PowerWater

# Program Business Need Identification

## Power and Water Corporation

**CONTROLLED DOCUMENT**

**PRD33387**

## Transmission Tower Earthing System Refurbishment Program

Proposed:

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Date: 7/2/2018

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Refer to email D2018/57847

Finance Review
Date: 06/02/2018

Refer to email D2018/5195

PMO QA
Date: 05/02/2018

# 1 Program Summary

| | | | |
|---|---|---|---|
| **Program Name:** | Transmission Tower Earthing System Refurbishment | | |
| **Program No:** | NMP11 PRD33387 | **SAP Ref:** | |
| **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:** | Compliance | Secondary Driver: | Renewal/ Replacement |
| **Program Classification:** | Capital Program of Works | | |

# 2 Recommendation

**MAJOR PROJECT >$1M OR PROGRAM**

It is recommended that IRC note the proposed five year transmission tower earthing refurbishment program for an estimated budget of $3.57 million, and approve the inclusion of this refurbishment program into the SCI for this amount, with a corresponding completion date of June 2024.

The forecast for this program of work extends beyond the current SCI period. The first three years of this program aligns with the last three 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 Cs to be approved by the Executive General Manager Power Networks.

# 3 Description of Issues

Transmission line earthing is a key mechanism for operating a safe and reliable transmission network. The transmission "earthing system" consists of an interconnected system of Overhead Earth Wires (OHEW) and tower/pole foundations earthing generally consisting of earth rods and grading rings. Management of this earthing system requires consideration of both the risks imposed by the earthing system as well as external factors that may alter the performance or even change the required performance of the system, as described by the Energy Networks Associations Power System Earthing Guide EG-0 risk profile in Figure 1 - Earthing System Risk Profile as defined in EG-0. As a consequence, the performance requirements for the earthing system design may differ from one tower to the next along the length of a transmission feeder depending on the environmental conditions at each site, such as soil type and population density.

In the context of Darwin, the urban areas where much of the original transmission system was constructed in the 1970's and 1980's has changed considerably, increasing the uncertainty associated with the risk factors defined in the EG-0 risk profile. What has become apparent during the current period is that the performance of existing tower earthing is inadequate as described further in this section. A report by specialist earthing consultants was commissioned in 2017[1] to provide a review of the historical and current performance and provide guidance on the management of this emerging risk. The report concluded that remediation of towers with the poorest performance was prudent and that further development of routine testing practices was also required to effectively manage these risks.

