduction of substantially faster electrical fault clearance times by taking advantage of:

- multiple characteristic curve shapes;
- a more flexible time shift multiplier;
- a more accurate characteristic (e.g. trip, overshoot and reset times) resulting in the potential for a safe reduction in coordination margins, and most importantly;
  the ability to use high speed or instantaneous protection at higher fault levels, and the ability to change this characteristic by SCADA remote control depending on the circumstances (e.g. high risk works such as switching and live line work).

4.2.2.2 Fault information and response

Newer numerical relays have the capability to provide fault information, immediate remote indication of fault type and fault current can enhance critical operational decisions. For example, knowledge of the fault level can assist in determining where on the network the fault is likely to be, and can potentially lead to faster restoration of load.

4.2.2.3 Condition based maintenance

Fault level data transmitted to SCADA presents some opportunities such as condition based CB maintenance. For example, maintenance could be scheduled based on actual wear and tear based on accurate knowledge of actual fault level and by knowing which phases were involved in each fault, rather than the existing practice which assumes maximum fault level and all three phases for each fault operation.

4.2.2.4 Forensic analysis of network incidents

Detailed fault records from protection relays can assist in the investigation of incidents, helping to permit a better understanding of events, which can lead to more appropriate choice of remedial actions and can help enhance safety and reliability in the future.

4.3 Key relay selection categories

In this program, 4 key risk areas have been identified:

- Relays with high failure rates:
  - Indicates that end of useful life has been reached
  - failure rates likely to further increase over time
  - Increased risk of relay non-operation

- Very low quantity relays:
  - Insufficient quantity to be able to monitor failure rate performance, and therefore an age based replacement strategy must be employed (run to failure is not considered to be a feasible option for protection relays).
  - Replacement when the relay has reached its industry anticipated early, mid, or late life expectancy, depending on the risk associated with each particular relay application.

- Relays without redundancy:
  - Typically 11kV feeders with only a single relay, however other schemes are not excluded.
  - Only very low failure rates are tolerable for an acceptable risk position
  - An excessive risk is likely to be realised prior to the detection of high failure rates (measured failure rates are a lagging indicator and relay replacement will take a long time depending upon population).
  - Replacement when the relay has reached its industry anticipated early, mid, or late life expectancy, depending on the risk associated with each particular relay application.

- High consequence relays (typically 132kV feeders):
  - Massive loss of load or stability impacts
  - Regulatory requirements
  - Only very low failure rates are tolerable
  - An excessive risk is realised prior to the detection of high failure rates (measured failure rates are a lagging indicator and relay replacement will take a long time depending upon population).
  - Have reached their industry anticipated life expectancy

There may be limited instances where other drivers justify replacement such as relays which do not meet system needs in other aspects of performance etc. Other factors such as ease of maintenance etc. have been considered in the prioritisation.

4.4 High failure rate relays

The defects recorded in Ellipse over the last five (5) years have been analysed and a yearly average failure rate has been calculated. Relays with a failure rate greater than 0.5% have been identified in APPENDIX A - CURRENT PRIORITY RELAYS. A high level risk assessment has been completed for all of these relays with the results outlined in APPENDIX A - CURRENT PRIORITY RELAYS. A more detailed risk assessment has been carried for a select group of relays which follows in the following sections and with more details in Low quantity relays

Relays or relay platforms which exist in very low quantities are unable to be managed and monitored in the same way as a larger fleet of relays. Issues and risks include:

- An inability to accurately determine and monitor relay failure rates. This is particularly a concern regarding end of life wear-out failures.
- A higher than normal cost of overheads per unit (e.g. maintaining test plans, expertise, relay documentation, work practices, management of spares etc.).
- A higher risk of setting, testing and commissioning errors due to low levels of familiarity.

The lack of knowledge regarding failure rates is of great concern, particularly once the realm of expected end-of-life wear out has been reached. With very low relay quantities, leaving them in situ without any real knowledge of failure rates until failure occurs is essentially employing a run to failure strategy which is not considered to be a reasonable strategy for protection systems. **The continued use of protection relays beyond their mid to late life expectancy is generally acceptable only if a sufficient quantity of that make and age range exists such that a reasonable indication of non-alarmed failure rate can be calculated and continually monitored.**

Particularly given that failure rate is a lagging indicator and that non-alarmed failures will not typically be detected until 1.5 years after failure (3 year maintenance interval).

4.4.1 Failure rates

Level	Failure rate
Extreme	>5% pa
High	>2% pa
Medium	>0.5% pa
Low (normal)	<0.5% pa

4.4.2 Expected end-of-life wear out failure range

Relay type/end-of-life (yrs)	Early	Mid	Late
Electromechanical	30	45	50
Static/Electronic	20	25	30
Microprocessor/Multi-function	10	20	25

4.4.3 Renewal criteria

# relays	Ability to monitor failure rates	Approach (typical applications)	Approach (high risk applications)
1 to 2	Not possible, essentially run to failure	Replace prior to mid-life expectancy	Replace relay prior to early life expectancy
3 to 5	Extreme failure rate detection time: 5 to 10 years. Degree of failure rate uncertainty: very high	Replace prior to late life expectancy	Replace prior to mid-life expectancy
6 to 10	Extreme failure rate detection time: 2 to 5 years. Degree of failure rate uncertainty: high	Replace prior to late life expectancy	Replace prior to late life expectancy
11 to 19	Extreme failure rate detection time: 1 to 3 years. Degree of failure rate uncertainty: moderate	Failure rate based	Replace prior to late life expectancy
>20	Acceptable	Failure rate based	Failure rate based

4.5 Relays without redundancy – Single Distribution Feeder Protection

There are 801 (excluding spare feeders, feeders supplying auxiliary bars and capacitor banks only) out of 2147 of 11/22kV distribution feeder overcurrent and earth fault protection relays that are not fully backed up. That is, for some bolted faults types at certain locations along the feeder, there is only one protection device that has the capability to detect the fault.

If the primary device fails to operate as intended, the fault may remain and potential damage could occur to other network components that supply the fault. This could result in mains on the ground at other locations upstream of the fault. This may then subsequently result in clearance by the zone transformer overcurrent's resulting in loss of zone substation supply, resulting in a typical STPIS impact of $500k.

There is also a small but non-negligible increased risk of harm to persons due to the:

- Increased energy released at the original fault site.
- Subsequent faults and potentially mains down at subsequent fault sites.
- Step and touch voltages both at the fault site and at other locations where there are transferred earth voltages.
- Fire ignition.

4.5.1 Indicative risk analysis - Distribution feeder faults with 1 protection (static/numerical)

The outcome analysis detailed in Figure 3 below considers the total risk value for a typical single protection feeder given the following assumptions:

- A non-alarmed failure rate of 1% per event.
- A fault frequency of 1 fault per annum.
- Backup coverage of 80% of the feeder length.
- 80% of all faults are earth faults and are therefore detected by the SEF relay.
- A loss of station load consequence value of $500k.

- A conductor damage consequence value of $100k.
- A prolonged uncleared feeder fault including conductor damage in several locations and loss of zone substation load consequence value of $1 million.

This analysis yields an NPV value of risk over the 20 year life of a modern relay of over $52k which exceeds the cost of relay renewal including duplication (~$32k to current standards which includes additional modernisation benefits). This analysis indicates that a failure rate of around 0.5% must be maintained to avoid a justified renewal need.

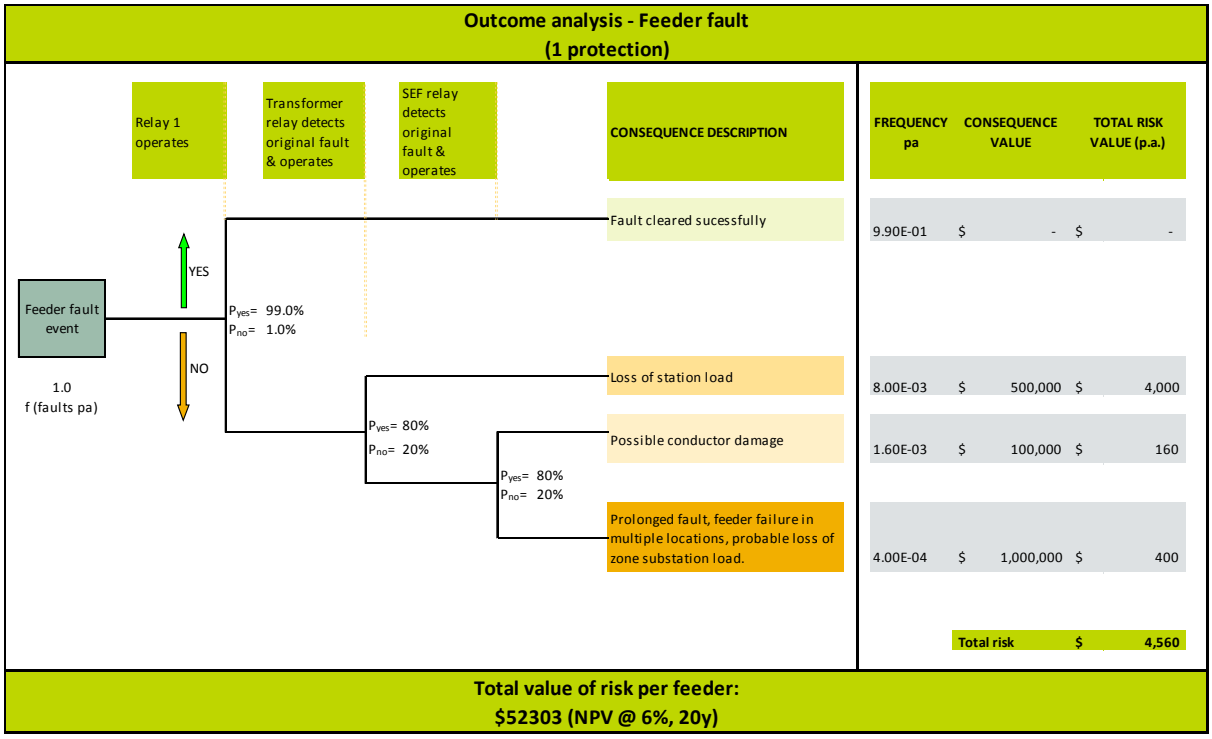

Figure 3 Single Distribution Feeder Protection Outcome Analysis

The current failure rate indicated by Ellipse maintenance records for the most prevalent relay model in this scenario (the Basler BE1-851) is currently less than 0.1% p.a. which if considered to all be non-alarmed, not operational failures corresponds to a failure rate per event below 0.2% given 3 yearly maintenance intervals and a fault frequency of 1 per annum.

Given the degree of variation of individual feeders (such as fault frequency) against the averages estimated in the analysis above, it is likely that some feeders would warrant duplication even at the current failure rate, and replacement would be warranted on most feeders when failure rates reach around 0.5% per event.

4.6 High consequence relays – 132kV Feeders

There are 299 x 132kV feeder protection relays that are candidates for replacement. The risk analysis in Diagram 4 below suggests 132kV feeder relays may be replaced proactively. These 299 microprocessor/static feeder relays providing the main protection on 132kV feeders that are not included in PS008 or other major projects.

The outcome analysis detailed in Figure 4 below considers the total risk value for a typical 132kV feeder with 2 protection systems, given the following assumptions:

- A non-alarmed failure rate of 1% per fault event on both relays.
- A fault frequency of 0.3 faults per annum.
- A prolonged uncleared feeder fault will cause a stability event to the scale of loss of 10% of NSW GDP, which is a consequence value of approximately $150 million.

This analysis yields an NPV value of risk over the 20-year life of a modern relay of $52k which exceeds the cost of renewal ($45k). This suggests that in this application, higher than normal failure rates (>1% per event) cannot be tolerated in many or most circumstances, and so relays in this application may need to be renewed on a proactive basis, particularly if low relay quantities make failure rates difficult to monitor.

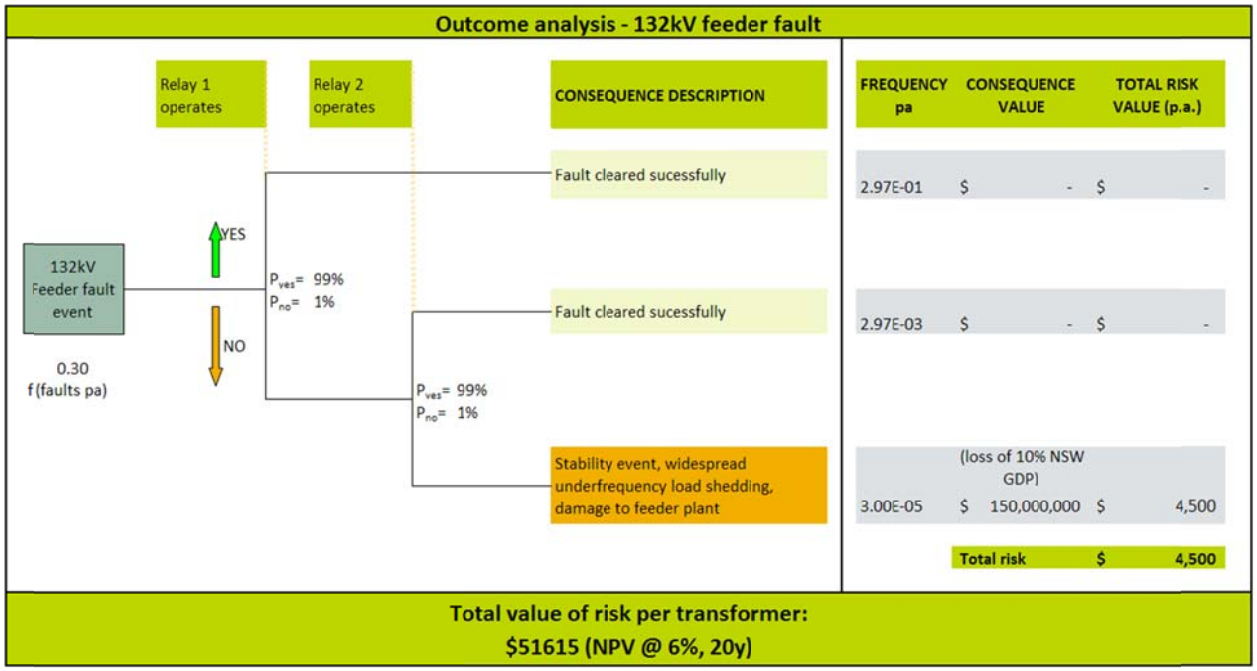

Figure 4 Risk analysis for 132kV feeder protection

5.0 SCOPE OF WORKS

5.1 Site selection

The sites selected for the 2017/18 and 2018/19 years have been identified in Appendix F. The total estimated costs for the two financial years are $5.435 million. These costs will need to be further refined at the Business Case stage.

5.2 Scope of replacement

As part of the detailed design it is necessary to consider the extent of renewal and whether or not the relay renewal activity should extend to:

- associated relays on the same panel or bay
- the hardware on the effected panel or bay, including links, fuses, panel indications etc.
- complete panel replacement of all of the above
- wiring and marshalling replacement, including the wiring of additional circuits to trip coils, circuit breaker failure circuits etc.
- associated relays on other panels and bays

A judgement has to be made in each instance to determine the most cost effective option and must give due regard to:

- The cost difference between the various options
- The condition of the existing panel, panel hardware, associated relays, and wiring.
- The level of risk and compliance with standards and regulations, for example the level of redundancy of the system
- safety in design considerations such as:
    - the safety of exposed live conductors both on the front of, and the rear of the panel.
    - Ergonomics for activities throughout the life cycle of the system (e.g. commissioning, maintenance, operation, de-commissioning).
- Standardisation and familiarity with respect to network security and STPIS
- Other factors such as the scale of the project and economies of scale

6.0 RECOMMENDATIONS

It is recommended that a business case be developed for approval to spend $5.435 million over 2017/18 and 2018/19 to replace the 244 protection relays identified in this report.

The sites are outlined in APPENDIX F – SITE LIST.

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7.0 APPENDIX A - CURRENT PRIORITY RELAYS

7.1 Relays with high failure rates and other issues

The relays to be replaced under this criteria are shown in Table 1.

Relay Model	Application	Risk Level	Basis for replacement	Qty
2C135	Single 11kV Feeders SEF relay	Medium-High	Age and will not pickup intermittent fault. Site was omitted from PS009 due to the expectation of a SAMP project.	8
2DCC	Duplicate 11kV Feeder OC/EF with bus blocking supplying capacitor bank only	Low-Medium	High Failure Rates - SPAJ140C	1
7SA510	66kV Feeder Distance and OC/EF with CO6	Medium-High	High Failure Rates - CDD	1
BE1-851	Single 11kV Feeder OC/EF supplying underground network, with potential to supply overhead network	Medium-Low	11kV Feeder with SEF protection	1
BE1-851E	33kV Feeder OC/EF with Distance Protection with long zone 2 timer	Medium	High Failure Rates - HOXXX	1
CDD	Single 33kV/66kV Directional OC/EF	Medium	Medium Failure Rates - CDD	6
CDD	33kV Directional OC/EF with HO2	Medium	Medium Failure Rates – CDD and HOXX	1
CMU	Single 11kV Feeder SEF supplying overhead - will not pickup intermittent fault and has high pickup	Medium-High	High Failure Rates – CMU	2
CMU	Single 11kV Feeder SEF supplying underground network, with potential to supply overhead network, will not pickup intermittent faults	Low	High Failure Rates – CMU	1
CO6	66kV Feeder Distance and OC/EF with CO6	Medium	High Failure Rates - CDD	1
FV/2	Duplicate 132kV BBP	Medium	High Failure Rates – FV/2	6
FV/2	Duplicate 33kV BBP	Medium	High Failure Rates – FV/2	8
HO2/HO4/HOA4	33kV Feeder Translay with OC/EF backup	Medium	High Failure Rates - HOXXX	14
HO2/HO4/HOA4	Single 33kV Feeder Translay	Medium	High Failure Rates - HOXXX	1

Relay Model	Application	Risk Level	Basis for replacement	Qty
HO2/HO4/ HOA4	33kV Feeder Translay with OC/EF backup – other feeder N/O	Medium-Low	High Failure Rates - HOXXX	5
KCEG140	132kV Feeder Directional OC/EF	Medium-High	High Failure Rates - KCEG140	2
KCEG140	TX LV OC/EF with frame leakage/busbar protection	Medium-Low	High Failure Rates - KCEG140	5
KCEG142	Single 33/11kV TX LV OC/EF with bus blocking	Medium	High Failure Rates - KCEG142	2
KCGG140	11kV OC/EF of 11kV/22kV Auto transformer	Medium-Low	High Failure Rates - KCGG140	2
KCGG140	11kV Feeder OC/EF/SEF	Medium-Low	High Failure Rates - KCGG140	2
KCGG142	Duplicate 11kV OC/EF with KCGU140 and MCGG53	Medium	High Failure Rates - KCGU140	1
KCGU140	Duplicate 11kV OC/EF with KCGU140 and MCGG53	Medium	High Failure Rates - KCGU140	19
MCGG53	Duplicate 11kV OC/EF with KCGU140 and MCGG53	Medium	High Failure Rates - KCGU140	20
MHOA04	33kV Feeder Translay with OC/EF backup	Medium	High Failure Rates - HOXXX	4
MHOA04	33kV Feeder Translay with OC/EF backup – other feeder N/O	Medium-Low	High Failure Rates - HOXXX	3
No Volt Change Over	66kV Feeder N/O without protection	Medium	66kV Feeder N/O without protection	1
P121	Duplicate 22kV Feeder OC/EF	Medium-low	High Failure Rates - P121	8
P121	33/11kV TX HV OC/EF with SR745	Medium-low	High Failure Rates - P121	1
P121	Single Aux TX OC	Medium-low	High Failure Rates - P121	2
P121	Single 33/11kV TX LV OC/EF	Medium-low	High Failure Rates - P121	1
P122	33/11kV TX HV OC with SR745	Low-Medium	High Failure Rates - SR745	4
P122	33/11kV TX LV OC/EF with frame leakage	Low-Medium	High Failure Rates - SR745	2

Relay Model	Application	Risk Level	Basis for replacement	Qty
P123	33/11kV TX LV OC/EF with frame leakage	Low-Medium	High Failure Rates - SR745	1
RXKL1	Timer to trip 11kV breaker after capacitor bank tripped	Low-Medium	High Failure Rates - SPAJ140C	2
RXKL1	Timer to trip 11kV breaker after capacitor bank tripped	Low-Medium	High Failure Rates - KCGU140	4
SPAJ140C	Single 11/22kV AT 11kV OC/EF	Low-Medium	High Failure Rates - SPAJ140C	2
SPAJ140C	Duplicate 11kV Feeder OC/EF with bus blocking supplying Capacitor bank only	Low-Medium	High Failure Rates - SPAJ140C	1
SR745	Transformer differential - TS	Medium	High Failure Rates - SR745	1
SR745	Transformer Differential - ZS - High speed trip through SR745	Medium	High Failure Rates - SR745	6
SR745	Transformer Differential - ZS	Medium	High Failure Rates - SR745	4
SR750	33/11kV TX LV OC/EF no busbar protection	Medium-High	High Failure Rates – SR750	3
SR750	132/66kV TX LV OC/EF no busbar protection	Medium-High	High Failure Rates – SR750	1
SR750	132/11kV TX LV OC/EF with busbar protection	Medium	High Failure Rates – SR750	2
SR750	33kV Feeder Directional OC/EF with Line Differential	Medium	High Failure Rates – SR750	2
SR750	132kV Feeder duplicate directional OC/EF	Medium	High Failure Rates – SR750	1
SR760	Single 33kV Feeder Directional OC/EF with Check Sync	High	High Failure Rates – SR760	2
SR760	33kV Bus Section Breaker Bus Blocking	Medium-High	High Failure Rates – SR760	2
SR760	33kV Feeder Directional OC/EF with 33kV busbar blocking	Medium-High	High Failure Rates – SR760	2
SR760	33kV Feeder Directional OC/EF with 7SD511	Medium	High Failure Rates – SR760	1
TDS	33kV BBP CBF Timer	Medium	High Failure Rates - TDS	8
TDS	132kV BBP CBF Timer	Medium	High Failure Rates - TDS	6
			Total	**187**

Table 1 Relay models targeted for replacement

Notes:

- The replacement of the CMU, 2C135 and the installation of a 2C138 relay should take TS146 Marayong ZS into consideration, if it is likely that the project will be commissioned with new 11kV switchgear within the next two years then the replacement of these relays should be removed from this program through a change control.
- The 2DCC and RXL1 relays are being replaced as part of the SPAJ140C replacement for the Anzac Village ZS feeder that supplies a capacitor bank.
- The 7SA510 and CO6 relays on feeder 815 are being replaced mainly under "High Failure Rates – CDD". Feeder 815 from Carlingford TS to Castle Hill ZS only has a single CDD relay at Castle Hill ZS providing directional OC/EF fault protection. There is existing fibre between Carlingford TS and Castle Hill ZS and hence it is proposed to replace the CDD relay with a P543 line differential relay (and BE1-1051 directional OC/EF) at Castle Hill ZS. Hence the 7SA510 relay also needs to be changed. It should be noted that the 7SA510 relay is currently 18 years old and the failure for the 7SA510/7SA511 series is 1.44% and hence it is likely it would have been replaced within the next few years. The CO6 relay is also proposed to be removed as it is potentially 50 years old and is also coming close to the end of its life. There are benefits to implementing a fast protection which are outlined in Section 7.1.5.
- The KCGG142 and the MCGG53 relays are being replaced as part of the "High Failure rates – KCGU140" at Penrith ZS. Refer to Section 7.1.2.

