2023-27 POWERLINK QUEENSLAND REVENUE PROPOSAL

Project Pack – PUBLIC

CP.02750 Ross to Chalumbin 275kV Transmission Line Refit

CP.02750 – Ross to Chalumbin 275kV Transmission Line Refit

Project Status: Not Approved

1. Network Requirement

The Ross to Chalumbin transmission line is 31 years old (commissioned in 1989) and runs for 244km from south Townsville to south of Cairns. The line consists of a 275kV feeder which is critical to the supply of Far North Queensland. An outage of this feeder would leave up to 340MW and up to 3000MWh of customer load per day at risk[2]. It would also constrain load in the Far North to 170MW[2].

A Condition Assessment (CA) conducted in March 2020 identified some of the line's structural members, attachment hardware, climbing step bolts, overhead earth wires and selected structures are exhibiting emerging condition risks due to corrosion[1]. Approximately 11% of tower bolts and 20% of structural fasteners are currently exhibiting Grade 2 (Low) and Grade 3 (Medium) corrosion with some isolated areas of Grade 4 (High) corrosion. By 2025, 55% of bolts are expected to exhibit Grade 2, 10.5% Grade 3, and 2.1% Grade 4 corrosion. This decline in asset condition increases the risk of structural failure that may cause network outages, safety incidents, and additional network costs to replace assets under emergency conditions.

Energy Queensland forecasts have revealed there is an enduring need to maintain electricity supply into Far North Queensland. The removal of the Ross to Chalumbin transmission lines would violate Powerlink's Transmission Authority reliability obligations (for N-1 and -50MW/600MWh). Failure to address the existing condition of this asset is likely to result in non-compliance with Powerlink's reliability obligations[6].

2. Recommended Option

As this project is currently 'Not Approved', project need and options will be subjected to the public Regulatory Investment Test for Transmission (RIT-T) consultation process to identify the preferred option closer to the time of investment.

The current recommended option is to refit poor condition components of the 275kV Ross to Chalumbin feeder by 2027[2].

The following options were considered but not proposed:

- Do Nothing – rejected due to non-compliance with reliability standards.
- Rebuild the 275kV circuit – not recommended due to additional cost over refit.
- Uprate the coastal circuit from Yabulu South to Woree to 275kV from the current 132kV – rejected as this configuration is unable to meet reliability standards under a critical contingency scenario.
- Non Network Option parameters identified and considered to meet reliability requirements for Yabulu to Woree 132kV uprate option – this option may be tested under the RIT-T consultation process.

Figure 2-1 below shows the current recommended option reduces the forecast risk monetisation profile of the Ross to Chalumbin line by approx. $80m p.a. in 2028.

Where a 'Do Nothing' scenario is adopted, the forecast level of risk associated with the asset escalates to over $160m p.a. by 2035. This is predominantly due to network risks associated with the loss of both 275kV feeders to Chalumbin Substation in the event of a failure (i.e. an n-2 event). Safety risks associated with overhead transmission line traversing roads and public tracks or trails were also considered[3].

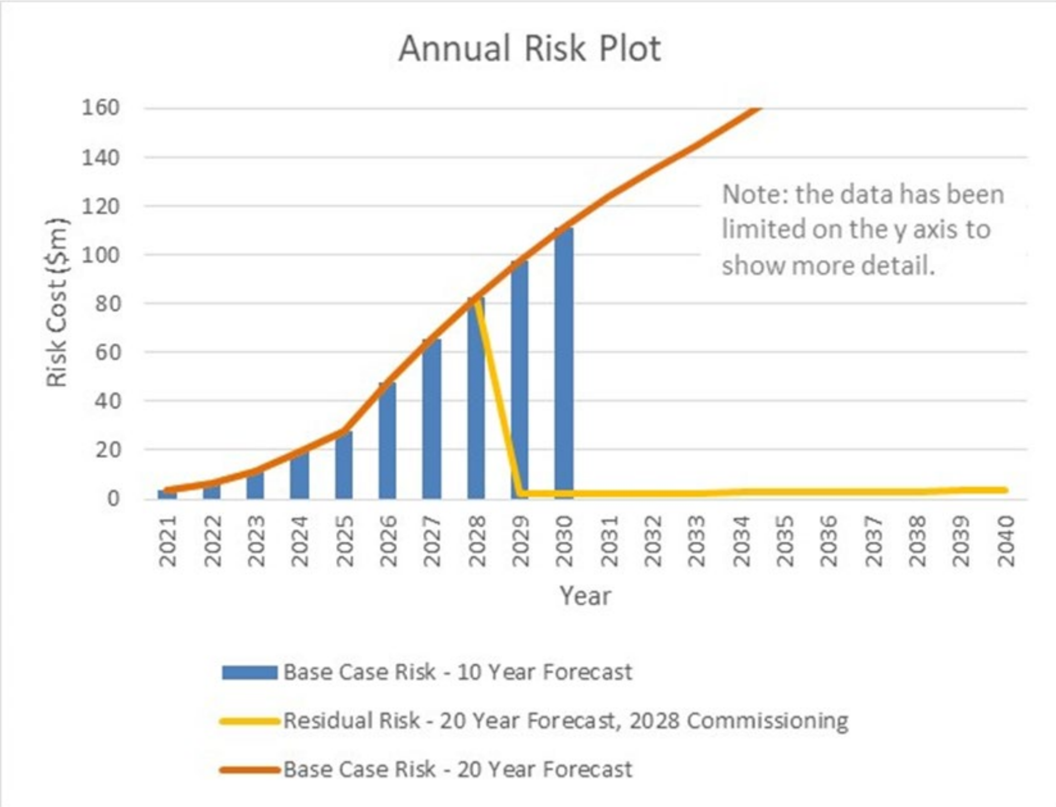


Figure 2-1 Annual Risk Monetisation Profile (Nominal)

3. Cost and Timing

The estimated cost to refit the Ross to Chalumbin 275kV line feeder is $145.6m ($2023/24 Base)[5].

Target Commissioning Date: October 2028

Note: *The target commissioning date has been extended to accommodate single circuit outage requirements for the project. In line with the CA, delay in investment is possible provided additional maintenance requirements are undertaken, and the works staged to address the most advanced condition risks.*

4. Documents in CP.02750 Project Pack

Public Documents

1. Transmission Line Condition Assessment Report Built Section 1220 Ross to Chalumbin 275kV
2. CP.02750 BS1220 Ross – Chalumbin Structure Refit – Planning Statement
3. Base Case Risk and Maintenance Costs Summary Report – CP.02750 BS1220 Ross to Chalumbin Transmission Line Reinvestment
4. Project Scope Report BS1220 Ross to Chalumbin Life Extension
5. Concept Estimate for CP.02750 – BS1220 Ross to Chalumbin Life Extension

Supporting Documents

6. Asset Reinvestment Criteria - Framework
7. Asset Management Plan 2021

Transmission Line Condition Assessment Report

Built Section 1220
Ross to Chalumbin 275kV

Record ID	A3339185	
Team	Delivery & Technical Solutions – Technology & Planning – Asset Strategies – Transmission Lines	
Authored by	Senior Lines Strategies Engineer	[redacted]
Reviewed by	Team Leader Lines Strategies	[redacted]
Approved by	Asset Strategies Manager	[redacted]

Version history

Version	Date	Section(s)	Summary of amendment	Author	Approver
1.0	25/03/2020	All	Original Document	[redacted]	[redacted]

Note: *Where indicator symbol ☼# is used (# referring to version number) it indicates a change/addition was introduced to that specific point in the document. If the indicator symbol ☼# is used in a section heading, it means the whole section was added / changed.*

IMPORTANT: - This Condition Assessment Report provides a summary of the built section condition outlined in the Report's Scope. As it is snapshot in time based upon available data and the accuracy of the prediction methodology, any estimates of remaining life are valid for 3 years only from the date of the report's approval.

1. Executive Summary

Built Section 1220 is located between Ross and Chalumbin substations. The double circuit steel lattice tower line with single sulphur conductor is very long (244km) and consists of 528 structures built in 1989. The Built Section carries 275kV feeders 857 and 858, and is a critical feeder supplying Far North Queensland. The line traverses from south of Townsville over a number of significant mountain ranges, bordering the wet tropics, with a section within Australian Defence Force land. Most of the line is very remote and access to most structures is difficult.

The line was designed and built in accordance with a lower specification than current Australian Standard prescribes; utilizing members of smaller thickness and smaller bolt diameters. However the line has been exposed to several cyclones over its more than 30 years life and has not shown any signs of serviceability problems.

The majority of the line sits in a high rainfall environment, with high average humidity. Those sections of the line that are elevated and border on the Wet Tropics exhibit higher levels of atmospheric corrosion than sections in the more protected, low lying and dryer areas.

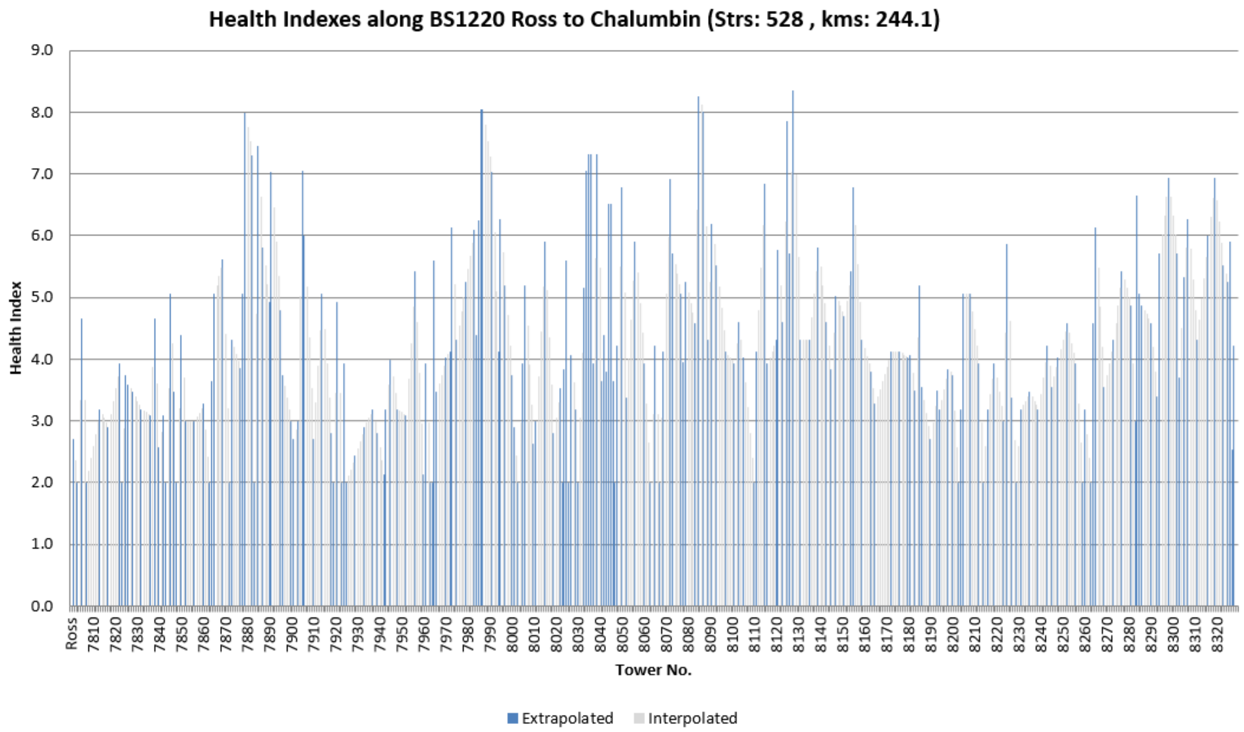
As a result, particularly in approximately six more exposed and elevated locations, galvanised tower bolts and members are exhibiting significant evidence of grade 3 and grade 4 corrosion. Between these areas of poor condition, corrosion levels vary from low to medium; relatively normal for the age of the line. Given the criticality and length of the feeders, and the difficulties of access to maintain the line in serviceable condition, it is necessary to consider when and how to maintain these structures in order to avoid reaching the point where extensive replacement of steelwork is necessary. If left untreated the maintenance costs could drive replacement of structures.

[redacted]

Figure 1: Built Section 1220 Ross- Chalumbin

Below are the health indices of structures along the built section. While structures in average condition are not of concern, structures in the more elevated and exposed locations are currently at a health Index of greater than 7 (representing a complete loss of galvanising on some members and bolts).

These values are based on the calculated health index data for the sample of structures that were inspected. The calculated values have been extrapolated from the date they were recorded to the current year. The values for towers between known (calculated) points have been interpolated to determine an estimated health index for those structures.



The highest risk on the line is related to the vertically installed and axially loaded bolts in the attachment areas of some towers.

The suspension insulator and bridging insulator assemblies are also of concern. While insulator strings are in relatively good condition, some of the insulators' originally installed hardware will require MSP attention in the next 12 months.

The worst third of the earthwire spans were replaced during the project in 2016. The remaining earthwire will need to be replaced in the next 4 years.

The phase conductors are in a serviceable condition with no work required.

Based upon the data presented in this report and health indices for 36.7% of structures, this line will require increased maintenance on the worst structures in the short term to keep it in a serviceable condition with reinvestment suggested in the medium term. A health index of 7.1 or greater was calculated for 2% of towers which equates to 25 towers on this built section, which will need to be monitored by the MSP to keep them in a serviceable condition until a project is delivered.

Predicted end of service life summary table								
Cond	EW	OPGW	Foundation Bored	Foundation Grillage	Structures (HI 8)	Bridging Strings	Suspension Strings	Tension Strings
2069	2024	2026*	2069	N/A	2021	2021	2021	2030

* - OPGW hardware only has an estimated EOL[1] in 2026. The OPGW estimated EOL is 2087.

[1] EOL End of Life

2. Purpose

This report outlines the assessed condition of Built Section 1220 which spans between Ross and Chalumbin substations. The report has been produced to assist in developing a future asset management strategy for the line.

3. Scope

The report examines the condition of the transmission line's major component groups, using field data and maintenance records based upon the asset management guidelines.

The Levels of Corrosion assigned to components are based on the corrosion/deterioration classifications used in Powerlink's Visual Inspection Guides and summarised below.

Level of Corrosion	Description
Grade 2 (G2)	Corrosion observed which should continue to be ***Monitored and Reviewed.***
Grade 3 (G3)	Corrosion which represents a loss of greater than 50% of the galvanising layer and in the worst cases unprotected carbon steel corrosion is about to commence.
Grade 4 (G4)	Corrosion which represents the total loss of galvanising and the onset of unprotected carbon steel corrosion.

4. Transmission Line Parameters

4.1 Overview

The line traverses from south of Townsville over the Hervey range, then bordering on the wet tropics areas of Paluma National Park, Girrungon National Park and Kirrama National Park reaching Koombooloomba National Park inside which Chalumbin substation is situated, about 60km from the Mission Beach coast.

Elevated sections of the line more exposed to salt laden winds appear in a more corroded condition than lower sections protected by natural shielding of terrain topography.

