Asset Management Plan

Transmission Line Support Structures

Asset Management Plan

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Authorisations

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Review cycle	2.5 Years	

Responsibilities

This document is the responsibility of the Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

The approval of this document is the responsibility of the General Manager, Strategic Asset Management.

Please contact the Asset Strategy Team Leader with any queries or suggestions.

- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

Record of revisions

Section number	Details
Whole document	Revised document structure into new template Updated tables throughout document Updated risk assessment

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1 Purpose

The purpose of this document is to describe for transmission line structure support foundations and related assets:

- TasNetworks' approach to asset management, as reflected through its legislative and regulatory obligations and strategic plans; and
- The key projects and programs underpinning its activities.

2 Scope

This document covers all transmission line support structures, including but not limited to;

- support structures types (eg lattice steel structures, steel poles, wooden poles);
- support structure fittings and hardware; and
- emergency restoration structures.

3 Strategic alignment and objectives

This asset management plan has been developed to align with both TasNetworks' Asset Management Policy and Strategic Objectives. This management plan describes the asset management strategies and programs developed to manage the transmission line support structures, with the aim of achieving these objectives.

For these assets the management strategy focuses on the following objectives:

- Safety will continue to be our top priority and we will continue to ensure that our safety performance continues to improve
- Service performance will be maintained at current overall network service levels, whilst service to poorly performing reliability communities will be improved to meet regulatory requirements
- Cost performance will be improved through prioritisation and efficiency improvements that enable us provide predictable and lowest sustainable pricing to our customers
- Customer engagement will be improved to ensure that we understand customer needs, and incorporate these into our decision making to maximise value to them
- Our program of work will be developed and delivered on time and within budget

4 Asset information systems

4.1 Systems

TasNetworks maintains an asset management information system (AMIS) that contains detailed information relating to transmission line support structure assets. AMIS is a combination of people, processes, and technology applied to provide the essential outputs for effective asset management. The following AMIS data integrity standards provides additional information relevant to transmission line support structures:

- R17087 AMIS DIS – Support Structure

Currently individual support structure asset information is located in the Works, Assets, Solutions and People (WASP) Asset management register. The WASP asset management register will be replaced in 2018 as part of the Ajilis Transformation program.

TasNetworks Geographic Information System (GIS) also captures asset data associated with transmission lines. This data is stored in a standalone database with links into WASP.

4.2 Asset management information improvement initiatives

To realise this capability at TasNetworks, the AMIS improvement program is delivering a rigorous and methodical series of targeted initiatives designed to build capability. When implemented, this program will deliver trusted, timely and high quality asset information that supports the strategic and operational asset management processes required for best-practice asset management. This program is complimentary with the current Ajilis project and will rely on and benefit from the integrated asset and works management system provided by that project.

The AMIS improvement program is currently delivering the foundations of a mature asset management system including the establishment of:

- asset hierarchies;
- asset data integrity standards; and
- asset nomenclature standards.

The establishment of a contemporary asset condition inspection system for network assets has also been identified as a priority initiative within the scope of the AMIS improvement program.

4.3 Asset information

Support structure asset information is recorded in the WASP asset register, which is used throughout TasNetworks for nameplate data, spares management, works scheduling and defect management.

5 Description of the assets

Transmission line support structures comprise the physical infrastructure from which insulators, electrical conductors or associated hardware are attached or suspended.

The transmission line support structures category includes:

- all the structural components above the foundation interface; and
- various safety and functional fittings attached to the structure. These include warning signs and labels, fall arrest systems and climbing barriers.

5.1 Support Structures

TasNetworks maintains 7908 support structures on the transmission system. Of these, 7742 support structures are owned by TasNetworks, and 166 are owned by a third party.

As shown in Table 1, most support structures are of the steel lattice (galvanised) type.

Table 1: Transmission line support structure assembly types (as at April 2015)

Owner and service status	Support structure material	Support structure type	Number	Percentage of total
TasNetworks (in service)	Steel	Lattice tower (galvanised)	6092	82
		Lattice tower (weather resistant steel)	477	6
		Single pole	534	6
		Kay poles	41	<1
		Lattice mast (weather resistant steel)	26	<1
		H-pole	25	<1
		Lattice mast (galvanised)	5	<1
	Wood	Single pole	47	<1
		H-pole	211	3
		Total	**7,458**	**96**
TasNetworks (out of service)	Steel	Lattice tower (galvanised)	284	4
		Sub total	**7,742**	**100**
Third Party (in service)	Steel	Single pole (maintained by TasNetworks)	166	
		Grand total	**7,908**	

5.1.1 Steel lattice towers (galvanised)

Lattice towers have traditionally been used extensively across the transmission system due to their high strength and ability to cost effectively span long distances.

A typical lattice tower, as shown in Figure 1, consists of numerous steel members jointed with plates and bolts for structural strength, with corrosion protection provided primarily via a galvanised layer. The design of the lattice tower can vary significantly, depending on the required structural capacity, the number of circuits required to be supported, and the associated voltage.

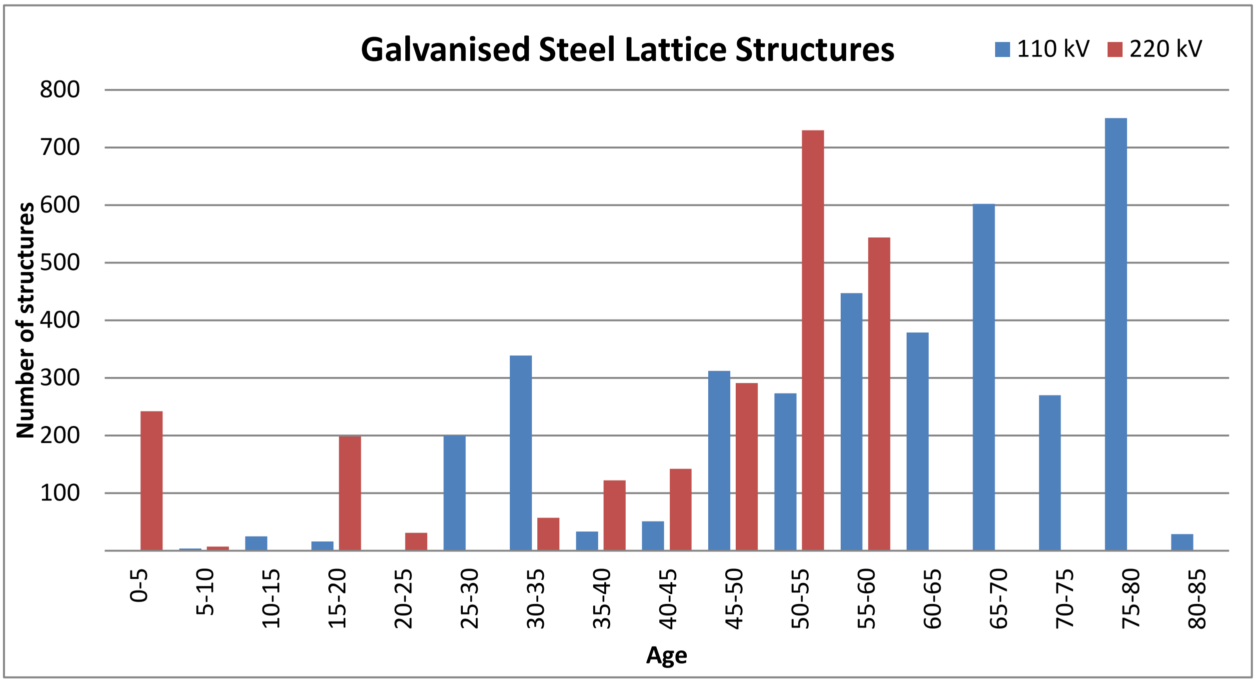
Lattice towers typically vary in height from 15m (110 kV, single circuit, flat spacing) up to 57m (220 kV, double circuit, vertical spacing).

The most common failure mode for steel lattice towers is strength reduction due to excessive corrosion and eventual failure of bolts and members. To assist in this all vegetation must also be kept clear of lattice tower base steelwork and inspection regimes to identify loss of the protective galvanised coating.

Figure 1: Steel lattice tower (galvanised)

The age profile of TasNetworks steel lattice towers (galvanised) is shown below.

Figure 2: Galvanised steel lattice structures age profile (as at May 2015)



It can be seen that approximately 54 per cent of 110 kV steel lattice (galvanised) support structures are greater than 60 years of age, while approximately 23 per cent of 220 kV support structures will exceed 60 years of age in the next regulatory control period.

