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Asset Inspection Manual (at risk overhead lines)

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1. Purpose

Pacific Hydro owns private overhead lines at three wind farms in Victoria. As part of its asset management strategies and to comply with all relevant legislation and regulations Pacific Hydro undertakes planned periodic overhead line inspections.

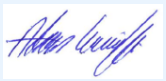
The objective of this manual is to provide guidance for conducting scheduled programmed inspections of overhead lines, the regulations that inspectors are to comply with and to identify the dominant failure modes of overhead line components.

2. Scope

This document contains information about the overhead assets that make up each of the overhead lines and their dominant failure modes which may cause significant asset failure, risk of fires or other health and safety risks. The symptoms associated with each of these failure modes are outlined which form the basis for the planned inspections.

This document is not intended to provide a detailed works description of how the inspections are to be undertaken.

3. Document approval

Name / Originator	Title	Description	Date	Signature
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4. Definitions

For the purposes of this document, the following terms and definitions apply:

Term	Definition/Abbreviations
Asset Inspector	A competent person carrying out inspections in accordance with current Pacific Hydro Asset Inspection Manual (at Risk Electric Line) and has satisfactorily completed a training course approved by Energy Safe Victoria.
Operations and maintenance provider	Contractor to which the scope of the contract is to operate and maintain the (Pacific Blue at risk assets
CCA	Copper chrome arsenic is a preservative added to timber to prolong the life of wooden poles
Defect	A defect is any fault in the design, function or qualitative characteristic of an item in operation which differs from the specification, the drawing or recognised standard of good workmanship for that item other than that classified as 'fair wear and tear' within manufacturer's limits and that effects operational functionality or performance
Failure	A Failure is a substandard condition of a component or asset that causes the plant to breakdown or trip. Immediate repair is needed to restore the plant to
Failure Symptoms	Observed or indicating condition of a possible failure that is apparent to the users, owners or downstream customers of the asset or equipment. The symptom may not necessarily be observed at the asset or where defect occurred
CMMS	Computerized Maintenance Management System
PHA	(Pacific Blue
CHWF	Challicum Hills Wind Farm
CRW	Crowlands Wind Farm
Failure Mode	How a component, equipment, asset or system can fail. It is possible to have several failure modes and several causes that contribute to an event.
Dominant Failure Mode	Are identified as key failure modes that are most probable to be evident on the component/equipment/asset or system in its current operating context across the network. This is usually identified through either industry data, O&M experience, failure history or condition assessment reports. Not all failure modes for an asset in different parts of the industry are necessarily considered dominant. Dominant failure modes are where the basis of inspection activities should occur at a minimum.

5. Roles and Responsibilities

The key roles and responsibilities as outlined on the following table:

Roles	Responsibilities
Asset Inspector	The person or persons conducting the asset and component inspection activity, be it scheduled or non-scheduled. Their responsibility is to carry out Asset inspections on (Pacific Blue assets in accordance with current Pacific Hydro Asset Inspection Manual (at Risk Electric Line) to identify, record and report any hazards and risk that would be deemed unserviceable.
Operations and Maintenance Provider	To perform routine asset inspection within the Pacific Hydro Bushfire Mitigation Pacific Blue and ensure all reports and rectifications are completed within the assessed timeframe. To ensure all contractors follow the health and safety advise, direction from this manual, policies and procedures.
Wind Fleet Contract Manager	To audit the Operations and Maintenance Provider against this Manual and the Bushfire Mitigation Plan Pacific Blue and ensure inspections and rectification are completed within the assessed timeframe.
Senior Operations Engineer	To provide technical advice and continuous improvement on this Manual. To audit the asset inspections and rectification plans.
Executive manager of Operations	Owner, reviewer and endorsement of this Manual and Bushfire Mitigation Plan. To ensure Pacific Hydro and the Operations and Maintenance Provider's policy and procedures are in compliance to the local acts and regulations.

6. References

[1] Pacific Hydro Australia. (n.d.). PHA.OPS.08.006 Bushfire Mitigation Plan. Melbourne: Operations .
[2] Standards Australia. (2016). AS 7000 Overhead Line Design. SAI Global.
[3] Victorian Government (2023). Electricity Safety (Bushfire Mitigation) Regulations (Statutory Rule Number 40/2023).