7.1.1 CDD

See 8.8 APPENDIX B – RELAY RISK ASSESSMENT.

7.1.2 KCGU140

There are currently 21 KCGU140 relays in service, with all of them at Penrith ZS providing 11kV OC/SEF protection with a MCGG53 which provides OC/EF protection.

There are seven (7) defects in Ellipse for KCGU140 relays and there has been another two (2) which aren't currently recorded in Ellipse, all of them are for the relays at Penrith ZS. Of these nine (9) defects four (4) were in 2013 and five (5) were in 2016.

The regions have also identified the following issues with the KCGU relays at Penrith ZS:

Loose wiring: PH1238. Protection Pos was loose in the wing and when touched, dropped the Protection pos for the rest of bus section 5B. It was so delicate that a CB operation may have caused it to drop.

Relay Failures KCGG/KCGU: PH1238, PH1223. PH1238 was replaced with the unit from PH1227 Cap6B as it was not in service. Mick Wasson replaced PH1227's unit with a KCGG142 the next day. PH1223 was replaced with a unit Frank located, but it can't have the SEF PU lower than 8A, so that's how it was tested.

IOC Timing: PH1234 as mentioned yesterday.

Spare Relays: We currently have 2 second hand KCGG relays as spares. Both have a minimum 8A SEF P/U.

Autoreclose: PH1201, PH1264, PH1293, PH1223. When all of these are tripped via a protection operation, there is no reclose. SCADA Events show the trip and then "Breaker Failed To Open". CB availability and CB position are via K bus and this seems slow. When manually open/close the CB from its

panel, on average it takes 5s for it to display CB position on SCADA. My presumption is that the CB failed to open message is because SCADA receives the CB position information outside the ½ sec window the SCADA allows to check breaker position after a trip.

8A SEF P/U. PH1212, PH1223. PH1212 is the original unit.

In summary:

- High failure rate
- Issues with K-bus not initiating auto-reclose for 4 feeders
- 3 feeders that are not able to have their SEF pickup set within the acceptable range of 4A.

All of these issues indicate a total replacement of the KCGU140 relays is required at Penrith ZS. It is also recommended that the MCGG53 relays being used for the #2 PROT on these feeder is also replaced at the same time as they are 21 years old as well and will likely require replacement within the next five (5) years (NPV of MCGG53 in five years + KCGU140 in two years = 25000/(1.06^3) + 15000 = $35,990 vs. full panel replacement cost of $32,000 + scada works).

In addition to this the KCEG140 relays providing TX LV OC/EF on 132/11kV TX5 and TX6 are to be also disabled and put out of service. The OC/EF functions provided by these relays are then to be implemented in the BE1-CDS240 and SEL-387A transformer differential relays already in service.

7.1.3 SR745

See 7.1.3 SR745.

7.1.4 SR760

See 7.1.4 SR760.

7.1.5 HO2/HOA2/ HOA4 and slow clearing of faults

The HO2/HOA2/HOA4 are used for translay (differential) protection on sub-transmission feeders. They have a combined non-alarmed failure rate of 1.76%. The relays rely on Hardex to provide this differential protection. Hardex is an older type of overhead earth wire typically used on 33kV feeders in North and Central region. Hardex incorporates copper signal cables within, which are used by protection systems to very quickly detect and clear electrical faults on the associated feeder.

Installed many decades ago (typically 30 to 60 years), and in many instances not adequately through fault rated, these are in very poor condition. Regular failures and communications outages occur, and for this reason these pilots are on a 1 year maintenance check cycle.

Hardex failures have impacted substantially on network reliability and are a legitimate cause for concern regarding safety risk. The Hardex status is not supervised hence Hardex failures are not alarmed.

Most of the impacts result from the following three issues, all of which originate from the Hardex failure:

- Slower temporary protection systems which:
  - increase the likelihood of Hardex or conductor burn down
  - can cause conductor clashing or tangling both on the faulted feeder and on parallel feeders
- A radial feeder configuration with manual restoration. In this configuration a simple permanent feeder fault can result in short or long restoration times depending on the level of operator

awareness/confidence following the fault. The radial configuration is often applied due to either a lack of protection redundancy (temporary protection is usually initially installed only at the source end), and due to the problems associated with slower protection systems which can result in longer outages.

- Human error associated with the design or commissioning of temporary protection schemes which occurs under significant time pressure.

As outlined in Table 2, in the last 5 years, there have been 15 reliability incidents totalling at least 3.92 minutes of SAIDI, an average of 0.78 minutes per annum where Hardex outages have been a contributing factor or slow clearing of faults has exacerbated the extent of an outage. A summary of the incidents is also provided in APPENDIX E – INCIDENTS ASSOCIATED WITH SLOW CLEARANCE.

Date	Impact	SAIDI	STPIS
07/03/2012	Loss of Cranebrook ZS – mains on ground	0.05	Before STPIS was introduced
07/03/2012	Loss of Emu Plains ZS	0.46	Before STPIS was introduced
06/04/2012	Loss of West Pennant Hills ZS	0.06	Before STPIS was introduced
16/09/2012	Loss of Greystanes ZS	1.64	Before STPIS was introduced
21/09/2012	Loss of Greystanes ZS	0.02	Before STPIS was introduced
11/10/2012	Loss of Greystanes ZS	0.02	Before STPIS was introduced
25/10/2013	Loss of Quarries ZS and Bossley Park ZS	0.02	Before STPIS was introduced
16/01/2014	Loss of Cranebrook ZS & Jordan Springs ZS	0.51	Before STPIS was introduced
06/08/2014	Loss of 33kV feeder 491, loss of 11kV feeder, lines down in multiple locations, lines fell across the western railway line causing 5 hour closure of the railway line disrupting 220 train services. Started 2 grass fires.	0.30	Before STPIS was introduced
09/08/2014	Loss of Emu Plains ZS (45 mins)	0.37	Before STPIS was introduced
11/08/2014	Loss of Emu Plains ZS (7 mins)	0.05	Before STPIS was introduced
25/08/2014	Loss of 33kV feeder 491, lines down across a house and car. Loss of 11kV feeder load.	0.16	Before STPIS was introduced
23/07/2016	Loss of Kingswood ZS (7 mins)	0.09	~$600k (indicative)
21/02/2017	Loss of Castle Hill ZS (5 mins)	0.17	$307,216
13/03/2017	Loss of Yennora ZS (possibly 1h 37 minutes)	0.6	~600k (indicative)
	Total		~1.5M

Table 2 Hardex outages or slow clearing of faults contributing to extended outage

Note 1: Kingswood ZS supplies approximately twice as many customers as Yennora ZS hence even though the outage was only for 7 minutes the STPIS impact is approximately the same.

Note 2: Yennora ZS – estimate of an outage 6,000 customer outage for 1h 37 minutes.

In summary the issues are:

- High failure rate for the HO2/HOA2/HOA4 series
- High number of hardex failures
- Hardex is not supervised
- Slow clearing of faults (not necessarily associated with Translay/Hardex) resulting in zone substation outages (Kingswood, Castle Hill and Yennora ZS)
- Potentially $1.5M STPIS impact attributable to these slow clearances for the just the three most recent incidents

To address this it is proposed to implement high speed supervised differential protection using existing OPGW/ADSS links which were installed under TM013 but for which the relays at the substations were not changed. In this program it is proposed that 31 relays are replaced at 19 substations, this will provide high speed supervised differential protection on 13 33kV/66kV feeders.

7.1.6 FV/2 and TDS Relays

The FV/2 provides high impedance busbar protection. It is mainly used at Transmission substations for the 33kV, 66kV and 132kV busbar protection. It has a “Non-alarmed” rate of 2.13%.

There are 93 TDS relays in service, which provide busbar CBF timing functions. The non-alarmed failure rate for the TDS relay is 0.63%. The average of the TDS relay is 42 years.

Both the FV/2 and TDS relays are coming to close to the end of their life.

Category	Number of Relays	Average Age
ZS – Single 33kV BBP	2	49
TS - Duplicate 33kV BBP	53	50
TS – Duplicate 66kV BBP	6	53
TS – 132kV BBP	13	41

As the FV/2 relay and TDS relay are predominantly used at Transmission substations an analysis of transmission substations has been completed to assess the potential of loss of load and potential STPIS impact if these relays were to fail.

The summary is shown in Table 3. It is evident that highset STPIS impact is at West Liverpool TS. Hence it is proposed to replace the FV/2 and TDS relays at West Liverpool TS under this program.

TS	Commissioning Year	Age in 2019	Average Load (MVA)	Customers Supplied	STPIS Impact
West	1967	52	110	58,961.00	$4,846,594
Blacktown	1976	43	130	56,555.00	$4,648,821
Springhill	2008	11	100	41,203.00	$3,386,887
Shoalhaven	1965	54	50	37,546.00	$3,026,208
Penrith	2014	5	70	36,570.00	$3,006,054
Bellambi	1963	56	45	27,117.00	$2,185,630
Carlingford	1964	55	100	25,832.00	$2,123,390
Baulkham	1964	55	70	23,956.00	$1,969,183
Fairfax Lane	1956	63	65	23,570.00	$1,937,454
Mt Druitt	1970	49	80	23,146.00	$1,902,601
Liverpool	2011	8	60	22,845.00	$1,877,859
Mt Terry	1968	51	60	21,727.00	$1,785,959
Guildford	2013	6	45	21,701.00	$1,783,822
Hawkesbury	1972	47	80	21,581.00	$1,756,693
Nepean	1970	49	60	16,485.00	$1,355,067
Katoomba	1996	23	17	13,344.00	$1,075,526
Camellia	1965	54	30	10,390.00	$854,058
Warrimoo	1982	37	30	7,670.00	$618,202
Lawson	1956	63	20	5,323.00	$429,034
Outer	1969	50	20	3,471.00	$285,316
Ilford	1986	33	4	2,915.00	$234,949
Denham	2014	5	7	1,012.00	$83,186

Table 3 TS Anlaysis

7.2 Low quantity relays

The relays identified for replacement under the low quantity criteria are outlined in Table 4. All the relays that met the "low quantity relay" criteria (the relays being replaced under this program and the ones not being replaced) are identified in 9.0 APPENDIX C – LOW POPULATION RELAYS .

Relay Model	Application	Number of Relays
RAZFE	High Risk Application – 132kV Feeder Distance Protection	1
RADSB	High Risk Application – 132/11kV TX Differential	2
RADSB	Typical Application – 33/11kV TX Differential	3
QUADRAMHO	High Risk Application – 132kV Feeder Distance Protection	2
QUADRAMHO	Typical Application – 33kV/66kV Feeder Distance Protection	2
2T146	Typical Application – 11kV/66kV BBP CBF Timer	2
KBCH130	High Risk Application – 132k/11kV TX Differential	2
VAT11/3	High Risk Application – 132kV BBP CBF Timer	4
ST3	High Risk Application – 132kV BBP CBF Timer	4
ST2	High Risk Application – 132kV BBP CBF Timer	2
B4	Typical Application - OC relay for frame leakage	6
B1	Typical Application - OC relay for frame leakage	2
	Total	**37**

Table 4 Relays for replacement under the Low Quantity criteria

Note:

- The future of Carlingford TS is currently being review by the Asset Strategy and Planning Branch. If their report finds that the Control Building at Carlingford TS is to be rebuilt then the replacement of the RAZFE, ST3 and VAT11/3 relays at Carlingford TS may need to be cancelled.
- In addition to the replacement of the Quadramho relay for Feeder 808 Hazelbrook ZS, the MCGG11 relay providing EF should be removed as it is a normally open feeder and the relay is 29 year old and close to end of life. Duplicate protection is not requires as the feeder is normally open.
- For the two RADSB relays at Kenny St the replacement of the P123 relays, providing HV OC, for a like for like P123 relay has also been proposed, as these existing P123 relays are 14 years old and would require replacement within the next few years.

7.3 Relays without redundancy – Single Distribution Feeder Protection

Of the 801 relays identified in 4.5 Relays without redundancy – Single Distribution Feeder Protection, 77 relays are being replaced under various other projects (PS012, TS122, TS146, TS009, PR673). Hence the number of feeders is reduced to 724. In this program it is proposed to replace 18 relays at four zone substations. The priority sites are outlined in Table 5.

Substation	Relay	Age in 2019	Replacement Category	Quantity
Culburra ZS	MCGG52	23	11kV Feeder Single Protection	2
Kembla Grange	SR760	20	11kV Feeder Single Protection and High Failure Rates - SR760	4
Narellan	P123	19	11kV Feeder Single Protection	8
Oakdale	P123	20	11kV Feeder Single Protection	4
			Total	**18**

Table 5 Single Distribution Feeder Protection Priority Sites

7.4 High consequence relays – 132kV Feeders

Of the 299 132kV feeder protection relays four relays were identified for replacement under the high consequence criteria, namely, the Quadramho relays at Outer Harbour TS and the 7SA511 relays at Bellambi Creek TS. The Quadramho relays have already been identified for replacement under the "Low quantity relay" criteria. Hence it is proposed to replace two relays under the "High consequence relays – 132kV feeders" criteria in this program are outlined in Table 6.

Scheme	Relay	Age in 2019	Replacement Category	Quantity
Bellambi Creek TS	7SA511	22	High Consequence Relays - 132kV Feeder	2
			Total	**2**

Table 6 High Consequence relays – 132kV Feeders

It should also be noted that these two 7SA511 relays are the Version 2 type, which the manufacturer has advised that they no longer support and the relay group "7SA510/7SA511" has an alarmed failure rate of 1.43%.

8.0 APPENDIX B – RELAY RISK ASSESSMENT

Relay and scheme defects recorded in Ellipse from the year 2012 to 2016 (five years) have been analysed for relays with an annual failure rate of 0.5% (MTBF of less than 200 years). In addition to these high-defect relays identified in Ellipse records, the maintenance records for relays identified by regional staff as consistently having out of tolerance have also been reviewed.

A risk assessment has been completed for all of these identified relays. The risk assessment considers the consequence of the failure modes (Failed to operate – alarmed, Failed to operate – non-alarmed, Mal-operation) in terms of loss of load or failure to clear a fault depending upon the specific application the relay is used for.

The individual failure rates have been given a rating as per Table 7.

Level	Failure rate	MTBF
Extreme	>5% pa	<20 years
High	>2% pa	<50 years
Medium	>0.5% pa	<200 years
Low	<0.5% pa	>200 years

Table 7 Failure ratings

The summary of the failures is shown in shown in Table 8.

8.1 High failure rate relays summary

Relay Model	Failed to Operate Alarmed (per annum)	Mis-operation (per annum)	Failed to Operate Non-alarmed (per annum)	Total (per annum)	Population	Strategy
SR750	12.41%	0.00%	15.86%	28.28%	16	See below
P121	8.33%	0.00%	3.33%	11.67%	12	See below
KCGU140	0.00%	0.00%	6.67%	6.67%	0	See below
7SA610	5.00%	0.00%	0.00%	5.00%	4	There are currently four (4) 7SA610 relays in service, with all four being commissioned in 2005 and being used for 33kV Feeder distance protection. All four of them are at Bellambi TS and they are in operation with either a line differential or translay relay in parallel. There are two defects recorded for the 7SA610 in Ellipse, both relays at Bellambi TS. One was in 2006 and one was in 2015. As they are only 10 years old and they have backup differential/translay protection they will be reviewed in 2 year.
D60	5.00%	0.00%	0.00%	5.00%	4	There are four (4) D60 relays in service, with all four being used for duplicate 132kV distance protection. Two were commissioned in 2010 and two in 2014. There has only been one alarmed failure which was due to a backup battery fail. As they are at a maximum seven (7) years old and due to only one alarmed failure they will be reviewed in 2 years.
QUADRAMHO	0.00%	0.00%	4.00%	4.00%	4	See below
ICP-640	4.00%	0.00%	0.00%	4.00%	5	There are five (5) ICP-640 relays being used for 33kV capacitor bank protection, with two commissioned in 2009 and three in 2015. All five of these schemes also have a secondary OC/EF relay providing protection as well. As there has been only one alarmed defect (in 2012, “relay watchdog permanently high”) recorded in Ellipse and the young age of these relays, currently there is no need for replacement.
OSM15	4.00%	0.00%	0.00%	4.00%	5	Recloser being used for feeders, not managed by Protection group
SR745	1.98%	0.40%	1.58%	3.96%	101	See below
P141	2.50%	0.00%	1.25%	3.75%	16	There are 16 P141 relays in service they are not seen as a high priority. They are relatively young.

SR760	1.67%	0.00%	1.67%	3.33%	36	See below.
SEL-487V	2.86%	0.00%	0.00%	2.86%	7	The SEL-487V is a capacitor bank protection relay. It is used for 1x132kV duplicate cap and 6x33kV duplicate cap with an average commissioning of 2012. There was one relay fail alarm in 2012 with the relay being replaced. As the relays are very young, they will be reviewed in 2 years again.
KCEG140	2.50%	0.00%	0.00%	2.50%	7	Replace all.
KCGG140	0.00%	0.00%	2.22%	2.22%	4	Replace all.
FV2	0.00%	0.00%	2.13%	2.13%	75	Replace all at West Liverpool TS.
CMU/CMU11/CMU31	0.00%	0.25%	1.75%	2.00%	13	Replace 3 at Marayong under this program, remaining six are spare, 2 are cap or aux bar only and 2 are SEF indication only.
SEL-311C	0.95%	0.00%	0.95%	1.90%	20	Only 2 failures, one input contacts coming lose and the other was alarmed “IO Module” failure which was already cleared when staff arrived on site. Monitor.
KCEG142	0.95%	0.00%	0.95%	1.90%	21	Review in 2 years.
BE1-CDS240	0.63%	0.71%	0.54%	1.88%	224	Review in 2 years.
CAPM5	1.25%	0.63%	0.00%	1.88%	28	Recloser being used for feeders, not managed by Protection group
P445	1.79%	0.00%	0.00%	1.79%	54	Review in 2 years.
P543	1.65%	0.00%	0.09%	1.73%	231	Review in 2 years.
KBCH120	1.67%	0.00%	0.00%	1.67%	12	Review in 2 years.
IEE786	0.00%	1.67%	0.00%	1.67%	12	Review in 2 years.
P633	1.67%	0.00%	0.00%	1.67%	12	Review in 2 years.
RXKL1	0.00%	0.00%	1.43%	1.43%	8	Review in 2 years.
7SA510/7SA511	1.43%	0.00%	0.00%	1.43%	10	Review in 2 years.
P632	1.43%	0.00%	0.00%	1.43%	42	Review in 2 years.
2C138	0.04%	0.02%	1.33%	1.39%	727	Review in 2 years.
HOA4	0.00%	0.00%	1.33%	1.33%	15	See above.
ST2	0.00%	0.00%	1.33%	1.33%	15	Review in 2 years.
SPAJ140C	0.71%	0.00%	0.57%	1.28%	113	Review in 2 years.
L90	0.89%	0.00%	0.18%	1.07%	112	Review in 2 years.
2H33	0.00%	0.00%	0.95%	0.95%	21	Review in 2 years.
CDD	0.00%	0.00%	0.93%	0.93%	105	See below.

SEL-2505	0.74%	0.00%	0.00%	0.74%	54	Review in 2 years.
MCGG11	0.36%	0.00%	0.36%	0.71%	17	Review in 2 years.
P922	0.24%	0.00%	0.48%	0.71%	84	Review in 2 years.
OC48	0.00%	0.00%	0.70%	0.70%	52	Review in 2 years.
KCGG142	0.23%	0.23%	0.23%	0.70%	33	Review in 2 years.
P541	0.32%	0.32%	0.00%	0.63%	63	Review in 2 years.
TDS	0.00%	0.00%	0.63%	0.63%	93	Replace all at West Liverpool TS BBP.
CAG34	0.00%	0.00%	0.60%	0.60%	64	Review in 2 years.
B90	0.59%	0.00%	0.00%	0.59%	34	Review in 2 years.
D30	0.57%	0.00%	0.00%	0.57%	35	Review in 2 years.
CAG32	0.00%	0.19%	0.38%	0.57%	106	Review in 2 years.
SEL-311B	0.30%	0.00%	0.20%	0.51%	187	Review in 2 years.