From the above chart it can be seen that approximately 82 per cent of the 110 kV steel lattice (galvanised) support structure population is greater than 45 years of age.

The 110 kV network has a large population of support structures currently within the 45-60 year age bracket, which will need appropriate management in the next 15 years to address deterioration of these structures due to age and the associated risk.

A comparison against other TNSPs shows that TasNetworks average 110 kV steel lattice support structure age of approximately 55 years is the highest in Australia, and is significantly higher than the Australian average of approximately 45 years.

At an average age of approximately 40 years, TasNetworks 220 kV galvanised lattice support structures are also the oldest in Australia.

Due to their environmental exposure, the degradation rate of steel structures typically increases with age, and hence the requirement for inspection, asset refurbishment and/or asset renewal activities is likely to increase with time.

5.1.2 Steel lattice towers (Weather Resistant Steel)

Weather resistant steel (WRS) Lattice towers, as shown in Figure 3, are similar to galvanised lattice towers in their structural design. The main difference being, the use of steel designed to corrode at the air/steel interface, providing a protective layer of ferrous oxide over the underlying steel. This ferrous oxide layer gives the steel a reddish brown appearance.

These structures have been installed in the past on transmission lines passing through environmentally sensitive areas, where it was desirable for the transmission line to blend in with the natural environment.

Joints in WRS structures are known to develop a high electrical resistance. To overcome this and maintain a conductive earth path through the structure, electrical bonds are placed across joints. The bonds are attached on the climbing and diagonal legs of these structures from the lowest cross arm to the overhead earth wire attachment points. Special earthing points are also provided on all strain tower cross arms and on the middle and bottom cross arms on suspension towers.

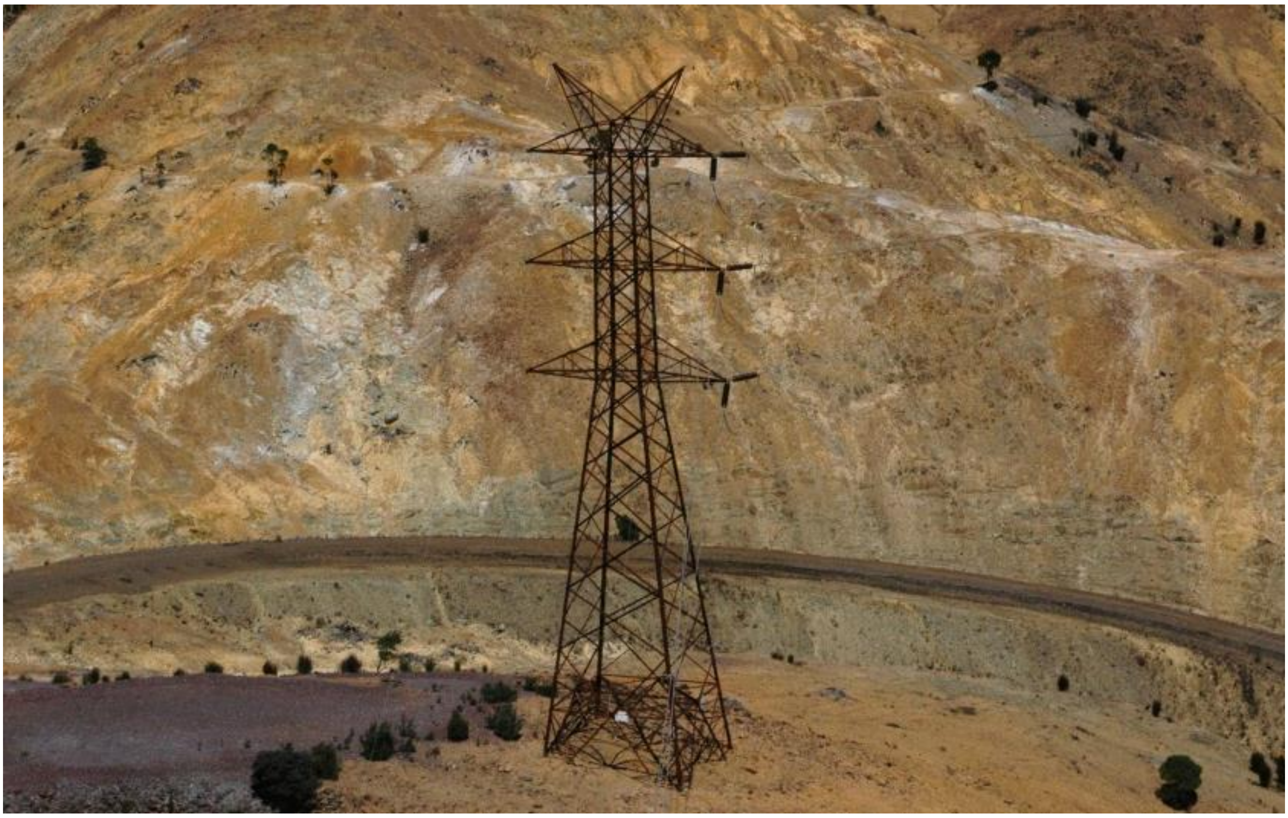
The most common mode of failure on WRS structures is caused by reduction of strength due to excessive corrosion and eventual failure of bolts and members. All base steelwork of the structure must also be kept clear of vegetation.

The use of dissimilar materials is a risk for WRS structures. Straps for signage, galvanised washers and anti-climbing barrier materials require careful consideration as their relationship to WRS in the galvanic table must be close to avoid high electrolytic potential differences which drive corrosive currents.

Recently some systemic installation issues have been identified with WRS structures. It appears that a combination of factors, is leading to the degradation of these structures. Not developing the required protective patina prior to installation and an insufficient wet/dry cycle is causing joint pack-out on some structures.

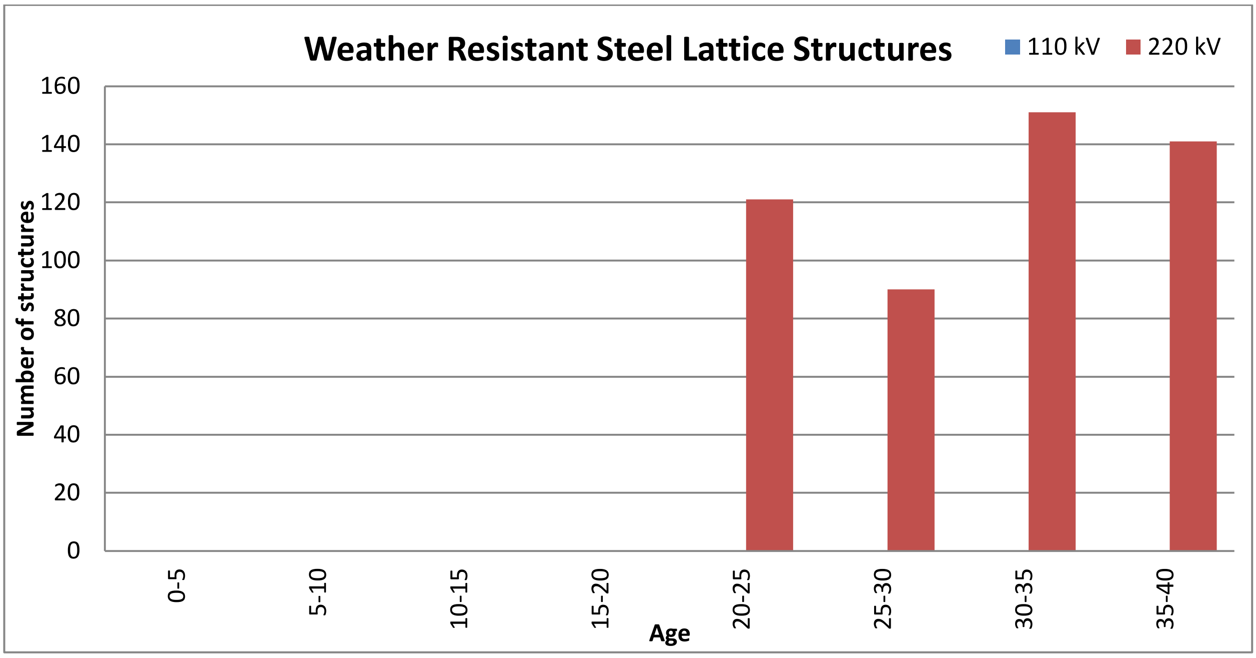
This may cause loss of metal from the joint members, and bolts & fittings may break reducing the strength of the structure.