[redacted]

Figure 2: Geographical Overview

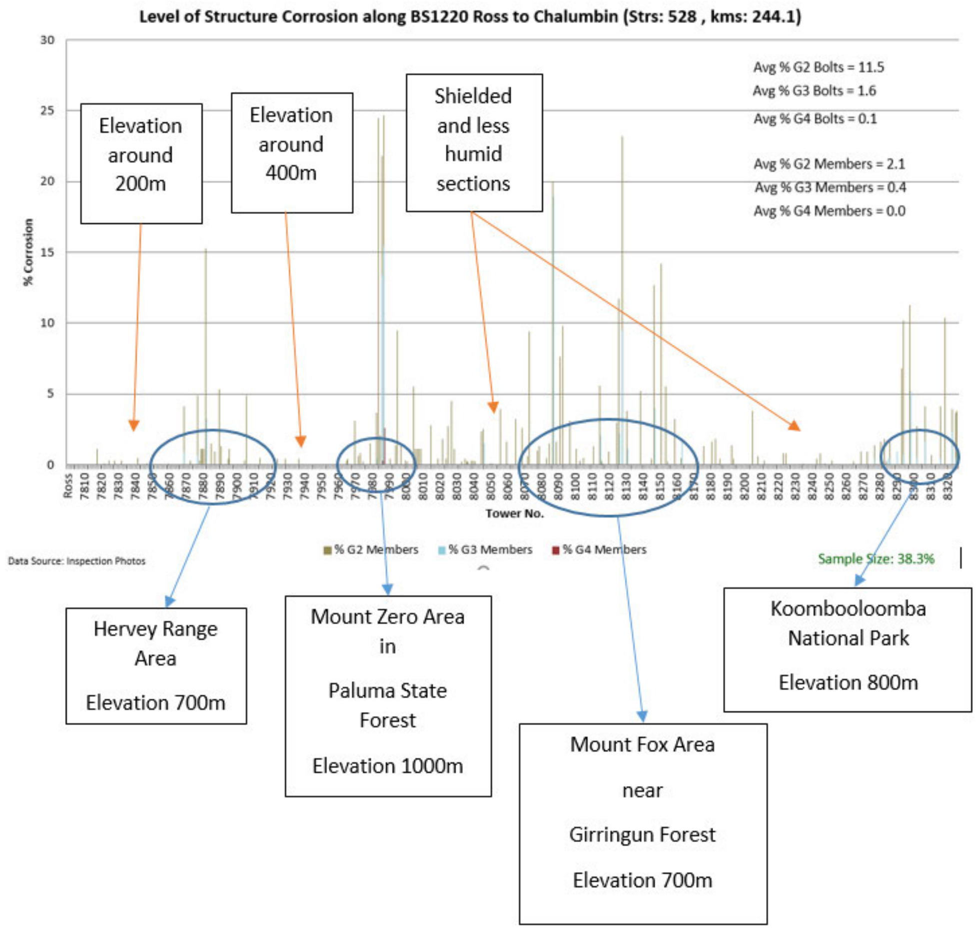


Figure 3: Line sections with towers exhibiting higher member corrosion levels

The tower geometry is double circuit as shown in the photos below.

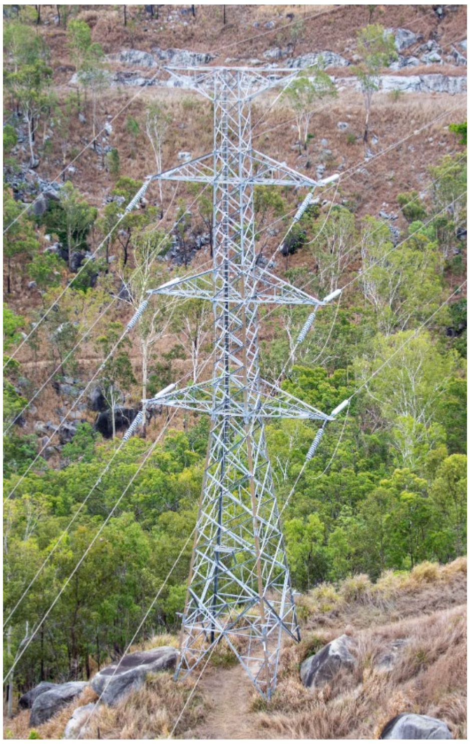


Figure 4: 1220-STR-7869 - Tension Tower

Figure 5: 1220-STR-7896 - Suspension Tower

4.2 Asset Summary Table

Commissioning Date	16.03.1989
Voltage	275kV
Contract Number	N399/87
No. of Circuits	2
Circuits	F857 (energized 1989) ; F858 (energized 1993)
Route Length (km)	244.1 km
No. of Towers	48 Tension, 480 Suspension
Type	Galvanised Steel Lattice Tower
Foundations	Standard steel reinforced concrete
Conductor	(61/3.75) AAAC/1120 Sulphur
Sub-Conductor /Phase	1
Conductor Line Clamps	Suspension - AGSU Tension – Aluminium and galvanised steel compression fittings
Conductor Vibration Dampers	Stockbridge - original
No. of OHEW	1
Earthwire	SC/GZ_7/3.25 - original; SC/AC/I_7/3.25 - repairs; Tennis 4/3/3.75 OD11.3mm - OR.02017
OHEW Line Clamps	Suspension - AGSU Tension - Preformed Deadend
OHEW Vibration Dampers	Spiral - original
No. of OPGW	1
OPGW	ALCOA_FUJI_24FIB_OPGW_11.4 (installed 2007)
OPGW Line Clamps	Suspension - AGSU Tension - Wedged Deadend
OPGW Vibration Dampers	Stockbridge
AVG Easement width	100 metres

4.2.1 Insulators

All insulators on the line were replaced since line was built and insulator strings are in good condition; however suspension and bridging insulators were replaced under the projects using live line techniques, while the original hardware remains. The insulator hardware in the areas with higher corrosiveness rates is likely to begin requiring MSP attention in the next 12 months.

Insulator Function	Strings	Material	Rating	Type	Discs	Installed
Suspension F857 (A side)	482	Porcelain	125kN	FOG	15	2002 to 2005
Suspension F858 (B side)	482	Porcelain	125kN	FOG	15	2008 to 2010
Bridging	78	Porcelain	125kN	FOG	15	2008 to 2010
Tension F857 (A side)	294	Porcelain	125kN	FOG	16	2014
Tension F858 (B side)	294	Porcelain	125kN	FOG	16	2014

5. Location and Environment

5.1 General Location

The transmission line is located in North Queensland north of Townsville in the Charters Towers and Tablelands regions. There is only one major and very few minor road crossings, meaning that line is not easily accessible along most of its length.

5.2 Atmospheric Corrosion

Built Section 1220 is located between 20km and 60km from the coast and experiences relatively high average rainfalls along the line; between 1000 and 2700 mm per annum. Humidity along the corridor is most likely directly related to its closeness to the rain forest.

The line traverses a corridor with non-homogenous corrosion conditions. The main contributors for higher corrosion levels are:

1. Tower elevation with consequent higher exposure to the salt laden winds; and
2. Proximity to the higher humidity environment of the Wet Tropics.

In contrast, towers installed in the areas with lower elevation benefit from the natural shielding from salty winds. While towers with larger distance from the Wet Tropics high humidity influence also display lower levels of corrosion deterioration. (Refer Figure 2)

The average corrosion region for the line is classed as C3, however many towers are installed in microclimatic areas consistent with C4 corrosion region characteristics.

On the single structure level; the highest rates of galvanised steel corrosion normally occur on sheltered or partially sheltered steel members, nuts, bolts and joint interfaces. Reduced exposure to cleansing rains and drying winds creates a microenvironment where the accumulation of air-borne pollutants and trapped moisture accelerates the corrosion process.

The thickness of the original coating also determines the subsequent service life of the coating as the rate of zinc loss is fairly constant for a given geographical area, although some localised variation due to structure orientation is possible.

This increased potential for corrosion based upon microclimatic conditions and coating thickness is, as a general rule, consistent with the observed condition of Powerlink's galvanised steel lattice towers, with spot rusting of major members accompanied by more advanced rusting of nuts, bolts and joint nodes.

Once the galvanised coating has been damaged or deteriorated to the point where visible corrosion is evident, the steel has effectively begun to break down (***AS/NZS 2312-2002 – Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings***). This point has been adopted as Level 2 corrosion in Powerlink's Visual Grading guide.

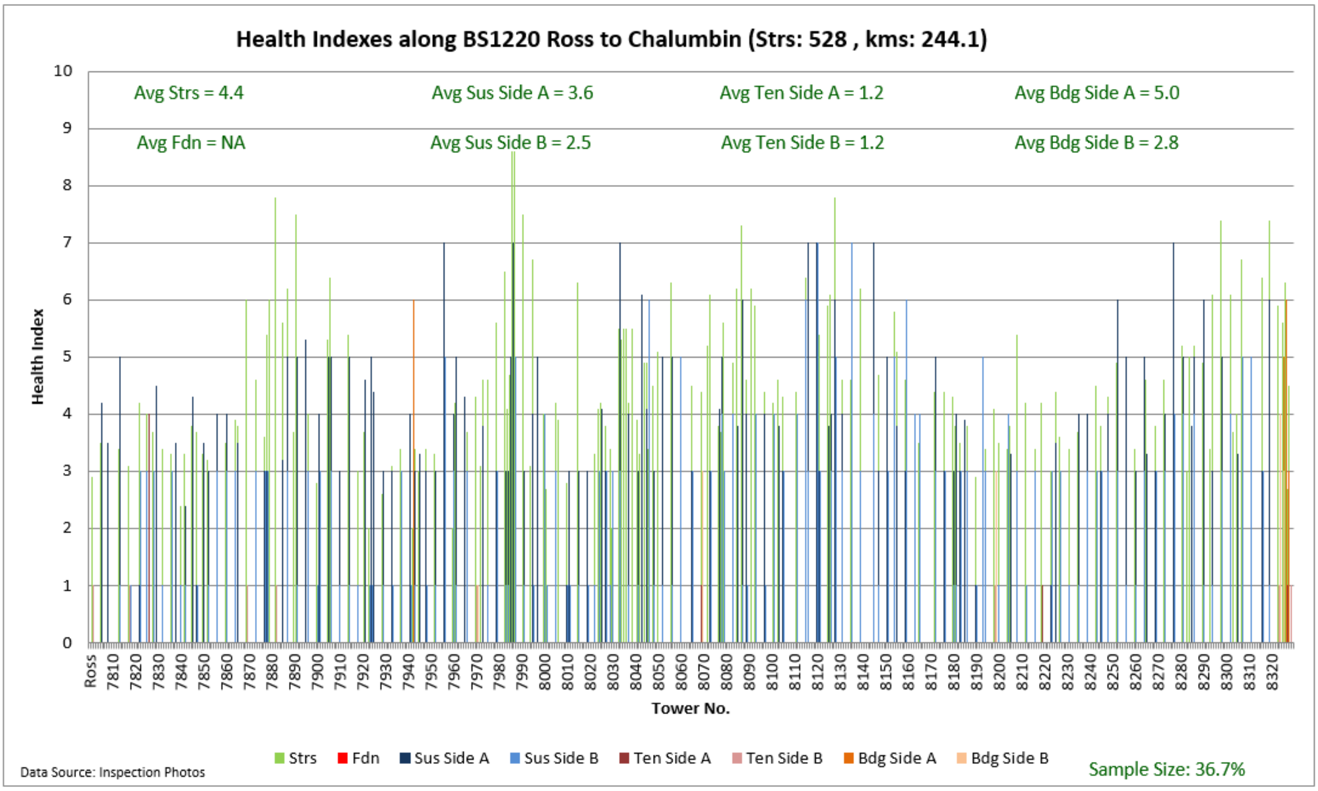
The Galvanizers' Association of Australia (refer Section 7) estimates the service life of nuts, bolts and members in this location to be as follows.

Component	Minimum coating thickness µm	Estimated life to First Service in Years *(First Appearance of Grade 2)*			
		C2	C3	C4	C5
Bolts & nuts	45	64	22	11	5
Members ≤ 6mm	70	100	33	17	8
Members > 6mm	85	121	40	20	10

The final stages of G3 Corrosion represent a total loss of galvanising and the onset of unprotected carbon steel corrosion. Rates of carbon steel corrosion can be between 10-300 times the rates of galvanised corrosion, depending upon the atmospheric conditions.

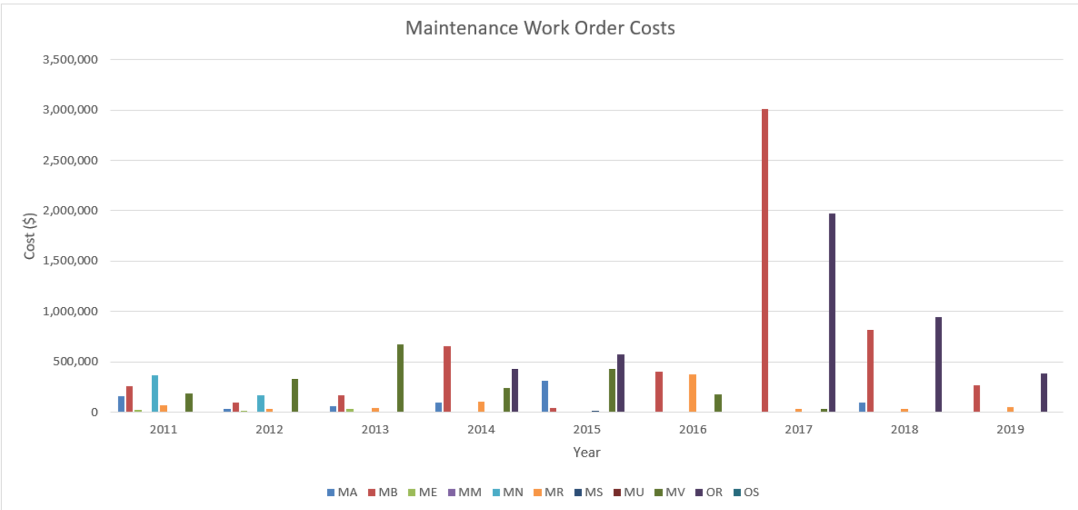
6. Condition Assessment

The condition data detailed in the below sections has been summarised in the following graph of available health indices for some major components.



Appendix 7 has two graphs of the number of notifications relating to corrosion. The notification graphs show correlation with the health indices and the percentages of corrosion.

The following work order costs show that on average $1,588 k p.a. is spent on maintenance across 528 structures.



6.1 Structure Condition

The average condition of each zone on the structure is detailed in Table 1. Based on visual assessment and past experience the estimated remaining service life has also been provided for the structure.

Average Observed Corrosion Grades are based upon Powerlink Visual Inspection Guides, as applied by field crews or to photographic evidence.

Structure Zone		Average Level of Corrosion (%)				Sample Size	Installed Year	Health Index (98%)	Estimated Years until HI of 8
Structure									
Foundations		G1	G2	G3	G4		1989	1.5	40
	Legs	99.9	0.1	0	0	43			
Structure Overall		G1	G2	G3	G4	194	1989	7.1	1
	Fasteners	86.5	11.8	1.6	0.1	195			
	Members	97.4	2.1	0.5	0	195			
Climbing Aids		G1	G2	G3	G4				
	Fasteners	81.9	17	1	0	173			
Tower Base		G1	G2	G3	G4				
	Fasteners	97.7	2.3	0	0	174			
	Members	99.2	0.7	0.1	0	174			
Tower Body		G1	G2	G3	G4				
	Fasteners	88.7	10.1	1.1	0.1	170			
	Members	98.6	1.1	0.3	0	171			
Superstructure		G1	G2	G3	G4				
	Fasteners	82.2	15	2.7	0.1	180			
	Members	97	2.4	0.6	0	180			
Cross Arms		G1	G2	G3	G4				
	Fasteners	83.3	15	1.5	0.2	183			
	Members	97.6	2.2	0.2	0	183			
Conductor Attachment Plate		G1	G2	G3	G4				
	Fasteners	82.6	14.3	2.4	0.7	175			
EW Peak		G1	G2	G3	G4	174			
	Fasteners	76.2	20.2	3.3	0.3	184			
	Members	96.2	3.4	0.4	0	184			
		Min	Max	Avg					
Structure Earthing Resistance		0	0			0			

Table 1: Average Structure Corrosion Values

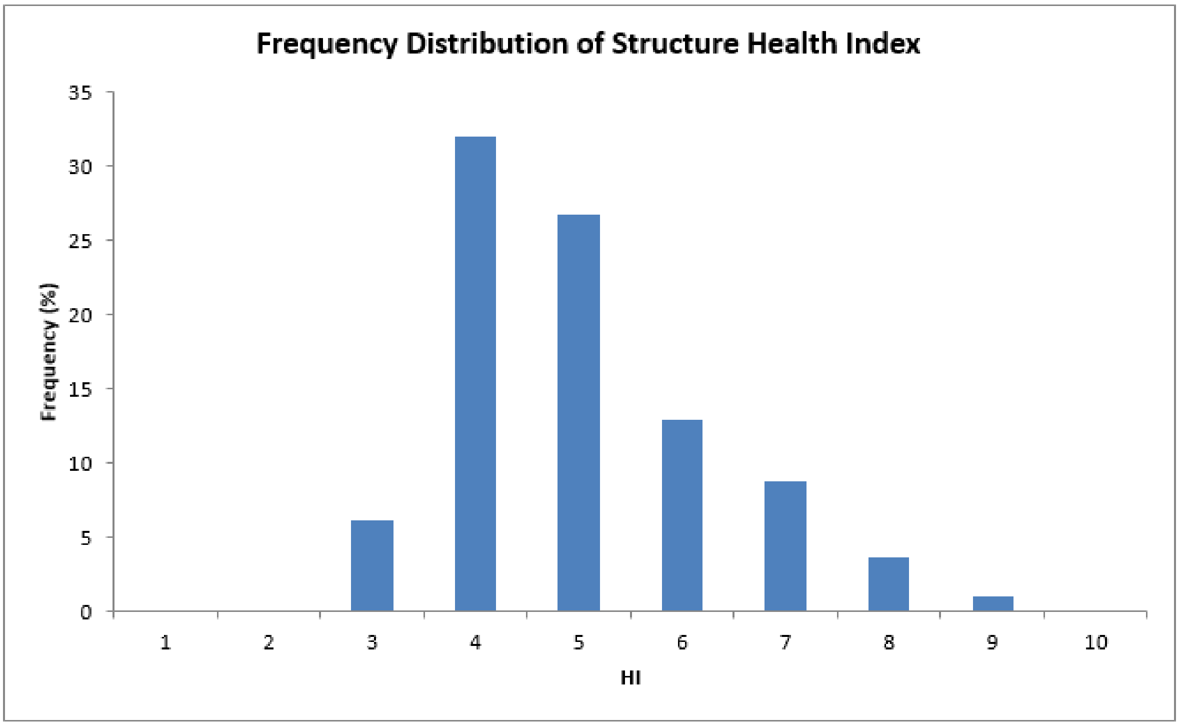
The health index is the 98th percentile value based on a normal distribution of the data sample. It is noted that the percentage which exceed this value (2%) equates to approximately 10 structures.