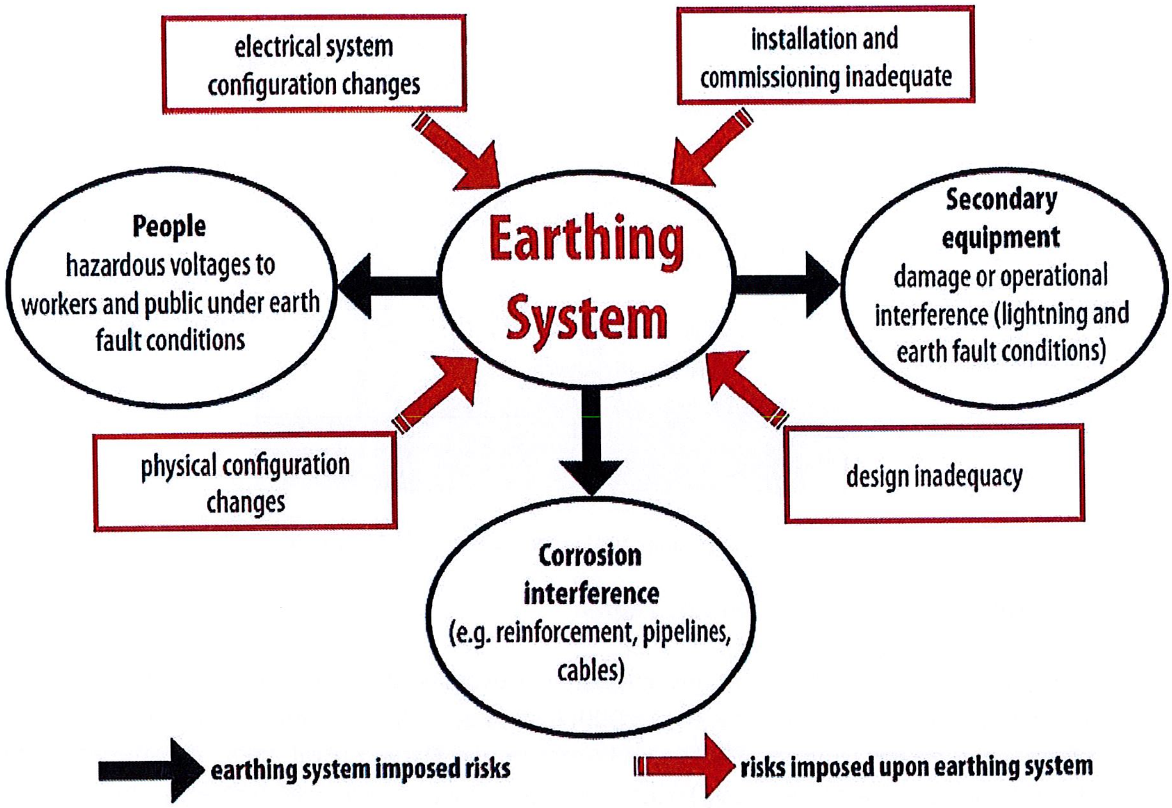


Figure 1 - Earthing System Risk Profile as defined in EG-0

## 3.1 Hazards associated with Transmission System Earthing

[1] Earthing Assessment Report – Aerial Transmission Structure Earthing

During a phase to earth fault, current flows back to the source via the OHEW and through the earthing system at each tower. Phase to earth faults in Darwin's transmission network are generally caused by lightning, animals and wind borne debris. The proportion of current following through either the OHEW or tower/pole structure is dependent on the impedance of the two return paths. In terms of risk to workers and the public, there are various design trade-offs that occur however a key principle is to achieve the lowest foundation resistance practical, particularly in populated areas to limit the Earth Potential Rise and subsequent Step and Touch voltages during fault conditions.

Figure 2 below demonstrates the touch voltage scenario. The higher the foundation earthing impedance, the higher the step and touch voltages will be during fault conditions. Touch and Step voltages during transmission line faults are an unavoidable and inherent hazard. However network operators are obligated to minimise these to as low as reasonably practicable through well-established control measures and based on the probabilistic approach defined in the Energy Networks Associations Power System Earthing Guide EG-0 to determine allowable voltage criteria and exposure under fault conditions[2].

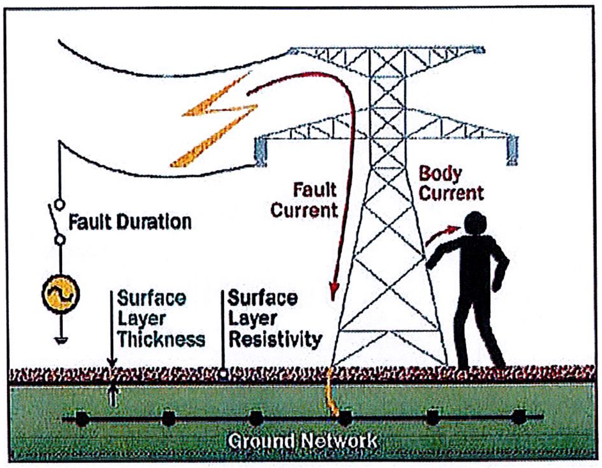


Figure 2 - Transmission Line Fault Touch Voltage Diagram[3]

### 3.2 Likelihood of Transmission Line Faults

The Darwin region is the lightning capital of Australia, with an extended annual storm season producing an average of 15,000 lightning strikes annually in a 1500 square kilometre area covering the Darwin, Palmerston and Darwin rural area[4]. A comparison of the 5 year average of lightning strikes between Darwin and a similar land area around other major Australian centres is summarised in Figure 3 below.