Figure 3: Example of reinforcing steel in concrete foundation



The age profile of TasNetworks WRS structures is shown below. WRS structures were installed on 220 kV transmission lines between 1976 and 1994.

Figure 4: Steel lattice towers (weather resistant steel) age profile (as at May 2015)



5.1.3 Wood poles

Wood pole structures are used on a small number of transmission lines, and have generally been unitised where either a shorter asset life or lower level of reliability can be tolerated. A typical wood pole structure is shown in Figure 5.

Wood pole structures generally consist of two wood poles treated with copper chromium arsenic (CCA), and a steel cross piece constructed in an 'H' arrangement, guy wires stabilise the hold structure in place.

There are 264 wood pole structures installed on TasNetworks' transmission network, a large number of these were installed in the 1960s resulting in many wood pole structures exceeding their design life of 45 years.

ID	Transmission line	Wood pole structures	Wood pole structure in exceedance of design life
TL445	Burnie–Waratah 110 kV	156	92
TL484	Huon River Spur 110 kV	82	0
TL417	Tarraleah–New Norfolk (East) 110 kV	9	0
TL400	Waddamana–Bridgewater Junction (West) 110 kV	8	0
TL501	Repulse–Cluny Spur 220 kV	4	4
TL418	Tarraleah–New Norfolk (Wast) 110 kV	3	0
TL409	Waddamana–Parknook 110 kV	1	0
TL463	New Norfolk–Creek Road 110 kV	1	0
Total		**264**	**96**

Due to their high lifecycle cost, TasNetworks prefers utilising alternative structures to wood poles structures where possible. However, wood poles can be used where a customer has agreed to a lower level of connection point reliability.

The most common failure mode for wood poles is structural failure due to wood rot, particularly below ground where the wood is subjected to moisture and bacteria, but also at the interface between the top of the pole and the pole riser (where fitted).

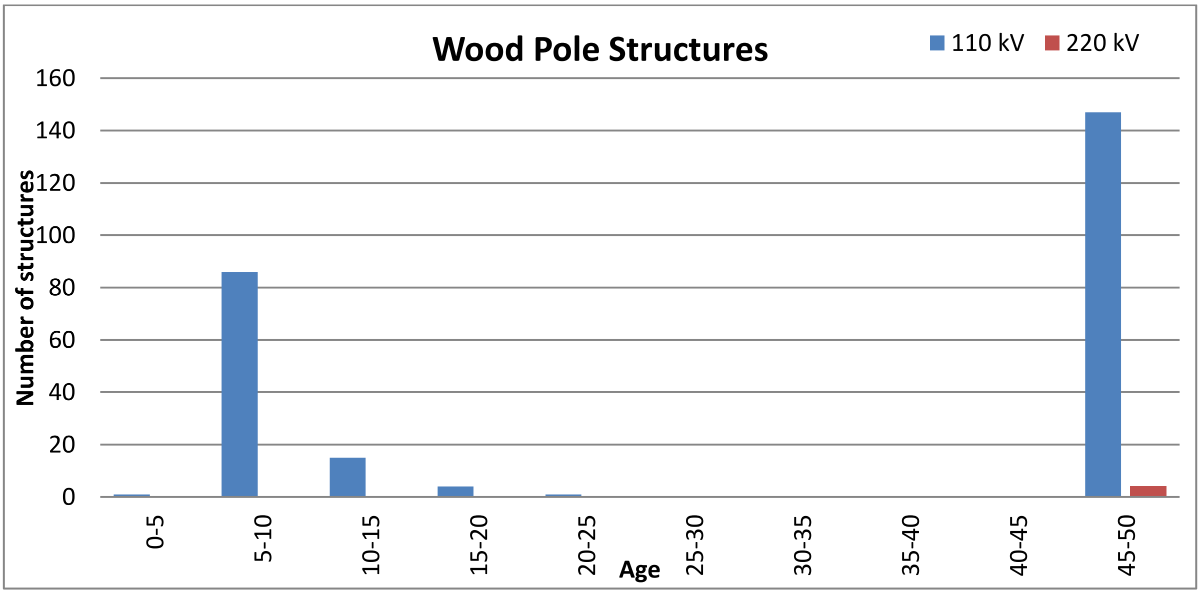
Figure 5: Wood pole structures

The age profile of TasNetworks wood pole structures is shown below.

It can be seen that 59 per cent of wood pole structures are older than 45 years of age, and hence exceed the economic life for wood poles.

It is generally accepted that most wood poles will last between 35–50 years before their condition deteriorates and replacement is required.

Figure 6: Wood pole structures age profile (as at May 2015)



5.1.4 Steel poles

Steel poles are generally used on transmission lines where long spans are not required and the cost of foundations is not excessive. Steel poles are typically utilised on 110 kV transmission lines only, due to the significant increase in cost when utilised at 220 kV.

Steel pole structures are usually constructed from a rolled or a bent steel plate with sections joined by overlapping or bolted connections, with corrosion protection provided by a galvanised layer. TasNetworks' preferred option is the use of steel lattice structures and steel poles on new transmission lines.

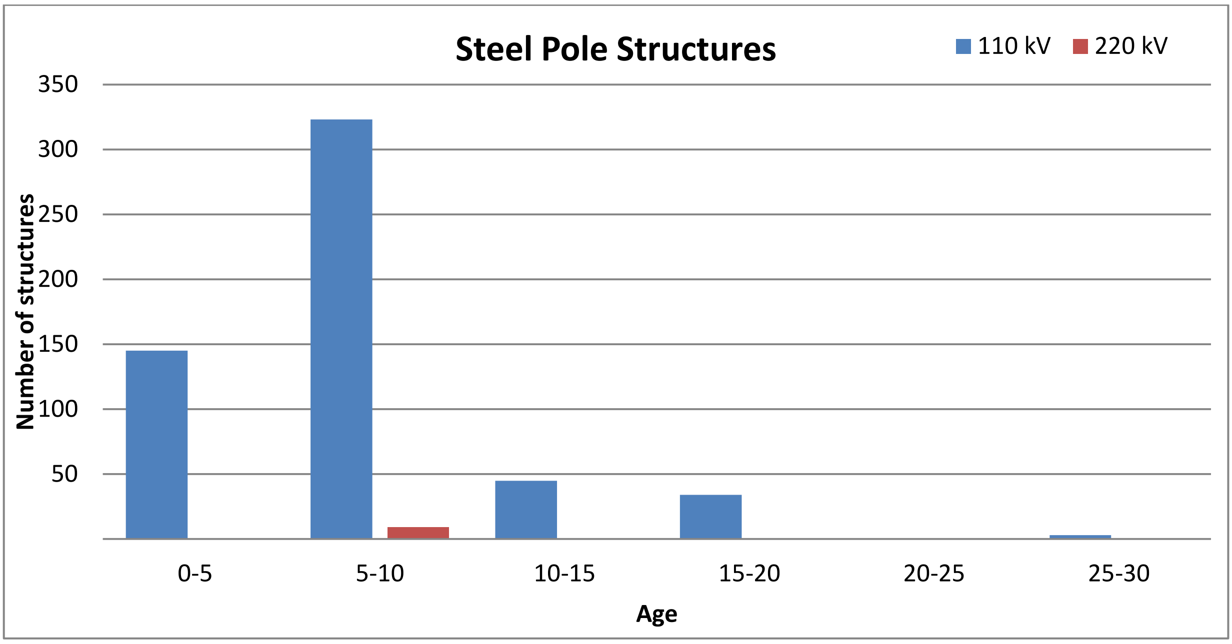
Typically these structures are a single pole, as shown in Figure 7, however in high load areas an H pole arrangement utilising two steel poles maybe required.

The most common failure mode for steel poles is structural failure due to corrosion, particularly below ground where water can collect in the pole base. All vegetation must also be kept clear of steel pole bases.

Figure 7: Steel pole structure

The age profile of TasNetworks steel pole structures is shown below. It can be seen that TasNetworks steel pole population is still relatively young.

Figure 8: Steel pole structures age profile (as at May 2015)



5.1.5 Kay poles

Steel Kay poles are not common on the transmission network, the last remaining Kay pole structures are on the Triabunna Spur 110 kV transmission line. This is a radial transmission line, where any support structure failure will result in an immediate and sustained interruption to supply.