Based on the data presented in Table 1 the following commentary has been provided. The commentary relates to items of interest from the table and typically only represents the worst sections of the line. These notes highlight the key condition drivers that could be used to develop a project scope.

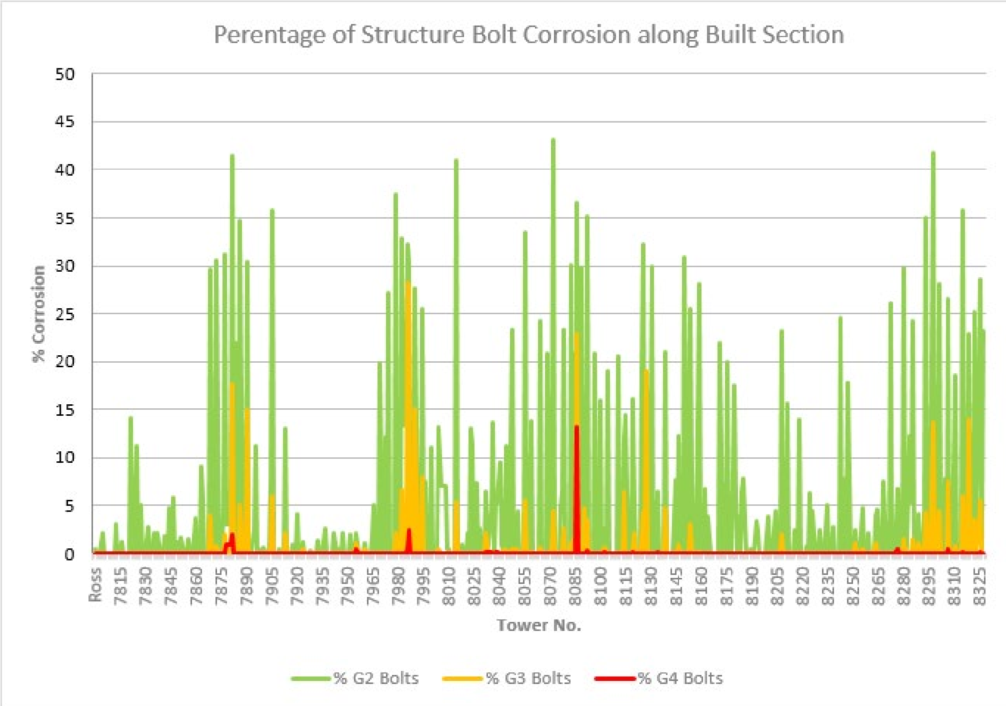
Structure Zone	Comment
Foundation	Structures utilise a standard steel reinforced concrete foundation. No foundation issues have been identified on this built section. ESL[2] is 80 years in this environment.
Climbing Aids	G2 corrosion has been observed on some step bolts and ladders however they are generally in acceptable condition. Isolated G4 corrosion is present on nuts associated with ladder attachments which should be addressed in the short term. These step bolts do not meet Powerlink current standards for climbing aids which incorporate a climbing attachment point.
Tower Base	G2 corrosion has been observed on a small percentage of nuts and bolts. Members are showing low levels of G2 with rare instances of G3 corrosion.
Tower Body	G2 and G3 corrosion has been observed on about 11% of nuts and bolts. Members are showing low levels of G2 with rare instances of G3 corrosion.
Superstructure	Close to 20% of fasteners have G2 and G3 corrosion, while rare instances of G4 bolt corrosion have been observed. A small percentage of G2 members are displaying instances of G3 corrosion.
Cross Arms	Similar condition to that of the Superstructure.
Cond. Attachment	The worst area of the tower where more than 3% of bolts have G3 and G4 corrosion.  1220-STR-7956
Earthwire Peak	Consistent with observed trend that shows more corrosion higher on the structures. Close to 25% of fasteners are at corrosion level G2 or worse. About 4% members are at corrosion level G2 or worse.
Anti-climbing Barrier	These towers are fitted with barbed wire barriers of current standard. These barriers are found to be in good condition.

[2] ESL - Estimated Service Life

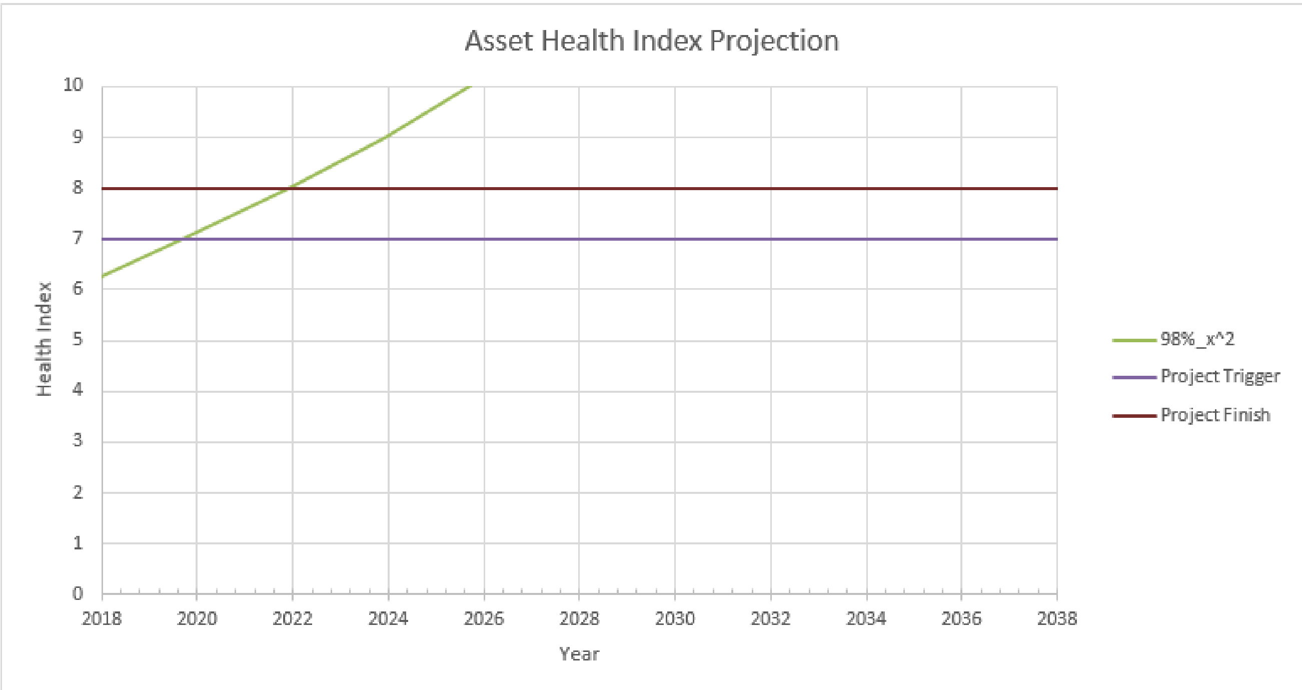
Below is the frequency distribution of structure health index based on the sample of data which can help to understand the spread of the data and determine if projects can have a staged delivery.



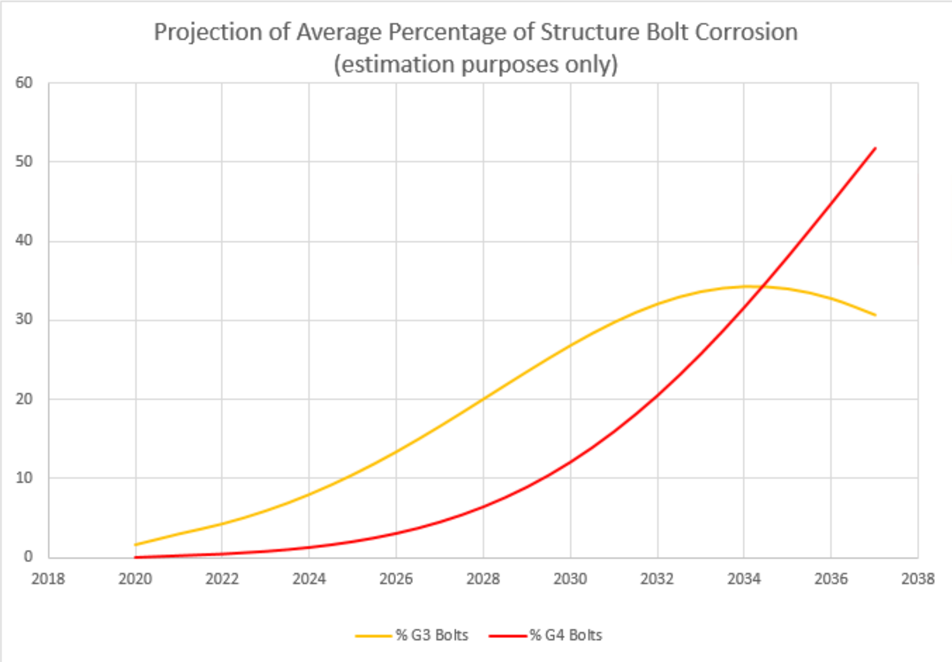
Below is the percentage corrosion of structures along the built section based on visual estimates on a sample of towers. The locations of structures with high nut, bot and member corrosion percentages along the line stands out clearly and correlates well with the SAP notifications graph (Appendix 7).



The percentages of corrosion are converted to a health index and based on statistical distribution of the results an Asset Health Index (AHI) is calculated. The following graph shows the AHI based on a threshold of 98% of towers which excludes the worst 2% of towers. The health index for the built section reflects the need to complete a project in the short term (2020-2022). However, since only a small percentage of bolts in a higher areas of towers is driving the need, a capital project could be deferred with increased maintenance or an operational refurbishment project.



To aid with estimation, the average levels of corrosion calculated. Below is the projection of average level of corrosion on the entire built section based on the sample of data.



As shown in the below table, in 2024 it is estimated that on average across the built section 8% of bolts will have reached grade 3 if no maintenance is performed. This table can be used for high level estimating.

Year	%G2 Bolts	% G3 Bolts	% G4 Bolts
2020	12	1.6	0.10
2021	38	3.0	0.32
2022	43	4.2	0.53
2023	48	5.9	0.86
2024	52	8.0	1.36
2025	55	10.5	2.10

Table 2: BS1220 Estimated Average Percentage of bolts to be replaced

6.2 Insulators and Hardware

The table below summarises the average condition of each insulator string. Based on visual assessment and experience the estimated remaining service life has also been provided.

Corrosion Grades are based upon Powerlink Visual Inspection Guides, as applied by field crews or to photographic evidence.

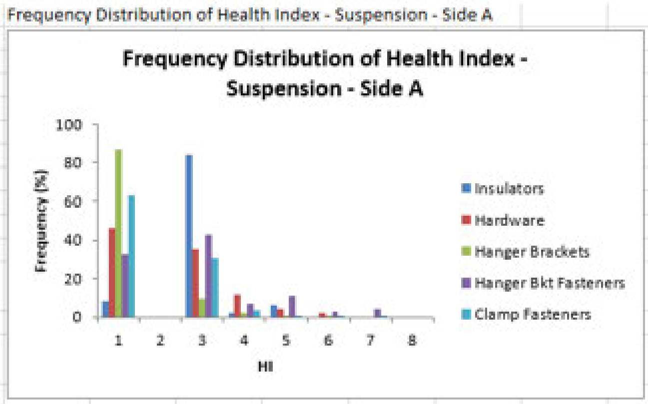
Component	Corrosion Grade / Condition (%)								Sample Size	Installed Year	Health Index (98%)	Estimated Years until HI of 8
Suspension - Side A										2002	6.5	1
Insulators	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	8	0	84	2	6	0	0	0	50			
Hardware	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	46.3	0	35.2	11.7	4.3	2.5	0	0	162			
Hanger Brackets	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	87	0	9.6	2.1	0.7	0.7	0	0	146			
Hanger Bkt Fasteners	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	32.4	0	42.8	6.9	11	2.8	4.1	0	145			
Clamp Fasteners	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	63.2	0	30.7	3.7	1.2	0.6	0.6	0	163			
Clamps	Ok	Worn Rubber	Aged									
	99.4	0	0.6						163			
Insulator Shed	OK	Polluted	Dust	Moss	Fungi	Disc-cracked	Disc-chipped					
	99.2	0	0	0	0	0	0		133			
Suspension - Side B										2002	5.6	3
Insulators	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	46.2	0	46.2	0	7.7	0	0	0	13			
Hardware	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	61.7	0	27.8	6	3	1.5	0	0	133			
Hanger Brackets	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	96.2	0	3	0	0.8	0	0	0	133			
Hanger Bkt Fasteners	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	66.9	0	23.8	3.8	3.1	0.8	1.5	0	130			
Clamp Fasteners	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	79.7	0	20.3	0	0	0	0	0	133			
Clamps	Ok	Worn Rubber	Aged									
	100	0	0						133			
Insulator Shed	OK	Polluted	Dust	Moss	Fungi	Disc-cracked	Disc-chipped					
	100	0	0	0	0	0	0		132			

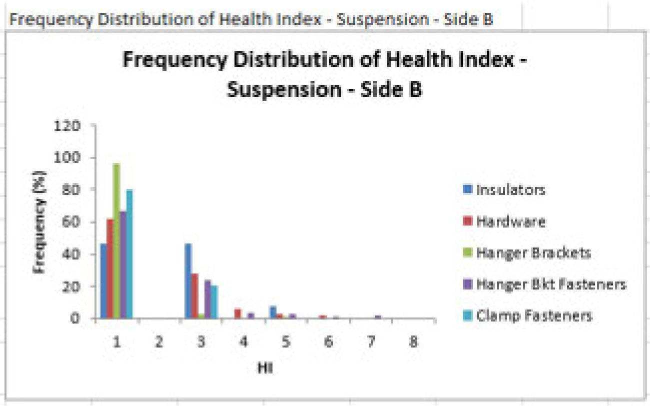
Component	Corrosion Grade / Condition (%)								Sample Size	Installed Year	Health Index (98%)	Estimated Years until HI of 8
Tension - Side A										2014	1	10
Insulators	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	92.3	7.7	0	0	0	0	0	0	13			
Hardware	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	92.3	0	0	7.7	0	0	0	0	13			
Deadend	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	100	0	0	0	0	0	0	0	13			
Insulator Shed	OK	Polluted	Dust	Moss	Fungi	Disc-cracked	Disc-chipped					
	100	0	0	0	0	0	0		12			
Tension - Side B										2014	1	10
Insulators	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	100	0	0	0	0	0	0	0	10			
Hardware	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	100	0	0	0	0	0	0	0	12			
Deadend	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	100	0	0	0	0	0	0	0	12			
Insulator Shed	OK	Polluted	Dust	Moss	Fungi	Disc-cracked	Disc-chipped					
	91.7	0	0	8.3	0	0	0		12			
Bridging - Side A										2008	6	1
Insulators	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
									0			
Hardware	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	50	0	50	0	0	0	0	0	4			
Clamp Fasteners	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	0	0	25	0	25		0	0	4			
Insulator Shed	OK	Polluted	Dust	Moss	Fungi	Disc-cracked	Disc-chipped					
	100	0	0	0	0	0	0		4			
Bridging - Side B										2008	4	4
Insulators	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
									0			
Hardware	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	20	0	60	20	0	0	0	0	5			
Clamp Fasteners	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	60	0	40	0	0	0	0	0	5			
Insulator Shed	OK	Polluted	Dust	Moss	Fungi	Disc-cracked	Disc-chipped					
	100	0	0	0	0	0	0		5			

The health index is either the maximum value or the 98% value based on a normal distribution of the data sample.