[2] EG-0 Power system earthing guide Part 1: management principles

[3] http://www.esgroundingsolutions.com/what-is-step-and-touch-potential/

[4] GPATS historical lightning data for Darwin

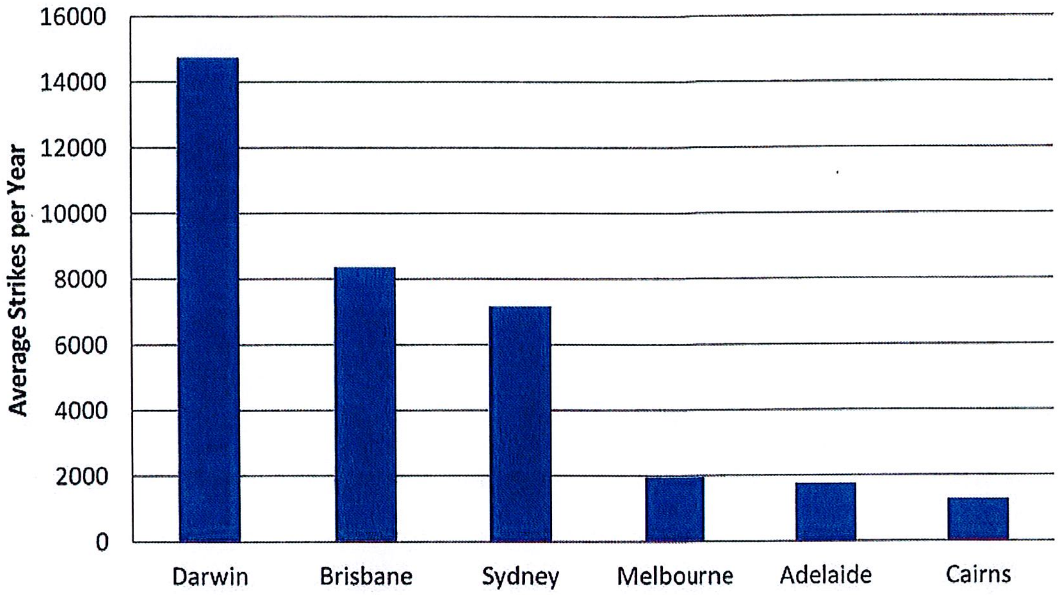


Figure 3 - Lightning Strikes 5 Year Average for Major Australian Centres

Data is not readily available to compare the actual frequency that lightning hits transmission lines, however it is reasonable to expect the frequency of transmission line faults will be much higher for the majority of PWC's transmission network which is located in Darwin, than for other utilities. This increases the probability of exposure to touch and step voltages. To partially mitigate this risk, work is not undertaken on transmission and distribution lines during lightning storms, which occur regularly between October and April. The public's interaction with the network is less controlled and therefore heavily relies on the tower's local earthing, in addition to media campaigns to raise awareness of the hazards associated with the annual storm season. Table 1 below demonstrates the difference in transmission line outages in the north of the NT by comparing transmission line outage rates from various TNSPs' RIN data.

Table 1 Summary of TNSP transmission line outage rates

| Service Provider | 3 Year Average Line Outage Rate |
|---|---|
| Power Link | 18.11% |
| Transgrid | 12.19% |
| Electranet | 25.97% |
| Ausnet | 21.49% |
| PWC 66kV Lines | 92.42% |
| PWC 132kV Lines | 186.67% |

The correlation between annual lightning strikes[5] and transmission line outage rates is also demonstrated in Figure 4 Transmission Line Outages and Recorded Lightning Strikes In Darwin Area below. This data shows a strong correlation between lightning and lightning related transmission outages. Note the growth in lightning sensors in the north of Australia will continue to improve the accuracy of lightning data, and additional focus on recording transmission line outages may partially explain the increasing trend in both series.