As can be seen in Figure 9, Kay pole support structures consist of a single vertical steel pole supported by four, shorter, steel pole 'legs', stabilised by guy wires attached between the base of each leg and the top of the vertical steel pole. These poles were designed during the First World War when steel availability was limited.

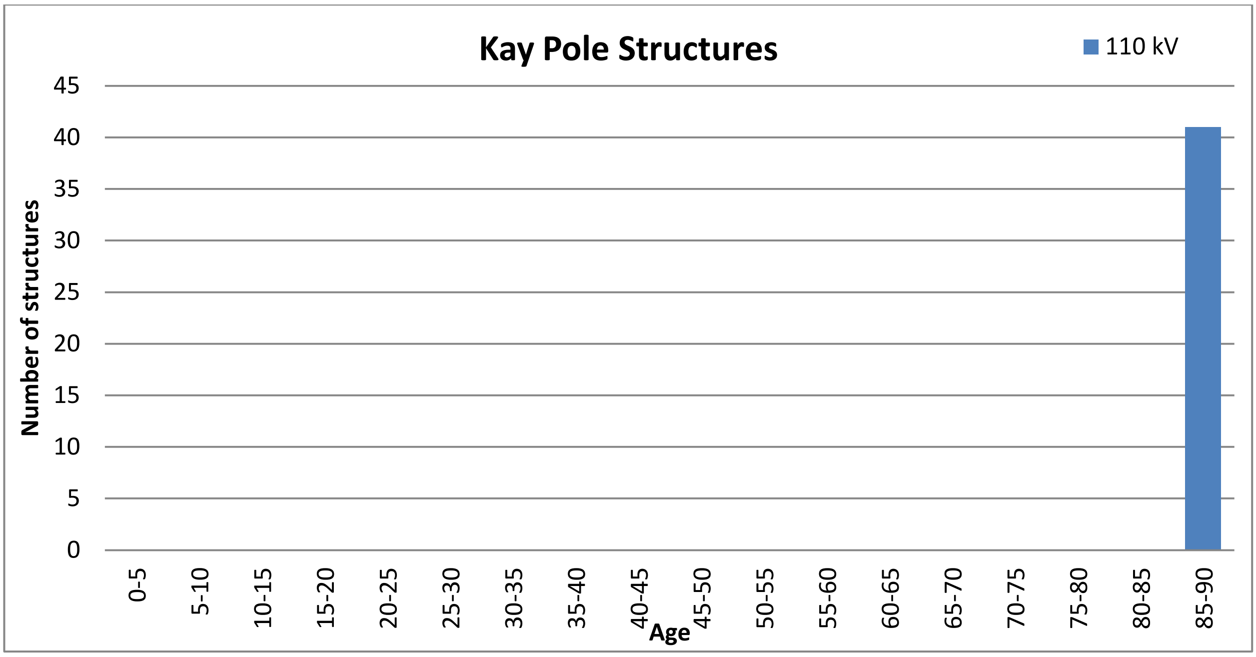
Kay pole support structures are no longer used by TasNetworks for new transmission lines. Due to a combination of extremely high fleet age and associated asset corrosion, they have been identified for replacement subject to condition monitoring in 2018–19 period.

The most common failure mode for Kay poles is structural failure due to guy wire corrosion, internal tube corrosion, and foundation degradation.

Figure 9: Kay pole structure

The age profile of TasNetworks Kay pole structures is shown below. Kay poles were manufactured and installed in the 1920s, and then refurbished in the 1970s for use on the Triabunna Spur 110 kV transmission line. It is suspected that this refurbishment only included remedial work on steel members located below ground. These transmission line structures are amongst the oldest in Australia

Figure 10: Kay pole structures age profile (as at May 2015)



5.2 Support structure fittings and hardware

Numerous structure fittings and other hardware are typically attached to transmission line support structures. A summary of the most prevalent fittings is presented in Table 2 below.

Table 2: Transmission line support structure fittings (as at April 2015)

Fitting Type	TasNetworks	Third Party
Climbing barriers	3315	3
Fall arrest systems	129	0
Warning signs	7550	166
Identification labels	11662	166
Total	**22656**	**335**

5.2.1 Climbing barriers

Climbing barriers are fitted to transmission line support structures to deter the public from climbing the support structures and approaching the high voltage conductors and insulators of the overhead transmission circuit(s).

Climbing barriers are installed on steel lattice support structures only, as pole type structures sufficiently deter climbing through their physical shape and design.

Climbing barriers are only required to be installed on steel lattice structures:

- located where human activity is likely; and or
- which support critical ancillary equipment.

Due to urban expansion and associated changes in land use, it is necessary for TasNetworks to purchase and install climbing barriers in new locations.

Climbing barriers are designed with an integral access gate located on the support structure climbing leg (between 3.5m and 6.0m above ground) to enable ‘controlled’ safe access through the climbing barrier for authorised personnel, without the use of externally placed ladders.

Where old type barriers exist (no access gate and require a ladder to access the structure), it is TasNetworks policy to replace these barriers with the modern equivalent, but only where the condition of the barrier is sufficiently poor.

The most common failure mode for climbing barriers are strength reduction due to steel corrosion and degradation.

Figure 11: Climbing barrier

5.2.2 Fall arrest systems

In accordance with NENS 05-2003 “National Fall Protection Guidelines for the Electricity Industry”, TasNetworks requires all personnel to utilise the ‘double attached’ climbing technique when climbing or working on steel lattice support structures at, or greater than, 2.4m above the ground. This requires the climber to wear a safety harness to which two lanyards are attached. While ascending or descending the support structure the climber has to ensure at least one lanyard is attached to either a step bolt, tower member or dedicated fall arrest anchor at all times. For historical reasons, most support structures comprising TasNetworks transmission network do not have fall arrest anchors fitted, with climbers expected to use support structure members or step bolts as attachment points.

Steel wire fall arrest systems offer numerous advantages over traditional tower climbing techniques, including:

- minimised consequence of a fall;
- less fatigue when climbing; and
- faster ascent and descent.

In 2011 TasNetworks adopted a new strategy[1] whereby fall arrest systems are to be installed:

- on new steel lattice support structures;
- on steel lattice support structures that are significantly refurbished; and
- on steel lattice structures that require frequent climbing.

[1] D10/51845, Fall Arrest Systems Strategy Review

To support this strategy TasNetworks secured capital funding for the installation of fall arrest systems in the 2014–19 regulatory control period.

Figure 12 shows a typical Latchways® fall-arrest system fitted to a transmission line support structure.

Figure 12: Fall Arrest System

5.2.3 Warning signs

Transmission line warning signs are installed to alert the general public to the dangers of climbing transmission line support structures, and the danger of approaching high voltage conductors.

TasNetworks Transmission Line Signage Standard - D11/48262 requires transmission line warning signs to be fitted to all new and existing transmission line structures.

The most common failure mode for warning signs is fading due to UV exposure, particularly the colour red.

Figure 13: Warning signage

5.2.4 Identification labels

Transmission line identification labels are installed to provide advice to TasNetworks employees and contractors regarding the name of a particular structure, circuit, transmission line or other asset type.

To comply with the Power System Safety Rules transmission line identification labels are required to be fitted to all transmission line structures to allow positive identification of the transmission line, structure number and circuit before work can commence.

Figure 14: Identification labels

5.2.5 OPGW Splice Pods

OPGW splice pods are installed on transmission lines that have OPGW installed. The splice pods are installed approximately every 10 structures, or at strategic points as required. These pods are installed on structures using brackets and allow for connection to the OPGW fibres.

Figure 15: OPGW Splice Pod

6 Standard of service

6.1 Technical Standards

In general, structures and their associated foundations have been designed to a range of standards over the last 90 years. Structures and foundations built since the mid-1960s were designed in accordance with ASTM/ASCE and Australian Standards. Prior to 2010, structures and foundations were also designed in accordance with "ENA C(b)1-2006 Guidelines for the design of overhead distribution and transmission lines". In 2010 this guideline was superseded by "AS/NZS 7000:2010 - Overhead line design – Detailed procedures".

6.2 Performance objectives

6.2.1 Service obligations for network assets

TasNetworks' performance incentive (PI) scheme, which has been produced in accordance with the Australian Energy Regulator's (AER's) Service Standards Guideline, is based on plant and supply availability. The PI scheme includes the following specific measures:

- plant availability:
  - transmission line circuit availability; and
  - transformer circuit availability.
- supply availability:
  - number of events in which loss of supply exceeds 0.1 system minutes; and
  - number of events in which loss of supply exceeds 1.0 system minutes.