Insulator String Function	Comment
Suspension	Suspension insulators on F857 (side A) were replaced between 2002 and 2005 under project OR.00314. Suspension insulators on F858 (side B) were replaced between 2008 and 2010 under project OR.01717.  1220-STR-8043-INSSUS_B Both projects were delivered utilizing live line techniques; leaving therefore original hardware on the line. Those components are now becoming deteriorated with suspension insulators health indices in the range 5.6 to 6.5. A failure of the insulator hardware, which attaches the insulator string to the structure or connecting a conductor to the insulators will result in a conductor drop.
Tension	Tension insulators and associated hardware were replaced in 2014 under project OR.01884. All components of tension insulation assemblies are in very good condition.
Bridging	The bridging insulators appear to be in similar condition as suspension insulators; due to the presence of the original hardware their health indices are being driven to moderately high levels (up to HI6).

Below is the frequency distribution of suspension insulator health index based on the sample of data.





6.3 Conductor and Conductor Hardware

The transmission line is strung with Single AAAC/1120 Sulphur, 61/3.75 conductor**,** containing all aluminium alloy strands.

No issues have been identified with the conductor and it is estimated to last 80 years in this environment.

Component	Installation Year	Comment	Estimated Remaining Service Life (years)
Conductor	1989	No visible deterioration	49
Conductor Dampers	1989	There are 10 notification in relation to dampers. Dampers need to be replaced during next project.	4
Conductor Spacers	NA		
Conductor Mid-Span Joints	1989	No mid span joints are recorded in SAP.	

Deadend fittings are not covered under this section, refer to the tension insulator assembly condition for details on the condition of deadend fittings.

6.4 Earthwire/Optical Ground wire and Hardware

The table below summarises the average condition of each earthwire or OPGW. Based on visual assessment and past experience the estimated remaining service life has also been provided.

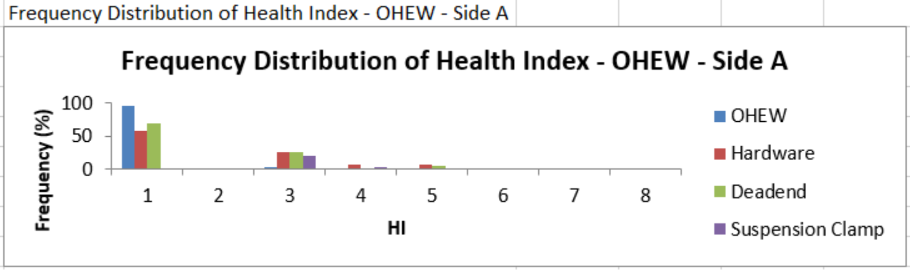
Corrosion Grades are based upon Powerlink Visual Inspection Guides, as applied by field crews or to photographic evidence.

Component	Average Level of Corrosion (%)								Sample Size	Installed Year	Health Index (98%)	Estimated Years until HI of 8
OHEW - Side A										1989/2016	5.2	4
OHEW	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	95.7	0	3.5	0	0.7	0	0	0	141			
Hardware	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	58.2	0	26.2	6.4	7.8	1.4	0	0	141			
Deadend	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	70	0	25	0	5	0	0	0	20			
Suspension Clamp	Nil	G1	G2L	G2H	G3L	G3H	G4L	G4H				
	0	0	19.7	3.9	0	1.6	0.8	0	127			

During 2015 and 2016 project OR.02017 replaced 181 spans of OHEW found to be in the worst condition (G3H and G4). An additional 21 spans of OHEW were replaced before the project under maintenance due to the damage, meaning that there are around 326 originally installed spans of the OHEW remaining on the line (around 62%).

Based on the latest visual inspection of the remaining original spans it is estimated that remaining service life of the OHEW system is 4 years.

Frequency Distribution of Health Index - OHEW - Side A



Component	Installation Date	Comment	Estimated Remaining Service Life (years)
Earthwire	1989	Low grade 3	7
Earthwire Hardware	1989	Low grade 4	4
Earthwire Dampers	1989	Some sagged dampers.	4-7

BS1220 was retrofitted with OPGW in 2007 under project CP.01313. Visual inspection found all major components of OPGW in relatively good condition. There are about 20 notifications on low G3 corrosion of the OPGW hardware; there are also around 50 notifications relating to the advanced corrosion of OPGW down lead clamps. Down lead clamps will need replacement in the very near future.

6.5 Earthing

Generally the earthing is in an acceptable condition with 15 known instances of earth strap damage or deterioration.

Resistance measurements are dating from 2015. There are 8 towers with footing earth resistances higher than 50 ohms (one of these towers [1220-STR-7910] has additional earthing installed). An additional 20 towers have earth resistance measurement in the range between 49 and 30 ohms. The remaining 95% of towers on the line have readings below 30 ohms.

Component	Installation Date	Corrosion Grade/Comment	Estimated Remaining Service Life (years)
Earthing	1989	15 instances of broken or worn earth straps.	4-8

7. Appendices

7.1 SAP Notifications Graph

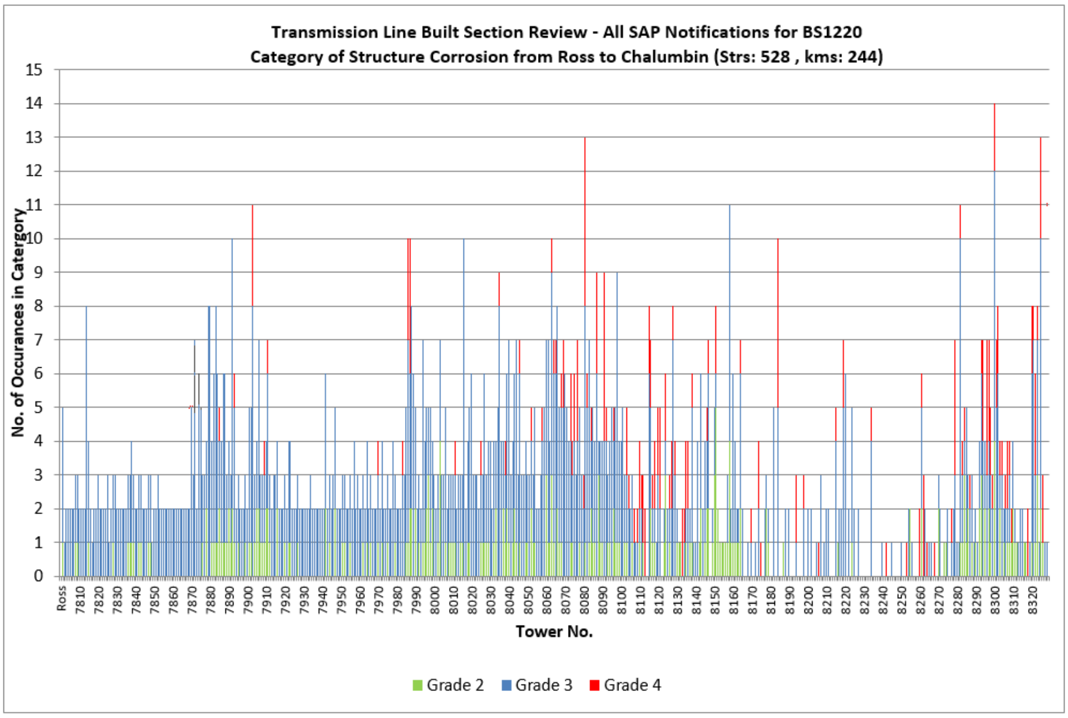


Figure 5: Graph of SAP all Notifications for Corrosion on Structures

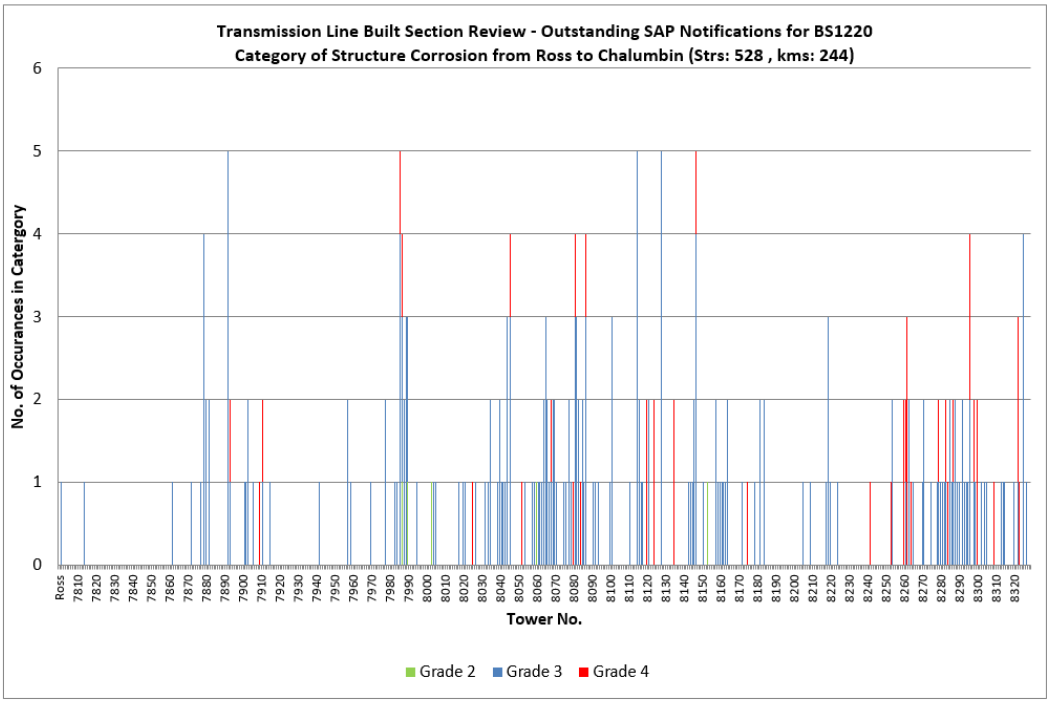
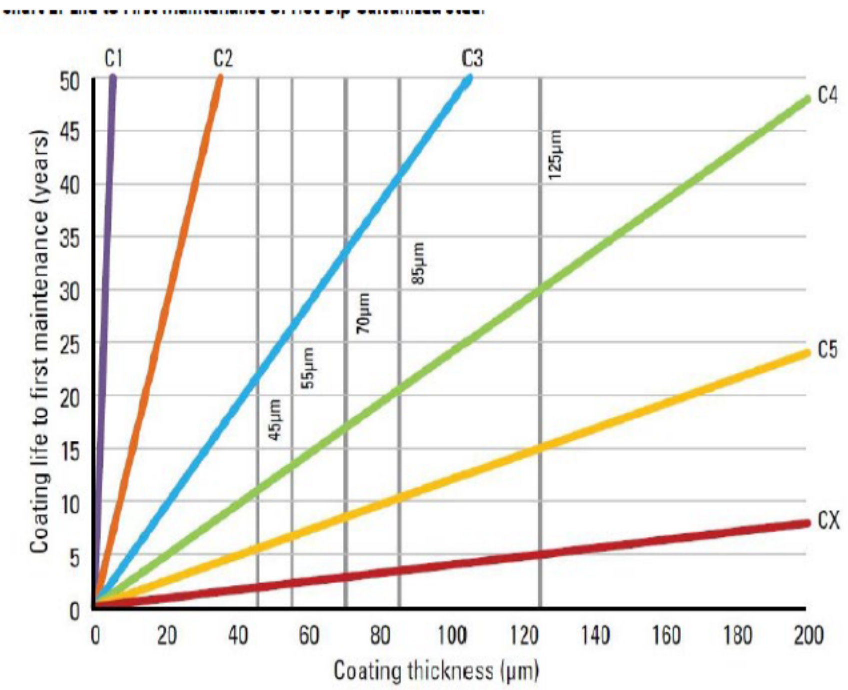


Figure 6: Graph of SAP Outstanding Notifications for Corrosion on Structures

7.2 Estimated Service Life of Galvanised Steel

Corrosivity Category	Corrosivity	Example
C2 (B)	Low	Very mild corrosion environment, such as semi-arid rural environment, with low humidity and rainfall, some rural activity, and/or minor vegetation encroachment into the easement.
C3 (C)	Medium	Mild corrosion environment, such as typical rural areas with moderate humidity and rainfall, average rural activity, and/or moderate vegetation encroachment into the easement.
C4 (D)	High	Moderate corrosion environment, such as in low density urban development or high activity rural areas, inland coastal regions, moderate to high humidity and rainfall, and/or moderate to heavy vegetation encroachment into the easement.
C5 (E)	Very High	Aggressive corrosion environment and/or close proximity to high salt coastal regions. Average Annual Rainfall may vary. Moderate to dense urbanised area with high public exposure will be included in this category.



Region	Max Rate (µm/yr)	Bolts & Nuts (45µm)		Members <= 6mm (70µm)		Members > 6mm (85µm)	
		Min Yrs	Max Yrs	Min Yrs	Max Yrs	Min Yrs	Max Yrs
C2 (B)	0.7	64	450	100	700	121	850
C3 (C)	2.1	21	64	33	100	40	121
C4 (D)	4.2	11	21	17	33	20	40
C5 (E)	8.3	5	11	8	17	10	20

Figure 7 - Life to First Maintenance of Galvanised Steel – Galvanisers Association of Australia

7.3 Estimated Service Life of Carbon Steel

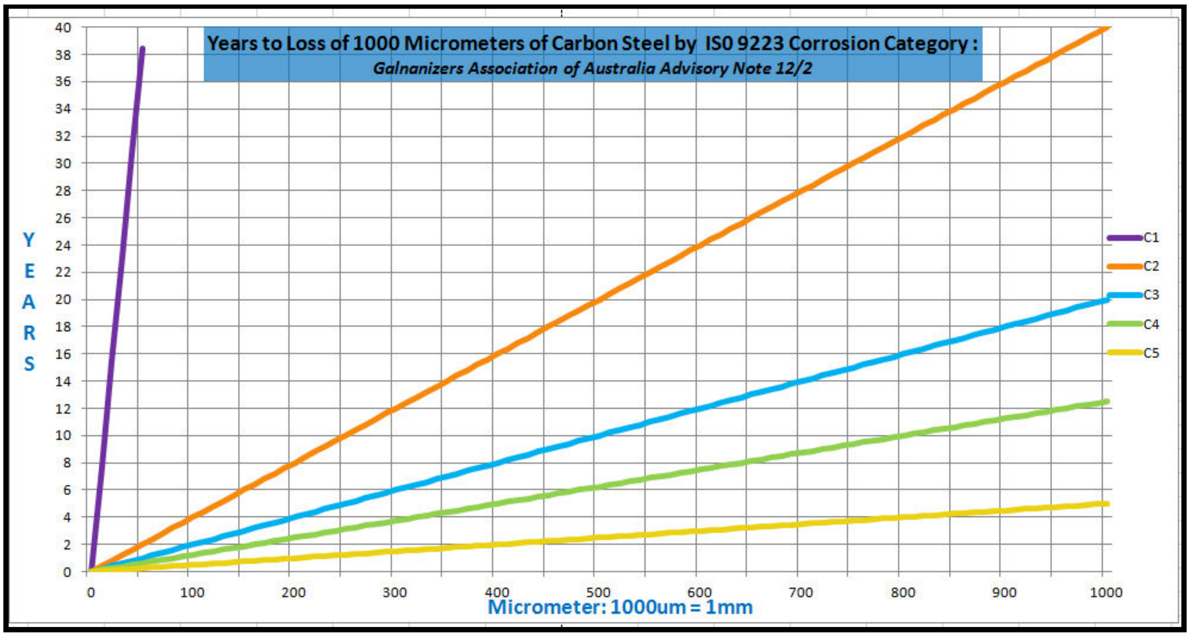


Figure 8 - Rate of Carbon Steel Loss

Source: Extrapolated from Table 2: Corrosion Rates for Steel and Zinc for the first year of exposure for different corrosivity categories. Galvanizers Association of Australia – Advisory Note GEN12/2 April 2012

7.4 References

Inspection Guides and Corrosion Models

- A2628257 Asset Strategies – Line Maintenance Principles – Specification
- A2791823 OSD – Transmission Line Patrol and Inspection – Guideline
- Galvanizers Association of Australia – Advisory Note GEN12/2 *"Atmospheric Corrosion Resistance of Hot Dipped Galvanized Coatings"* April 2012.
- AS/NZS 2312-2002 – Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

Built Section Configuration

- SAP Reports

Condition Assessment Data

- M Drive Photos
- SAP IK17 Measurement Documents
- Notifications and Work Orders

Planning Statement		22/04/2020
Title	CP.02750 BS1220 Ross – Chalumbin Structure Refit – Planning Statement [1]	
Zone	Far North Queensland	
Need Driver	Condition assessment of the transmission line recommending selective refit by December 2027 to ensure ongoing compliance with Electricity Act, Electrical Safety Act and Electricity Safety Regulation obligations.	
Network Limitation	The Ross to Chalumbin Transmission Line is required to meet Powerlink Queensland's N-1-50MW/600MWh reliability obligations in Far North Queensland	
Pre-requisites	None	

Executive Summary

Feeders 857 and 858 on BS1220 form part of the North Queensland transmission backbone and facilitate power flow from Central and Northern Queensland to Far North Queensland and, increasingly, in the opposite direction following the commissioning of several renewable generation in the area. The line was energized in 1989 with only the eastern feeder (857) strung. The opposite side, feeder 858 was strung and energized 4 years later in 1993.

