PowerWater

Program Business Need Identification

Power and Water Corporation

CONTROLLED DOCUMENT

NMP1 / PRD33433

Darwin Northern Suburbs High Voltage Replacement Program

Proposed:	Approved:
Stuart Eassie Manager Strategic Asset Engineering Power Networks Date: 15/ 2/2018	Michael Thomson Chief Executive Power Water Corporation Date: 23/02/2018

	Refer to email D2018/72353	Refer to email D2018/~~73733~~ 67080
Djuna Pollard Executive General Manager Power Networks Date: 15/2/2018	Finance Review Date: 06/02/2018	PMO QA Date: 13/02/2018

1 Program Summary

Program Name:	Darwin Northern Suburbs High Voltage Replacement Program		
Program No:	NMP1 / PRD33433		
Financial Year Commencement:	2019/20		
Business Unit:	Power Networks		
Program Owner (GM):	Djuna Pollard	**Phone No:**	08 8985 8431
Contact Officer:	Stuart Eassie	**Phone No:**	08 8924 5214
Date of Submission:		**File Ref No:**	
Submission Number:		**Priority Score:**	
Primary Driver:	Renewal/Replacement	**Secondary Driver:**	Service Improvement
Program Classification:	Capital Program of Works		

2 Recommendation

2.1 MAJOR PROJECT >$1M OR PROGRAM

It is recommended that Chief Executive note the proposed five year replacement program for an estimated budget of $20.6M, and approve the inclusion of this Program into the SCI for this amount, with a corresponding completion date of June 2024.

The current forecast for this program of work extends beyond the current SCI period. The first two years of this program aligns with the last two years of the 2017-18 SCI. This program will be included in the 2019-24 Regulatory Proposal to the Australian Energy Regulator (AER).

Note that individual projects within the program will be documented in Business Case Category C to be approved by the Executive General Manager Power Networks.

3 Description of Issues

3.1 Current Cable Replacement Program

The current High Voltage Cable Replacement program was approved in 2013 and included in the 2014-2019 Network Price Determination (NPD)[1]. This program was approved for 5 years with a budget of $7.7M ($2013-14). The scope of the program included the replacement of cables deemed unrepairable after failure and the proactive replacement of cables in very poor condition (based on comprehensive testing) to address an increasing trend in cable failures. In particular, the developing issue associated with the deterioration of the earthing system due to the failure of aluminium screens of XLPE cable installed in Darwin's northern suburbs. The total expenditure in the first 3 years of cable program is $3.4M and has been largely associated with cable replacements in Darwin's northern suburbs.

3.2 Asset Portfolio Context

Power Networks owns and maintains a portfolio of 878 km of high voltage cables distributed across the four regions of Alice Springs, Darwin, Katherine and Tennant Creek. The portfolio consists of mainly Paper Insulated Lead Covered (PILC), Polyvinyl Chloride (PVC), and cross-linked polyethylene (XLPE). XLPE makes up the majority and the largest population is located in the Darwin Region.

Region	HV Cables Total (km)	HV - XLPE (km)	HV - PILC (km)	HV - PVC (km)	HV - Unknown (km)
Alice Springs	132	78	20	0	34
Darwin	724	489	207	2	26
Katherine	20	3	0	0	17
Tennant Creek	3	0	1	0	1
Total	**878**	**571**	**228**	**2**	**77**

XLPE started to replace paper cables in the 1960's as a long life alternative with no electrical property degradation. However, towards the end of the 1970's field service performance recognised that XLPE cables undergo a degradation process called water treeing and an accelerated corrosion of the neutral / earthing wires when exposed to moisture and electrical stress. In the early 1980's an improved version of XLPE called TR-XLPE was introduced, and has shown much improved field service performance[2&3]. A large portion of PWC's XLPE cables (103 km or 12% of total HV cable population) were

[1] D2013/323329 Sub8260 - BNI - Power Networks High Voltage (HV) Cable Replacement Program.
[2] LONG-LIFE XLPE INSULATED POWER CABLE, Nigel HAMPTON, NEETRAC, Georgia Tech, USA
[3] Global Trends and Motivation Toward the Adoption of TR-XLPE Cable, The Dow Chemical Company

installed from the 1960's to mid-1980's in the northern suburbs of Darwin. These cables are also unique in the fact that the screen conductor is aluminium.

3.3 Northern Suburbs XLPE Cable Condition Observations

In 2011 an investigation into the cause of cable failures was launched due to the significant contribution of cable failures to reliability performance and consistent reports from field crews that cables were in poor condition, affecting their reparability. The investigation confirmed the consistently poor condition of XLPE cables in the northern suburbs.

Water ingress has been identified as the main factor causing the cable failures. It is believed that small cracks in the cable jacket - due to poor installation practices, mechanical damage or age degradation – allow moisture to enter the cable. The aluminium screens oxidise and swell, deforming the cable. As a result the cable jacket is damaged further, exacerbating the moisture ingress. The old XLPE insulation suffers from water-treeing and mechanical stress and eventually fails.