Details of the PI scheme and performance targets can be found in TasNetworks' SAMP.

6.2.2 Service obligations for non-regulated assets

6.2.2.1 Hydro Tasmania

TasNetworks has a PI scheme in place with Hydro Tasmania under its Connection and Network Service Agreement (CANS 2) for connection assets between the two companies. The PI scheme includes connection asset availability which can be impacted by TasNetworks asset category assets. An overview of Hydro Tasmania PI scheme and performance targets can be found in the SAMP.

6.2.2.2 Tamar Valley Power Station (TVPS)

TasNetworks has a PI scheme in place with TVPS under its Generator Connection Agreement for connection assets between the two companies. The PI scheme includes the connection asset availability measure. An overview of TVPS PI scheme and performance targets can be found in the associated Connection Agreement.

6.2.2.3 Major Industrial Direct Customer Connections

TasNetworks has a number of direct connections to major industrial customers through EHV and Transmission Lines. The following transmission line assets provide these direct connections:

- George Town – Colmalco 220 kV;
- George Town – Temco 110 kV;
- George town – Starwood 110 kV); and

- Burnie Hampshire 110 kV (via Hampshire switching station).

The individual connection agreements describe the level of service and performance obligations required from the associated connection assets.

6.3 Key Performance Indicators

TasNetworks monitors support structure performance for major faults through its incident reporting process. The process involves the creation of a fault incident record in the event of a major asset category failure that has an immediate impact on the transmission system. The fault is then subjected to a detailed investigation that establishes the root cause of the failure and recommends remedial strategies to reduce the likelihood of reoccurrence of the failure mode within the asset category population.

For support structure failures that do not initiate a transmission system event, such as defects, TasNetworks maintains a defects management system that enables internal performance monitoring and trending of all asset category related faults or defects.

TasNetworks' inspection and defect management practices have been sufficient to prevent TasNetworks from experiencing any transmission line support structure foundation failures.

6.3.1 Foundation KPIs

The following Key Performance Indicators (KPIs) are used to monitor the support structures asset base:

- Support structure defect volumes are maintained at a consistent level over a 5 year period.

6.4 Benchmarking

TasNetworks participates in various formal benchmarking forums with the aim to benchmark asset management practices against international and national transmission companies. Key benchmarking forums include:

- International Transmission Operations & Maintenance Study (ITOMS); and
- Australian Energy Regulator (AER) Regulatory Information Notices (RIN).

In addition, TasNetworks works closely with transmission companies in other key industry forums, such as CIGRE (International Council on Large Electric Systems), to compare asset management practices and performance.

6.4.1 External benchmarking

ITOMS provides a means to benchmark performance (maintenance cost & service levels) between related utilities from around the world. For transmission line assets, the benchmarking exercise combines patrol and inspection costs into one category, and maintenance costs in another.

6.4.1.1 Service Performance

Figure 16 and Figure 17 on the following page shows that TasNetworks' service performance has been better than the ITOMS study participant's average for 220 kV transmission line assets. Similarly, 110 kV transmission line assets have shown a path of continual and significant improvement as benchmarked against ITOMS study participants.

The low number of fault outages attributable to transmission line assets is confirmation of the effectiveness of TasNetworks' inspection and defect management regime. Under this regime, assets in poor condition are identified, prioritised and replaced in a timely and planned manner. TasNetworks' whole-of-life risk based approach to asset management results in effective fleet management of transmission line assets, ensuring that assets are systematically replaced as they approach end of life.

Figure 16: ITOMS Overall transmission line composite performance trend

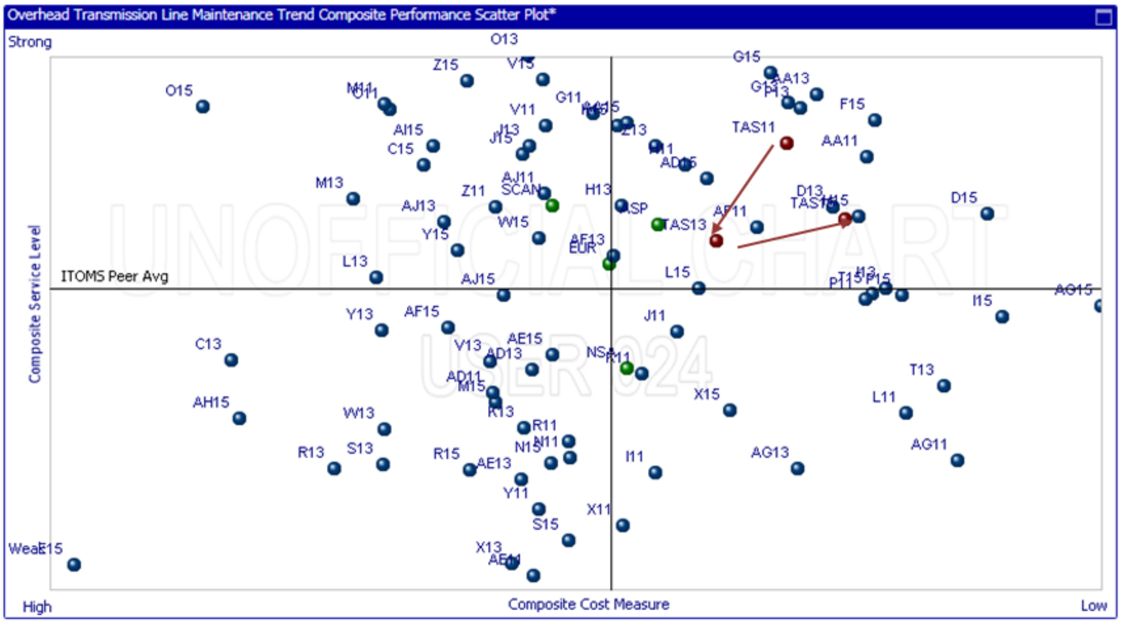
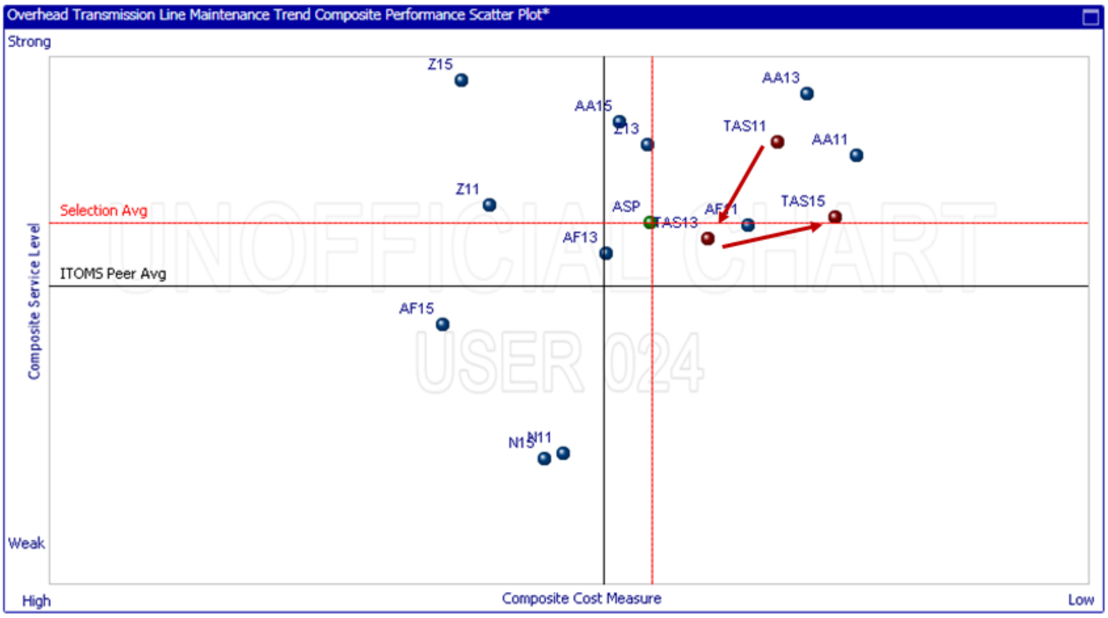


Figure 17: ITOMS Overall transmission line composite regional performance trend



7 Associated risk

TasNetworks has adopted the risk management principles detailed in Australian Standard AS/NZS ISO 31000:2009 'Risk management – principles and guidelines' in managing risks associated with its transmission line support structures. The primary goals of the risk management strategy are to:

- ensure the safety of personnel and the public as far as practicable;
- manage the impact of defective insulators on transmission system performance; and
- reduce the risk of fire starts due to insulator failure to an acceptable level.