Energy Queensland forecasts have revealed there is an enduring need to maintain electricity supply into Far North Queensland

A 2020 assessment of the line revealed a number of emerging safety and network risks arising from the condition of the ageing asset. Removal of the Ross to Chalumbin 275kV transmission line to address the emerging condition risks would result in Powerlink breaching its N-1-50MW/600MWh reliability obligations.

Grid Planning have assessed several options to address the network risks arising from the ageing asset and has recommended maintaining the existing topology of feeders 857 and 858 as the most effective solution to meeting Powerlink's jurisdictional and Rules obligations.

Replacement of selected structural members, attachment hardware, climbing step bolts, overhead earth wires, and the repainting of selected structures by 2027 will ensure ongoing compliance with Powerlink's Electricity Act, Electrical Safety Act and Electricity Safety Regulation obligations

[1] *This report contains confidential information, which is the property of Powerlink, and the Registered Participant mentioned in the report, and has commercial value. It qualifies as Confidential Information under the National Electricity Rules (NER). The NER provides that Confidential Information:*

- *must not be disclosed to any person except as permitted by the NER;*
- *must only be used or copied for the purpose intended in this report;*
- *must not bade available to unauthorised persons*

Contents

1. Introduction

The 244km transmission line built section BS 1220 and its associated feeders 857 and 858 between Ross and Chalumbin substations is built through the rugged terrain of the North Queensland tropical rain forest, traversing environmentally sensitive and protected areas, regional roads and rivers. A geographical map is shown below:

[redacted]

Figure 1: Geographical Map of feeders 857 & 858

From Chalumbin Substation, feeders 876 and 877 are 275kV transmission lines extending 136 km north-east to the main injection point for Far North Queensland, Woree Substation within the city of Cairns. Feeder 876 is the point of connection for Mt. Emerald Wind Farm (180 MW) which connects to Powerlink's Walkamin Substation along feeder 876.

The network single line diagram is shown below with both the 275kV and 132kV network between the Townsville and Cairns region.

[redacted]

Figure 2: Single Line Diagram of FNQ Region

A 2020 condition appraisal of the line has revealed several structures are reaching the end of life and recommends that action is taken to address the network and safety risks arising from the condition of these ageing assets.

This report assesses the impact that removal of the ageing line would have on the performance of the network and Powerlink's statutory obligations. It also establishes the indicative requirements of any potential alternative solutions to the current services supported by the line.

2. Load Forecast and Historical Demand

The load forecast used as the basis for these studies is as provided in the 2019 TAPR, and includes forecasts of Energy Queensland and Powerlink's Transmission Connected customers.

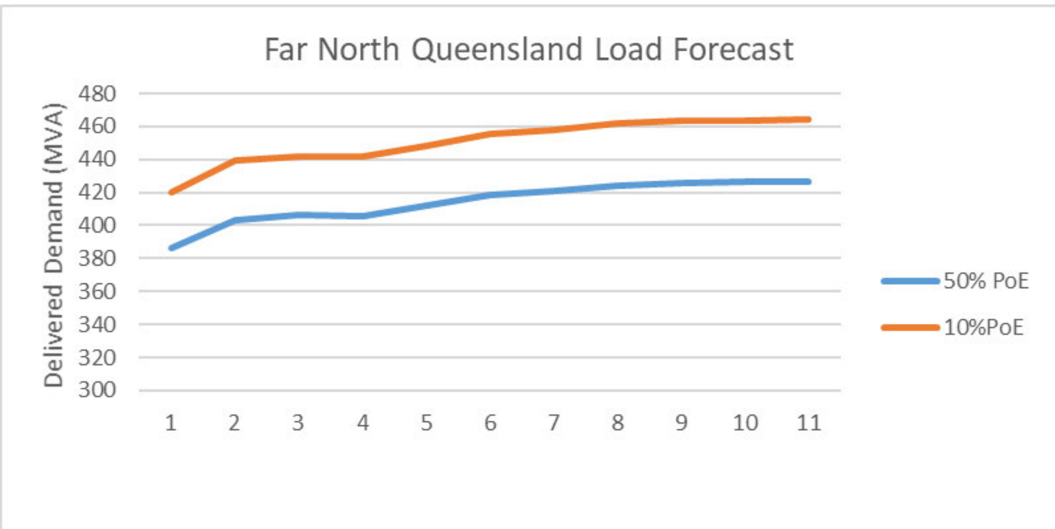


Figure 3: Total FNQ Forecasted Loading

As well as the forecast, the Load duration curves given below shows the historical peak demand in relation to the average demand for the Far North region on a yearly basis:

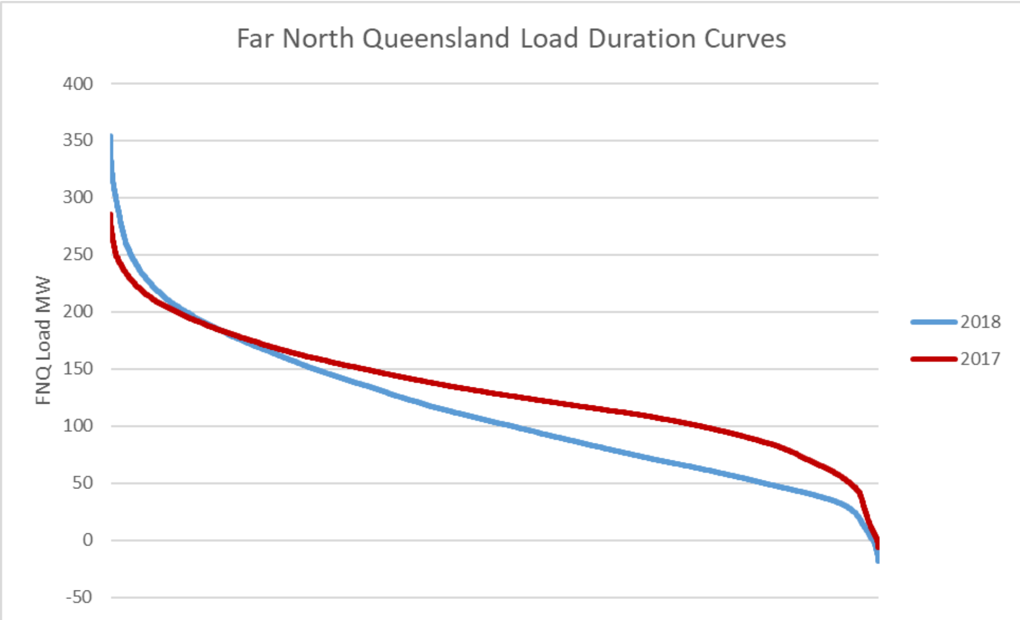


Figure 4: Historical Load Duration Curves for FNQ

3. Statement of Investment Need

Energy Queensland forecasts have revealed there is an enduring need to maintain electricity supply into Far North Queensland.

The removal of the Ross to Chalumbin transmission line to address emerging condition-based safety issues would have a major impact on loads in the area and violate Powerlink's N-1-50MW/600MWh reliability obligations.

Powerlink must therefore preserve the functionality of the Ross to Chalumbin Transmission Line to ensure ongoing compliance with its Transmission Authority reliability obligations for the supply of electricity.

4. Network Risk

4.1 Asset End of Life Considerations

From the condition assessment for BS 1220, based upon the photographic evidence, SAP Notifications and SAP Measurement Documents, the estimated remaining service life for Built Section 1220, without any refurbishment, life extension or increased maintenance is shown in the following table.

Table 1: Predicted BS EOL by component

Predicted EOL of Components*													
Cond	Hardware	Dampers	Spacers	EW	OPGW	Earthing	Fdn.Bored	Fdn.Kpt	Structure	Ins.Bdg.Disc	Ins.Susp.I.Disc	Ins.Susp.V.Disc	Ins.Ten.Disc
2069	2022	2027	N/A	2021	2087	2019	2069	2029	2019^	2033	2027	N/A	2046

The predicted condition based end-of-life for the feeders themselves is shown in Table 2 below.

Table 2: Feeder End of Life

Feeder	Length (Total)	Predicted End of Life
BS 1220 – 857 - Ross – Chalumbin	244km	2025
BS 1220 – 858 - Ross - Chalumbin	244km	2026

This shows that some form of refurbishment is required on BS1220 in order to maintain network supply.

4.2 System strength shortfalls in Far North Queensland

Far North Queensland has been experiencing unprecedented interest in connecting asynchronous generation in the past 3 years, and these trends are likely to continue. Apart from the local hydro power stations, this region is quite remote from conventional synchronous generation. Adverse system strength impacts may be caused by the aggregation of multiple electrically close asynchronous generating units. The National Electricity Amendment (Managing Power System Fault Levels) Rule 2017 No.10 created a framework in the National Electricity Rules for the management of system strength in the National Electricity Market. Powerlink is obliged to perform initial system-strength impact assessments for connecting asynchronous plant using the *Available Fault Level* methodology from this document.

Currently there is one asynchronous plant connected to Powerlink's network in the FNQ area (Mt. Emerald Wind Farm). [redacted]

In addition, detailed electromagnetic–type analysis of the Far North Queensland network shows that system strength is likely to be a limitation for new asynchronous generators wishing to connect in FNQ even for single credible contingency events. As a result, it is likely that new asynchronous generators wishing to connect in FNQ will need to address a system strength gap. The AEMC's 'Managing Power System Fault Levels' rule change places an obligation on new asynchronous generators to 'do no harm' to the security of the power system. Under this new obligation, new asynchronous generators must not cause any adverse impacts on the ability of the power system to maintain system stability or on a nearby generating system to maintain stable operation, in accordance with AEMO's system strength, impact assessment guidelines. This is likely to require the new asynchronous generator to make additional investment in a system strength remediation (e.g. synchronous condenser).

4.3 Existing network capability

In the current configuration, there are two double-circuit supplies to the Far North; the inland 275kV backbone and the coastal 132kV circuits. The coastal 132kV network between Ross and Woree cannot support the peak loading in the Far North in both intact and N-1 scenarios without the support of the 275kV backbone due to voltage instability as a result trying to supply the Far North with the 132kV coastal circuits. From previous simulations and studies undertaken by Powerlink, it was found that the 132kV network is only able to support up to 200MW in the Far North before protection will operate due to voltage collapse.

Currently the Ross-Chalumbin 275kV double circuit line is classified as a 'proven contingency' under AEMO's Power System Security Guidelines, which means that this double circuit outage will be declared a credible contingency event during lightning storms. Due to this, Powerlink's Network Operations team often split the 132kV network north of Tully when there are storms and when the load north of Tully exceeds 200MW. This practice has led to a load shed of the entire Far North region on separate occasions but has prevented cascading instability from affecting the rest of the Powerlink network.

[redacted]

4.4 Losses on the network

The existing conductors on BS 1220 are single sulphur energised at 275kV. Feeders 857 and 858 are long feeders and as such, the losses associated with these feeders play an important impact on the network in North Queensland. Planning has engaged with Transmission Line Design on resistive and corona losses on the network currently and what they would be after any reinvestment. The results for a single sulphur, twin-phosphorus conductor, and a twin sulphur conductor were investigated and the results are shown below:

Table 3: Conductor Loss Calculations for Feeders 857 & 858

Configuration	Voltage	SVG (kV/cm)	Design Target SVG	Ohmic Loss (kw/km)	Long Line Corona Loss (kW/cm)	Audible Noise (dBA)	Total Losses over line length (MW)
Single Sulphur	275	17.7	16	144	14	48	**38.6**
Twin Phosphorus	275	15.6		112	5	34	**28.5**
Twin Sulphur	275	13.5		69	4	30	**17.8**

These results show that currently both the resistive and corona losses associated with the existing feeders are greater than a twin phosphorus alternative. Over the length of the entire feeder, the single sulphur conductors are currently experiencing approximately 38.6 MW of both resistive loses and corona losses. Should this conductor be replaced with a higher rated twin phosphorus conductor, the losses would reduce to 28.5 MW of resistive and corona loses. The losses are further reduced to approximately 17.8 MW by uprating the feeders to twin sulphur configuration.

Purely on network optimisation, the reduction of losses and the increased capacity means that a twin phosphorus solution is the better network outcome, with the best being a twin-sulphur conductor. This data has also shown that the existing feeder actually exceeds the surface gradient voltage (SVG) design standard employed by Powerlink. According to Transmission Line Design, an uprate to at least a twin phosphorus conductor should be used for feeders 857 and 858. Both of the twin conductor options would however require the line to be rebuilt with new structures.

4.5 Unserved Energy

When calculating the risk cost of the loss of BS 1220 the following assumptions were made in order to quantify the load at risk for such an event in the existing network. They are as follows:

- The loss of BS 1220 (due to tower collapse) would take 5 days (120 hours) to rectify due to the complex terrain that the feeders traverse and the temporary tower requirements
- The 132kV network is only capable of supporting in the region of a *maximum* of 200 MW in the Far North, for firm supply of the far north after a loss of BS 1220, the operators will require a safety margin on the supportable load. As such, it is assumed that load in the Far North would be constrained to 170 MW.
- If the load is above 170 MW when BS 1220 is lost, the entire Far North load will be tripped and operators will take 1 hour to restore to 170 MW.
- The risk of tower collapse increases *dramatically* in the summer months (storm season). As such, the risk cost was evaluated only in the summer months when the risk is greater.
- The value of customer reliability was set at the Queensland average consumer value of $39,500 / MWh.

Given the above set of assumptions, the following risk costs were calculated for loss of BS 1220 (Feeders 857 and 858).