Table 8 Failure rates for relays

8.2 GE SR750

GE SR750			
			
Known issues			
Failure mode	**Failure rate**	**Comments**	
Non-operation (Alarmed)	Extreme	12.4%	
Non-operation (Non-alarmed)	Extreme	15.9%	
Total	Extreme	28.3%	
Applications			
Application	**Risk level**	**Qty**	**Comments**
33/11kV TX LV OC/EF no busbar protection	Medium-High	3	Replace in this program with a P142
33/11kV TX LV OC/EF no busbar protection	Medium-High	3	Replace under TS146 Marayong ZS Project with a P142. TX1 relay failed in June 2016. TX2 relay failed in March 2016.
132/66kV TX LV OC/EF no busbar protection	Medium-High	1	Replace in this program with a P142
132/11kV TX LV OC/EF with busbar protection	Medium	2	Remove/put out of service in this program, the new duplicate TX differential relays will also provide TX LV OC/EF
33kV Feeder Directional OC/EF with Line Differential	Medium	2	Feeder 306 relay failed in October 2007, Feeder 311 relay failed in November 2015 – they were replaced with spares. Replace in this program with a P142
132kV Feeder duplicate directional OC/EF	Medium	1	Replace in this program with a P445
66/11kV TX LV OC/EF with busbar protection	Low-Medium	3	As there is busbar protection and HV backup, these are seen as low priority. Review in 2 years possibly to align with SR745 replacement.
33/11kV TX LV OC/EF no busbar protection	Low-Medium	2	Review in 8 years as they were only manufactured in 2008.
Various		12	Already included in previous PS008 program or other projects (PS011 and TS122) for replacement
	Total	**29**	
Notes			
• The GE Multilin SR 750 relays are the first batch of numeric OC & EF relays introduced around 2000 in Endeavour Energy's network • The manufacturer has advised that these relays are approaching toward the end of their design life. • 43 relay failures in the last five years			

8.3 ALSTOM P121

ALSTOM P121			
			
Known issues			
Failure mode	**Failure rate**	**Comments**	
Non-operation (Alarmed)	Extreme	8.3%	
Non-operation (Non-alarmed)	High	3.3%	
Applications			
Application	**Risk level**	**Qty**	**Comments**
Single Aux Transformer OC	Medium-Low	2	Like for like replacement with P123
Duplicate 22kV OC/EF	Medium-Low	8	All at Parklea ZS – six P121 relays have failed at Parklea ZS over the last three years. Like for like replacement with P123 at next maintenance (bring maintenance forward by 18 months if required)
Single 33/11kV TX LV OC/EF	Medium-Low	1	Like for like replacement with P123
33/11kV TX HV OC/EF with SR745	Medium-Low	1	Replace in this program with a P123, align with the replacement of the SR745
	Total	**12**	

8.4 KCGU140

KCGU140			
Known issues			
Failure mode	**Failure rate**	**Comments**	
Non-operation (Non-alarmed)	Extreme	6.67% - Four failures in 2013 and five in 2016. Relay seems to be approaching end of life.	
Applications			
Application	**Risk level**	**Qty**	**Comments**
Duplicate 11kV OC/EF with KCGU140 and MCGG53	Medium	21	Replace in this program with full panel replacement due to: • High failure rate • Issues with K-bus not initiating auto-reclose for 4 feeders • 3 feeders that are not able to have their SEF pickup set within the acceptable range of 4A.
Total		**21**	

8.5 GE SR745

GE SR745			
			
Known issues			
Failure mode	**Failure rate**	**Comments**	
Non-operation (Alarmed)	Medium	1.98% - Relay found failed at maintenance. One example of transformer fault failed to clear with differential.	
Non-operation (Non-alarmed)	Low	0.4% - Inner Harbour, internal transformer fault, differential failed to operate leading to delayed trip of transformer.	
Mal-operation	Medium	1.58% - Phantom current issues, input sensitivity issues, Inrush restraint, initial application included all instantaneous devices trip through the relay. Lithgow loss of load. Springhill malop (triggered CB fail).	
Applications			
Application	**Risk level**	**Qty**	**Comments**
Transformer Differential - TS - High speed trip through SR745	Medium	1	Non-alarmed failure of the relay can cause failure to achieve instantaneous clearance of high level transformer faults. One example of this occurred at Inner Harbour where there was a delayed trip for a transformer internal fault. – Replace in this program
Transformer Differential - ZS - High speed trip through SR745	Medium	5	Non-alarmed failure of the relay can cause failure to achieve instantaneous clearance of high level transformer faults. One example of this occurred at Inner Harbour where there was a delayed trip for a transformer internal fault. – Replace in this program.
Transformer differential - TS	Medium	3	These three relays at Fairfax TS are 17 years old. A mal-operation or a failure to operate could result in a TS outage. Replace in this program.
Transformer differential – ZS	Medium	2	Replace in this program
Transformer Differential - ZS - High speed trip through SR745	Low-Medium	12	Review in 2 years as the relays are slightly younger
Transformer differential (transmission substation)	Low-Medium	53	Review in future programs as the relays are slightly younger
Transformer differential (zone substation)	Low-Medium	25	Review in future programs as the relays are slightly younger
	Total	**101**	

Notes

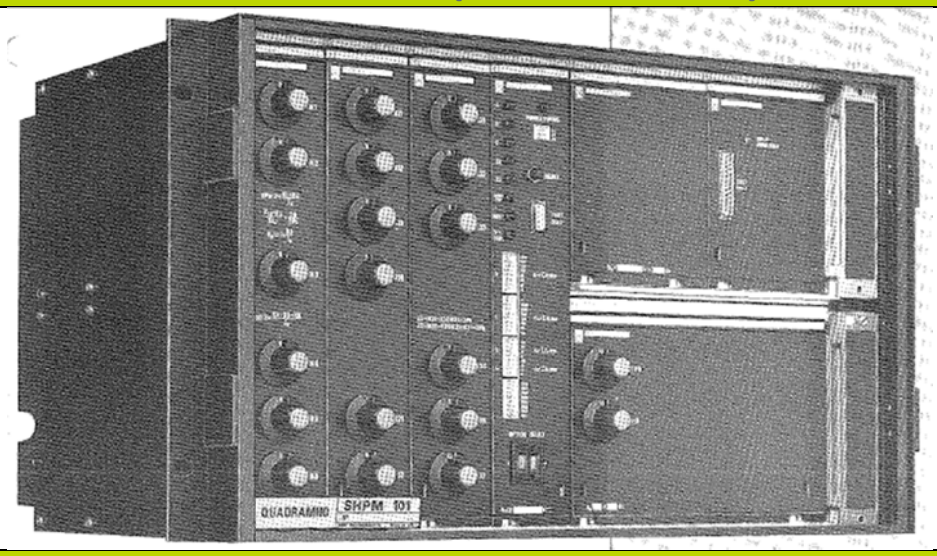
- One of the early versions of numerical relays, first introduced in 1997/98.
- The input burden is very low & very sensitive so can maloperate if it is accidentally touched when working on its panel resulting in the loss of a transformer
- The relay communication modules have failed on many occasions for these relays.
- There have been some false trips in recent times; as such they are a reliability concern.
- In the initial series of protection designs with these relays all auxiliary relay outputs (buchholz, pressure relief, hot winding etc.) were brought to this relay via its opto-inputs; this caused unintended operational & testing issues.

8.6 GE SR760

GE SR760			
			
Known issues			
Failure mode	**Failure rate**	**Comments**	
Non-operation (Alarmed)	Medium	1.67%	
Non-operation (Non-Alarmed)	Medium	1.67%	
Total	High	3.33%	
Applications			
Application	**Risk level**	**Qty**	**Comments**
Single 11kV Feeder OC/EF	High	4	Replace in this program with P142 and BE1-851E
Single 33kV Feeder Directional OC/EF with Check Sync	High	2	Potential full zone substation outage if the relay fails. Potential damage to customer generator if feeder is closed in when it is out of sync. Replace in this program with a P543 with sync check and BE1-1051.
33kV Bus Section Breaker Bus Blocking	Medium-High	2	Potential full zone substation outage if the relay fails to block. Replace in this program with a P142
33kV Feeder Directional OC/EF with 33kV busbar blocking	Medium-High	2	Potential full zone substation outage if the relay fails to block. Replace in this program with a P142
33kV Feeder Directional OC/EF with 7SD511	Medium	1	The 7SD511 has already failed and a temp L90 panel is in place. Replace both the 7SD511 and SR760 in this program.
33/11kV TX LV OC/EF with no busbar protection	Low-Medium	1	
33/11kV TX LV OC/EF with Frame Leakage	Low-Medium	2	
33/11kV TX LV OC/EF with bus blocking	Low-Medium	1	
33kV Feeder Directional OC/EF with backup relay	Low-Medium	15	Backup relay present.
Single 33kV Directional OC/EF	Low-Medium	2	Minimal consequence if there is a relay fail. Upstream protection provides backup.
Single 33kV Directional OC/EF	Low-Medium	2	Only 11 years old.
Single 33kV Feeder Directional OC/EF without source of fault current	Low	1	Feeder normally doesn't have any source for fault contribution
Single 11kV Feeder OC/EF supplying auxiliary bar only	Low	1	Low chance of fault on feeder.
	Total	**36**	

8.7 GEC ALSTOM (QUADRAMHO)

GEC ALSTOM (QUADRAMHO)



Known issues

Failure mode	Failure rate	Comments
Non-operation (Non-alarmed)	High	4.0% - Capacitor inside power supply module has dried out. (Note: failure rate is elevated as some relays have been removed in the past few years)

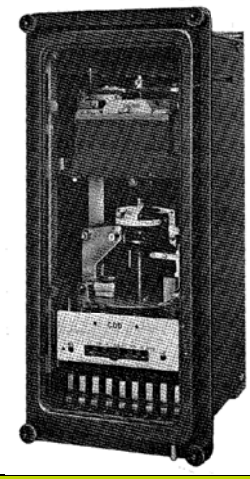
Applications

Application	Risk level	Qty	Comments
Duplicate 132kV Distance	High	2	Due to the low population the relay failure rates cannot be monitored. Replace in this program, also as it is being used in 132kV feeder application it is “High Consequence relay”
33kV Feeder Distance with OC/EF	High	1	Due to the low population the relay failure rates cannot be monitored. Replace in this program.
66kV Feeder Distance with Directional EF backup N/O	High	1	Due to the low population the relay failure rates cannot be monitored. Replace in this program.
33kV Feeder Distance with OC/EF	Low	1	Spare feeder – the relay is to be replaced under a customer application.
	Total	**9**	

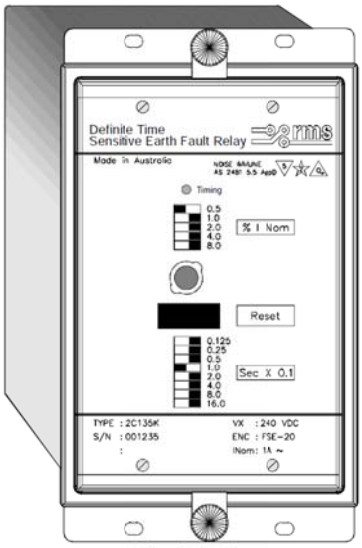
Notes

- Note: Not all defects have been recorded in Ellipse however comments are based on consultation with Protection Technicians and Operations Managers
- This type of static relay uses discrete electronic components. Generally it uses analogue devices for creation of operating characteristics.
- There are limited manual setting features and no feature to extract data out of the relay
- Currently only a few protection technicians have the ability to manage and test the relays.
- Testing is difficult

8.8 CDD

CDD			
			
Known issues			
Failure mode	**Failure rate**	**Comments**	
Non-operation (Non-alarmed)	0.93%	Six defects in the last two years – relay not operating trips, relay not picking up, relay out of tolerance	
Applications			
Application	**Risk level**	**Qty**	**Comments**
Single 33kV Feeder Directional OC/EF	Medium	1	Failure of the relay could cause total zone substation loss – replace in this program with a SEL-311C and P142.
Single 66kV Feeder Directional OC/EF	Medium	4	Failure of the relay could cause total zone substation loss – replace in this program with a SEL-311C and P142.
Single 66kV Feeder Directional OC/EF	Medium	1	Failure of the relay could cause total zone substation loss - Replace in this program with P543 using existing fibre/ADSS and BE1-1051
33kV Feeder Directional OC/EF with backup	Medium	1	Both #1 and #2 relays have medium failure rates. Replace in this program with P543 using existing fibre/ADSS and BE1-1051
Single 66kV Feeder Directional OC/EF with other feeder N/O	Low-Medium	2	Review in 2 years
66kV Feeder Directional OC/EF with same relay as backup	Low-Medium	2	Review in 2 years
33kV Feeder Directional OC/EF with backup	Low	29	Review in 2 years
66kV Feeder Directional OC/EF with backup	Low	4	Review in 2 years
132kV Feeder Directional OC/EF with backup	Low	1	
	Total	**45**	

8.9 2C135

2C135			
			
Known issues			
Failure mode	**Failure rate**	**Comments**	
Instantaneous Reset	N/A	As the relay has an instantaneous reset it is not able to detect intermittent/pecking faults. There is a potential for pecking faults to not be cleared for extended periods.	
Applications			
Application	**Risk level**	**Qty**	**Comments**
Single 11kV Feeder SEF supplying overhead, will not pickup intermittent fault	Medium-High	7	Replace in this program with 2C138 removed from PS012 sites.
Single 11kV Feeder SEF supplying underground	Medium	1	Replace in this program with 2C138 removed from PS012 sites.
11kV SEF		16	Being replaced under other projects (PS012 and PR673)
Total		**24**	

9.0 APPENDIX C – LOW POPULATION RELAYS

Relay Group	Technology	Age in 2019	No. of Relays Suggested for Replacement Based On Low Population Criteria	No. of relays in service (after relays removed under other projects)	Application	Strategy
2C135	Static	39	2	8	Typical Application – SEF Protection	Already being replaced under PR673
2DCC	Static	40	1	5	Typical Application – TX LV OC/EF	Review in 2 years, there are still some other 2DCC relays in service
2T146	Static	40	1	2	Typical Application – 11kV/66kV BBP CBF Timer	Replace in this program with a 2T105 timer
2T146	Static	40	1	2	Typical Application – 11kV/66kV BBP CBF Timer	Already being replaced under PS012 PD T 1552
2T146	Static	40	1	2	Typical Application – 11kV/66kV BBP CBF Timer	Replace in this program with a 2T105 timer
2T649	Static	38	2	2	Typical Application – 33kV BBP Supervision Timer	Review in 2 years as it does not provide a critical protection function
7SA510/7SA511	Microprocessor	27	2	10	High Risk Application – 132kV Distance Protection	Already being replaced under PS008 - PD T-1523 2017/18
AKA	Electromechanical	56	1	1	Typical Application – 66kV BBP Supervision Timer	Review in 2 years as it does not provide a critical protection function
AYDM/11	Electromechanical	34	2	2	High Risk Application – Check Sync Relay	Is being reviewed as a part of a customer application
B1	Electromechanical	55	2	2	Typical Application - OC relay for frame leakage	Replace in this program with a BE1-851E
B4	Electromechanical	55	6	6	Typical Application - OC relay for frame leakage	Replace in this program with a BE1-851E
CF3	Electromechanical	52	3	6	Typical Application – 33kV Underfrequency	Already disabled - put out of service in Ellipse and warning tag on site

FP/2	Electromechanical	56	1	1	Typical Application - 66kV Ripple Filter Neutral Unbalance Relay	Being Reviewed in the Legacy Protection Review
HHTA	Electromechanical	53	1	5	Typical Application – Translay Protection	Spare Feeder - Replace when a feeder is connected to it
KBCH130	Microprocessor	19	2	2	High Risk Application – 132k/11kV TX Differential	Replace in this program with a BE1-CDS240
MCSU	Static	32	1	7	Typical Application – TX 11kV SEF Indication	Put into out of service as it is indication only, downstream feeders already have SEF
MCSU	Static	32	1	7	Typical Application - Single 11kV Feeder SEF supplying auxiliary bar and capacitor bank	Put into out of service as it is supplying an auxiliary bar and capacitor bank and SEF is not enabled for the feeder
MCSU	Static	31	8	7	Typical Application - Single 11kV Feeder SEF	PS012 Future PD
MCSU	Static	31	2	7	Typical Application - TX 11kV SEF Indication	Put into out of service as it is indication only, downstream feeders already have SEF
QUADRAMHO	Static	36	2	4	High Risk Application – 132kV Feeder Distance Protection	Replace in this program with a P445
QUADRAMHO	Static	36	1	4	Typical Application – 33kV/66kV Feeder Distance Protection	Replace in this program with a P543
QUADRAMHO	Static	32	1	4	Typical Application – 33kV/66kV Feeder Distance Protection	Replace in this program with a SEL-311C
QUADRAMHO	Static	40	1	4	Typical Application – 33kV/66kV Feeder Distance Protection	Replace under UCL7388
RADSB	Static	32	2	9	High Risk Application – 132/11kV TX Differential	Replace in this program with a BE1-CDS240
RADSB	Static	32	1	9	Typical Application – 33/11kV TX Differential	Replace in this program with a BE1-CDS240

RADSB	Static	31	2	9	Typical Application – 33/11kV TX Differential	Replace in this program with a BE1-CDS240
RAZFE	Static	34	1	1	High Risk Application – 132kV Feeder Distance Protection	Replace in this program with a P543
ST2	Electromechanical	56	4	15	High Risk Application – 132kV BBP CBF Timer	Replace in this program with 2T105 timer
ST3	Electromechanical	56	4	4	High Risk Application – 132kV BBP CBF Timer	Replace in this program with 2T105 timer
VAT11/3	Electromechanical	56	4	4	High Risk Application – 132kV BBP CBF Timer	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS

Table 9 Relays that met the low population criteria

10.0 APPENDIX D – AGE PROFILE FOR SINGLE DISTRIBUTION FEEDER PROTECTION RELAYS

Relay	1997	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Grand Total
BE1-851				2	11	25	50	56	75	28	2	43		2	9	7	1	1	312
BE1-851E								1	2	42	27	23	77	103	64	19	2		360
CAPM5											1			2	3				6
MCGG11											1								1
MCGG52	2																		2
OSM15										2									2
P123		4	8		1	4								3	8				28
P141											2		1		3				6
SEL-551				2										1					3
SR760		4																	4
Grand Total	**2**	**8**	**8**	**4**	**12**	**29**	**50**	**57**	**77**	**72**	**33**	**66**	**78**	**111**	**87**	**26**	**3**	**1**	**724**

Table 10 Age profile of Singele Distribution Feeder Protection

Note: Relays already included in other projects have not been shown.

11.0 APPENDIX E – INCIDENTS ASSOCIATED WITH SLOW CLEARANCE

16 January 2014 – Loss of Cranebrook ZS and Jordan Springs ZS (0.51 min)

The HARDEX was out of service and was replaced with temporary overcurrent protection. The temporary overcurrent protection pick up was set lower than load current under worst case contingency (N-1) conditions. A contingency occurred when an advertising balloon moved into the path of the parallel feeder.

6 August 2014 – Loss of 33kV feeder 491 (0.3 min)

- The Hardex had been out of service since July 2013 and slower temporary overcurrent protection systems were installed in place of Translay differential.
- Phase conductors and Hardex broken and fallen across the Western Railway line at one location. This included and caused outage on the Sydney Trains DC system as well as a Sydney Trains 11kV feeder.
- Hardex burn down causing an 11kV feeder fault and outage at second location.
- Cross arm broken at a third location
- Phase conductors and Hardex wrapped together on 4 spans at a fourth location.
- Several broken/smashed insulators.
- Hardex joint junction boxes blown off the pole
- Railway line outage and 220 train services disrupted or cancelled.
- Grass fires on both sides of the railway track.

Post incident assessment concluded that the conductors are protected within their through-fault rating in spite of the slower temporary protection system. This along with the failure of the cross arm, and broken insulators might indicate that the line is in poor condition. Tensile strength tests will be done on the failed conductor to determine its condition.

9 August 2014 - Loss of Emu Plains ZS (0.37 min)

- The Hardex had been out of service since March 2012 and slower temporary overcurrent protection systems were installed in place of Translay differential.
- The 33kV supply configuration was made radial (for protection redundancy), and the restoration was to be by way of manual system operator changeover to the other 33kV feeder.
- A phase conductor failed mechanically and dropped into the Nepean River causing a permanent fault on feeder 454.
- Manual changeover was not actioned due to confusion and concerns over an unexplained simultaneous busbar protection operation at the source (Penrith Transmission Substation). This busbar protection operation was due to an incorrectly isolated busbar protection system.

11 August 2014 - Loss of Emu Plains ZS (0.05 min)

- The phase conductor flashed over to the Hardex due to incorrect tensioning/clearances in the repair of the phase conductor from the previous incident (9th August)
- Manual changeover was actioned in 7 minutes.

25 August 2014 - Loss of 33kV feeder 491 (0.16 min)

A lightning struck the conductor where the HARDEX had been damaged and removed (from the event on the 6th August), and it failed, falling onto the ground and onto an 11kV feeder, a house and a car.

St Marys ZS station outage in August 2014, as St Mary ZS was supplied radially due to it having only one protection on feeder 491 as the fast protection was out of service due to a faulty pilot wire. A fault on feeder 491 was cleared in a slow clearance time of 1.1, the feeder attempted a reclose but tripped out again. The report finds that a faster clearance time may have prevented this total outage.

23 July 2017 - Loss of Kingswood ZS

Kingswood ZS experience a total substation outage on 23 July 2016, due to conductor clashing on both feeder 461 and 457 that supply Kingswood ZS. The investigation report found that the reducing fault clearance times on feeder 461 may reduce the possibility of conductor clashing and thus reduce the likelihood of a complete zone substation outage. The report found that the clearance times could be improved by the installation of feeder differential relays on feeder 461 by using existing fibre. In addition to the above, Feeder 461 at Kingswood ZS has a SEL-351A on temporary panel and CDD relays providing duplicate directional OC/EF. The HO2 relay on feeder 461 was removed in anticipation of the installation of an MBCI relay under the Penrith project. However this was cancelled for some reason which resulted in a SEL-351A temporary panel being installed

21 February 2017 - Loss of Castle Hill ZS

Castle Hill ZS experienced a total substation outage on 21 March 2017, when both feeders, 815 and 825, supplying the substation tripped. The report found that the tripping of feeder 815, the healthy feeder, could have been avoided if:

- The directionality of feeder 815 protection at Castle Hill ZS was correct
- If the feeder 825 had operated quicker than the ,

13 March 2017 - Loss of Yennora ZS

Yennora ZS experience a total substation outage on 13 March 2017, feeder 685 was cleared in Zone 1 from Guildford TS, the clearance from Yennora ZS took 1.28s due to the fault being intermittent. Feeder 686 tripped approximately 1.5s after the Feeder 685 fault. It is possible that this could have been due to conductor clashing which would have been exacerbated due to the extended clearance time of Yennora ZS feeder 685. It is possible that if the existing fibre to Yennora ZS had been used and a line differential scheme was in place on feeder 685 the clearance time would have been much faster and the tripping of feeder 686 and subsequent total loss of the zone substation could have been avoided.