7.1 Risk Management Framework

TasNetworks has developed a Risk Management Framework for the purposes of

- Demonstrating the commitment and approach to the management of risk – how it is integrated with existing business practices and processes and ensure risk management is not viewed or practiced as an isolated activity;
- Setting a consistent and structured approach for the management of all types of risk; and
- Providing an overview on how to apply the risk management process.

Assessment of the risks associated with the transmission line support structures has been undertaken in accordance with the Risk Management Framework. The risk assessment involves:

- Identification of the individual risks including how and when they might occur
- Risk analysis of the effectiveness of the existing controls, the potential consequences from the risk event and the likelihood of these consequences occurring to arrive at the overall level of risk.
- Risk evaluation where risks are prioritised based on their ratings and whether the risk can be treated) or managed at the current level.
- The likelihood and consequence of risk events occurred are assessed using the following risk rating matrix in Figure 18:

Figure 18: Risk Ranking Matrix

LIKELIHOOD		CONSEQUENCE 1 NEGLIGIBLE	2 MINOR	3 MODERATE	4 MAJOR	5 SEVERE
• ≥ 99% probability • Impact occurring now • Could occur within "days to weeks"	5 ALMOST CERTAIN	MEDIUM	MEDIUM	HIGH	VERY HIGH	VERY HIGH
• 50% - 98% probability • Balance of probability will occur • Could occur within "weeks to months"	4 LIKELY	LOW	MEDIUM	HIGH	HIGH	VERY HIGH
• 20% - 49% probability • May occur shortly but a distinct probability it won't • Could occur within "months to years"	3 POSSIBLE	LOW	LOW	MEDIUM	HIGH	HIGH
• 1% - 19% probability • May occur but not anticipated • Could occur in "years to decades"	2 UNLIKELY	LOW	LOW	MEDIUM	MEDIUM	HIGH
• ≤1% probability • Occurrence requires exceptional circumstances • Only occur as a "100 year event"	1 RARE	LOW	LOW	LOW	MEDIUM	MEDIUM

The Risk Management Framework requires that each risk event is assessed against all of the following consequence categories:

- Safety and People
- Financial
- Customer
- Regulatory Compliance
- Network Performance
- Reputation
- Environment and Community

This asset management plan describes the major risks associated with transmission line insulator assemblies and the current or proposed treatment plans.

7.2 Risk Identification

The following areas have been identified as risk areas in the management of transmission line support structure foundations.

7.2.1 Unidentified degradation of support structures

Steel transmission line support structures have a defined design life based on assumptions of loss of strength due to corrosion. Significant degradation of a support structure has the potential to cause a transmission line failure. The consequence of such an event may include injuries, fatalities and a transmission line outage. TasNetworks undertake regular full condition assessment of structures on a periodic basis and ground inspection annually. Where required, assessment of the load bearing capacity of existing support structures is undertaken.

7.2.2 Deterioration and failure due to poor maintenance

Support structures will deteriorate over time and need maintenance to retain structural integrity. Various structural fittings (e.g. bolts) could degrade or perform poorly due to lack of maintenance.

7.2.3 Wood pole rot/decay

Wood poles are vulnerable to rot and decay both above and below ground. A significant loss of structural strength in the wood can result in a failure particularly in high wind events.

7.2.4 Transmission line augmentation

Overtime there may be a requirement for additional loads to be added to existing transmission lines, such as OPGW, or for a line to be augmented. When this occurs there is an obligation for an assessment for compliance against the latest transmission line standards and codes, including AS7000. There is a risk that the existing support structures may not be compliant and therefore additional refurbishment or replacement of assets is required.

7.2.5 Unauthorised access

Climbing barriers and safety signage are subject to vandalism, damage and degradation. These structure fittings provide the only means of notifying, informing and/or restricting the general public to live conductors and a significant safety event.

7.2.6 Extreme weather events (climate change)

Climate change and an increase in extreme weather events (wind or microburst) beyond the current design capabilities of the support structure resulting in a fallen support structure and death or serious injury, loss of supply to customer load or a bushfire as a result of fallen conductors. Older support structures built to obsolete standards in particular may be more susceptible to failure in extreme weather events.

7.3 Historical condition monitoring

All TasNetworks transmission line support structures undergo routine visual inspections, with any defective assets recorded and prioritised within TasNetworks asset management system in accordance with the ‘Transmission Line Defect Priority Standard’. These defects are then issued to TasNetworks staff or contractors for action within the specified timeframes.

The analysis of historical defects for particular support structure types can be useful in identifying systemic or emerging failure modes, with the results of this analysis influencing operational or capital expenditure. This information is detailed within TasNetworks condition assessment reports.

7.3.1 Steel lattice towers (galvanised)

There are no asset specific condition monitoring activities for galvanised steel lattice towers.

7.3.2 Steel lattice towers (weather resistant steel)

Recent inspections of weather resistant steel (WRS) towers have revealed significant joint pack-out is occurring on some structures.

A new strategy has been developed to manage the circumstances of join pack out, centres around specific condition monitoring activities for steel lattice towers (WRS), replacement of members, and treatment where join pack out is significant.

7.3.3 Wood poles

Wood pole structures generally consist of two wood poles treated with copper chromium arsenic (CCA), and a steel cross piece constructed in an ‘H’ arrangement with guy wires as required.

These structures must be maintained in a serviceable state to mitigate pole failure and the risk of the conductor falling to ground, and to ensure that transmission faults do not pose an unacceptable risk to the public or personnel.

Wood pole structures have an economic life of 45 years, and while economic age is not the predominant driver for asset replacement decisions, it is important to recognise that the probability of failure increases significantly towards the end of an asset’s useful life. As such, incremental component renewal is no longer considered viable when a wood pole structure approaches its stated economic life.

TasNetworks routinely tests wood pole cores every three years to determine the remaining sound wood within a pole. TasNetworks policy that any pole found to have insufficient sound wood will be condemned, with replacement to occur within three months.

A cost-benefit analysis of the various wood pole replacement options have identified that the option with the lowest whole of life cost is:

- suspension structures – in the event of one or both wood poles being condemned, TasNetworks will replace the structure with a single steel pole; and
- strain structures - in the event of one or both wood poles being condemned, TasNetworks will replace the structure with two steel poles.

Pole staking (as commonly used on distribution wood poles) has been considered as a refurbishment option. This option was rejected due to the greater height of transmission line wood poles, and the associated increase in pole loading. These additional loads decrease the effectiveness of pole staking and fail to sufficiently mitigate the risk of pole failure. Due to safety and reliability factors, as well as being the lowest whole of life cost, pole replacement is preferred.

Prior to 2011, poles were only tested at the base of each wood pole. In 2011 pole rot was identifies at the pole tops, where the pole is connected to the pole riser. TasNetworks has subsequently expanded the scope of its testing regime to include pole tops.

7.3.4 Steel poles

As part of its post-project quality assurance activities, TasNetworks measures the galvanising thickness for a selection of steel poles. Initially poles with insufficient galvanising are identified, these measurements are used as a benchmark by TasNetworks, against which future rates of corrosion or degradation can be compared.

7.3.5 Kay poles

There are no asset specific condition monitoring activities for kay poles. At present there are 20 Kay poles in the transmission located on the Triabunna Spur transmission line, and these poles are due for replacement during the 2017 -2018 financial year, as part of the Kay pole replacement program.

7.4 Summary of risk

Table 3 summarises the transmission line support structure foundations risks, their mitigation strategy and residual risk levels.