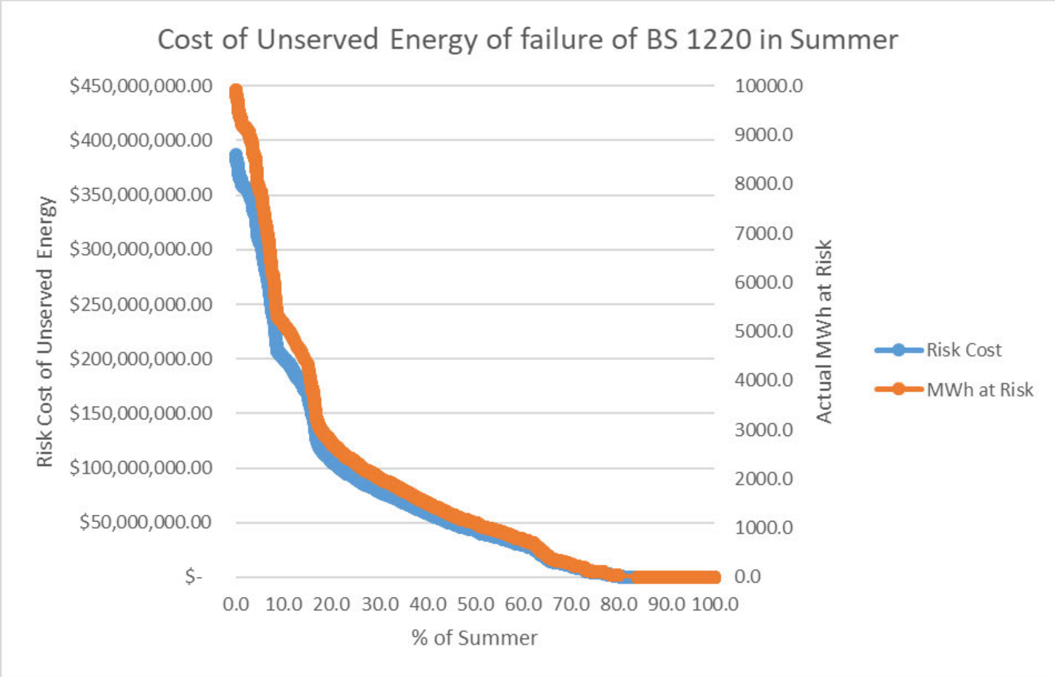


Figure 5: Risk Cost of Unserved Energy for FNQ during summer

This shows the total risk costs of an outage resulting in the Far North load being constrained to 170MW in summer. From the graph, it can be shown the *maximum* risk cost is in excess of $350 million dollars with approximately 9900 MWh at risk, however, this is only for 3% of the summer. The *average* risk cost of a loss of BS 1220 in summer is approximately **$72.6 million** with roughly **1860 MW** at risk**.**

4.6 Access to outages

Currently, any outage affecting the 275kV into Far North Queensland must be planned in the winter season to limit risk of unserved energy. Under a contingency post outage (N-1-1) scenario of the Ross-Chalumbin lines there is unserved energy of approximately 200 000 MWh per year. The load in the Far North is *below* the 200MW threshold almost 90% of the year, generally from the months of March until October (see Load Duration Curves above). This means that ultimately outages are possible during the winter and shoulder periods, in terms of supplying load. However, in terms of access to market for generation, due to the Special Protection Scheme outlined above, under N-1-1 of the Ross-Chalumbin lines, any generation in the Far North will be constrained to zero MW and this may incur M.I.T.C penalties for Powerlink.

5. Non Network Options

As outlined above, there is an enduring need to supply the Far North now and into the future. However, there is an opportunity to address the security and reliability limitations associated with the removal of BS 1220 with a Non-network solution. In this scenario, BS 1220 would be allowed to reach the end of life without a regulated reinvestment in place. Network Support will require regulatory consultation and would have to take the form of firm generation somewhere in the far north, ideally at Chalumbin or Woree. As well as the regulated requirements, there would also be a requirement to lift the system strength shortfalls that occur because of the decommissioning of BS 1220 and associated feeders 857 and 858. These requirements are detailed below.

5.1 System normal

Under a possible future system normal scenario, without feeders 857 and 858, any generation would require day and night injection in the Far North, of up to $300MW_{peak}$/2400 MWh (along with voltage support in the order of ~150 MVAR). In order to ensure compliance with Powerlink's Transmission Authority a large portion of this would need to be operating pre-contingent such that for any N-1 scenario the system is able to land satisfactory.

In addition, any non-network solution would be required to restore the lost synchronous fault level (system strength) in the area because of the decommissioning of BS 1220. Thus, it should be able to rectify the reduction of 520 MVA of *synchronous fault level* at a node in the Far North (e.g. H032 Chalumbin) which is roughly equivalent to 215 MVA of *Available Fault Level*.

5.2 Uprate Coastal 132kV and network support

An alternative solution would have the coastal circuit uprated to 275kV as explained above with a non-network solution to support the load in the Far North. If BS 1220 was decommissioned at end of life, and there was a single 275kV feeder, the non-network solution would be require day and night injection in the Far North of up to 260 MW_{peak}/ 2080 MWh (along with voltage support of roughly 140 MVAR). In order to ensure compliance with Powerlink's Transmission Authority a large portion of this would need to be operating pre-contingent such that for any N-1 scenario the system is able to land satisfactory.

In this scenario, the non-network solution would also be required to restore the synchronous fault level to rectify the loss of 380 MVA as a result of the decommissioning of Ross-Chalumbin feeders.

5.3 Access to outages

Even with 260 / $300MW_{peak}$ of firm and dispatchable generation in the Far North, outages would be limited to the winter and shoulder periods such that the system remains secure. With 260 / 300MW of generation, the access to outages would be essentially identical to the current access to outages available to Powerlink in the current network.

6. Network Options

Grid Planning has investigated several different network reinvestment options to address the continuing network need as outlined below.

6.1 Preferred Option – Maintain line topology

In this scenario, the BS1220 would be preserved in its current configuration as a double circuit single conductor transmission line.

Consideration may be given to uprating from a single sulphur conductor, to a twin phosphorus conductor. This uprate not only ensures Powerlink is complying with its current transmission line design standards, but also reduces the losses associated with the feeders in the network. A twin phosphorous line will also allow Powerlink to support more power to flow to and from the Far North into the wider network as well as lift the fault levels via a reduction in network impedance, which will increase system strength in the Far North.

6.2 Options Considered but not proposed

This section discusses alternative options that Powerlink has investigated but does not consider technically and/or economically feasible to address the above identified issues, and thus are not considered credible options.

6.2.1 Do Nothing

"Do Nothing" would not be an acceptable option as the primary driver (transmission line condition) and associated safety, reliability and compliance risks would not be resolved. Furthermore, the "Do Nothing" option would not be consistent with good industry practice and would result in Powerlink breaching their obligations with the requirements of the System Standards of the National Electricity Rules and its Transmission Authority.

6.2.2 Uprate Coastal Route to 275kV

In this scenario, the existing topology would be retained, however, the coastal circuits are unique in that one of the circuits is strung as a twin phosphorus conductor and is rated at 275kV, but energised at 132kV. As such, this circuit would be lifted to 275kV in order to access the benefits that having 3x 275kV circuits into the Far North would unlock.

6.2.2.1 System Normal Supportable Load

With the coastal circuit at 275kV, the Far North would no longer be susceptible to losing the entire Far North when the loss of both Ross-Chalumbin feeders becomes a classified contingency. In this scenario, the 275kV and 132kV coastal circuit is able to support the entire Far North on its own (lands satisfactory). A voltage stability study was conducted to determine the increase to supportable load that would result from uplifting one of the coastal circuits to 275kV.

The following QV curve was conducted with the existing network intact and with the most onerous single contingency, which is the loss of a single Ross-Chalumbin circuit:

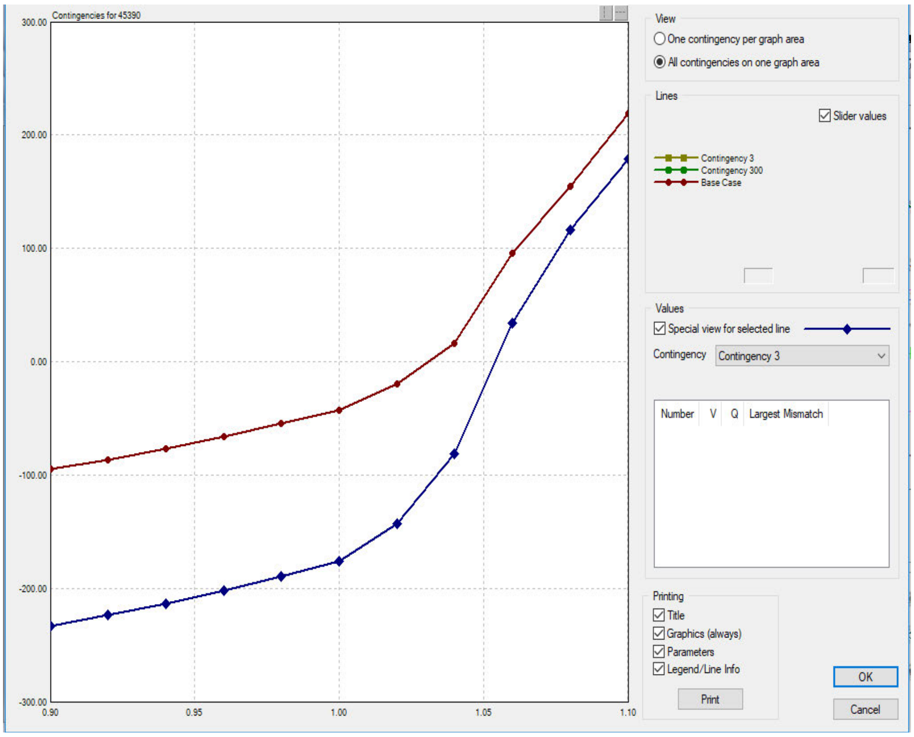


Figure 6: QV curves for the existing system

This QV demonstrates that in the existing network, under a N-1 scenario the system is able to support roughly up to an additional 100 MVA load before the system suffers from voltage instability.

If the coastal circuit was uplifted to 275kV, the following QV curve would demonstrate the stability of the new network:

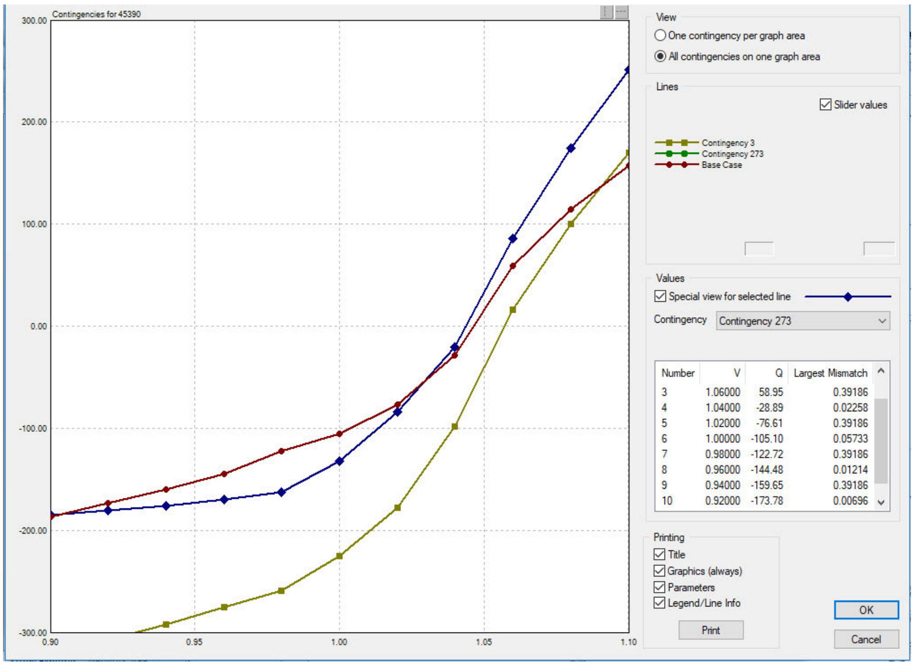


Figure 7: QV Curves for a coastal 275kV system

The above QV curve shows that uplifting the coastal circuit to 275kV will unlock the benefits of a further to 100MVA of N-1 additional load that could be connected.

6.2.2.2 System normal – system strength

Despite these advantages, the main driver of such a network augmentation would be to unlock an extremely cost effective method of increasing the system strength in the area.

Far North Queensland has been experiencing unprecedented interest in connecting asynchronous generation in the past 3 years, and these trends are likely to continue. Due to the large amount of committed and proposed asynchronous generation in the area, an investment to increase the system strength may be prudent.

The following table represents the increase in system strength as a function of Fault Level at H032 Chalumbin and the possible generator capacity because of this network

Table 4: Fault Levels at H032 Chalumbin in different network topologies

Network	Min. Fault Level (N-1)
Current Network	197 MVA
Coastal 275kV	336 MVA
Increase:	+139 MVA

Thus, the overall benefit of uplifting the coastal circuit not only provides additional system stability, but also the uplift of fault level by ~139 MVA which will facilitate a much more stable system in the Far North.

6.2.2.3 System normal – network losses

Additional advantage of uplifting the coastal circuit from 132kV to 275kV would be the large reduction in network losses. The following detail shows the difference in expected network losses in both configurations of the coastal circuit:

Table 5: Conductor Loss Calculations for coastal 275kV vs 132kV

Configuration	Voltage	SVG (kV/cm)	Design Target SVG	Ohmic Loss (kw/km)	Long Line Corona Loss (kW/cm)	Audible Noise (dBA)	Total Losses over line length (MW)
Twin Phosphorus	275	15.6	16	112	5	34	**44.3**
Twin Phosphorus	132	7.5		264	~0	~0	**100.1**

The table shows that currently, the network is subject to over 100MW of losses over the length of the feeder from Yabulu South in the Townsville region to Woree in the Cairns Region. However, if this line was lifted to its current design voltage of 275kV, the losses would decrease dramatically to approximately 44 MW.

6.2.2.4 Access to outages

The following table shows a selection of critical outages and contingencies, which can lead to a risk of unserved energy. It shows a system security comparison between the existing network and a potential 275kV network:

Table 6: Network Security after loss of BS1220 feeders for different network configurations

Network Configuration:	Outage	Additional Contingency	Period	System Secure?
Existing	857	858	Winter	Yes
	857	858	Shoulder	82% of time
	857	858	Summer	61% of time
275kV Coastal Circuit	857	858	Winter	Yes
	857	858	Shoulder	Yes
	857	858	Summer	Yes

The above table shows that Powerlink is able to maintain a secure operating network for critical outages along the 275kV backbone (i.e. BS 1220) for all parts of the year if the coastal circuit was lifted to 275kV, the potential unserved energy from a loss of this built section during high loading is also reduced to $0.

Lifting the coastal circuit from 132kV to 275kV from Yabulu South to Woree should be seriously considered as a long term plan for 'powering Far North Queensland'. The additional system security, flexibility and system strength this provides whilst significantly reducing losses and opening up additional non-regulated renewable generation connection should outweigh the capital expenditure involved in lifting the voltage.

7. Option summary and recommendations

Recent investigations have highlighted concerns about the condition of Built Section 1220 and associated feeders 857 and 858 a double circuit 275kV transmission line from Ross to Chalumbin substations. In this report, it has been demonstrated there is an enduring network need to supply the Far North and the alternative supply to this region via the coastal 132kV circuit is not able to support this load without network support of some description.

Planning studies have investigated several alternative options, but they are not considered at this stage to be credible options from a technical or economic point of view. However, any non-network proposals are welcome and will be assessed during the RIT-T consultation process.

Planning has identified the most prudent network investment to address the need arising from approaching end of life of this built section is to maintain the functionality of the existing asset and network topology. As part of the reinvestment, consideration may be given to uprating the circuits from a single sulphur to twin phosphorus conductor to meet Powerlink's current transmission line designs as well as reduce transmission losses and facilitate an increase in system strength through increased fault levels in Far North Queensland.

It should be noted that this solution is still susceptible to the classified contingency of the loss of both Ross – Chalumbin feeders, which means there is still the possibility of load shedding the entire Far North during the storm season.

In addition, as a long term plan for 'powering Far North Queensland' consideration must be given to uplifting the coastal circuit from Yabulu South to Woree to 275kV from its current 132kV. The additional system security, flexibility and strength this provides whilst significantly reducing losses and opening up additional opportunity for connection of renewable generation should outweigh the capital expenditure required to lift the voltage to 275kV. If Powerlink is to stay ahead of a rapidly changing energy environment, effort should be made to future-proof the North Queensland grid section

8. References

1. Transmission Line Condition Assessment Report – BS1220 Ross to Chalumbin 275kV March 2020
2. Transmission Annual Planning Report 2020
3. Asset Planning Criteria Framework

Base Case Risk and Maintenance Costs Summary Report

CP.02750 BS1220 Ross to Chalumbin Transmission Line Reinvestment

Version Number	Objective ID	Date	Description
1.0	A3388092	26/06/2020	Original document.
2.0	A3388092	11/11/2020	Planning report updated, revised network risks.
3.0	A3388092	10/12/2020	Risk models updated with revised methodology to incorporate updated safety risks and optioning.

1. Purpose

The purpose of this model is to quantify the base case risk cost profiles and maintenance costs for BS1220 Ross to Chalumbin which is a candidate for reinvestment under CP.02750.

Base case risk costs and maintenance costs have been analysed over a ten year study horizon.

2. Topography

Built section 1220 is a double circuit transmission line between Ross and Chalumbin 275kV substations, and is approximately 250km long. The transmission line is the primary source of supply to the far north Queensland area. There is a lower capacity coastal 132kV sub-transmission supply from Ross substation to the Cairns area which supplies local regional load centres and townships along the route.