7. Site Descriptions

7.1 Portland Wind Energy Project

The Portland Wind Farm consists of four connected individual wind farms located to the South and West of the city of Portland:

- Cape Bridgewater windfarm consisting of 29 turbines
- Cape Nelson South Wind Farm consisting of 22 turbines
- Cape Nelson North / Sir William Grant Wind Farm consisting of 23 turbines.

These wind farms are connected via sub-transmission overhead lines with a total length of approximately 45 km of 66kV overhead lines (some single and some double circuit. The lines run

from the P3C substation at the Alcoa Portland Aluminium Switchyard to the Cape Bridgewater, Cape Nelson North and Cape Nelson South substations. Some of the poles are owned by Powercor with Pacific Hydro owned pole top asset components.

Powercor Australia Ltd, now Beon Energy Solutions, have been the main contracted Operations and Maintenance provider for the assets since the commissioning of the Wind Farm/s in 2008. Figure 1 below shows an overview of the overhead lines.

Key	Description
	Wind turbine generator
	Overhead power line
	Overhead power line Challicum Hills
	Underground cable
	Poles owned by Pacific Hydro
	Poles owned and maintained by DNSP (Powercor)

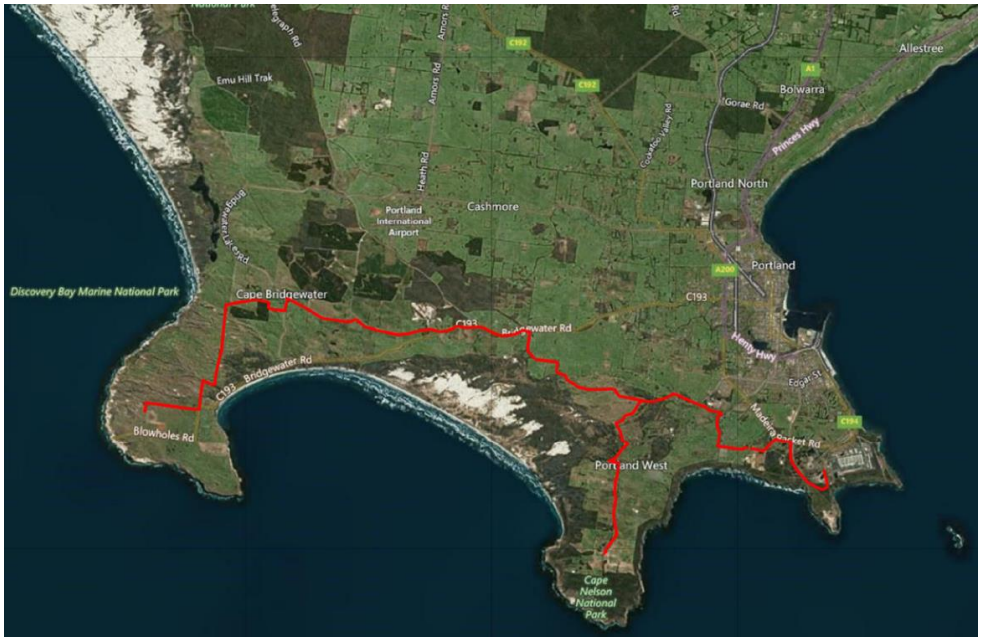


Figure 1 - Portland Wind Farm site layout - Overhead power line

7.2 Challicum Hills Wind Farm

Challicum Hills Wind Farm consists of 35 turbines commissioned in 2003 located on private farming land to the east of Ararat.

The 66kV overhead electric lines under the ownership of Pacific Hydro are located between the Buangor (BGR) switching station and the Challicum Hills substation are a single pole (double circuit) line 5 km in length. Powercor Australia Ltd, now Beon Energy Services, has been the main contracted Operations and Maintenance provider for the assets since the commissioning of the Wind Farm in 2003. Figure 2 below shows an overview of the overhead lines.