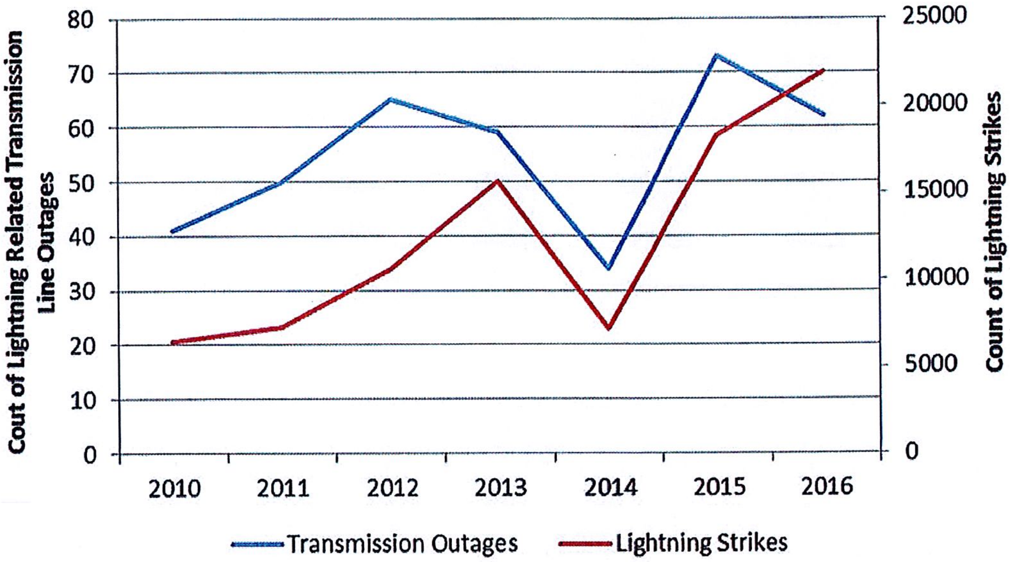


Figure 4 Transmission Line Outages and Recorded Lightning Strikes In Darwin Area

### 3.3 Poor Earthing Performance and Insulator Damage

A secondary issue associated with poor transmission tower/pole earthing is known as insulator "back-flash". This occurs when the high frequency surges associated with lightning strikes cause voltages on towers to exceed the Base Insulation Level (BIL) of line insulators, leading to a flashover across the insulator. A secondary flash-over from the phase conductor to earth is then established and can only be cleared by network protection systems. This damages insulator surfaces and corrosion protection of insulator fittings. Insulator life is then limited depending on the rate of corrosion or deterioration of insulator surfaces. It also stresses network equipment such as circuit breakers that are required to operate under fault conditions more frequently. Back-flash can only be avoided through effective tower earthing or the installation of Lightning Arrestors on transmission towers.

[5] GPATS historical lightning data for Darwin

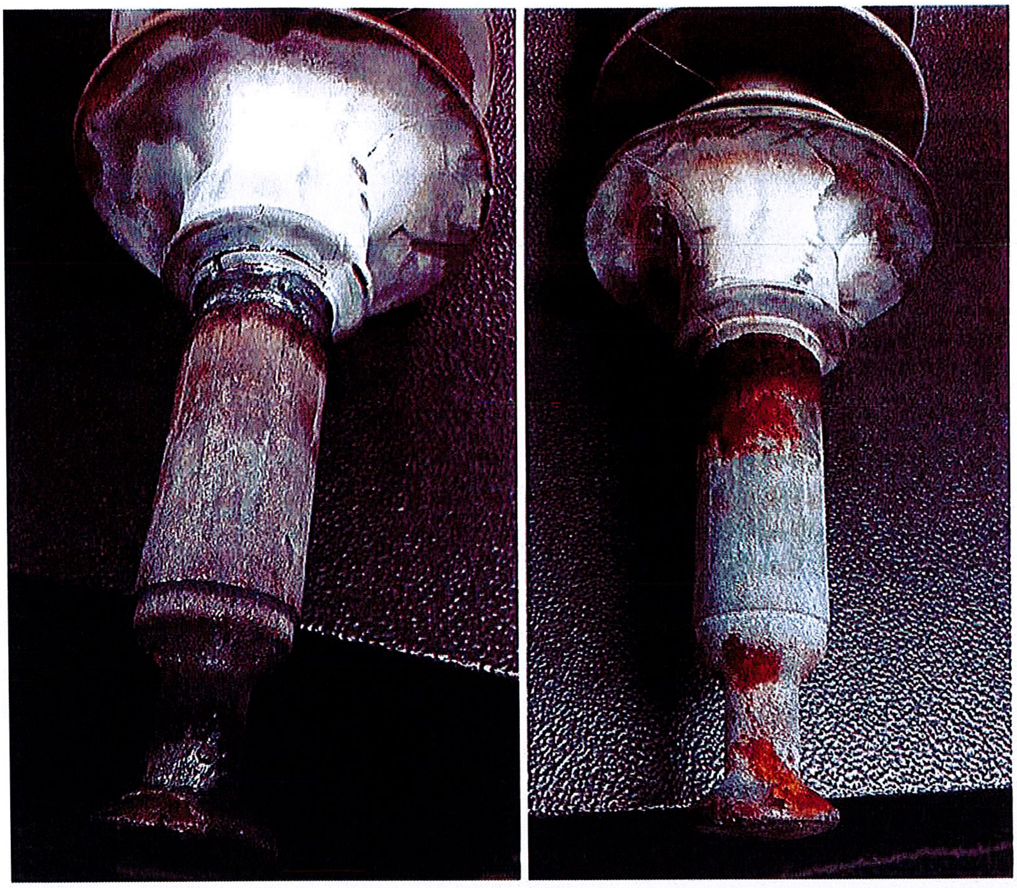

Figure 5 Damage to polymer insulators. Back-flash directly after strike (L) and after corrosion initiated (R)

Back-flash damage is observable on a significant proportion of 66kV lines in the Darwin network and sporadically on the 132kV lines. During the 2000's a transition from porcelain insulators to polymer type for 66kV lines was made due to the higher tolerance to surface damage of polymer materials and reduced manual handling hazards. Maximo work order data identifies 300 towers and poles in service are currently identified as having insulator damage, the majority of which are polymer suspension insulators with flash damage and corrosion. While polymer insulators have proven to be highly resilient to flash damage, live work on these towers is restricted due to the inability to test insulator integrity. The potential for compromised performance and service life reduction due to back-flash induced corrosion requires further analysis.