Table 3 Transmission line support structure foundation risk analysis

RISK IDENTIFICATION		RISK ANALYSIS				RISK MITIGATION	
Risk	**Detailed Risk**	**Category**	**Likelihood**	**Consequence**	**Risk Rank**	**Mitigating Action(s)**	**Residual Risk Rating**
Unidentified degradation of support structures	Unidentified degradation and loss of strength through corrosion results in fallen support structure, death or serious injury, loss of supply to customer load or a bushfire as a result of fallen conductors.	Safety and People	Rare	Severe	Medium	• Perform full condition assessment of support structures on a periodic basis and ground inspection annually. • Continued implementation of the support structure risk integrity testing regime. • Where required, confirm load bearing capacity of existing support structures. • Asset refurbishment or replacement as required.	Medium
		Financial	Rare	Moderate	Low		Low
		Customer	Rare	Moderate	Low		Low
		Regulatory Compliance	Rare	Minor	Low		Low
		Network Performance	Rare	Moderate	Low		Low
		Reputation	Rare	Moderate	Low		Low
		Environment & Community	Rare	Severe	Medium		Medium
Deterioration and failure due to poor maintenance	Support structure failure through lack of maintenance to bolts or member failure results in fallen support structure, death or serious injury, loss of supply to customer load or a bushfire as a result of fallen conductors.	Safety and People	Rare	Severe	Medium	• Perform full condition assessment of support structures on a periodic basis and ground inspection annually. • Repair or replace defective fittings through condition assessment activities. • Continued implementation of the support structure preventative maintenance regimes. • Asset refurbishment or replacement as required.	Medium
		Financial	Rare	Moderate	Low		Low
		Customer	Rare	Moderate	Low		Low
		Regulatory Compliance	Rare	Minor	Low		Low
		Network Performance	Rare	Moderate	Low		Low
		Reputation	Rare	Moderate	Low		Low
		Environment & Community	Rare	Severe	Medium		Medium
Wood pole rot/decay	Wood pole failure results in fallen support structure, death or serious injury, loss of supply to customer load or a bushfire as a result of fallen conductors.	Safety and People	Rare	Severe	Medium	• Perform full condition assessment of structures on a periodic basis and ground inspection annually. • Asset replacement as required.	
		Financial	Rare	Moderate	Low		Low
		Customer	Rare	Moderate	Low		Low
		Regulatory Compliance	Rare	Minor	Low		Low
		Network Performance	Rare	Moderate	Low		Low
		Reputation	Rare	Moderate	Low		Low
		Environment & Community	Rare	Severe	Medium		Low

RISK IDENTIFICATION		RISK ANALYSIS				RISK MITIGATION	
Risk	**Detailed Risk**	**Category**	**Likelihood**	**Consequence**	**Risk Rank**	**Mitigating Action(s)**	**Residual Risk Rating**
Transmission line augmentation	Failure to reassess structural load changes results in a fallen support structure and death or serious injury, loss of supply to customer load or a bushfire as a result of fallen conductors.	Safety and People	Rare	Severe	Medium	• Assess all structural changes to support structures for compliance against AS7000. If required, modify or replace the support structure to bring it up to the required standard.	Low
		Financial	Rare	Moderate	Low		Low
		Customer	Rare	Moderate	Low		Low
		Regulatory Compliance	Rare	Minor	Low		Low
		Network Performance	Rare	Moderate	Low		Low
		Reputation	Rare	Moderate	Low		Low
		Environment & Community	Rare	Severe	Medium		Low
Unauthorised access	Lack of climbing barriers and signage results in serious injury/death to a member of the public through unauthorised climbing.	Safety and People	Rare	Severe	Medium	• Perform visual inspections of barriers on a periodic basis and ground inspection annually. • Public education of dangers of electrical infrastructure • Installation of new barriers and signage where land use changes to a more urban environment	Medium
		Financial	Rare	Moderate	Low		Low
		Customer	Rare	Moderate	Low		Low
		Regulatory Compliance	Rare	Minor	Low		Low
		Network Performance	Rare	Moderate	Low		Low
		Reputation	Rare	Moderate	Low		Low
		Environment & Community	Rare	Severe	Medium		Medium
Extreme weather events	Extreme weather event (wind or microburst) beyond the design capabilities of the support structure resulting in a fallen support structure and death or serious injury, loss of supply to customer load or a bushfire as a result of fallen conductors. Bushfire event damages support structure through temperature (steel) or burning (wood) increasing the risk of failure.	Safety and People	Rare	Severe	Medium	• Monitor weather pattern trends in Australia to determine any potential change to likelihood of extreme weather events. • Ensure any renewals take future weather changes and bushfire risk into consideration during design. • Assess impacted support structures post extreme event for evidence of damage. • Replace wood pole with steel poles in bushfire areas.	Medium
		Financial	Rare	Minor	Low		Low
		Customer	Rare	Moderate	Low		Low
		Regulatory Compliance	Rare	Minor	Low		Low
		Network Performance	Rare	Moderate	Low		Low
		Reputation	Rare	Moderate	Low		Low
		Environment & Community	Rare	Severe	Medium		Medium

8 Management plan

8.1 Maintenance strategy

The good performance of transmission line support structures is partially achieved through the implementation of a programmed condition assessment regime and resulting asset management activities such as asset refurbishment or replacement.

As transmission line support structures age, different life cycle issues and failure modes arise and must be captured in the preventative and corrective practices. Table 4 provides a summary of the life cycle issues applicable to insulator assemblies.

Table 4: Life cycle issues

Type of support structure	Issue
All	TasNetworks' transmission line support structures are among the oldest transmission line support structures in Australia and it is likely that structure condition will exhibit an increase in deterioration. To support TasNetworks' medium and long term vision, it may be necessary for transmission lines to be either augmented or decommissioned. Where this occurs it is important that TasNetworks consider the requirements of new and more onerous design standards to ensure that compliance is maintained. New conductor design technologies are providing greater electrical energy transfer capacity and/or reduced structural loading. Re-conductoring options are increasingly likely to be utilised as part of augmentation activities, ultimately resulting in an extension of the useful life of transmission line support structures.
Lattice steel towers (mild and WRS), steel poles and climbing barriers	Steel corrosion due to environmental conditions.
K-poles	Steel corrosion due to environmental conditions. K-poles were manufactured in the 1920s and are amongst the oldest transmission line structures in Australia. It is likely that structure condition will exhibit an increase in deterioration.
Wood	Wood rot at pole base Pole top rot due to previous deep scarfing to accommodate a pole top extension. Wood poles are susceptible to bushfires, with replacement often required in this event. The increasing difficulty of sourcing wooden poles, reducing costs of steel poles, and the environmental obligations for the disposal of wood poles, have provided economic and practical justification to replace wood poles with modern equivalent steel poles.
Decommissioned structures	There are a small number of transmission line support structures in the fleet where circuits are no longer energised or where the conductors have been removed. These transmission line support structures are being kept in 'vertical storage' so as to protect TasNetworks' right to the easement or right of way. Any attempt to abandon or remove the infrastructure may take away TasNetworks' right to utilise the easement for the construction of new transmission lines in the future. Preventive maintenance on these transmission line support structures is conducted to ensure that safety and environmental risks are managed.
Warning signs	Exposure to UV light results in the deterioration of colours (particularly the colour red) and lettering used on TasNetworks' warning signs. TasNetworks has recently tested a new type of sign with a significantly longer life (up to 30 years) than those previously installed on transmission line structures (up to 7 years). These signs will be utilised more often in the future.

8.1.1 Preventative maintenance

Preventive maintenance is, by its nature, a planned and scheduled maintenance activity that is completed to a predetermined scope, and consists of:

- Condition assessment - the routine inspection, testing and monitoring of assets to ascertain their condition.
- Maintenance (routine and condition based) - assets are maintained either on predetermined frequency basis (time-based) or in response to findings arising from condition assessment activities.

TasNetworks has adopted internationally recognised procedures for the assessment and maintenance of its transmission line support structure foundations. Condition assessments by air and by ground each have their merits which must be balanced to achieve an optimum level of cost effectiveness and overall outcomes efficiency.

After consideration of the many factors applying to Tasmania's geography, climatic conditions and the history of known deterioration of transmission line support structure foundations in this environment, TasNetworks' has adopted the preventive maintenance strategies summarised in Table 5.