A proactive testing and replacement program commenced in 2013[4]. After development of internal cable testing capability, further condition assessments were undertaken over the period June 2014 to August 2017 involving 13 (42%) of the 31 northern suburb feeders.

The condition assessments found varying levels of degradation, but overall the test results were very poor. 40% of tested cables, representing 54% of the tested feeders, failed the earth screen testing. This indicates that the affected cable screens are completely discontinuous or at best exposed directly to moisture and in the process of corroding. A significant portion of the cables (39%) also failed tan delta insulation testing, indicating a high operating risk according to the IEEE 400.2:2013 standard. It is expected that the poor insulation test results are predominantly due to moisture ingress as there is a high correlation of insulation failure with screen failure. The results of the testing program are summarised in Appendix A.

Visual inspection of many sections of cable (during repairs or when exposed as part of other work) within these areas corroborates the poor cable condition. Swelling and damage to cable jackets has been observed consistently, indicating that damaging water ingress and corrosion has already occurred.

3.4 Reliability Observations

Increasing XLPE cable fault rates have been observed in these installations in recent years, nearly doubling over the last 9 years, and contributing 5% and 3% to the total Darwin System SAIDI and SAIFI respectively for the period July 2013 to June 2017. The XLPE cable faults over the last four years calculate to 3% of the customer minutes lost (CML) in Darwin[5]. Figure 1 below demonstrates the trend and contribution of cable failures in the Northern Suburbs. While only making up 12% of the total HV cable population, the XLPE

[4] D2013/323329 Sub8260 - BNI - Power Networks High Voltage (HV) Cable Replacement Program.

[5] ESAA Outage Dataset 2000-2017.

cables with aluminium screen conductors typically account for more than half of HV cable NT SAIDI contribution.

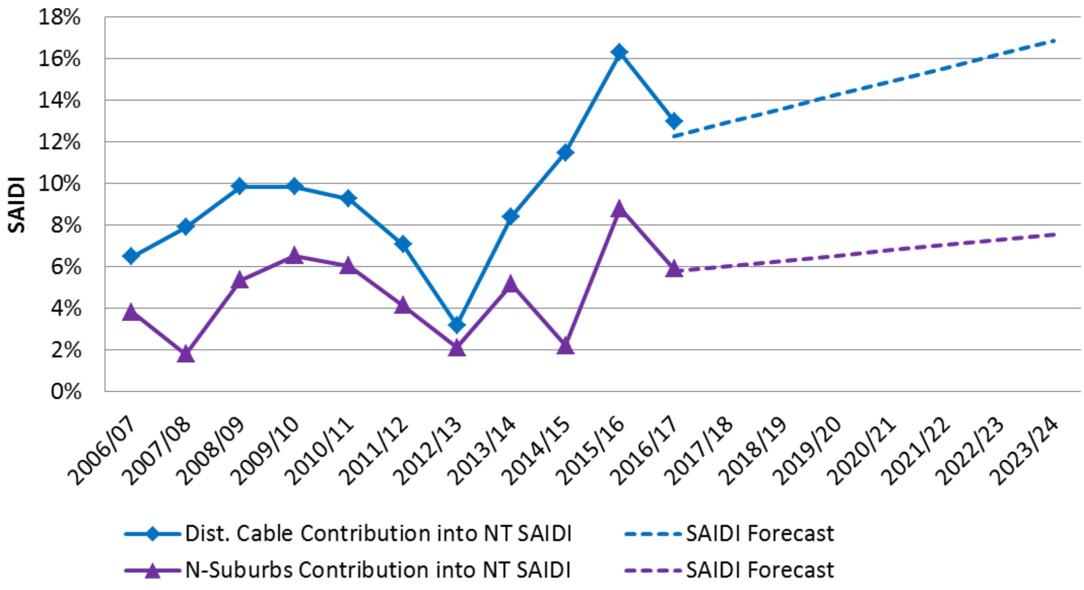

Figure 1 - Northern Suburbs Cable NT SAIDI Contribution and Forecast Trend (Linear)

3.5 Public and Worker Risk

Cable degradation is also a risk to public and worker safety.

Failure of the cable screens is linked to potential earth system integrity failure. Cable screens serve a primary function in terms of cable design to provide an effective earth return path for fault current in the event of a cable failure, either an internal failure due to insulation degradation, or an external impact such as being struck by earth moving equipment by a member of the public, PWC maintainers or contractors/developers. Since 2012, damage to live cables caused by earth moving equipment has occurred more than 3 times per year including LV, HV and Transmission cables[6].

The absence of a continuous screen substantially increases consequence of an externally caused fault due to:

- The fault return path is no longer provided by the screen but by the equipment or tool that strikes the cable, likely to be in contact with a person.
- The impedance of the fault current return path increases, slowing the response time of protection systems.
- Safe work methods for cutting cables also rely on the existence of a screen to provide a defence against possible misidentification of cables being cut, such as

[6] D2017/498719 - Incident Event History Analysis - Grace & RISQ Data Extract.

what occurred in the October 2011 incident that resulted in severe burns and permanent injuries to two PWC[7] employees.