### 3.4 Historical Testing

Earthing tests performed since 1986 have been extracted from historical records and compared with the most recent tests undertaken in 2015/16 by PWC's earth testing contractor. The test results demonstrate deterioration in tower base earth systems. Tests were undertaken on 271 transmission towers and poles covering both 132kV and 66kV installations. The test sample was selected based on known areas with back-flash damage. The test sample represents 10.4% of the transmission network in the Darwin region, and 7.6% of the total transmission tower and pole population.

The results summarised in Table 2 show 46% of the test sample exceeded 10Ω earthing resistance, and 28% exceeded 30 Ω.

Table 2 Summary of 2015 Tower Earth Testing Results

| Number Tested | ER > 10Ω | % ER >10Ω | ER > 30Ω | % ER >30Ω |
|---|---|---|---|---|
| 271 | 124 | 46% | 76 | 28% |

The correlation of consistent back-flash damage and poor earthing performance demonstrate that the foundation earthing systems on a significant proportion of transmission network structures are no longer effective, and have been for some time as evidenced by significant insulator replacement programs performed in the 2000's. The defective earth systems directly impact on public and worker safety due to increased step and touch potentials, particularly in urban areas. It also impacts on the frequency of faults experienced on the transmission network as fault currents aren't effectively dissipated across the earthing system. A common indicator for likely fault events is the average footing resistance of a line. The below summarises the average resistance for the lines tested in 2015. While the 66kV lines tested are typically less critical in terms of system security, they typically traverse urban areas and are also the oldest lines in the network.

Table 3 Average Footing Resistance for Lines Tested

| Transmission Line | Average Footing Resistance (Ω) | Towers Tested |
|---|---|---|
| 132 CI-HC A | 8.4 | 64 |
| 132 CI-HC B | 9.9 | 64 |
| 66kV CA-BE | 84.4 | 40 |
| 66kV HC-PA | 73.6 | 35 |
| 66kV HC-WN | 118.2 | 35 |
| 66kV HC-BE | 26.9 | 33 |

### 3.5 Link to Darwin-Katherine System Black Events 2010 and 2014

Further investigations triggered by the 2014 System Black event determined that particular feeders, specifically the 132 kV Channel Island to Hudson Creek (132 CI-HC) transmission line had 25% of its earthing systems exceed 10Ω, which is PWC's current pass criteria in lieu of tower specific assessments. The investigation also found that connections to the OHEW may have been compromised at some installations impacting on the effective fault return path and corrective action has been performed to address this issue. It is worth noting that both the 2010 and 2014 Darwin-Katherine "System Black" events were initiated by lightning strikes on the 132 CI-HC line. It is not clear whether this was due to a back-flash occurring. A report commissioned by the System Operator as a result of System Black investigation findings recommended corrective action associated with earthing connections, which have been resolved, and further consideration of earthing system improvements to mitigate possible future back-flash caused by lightning strikes. Figure 6 below demonstrates the increase in average footing resistance for these two lines.

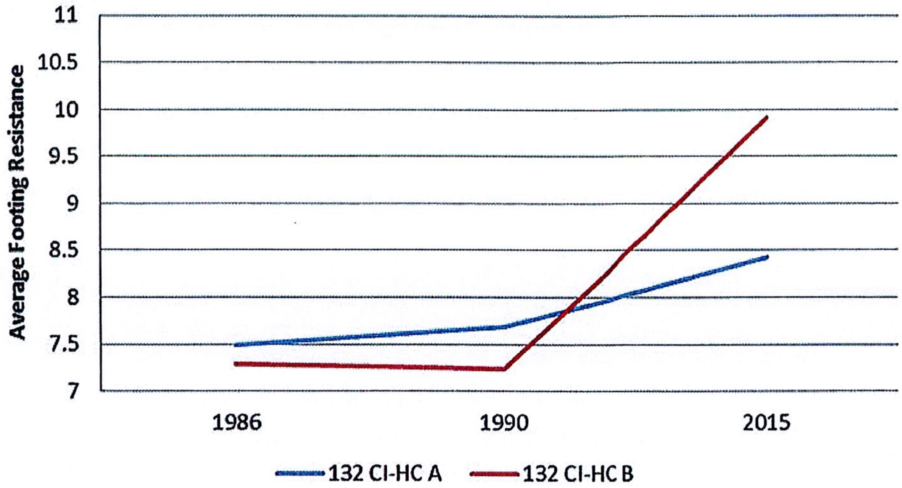


Figure 6 - Available 132kV CI-HC Lines Historical Test Results

### 3.6 Performance Criteria

Establishing individual structure earthing requirements is done at the design stage based on analysis of lightning density, soil testing and desired performance criteria. Much of this information is no longer available for lines except for 132 CI-HC and may not have been done for some lines. Significant changes to the urban environment of Darwin and surrounding areas also have the potential to compromise the original design parameters and damaged local tower earthing.