12.0 APPENDIX F – SITE LIST

12.1 Central Region

Substation	Scheme	Relay Type	Works	Estimated Cost
ANZAC VILLAGE	11kV Feeder AZ1268(17095) ANZAC VILLAGE #1Tripping Timer	RXKL1	Replace in this program with P142 and BE1-851E, align with PS012 works at the site	$0
ANZAC VILLAGE	11kV Feeder AZ1268(17095) ANZAC VILLAGE #2Tripping Timer	RXKL1	Replace in this program with P142 and BE1-851E, align with PS012 works at the site	$0
ANZAC VILLAGE	11kV Feeder AZ1268(17095) ANZAC VILLAGE Ovecurrent & Earthfault Relay	SPAJ140C	Replace in this program with P142 and BE1-851E, align with PS012 works at the site	$32,000
ANZAC VILLAGE	11kV Feeder AZ1268(17095) ANZAC VILLAGE Ovecurrent & SEF	2DCC	Replace in this program with P142 and BE1-851E, align with PS012 works at the site	$0
ANZAC VILLAGE	Transformer #2 ANZAC VILLAGE ZS LV O/C & E/F and Bus Blocking relay	KCEG142	Replace in this program with P142	$25,000
ANZAC VILLAGE	Transformer #3 ANZAC VILLAGE ZS LV O/C & E/F and Bus Blocking Relay	KCEG142	Replace in this program with P142	$25,000
BOSSLEY PARK	33kV Feeder 745 BOSSLEY PARK ZONE SUB	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
EAST PROSPECT HVC	33kV Feeder 431 EAST PROSPECT HVC	HO4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
EAST PROSPECT HVC	33kV Feeder 440 EAST PROSPECT HVC	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
FAIRFAX LANE TS	Transformer #1 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program with SEL-387A	$35,000
FAIRFAX LANE TS	Transformer #2 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program with SEL-387A	$35,000
FAIRFAX LANE TS	Transformer #3 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program with SEL-387A	$35,000

Substation	Scheme	Relay Type	Works	Estimated Cost
HOLROYD	33kV Feeder 432 HOLROYD ZONE SUB Feeder Differential Relay	HO2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
HORSLEY PARK	33kV Feeder 48C HORSLEY PARK ZS Pilot Iwre Relay	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
KENTLYN	11kV BBP KENTLYN ZONE SUB	2T146	Replace in this program with a 2T105 timer	$10,000
MINTO	66kV BBP Sect A MINTO ZONE SUB	2T146	Replace in this program with a 2T105 timer	$10,000
NARELLAN	11KV FEEDER 27027 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	$32,000
NARELLAN	11KV FEEDER 27028 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	$32,000
NARELLAN	11KV FEEDER 27031 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	$32,000
NARELLAN	11KV FEEDER 27032 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	$32,000
NARELLAN	11KV FEEDER 27035 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	$32,000
NARELLAN	11KV FEEDER 27039 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	$32,000
NARELLAN	11KV FEEDER 27041 NARELLAN ZS	P123	Replace in this program with a P142 and BE1-851E	$32,000
NARELLAN	11KV FEEDER 27042 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	$32,000
NEPEAN TS	33kV Feeder 306 (#2 PROT) NEPEAN TS #2 Overcurrent & Earthfault Relay	SR750	Replace in this program with a P142	$25,000
NEPEAN TS	33kV Feeder 311 (#2 PROT) NEPEAN TS #2 Overcurrent & Earthfault Relay	SR750	Replace in this program with a P142	$25,000
OAKDALE	11kV Feeder H736 OAKDALE ZONE SUB	P123	Replace in this program with P142 and BE1-851E	$32,000

Substation	Scheme	Relay Type	Works	Estimated Cost
OAKDALE	11kV Feeder H745 OAKDALE ZONE SUB	P123	Replace in this program with P142 and BE1-851E	$32,000
OAKDALE	11kV Feeder P608 OAKDALE ZONE SUB	P123	Replace in this program with P142 and BE1-851E	$32,000
OAKDALE	11kV Feeder P611 OAKDALE ZONE SUB	P123	Replace in this program with a P142 and BE1-851E	$32,000
PRESTONS	PRESTONS ZS Camden Valley Way Prestons	P121	Replace in this program with a P123, align with the replacement of the SR745	$1,500
PRESTONS	PRESTONS ZS Camden Valley Way Prestons	SR745	Replace in this program with a BE1-CDS240 and also replace the P121 HV OC with a P123	$35,000
PRESTONS	PRESTONS ZS Transformer #1	P122	Replace in this program with a P123 as it coming close to the end of its life and to align with the replacement of SR745	$5,000
PRESTONS	PRESTONS ZS Transformer #1	SR745	Replace in this program with a BE1-CDS240 and also replace the P121 HV OC with a P123	$35,000
QUARRIES	33kV Feeder 434 QUARRIES ZONE SUB	MHOA	Replace in this program with P543 using existing Fibre/ADSS	$35,000
QUARRIES	33kV Feeder 434 QUARRIES ZONE SUB	SR760	Replace in this program with a P142	$25,000
QUARRIES	33kV Feeder 440 QUARRIES ZONE SUB	MHOA	Replace in this program with P543 using existing Fibre/ADSS	$35,000
QUARRIES	33kV Feeder 440 QUARRIES ZONE SUB	SR760	Replace in this program with a P142	$25,000
QUARRIES	33kV Sect.A-B BBP QUARRIES ZONE SUB Bus-Blocking Scheme Relay	SR760	Replace in this program with a P142	$25,000
QUARRIES	33kV Sect.B-C BBP QUARRIES ZONE SUB	SR760	Replace in this program with a P142	$25,000
SMITHFIELD	33kV Feeder 745/1 SMITHFIELD ZONE SUB	MHOA	Replace in this program with P543 using existing Fibre/ADSS	$35,000
SOUTH PROSPECT	33kV Feeder 431 SOUTH PROSPECT HVC	HO4	Replace in this program with P543 using existing Fibre/ADSS	$35,000

Substation	Scheme	Relay Type	Works	Estimated Cost
WEST LIVERPOOL	132kV BBP Sect A1(PRI) WEST LIVERPOOL TS #1 Bus Differential Relay	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	132kV BBP Sect A1(PRI) WEST LIVERPOOL TS Busbar CB Fail Timer (#1PROT)	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	132kV BBP Sect A1(SEC) WEST LIVERPOOL TS #2 Bus Differential Relay	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	132kV BBP Sect A1(SEC) WEST LIVERPOOL TS #2 Protection CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	132kV BBP Sect A2(PRI) WEST LIVERPOOL TS #1 Bus Differential Relay (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	132kV BBP Sect A2(PRI) WEST LIVERPOOL TS #1 CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	132kV BBP Sect A2(SEC) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	132kV BBP Sect A2(SEC) WEST LIVERPOOL TS #2 Bus Differential Relay (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	132kV BBP Sect B1(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	132kV BBP Sect B1(PRI) WEST LIVERPOOL TS #1 Protection CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	132kV BBP Sect B1(SEC) WEST LIVERPOOL TS	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	132kV BBP Sect B1(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	33kV BBP Sect 1(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	33kV BBP Sect 1(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000

Substation	Scheme	Relay Type	Works	Estimated Cost
WEST LIVERPOOL	33kV BBP Sect 1(SEC) WEST LIVERPOOL TS #2 BBP CB Fial Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	33kV BBP Sect 1(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	33kV BBP Sect 2 (PRI)WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	33kV BBP Sect 2 (PRI)WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	33kV BBP Sect 2 (SEC)WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	33kV BBP Sect 2 (SEC)WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	33kV BBP Sect 3(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	33kV BBP Sect 3(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	33kV BBP Sect 3(SEC) WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	33kV BBP Sect 3(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	33kV BBP Sect 4(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	33kV BBP Sect 4(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000
WEST LIVERPOOL	33kV BBP Sect 4(SEC) WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with 2T105	$10,000
WEST LIVERPOOL	33kV BBP Sect 4(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	$50,000

Substation	Scheme	Relay Type	Works	Estimated Cost
WEST LIVERPOOL	33kV Feeder 512 (#1 PROT) WEST LIVERPOOL TRANS SUB	QUADRAMHO	Replace in this program with a P543	$35,000
WETHERILL PARK WEST	33kV FEEDER 745 WEST WETHERILL PARK TS	MHOA	Replace in this program with P543 using existing Fibre/ADSS	$35,000
		Total Replacement	**72**	**$2,042,500**

12.2 Northern Region

Substation	Scheme	Relay Type	Works	Estimated Cost
BAULKHAM HILLS	132kV BBP SEC 1-2(#1Pr)BAULKHAM HILLS TS	ST2	Replace in this program with 2T105 timer	$10,000
BAULKHAM HILLS	132kV BBP SEC 1-2(#2PR)BAULKHAM HILLS TS	ST2	Replace in this program with 2T105 timer	$10,000
BAULKHAM HILLS	132kV BBP SEC 3-4(#1PR)BAULKHAM HILLS TS	ST2	Replace in this program with 2T105 timer	$10,000
BAULKHAM HILLS	132kV BBP SEC 3-4(#2PR)BAULKHAM HILLS TS	ST2	Replace in this program with 2T105 timer	$10,000
BLACKMANS FLAT	66kV Feeder 831 BLACKMANS FLAT ZONE SUB	CDD21	Replace in this program with a SEL-311C and a P142	$35,000
BLACKMANS FLAT	66kV Feeder 835/2 BLACKMANS FLAT ZS	CDD21	Replace in this program with a SEL-311C and a P142	$35,000
BLACKTOWN TS	33kV Feeder 432 (#1 PR) BLACKTOWN TS	HO2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
BLACKTOWN TS	33kV Feeder 434 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
BLACKTOWN TS	33kV Feeder 440 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
BLACKTOWN TS	33kV Feeder 450 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
BLACKTOWN TS	Transformer #4 (#1 PR) BLACKTOWN TS	SR745	Replace in this program with a BE1-CDS240, the KBCH120 to be review in three years time as the series doesn't have a high failure rate	$35,000
CARLINGFORD TS	132kV BBP Sect A1-2 Pri CARLINGFORD TS	ST3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	$10,000
CARLINGFORD TS	132kV BBP Sect A1-2 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	$10,000
CARLINGFORD TS	132kV BBP Sect A3 Pri CARLINGFORD TS	ST3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	$10,000

Substation	Scheme	Relay Type	Works	Estimated Cost
CARLINGFORD TS	132kV BBP Sect A3 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	$10,000
CARLINGFORD TS	132kV BBP Sect B1-2 Pri CARLINGFORD TS	ST3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	$10,000
CARLINGFORD TS	132kV BBP Sect B1-2 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	$10,000
CARLINGFORD TS	132kV BBP Sect B3 Pri CARLINGFORD TS	ST3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	$10,000
CARLINGFORD TS	132kV BBP Sect B3 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	$10,000
CARLINGFORD TS	132kV Feeder 229 (#1 PR) CARLINGFORD TS	RAZFE/M	Replace in this program with a three terminal P543	$45,000
CARLINGFORD TS	66kV Feeder 815 (#1 PR) CARLINGFORD TS	7SA510	Replace in this program with P543 using existing Fibre/ADSS	$20,000
CARLINGFORD TS	66kV Feeder 815 (#2 PR) CARLINGFORD TS	CO6	Replace in this program with BE1-851	$20,000
CASTLE HILL	11kV Frame Leakage Sect 1 CASTLE HILL ZS	B4	Replace in this program with a BE1-851E	$6,250
CASTLE HILL	11kV Frame Leakage Sect 1 CASTLE HILL ZS	B4	Replace in this program with a BE1-851E	$6,250
CASTLE HILL	11kV Frame Leakage Sect 2 CASTLE HILL ZS	B4	Replace in this program with a BE1-851E	$6,250
CASTLE HILL	11kV Frame Leakage Sect 2 CASTLE HILL ZS	B4	Replace in this program with a BE1-851E	$6,250
CASTLE HILL	11kV Frame Leakage Sect 3 CASTLE HILL ZS	B1	Replace in this program with a BE1-851E	$6,250
CASTLE HILL	11kV Frame Leakage Sect 3 CASTLE HILL ZS	B1	Replace in this program with a BE1-851E	$6,250
CASTLE HILL	66kV Feeder 815 CASTLE HILL ZONE SUB	CDD	Replace in this program with P543 using existing Fibre/ADSS and BE1-1051	$35,000
CASTLE HILL	Transformer #1 CASTLE HILL ZONE SUB	B4	Replace in this program with a BE1-851E	$6,250
CASTLE HILL	Transformer #2 CASTLE HILL ZONE SUB	B4	Replace in this program with a BE1-851E	$6,250

Substation	Scheme	Relay Type	Works	Estimated Cost
EAST WALLGROVE	33kV Feeder 489 EAST WALLGROVE SS	MHOA	Replace in this program with P543 using existing Fibre/ADSS	$35,000
EAST WALLGROVE	33kV Feeder 48C EAST WALLGROVE SS	MHOA	Replace in this program with P543 using existing Fibre/ADSS	$35,000
HAZELBROOK	66kV Feeder 808 HAZELBROOK ZS	MCGG11	Remove in this program as it is a normally open feeder and only one protection is required	$0
HAZELBROOK	66kV Feeder 808 HAZELBROOK ZS	QUADRAMHO	Replace in this program with a SEL-311C	$35,000
HAZELBROOK	66kV Feeder 826 HAZELBROOK ZS	No Volt Change Over Relay	Replace in this program with a SEL-311C	$35,000
ILFORD TS	Transformer #1 ILFORD TS Ilford	SR750	Replace in this program with P142	$25,000
KANDOS	Transformer #1 KANDOS ZONE SUB	SR750	Replace in this program with P142	$25,000
KINGSWOOD	33kV Feeder 461 KINGSWOOD ZONE SUB	CDD	Replace in this program with P543 using existing Fibre/ADSS and BE1-1051	$15,000
KINGSWOOD	33kV Feeder 461 KINGSWOOD ZONE SUB	HO2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
LENNOX	11kV Feeder 19869 LENNOX ZS	KCGG140	Replace in this program with a P142 and BE1-851E	$25,000
LENNOX	11kV Feeder 19872 LENNOX ZS	KCGG140	Replace in this program with a P142 and BE1-851E	$25,000
LENNOX	Transformer #2 LENNOX ZONE SUB	KCEG140	Replace in this program with a P142	$25,000
LITHGOW	66kV Feeder 857 LITHGOW ZONE SUB	CDD21	Replace in this program with a SEL-311C and a P142	$35,000
LITHGOW	66kV Feeder 85X LITHGOW ZONE SUB	CDD21	Replace in this program with a SEL-311C and a P142	$35,000
MARAYONG	11kV 1951 COKE 1&GARLING RD MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	$10,000
MARAYONG	11kV 1952 BOWMANS&GLENWOOD MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	$10,000
MARAYONG	11kV FDR 1950 DUNSTABLE RD MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	$5,000
MARAYONG	11kV Feeder 1953 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	$5,000
MARAYONG	11kV Feeder 1954 MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	$10,000

Substation	Scheme	Relay Type	Works	Estimated Cost
MARAYONG	11kV Feeder 1956 FORGE ST MARAYONG ZS	BE1-851	Replace in this program, by install a 2C138 removed from PS012 sites.	$5,000
MARAYONG	11kV Feeder 1957 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	$5,000
MARAYONG	11kV Feeder 1958 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	$5,000
MARAYONG	11kV Feeder 1959 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	$5,000
MARAYONG	11kV Feeder 1960 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	$5,000
MARAYONG	11kV Feeder 1962 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	$5,000
MARAYONG	11kV Feeder 1963 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites.	$5,000
MT DRUITT TS	33kV Feeder 487 (#1 PROT) MT DRUITT TS	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
MT DRUITT TS	33kV Feeder 488 (#1 PROT) MT DRUITT TS	HO2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
MT DRUITT TS	33kV Feeder 489 (#1 PROT) MT DRUITT TS	HOA2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
MT DRUITT TS	33kV Feeder 495 (#1 PROT) MT DRUITT TS	HO2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
NEWTON	33kV Feeder 450 NEWTON ZONE SUB	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
NORTH KATOOMBA TS	132kV Fdr 940 (#1 PR) NORTH KATOOMBA TS	KCEG140	Replace in this program with a SEL-311C	$35,000
NORTH KATOOMBA TS	132kV Fdr 940 (#2 PR) NORTH KATOOMBA TS	KCEG140	Replace in this program with a P445	$35,000
NORTH KATOOMBA TS	132kV FDR 941 (#2 PR) NORTH KATOOMBA TS	SR750	Replace in this program with a P445	$35,000
PARKLEA	22KV FEEDER CB 25772 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
PARKLEA	22KV FEEDER CB 25773 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
PARKLEA	22KV FEEDER CB 25775 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
PARKLEA	22KV FEEDER CB 41361 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
PARKLEA	22KV FEEDER CB 41362 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000

Substation	Scheme	Relay Type	Works	Estimated Cost
PARKLEA	22KV FEEDER CB 41363 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
PARKLEA	22KV FEEDER CB 41365 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
PARKLEA	22KV FEEDER CB 41367 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
PENRITH TS	33kV Feeder 461(#1PROT) PENRITH TS	BE1-851E	Replace in this program with P543 using existing Fibre/ADSS	$35,000
Penrith ZS	11kV Feeder PH1201 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1201 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1208 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1208 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1212 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1212 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1219 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1219 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1223 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1223 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1227 (#1 PROT) PENRITH ZS	KCGG142	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1227 (#1 PROT) PENRITH ZS	RXKL1	Replace in this program with P142 and BE1-851E	$0
Penrith ZS	11kV Feeder PH1227 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1227 (#2 PROT) PENRITH ZS	RXKL1	Replace in this program with P142 and BE1-851E	$0
Penrith ZS	11kV Feeder PH1230 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1230 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1234 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1234 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1238 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1238 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1245 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1245 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250

Substation	Scheme	Relay Type	Works	Estimated Cost
Penrith ZS	11kV Feeder PH1249 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1249 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1256 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1256 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1260 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1260 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1264 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1264 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1267 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1267 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1271 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1271 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1286 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1286 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1290 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1290 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1293 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1293 (#1 PROT) PENRITH ZS	RXKL1	Replace in this program with P142 and BE1-851E	$0
Penrith ZS	11kV Feeder PH1293 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1293 (#2 PROT) PENRITH ZS	RXKL1	Replace in this program with P142 and BE1-851E	$0
Penrith ZS	11kV Feeder PH1297 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	11kV Feeder PH1297 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	$18,250
Penrith ZS	Transformer #5 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	$5,000
Penrith ZS	Transformer #5 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	$5,000

Substation	Scheme	Relay Type	Works	Estimated Cost
Penrith ZS	Transformer #6 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	$5,000
Penrith ZS	Transformer #6 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	$5,000
PLUMPTON	33kV Feeder 487 PLUMPTON ZONE SUB	MHOA	Replace in this program with P543 using existing Fibre/ADSS	$35,000
PLUMPTON	33kV Feeder 488 PLUMPTON ZONE SUB	HO2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
PLUMPTON	Transformer #2 PLUMPTON ZONE SUB	SR750	Replace in this program with P142	$25,000
PLUMPTON	Transformer #3 PLUMPTON ZONE SUB	SR750	Replace in this program with P142	$25,000
QUAKERS HILL	33kV Feeder 450 QUAKERS HILL ZONE SUB	HOA4	Replace in this program with P543 using existing Fibre/ADSS	$35,000
RIVERSTONE	33kV Feeder 441 RIVERSTONE ZONE SUB	CDD	Replace in this program with a SEL-311C and a P142	$35,000
SPRINGWOOD	Transformer #3 SPRINGWOOD ZONE SUB	KCGG140	Replace in this program with P123	$15,000
SPRINGWOOD	Transformer #3 SPRINGWOOD ZONE SUB	SPAJ140C	Replace in this program with a P142	$25,000
SPRINGWOOD	Transformer #4 SPRINGWOOD ZONE SUB	KCGG140	Replace in this program with P123	$15,000
SPRINGWOOD	Transformer #4 SPRINGWOOD ZONE SUB	SPAJ140C	Replace in this program with a P142	$25,000
WEST CASTLE HILL	TX #1 (#1 PR) WEST CASTLE HILL ZS	KBCH130	Replace in this program with BE1-CDS240	$25,000
WEST CASTLE HILL	TX #1 (#2 PR) WEST CASTLE HILL ZS	SR745	Replace in this program with SEL-387A and disable the SR750 as it is no longer required	$25,000
WEST CASTLE HILL	TX #1 (#2 PR) WEST CASTLE HILL ZS	SR750	Replace in this program, the new duplicate TX Differential relays will also provide TX LV OC/EF	$0
WEST CASTLE HILL	TX #2 (#1 PR) WEST CASTLE HILL ZS	KBCH130	Replace in this program with BE1-CDS240	$25,000
WEST CASTLE HILL	TX #2 (#2 PR) WEST CASTLE HILL ZS	SR745	Replace in this program with SEL-387A and disable the SR750 as it is no longer required	$25,000
WEST CASTLE HILL	TX #2 (#2 PR) WEST CASTLE HILL ZS	SR750	Replace in this program, the new duplicate TX Differential relays will also provide TX LV OC/EF	$0

Substation	Scheme	Relay Type	Works	Estimated Cost
WHALAN	33kV Feeder 487(1#PROT) WHALAN ZONE SUB	HOA2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
WHALAN	33kV Feeder 495(1#PROT) WHALAN ZONE SUB	HOA2	Replace in this program with P543 using existing Fibre/ADSS	$35,000
		Total Replacement	**140**	**$2,540,000**

12.3 Southern Region

Substation	Scheme	Relay Type	Works	Estimated Cost
ALBION PARK	Transformer #1 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	$5,000
ALBION PARK	Transformer #1 ALBION PARK ZONE	P123	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	$5,000
ALBION PARK	Transformer #1 ALBION PARK ZONE	SR745	Replace in this program with BE1-CDS240 and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	$35,000
ALBION PARK	Transformer #2 ALBION PARK ZONE	P122	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	$5,000
ALBION PARK	Transformer #2 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	$5,000
ALBION PARK	Transformer #2 ALBION PARK ZONE	SR745	Replace in this program and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	$35,000
ALBION PARK	Transformer #3 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	$5,000
ALBION PARK	Transformer #3 ALBION PARK ZONE	P122	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	$5,000
ALBION PARK	Transformer #3 ALBION PARK ZONE	SR745	Replace in this program and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	$35,000
BELLAMBI CREEK TS	132kV Feeder 980 (#1 PROT) BELLAMBI CREEK	7SA511	Replace in this program with a P445	$45,000
BELLAMBI CREEK TS	132kV Feeder 981 (#1 PROT) BELLAMBI CREEK	7SA511	Replace in this program with a P445	$45,000
BELLAMBI CREEK TS	TRANSFORMER #1 (#2 PROT) BELLAMBI CREEK	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
BELLAMBI CREEK TS	TRANSFORMER #2 (#2 PROT) BELLAMBI CREEK	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
CULBURRA	11kV Feeder CLA2 CULBURRA	MCGG52	Replace in this program with P142 and BE1-851E	$32,000
CULBURRA	11kV Feeder CLD2 CULBURRA	MCGG52	Replace in this program with P142 and BE1-851E	$32,000

Substation	Scheme	Relay Type	Works	Estimated Cost
KEMBLA GRANGE	11kV Feeder CB 25449 Kembla Grange ZS	SR760	Replace in this program with a P142 and BE1-851E	$32,000
KEMBLA GRANGE	11kV Feeder CB 25450 Kembla Grange ZS	SR760	Replace in this program with a P142 and BE1-851E	$32,000
KEMBLA GRANGE	11kV Feeder CB 25451 Kembla Grange ZS	SR760	Replace in this program with a P142 and BE1-851E	$32,000
KEMBLA GRANGE	11kV Feeder CB 35590 Kembla Grange ZS	SR760	Replace in this program with P142 and BE1-851E	$32,000
KEMBLA GRANGE	33kV Feeder 7117 Kembla Grange ZS	SR760	Replace in this program with a P543 with sync check and BE1-1051	$40,000
KEMBLA GRANGE	33kV Feeder 7341 Kembla Grange ZS	SR760	Replace in this program with a P543 with sync check and BE1-1051	$40,000
KENNY STREET	Transformer #1 KENNY ST ZS	P123	Replace in this program with a P123 to align with RADSB replacement as it is close to end of life	$3,000
KENNY STREET	Transformer #1 KENNY ST ZS	RADSB	Replace in this program with a BE1-CDS240	$35,000
KENNY STREET	Transformer #2 KENNY ST ZS	P123	Replace in this program with a P123 to align with RADSB replacement as it is close to end of life	$3,000
KENNY STREET	Transformer #2 KENNY ST ZS	RADSB	Replace in this program with a BE1-CDS240	$35,000
KIAMA	33kV Feeder 730 KIAMA	SR760	Replace in this program with a L90 and P142	$40,000
OUTER HARBOUR TS	132kV Feeder 985 (#2 PROT) OUTER HARBOUR TS	QUADRAMHO	Replace in this program with a P445	$45,000
OUTER HARBOUR TS	132kV Feeder 989 (#2 PROT) OUTER HARBOUR TS	QUADRAMHO	Replace in this program with a P445	$45,000
ULLADULLA	11kV Feeder ULG2 ULLADULLA	RADSB	Replace in this program with a BE1-CDS240	$45,000
ULLADULLA	Transformer #1 ULLADULLA ZS	RADSB	Replace in this program with a BE1-CDS240	$45,000
ULLADULLA	Transformer #2 ULLADULLA ZS	RADSB	Replace in this program with a BE1-CDS240	$45,000
UNANDERRA	Tfr1 ORRCON Orrcon	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	$5,000
		Total Replacement	**32**	**$853,000**

APPENDIX B - **STATEMENT OF ASSET NEED – PROTECTION SCHEME RENEWAL NEED**

REFER TO THE ATTACHED APPENDIX B – STATEMENT OF ASSET NEED – PROTECTION SCHEME RENEWAL, JUNE 2015

#1000 7620

Endeavour Energy

Statement of Asset Need

To	Manager Asset Strategy & Planning	File no	
From	Protection Manager	Date	29 July 2016
Subject	Protection Scheme Renewal Need (PS008 & PS011)		
Copies	Preliminary Phase Manager		

Background

SARP programs PS008 and PS011 are ongoing condition and renewal based programs for the replacement of protection relays and associated panel equipment as it reaches the end of its life as evidenced by risk of malfunction, technological redundancy or non-conformance with current standards of network reliability or safety.