Additionally, the increasing frequency of HV cable faults poses significant risks to public and worker safety. More faults means more public exposure to Earth Potential Rise (EPR) on the potentially compromised earthing system, increasing the both the likelihood of an electric shock and its severity.

Personnel working adjacent in the proximity of live HV cables are also at risk. This is a relatively frequent occurrence during emergency repairs or preliminary inspections for capital works. There has been at least one instance of a cable failing in the months after it was inspected via vacuum excavation of a cable pit. The photo in Figure 2 was taken during the inspection, and shows the cable and the location of the fault prior to the fault occurring.

Figure 2 – Cable inspected prior to failure

3.6 Earthing System Design Impacts

Arguably the most critical function provided by cable screens is providing the backbone of the underground network earthing system. The climate and soil conditions for much of the NT are such that soil resistivity is extremely high for portions of each year (Dry season), rendering the local equipment earthing almost ineffective and relying heavily on the interconnectedness of the earthing system. Extreme wet conditions for the other proportion of the year significantly reduces soil resistivity meaning earthing design needs to cater for vastly different soil conditions.

[7] Investigation Report - RISQ 3352 - Power Networks' crew injured when a HV cable was cut.

To mitigate this risk, PWCs network design requires the interconnection of screens and a common earth conductor at every termination point. Under HV fault conditions, HV cable screens provide the primary return path for fault current due to the magnetic coupling between the faulted phase and its screen. This ensures that fault current returning via local earth grids around HV equipment is minimised, limiting EPR and associated touch and step voltage hazards to members of the public to allowable levels. This approach ensures that PWC meets WHS legislation requirements related to power system earthing without the need for significant design and engineering reviews of individual distribution substations and switchgear. It ensures that the earthing hazards associated with abnormal system conditions are effectively mitigated and allows testing to be conducted to verify the continuity of the earthing conductors between termination points, without which failures of earthing conductors would be undetectable.

However, as cable screens continue to corrode and become discontinuous, the basis for the underground network earthing design is compromised. The risks to the public and workers will increase as the earth return paths provided by cable screens fail, particularly in areas of limited HV cable interconnectivity. As these earth paths fail, the proportion of fault current returning via earth grids and other public infrastructure increases, subsequently increasing EPR and the safety risk.

In 2017, engineering consultants specialising in utility earthing system design and performance analysis were engaged to quantify the increasing risk to earthing system performance associated with screen degradation[8]. An interim report has confirmed the step and touch voltages increase as the earth return path provided by HV cable screens fail. Table 3-1 of the report summarises the output from initial modelling, and shows increases of EPR from 30% to 82% for various scenarios. A key basis for the scenarios is the local earthing grid performance, which can vary greatly due to soil and climate conditions. The report recommended the replacement of cables with discontinuous screens and additional testing to mitigate the risk until replacement.

3.7 Project Needs

a. Safety
Replacement of the select XLPE cables addresses the worker and public safety risk caused by the deterioration of the aluminium earth screen, which compromises the overall earthing system and inherent network safety. Step and touch voltages during network fault conditions will increase as cable screens continue to deteriorate across a signficaint proportion of the Darwin northern suburbs. This increases the safety risk to the public as well as PWC employees involved in undertaking works on the cables and connected assets. This failure mode is the same as that seen with this type and vintage cable in other organisations in the electricity industry nationally and internationally.

[8] D2017/494154 Earthing System Assessment Report – HV Cable Screen Deterioration Wulagi.

b. Compliance
A fundamental business driver for PWC is compliance with the Network Technical Code and Network Planning Criteria objective of providing safe, secure, reliable, high quality power supply at a minimal cost. Replacement of the select XLPE cables is compliant with this objective.
c. Reliability (if not compliance obligation)
The underground cable network contributes to the reliability performance of the power network. The early XLPE cable are recognised in industry for their design deficiency and deteriorating performance over time. This has been observed in the PWC network through a significant increase in the number of XLPE cable fault events experienced involving the early XLPE installations. Replacement of the select XLPE cables will ensure continued maintenance of system reliability and contribute to the achievement of PWC's reliability performance objectives and local regulators targets.

4 Potential Solutions

Opportunities to maintain the safe and reliable operation of the network have been considered. These include:

Option 1 - Run to failure

The reactive replacement of cables at failure was the historical approach to the management of PWC's cables as the risk to achievement of reliability and safety objectives was considered acceptable. This approach involves the repair or sectional replacement of the asset at the point of failure.

In 2014 it was recognised that this was not an acceptable approach for cables in Darwin's northern suburbs with known and developing issues. The high and increasing level of fault rates recorded in recent years, and the corresponding impact on reliability, and risk to public and worker safety has indicated that a run to failure approach is not acceptable.

Option 2 - Test and replace

This approach involves the testing of cables to determine if the cables are likely to fail in the near future. Based on an assessment of the expected remaining life and screen continuity, a replacement of the cables is then scheduled.