[redacted]

Figure 1 – Network Topography

3. Key Assumptions

In calculating the potential unserved energy (USE) arising from a failure of the ageing structures within BS1220, the following modelling assumptions have been made:

- historical load profiles have been used when assessing the likelihood of unserved energy under tower failure events;
- consideration has been given to potential concurrent failures within the wider far north Queensland network;
- BS1220 supplies a mixture of residential, commercial and tourist load types within the far north Queensland area. Historical load data has been analysed to approximate the proportion of load for each customer category resulting in a weighted VCR of $28,064/MWh; and
- The most relevant residential and commercial VCR values published within the AER's 2019 Value of Customer Reliability Review Final Report have been used to determine the VCR.

4. Base Case Risk Analysis

4.1 Risk Categories

Four main categories of risk are assessed within Powerlink's risk approach; safety, network, financial and environmental. Network, safety and financial risks are considered material for this project and have been modelled for this analysis.

4.2 Transmission Line Analysis

This section analyses the risks presented by BS1220.

Table 1 – Risks associated with at risk structures

	Mode of failure	
Equipment	**Peaceful**	**Explosive**
Transmission Line Structure	Network risks (unserved energy) due to a failed structure. Safety risks due to a failed structure or failed suspension insulators. Financial risks to replace a failed structure in an emergency manner.	Not applicable

- The probability that a structures will fail includes the probability that a wind event, sufficient to bring the tower down, has occurred.
- BS1220 is a double circuit overhead transmission line which means that failure of a structure will result in loss of both 275kV feeders to Chalumbin substation (i.e. an n-2 event).
- Parts of the built section traverse sensitive and remote environments and access can be difficult. Any emergency rectification work will incur a premium compared to rectification of transmission structures within conventional rural areas.
- Safety risks are mainly associated where the overhead transmission line traverses roads and publically accessible tracks/trails.

4.2.1 Structures – Risk Cost by Year

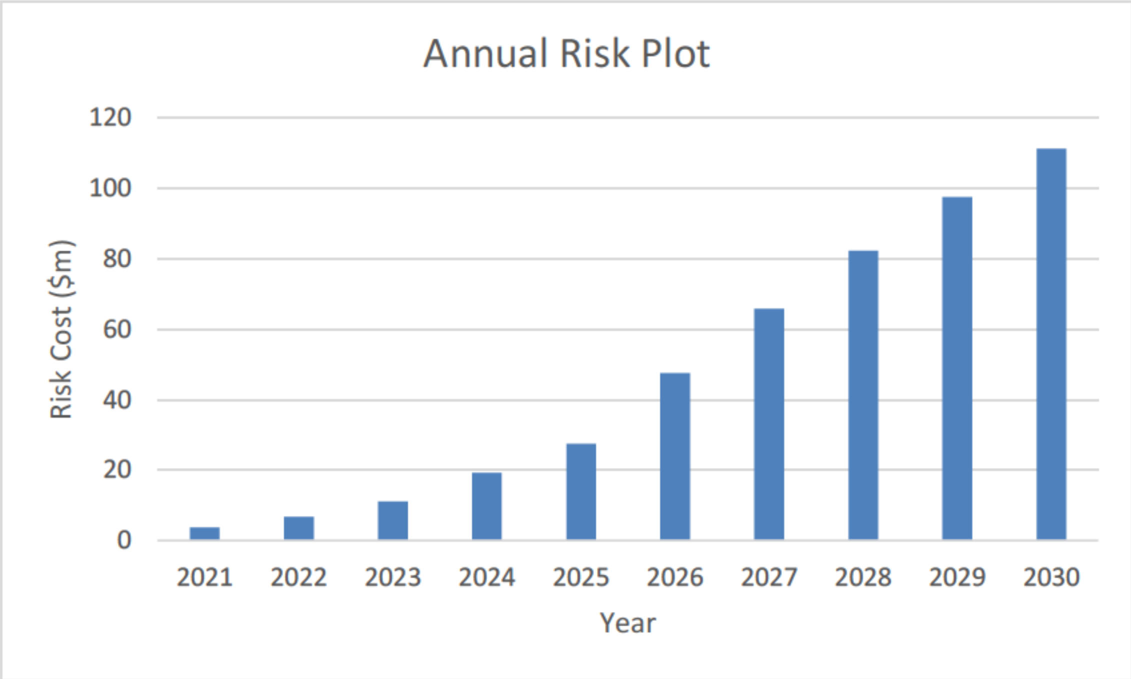


Figure 2 – Structure risk (10 years)

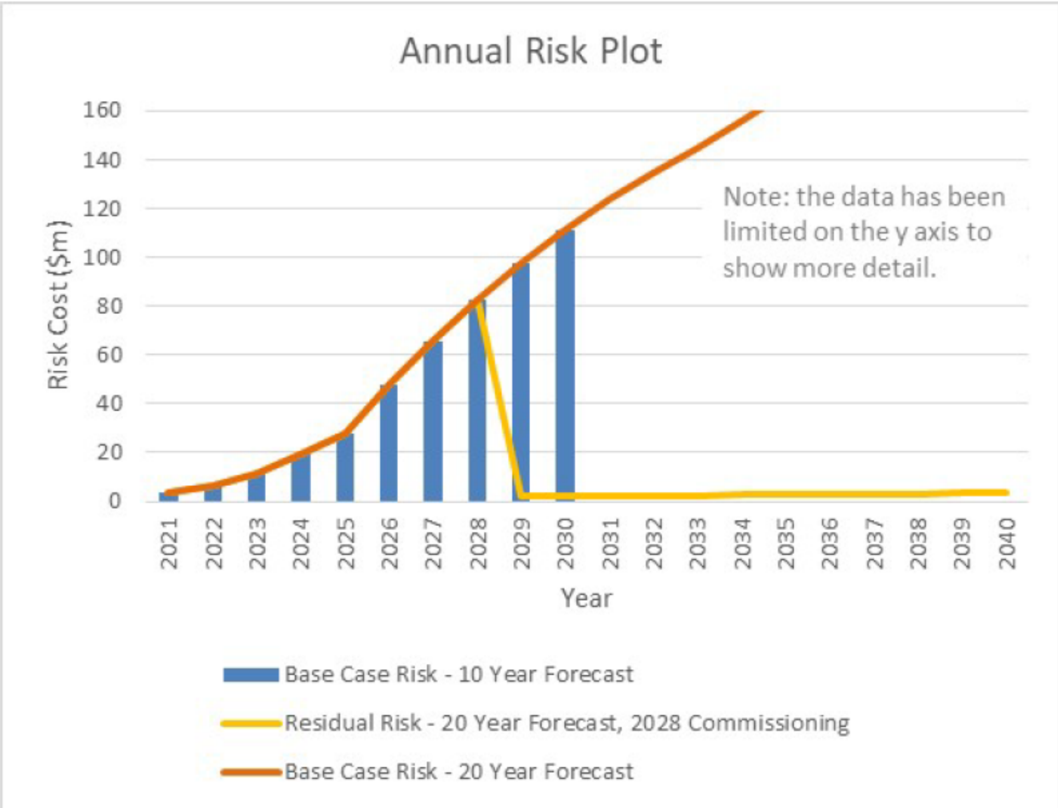


Figure 3 – Annual risk over time

4.2.2 Structures – Risk Breakdown by Risk Category

Figure 4 – Structure risk by category

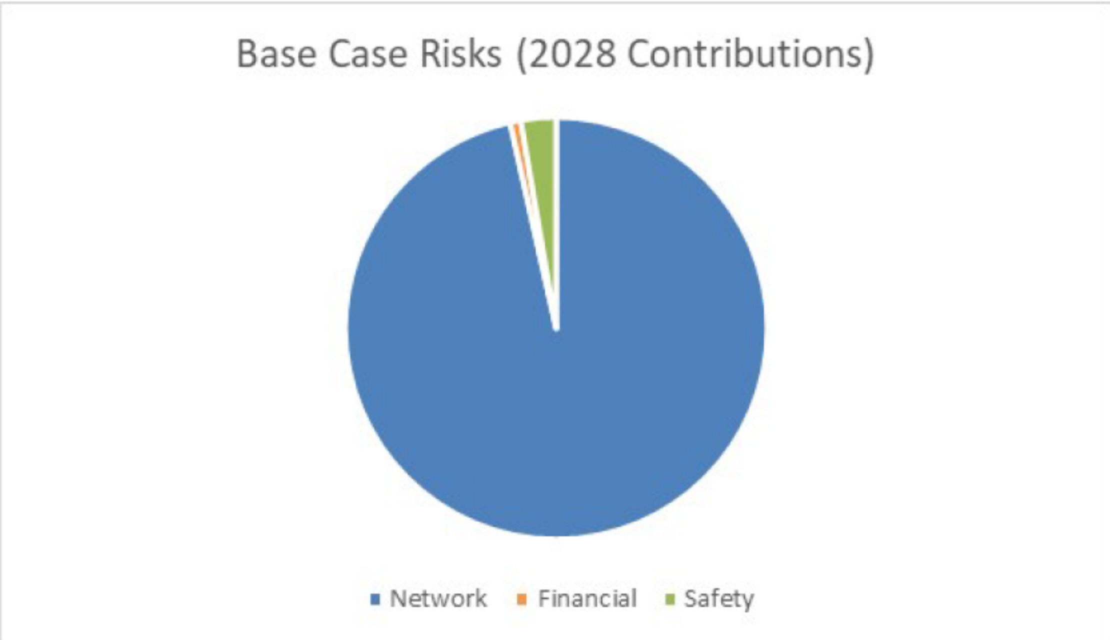


Figure 5 –Structure risk in 2028 by category

4.3 Base case risk statement

The main base case risks for BS1220 Ross to Chalumbin reinvestment are network risk (unserved energy) due to potential failure of a double circuit tower structure. There are also safety risks associated with failed structures and insulators, and financial risks to replace failed structures.

5. Maintenance costs

Maintenance costs are still being developed. For the purposes of this report, maintenance has been modelled as 0.8% of the project capital cost inflated by 2% annually.

The total base case risk and maintenance cost is show below:

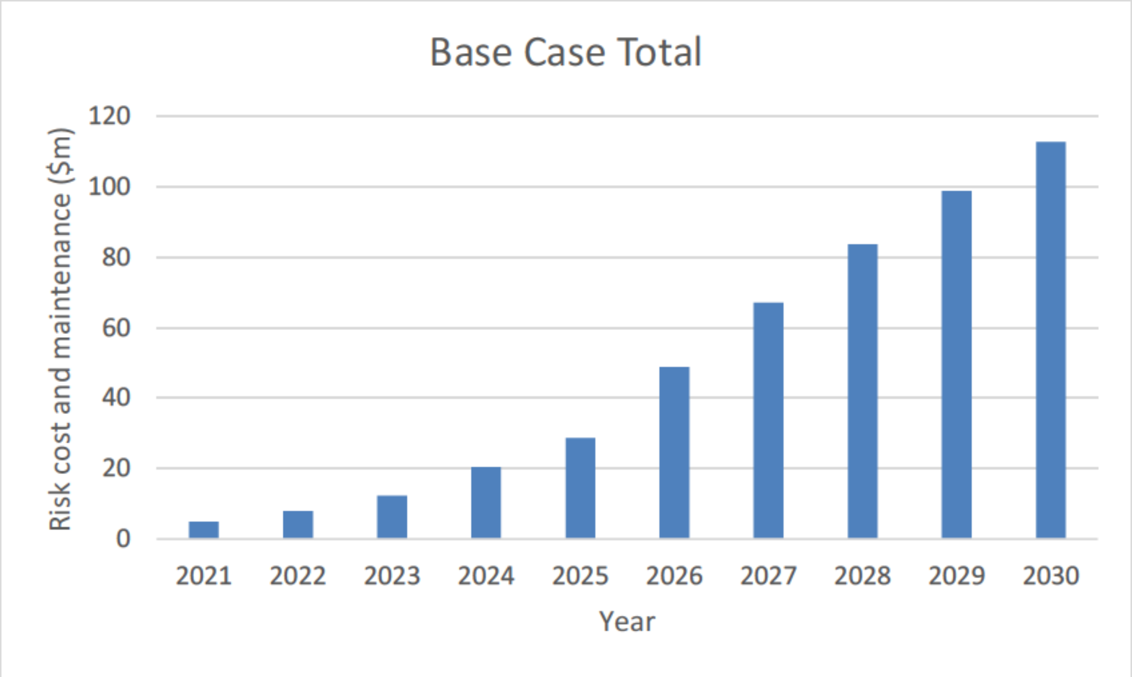


Figure 6 – Base case Total (Risk Cost + Maintenance) 2020 to 2029

6. Input participation

One of the main dependencies of this risk cost model is the Value of Statistical Life (VSL), since this forms the key input to the safety risk cost.

Risk Category	Input	Value	Unit
Network	VCR	28064	$/MWh
	Restoration time	168	hours
Financial	Tower restoration cost	1	$m
Safety	VSL	5	$m

Figure 2 – Transmission line risk cost model inputs

A 100% increase in the input values for VCR or tower restoration time will result in the overall risk increasing by approximately 98%.

A 100% increase in the input value for tower restoration cost will result in the overall risk increasing by approximately 0.6%.

Project Scope Report

CP.02750

BS1220 Ross to Chalumbin Life Extension

Concept – Version 2

Document Control

Change Record

Issue Date	Responsible Person	Objective Document Name	Background
11/05/20	[redacted]	Revenue Reset 2023-2027 BS1220 Ross to Chalumbin Life Extension	Preliminary scope
20/10/20	[redacted]	Revenue Reset 2023-2027 BS1220 Ross to Chalumbin Life Extension	Revised based on full inspection

Related Documents

Issue Date	Responsible Person	Objective Document Name
25/03/20	[redacted]	BS1220 Ross to Chalumbin Transmission Line Condition Assessment - Report 2020 (A3343100)

Project Contacts

Project Sponsor	[redacted]	[redacted]
Connection & Development Manager	[redacted]	[redacted]
Lines Strategies Engineer	[redacted]	[redacted]
Planner – Main/Regional Grid	[redacted]	[redacted]
Network Property Group	[redacted]	[redacted]
Manager Projects	TDB	Ext.
Project Manager	TDB	Ext.
Design Coordinator	TDB	Ext.

Project Details

1. Project Need & Objective

Built Section 1220 (feeders F857 & F858) is a double circuit 275kV transmission line from H013 Ross to H032 Chalumbin. The line contains 528 steel lattice towers built under contract N399/87 and commissioned in 1989. The 244km transmission line between Ross and Chalumbin substations is built through the rugged terrain of the North Queensland tropical rain forest, traversing environmentally sensitive and protected areas, regional roads and rivers.

The line was energized in 1989 with only the eastern (coastal) feeder 857 strung. The opposite side, feeder 858 (less corroded) was strung and energized 4 years later in 1993. Also, the tower design used 'valued engineered' principles to reduce costs. Such a specification resulted in non-standard 3mm thick members and M12 size bolts.

The majority of the line sits in a high rainfall environment, with high average humidity. Those sections of the line that are elevated and border on the Wet Tropics exhibit higher levels of atmospheric corrosion than sections in the more protected, low lying and dryer areas. As a result, particularly in approximately six more exposed and elevated locations, galvanised tower bolts and members are exhibiting significant evidence of grade 3 and grade 4 corrosion. Between these areas of poor condition, corrosion levels vary from low to medium; relatively normal for the age of the line.

The original condition assessment was based on 10% of the towers with a further 20% of towers inspected in late 2019 to give a better understanding of the asset condition. The original scope assumptions were based upon the 30% inspection. However, in parallel with the preliminary estimating, a full inspection was undertaken that involved climbing every tower. This inspection has confirmed a high degree of non-homogeneity in the condition of the built section, and allowed for significant targeting of refit works.

The objective of this project is to undertake targeted refit activities on BS1220 to provide secure reliable power transmission from Ross to Chalumbin substation, with all work to be completed by 30th December 2027.

2. Project Drawing

[redacted]

Figure 1: Built Section 1220 Ross-Chalumbin

3. Project Scope

3.1. Original Scope

The following scope presents a functional overview of the desired outcomes of the project. The proposed solution presented in the estimate must be developed with reference to the remaining sections of this Project Scope Report, in particular *Section 6 Special Considerations*.

Briefly, the project consists of the targeted refit of Built Section 1220 (feeders F857 & F858) to achieve additional useful life of the entire built section.