Network need

The purpose of protection schemes is to react to and isolate parts of the electrical network in the case of electrical faults and some other abnormal conditions (for example, frequency excursion) in order to:

- prevent system instability.
- prevent equipment damage to plant carrying the fault current.
- minimise the extent of damage at the fault site and reduce the likelihood of collateral damage to other equipment through fire or explosion.
- minimise the safety risk to humans and livestock .
- minimise the extent of any outage.

The two main ways a protection system can fail are:

- Failure to operate when required, causing a risk that the above objectives are not achieved.
- Unwanted operation resulting in needless loss of load, which influences reliability performance and results in a negative STPIS outcome.

Protection systems need to be renewed when the risk of failure outweighs the costs of renewal.

Approach to asset renewal

Endeavour Energy's approach to these renewal-driven investment programs has several key elements including:

- End of life/condition based renewal - where it is assessed that the assets are no longer fit for purpose due to their deteriorating condition, deteriorating performance, inability to be effectively maintained or when it becomes more cost-effective to replace than to continue to maintain or refurbish.

- Consequence Based Risk Analysis – assessment processes to monitor asset performance and target replacement once risk levels become unacceptable.
- Comparison to the high level asset renewal expenditure modelling using the Value Development Algorithm (VDA) to ensure the proposed expenditure is appropriate and consistent with long-term needs.

End of life/Condition based renewal

Ideally, relay renewal would be based on continuously monitored failure rate data and risk criteria rather than age, however there are several issues with this reactive approach:

- Relay failure data in Ellipse is partial and the format of captured data does not easily yield itself to analysis, for example, separating failure modes which do not affect the protection, such as SCADA communication failures, with non-operation failures requires manual interpretation of data which is in text format.
- Platform failure rate may increase beyond the appropriate level before it is identified, and this is particularly the case with low quantity relays.
- Platform failure for large quantity relays will result in a peaky replacement profile, and resources might not be available to respond quickly enough to a newly recognised requirement.

The accuracy and format of protection asset data is a known area for improvement. To address this, there is an established project and budget allocation for the improvement of protection data (EF002 – Technology Pilots).

The generally accepted life expectancy ranges used within the industry for protective relays is as detailed in the following table:

Relay type / Life expectancy	Low	Average	High
Microprocessor complex multifunction	10	15 to 20	25 to 30
Static simple single function electronic	15 to 20	25	30
Electromechanical moving parts, few or no electronic components	30	45	>50

Endeavour Energy generally does not strictly control the protection relay environment as some utilities do, and has different environmental conditions. The life expectancy of an electronic relay will correlate with temperature. For this reason, the relay life data of other utilities may not be highly relevant to Endeavour Energy's operations. Supporting this argument are the minimum relay life expectancy results from GE's recent protection relay accelerated life testing for their SR platform relays:

- 36 years at 25°C.
- 13 years at 40°C.

Note: GE has advised that these life expectancy results are not applicable to the majority of SR relays in Endeavour's system, which are of an older design and have a much lower life expectancy.

End of life/condition based renewal investment is currently provisioned within PIPv7.1a, allowing for $14m over the next 10 years.

Risk based analysis

The risk analysis has considered the following most common plant types:

- Distribution feeders with only a single overcurrent relay.
- Distribution feeders with two protection schemes.
- Transformer protection schemes.
- 132kV feeder protection schemes.

Distribution feeders with single overcurrent protection (static/numerical)

There are 972 out of 2147 of 11/22kV distribution feeder overcurrent and earthfault protection relays that are not fully backed up. That is, for some bolted faults types at certain locations along the feeder, there is only one protection device that has the capability to detect the fault.

If the primary device fails to operate as intended, the fault may remain and potential damage could occur to other network components that supply the fault. This could result in mains on the ground at other locations upstream of the fault. This may then subsequently result in clearance by the zone transformer overcurrent's resulting in loss of zone substation supply, resulting in an average STPIS impact of $500k.

There is also a small but non-negligible increased risk of harm to persons due to the:

- Increased energy released at the original fault site.
- Subsequent faults and potentially mains down at subsequent fault sites.
- Step and touch voltages both at the fault site and at other locations where there are transferred earth voltages.
- Fire ignition.

Risk analysis - Distribution feeder faults with 1 protection (static/numerical)

The outcome analysis detailed in Diagram 1 below considers the total risk value for a typical single protection feeder given the following assumptions:

- A non-alarmed failure rate of 1% per event.
- A fault frequency of 1 fault per annum.
- Backup coverage of 80% of the feeder length.
- 80% of all faults are earth faults and are therefore detected by the SEF relay.
- A loss of station load consequence value of $500k.
- A conductor damage consequence value of $100k.
- A prolonged uncleared feeder fault including conductor damage in several locations and loss of zone substation load consequence value of $1 million.

This analysis yields an NPV value of risk over the 20 year life of a modern relay of over $52k which exceeds the cost of relay renewal. This analysis indicates that a failure rate well below 1% must be maintained to avoid a justified renewal need in this case.

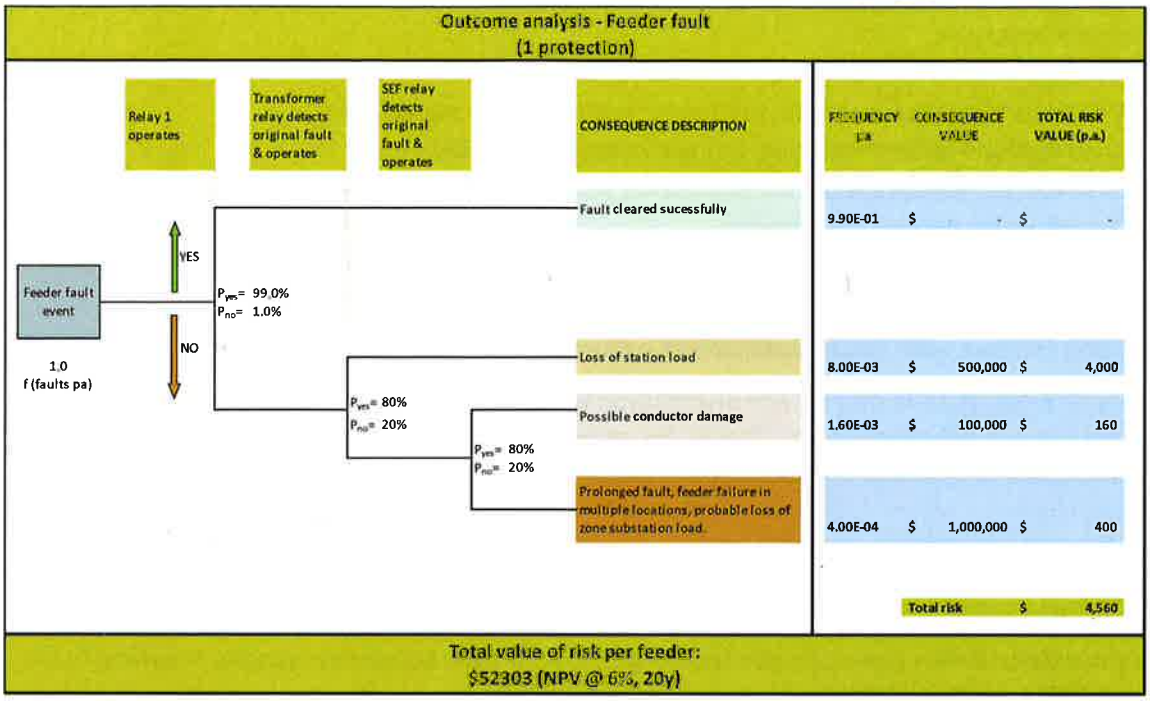


Diagram 1 – Risk analysis for distribution feeder faults with only 1 protection

The current failure rate indicated by Ellipse maintenance records for the most prevalent relay model in this scenario (the Basler BE1-851) is currently less than 0.1% p.a. which if considered to all be non-alarmed, not operational failures corresponds to a failure rate per event below 0.2% given 3 yearly maintenance intervals and a fault frequency of 1 per annum.

Given the degree of variation of individual feeders (such as fault frequency) against the averages estimated in the analysis above, it is likely that some feeders would warrant duplication even at the current failure rate, and replacement would be warranted on most feeders when failure rates double to around 0.4% per event.

For this circumstance, the analysis suggests that a proactive replacement is warranted. Of the 972 relays there are 481 relays that were installed in 2007 or prior (20 year life time). The age profile for these are shown in Appendix 1.

The funding requirement to replace the 481 relays, identified in Appendix 2, over 10 years is $12m.

Risk analysis - Distribution feeder faults – 2 protections

There are 1175 out of 2147 of 11/22kV distribution feeder overcurrent and earthfault protection relays that have back up protection. The risk analysis in Diagram 2 below has identified that two independent protections can tolerate a protection failure rate substantially higher than normal (<1% per event) before renewal is warranted

The outcome analysis detailed in Diagram 2 below considers the total risk value for a typical 2-protection feeder given the following assumptions:

- A non-alarmed failure rate of 1% and 10% per event in each of 2 respective relays.

- A fault frequency of 1 fault per annum.
- A prolonged uncleared feeder fault will cause conductor damage in several locations and loss of zone substation load consequence and has a consequence value of $1 million.

This analysis yields an NPV value of risk over the 20-year life of a modern relay of $11k which is not dissimilar to the cost of renewal. This suggests that in this application, higher than normal failure rates could be tolerated in some circumstances, particularly for the duration of a reactive replacement response, provided that the failure rate of the backup scheme is normal (less than 1% per event).

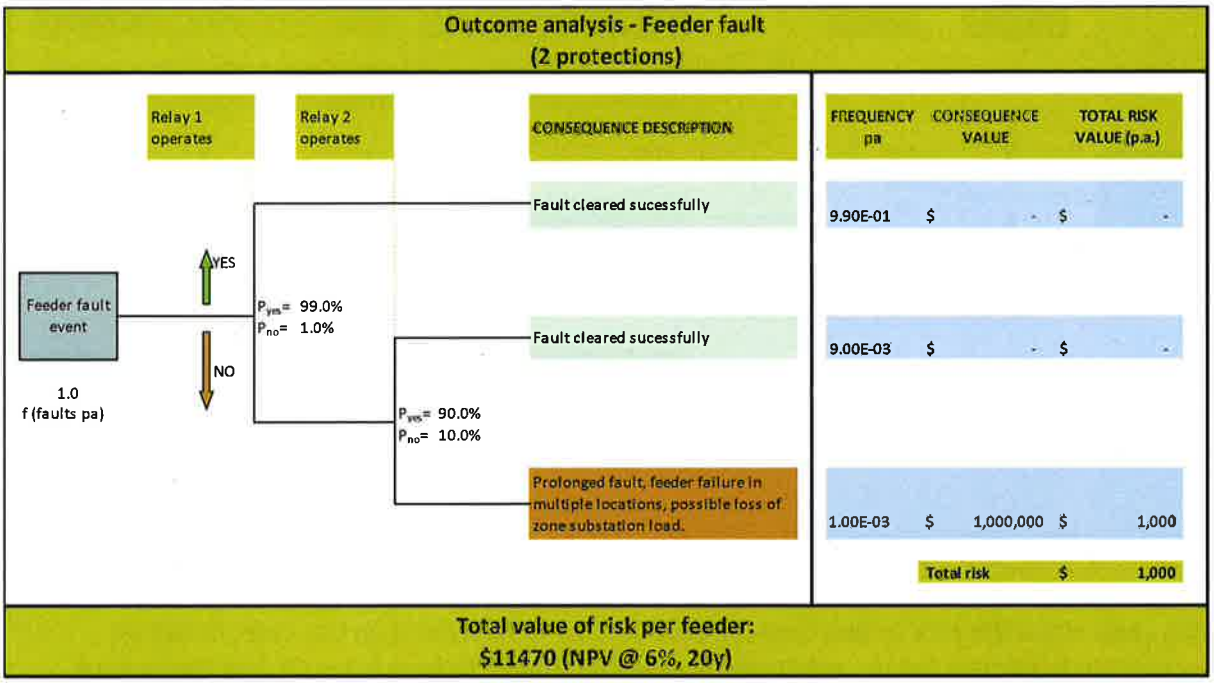


Diagram 2 – Risk analysis for distribution feeder faults with two protections

This case shows the NPV as less than the cost of relay replacement. In this case, it may be acceptable to adopt a failure rate based renewal approach, if there is a sufficient quantity of similar make, model and age of relay in the system to monitor.

Risk analysis - Transformer faults

There are 1435 of Transformer overcurrent and earthfault protection relays that have back up protection. The risk analysis in Diagram 3 below has identified that two independent protections can tolerate a protection failure rate substantially higher than normal (<1% per event) before renewal is warranted.

The outcome analysis detailed in Diagram 3 below considers the total risk value for a typical 2 protection transformer given the following assumptions:

- A non-alarmed failure rate of 1% and 10% per event in each of the 2 respective relays.
- A fault frequency of 1 in 25 per annum.

- A prolonged uncleared transformer fault will result in destruction of the transformer, major loss of load, and extensive site damage and has consequence value of $10 million.

This analysis yields an NPV value of risk over the 20-year life of a modern relay of $4.6k, which is less than the cost of relay renewal. This suggests that in this application, higher than normal failure rates could be tolerated in some circumstances, particularly for the duration of a reactive replacement response, provided that the failure rate of the backup scheme is normal (less than 1% per event).

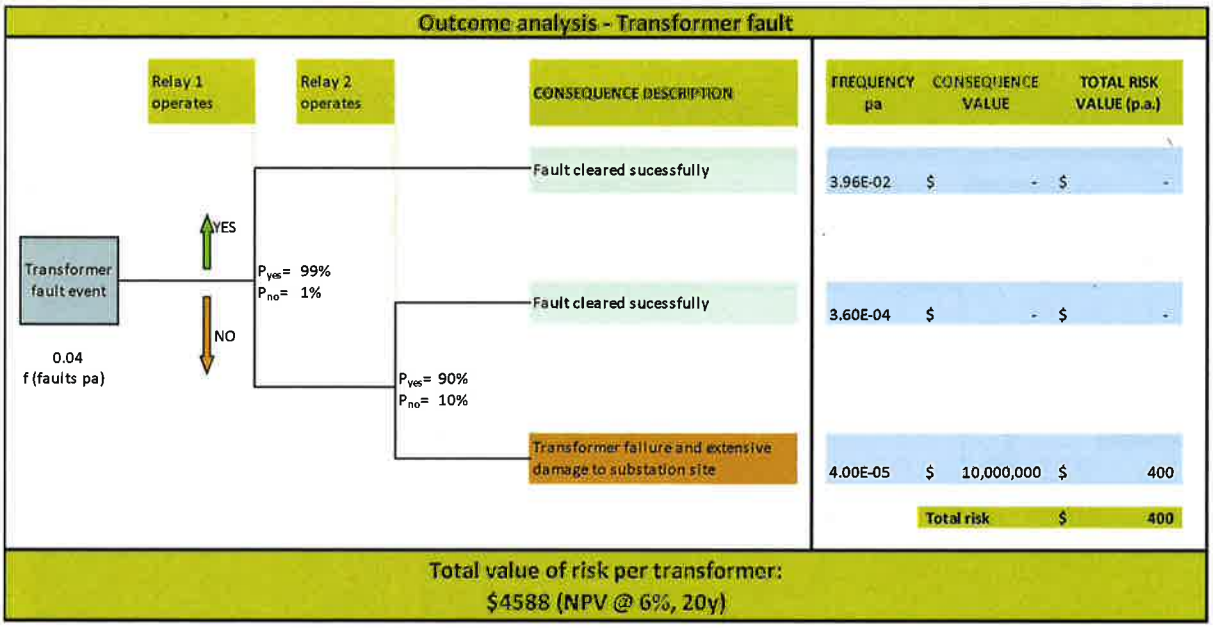


Diagram 3 – Risk analysis for Transformer protection

This cases show the NPV as less than the cost of relay replacement. In this case, it may be acceptable to adopt a failure rate based renewal approach, if there is a sufficient quantity of similar make, model and age of relay in the system to monitor.

Risk analysis - 132kV feeder faults

There are 309 132kV feeder protection relays that are candidates for replacement. The risk analysis in Diagram 4 below suggests 132kV feeder relays may be replaced proactively. These 309 microprocessor/static feeder relays providing the main protection on 132kV feeders that are not included in PS008 or other major projects.

The outcome analysis detailed in Diagram 4 below considers the total risk value for a typical 132kV feeder with 2 protection systems, given the following assumptions:

- A non-alarmed failure rate of 1% per event on both relays.
- A fault frequency of 0.3 faults per annum.
- A prolonged uncleared feeder fault will cause a stability event to the scale of loss of 10% of NSW GDP, which is a consequence value of approximately $150 million.

This analysis yields an NPV value of risk over the 20-year life of a modern relay of $52k which exceeds the cost of renewal. This suggests that in this application, higher than normal failure

rates (>1% per event) cannot be tolerated in many or most circumstances, and so relays in this application may need to be renewed on a proactive basis, particularly if low relay quantities make failure rates difficult to monitor.

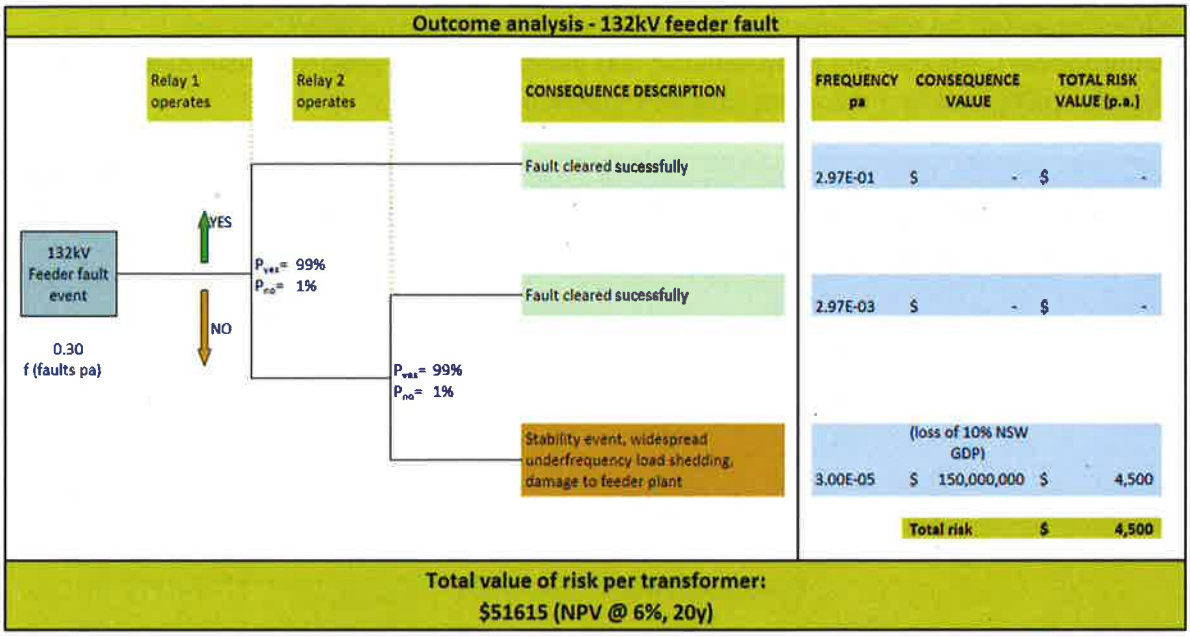


Diagram 4 – Risk analysis for 132kV feeder protection

For this circumstance, the analysis suggests that a proactive replacement is warranted. Of the 309 relays there are 50 relays that were installed in 2007 or prior (20 year life time). The age profile for these are shown in Appendix 1.

The funding requirement to replace the 50 relays, identified in Appendix 2, over 10 years is $2.3m.

Comparison to VDA

Asset Strategy & Planning conducted a projection for protection relay replacement. This analysis estimated the following average planned replacement levels per annum over a 10 year period, which is dependent on relay replacement age by type (Electromechanical/Electronic /Microprocessor). The cost per relay replaced was estimated to be $25k. This VDA Base Age is the age base profiling tool for forecasting program expenditure.

Replacement Criteria	Replacement Scenarios (10 year average per annum)		
	Scenario 1 (Minimum Age) 30/20/10 years	Scenario 2 (Base Age) 45/25/20 years	Scenario 3 (Maximum Age) 50/30/25 years
Relays replaced (p.a.)	621	179	101
Cost (p.a.)	$15.5 million	$4.5 million	$2.5 million
Total Cost	$155 million	$45 million	$25 million

The additional risk based analysis requires an additional $14.3m investment over a 10-year period, over the current PIP v7.1a investment levels, taking the total funding requirement to$28.3m over the 10-year period. This falls between the VDA Base and maximum age investment profiles.

Recommendations

It is recommended to progress with the addition of scope, identified in Appendix 2, for the two scenarios identified where the risk of failure is not tolerable, at an additional cost of $14.3m over the 10-year period. This results in a total investment over a 10-year period of $28.3m which falls between the VDA Base and maximum age investment profiles.