To determine what acceptable foundation earthing performance should be, contact has been made with several other Transmission Network Service Providers. This indicates an in-service limit of 5Ω is common for 66kV and 132kV, with some variation based on distance from substations, and location with respect to proximity to public and other infrastructure. This could be interpreted as a consequence (fault level) and likelihood (public exposure) based approach. The application of the probabilistic approach defined in EG-0 is resulting in a move away from specific limits; however this also requires significant investment in engineering capability, asset data and associated modelling and design software.

It is evident from the most recent test results, evidence of ongoing insulator damage and stress of other network equipment that Power Networks current methods of risk mitigation are well below that of industry peers and investment is required to maintain the safe and reliable operation of the transmission network as required by the Network

Technical Code and Planning Criteria. The proposed investment approach prioritises high risk tower and pole earthing systems based on feeder criticality, asset location, and asset health.

### 3.7 Project Drivers

| Safety |
| --- |
| Deterioration in the transmission network earthing system poses an increasing safety risk to the public as well as PWC employees involved in undertaking works on and in proximity of the asset. Action to restore system condition or other effective control measures are required to effectively addresses the public and worker safety risk. |
| **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. Restoring or augmenting defective earthing systems will maintain the effectiveness of the transmission earthing system reducing employee and public safety risk, and system reliability risk related to earthing system failure in compliance with the business objective. |
| **Reliability (if not compliance obligation)** |
| The transmission network contributes to the reliability of the power system. The deficiency of the earthing system impacts on the ability to effectively maintain network reliability. In particular, outages on radial transmission lines 66 MR-SY, 66 CP-DA, 66 PC-CH, 132 CI-MT and 132 MT-PK result in customers being directly affected.<br><br>Addressing earthing system intergrity will contribute to continued maintenance of system reliability and achievement of PWC's system reliability objectives. |

# 4 Potential Solution

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

**Option 1 – Run to failure**

Run to failure involves the reactive maintenance and repair of the transmission earthing systems. Earth system failure can only effectively be determined through testing. PWC does not currently have a routine earth testing program for transmission towers and poles. , but the results from the sample of towers already tested indicates that many earthing systems have already failed.

The run to failure approach is not considered an effective means of operating a safe and reliable transmission earthing system.

### Option 2 – Inspection and refurbishment

This approach involves the routine inspection and performance tracking of transmission earthing systems to determine asset refurbishment requirements.

Depending on location PWC applies a 3 yearly ground based visual inspection and an annual visual/aerial inspection cycle to assess the health of transmission structures. Included in this inspection is an assessment of the earthing systems. The inspection involves a judgement of condition and risk of failure based on a visual assessment and in conjunction with system performance tracking provides a pointer to potential earthing system integrity issues. Earthing system testing is then undertaken to assess asset conditions. The results from the sample of towers already tested based on this approach indicates that many earthing systems have already failed and many are well above what was previously considered industry accepted values, typically 10Ω, for transmission tower earthing.

Design data for most lines is not available and therefore determining what constitutes a failure based on a defined performance criteria is also difficult. Applying general criteria can lead to over investment as towers may require significant works to achieve a "nominal" value without consideration of the actual risk factors in-line with EG-0 or lightning performance of the line with due consideration of adjacent towers and environmental conditions.

The inspection and refurbishment approach is not considered effective. The visual inspections are limited to above ground and accessible components, and system performance tracking is generally shrouded by other system considerations such as system configuration, asset conditions, and operational environment.

PWC has been implementing the inspection and refurbishment approach on the transmission earthing systems and have recognised the need for a more effective approach to maintain the safe and reliable operation of the network.

### Option 3 – Targeted refurbishment

The targeted proactive refurbishment of transmission earthing systems 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 transmission earthing systems taking into consideration the asset health and criticality to inform a refurbishment program. The towers identified through this method will then be assessed based on the guidelines defined in EG-0. This approach involves the periodic testing of transmission earthing systems to determine asset condition, forecast asset failures, and schedule refurbishment works. This approach is also recommended in a report by specialist earthing consultants to ensure effective management of public risk and line performance.

Periodic testing is the most effective way of assessing the condition of the earthing systems and provides a means of monitoring the earthing system condition over time and targeting refurbishment works. The frequency of testing should also consider the health and criticality of the transmission lines, reducing the operating costs of future monitoring programs.