Following the full climbing inspection undertaken, the structural refit works have been separated into three categories as follows:

- Paint refit – replace all members with G4 corrosion and all nuts & bolts with G3 or G4 corrosion, prepare all surfaces and paint with zinc-rich coating.

- Heavy refit – replace all members with G3 or G4 corrosion and all nuts & bolts with G2, G3 or G4 corrosion.
- Light refit – replace all members with G3 or G4 corrosion and all nuts & bolts with G3 or G4 corrosion.

3.1.1. Transmission Line Works

Design, procure and commission all works to extend the useful life of Built Section 1220, as follows:

- Undertake "paint refit" works on 16 towers:
    - typically 0.3% of light members will require replacement;
    - typically 16.5% of nuts & bolts will require replacement;
    - replace all climbing bolts with new style climbing attachments with loops; and
    - prepare surfaces, nuts & bolts for painting and apply a zinc-rich paint to entire structure.
- Undertake "heavy refit" works on 32 towers:
    - typically 0.4% of light members will require replacement;
    - typically 41% of nuts & bolts will require replacement; and
    - replace all climbing bolts with new style climbing attachments with loops.
- Undertake "light refit" works on 240 towers:
    - typically 0.2% of light members will require replacement;
    - typically 1.2% of nuts & bolts will require replacement; and
    - replace all climbing bolts with new style climbing attachments with loops.
- Replace all climbing bolts with new style climbing attachments with loops on remaining 240 towers.
- Replace bridging insulators and associated hardware including trunnion clamps and vibration dampers on 22 towers.
- Replace suspension insulators and associated hardware including bolts on the armor grip suspension units (AGSUs) and vibration dampers on 422 towers:
    - where elastomer inserts are cracked, complete AGSU unit needs to be replaced – assume 1% AGSU units will need replacement.
- Measure structure footing resistances of all 528 towers:
    - install additional earthing to achieve compliance to Powerlink standards – assume additional earthing at 10 structures; and
    - repair galvanised earthing strap corrosion and damage – assume 50% of structures.
- Repair ground level (interface) of 65 towers:
    - prepare surfaces, nuts & bolts for painting – removing all G2, G3 or G4 corrosion – and apply a zinc-rich paint to affected area; and
    - for interfaces with G4 corrosion and more than 5% loss of steel, ensure that the interface has been structurally repaired before painting.
- Replace OPGW/OHEW hardware and fittings on 87 towers where corroded to G2 level or worse:

    - typically these will be the shackle and twisted eye tongue.

- Replace the OPGW downlead clamps, where corroded to G2 level or worse, on 48 towers:
    - it is expected that a total 380 clamps will need to be replaced.
- Repair or replace all damaged or defective anti-climb barriers, and replace damaged or missing signage.
- Asset information shall be captured in accordance with Asset Strategies Line Maintenance Principles Specification objective reference A2628257 before and after completion of work.
- Access track work to improve access to facilitate maintenance and project work as required.
- Update SAP, drawings and corporate data systems as necessary.

3.1.2. Telecoms Works

Not Applicable.

3.1.3. Easement/Land Acquisition & Permits Works

Easement rights and approvals must be considered with the Property team.

In order to traverse protected areas (National Parks, State Forests, Wet Tropics), it is necessary to obtain permits under the relevant legislation (Nature Conservation Act, Forestry Act and Wet Tropics World Heritage Protection and Management Act). These permits are likely to contain conditions which seek to minimise the environmental impact, resulting in increased construction and maintenance costs.

Maintenance of infrastructure in National Parks and Wet Tropics areas is subject to the QESI Maintenance Code for the Wet Tropics World Heritage Area.

3.2. Key Scope Assumptions

The following assumptions should be included in the estimating of this scope:

- The 244km transmission line between Ross and Chalumbin substations is built through the rugged terrain of the North Queensland tropical rain forest, traversing environmentally sensitive and protected areas, regional roads and rivers. Work on BS1220 may require specific permits for different areas of the transmission line easement;
- The most significant infrastructure crossed by 30km of the existing transmission line alignment is the Australian Army High Range Live Fire Training Area. Our MSP has restricted access to this area and often has to re-arrange work with limited notice;
- The line traverses a wide range of topography from flat to hilly to very steep terrain with a maximum slope of approximately 33 degrees. The most significant environmental features are the crossings of Herveys Range and Mount Zero, the Hidden Valley area and the Herbert River crossing (longest span in Queensland at 1.8km); and
- There are at least six, possible seven Native Title parties along this line. Further research is necessary to correctly identify all parties and which areas they speak for.

4. Project Timing

4.1. Project Approval Date

The anticipated date by which the project will be approved is June 2023.

4.2. Site Access Date

Site access is immediately available for Powerlink construction works as all works are to be done on BS 1220 easement. Some negotiations may be required for the areas within the Australian Army High Range Live Fire Training Area.

4.3. Commissioning Date

The latest date for the commissioning of the new assets included in this scope along with decommissioning and removal of redundant assets by 31st December 2027.

5. Special Considerations

The following issues are important to consider during the implementation of this project:

- Compliance with the Land Access Protocol and environmental, cultural and heritage, and health and safety obligations;
- The estimate shall identify and permits required actions, activities or obligations outstanding, pending or imposed by the permits, approvals or plans;
- The estimate shall identify if any access track work required for work on BS1220;
- The estimate shall identify if any outage constraints that are applicable to this work and its impact on other delivery timetables, projects, network elements, or network participants; and
- A high level project implementation plan including staging and outage plans should be considered and produced as part of the estimate.

6. Asset Management Requirements

Equipment shall be in accordance with Powerlink equipment strategies.

Unless otherwise advised [redacted] will be the Project Sponsor for this project. The Project Sponsor must be included in any discussions with any other areas of Investment & Planning.

7. Asset Ownership

The works detailed in this project will be Powerlink Queensland assets.

8. System Operation Issues

Operational issues that should be considered as part of the scope and estimate include:

- interaction of project outage plan with other outage requirements;
- likely impact of project outages upon grid support arrangements; and
- likely impact of project outages upon the optical fibre network.

9. Options

Not applicable

10. Division of Responsibilities

Not applicable

11. Related Projects

No related projects

Concept Estimate for CP.02750 - BS1220 Ross to Chalumbin Life Extension

Record ID	A3428010	
Policy stream	Asset Management	
Authored by	Senior Project Manager	[redacted]
Reviewed by	Team Leader Projects	[redacted]
Approved by	Team Leader Projects	[redacted]

Contents

1. Executive Summary

Built Section 1220 (feeders F857 & F858) is a double circuit 275kV transmission line from H013 Ross to H032 Chalumbin. The line contains 528 steel lattice towers commissioned in 1989. The 244km transmission line between Ross and Chalumbin substations is built through the rugged terrain of the North Queensland tropical rain forest, traversing environmentally sensitive and protected areas, regional roads and rivers.

The line was energized in 1989 with only the eastern (coastal) feeder 857 strung. The opposite side, feeder 858 (less corroded) was strung and energized 4 years later in 1993.

The majority of the line sits in a high rainfall environment, with high average humidity. Those sections of the line that are elevated and border on the Wet Tropics exhibit higher levels of atmospheric corrosion than sections in the more protected, low lying and dryer areas.

As a result, particularly in approximately six more exposed and elevated locations, galvanised tower bolts and members are exhibiting significant evidence of grade 3 and grade 4 corrosion. Between these areas of poor condition, corrosion levels vary considerably from low to medium.

Also, the tower design used 'value engineering' principles to reduce costs. The specification resulted in non-standard 3mm thick members and M12 size bolts.

The original condition assessment was based on 10% of the towers with a further 20% of towers inspected in late 2019 to give a better understanding of the asset condition. The original scope assumptions were based upon the 30% inspection. However, in parallel with the preliminary estimating, a full inspection was undertaken that involved climbing every tower. This inspection has confirmed a high degree of non-homogeneity in the condition of the built section, and allowed for significant targeting of refit works.

The objective of this project is to undertake targeted refit activities on BS1220 to provide secure reliable power transmission from Ross to Chalumbin substation, with all work to be completed by 30th December 2027.

1.1 Project Estimate

Estimate Components		Base $	Escalated $
Estimate Class	5		
Estimate Accuracy	+100% / -50%		
Base Estimate		**72,175,113**	**89,066,411**
Mitigated Risk	[redacted]	[redacted]	[redacted]
Contingency Allowance	[redacted]	[redacted]	[redacted]
TOTAL		[redacted]	[redacted]

1.2 Project Financial Year Cash Flows

	June 2021 Base $	Escalated $
To June 2024	3,608,756	4,071,080
To June 2025	16,600,276	19,494,775
To June 2026	21,652,534	26,470,514
To June 2027	21,652,534	27,555,805
To June 2028	8,661,014	11,474,237
TOTAL	**72,175,113**	**89,066,411**

2. Project and Site Specific Information

2.1 Project Dependencies & Interactions

This Concept Estimate provides for the reduced refit requirements of the Project Scope Report version 2.

No material dependencies have been identified at this stage. However, it is noted that outages will need to be coordinated to ensure the coastal network between Townsville and Cairns is intact during the proposed refit works.

A dependency within this project is utilisation of the winter shoulder outage periods for 2024 to 2028 inclusive.

2.2 Site Specific Issues

The site has the following features:

- 244km length
- 528 towers consisting of the following structure types:
  - D2S0 – 276 structures
  - D2S2 – 205 structures
  - D2T15 – 25 structures
  - D2T40 – 22 Structures
- Approximately 83km of the existing alignment is not covered by registered easements. This is predominantly associated with several protected areas (National Parks, State Forests) which cover 52km of the existing alignment. The other significant area (30km) is the Australian Army High Range Live Fire Area
- Construction of infrastructure in National Parks and Wet Tropics areas is subject to the QESI Maintenance Code for the Wet Tropics World Heritage Area.
- The line traverses a wide range of topography from flat to hilly to very steep terrain with a maximum slope of approximately 33 degrees. The most significant environmental features are the crossings of Herveys Range and Mount Zero, the Hidden Valley area and the Herbert River crossing (longest span in Queensland at 1.8km).

- There are at least six, possible seven Native Title parties along this line. Further research is necessary to correctly identify all parties and which areas they speak for –
  - At the Ross – Gurambilbarra Wulgurukaba People - no recent dealings;
  - Unclaimed portion of about 52km, further research would be needed to identify the party/parties;
  - Gugu Badhun – we have had recent dealings and a good relationship;
  - Warrgamay – some work with them some years ago, good relationship at that time;
  - Warrungnu – no recent dealings;
  - Jirrbal People #3 – no recent dealings;
  - At the Chalumbin end - Jirrbal People #4 – no recent dealings.

[redacted]

Figure 1 – Site Overview

3. Refit and Select Paint of Built Section 1220

3.1 Option Definition

3.1.1 Option Scope

The project consists of the targeted refit of Built Section 1220 (feeders F857 & F858) to achieve additional useful life of the entire built section.

As described in the Project Scope Report, the structural refit works are broken into three categories based upon the condition findings from the full inspection undertaken:

- Paint refit – replace all members with G4 corrosion and all nuts & bolts with G3 or G4 corrosion, prepare all surfaces and paint with zinc-rich coating per Powerlink standards.
- Heavy refit – replace all members with G3 or G4 corrosion and all nuts & bolts with G2, G3 or G4 corrosion.
- Light refit – replace all members with G3 or G4 corrosion and all nuts & bolts with G3 or G4 corrosion.

3.1.1.1 Substations Works

There are no substation works other than operational switching.

3.1.1.2 Transmission Line Works

The transmission line works consists of:

- Undertake “paint refit” works on 16 towers, including replacing all climbing bolts with new style climbing attachments with loops.
- Undertake “heavy refit” works on 32 towers, including replacing all climbing bolts with new style climbing attachments with loops.
- Undertake “light refit” works on 240 towers, including replacing all climbing bolts with new style climbing attachments with loops:
- Replace all climbing bolts with new style climbing attachments with loops on remaining 240 towers.
- Replace bridging insulators and associated hardware including trunnion clamps and vibration dampers on 22 towers.
- Replace suspension insulators and associated hardware including bolts on the armor grip suspension units (AGSUs) and vibration dampers on 422 towers.
- Measure structure footing resistances of all 528 towers, and install additional earthing to achieve compliance to Powerlink standards where necessary.
- Repair ground level (interface) of 65 towers, spot painting as required.
- Replace OPGW/OHEW hardware and fittings on 87 towers where corroded to G2 level or worse.
- Replace the OPGW download clamps, where corroded to G2 level or worse, on 48 towers (it is expected that a total 380 clamps will need to be replaced).
- Repair or replace all damaged or defective anti-climb barriers, and replace damaged or missing signage.
- Asset information shall be captured in accordance with Asset Strategies Line Maintenance Principles Specification objective reference A2628257 before and after completion of work.
- Access track work to improve access to facilitate maintenance and project work as required.
- Update SAP, drawings and corporate data systems as necessary.

3.1.1.3 Telecommunication Works

There are no telecommunications works.

3.1.1.4 Easement/Land Acquisition & Permit Works

There are no easement or permit works required. The works will need to be performed in accordance with the QESI Code for the Wet Tropics World Heritage Area.

3.1.2 Major Scope Assumptions

The Project assumptions are:

- For “paint” refit:
  - typically 0.3% of light members will require replacement; and
  - typically 16.5% of nuts & bolts will require replacement.
- For “heavy” refit:
  - typically 0.4% of light members will require replacement; and
  - typically 41% of nuts & bolts will require replacement.
- For “light” refit:
  - typically 0.2% of light members will require replacement; and
  - typically 1.2% of nuts & bolts will require replacement.
- 1% AGSU units will need replacement on the 422 towers where suspension insulators are to be replaced due to cracking of elastomer insert.
- Surfaces will be prepared for painting using abrasive blasting, or manual preparation for spot painting, and ‘Zinga’ will be the high zinc content coating system per Powerlink standards.
- Additional earthing to be installed at 10 towers, with repairs to galvanised earthing straps at 260 towers.
- 296 structures to have anti-climb devices and signage replaced.
- Costs associated with Cultural Heritage Management are consistent with usual stakeholder management costs.
- Department of Defence approval is obtainable to work within the Australian Army High Range Live Fire Area at scheduled times.

3.1.3 Scope Exclusions

The following activities and items are specifically excluded from the estimate:

- Replacement of tension insulator strings.
- Repairs to concrete foundations or tower stubs.
- Acquisition of missing easements.
- Additional costs associated with meeting the QESI Code.
- Design assessment and works for structural capacity upgrades.
- Treatment of UXOs.

3.2 Project Execution

3.2.1 Project Schedule

A High Level Project Schedule should be developed and should address the following project stages:

Task	Target Completion
Project Approval	June 2023
Site Access	February 2024
Transmission Line Works completed	October 2027
Construction close out	December 2027

3.2.2 Network Impacts

Network Operations advice is single circuit outages during winter shoulder period will only be permissible subject to no other conflicting outages. The project has been scheduled based around single circuit outages for the following tasks from beginning April to end of September:

- Insulator replacements
- Refit on cross arms
- Surface preparation and painting above 6m below lowest conductor

3.2.3 Project Staging

There is no distinct staging for this scope of works. There will be a number of work fronts between the Contractor and MSP to be managed under an Interface Management Plan.

3.2.4 Resourcing

MSP Lines crews will be required for insulator replacements.

3.3 Project Estimate

Estimate Components		Base $	Escalated $
Estimate Class	5		
Estimate Accuracy	+100% / -50%		
Base Estimate		72,175,113	89,066,411
Mitigated Risk	[redacted]	[redacted]	[redacted]
Contingency Allowance	[redacted]	[redacted]	[redacted]
TOTAL		[redacted]	[redacted]

3.4 Project Financial Year Cash Flows

	June 2021 Base $	Escalated $
To June 2024	3,608,756	4,071,080
To June 2025	16,600,276	19,494,775
To June 2026	21,652,534	26,470,514
To June 2027	21,652,534	27,555,805
To June 2028	8,661,014	11,474,237
TOTAL	**72,175,113**	**89,066,411**

3.5 Project Asset Classification

Asset Class	Asset Life	Base $	Percentage
Secondary systems	15 years		
Communications	15 years		
Transmission lines refit	35 years	72,175,113	100%
Primary plant	40 years		
Transmission lines	50 years		
TOTAL		**72,175,113**	

4. References

Document name	Version	Date
Project Scope Report BS1220 Ross to Chalumbin Life Extension	2.0	20/10/2020