Since approximately 2014, PWC has been implementing the testing and replace approach on the select XLPE cable population. This approach has provided information on cable condition to better understand the failure modes and associated risks. However, in many instances the replacement work becomes reactive following the failure of the cable and the need for a more effective approach to maintain the safe and reliable operation of the network is needed. Additionally, this approach does not consider the potential for screens to be at the point of failure during testing, neither does it effectively manage the risk associated with a large proportion of degraded or discontinuous screens affecting the earthing systems performance.

Option 3 - Targeted proactive replacement (preferred option)

The targeted proactive replacement of the select XLPE cables is a concerted approach directed at maintaining system safety and reliability in a prudent and cost efficient manner. It relies on a risk based prioritisation of cable replacements taking into consideration cable health and criticality. Using data from testing performed on a sample of the population, the cables most likely to fail and with the most significant impact to reliability can be prioritised for testing and replacement. Cables found in serviceable condition and with continuous earth screens will be left in service and retested in future based on test results. This ensures only the cables in the poorest condition and highest consequence of failure will be replaced. This approach is represented in Figure 3 below.

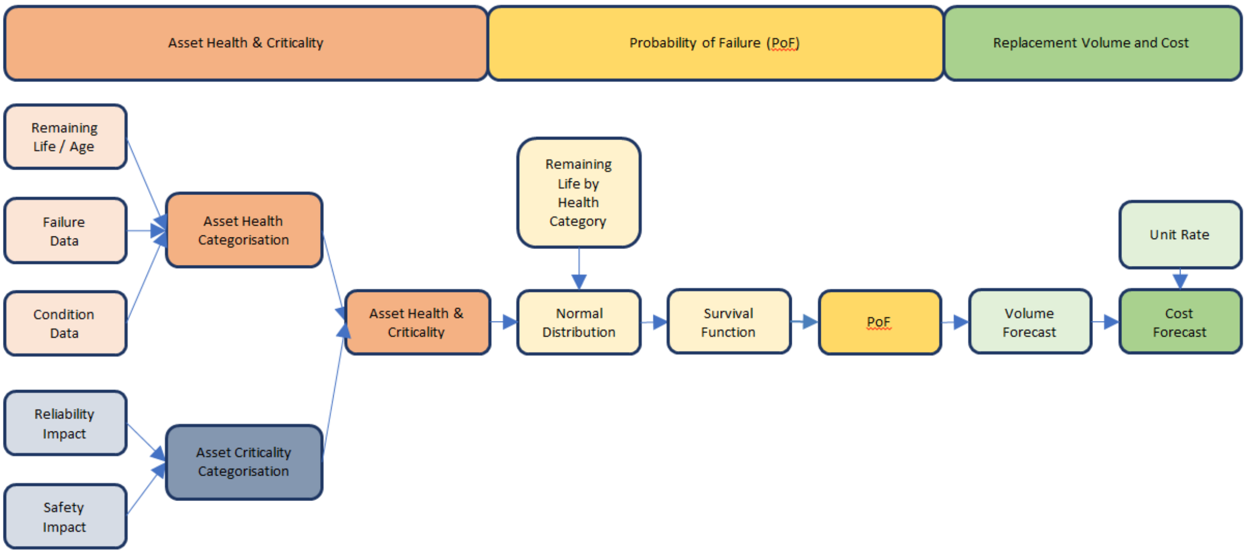

Figure 3 – Asset Health and Criticality based Forecast Methodology

4.1 Comparative Cost Analysis

A comparative cost analysis of the three options has been undertaken. The net present cost of each option including Opex and Capex over a 40 year period is detailed in the table below. The value of customer reliability and reduction in maintenance Opex has been modelled in the Net Present Cost.

Option	Capital cost ($M)	Net Present Cost ($M)	Comments
1 – Run to failure	2.3	17.2	Assumes some cable replaced each

Option	Capital cost ($M)	Net Present Cost ($M)	Comments
			year under fault conditions.
2 – Test and replace	6.8	19.0	Assumes around one third of cable replaced compared with option three
3 – Targeted proactive replacement	20.6	23.1	

As outlined above, option 1 has the lowest capital cost and net present cost of the three options. A run to failure approach, however, is not deemed acceptable for the reasons outlined in Section 4.

4.2 Non-cost attributes

An analysis of the non-cost attributes for each option has been completed using the multi-criteria analysis method. The attributes are selected considering major risks and priorities to achieve Project Objectives. A weighting is allocated to each, totalling 100%. Each attribute is given a score out of 5 (from 1 – Fails to satisfy, to 5 – exceeds requirements); the score is then multiplied by the relevant weighting to give the weighted score that is summarised in the table below.

	Technical & System Risk		Stakeholder Risk	Commercial	
Criteria	**Reliability**	**Compliance**	**Safety**	**NPC**	**Weighted Scores**
Weighting (%)	20	20	30	30	100
Option 1	0.2	0.2	0.3	1.2	**1.9**
Option 2	0.6	0.6	0.9	0.9	**3.0**
Option 3	1.0	1.0	1.5	0.6	**4.1**

4.3 Preferred Option

Option 3 is the preferred option. While this option has the highest NPC, the critical safety and compliance drivers are not modelled by NPC analysis and these are only adequately addressed by selecting option 3. This is borne out by the non-cost attributes in section 4.2 in which option 3 is the clear winner.