The 10-year period forecasted expenditure can be summarised as:

Relay application	10 year contribution
Distribution with single protection	$12.0m
132kV feeder protection	$2.3m
End of life/condition based renewal (PIP v7.1a)	$14m
Total	**$28.3m**

Recommended by:

1/8/16

for Matthew Browne
Protection Manager

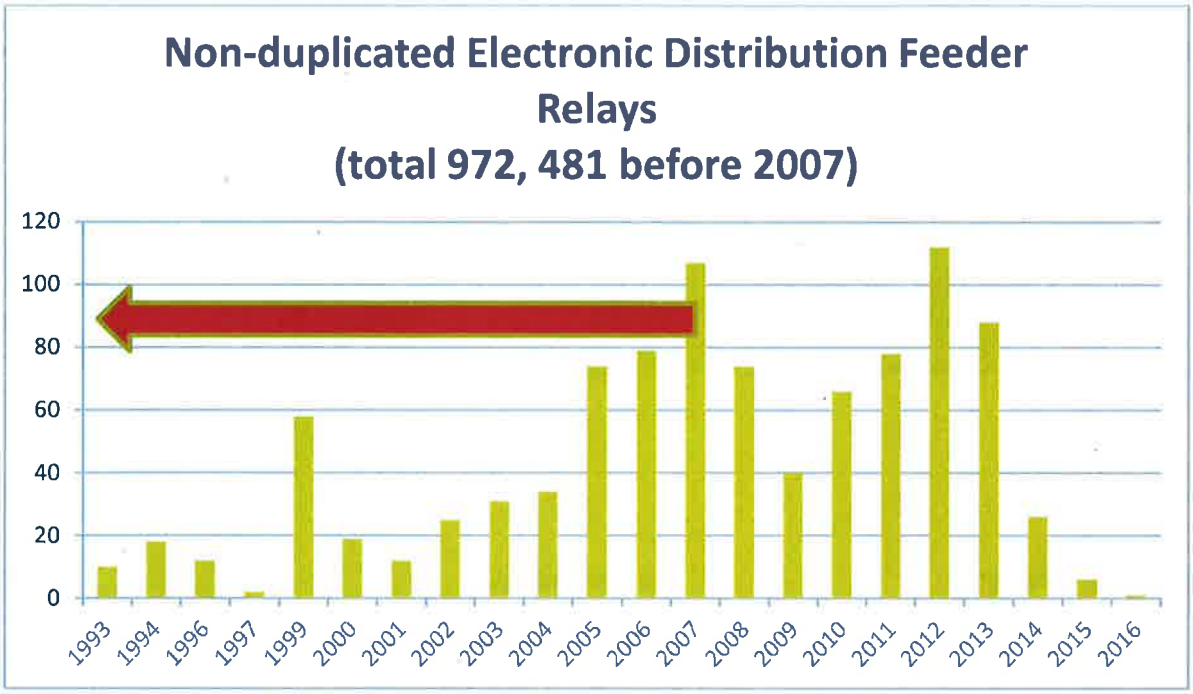
Endorsed by:

Danny Asvestas
Manager Asset Standards & Design
1.8.16

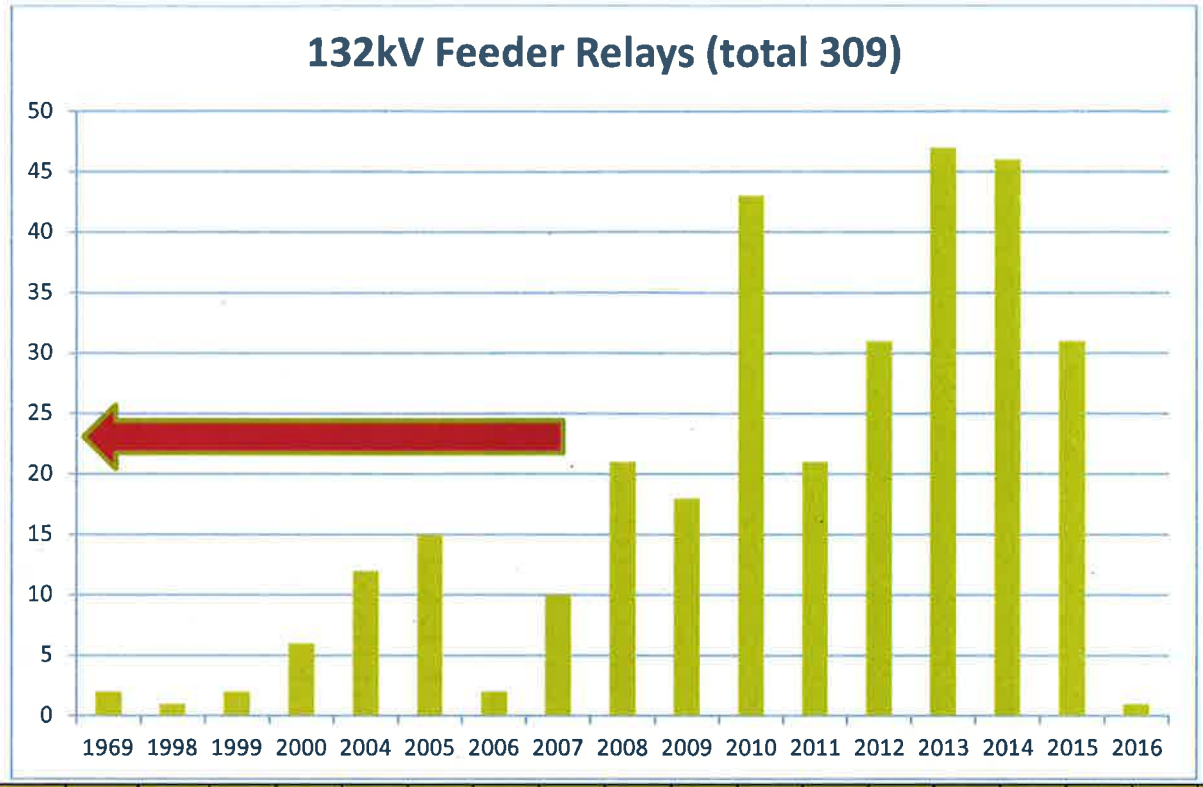
Appendices

1. Age profiles for Distribution feeders with single overcurrent protection and 132kV feeder protection relays.
2. Locations of the distribution feeders with single overcurrent protection and 132kV feeder protection relays to be replaced in 10 years.

Appendix 1 – Age profiles for Distribution feeders with single overcurrent protection and 132kV feeder protection relays



Row Labels	1993	1994	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Grand Total
7SJ610						2		3															5
BE1-851						1		6	21	31	60	76	103	30	2	43		3	10	7	1	1	395
BE1-851E												1	2	42	32	23	77	103	65	19	2		366
CAPM5																		1	3				4
KCEG142					1				1														2
KCGG140			2		5																		7
KCGG142		5			43				8		8								1		1		66
KCGU140			2																				2
MCGG11			1												5								6
MCGG22	1																						1
MCGG52				2		4	1	1															8
MCGG53			7																				7
N12/CAP M2					2																		2
N12/CAP M5					5		3	8			3	1						1					21
N15/CAP M5											2		2		1								5
OSM15											1	1		2									4
P123						7	8		1	1							1		2				20
P123A																		3	6				9
P141																			1				1
SEL-551								7		1								1					9
SPAJ140C	9	13			2					1											2		27
SR760						5																	5
Total	**10**	**18**	**12**	**2**	**58**	**19**	**12**	**25**	**31**	**34**	**74**	**79**	**107**	**74**	**40**	**66**	**78**	**112**	**88**	**26**	**6**	**1**	**972**



Row Labels	1969	1998	1999	2000	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Grand Total
7SA510		1	2															3
7SA511				2	2													4
7SD511													1	1				2
7SD522						3									1			4
7SD610						1			1				1					3
D30				1		2	1			5	8		1					18
D60											2				2			4
KCEG140									2									2
L90				1				4	9	4	10	8	5	13	12	15		81
LFZP 112				1	1													2
P445												3	9	10	6	1	1	30
P541						1			1		4	2	1	1				10
P543				1		3			1	4	6	6	6	13	11	14		65
P544							1	3	7		1				2			14
SEL-311B					9	5		1		5	10	2	1	6	5			44
SEL-311C											2		6	3	7	1		19
SEL-351A								1										1
SHPM/1	2																	2
SR750								1										1
Grand Total	**2**	**1**	**2**	**6**	**12**	**15**	**2**	**10**	**21**	**18**	**43**	**21**	**31**	**47**	**46**	**31**	**1**	**309**

Endeavour Energy

Appendix 2 – Locations of the distribution feeders with single overcurrent protection and 132kV feeder protection relays to be replaced in 10 years.

Locations	Number of distribution relays
ALBION PARK	2
AMBARVALE	1
ANZAC VILLAGE	10
ARNDELL PARK	19
BAULKHAM HILLS ZS	20
BELLA VISTA	33
BERRY	4
BLAXLAND	1
BOLONG	2
BOMADERRY	6
BONNYRIGG	5
BOSSLEY PARK	2
BOW BOWING	20
BOWRAL	8
BYLONG	3
CABRAMATTA	1
CAMBRIDGE PARK	1
CARRAMAR	1
CASTLE HILL	12
CATTAI	8
CRANEBROOK	2
CULBURRA	3
DARKES FOREST	1
DUNDAS	1
EMU PLAINS	1
GLENMORE PARK	1
GREYSTANES	1
HARTLEY VALE	1
HINCHINBROOK	17
HOMEPRIDE	5
HORSLEY PARK	1
HUSKISSON	6
JAMBEROO	2
KANGAROO VALLEY	3
KELLYVILLE	1
KEMBLA GRANGE	5
KENTHURST	1
KENTLYN	2

Locations	Number of distribution relays
KINGSWOOD	1
LEABONS LANE	1
LENNOX	6
Liverpool ZS	6
MACQUARIE FIELDS	1
MALDON	12
MAMRE	20
MARAYONG	1
MEADOW FLAT	2
MOOREBANK	2
MOSS VALE	2
NARELLAN	16
NEWTON	6
NORTH PARRAMATTA	19
NORTH RICHMOND	9
NORTH ROCKS	1
NORTH WOLLONGONG	1
OAKDALE	4
Penrith ZS	9
PORT CENTRAL	1
PRESTONS	17
PROSPECT	2
QUAKERS HILL	6
RIVERSTONE	2
ROBERTSON	5
ROOTY HILL	1
SEVEN HILLS	2
SHELLHARBOUR	11
SHERWOOD	2
SOUTH WOLLONGONG	1
SPRINGWOOD	12
SUSSEX INLET	4
TAHMOOR	12
ULLADULLA	8
UNANDERRA	4
WARRAGAMBA	3
WERRINGTON	25
WEST CASTLE HILL	12
WOMBARRA	6
YATTE YATTAH	2
YENNORA	11
Grand Total	**481**

Locations	Number of 132kV relays
BAULKHAM HILLS	6
BELLA VISTA	6
BELLAMBI CREEK TS	4
BLACKTOWN TS	1
FAIRFAX LANE TS	1
GLENMORE PARK	4
MAMRE	4
MOUNT TERRY TS	2
MT DRUITT TS	2
NORTH KATOOMBA TS	2
PARKLEA	2
SHOALHAVEN TS	7
WEST LIVERPOOL	7
OUTER HARBOUR TS	2
Grand Total	**50**

APPENDIX C – **COST ESTIMATE**
REFER TO THE ATTACHED APPENDIX C – PS008_ESTIMATE_07-04-17

2017/18-2018/19 PS008 Cost Estimate

Substation	Protection Scheme	Part No	Replacement	Revised Comment	Indicative #1 Relay	Indicative #1 relay cost	Indicative #2 relay	Indicative #2 relay cost	Total Indicative Relay costs	Cost, $ (Estimated by Protection Section)	Cost, $ including Proj. Mgt., $ (Estimated by TSD)	Variance Between Estimates, $	Project Mgt (Included in total cost), $
ANZAC VILLAGE	Transformer #2 ANZAC VILLAGE ZS LV O/C & E/F and Bus Blocking relay	KCEG142	Replace in this program with P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
ANZAC VILLAGE	Transformer #3 ANZAC VILLAGE ZS LV O/C & E/F and Bus Blocking Relay	KCEG142	Replace in this program with P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
BOSSLEY PARK	33kV Feeder 745 BOSSLEY PARK ZONE SUB	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100
EAST PROSPECT HVC	33kV Feeder 431 EAST PROSPECT HVC	HO4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
EAST PROSPECT HVC	33kV Feeder 440 EAST PROSPECT HVC	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
FAIRFAX LANE TS	Transformer #1 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program with SEL-387A	Replace in this program	SEL-387A	$5,435		#N/A	$5,435	$35,000	36,000	$1,000	3,100
FAIRFAX LANE TS	Transformer #2 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program with SEL-387A	Replace in this program	SEL-387A	$5,435		#N/A	$5,435	$35,000	36,000	$1,000	3,100
FAIRFAX LANE TS	Transformer #3 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program with SEL-387A	Replace in this program	SEL-387A	$5,435		#N/A	$5,435	$35,000	36,000	$1,000	3,100
HOLROYD	33kV Feeder 432 HOLROYD ZONE SUB Feeder Differential Relay	HO2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
HORSLEY PARK	33kV Feeder 48C HORSLEY PARK ZS Pilot Iwre Relay	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
KENTLYN	11kV BBP KENTLYN ZONE SUB	2T146	Replace in this program with a 2T105 timer	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	10,000	$0	3,100
MINTO	66kV BBP Sect A MINTO ZONE SUB	2T146	Replace in this program with a 2T105 timer	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	10,000	$0	3,100
NARELLAN	11KV FEEDER 27027 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	1,900
NARELLAN	11KV FEEDER 27031 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	1,900
NARELLAN	11KV FEEDER 27032 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	1,900
NARELLAN	11KV FEEDER 27035 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	1,900
NARELLAN	11KV FEEDER 27039 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	1,900
NARELLAN	11KV FEEDER 27041 NARELLAN ZS	P123	Replace in this program with a P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	1,900
NARELLAN	11KV FEEDER 27042 NARELLAN ZS	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	1,900
NEPEAN TS	33kV Feeder 306 (#2 PROT) NEPEAN TS #2 Overcurrent & Earthfault Relay	SR750	Replace in this program with a P142	Replace in this program with a distance relay	SEL-311C	$6,426		#N/A	$6,426	$25,000	32,000	$7,000	3,100
NEPEAN TS	33kV Feeder 311 (#2 PROT) NEPEAN TS #2 Overcurrent & Earthfault Relay	SR750	Replace in this program with a P142	Replace in this program with a distance relay	SEL-311C	$6,426		#N/A	$6,426	$25,000	32,000	$7,000	3,100
OAKDALE	11kV Feeder H736 OAKDALE ZONE SUB	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	2,200
OAKDALE	11kV Feeder H745 OAKDALE ZONE SUB	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	2,200
OAKDALE	11kV Feeder P608 OAKDALE ZONE SUB	P123	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	2,200
OAKDALE	11kV Feeder P611 OAKDALE ZONE SUB	P123	Replace in this program with a P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	37,000	$5,000	2,200
PRESTONS	PRESTONS ZS Camden Valley Way Prestons	P121	Replace in this program with a P123, align with the replacement of the SR745	Replace in this program with a P123, align with the replacement of the SR745	P123	$1,748		#N/A	$1,748	$1,500	1,500	$0	-
PRESTONS	PRESTONS ZS Camden Valley Way Prestons	SR745	Replace in this program with a BE1-CDS240 and also replace the P121 HV OC with a P123	Replace in this program with a BE1-CDS240 and also replace the P121 HV OC with a P123	BE1-CDS240	$5,091		#N/A	$5,091	$35,000	32,500	-$2,500	3,100
PRESTONS	PRESTONS ZS Transformer #1	P122	Replace in this program with a P123 as it coming close to the end of its life and to align with the replacement of SR745	Replace in this program with a P123 as it coming close to the end of its life and to align with the replacement of SR745	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	-
PRESTONS	PRESTONS ZS Transformer #1	SR745	Replace in this program with a BE1-CDS240 and also replace the P121 HV OC with a P123	Replace in this program with a BE1-CDS240 and also replace the P122 HV OC with a P123	BE1-CDS240	$5,091		#N/A	$5,091	$35,000	32,500	-$2,500	3,100
QUARRIES	33kV Feeder 434 QUARRIES ZONE SUB	MHOA	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
QUARRIES	33kV Feeder 434 QUARRIES ZONE SUB	SR760	Replace in this program with a P142	Replace in this program with a distance relay	SEL-311C	$6,426		#N/A	$6,426	$25,000	28,500	$3,500	3,100
QUARRIES	33kV Feeder 440 QUARRIES ZONE SUB	MHOA	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
QUARRIES	33kV Feeder 440 QUARRIES ZONE SUB	SR760	Replace in this program with a P142	Replace in this program with a distance relay	SEL-311C	$6,426		#N/A	$6,426	$25,000	28,500	$3,500	3,100
QUARRIES	33kV Sect.A-B BBP QUARRIES ZONE SUB Bus-Blocking Scheme Relay	SR760	Replace in this program with a P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
QUARRIES	33kV Sect.B-C BBP QUARRIES ZONE SUB	SR760	Replace in this program with a P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
SMITHFIELD	33kV Feeder 745/1 SMITHFIELD ZONE SUB	MHOA	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100

2017/18-2018/19 PS008 Cost Estimate

Substation	Protection Scheme	Part No	Replacement	Revised Comment	Indicative #1 Relay	Indicative #1 relay cost	Indicative #2 relay	Indicative #2 relay cost	Total Indicative Relay costs	Cost, $ (Estimated by Protection Section)	Cost, $ including Proj. Mgt., $ (Estimated by TSD)	Variance Between Estimates, $	Project Mgt (Included in total cost), $
SOUTH PROSPECT	33kV Feeder 431 SOUTH PROSPECT HVC	HO4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
WEST LIVERPOOL	132kV BBP Sect A1(PRI) WEST LIVERPOOL TS #1 Bus Differential Relay	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	132kV BBP Sect A1(PRI) WEST LIVERPOOL TS Busbar CB Fail Timer (#1PROT)	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	132kV BBP Sect A1(SEC) WEST LIVERPOOL TS #2 Bus Differential Relay	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	132kV BBP Sect A1(SEC) WEST LIVERPOOL TS #2 Protection CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	132kV BBP Sect A2(PRI) WEST LIVERPOOL TS #1 Bus Differential Relay (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	132kV BBP Sect A2(PRI) WEST LIVERPOOL TS #1 CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	132kV BBP Sect A2(SEC) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	132kV BBP Sect A2(SEC) WEST LIVERPOOL TS #2 Bus Differential Relay (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	132kV BBP Sect B1(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	132kV BBP Sect B1(PRI) WEST LIVERPOOL TS #1 Protection CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	132kV BBP Sect B1(SEC) WEST LIVERPOOL TS	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	132kV BBP Sect B1(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 1(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 1(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 1(SEC) WEST LIVERPOOL TS #2 BBP CB Fial Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 1(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 2 (PRI)WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 1(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 2 (PRI)WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 2 (PRI)WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 2 (SEC)WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 2 (SEC)WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 3(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 3(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 3(SEC) WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 3(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 4(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 4(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV BBP Sect 4(SEC) WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with 2T105	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	5,000	-$5,000	-
WEST LIVERPOOL	33kV BBP Sect 4(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program with a 2V73	Replace in this program	2V73	$2,295		#N/A	$2,295	$50,000	45,000	-$5,000	3,100
WEST LIVERPOOL	33kV Feeder 512 (#1 PROT) WEST LIVERPOOL TRANS SUB	QUADRAMHO	Replace in this program with a P543	Replace in this program	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
WETHERILL PARK WEST	33kV FEEDER 745 WEST WETHERILL PARK TS	MHOA	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100
BAULKHAM HILLS	132kV BBP SEC 1-2(#1Pr)BAULKHAM HILLS TS	ST2	Replace in this program with 2T105 timer	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
BAULKHAM HILLS	132kV BBP SEC 1-2(#2PR)BAULKHAM HILLS TS	ST2	Replace in this program with 2T105 timer	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
BAULKHAM HILLS	132kV BBP SEC 3-4(#1PR)BAULKHAM HILLS TS	ST2	Replace in this program with 2T105 timer	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
BAULKHAM HILLS	132kV BBP SEC 3-4(#2PR)BAULKHAM HILLS TS	ST2	Replace in this program with 2T105 timer	Replace in this program with a new timer relay	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
BLACKMANS FLAT	66kV Feeder 831 BLACKMANS FLAT ZONE SUB	CDD21	Replace in this program with a SEL-311C and a P142	Replace in this program with duplicate protection	SEL-311C	$6,426		#N/A	$6,426	$35,000	36,000	$1,000	3,100
BLACKMANS FLAT	66kV Feeder 835/2 BLACKMANS FLAT ZS	CDD21	Replace in this program with a SEL-311C and a P142	Replace in this program with duplicate protection	SEL-311C	$6,426	P142	$2,685	$9,111	$35,000	36,000	$1,000	3,100
BLACKTOWN TS	33kV Feeder 432 (#1 PR) BLACKTOWN TS	HO2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	47,000	$12,000	3,100
BLACKTOWN TS	33kV Feeder 434 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	47,000	$12,000	3,100

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Substation	Protection Scheme	Part No	Replacement	Revised Comment	Indicative #1 Relay	Indicative #1 relay cost	Indicative #2 relay	Indicative #2 relay cost	Total Indicative Relay costs	Cost, $ (Estimated by Protection Section)	Cost, $ including Proj. Mgt., $ (Estimated by TSD)	Variance Between Estimates, $	Project Mgt (Included in total cost), $
BLACKTOWN TS	33kV Feeder 440 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	47,000	$12,000	3,100
BLACKTOWN TS	33kV Feeder 450 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	48,000	$13,000	3,100
BLACKTOWN TS	Transformer #4 (#1 PR) BLACKTOWN TS	SR745	Replace in this program with a BE1-CDS240, the KBCH120 to be review in three years time as the series doesn't have a high failure rate	Replace in this program	BE1-CDS240	$5,091		#N/A	$5,091	$35,000	36,000	$1,000	3,100
CARLINGFORD TS	132kV BBP Sect A1-2 Pri CARLINGFORD TS	ST3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
CARLINGFORD TS	132kV BBP Sect A1-2 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
CARLINGFORD TS	132kV BBP Sect A3 Pri CARLINGFORD TS	ST3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
CARLINGFORD TS	132kV BBP Sect A3 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
CARLINGFORD TS	132kV BBP Sect B1-2 Pri CARLINGFORD TS	ST3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
CARLINGFORD TS	132kV BBP Sect B1-2 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
CARLINGFORD TS	132kV BBP Sect B3 Pri CARLINGFORD TS	ST3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
CARLINGFORD TS	132kV BBP Sect B3 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a 2T105 - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	2T105	$515		#N/A	$515	$10,000	10,000	$0	600
CARLINGFORD TS	132kV Feeder 229 (#1 PR) CARLINGFORD TS	RAZFE/M	Replace in this program with a three terminal P543	Replace in this program with a three terminal line differential relay	P543	$13,902		#N/A	$13,902	$45,000	49,000	$4,000	3,100
CARLINGFORD TS	66kV Feeder 815 (#1 PR) CARLINGFORD TS	7SA510	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$20,000	47,000	$27,000	3,100
CARLINGFORD TS	66kV Feeder 815 (#2 PR) CARLINGFORD TS	CO6	Replace in this program with BE1-851	Replace in this program	BE1-851E	$2,579		#N/A	$2,579	$20,000	28,500	$8,500	3,100
CASTLE HILL	11kV Frame Leakage Sect 1 CASTLE HILL ZS	B4	Replace in this program with a BE1-851E	Replace in this program	BE1-851E	$2,579		#N/A	$2,579	$6,250	6,250	$0	600
CASTLE HILL	11kV Frame Leakage Sect 1 CASTLE HILL ZS	B4	Replace in this program with a BE1-851E	Replace in this program	BE1-851E	$2,579		#N/A	$2,579	$6,250	6,250	$0	600
CASTLE HILL	11kV Frame Leakage Sect 2 CASTLE HILL ZS	B4	Replace in this program with a BE1-851E	Replace in this program	BE1-851E	$2,579		#N/A	$2,579	$6,250	6,250	$0	600
CASTLE HILL	11kV Frame Leakage Sect 2 CASTLE HILL ZS	B4	Replace in this program with a BE1-851E	Replace in this program	BE1-851E	$2,579		#N/A	$2,579	$6,250	6,250	$0	600
CASTLE HILL	11kV Frame Leakage Sect 3 CASTLE HILL ZS	B1	Replace in this program with a BE1-851E	Replace in this program	none - covered	#N/A	none - covered	#N/A	$0	$6,250	6,250	$0	600
CASTLE HILL	11kV Frame Leakage Sect 3 CASTLE HILL ZS	B1	Replace in this program with a BE1-851E	Replace in this program	none - covered	#N/A	none - covered	#N/A	$0	$6,250	6,250	$0	600
CASTLE HILL	66kV Feeder 815 CASTLE HILL ZONE SUB	CDD	Replace in this program with P543 using existing Fibre/ADSS and BE1-1051	Replace in this program with line differential relay using existing Fibre/ADSS and a #2 distance relay	P543	$13,902	SEL-311C	$6,426	$20,328	$35,000	50,750	$15,750	3,100
CASTLE HILL	Transformer #1 CASTLE HILL ZONE SUB	B4	Replace in this program with a BE1-851E	Replace in this program	none - covered	#N/A	none - covered	#N/A	$0	$6,250	6,250	$0	600
CASTLE HILL	Transformer #2 CASTLE HILL ZONE SUB	B4	Replace in this program with a BE1-851E	Replace in this program	none - covered	#N/A	none - covered	#N/A	$0	$6,250	6,250	$0	600
EAST WALLGROVE	33kV Feeder 489 EAST WALLGROVE SS	MHOA	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
EAST WALLGROVE	33kV Feeder 48C EAST WALLGROVE SS	MHOA	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100