## 4.1 Comparative Cost Analysis

Net present cost analysis has not been performed for this project, since the safety and reliability drivers were not able to be expressed as a cost for comparison. Options 2 and 3 are expected to be a similar cost for the period, with the main difference being Option 3 will ensure the towers refurbished are targeted appropriately based on risk, rather than arbitrary limits.

## 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 3 below.

Table 3 Non-cost Attributes Assessment

| | Technical & System Risk | | Stakeholder Risk | |
|---|---|---|---|---|
| Criteria | Reliability | System Security | Safety | Weighted Scores |
| Weighting (%) | 20 | 40 | 40 | 100 |
| Option 1 | 0.2 | 0.4 | 0.4 | 1 |
| Option 2 | 0.4 | 1.2 | 0.8 | 2.4 |
| Option 3 | 0.8 | 1.6 | 1.6 | 4 |

## 4.3 Preferred Option

The targeted refurbishment program detailed in Option 3 applying a risk based approach has been selected as the preferred option. While this is higher cost than the other options it is considered the only option which adequately addresses the identified safety and compliance risks.

The program will, as a priority, refurbish 313 tower earthing systems in the next regulatory period, 2019/20 to 2023/24 focusing on the highest risk installations.

It is expected to cost $3.57 million over the 5 year period. This strategy will result in the refurbishment of all the identified failed earthing installations during the regulatory period, including for failed and yet unidentified earthing systems, and an allowance for new failures expected to develop during the 5 year period. The strategy refurbishes 313, or 12% of the Darwin transmission tower and pole earthing systems over the 5 year period.

The program considers feeder criticality, asset location and health, soil types, and probability of failure to prioritise the transmission earthing systems that poses the higher risk. In particular, the 132kV Channel Island to Hudson Creek feeder has been identified as a key priority based on its criticality within the network and earthing systems tests indicating a 20% failure of earthing systems on the feeder.

Earth system health has been based on test results that identified a significant number of failed installations. Probability of failure has been based on the findings of the earth system tests.

| Year | 2019-20 Qty | 2020-21 Qty | 2021-22 Qty | 2022-23 Qty | 2023-24 Qty | Total Qty |
|---|---|---|---|---|---|---|
| Earth System Refurbishment volumes | 76 | 60 | 60 | 60 | 57 | 313 |

### 4.4 Non Network alternatives

No viable non-network alternatives were identified that would mitigate the need for the refurbishing the transmission earth systems.

### 4.5 Capex/Opex substitution

The proposed transmission earthing system refurbishment program addresses an asset degradation issue that cannot be solved through operations and maintenance activities.

### 4.6 Contingent Project

The expenditure does not meet the criteria for a contingent project - National Electricity Rules, section 6.6A.1(b)(2).

## 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 boards Strategic Directions and SCI Key Result Areas of Health and Safety and Compliance.

# 6 Timing Constraints

It is essential that this project commence as proposed to manage the continued safe and reliable operation of the transmission network. Earthing system performance on the transmission network needs to be adequately maintained to mitigate the risk of public and worker safety, and maintain system security and reliability.

Deferral of this program would result in continued deterioration of transmission tower earthing systems, particularly towers in Darwin's urban areas which have been in service since the 1970's and early 1980's.

At the time of installation these lines were constructed in areas that were sparsely populated. The rapid urban development in Darwin over the last decade has changed the operating context of these lines, and the industry's understanding of risks associated with transmission earthing systems and their influence on adjacent infrastructure has also changed substantially allowing improvements to be targeted based on probabilistic based assessments of risk for each tower and line. An example of infill around an established transmission corridor is shown in Appendix A. This approach does require further development of risk assessment processes, additional data capture on service conditions and analysis of current performance. In particular, the capture of current performance information requires further sampling over the range of service conditions, in particular the extremes of the dry and wet seasons. Ultimately the development of PWC's understanding will enable PWC to use a quantitative risk assessment process for targeted remediation to ensure investment is prudent and efficient.

# 7 Expected Benefits

| Driver | Benefit | Measure |
|---|---|---|
| Asset Renewal | Network reliability<br>Assets fit for purpose | SAIDI/SAIFI performance |
| Compliance | Compliance with Network Technical Code and Network Planning Criteria objective | Non-compliance |
| Social / Environmental | Network safety | Duty of care to customers interacting with transmission assets. |

# 8 Milestones (mm/yyyy)

| Investment Planning | Project Development | Project Commitment | Project Delivery | Review |
|---|---|---|---|---|
| 01/2018 | 01/2019 | 06/2019 | 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 |
| | Chief Engineer |
| Internal design stakeholders | Senior Manager Contracts and Projects |
| | Senior Manager Asset Management |
| | General Manager System Control |
| External – Unions and public | Local Residents |
| | ETU |
| | Ministers |
| External regulators | Utilities Commission |
| | Australian Energy Regulator |

# 10 Resource Requirements

Not applicable. 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 individual replacement.