A risk based approach has been used to establish a targeted replacement program. The program will replace 44.2 km of the select XLPE in the next regulatory period, 2019/20 to 2023/24, focussing on the replacement of the highest safety and reliability risk cables. It is expected to cost $20.6M ($2017-18) over the 5 year period but continue beyond this in order to replace of the entire population of the vintage XLPE cables over a twenty-year period.

Year	2019-20 Qty	2020-21 Qty	2021-22 Qty	2022-23 Qty	2023-24 Qty	Total Qty
Replacement volume (km)	8.5	14.2	9.8	5.3	6.5	44.2

The replacement program considers cable criticality, health, and probability of failure to prioritise cables that pose the higher risk. Criticality has been determined by the number of customers impacted by an outage, and cable test results are used for asset health. The probability of failure has been based on recent cable fault rates, and adjusted to allow for an expected initial increase in failure rates as the asset condition deteriorates. Ultimately a downturn in failure rates over the regulatory period is expected as result of the prioritised replacements.

4.4 Non Network alternatives

No non-network alternatives were identified that would mitigate the need for the replacement of the select XLPE cables. The cables provide a backbone to the interconnected earth system and support achieving supply reliability requirements.

4.5 Capex/Opex substitution

The proposed cable replacement program addresses an asset design concern that cannot be solved through operations and maintenance activities.

4.6 Contingent Project

The expenditure does not meet the criteria for a contingent project as outlined in the Northern Territory National Electricity Rules, section 6.6A.1.

5 Strategic Alignment

This program aligns with the Asset Objectives defined in the Strategic Asset Management Plan (SAMP) and Asset (Class) Management Plans (AMP). The capital investment into cables outlined in this program will contribute to the Corporation achieving the goals defined in the Board's Strategic Directions and SCI Key Result Areas of Health and Safety and Operational Performance.

6 Timing Constraints

The condition of cables in Darwin's northern suburbs continues to deteriorate, increasing the risk to public and worker safety and reliability impact of cable failures. The continuation of this program with an increased scope is considered prudent to address these increasing risks.

7 Expected Benefits

Driver	Benefit	Measure
Asset Renewal	Network safety Network reliability	Health and Safety Index SAIDI/SAIFI performance
Service Improvement	Network reliability	Performance against SAIDI and SAIFI targets
Social / Environmental	Reduced customer impact from frequent cable faults	Reduced customer complaints from Northern Suburbs residents
Commercial / Efficiency	Reduced Opex	Reduced Cable fault related Opex costs

8 Milestones (mm/yyyy)

Investment Planning	Project Development	Project Commitment	Project Delivery	Review
01/2018	06/2018	07/2019	06/2024	09/2024

The program delivery is scheduled to run over 5 years from July 2019 to June 2024. A program review will be held at the end of the 5 year program as well as interim reviews at the end of each financial year.

9 Key Stakeholders

Stakeholder	Responsibility
Internal governance stakeholders	Executive General Manager Power Networks
	Group Manager Service Delivery

Stakeholder	Responsibility
	Chief Engineer
Internal design stakeholders	Senior Manager Network Development and Planning
	Senior Manager Contracts and Projects
	Senior Manager Asset Management
	Manager Test & Protection Services
	General Manager System Control
	Manager SCADA and Communication Services
External – Unions and public	Local Residents
	Local Councils and Road Owners
	ETU
	Ministers
External regulators	Utilities Commission
	Australian Energy Regulator

10 Resource Requirements

Resourcing requirements for this program are considered Business as Usual and will be incorporated into the development of Category C Business Case's for each batch of replacements.

11 Delivery Risk

Site access for the removal and installation of cables may need to be negotiated on a site by site basis with relevant council or road owners. These negotiations could impact on the timely and effective delivery of the program. Early stakeholder notification and consultation would assist in managing the delivery of the program.

Consequential, site specific costs may result from works being undertaken on existing installations in existing built up environments. The expenditure estimates have been based on similar brown field works undertaken in recent years and allows for potential variances in costs.

Expenditure forecast has been based on recent similar investments and makes allowance for contracted resourcing.

12 Financial Impacts

12.1 Expenditure Forecasting Method

The expenditure forecast has been based on a programmed approach. The forecast volumes have been determined using a risk based prioritisation of assets focusing on replacing the highest safety and reliability risk installations early.

12.2 Historical and Forecast Expenditure

Figure 3 below summarises the historical and forecast expenditure for 11kV cables. The increase in expenditure in the next period reflects the increasing risk associated with continued deterioration of 11kV cables in Darwin's Northern Suburbs and the Port Feeder[9]. Note that the increasing failure rate may lead to increased expenditure in the FY18 and FY19 budget years to replace cables that fail and are not able to be repaired.