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Substation	Protection Scheme	Part No	Replacement	Revised Comment	Indicative #1 Relay	Indicative #1 relay cost	Indicative #2 relay	Indicative #2 relay cost	Total Indicative Relay costs	Cost, $ (Estimated by Protection Section)	Cost, $ including Proj. Mgt., $ (Estimated by TSD)	Variance Between Estimates, $	Project Mgt (Included in total cost), $
HAZELBROOK	66kV Feeder 808 HAZELBROOK ZS	MCGG11	Remove in this program as it is a normally open feeder and only one protection is required	Remove in this program as it is a normally open feeder and only one protection is required		#N/A		#N/A	$0	$0	0	$0	-
HAZELBROOK	66kV Feeder 808 HAZELBROOK ZS	QUADRAMHO	Replace in this program with a SEL-311C	Replace in this program	SEL-311C	$6,426		#N/A	$6,426	$35,000	32,500	-$2,500	3,100
HAZELBROOK	66kV Feeder 826 HAZELBROOK ZS	No Volt Chang	Install a SEL-311C	Install distance protection	SEL-311C	$6,426		#N/A	$6,426	$35,000	32,500	-$2,500	3,100
ILFORD TS	Transformer #1 ILFORD TS Ilford	SR750	Replace in this program with P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
KANDOS	Transformer #1 KANDOS ZONE SUB	SR750	Replace in this program with P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
KINGSWOOD	33kV Feeder 461 KINGSWOOD ZONE SUB	CDD	Replace in this program with P543 using existing Fibre/ADSS and BE1-1051	Replace in this program with a distance relay		#N/A	SEL-311C	$6,426	$6,426	$15,000	7,500	-$7,500	-
KINGSWOOD	33kV Feeder 461 KINGSWOOD ZONE SUB	HO2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100
LENNOX	11kV Feeder 19869 LENNOX ZS	KCGG140	Replace in this program with a P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$25,000	25,000	$0	1,500
LENNOX	11kV Feeder 19872 LENNOX ZS	KCGG140	Replace in this program with a P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$25,000	25,000	$0	1,500
LENNOX	Transformer #2 LENNOX ZONE SUB	KCEG140	Replace in this program withh a P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
LITHGOW	66kV Feeder 857 LITHGOW ZONE SUB	CDD21	Replace in this program with a SEL-311C and a P142	Replace in this program and install duplicate protection	SEL-311C	$6,426	P142	$2,685	$9,111	$35,000	36,000	$1,000	3,100
LITHGOW	66kV Feeder 85X LITHGOW ZONE SUB	CDD21	Replace in this program with a SEL-311C and a P142	Replace in this program and install duplicate protection	SEL-311C	$6,426	P142	$2,685	$9,111	$35,000	36,000	$1,000	3,100
MARAYONG	11kV 1951 COKE 1&GARLING RD MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$10,000	10,000	$0	600
MARAYONG	11kV 1952 BOWMANS&GLENWOOD MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$10,000	10,000	$0	600
MARAYONG	11kV FDR 1950 DUNSTABLE RD MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$5,000	5,000	$0	600
MARAYONG	11kV Feeder 1953 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$5,000	5,000	$0	600
MARAYONG	11kV Feeder 1954 MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$10,000	10,000	$0	600
MARAYONG	11kV Feeder 1956 FORGE ST MARAYONG ZS	BE1-851	Replace in this program, by install a 2C138 removed from PS012 sites.	Replace in this program, by install a 2C138 removed from PS012 sites.		#N/A		#N/A	$0	$5,000	5,000	$0	600
MARAYONG	11kV Feeder 1957 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$5,000	5,000	$0	600
MARAYONG	11kV Feeder 1958 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$5,000	5,000	$0	600
MARAYONG	11kV Feeder 1959 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$5,000	5,000	$0	600
MARAYONG	11kV Feeder 1960 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$5,000	5,000	$0	600
MARAYONG	11kV Feeder 1962 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Replace in this program with 2C138 removed from PS012 sites		#N/A		#N/A	$0	$5,000	5,000	$0	600
MARAYONG	11kV Feeder 1963 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites.	Replace in this program with 2C138 removed from PS012 sites.		#N/A		#N/A	$0	$5,000	5,000	$0	600
MT DRUITT TS	33kV Feeder 487 (#1 PROT) MT DRUITT TS	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100
MT DRUITT TS	33kV Feeder 488 (#1 PROT) MT DRUITT TS	HO2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100
MT DRUITT TS	33kV Feeder 489 (#1 PROT) MT DRUITT TS	HOA2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100
MT DRUITT TS	33kV Feeder 495 (#1 PROT) MT DRUITT TS	HO2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100
NEWTON	33kV Feeder 450 NEWTON ZONE SUB	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	44,500	$9,500	3,100
NORTH KATOOMBA TS	132kV Fdr 940 (#1 PR) NORTH KATOOMBA TS	KCEG140	Replace in this program with a SEL-311C	Replace in this program	SEL-311C	$6,426		#N/A	$6,426	$35,000	32,500	-$2,500	3,100
NORTH KATOOMBA TS	132kV Fdr 940 (#2 PR) NORTH KATOOMBA TS	KCEG140	Replace in this program with a P445	Replace in this program	P445	$5,593		#N/A	$5,593	$35,000	32,500	-$2,500	3,100
NORTH KATOOMBA TS	132kV FDR 941 (#2 PR) NORTH KATOOMBA TS	SR750	Replace in this program with a P445	Replace in this program	P445	$5,593		#N/A	$5,593	$35,000	32,500	-$2,500	3,100
PARKLEA	22KV FEEDER CB 25772 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
PARKLEA	22KV FEEDER CB 25773 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600

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Substation	Protection Scheme	Part No	Replacement	Revised Comment	Indicative #1 Relay	Indicative #1 relay cost	Indicative #2 relay	Indicative #2 relay cost	Total Indicative Relay costs	Cost, $ (Estimated by Protection Section)	Cost, $ including Proj. Mgt., $ (Estimated by TSD)	Variance Between Estimates, $	Project Mgt (Included in total cost), $
PARKLEA	22KV FEEDER CB 25775 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
PARKLEA	22KV FEEDER CB 41361 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
PARKLEA	22KV FEEDER CB 41362 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
PARKLEA	22KV FEEDER CB 41363 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
PARKLEA	22KV FEEDER CB 41365 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
PARKLEA	22KV FEEDER CB 41367 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
PENRITH TS	33kV Feeder 461(#1PROT) PENRITH TS	BE1-851E	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	47,000	$12,000	3,100
Penrith ZS	11kV Feeder PH1201 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1201 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1208 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1208 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1212 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1212 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1219 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1219 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1223 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1223 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1227 (#1 PROT) PENRITH ZS	KCGG142	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1227 (#1 PROT) PENRITH ZS	RXKL1	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	none - will be i	#N/A	none - will be i	#N/A	$0	$0	0	$0	
Penrith ZS	11kV Feeder PH1227 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1227 (#2 PROT) PENRITH ZS	RXKL1	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	none - will be i	#N/A	none - will be i	#N/A	$0	$0	0	$0	
Penrith ZS	11kV Feeder PH1230 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1230 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1234 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1234 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1238 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1238 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1245 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1245 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1249 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1249 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1256 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1256 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600

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Substation	Protection Scheme	Part No	Replacement	Revised Comment	Indicative #1 Relay	Indicative #1 relay cost	Indicative #2 relay	Indicative #2 relay cost	Total Indicative Relay costs	Cost, $ (Estimated by Protection Section)	Cost, $ including Proj. Mgt., $ (Estimated by TSD)	Variance Between Estimates, $	Project Mgt (Included in total cost), $
Penrith ZS	11kV Feeder PH1260 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1260 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1264 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1264 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1267 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1267 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1271 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1271 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1286 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1286 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1290 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1290 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1293 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1293 (#1 PROT) PENRITH ZS	RXKL1	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	none - will be i	#N/A	none - will be i	#N/A	$0	$0	0	$0	
Penrith ZS	11kV Feeder PH1293 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1293 (#2 PROT) PENRITH ZS	RXKL1	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	none - will be i	#N/A	none - will be i	#N/A	$0	$0	0	$0	
Penrith ZS	11kV Feeder PH1297 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	11kV Feeder PH1297 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$18,250	16,250	-$2,000	1600
Penrith ZS	Transformer #5 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay		#N/A		#N/A	$0	$5,000	5,000	$0	600
Penrith ZS	Transformer #5 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay		#N/A		#N/A	$0	$5,000	5,000	$0	600
Penrith ZS	Transformer #6 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay		#N/A		#N/A	$0	$5,000	5,000	$0	600
Penrith ZS	Transformer #6 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay		#N/A		#N/A	$0	$5,000	5,000	$0	600
PLUMPTON	33kV Feeder 487 PLUMPTON ZONE SUB	MHOA	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
PLUMPTON	33kV Feeder 488 PLUMPTON ZONE SUB	HO2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
PLUMPTON	Transformer #2 PLUMPTON ZONE SUB	SR750	Replace in this program with P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
PLUMPTON	Transformer #3 PLUMPTON ZONE SUB	SR750	Replace in this program with P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
QUAKERS HILL	33kV Feeder 450 QUAKERS HILL ZONE SUB	HOA4	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	46,500	$11,500	3,100
RIVERSTONE	33kV Feeder 441 RIVERSTONE ZONE SUB	CDD	Replace in this program with a SEL-311C and a P142	Replace in this program with duplicate distance relays	SEL-311C	$6,426	P142	$2,685	$9,111	$35,000	36,000	$1,000	3,100
SPRINGWOOD	Transformer #3 SPRINGWOOD ZONE SUB	KCGG140	Replace in this program with P123	Replace in this program	P123	$1,748		#N/A	$1,748	$15,000	3,000	-$12,000	-
SPRINGWOOD	Transformer #3 SPRINGWOOD ZONE SUB	SPAJ140C	Replace in this program with a P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
SPRINGWOOD	Transformer #4 SPRINGWOOD ZONE SUB	KCGG140	Replace in this program with P123	Replace in this program	P123	$1,748		#N/A	$1,748	$15,000	3,000	-$12,000	-
SPRINGWOOD	Transformer #4 SPRINGWOOD ZONE SUB	SPAJ140C	Replace in this program with a P142	Replace in this program	P142	$2,685		#N/A	$2,685	$25,000	28,500	$3,500	3,100
WEST CASTLE HILL	TX #1 (#1 PR) WEST CASTLE HILL ZS	KBCH130	Replace in this program with BE1-CDS240	Replace in this program	BE1-CDS240	$5,091		#N/A	$5,091	$25,000	32,500	$7,500	3,100

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Substation	Protection Scheme	Part No	Replacement	Revised Comment	Indicative #1 Relay	Indicative #1 relay cost	Indicative #2 relay	Indicative #2 relay cost	Total Indicative Relay costs	Cost, $ (Estimated by Protection Section)	Cost, including Proj. Mgt., $ (Estimated by TSD)	Variance Between Estimates, $	Project Mgt (Included in total cost), $
WEST CASTLE HILL	TX #1 (#2 PR) WEST CASTLE HILL ZS	SR745	Replace in this program with SEL-387A and disable the SR750 as it is no longer required	Replace in this program a TX differential relay and disable the SR750 as it is no longer required	SEL-387A	$5,435		#N/A	$5,435	$25,000	32,500	$7,500	3,100
WEST CASTLE HILL	TX #1 (#2 PR) WEST CASTLE HILL ZS	SR750	Replace in this program, the new duplicate TX Differential relays will also provide TX LV OC/EF	Replace in this program, the new duplicate TX Differential relays will also provide TX LV OC/EF		#N/A		#N/A	$0	$0	0	$0	-
WEST CASTLE HILL	TX #2 (#1 PR) WEST CASTLE HILL ZS	KBCH130	Replace in this program with BE1-CDS240	Replace in this program	BE1-CDS240	$5,091		#N/A	$5,091	$25,000	32,500	$7,500	3,100
WEST CASTLE HILL	TX #2 (#2 PR) WEST CASTLE HILL ZS	SR745	Replace in this program with SEL-387A and disable the SR750 as it is no longer required	Replace in this program a TX differential relay and disable the SR750 as it is no longer required	SEL-387A	$5,435		#N/A	$5,435	$25,000	32,500	$7,500	3,100
WEST CASTLE HILL	TX #2 (#2 PR) WEST CASTLE HILL ZS	SR750	Replace in this program, the new duplicate TX Differential relays will also provide TX LV OC/EF	Replace in this program, the new duplicate TX Differential relays will also provide TX LV OC/EF		#N/A		#N/A	$0	$0	0	$0	-
WHALAN	33kV Feeder 487(1#PROT) WHALAN ZONE SUB	HOA2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
WHALAN	33kV Feeder 495(1#PROT) WHALAN ZONE SUB	HOA2	Replace in this program with P543 using existing Fibre/ADSS	Replace in this program with with line differential relay using existing Fibre/ADSS	P543	$13,902		#N/A	$13,902	$35,000	43,500	$8,500	3,100
ALBION PARK	Transformer #1 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
ALBION PARK	Transformer #1 ALBION PARK ZONE	P123	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	P142	$2,685		#N/A	$2,685	$5,000	5,000	$0	-
ALBION PARK	Transformer #1 ALBION PARK ZONE	SR745	Replace in this program with BE1-CDS240 and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	Replace in this program with BE1-CDS240 and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	BE1-CDS240	$5,091		#N/A	$5,091	$35,000	36,000	$1,000	3,100
ALBION PARK	Transformer #2 ALBION PARK ZONE	P122	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	P142	$2,685		#N/A	$2,685	$5,000	5,000	$0	600
ALBION PARK	Transformer #2 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	-
ALBION PARK	Transformer #2 ALBION PARK ZONE	SR745	Replace in this program and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	Replace in this program and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	SEL-387A	$5,435		#N/A	$5,435	$35,000	36,000	$1,000	3,100
ALBION PARK	Transformer #3 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
ALBION PARK	Transformer #3 ALBION PARK ZONE	P122	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	P142	$2,685		#N/A	$2,685	$5,000	5,000	$0	-
ALBION PARK	Transformer #3 ALBION PARK ZONE	SR745	Replace in this program and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	Replace in this program and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	SEL-387A	$5,435		#N/A	$5,435	$35,000	36,000	$1,000	3,100
BELLAMBI CREEK TS	132kV Feeder 980 (#1 PROT) BELLAMBI CREEK	7SA511	Replace in this program with a P445	Replace in this program with a distance relay	P445	$5,593		#N/A	$5,593	$45,000	32,500	-$12,500	3,100
BELLAMBI CREEK TS	132kV Feeder 981 (#1 PROT) BELLAMBI CREEK	7SA511	Replace in this program with a P445	Replace in this program with a distance relay	P445	$5,593		#N/A	$5,593	$45,000	32,500	-$12,500	3,100
BELLAMBI CREEK TS	TRANSFORMER #1 (#2 PROT) BELLAMBI CREEK	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
BELLAMBI CREEK TS	TRANSFORMER #2 (#2 PROT) BELLAMBI CREEK	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	-
CULBURRA	11kV Feeder CLA2 CULBURRA	MCGG52	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	43,000	$11,000	2200
CULBURRA	11kV Feeder CLD2 CULBURRA	MCGG52	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	43,000	$11,000	2200
KEMBLA GRANGE	11kV Feeder CB 25449 Kembla Grange ZS	SR760	Replace in this program with a P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	39,000	$7,000	2200
KEMBLA GRANGE	11kV Feeder CB 25450 Kembla Grange ZS	SR760	Replace in this program with a P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	39,000	$7,000	2200
KEMBLA GRANGE	11kV Feeder CB 25451 Kembla Grange ZS	SR760	Replace in this program with a P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	39,000	$7,000	2200
KEMBLA GRANGE	11kV Feeder CB 35590 Kembla Grange ZS	SR760	Replace in this program with P142 and BE1-851E	Replace in this program and install duplicate protection	P142	$2,685	BE1-851E	$2,579	$5,264	$32,000	39,000	$7,000	2200

2017/18-2018/19 PS008 Cost Estimate

Substation	Protection Scheme	Part No	Replacement	Revised Comment	Indicative #1 Relay	Indicative #1 relay cost	Indicative #2 relay	Indicative #2 relay cost	Total Indicative Relay costs	Cost, $ (Estimated by Protection Section)	Cost, $ including Proj. Mgt., $ (Estimated by TSD)	Variance Between Estimates, $	Project Mgt (Included in total cost), $
KEMBLA GRANGE	33kV Feeder 7117 Kembla Grange ZS	SR760	Replace in this program with a P543 with sync check and BE1-1051	Replace in this program by installing a #1 and #2 protection	P543	$13,902	BE1-1051	$2,716	$16,618	$40,000	55,750	$15,750	3,100
KEMBLA GRANGE	33kV Feeder 7341 Kembla Grange ZS	SR760	Replace in this program with a P543 with sync check and BE1-1051	Replace in this program by installing a #1 and #2 protection	P543	$13,902	BE1-1051	$2,716	$16,618	$40,000	55,750	$15,750	3,100
KENNY STREET	Transformer #1 KENNY ST ZS	P123	Replace in this program with a P123 to align with RADSB replacement as it is close to end of life	Replace in this program with a P123 to align with RADSB replacement as it is close to end of life	P123	$1,748		#N/A	$1,748	$3,000	3,000	$0	600
KENNY STREET	Transformer #1 KENNY ST ZS	RADSB	Replace in this program with a BE1-CDS240	Replace in this program with a BE1-CDS240	BE1-CDS240	$5,091		#N/A	$5,091	$35,000	32,500	-$2,500	3,100
KENNY STREET	Transformer #2 KENNY ST ZS	P123	Replace in this program with a P123 to align with RADSB replacement as it is close to end of life	Replace in this program with a P123 to align with RADSB replacement as it is close to end of life	P123	$1,748		#N/A	$1,748	$3,000	3,000	$0	600
KENNY STREET	Transformer #2 KENNY ST ZS	RADSB	Replace in this program with a BE1-CDS240	Replace in this program with a BE1-CDS240	BE1-CDS240	$5,091		#N/A	$5,091	$35,000	32,500	-$2,500	3,100
KIAMA	33kV Feeder 730 KIAMA	SR760	Replace in this program with a L90 and P142	Replace in this program by installing a #1 line differential and #2 distance relay	L90	$10,974	P445	$5,593	$16,567	$40,000	36,000	-$4,000	3,100
OUTER HARBOUR TS	132kV Feeder 985 (#2 PROT) OUTER HARBOUR TS	QUADRAMHO	Replace in this program with a P445	Replace in this program with a distance relay	P445	$5,593		#N/A	$5,593	$45,000	36,000	-$9,000	3,100
OUTER HARBOUR TS	132kV Feeder 989 (#2 PROT) OUTER HARBOUR TS	QUADRAMHO	Replace in this program with a P445	Replace in this program with a distance relay	P445	$5,593		#N/A	$5,593	$45,000	36,000	-$9,000	3,100
ULLADULLA	11kV Feeder ULG2 ULLADULLA	RADSB	Replace in this program with a BE1-CDS240	Replace in this program with a BE1-CDS240	BE1-CDS240	$5,091		#N/A	$5,091	$45,000	32,500	-$12,500	3,100
ULLADULLA	Transformer #1 ULLADULLA ZS	RADSB	Replace in this program with a BE1-CDS240	Replace in this program with a BE1-CDS240	BE1-CDS240	$5,091		#N/A	$5,091	$45,000	32,500	-$12,500	3,100
ULLADULLA	Transformer #2 ULLADULLA ZS	RADSB	Replace in this program with a BE1-CDS240	Replace in this program with a BE1-CDS240	BE1-CDS240	$5,091		#N/A	$5,091	$45,000	32,500	-$12,500	3,100
UNANDERRA	Tfr1 ORRCON Orrcon	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	P123	$1,748		#N/A	$1,748	$5,000	5,000	$0	600
										$5,371,500	$5,583,250	$211,750	$439,800

Project Definition	$20,000
TOTAL, EXCL. CONTINGENCY (ROUNDED)	**$5,600,000**
CONTINGENCY	**$350,000**
TOTAL, INCL. CONTINGENCY (ROUNDED)	**$5,950,000**

APPENDIX D – **RELAY REPLACEMENTS**

Substation	Scheme	Relay Type	Works	Technology
ANZAC VILLAGE	Transformer #2 ANZAC VILLAGE ZS LV O/C & E/F and Bus Blocking relay	KCEG142	Replace in this program	Microprocessor
ANZAC VILLAGE	Transformer #3 ANZAC VILLAGE ZS LV O/C & E/F and Bus Blocking Relay	KCEG142	Replace in this program	Microprocessor
BOSSLEY PARK	33kV Feeder 745 BOSSLEY PARK ZONE SUB	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
EAST PROSPECT HVC	33kV Feeder 431 EAST PROSPECT HVC	HO4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
EAST PROSPECT HVC	33kV Feeder 440 EAST PROSPECT HVC	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
FAIRFAX LANE TS	Transformer #1 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program	Microprocessor
FAIRFAX LANE TS	Transformer #2 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program	Microprocessor
FAIRFAX LANE TS	Transformer #3 (#1 PROT) FAIRFAX LANE TS	SR745	Replace in this program	Microprocessor
HOLROYD	33kV Feeder 432 HOLROYD ZONE SUB Feeder Differential Relay	HO2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
HORSLEY PARK	33kV Feeder 48C HORSLEY PARK ZS Pilot Iwre Relay	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
KENTLYN	11kV BBP KENTLYN ZONE SUB	2T146	Replace in this program with a new timer relay	Static
MINTO	66kV BBP Sect A MINTO ZONE SUB	2T146	Replace in this program with a new timer relay	Static
NARELLAN	11KV FEEDER 27027 NARELLAN ZS	P123	Replace in this program and install duplicate protection	Microprocessor
NARELLAN	11KV FEEDER 27031 NARELLAN ZS	P123	Replace in this program and install duplicate protection	Microprocessor
NARELLAN	11KV FEEDER 27032 NARELLAN ZS	P123	Replace in this program and install duplicate protection	Microprocessor
NARELLAN	11KV FEEDER 27035 NARELLAN ZS	P123	Replace in this program and install duplicate protection	Microprocessor
NARELLAN	11KV FEEDER 27039 NARELLAN ZS	P123	Replace in this program and install duplicate protection	Microprocessor
NARELLAN	11KV FEEDER 27041 NARELLAN ZS	P123	Replace in this program and install duplicate protection	Microprocessor
NARELLAN	11KV FEEDER 27042 NARELLAN ZS	P123	Replace in this program and install duplicate protection	Microprocessor