Table 5: Preventative maintenance strategies

Strategy	Frequency	Description
'Detailed methodical' aerial condition assessment	3 year cycle	• A detailed condition assessment is conducted utilising a helicopter (approximately 33 per cent of total structures per year). • Effective for approximately 97 per cent of the transmission line population over the 3 year period. The remainder is subject to a climbing condition assessment.
'Detailed methodical' climbing condition assessment	3 year cycle	• A detailed condition assessment is conducted by climbing individual structures. • Applies to approximately 3 per cent of total structures over the 3 year period. • Only applicable where 'no-fly' areas prevent the use of a helicopter.
Ground-based inspections (non-climbing)	Annually	• A visual inspection aimed at identifying obvious defects that could impair the electrical or structural integrity of the transmission line. • Any defects are reported. • Applies to the structures that did not receive a 'detailed methodical' inspection (i.e. 67 per cent of total structures).
Wood pole testing	3 year cycle	• Every three years TasNetworks tests 100 per cent of the wood pole population for rot. Testing of poles within new lines does not commence until they are 20yrs old. • Condemned poles are programmed for replacement within three months.
Specialised inspection and test regimes	As required	• If TasNetworks identifies a new or unusual failure mode, then targeted inspection or test regimes may be employed.

8.1.2 Corrective maintenance

In the event of a fault condition TasNetworks will arrange for corrective maintenance to occur to either replace the asset, or undertake other activities to restore the asset to an appropriate level of service.

8.1.3 Routine maintenance versus non routine maintenance

Transmission line support structure failures may cause serious or catastrophic damage to a transmission line causing transmission outages and a real risk to the public and surrounding infrastructure. Whilst these assets have a low unit value, the failure of a foundation could cause significant damage to a transmission line so a preventative corrective maintenance program represents a cost effective alternative to a reactive corrective maintenance program.

8.1.4 Refurbishment

Transmission line support structures may be able to be refurbished in situ. The decision to refurbish or replace is determined on a condition, risk and economic basis.

8.1.5 Planned asset replacement versus reactive asset replacement

Similarly to Section 8.1.3, a reactive replacement does not represent an attractive alternative to a planned renewal activity. Transmission lines predominately connect generators to the network or supply major customers or population areas with high reliability requirements. Also reactive replacements are generally more expensive, incurring overtime, potential outage penalties and additional repair costs to structures and nearby infrastructure.

Replacement is generally only preferred when this is a more economic proposition compared to ongoing maintenance costs over the estimated remaining service life of the asset. These are identified from the maintenance and inspections activities and feed into the list of proposed capital expenditure projects for prioritisation.

8.1.6 Non network solutions

Transmission line structure structures form a critical part of the transmission network. As such any potential non-network solution would need to provide an alternative to the entire transmission line as a system rather than any specific solution which addresses only individual transmission line support structures.

8.1.7 Network augmentation impacts

TasNetworks' requirements for developing the power transmission system are principally driven by five elements:

- Demand forecasts
- New customer connection requests
- New generation requests
- Network performance requirements
- National electricity rules (NER) compliance

Installation of new foundations would be required as part of any transmission line development as a result of a network augmentation requirement.

8.1.8 Spares management

TasNetworks' maintains appropriate levels of asset spares for emergency response and other activities as defined within the System Spares Policy R517373.

8.2 Replacement

The cost of asset replacement activities that meet the capitalisation requirements outlined within TasNetworks' Asset Accounting Standard can be capitalised. These capital projects are detailed below.

Asset replacement activities not meeting these requirements will be undertaken as operational expenditure.

8.2.1 Kay Pole replacement program

Replacement of 42 Kay-poles on the Triabunna Spur 110 kV transmission line. This program will see the removal of all Kay poles from the transmission network.

8.2.2 Transmission lines support assembly refurbishment program

Transmission line support assemblies are assessed periodically with regard to economic, operational, and safety considerations. Condition assessment is used to identify the need to replace those support assemblies found to be at end of life; where there is evidence to suggest that the design characteristics of support assemblies are compromised. Common problems include corroded nuts and bolts, member corrosion, and member damage.

TasNetworks intends of replacing bolts on 100 support structure assemblies and bolts and members on 100 support structure assemblies on an annual basis.

8.2.3 Transmission Line wood pole renewal program

Replacement of wood pole structures identified as being at risk of failure, with either one (suspension) or two (strain) new steel poles. This program addresses all the requirements to mitigate the risk of asset failure by replacing those assets that are deemed to be in poor condition. This decreases the risk to public safety, and the risk to the environment.

As part of this program the remaining wood pole structures will be replaced on the Burnie – Waratah 110kV transmission line in the 2019-24 regulatory period.

8.2.4 Transmission line renewals

Recent condition assessments after aerial inspection in late 2016 has identified numerous Priority 3 defects[2] on two radial transmission lines connected to George Town Substation, all of which are caused by corrosion to the towers structural members, bolts, insulator strain assemblies, step bolts and anti-climbing devices. These issues apply to all of the support structures and both transmission lines have been deemed to be at end of life and should be renewed.

if corrective maintenance is not carried out to address these issues, ongoing reliability of the line cannot be ensured.

[2] Priority 3 transmission line defects have a 12 month resolution timeframe.

8.3 Program delivery

The needs assessment and options analysis for undertaking an asset management activity is documented in the Investment Evaluation Summary for that activity.

The delivery of these activities follows TasNetworks' end to end (E2E) works delivery process.

8.4 Disposal plan

Due to the need to preserve TasNetworks' easements there are some transmission line structures held on-site in vertical storage even though the line is out-of-service. Maintenance must continue on these structures until easement arrangements are finalised and the structures can be dismantled and recovered or disposed of. Disposal of any transmission line support structures will be done in accordance with the relevant standards and procedures. All support structures will be removed and sites will be rehabilitated.

8.5 Technology and Innovation

TasNetworks recognises that a proactive approach to the life-cycle management of its assets is an established and accepted practice within the electrical industry.

This is evident through TasNetworks' participation in various benchmarking and best practice activities, locally and internationally.

9 Financial summary

9.1 Operational expenditure

Requirements for operating expenditure are a function of the defined periodic condition monitoring regimes, defined maintenance requirements and expected minor and major conductor assembly works.

The developed works plan is held and maintained in the works planning tool. It contains details such as planning dates, task types, specific assets and planned costs.

The planned costs for each differing task type are derived from either unit rates from Contractors or averaged historical costs.

9.2 Capital expenditure

Transmission line support structures capital works are typically combined with other works to optimise system performance and mitigate network and business risk.

The projected capital expenditure required to implement the support structures capital program is subject to change and optimisation as the integrated works plan is refined and further developed.

Each project within the program is then subjected to a detailed investment evaluation.

9.3 Investment evaluation

For each program or project to be included within the upcoming revenue proposal, an Investment Evaluation Summary (IES) is prepared describing the condition, performance and risk issues identified within this and other asset management plans.

The IES then identifies a preferred option using cost estimates that have been developed in line with TasNetworks' estimation process. Each option is evaluated on both technical and financial merits and the preferred option is submitted for regulatory approval.

The Investment Evaluation Summaries associated with the current 2014–2019 capital program and proposed 2019-2024 capital program for transmission line support structure foundations are listed in Appendix B.

10 Related standards and documentation

The following documents have been used to either in the development of this management plan, or provide supporting information to it:

- AS/NZS 7000:2016 Overhead line design
- D13/29434 TasNetworks Normative to AS/NZS7000:2010
- D05/12858 Transmission Line Design standard
- D04/10170 Transport and Use of Chemicals
- D05/44571 Excavation Standard
- D07/67177 Transmission Line Construction standard

Appendix A Support structures renewals profile

Year	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29
Kay Poles		42										
Support assemblies - bolts (support structures)	100	100	100	100	100	100	100	100	100	100	100	100
Support assemblies - members (support structures)	100	100	100	100	100	100	100	100	100	100	100	100
Wood Pole Replacements			47			40						
Transmission Line renewals		TL511				TL447						

Appendix B Investment Evaluation Summaries

The following Investment Evaluation Summary (IES) documents relate to transmission line support structure foundations.

Reference	Name	Expenditure Type	Regulatory Period
R434058	Transmission Line Support Assembly Renewal Program Investment Evaluation Summary	CAPEX	2014-2019
R436233	Burnie-Waratah H-Pole Replacement Program Investment Evaluation Summary	CAPEX	2014-2019
R390082	Kay pole Replacement Program Investment Evaluation Summary	CAPEX	2014-2019
R778453	GT – CO 220 kV Transmission Line Renewal Investment Evaluation Summary	CAPEX	2014-2019
01421	Transmission Line Support Assembly Renewal Program Investment Evaluation Summary	CAPEX	2019-2024
01425	Burnie-Waratah H-Pole Replacement Program Investment Evaluation Summary	CAPEX	2019-2024
01428	GT – TE 110 kV Transmission Line Renewal Investment Evaluation Summary	CAPEX	2019-2024