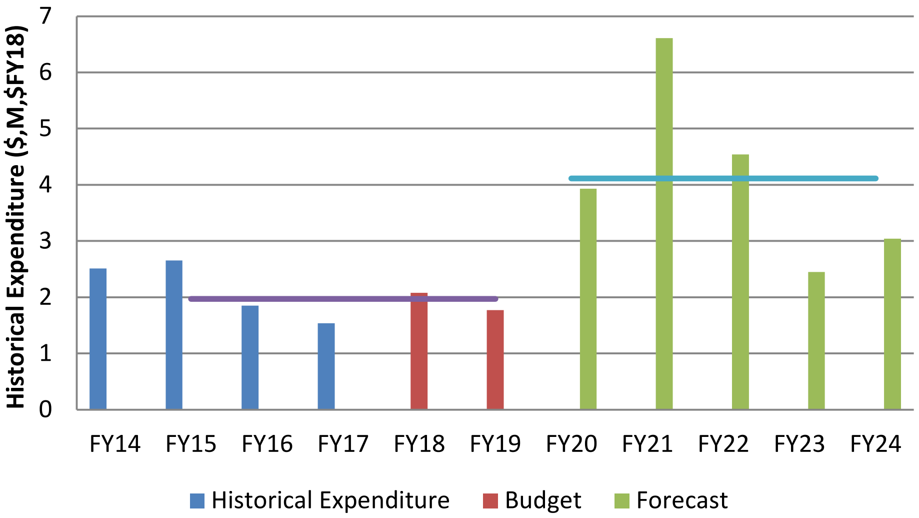

Figure 4 Historical and Forecast Expenditure 11kV Cable Replacement

12.3 Validation

The cost estimate has been based on recent (2015/16) replacement works undertaken by PWC. A benchmark of the cost against similar works undertaken by peer utilities indicates that the unit cost is reasonable. In comparison with peer utilities, PWC's unit cost compares slightly above average but is reflective of a unique network, climate conditions, and work environment.

[9] D2017/394399 - PRD33006 - Preliminary Business Case – Darwin – Replace Port Feeder.

Works undertaken in the Northern Territory are characterised by higher costs than other areas in Australia. This can partly be attributed to the remoteness of the network attracting additional transport and logistic costs, as well as the harsh weather conditions set apart by extended wet periods that impedes the effective execution of works and a tropical climate that impacts on the productivity that can be achieved during normal work hours.

Activity associated with cable installation is considered to require a high metabolic work rate, and is therefore heavily affected by the weather conditions in Darwin. Based on analysis conducted by Thermal Hyperformance[10], workability for High metabolic activity reaches approximately 70% during only the coolest months of the year, June. Workability is not affected in any other major Australian population centre except for during the hottest 2-3 months of summer.

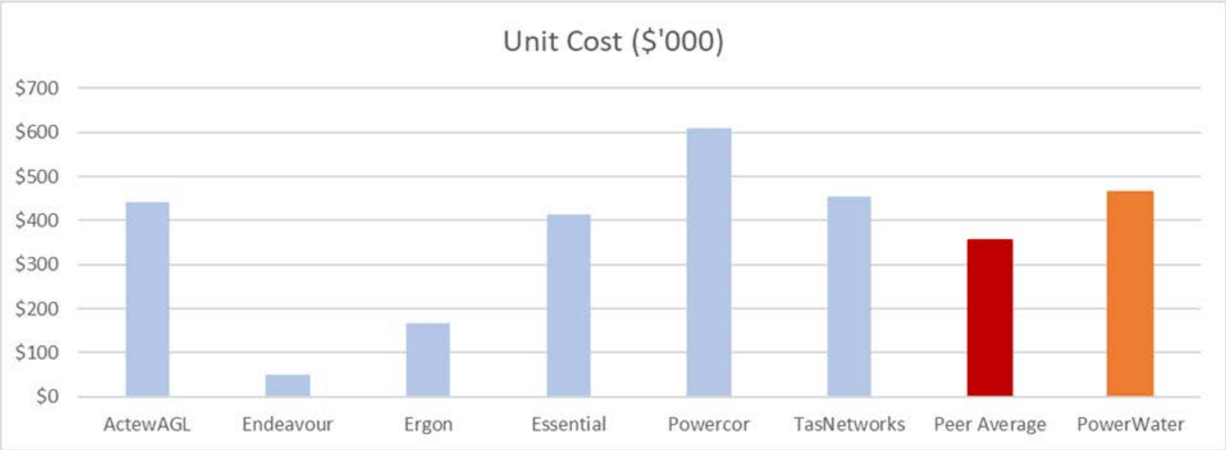

Figure 5 Unit cost comparison with other utilities

The comparison has been based on publicly available data sourced from the Australian Energy Regulator's (AER's) Repex modelling and utilities' Regulatory Information Notice (RIN) submissions. There are a number of internal and external operational, asset type, and environmental factors that influence the benchmark costs and provide a challenge in respect of the ability to undertake accurate comparisons. Normalisation for these factors has not been undertaken and the benchmark comparisons provided are an indicative measure of reasonableness only.