Substation	Scheme	Relay Type	Works	Technology
NEPEAN TS	33kV Feeder 306 (#2 PROT) NEPEAN TS #2 Overcurrent & Earthfault Relay	SR750	Replace in this program with a distance relay	Microprocessor
NEPEAN TS	33kV Feeder 311 (#2 PROT) NEPEAN TS #2 Overcurrent & Earthfault Relay	SR750	Replace in this program with a distance relay	Microprocessor
OAKDALE	11kV Feeder H736 OAKDALE ZONE SUB	P123	Replace in this program and install duplicate protection	Microprocessor
OAKDALE	11kV Feeder H745 OAKDALE ZONE SUB	P123	Replace in this program and install duplicate protection	Microprocessor
OAKDALE	11kV Feeder P608 OAKDALE ZONE SUB	P123	Replace in this program and install duplicate protection	Microprocessor
OAKDALE	11kV Feeder P611 OAKDALE ZONE SUB	P123	Replace in this program and install duplicate protection	Microprocessor
PRESTONS	PRESTONS ZS Camden Valley Way Prestons	P121	Replace in this program with a P123, align with the replacement of the SR745	Microprocessor
PRESTONS	PRESTONS ZS Camden Valley Way Prestons	SR745	Replace in this program with a BE1-CDS240 and also replace the P121 HV OC with a P123	Microprocessor
PRESTONS	PRESTONS ZS Transformer #1	P122	Replace in this program with a P123 as it coming close to the end of its life and to align with the replacement of SR745	Microprocessor
PRESTONS	PRESTONS ZS Transformer #1	SR745	Replace in this program with a BE1-CDS240 and also replace the P122 HV OC with a P123	Microprocessor
QUARRIES	33kV Feeder 434 QUARRIES ZONE SUB	MHOA	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
QUARRIES	33kV Feeder 434 QUARRIES ZONE SUB	SR760	Replace in this program with a distance relay	Microprocessor
QUARRIES	33kV Feeder 440 QUARRIES ZONE SUB	MHOA	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
QUARRIES	33kV Feeder 440 QUARRIES ZONE SUB	SR760	Replace in this program with a distance relay	Microprocessor
QUARRIES	33kV Sect.A-B BBP QUARRIES ZONE SUB Bus-Blocking Scheme Relay	SR760	Replace in this program	Microprocessor
QUARRIES	33kV Sect.B-C BBP QUARRIES ZONE SUB	SR760	Replace in this program	Microprocessor
SMITHFIELD	33kV Feeder 745/1 SMITHFIELD ZONE SUB	MHOA	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical

Substation	Scheme	Relay Type	Works	Technology
SOUTH PROSPECT	33kV Feeder 431 SOUTH PROSPECT HVC	HO4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
WEST LIVERPOOL	132kV BBP Sect A1(PRI) WEST LIVERPOOL TS #1 Bus Differential Relay	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	132kV BBP Sect A1(PRI) WEST LIVERPOOL TS Busbar CB Fail Timer (#1PROT)	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	132kV BBP Sect A1(SEC) WEST LIVERPOOL TS #2 Bus Differential Relay	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	132kV BBP Sect A1(SEC) WEST LIVERPOOL TS #2 Protection CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	132kV BBP Sect A2(PRI) WEST LIVERPOOL TS #1 Bus Differential Relay (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	132kV BBP Sect A2(PRI) WEST LIVERPOOL TS #1 CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	132kV BBP Sect A2(SEC) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	132kV BBP Sect A2(SEC) WEST LIVERPOOL TS #2 Bus Differential Relay (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	132kV BBP Sect B1(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	132kV BBP Sect B1(PRI) WEST LIVERPOOL TS #1 Protection CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	132kV BBP Sect B1(SEC) WEST LIVERPOOL TS	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	132kV BBP Sect B1(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 1(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical

Substation	Scheme	Relay Type	Works	Technology
WEST LIVERPOOL	33kV BBP Sect 1(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 1(SEC) WEST LIVERPOOL TS #2 BBP CB Fial Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 1(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 2 (PRI)WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 2 (PRI)WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 2 (SEC)WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 2 (SEC)WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 3(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 3(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 3(SEC) WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 3(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 4(PRI) WEST LIVERPOOL TS #1 BBP CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 4(PRI) WEST LIVERPOOL TS #1 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV BBP Sect 4(SEC) WEST LIVERPOOL TS #2 BBP CB Fail Timer	TDS	Replace in this program with a new timer relay	Electromechanical

Substation	Scheme	Relay Type	Works	Technology
WEST LIVERPOOL	33kV BBP Sect 4(SEC) WEST LIVERPOOL TS #2 Bus Differential (High Z)	FV2	Replace in this program	Electromechanical
WEST LIVERPOOL	33kV Feeder 512 (#1 PROT) WEST LIVERPOOL TRANS SUB	QUADRAMHO	Replace in this program	Static
WETHERILL PARK WEST	33kV FEEDER 745 WEST WETHERILL PARK TS	MHOA	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
BAULKHAM HILLS	132kV BBP SEC 1-2(#1Pr)BAULKHAM HILLS TS	ST2	Replace in this program with a new timer relay	Electromechanical
BAULKHAM HILLS	132kV BBP SEC 1-2(#2PR)BAULKHAM HILLS TS	ST2	Replace in this program with a new timer relay	Electromechanical
BAULKHAM HILLS	132kV BBP SEC 3-4(#1PR)BAULKHAM HILLS TS	ST2	Replace in this program with a new timer relay	Electromechanical
BAULKHAM HILLS	132kV BBP SEC 3-4(#2PR)BAULKHAM HILLS TS	ST2	Replace in this program with a new timer relay	Electromechanical
BLACKMANS FLAT	66kV Feeder 831 BLACKMANS FLAT ZONE SUB	CDD21	Replace in this program with duplicate protection	Electromechanical
BLACKMANS FLAT	66kV Feeder 835/2 BLACKMANS FLAT ZS	CDD21	Replace in this program with duplicate protection	Electromechanical
BLACKTOWN TS	33kV Feeder 432 (#1 PR) BLACKTOWN TS	HO2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
BLACKTOWN TS	33kV Feeder 434 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
BLACKTOWN TS	33kV Feeder 440 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
BLACKTOWN TS	33kV Feeder 450 (#1 PR) BLACKTOWN TS	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
BLACKTOWN TS	Transformer #4 (#1 PR) BLACKTOWN TS	SR745	Replace in this program	Microprocessor
CARLINGFORD TS	132kV BBP Sect A1-2 Pri CARLINGFORD TS	ST3	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Electromechanical

Substation	Scheme	Relay Type	Works	Technology
CARLINGFORD TS	132kV BBP Sect A1-2 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Electromechanical
CARLINGFORD TS	132kV BBP Sect A3 Pri CARLINGFORD TS	ST3	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Electromechanical
CARLINGFORD TS	132kV BBP Sect A3 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Electromechanical
CARLINGFORD TS	132kV BBP Sect B1-2 Pri CARLINGFORD TS	ST3	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Electromechanical
CARLINGFORD TS	132kV BBP Sect B1-2 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Electromechanical
CARLINGFORD TS	132kV BBP Sect B3 Pri CARLINGFORD TS	ST3	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Electromechanical
CARLINGFORD TS	132kV BBP Sect B3 Sec CARLINGFORD TS	VAT11/3	Replace in this program with a new timer relay - with the potential of this being reviewing depending on the outcome of the NIO for Carlingford TS	Electromechanical
CARLINGFORD TS	132kV Feeder 229 (#1 PR) CARLINGFORD TS	RAZFE/M	Replace in this program with a three terminal line differential relay	Static
CARLINGFORD TS	66kV Feeder 815 (#1 PR) CARLINGFORD TS	7SA510	Replace in this program with with line differential relay using existing Fibre/ADSS	Microprocessor
CARLINGFORD TS	66kV Feeder 815 (#2 PR) CARLINGFORD TS	CO6	Replace in this program	Electromechanical
CASTLE HILL	11kV Frame Leakage Sect 1 CASTLE HILL ZS	B4	Replace in this program	Electromechanical

Substation	Scheme	Relay Type	Works	Technology
CASTLE HILL	11kV Frame Leakage Sect 1 CASTLE HILL ZS	B4	Replace in this program	Electromechanical
CASTLE HILL	11kV Frame Leakage Sect 2 CASTLE HILL ZS	B4	Replace in this program	Electromechanical
CASTLE HILL	11kV Frame Leakage Sect 2 CASTLE HILL ZS	B4	Replace in this program	Electromechanical
CASTLE HILL	11kV Frame Leakage Sect 3 CASTLE HILL ZS	B1	Replace in this program	Electromechanical
CASTLE HILL	11kV Frame Leakage Sect 3 CASTLE HILL ZS	B1	Replace in this program	Electromechanical
CASTLE HILL	66kV Feeder 815 CASTLE HILL ZONE SUB	CDD	Replace in this program with line differential relay using existing Fibre/ADSS and a #2 distance relay	Electromechanical
CASTLE HILL	Transformer #1 CASTLE HILL ZONE SUB	B4	Replace in this program	Electromechanical
CASTLE HILL	Transformer #2 CASTLE HILL ZONE SUB	B4	Replace in this program	Electromechanical
EAST WALLGROVE	33kV Feeder 489 EAST WALLGROVE SS	MHOA	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
EAST WALLGROVE	33kV Feeder 48C EAST WALLGROVE SS	MHOA	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
HAZELBROOK	66kV Feeder 808 HAZELBROOK ZS	MCGG11	Remove in this program as it is a normally open feeder and only one protection is required	Static
HAZELBROOK	66kV Feeder 808 HAZELBROOK ZS	QUADRAMHO	Replace in this program	Static
HAZELBROOK	66kV Feeder 826 HAZELBROOK ZS	No Volt Change Over Relay	Install distance protection	Electromechanical
ILFORD TS	Transformer #1 ILFORD TS Ilford	SR750	Replace in this program	Microprocessor
KANDOS	Transformer #1 KANDOS ZONE SUB	SR750	Replace in this program	Microprocessor
KINGSWOOD	33kV Feeder 461 KINGSWOOD ZONE SUB	CDD	Replace in this program with a distance relay	Electromechanical
KINGSWOOD	33kV Feeder 461 KINGSWOOD ZONE SUB	HO2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
LENNOX	11kV Feeder 19869 LENNOX ZS	KCGG140	Replace in this program and install duplicate protection	Microprocessor
LENNOX	11kV Feeder 19872 LENNOX ZS	KCGG140	Replace in this program and install duplicate protection	Microprocessor
LENNOX	Transformer #2 LENNOX ZONE SUB	KCEG140	Replace in this program	Microprocessor

Substation	Scheme	Relay Type	Works	Technology
LITHGOW	66kV Feeder 857 LITHGOW ZONE SUB	CDD21	Replace in this program and install duplicate protection	Electromechanical
LITHGOW	66kV Feeder 85X LITHGOW ZONE SUB	CDD21	Replace in this program and install duplicate protection	Electromechanical
MARAYONG	11kV 1951 COKE 1&GARLING RD MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	Electromechanical
MARAYONG	11kV 1952 BOWMANS&GLENWOOD MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	Electromechanical
MARAYONG	11kV FDR 1950 DUNSTABLE RD MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Static
MARAYONG	11kV Feeder 1953 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Static
MARAYONG	11kV Feeder 1954 MARAYONG ZS	CMU31	Replace in this program with 2C138 removed from PS012 sites	Electromechanical
MARAYONG	11kV Feeder 1956 FORGE ST MARAYONG ZS	BE1-851	Replace in this program, by install a 2C138 removed from PS012 sites.	Microprocessor
MARAYONG	11kV Feeder 1957 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Static
MARAYONG	11kV Feeder 1958 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Static
MARAYONG	11kV Feeder 1959 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Static
MARAYONG	11kV Feeder 1960 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Static
MARAYONG	11kV Feeder 1962 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites	Static
MARAYONG	11kV Feeder 1963 MARAYONG ZS	2C135	Replace in this program with 2C138 removed from PS012 sites.	Static
MT DRUITT TS	33kV Feeder 487 (#1 PROT) MT DRUITT TS	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
MT DRUITT TS	33kV Feeder 488 (#1 PROT) MT DRUITT TS	HO2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
MT DRUITT TS	33kV Feeder 489 (#1 PROT) MT DRUITT TS	HOA2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
MT DRUITT TS	33kV Feeder 495 (#1 PROT) MT DRUITT TS	HO2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
NEWTON	33kV Feeder 450 NEWTON ZONE SUB	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
NORTH KATOOMBA TS	132kV Fdr 940 (#1 PR) NORTH KATOOMBA TS	KCEG140	Replace in this program	Microprocessor

Substation	Scheme	Relay Type	Works	Technology
NORTH KATOOMBA TS	132kV Fdr 940 (#2 PR) NORTH KATOOMBA TS	KCEG140	Replace in this program	Microprocessor
NORTH KATOOMBA TS	132kV FDR 941 (#2 PR) NORTH KATOOMBA TS	SR750	Replace in this program	Microprocessor
PARKLEA	22KV FEEDER CB 25772 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
PARKLEA	22KV FEEDER CB 25773 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
PARKLEA	22KV FEEDER CB 25775 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
PARKLEA	22KV FEEDER CB 41361 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
PARKLEA	22KV FEEDER CB 41362 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
PARKLEA	22KV FEEDER CB 41363 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
PARKLEA	22KV FEEDER CB 41365 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
PARKLEA	22KV FEEDER CB 41367 PARKLEA ZS	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
PENRITH TS	33kV Feeder 461(#1PROT) PENRITH TS	BE1-851E	Replace in this program with with line differential relay using existing Fibre/ADSS	Microprocessor
Penrith ZS	11kV Feeder PH1201 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1201 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static

Substation	Scheme	Relay Type	Works	Technology
Penrith ZS	11kV Feeder PH1208 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1208 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1212 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1212 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1219 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1219 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1223 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1223 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1227 (#1 PROT) PENRITH ZS	KCGG142	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1227 (#1 PROT) PENRITH ZS	RXKL1	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1227 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1227 (#2 PROT) PENRITH ZS	RXKL1	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1230 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1230 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1234 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1234 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1238 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1238 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1245 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1245 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1249 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor

Substation	Scheme	Relay Type	Works	Technology
Penrith ZS	11kV Feeder PH1249 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1256 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1256 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1260 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1260 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1264 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1264 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1267 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1267 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1271 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1271 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1286 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1286 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1290 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1290 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1293 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1293 (#1 PROT) PENRITH ZS	RXKL1	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1293 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1293 (#2 PROT) PENRITH ZS	RXKL1	Replace in this program and install duplicate protection	Static
Penrith ZS	11kV Feeder PH1297 (#1 PROT) PENRITH ZS	KCGU140	Replace in this program and install duplicate protection	Microprocessor
Penrith ZS	11kV Feeder PH1297 (#2 PROT) PENRITH ZS	MCGG53	Replace in this program and install duplicate protection	Static

Substation	Scheme	Relay Type	Works	Technology
Penrith ZS	Transformer #5 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	Microprocessor
Penrith ZS	Transformer #5 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	Microprocessor
Penrith ZS	Transformer #6 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	Microprocessor
Penrith ZS	Transformer #6 (#1 PROT) PENRITH ZS	KCEG140	Replace in this program by disabling this relay and implementing its function in the existing BE1-CDS240 and SEL-387A relay	Microprocessor
PLUMPTON	33kV Feeder 487 PLUMPTON ZONE SUB	MHOA	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
PLUMPTON	33kV Feeder 488 PLUMPTON ZONE SUB	HO2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
PLUMPTON	Transformer #2 PLUMPTON ZONE SUB	SR750	Replace in this program	Microprocessor
PLUMPTON	Transformer #3 PLUMPTON ZONE SUB	SR750	Replace in this program	Microprocessor
QUAKERS HILL	33kV Feeder 450 QUAKERS HILL ZONE SUB	HOA4	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
RIVERSTONE	33kV Feeder 441 RIVERSTONE ZONE SUB	CDD	Replace in this program with duplicate distance relays	Electromechanical
SPRINGWOOD	Transformer #3 SPRINGWOOD ZONE SUB	KCGG140	Replace in this program	Microprocessor
SPRINGWOOD	Transformer #3 SPRINGWOOD ZONE SUB	SPAJ140C	Replace in this program	Microprocessor
SPRINGWOOD	Transformer #4 SPRINGWOOD ZONE SUB	KCGG140	Replace in this program	Microprocessor
SPRINGWOOD	Transformer #4 SPRINGWOOD ZONE SUB	SPAJ140C	Replace in this program	Microprocessor
WEST CASTLE HILL	TX #1 (#1 PR) WEST CASTLE HILL ZS	KBCH130	Replace in this program	Microprocessor

Substation	Scheme	Relay Type	Works	Technology
WEST CASTLE HILL	TX #1 (#2 PR) WEST CASTLE HILL ZS	SR745	Replace in this program a TX differential relay and disable the SR750 as it is no longer required	Microprocessor
WEST CASTLE HILL	TX #1 (#2 PR) WEST CASTLE HILL ZS	SR750	Replace in this program, the new duplicate TX Differential relays will also provide TX LV OC/EF	Microprocessor
WEST CASTLE HILL	TX #2 (#1 PR) WEST CASTLE HILL ZS	KBCH130	Replace in this program	Microprocessor
WEST CASTLE HILL	TX #2 (#2 PR) WEST CASTLE HILL ZS	SR745	Replace in this program a TX differential relay and disable the SR750 as it is no longer required	Microprocessor
WEST CASTLE HILL	TX #2 (#2 PR) WEST CASTLE HILL ZS	SR750	Replace in this program, the new duplicate TX Differential relays will also provide TX LV OC/EF	Microprocessor
WHALAN	33kV Feeder 487(1#PROT) WHALAN ZONE SUB	HOA2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
WHALAN	33kV Feeder 495(1#PROT) WHALAN ZONE SUB	HOA2	Replace in this program with with line differential relay using existing Fibre/ADSS	Electromechanical
ALBION PARK	Transformer #1 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	Microprocessor
ALBION PARK	Transformer #1 ALBION PARK ZONE	P123	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	Microprocessor
ALBION PARK	Transformer #1 ALBION PARK ZONE	SR745	Replace in this program with BE1-CDS240 and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	Microprocessor
ALBION PARK	Transformer #2 ALBION PARK ZONE	P122	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	Microprocessor
ALBION PARK	Transformer #2 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	Microprocessor
ALBION PARK	Transformer #2 ALBION PARK ZONE	SR745	Replace in this program and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	Microprocessor
ALBION PARK	Transformer #3 ALBION PARK ZONE	P122	Replace in this program with a P123 as it is close to end of life to align with the SR745 replacement	Microprocessor

Substation	Scheme	Relay Type	Works	Technology
ALBION PARK	Transformer #3 ALBION PARK ZONE	P122	Replace in this program with a P142 as it is close to end of life to align with the SR745 replacement	Microprocessor
ALBION PARK	Transformer #3 ALBION PARK ZONE	SR745	Replace in this program and also replace the P122 HV OC with a P123 and the P123 LV OC/EF with a P142	Microprocessor
BELLAMBI CREEK TS	132kV Feeder 980 (#1 PROT) BELLAMBI CREEK	7SA511	Replace in this program with a distance relay	Microprocessor
BELLAMBI CREEK TS	132kV Feeder 981 (#1 PROT) BELLAMBI CREEK	7SA511	Replace in this program with a distance relay	Microprocessor
BELLAMBI CREEK TS	TRANSFORMER #1 (#2 PROT) BELLAMBI CREEK	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
BELLAMBI CREEK TS	TRANSFORMER #2 (#2 PROT) BELLAMBI CREEK	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor
CULBURRA	11kV Feeder CLA2 CULBURRA	MCGG52	Replace in this program and install duplicate protection	Static
CULBURRA	11kV Feeder CLD2 CULBURRA	MCGG52	Replace in this program and install duplicate protection	Static
KEMBLA GRANGE	11kV Feeder CB 25449 Kembla Grange ZS	SR760	Replace in this program and install duplicate protection	Microprocessor
KEMBLA GRANGE	11kV Feeder CB 25450 Kembla Grange ZS	SR760	Replace in this program and install duplicate protection	Microprocessor
KEMBLA GRANGE	11kV Feeder CB 25451 Kembla Grange ZS	SR760	Replace in this program and install duplicate protection	Microprocessor
KEMBLA GRANGE	11kV Feeder CB 35590 Kembla Grange ZS	SR760	Replace in this program and install duplicate protection	Microprocessor
KEMBLA GRANGE	33kV Feeder 7117 Kembla Grange ZS	SR760	Replace in this program by installing a #1 and #2 protection	Microprocessor
KEMBLA GRANGE	33kV Feeder 7341 Kembla Grange ZS	SR760	Replace in this program by installing a #1 and #2 protection	Microprocessor
KENNY STREET	Transformer #1 KENNY ST ZS	P123	Replace in this program with a P123 to align with RADSB replacement as it is close to end of life	Microprocessor
KENNY STREET	Transformer #1 KENNY ST ZS	RADSB	Replace in this program	Static

Substation	Scheme	Relay Type	Works	Technology
KENNY STREET	Transformer #2 KENNY ST ZS	P123	Replace in this program with a P123 to align with RADSB replacement as it is close to end of life	Microprocessor
KENNY STREET	Transformer #2 KENNY ST ZS	RADSB	Replace in this program	Static
KIAMA	33kV Feeder 730 KIAMA	SR760	Replace in this program	Microprocessor
OUTER HARBOUR TS	132kV Feeder 985 (#2 PROT) OUTER HARBOUR TS	QUADRAMHO	Replace in this program with a distance relay	Static
OUTER HARBOUR TS	132kV Feeder 989 (#2 PROT) OUTER HARBOUR TS	QUADRAMHO	Replace in this program with a distance relay	Static
ULLADULLA	11kV Feeder ULG2 ULLADULLA	RADSB	Replace in this program	Static
ULLADULLA	Transformer #1 ULLADULLA ZS	RADSB	Replace in this program	Static
ULLADULLA	Transformer #2 ULLADULLA ZS	RADSB	Replace in this program	Static
UNANDERRA	Tfr1 ORRCON Orrcon	P121	Replace in this program, like for like with a P123, bring maintenance forward by 18 months if required	Microprocessor