# 11 Delivery Risk

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 includes for potential variances in costs.

Capacity of the internal workforce during the peak dry season period can be augmented by contract labour to mitigate delivery risks. The majority of the work is civil works and minimal internal staff involvement is required other than validation of refurbished earthing performance through testing.

# 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 the refurbishment of the highest risk installations.

## 12.2 Historical and Forecast Expenditure

No historical expenditure for the replacement of transmission tower and pole earth grids has been identified. Investigation and testing of earthing performance has been completed over the last few years, however this has typically been part of wider assessments of earthing performance of both the distribution and transmission networks. The cost associated with engaging external expertise to assist with earthing assessments are significant and work between distribution and transmission is combined for efficiency. Costs specific to transmission earthing are therefore not possible to isolate. Forecast expenditure is shown in Section 12.4 Capex Profile.

## 12.3 Validation

The earth system refurbishment expenditure forecast has been based on a bottom up estimate of labour, material, and services costs and includes an allowance for corrosion resistance coating of Towers. Recent quotes from service providers for similar works have also been used to ensure the estimates are reasonable.

## 12.4 Capex Profile

| 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 | 865 | 683 | 683 | 683 | 654 | 3,568 |
| Review | | | | | | |
| **Total** | **865** | **683** | **683** | **683** | **654** | **3,568** |

## 12.5Opex Implications

No step change in operating cost is forecast for the next regulatory period as result of investing in the refurbishment of the transmission earthing systems.

## 12.6Variance

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


Figure 7 Example of Urban Infill Along 132kV and 66kV Line Corridor including houses, sheds, swimming pools

# APPENDIX B

## 1 Forecast Expenditure by Expenditure Category

| RAB Category | Regulatory Year (A$M, $2017-18, Jul to Jun years) | | | | |
|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 |
| **Total** | 0.87 | 0.68 | 0.68 | 0.68 | 0.65 |
| | | | | | |
| **Labour** | 0.10 | 0.08 | 0.08 | 0.08 | 0.07 |
| **Materials** | 0.66 | 0.52 | 0.52 | 0.52 | 0.50 |
| **Contractors** | 0.11 | 0.08 | 0.08 | 0.08 | 0.08 |
| **Other** | | | | | |

Definitions

**Labour** – The cost of direct Labour for the project. No overheads.

**Materials** – the cost of materials used in the project. No overheads.

**Contractors** – the cost of work performed by Contractors in the project, whether Labour or Materials. No overheads.

**Other** – expenditure that is not Labour, Materials or Contractors. No overheads.

## 2 Forecast Expenditure by RAB Category

| RAB Category | Regulatory Year (A$M, $2017-18, Jul to Jun years) | | | | |
|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 |
| **Total** | **0.87** | **0.68** | **0.68** | **0.68** | **0.65** |
| **System Capex** | | | | | |
| **Substations** | | | | | |
| **Distribution Lines** | | | | | |
| **Transmission Lines** | 0.87 | 0.68 | 0.68 | 0.68 | 0.65 |
| **LV Services** | | | | | |
| **Distribution Substations** | | | | | |
| **Distribution Switchgear** | | | | | |
| **Protection** | | | | | |
| **SCADA** | | | | | |
| **Communications** | | | | | |
| **Non-system Capex** | | | | | |
| **Land and Easements** | | | | | |
| **Property** | | | | | |
| **IT and Communications** | | | | | |
| **Motor Vehicles** | | | | | |
| **Plant and Equipment** | | | | | |

## 3 Forecast Expenditure by CA RIN Category

| RAB Category | Regulatory Year (A$M, $2017-18, Jul to Jun years) | | | | |
|---|---|---|---|---|---|
| | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 |
| **Total** | **0.87** | **0.68** | **0.68** | **0.68** | **0.65** |
| | | | | | |
| Repex | 0.87 | 0.68 | 0.68 | 0.68 | 0.65 |
| Augex | | | | | |
| Connections | | | | | |
| Non-network: IT | | | | | |
| Non-network: Vehicles | | | | | |
| Non-network: Buildings and property | | | | | |
| Non-network SCADA & network control | | | | | |
| Non-network: Other | | | | | |