[10] Labour Efficiency and Work Management in Hot Humid Climates, Thermal Hyperformance.

12.4 Capex Profile

The capex in the table below is in $2017-18, and is excluding capitalised overheads and cost escalation.

Phase	2019-20 ($'000)	2020-21 ($'000)	2021-22 ($'000)	2022-23 ($'000)	2023-24 ($'000)	Total ($'000)
Investment Planning						
Project Development						
Project Commitment						
Project Delivery	3,931	6,605	4,540	2,453	3,038	20,567
Review						
Total	**3,931**	**6,605**	**4,540**	**2,453**	**3,038**	**20,567**

12.5 Opex Implications

Routine cable maintenance centres on the inspection of accessible components of the cable network. These may include cable terminations at various termination locations, cables located in tunnels, and overhead-to-underground cable transitions. The very nature of underground systems requires very few intrusive maintenance programs.

Corrective maintenance expenditure associated with the Northern Suburbs cables is significantly over represented in comparison with the wider cable population. The 103km of affected cables represents 6.5% of the total LV and HV cable population, but the maintenance costs associated with the population is significantly higher (approximately 23% on average) as demonstrated by Figure 5 below. The proportion of spend has reduced in recent years due to a cable joint type issue emerging in the Palmerston area.

There has been a reduction in cable related expenditure during the current period, despite the increase in failures, as result of improved repair and testing practices and an improvement in the capitalisation processes for cable replacement activity. Expenditure prior to the introduction of contemporary testing practices was much higher, due to a combination of additional time required to locate faults and attempting repairs multiple times on cables that were not serviceable.

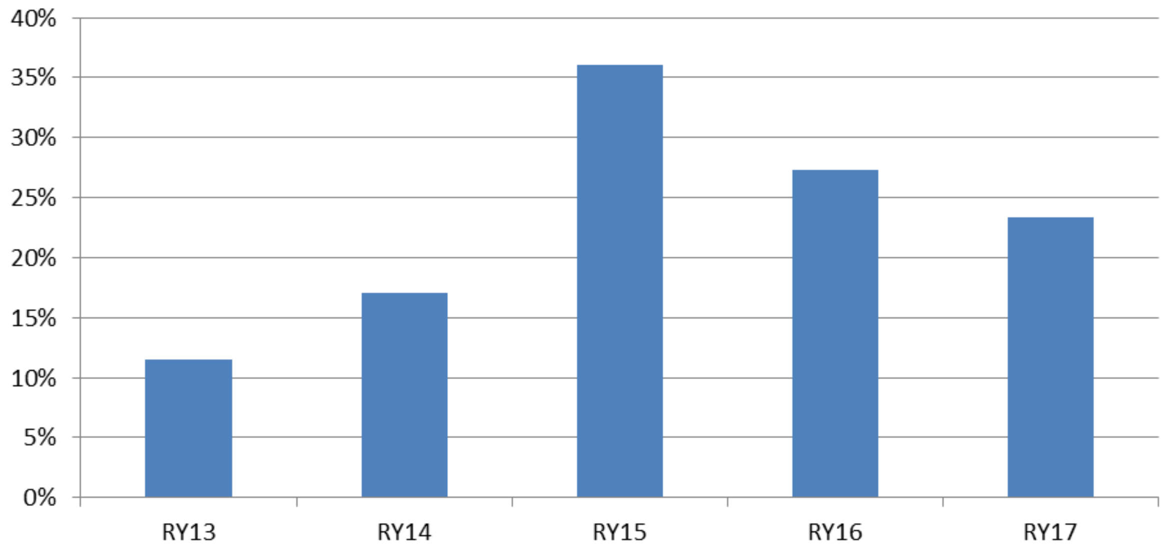

Figure 6 Historical Maintenance Expenditure – All cables and Northern Suburbs Cables

12.6 Variance

The forecast for this program of work extends beyond the current SCI period. The first two years of this program aligns with the last two years of the 2017-18 SCI.

APPENDIX A

The tables below are a collation of reliability and tests results per feeder during the northern suburbs cable condition assessment program. Exclusions have been applied to outage data as per the NT Utilities Commission Electricity Industry Performance Code.

Table 1A Summary of Cable Faults and Test Results for Northern Suburbs Feeders from 2013/14 to 2016/17

Item	Darwin Northern Suburb Feeders with XLPE installed between 1970 and 1985	Total cable fault events *	Cable fault contribution to Darwin SAIDI *	Percentage cable fault contribution to Darwin SAIDI *	Cable fault contribution to Darwin SAIFI *	Percentage cable fault contribution to Darwin SAIFI *	Cable fault Customer Minutes Lost [CML] *	Percentage cable fault contribution to Darwin CML *	Cable Tests conducted Jun-14 to Aug-17
1	11BE01 LEANYER	7	20	1.0%	0.174	0.5%	1,175,800	1.1%	Tested - Earth screen failed
2	11CA24 PARER	7	4	0.2%	0.028	0.1%	225,563	0.2%	Not Tested
3	11BE04 MCMILLANS	6	2	0.1%	0.008	0.0%	103,990	0.1%	Not Tested
4	11CA19 [redacted]	6	1	0.1%	0.019	0.1%	63,140	0.1%	Not Tested
5	11CA25 BRINKIN	5	5	0.3%	0.016	0.0%	304,463	0.3%	Tested - Okay
6	11LE03 LYONS 1	5	3	0.2%	0.012	0.0%	208,796	0.2%	Tested - Earth screen failed
7	11BE06 KARAMA 1	5	4	0.2%	0.052	0.2%	205,568	0.2%	Tested - Earth screen failed
8	11CA21 NIGHTCLIFF 2	5	3	0.2%	0.056	0.2%	186,390	0.2%	Tested - Okay
9	11CA00 NIGHTCLIFF 1	4	3	0.2%	0.054	0.2%	191,067	0.2%	Not Tested
10	11CA08 NTHLAKES	4	2	0.1%	0.020	0.1%	128,234	0.1%	Tested - Okay
11	11BE16 ANULA	4	1	0.0%	0.017	0.1%	44,300	0.0%	Not Tested
12	11CA12 MARRARA	4	1	0.0%	0.016	0.0%	39,242	0.0%	Not Tested
13	11CA16 NAKARA	3	4	0.2%	0.025	0.1%	246,533	0.2%	Tested - Okay

Item	Darwin Northern Suburb Feeders with XLPE installed between 1970 and 1985	Total cable fault events *	Cable fault contribution to Darwin SAIDI *	Percentage cable fault contribution to Darwin SAIDI *	Cable fault contribution to Darwin SAIFI *	Percentage cable fault contribution to Darwin SAIFI *	Cable fault Customer Minutes Lost [CML] *	Percentage cable fault contribution to Darwin CML *	Cable Tests conducted Jun-14 to Aug-17
14	11CA06 [redacted]	3	1	0.1%	0.026	0.1%	83,730	0.1%	Not Tested
15	11WN22 LUDMILLA	3	1	0.0%	0.021	0.1%	33,372	0.0%	Not Tested
16	11CA13 WANGURI	3	0	0.0%	0.001	0.0%	9,412	0.0%	Tested - Okay
17	11CA07 JINGILI	3	0	0.0%	0.010	0.0%	3,353	0.0%	Not Tested
18	11BE10 KARAMA 2	2	0	0.0%	0.002	0.0%	22,755	0.0%	Tested - Earth screen failed
19	11CA10 MILLNER	2	0	0.0%	0.000	0.0%	400	0.0%	Not Tested
20	11CA03 BRADSHAW	1	39	2.0%	0.323	1.0%	183,960	0.2%	Tested - Okay
21	11CA23 MOIL	1	2	0.1%	0.024	0.1%	125,028	0.1%	Tested - Earth screen failed
22	11WN01 BAGOT	1	0	0.0%	0.000	0.0%	171	0.0%	Not Tested
23	11LE08 PARKSIDE	1	0	0.0%	0.000	0.0%	117	0.0%	Not Tested
24	11CA04 [redacted]	1	0	0.0%	0.000	0.0%	42	0.0%	Not Tested
25	11CA02 [redacted]	0	0	0.0%	0.000	0.0%	0	0.0%	Not Tested
26	11CA15 [redacted]	0	0	0.0%	0.000	0.0%	0	0.0%	Not Tested
27	11CA17 [redacted]	0	0	0.0%	0.000	0.0%	0	0.0%	Not Tested
28	11LE01 [redacted]	0	0	0.0%	0.000	0.0%	0	0.0%	Tested - Earth screen failed
29	11LE04 TAMBLING	0	0	0.0%	0.000	0.0%	0	0.0%	Tested - Earth screen failed
30	11LE12 MUIRHEAD	0	0	0.0%	0.000	0.0%	0	0.0%	Not Tested
31	11LE17 LYONS 2	0	0	0.0%	0.000	0.0%	0	0.0%	Not Tested

Item	Darwin Northern Suburb Feeders with XLPE installed between 1970 and 1985	Total cable fault events *	Cable fault contribution to Darwin SAIDI *	Percentage cable fault contribution to Darwin SAIDI *	Cable fault contribution to Darwin SAIFI *	Percentage cable fault contribution to Darwin SAIFI *	Cable fault Customer Minutes Lost [CML] *	Percentage cable fault contribution to Darwin CML *	Cable Tests conducted Jun-14 to Aug-17
	Total	**86**	**97**	**5.0%**	**0.905**	**2.8%**	**3,585,425**	**3.2%**	

Table 2A Test and Failure Summary of Northern Suburbs Feeders

Northern suburb feeders	Qty	%
Total number of XLPE cable feeders	31	100%
Number of XLPE feeders tested	13	42%
Number of XLPE cable screens failed	7	54%
Number of XLPE cables screens okay	6	46%