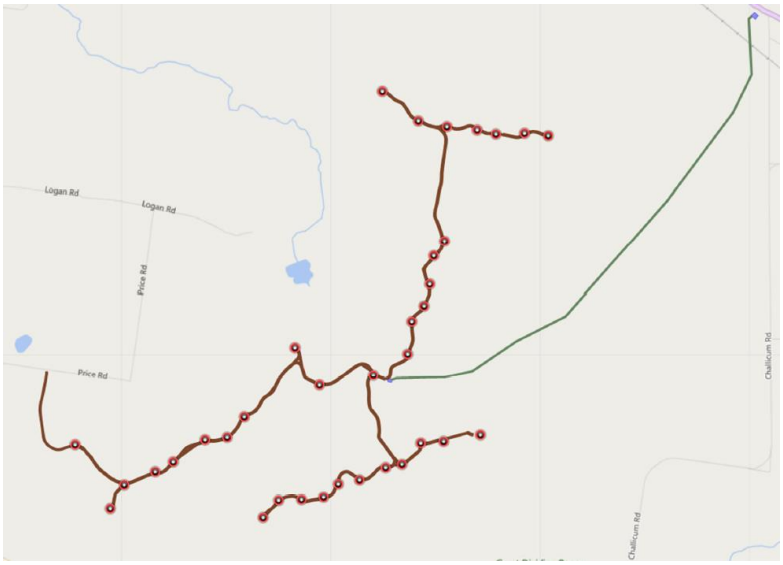


Figure 2 - Challicum Hills Wind Farm Site Layout - Overhead Lines

7.3 Crowlands Wind Farm

Crowlands Wind Farm is located in Western Victoria's Pyrenees Shire Council, 25km north-east of Ararat (205km west of Melbourne) consisting of 39 turbines.

The 33kV overhead electric lines under the ownership of Pacific Hydro are located immediately to the north of the 220kV Crowlands terminal station (Pole# 1 & 22) and the branch to the North (pole#2 – pole#21) and East (pole# 23 – pole#43). They consist of single pole, single and double circuit line with a combined approximately length of 15 km in length.

TW Power Services Pty Ltd has been engaged as the main Operations and Maintenance provider for the Wind Farm, including the overhead line assets.

Figure 3 below shows an overview of the overhead lines.

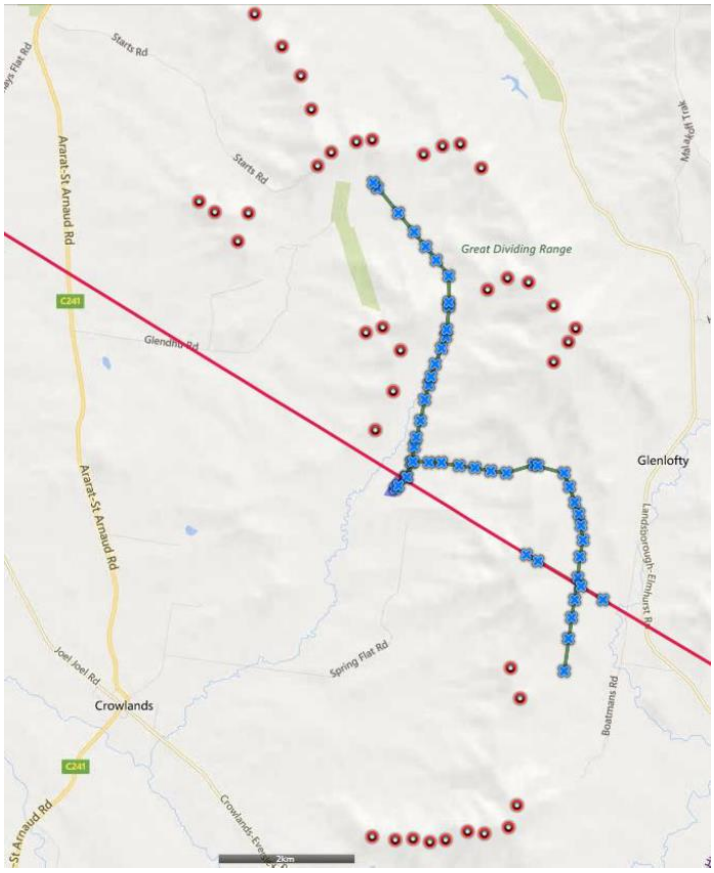


Figure 3 - Crowlands Wind Farm Site Layout - Overhead lines

8. Asset Descriptions

8.1 Asset Component Descriptions

8.1.1 Insulators

There are two types of insulators used for Pacific Hydro overhead lines: post and string type with materials of either porcelain, ceramic or glass. The following table summarises the insulators at each of the sites:

Wind Farm Site	Voltage	Insulator Type	Insulator Material
Portland Wind Energy Project	66kV	Post and Strain+String	Porcelain (CBW, CSWG, CNN) Silicone (CNS)
Challicum Hills Wind Farm	66kV	Post and Strain+String	Porcelain, Silicone
Crowlands Wind Farm	33kV	Post and Strain+String	Glass, Porcelain

There are a number of issues that may cause insulators to fail including:

- Incorrect installation such as incorrect fastening which may cause the insulator to become loose over time
- Excessive wind stress or tension which may cause loose connections or cracking
- Corrosion of the pin holding the insulators
- Less than the minimum required creepage
- A lightning strike causing a flashover
- Biological growth such as fungi resulting in a partial discharge from the degradation of the insulation

Below are images of some these defects; a missing insulator bolt, loose connections, punctured insulators and flashovers:





Figure 4 missing insulator bolt Figure 5 loose insulator connection





Figure 6 Punctured insulator Figure 7 Insulators with potential flashovers

8.1.2 Fauna Covers

Pacific Hydro uses fauna covers at Crowlands Windfarm at the interface points between the underground and overhead line. They are used to prevent animals such as possums climbing structures resulting in live bare conductor flashovers.

There are several issues that may cause insulators to fail including:

- Incorrect installation such as incorrect fastening which may cause the cover to become loose over time

- Flashovers from animals or vegetation (potentially from ill-fitting covers)
- Age or general wear of the covers

8.1.3 Surge Arresters

Surge arresters are primarily use on Pacific Hydro sites to protect switchgear, transformers and cables from overvoltage events. Surge arrester can be identified by the two terminals; one connects to the line voltage and the other to earth. The earth point is usually at the base of the device.

There are a number of issues that may cause surge arrestors to fail including:

- Incorrect installation such as incorrect fastening which may cause the surge arrestor to become loose over time
- Temporary over-voltages causing flashover
- Moisture ingress into the arrestor which could flashover
- Incorrect earthing of the arrestor
- Excess energy containment during surge events could cause bulging of the arrestor tank

Below are examples of damaged surge arrestors.



Figure 8 Damaged Surge Arrestors

8.1.4 Conductors

The main conductor type utilised by Pacific Hydro is bare open wire conductor, All Aluminium Conductor (AAC). There is currently no Aluminium Conductor Steel Reinforced (ACSR) installed for any of the overhead lines.

Earthing conductors are used to connect non-current carrying metal components to the earthing system by providing a low impedance path for the flow of earth fault current.

Pacific Hydro has small quantities of covered conductor for small sections of the pole (1-2 metres) where the transition from overhead to the underground network occurs. In addition, there are small quantities of underground cables that run from the UGOH transition point down to the base of the pole.

The following table summarises the conductors at each of the sites:

Wind Farm Site	Conductor Usage	Conductor Type
Portland Wind Energy Project	Primary overhead conductor	Oxygen 19/4.75 AAC Neon 19/3.75 AAC
Challicum Hills Wind Farm	Primary overhead conductor	Oxygen 19/4.75 AAC
Crowlands Wind Farm	Primary overhead conductor	Nobelium 37/3.25 AAAC Phosphorus 37/3.75 AAAC
	Overhead earthing conductor	ZTT 13.9mm
	UGOH termination conductor	Raychem 36KV OXSU-F ABB 36KV Kabeldon 33KV 3 core Al XLPE PVC HDPE 400mm2 Circular

There are a number of issues that may cause conductors to fail including:

- Wear and tear (particularly strands and ties) as the conductor ages
- Corrosion from long term exposure to areas near the coast
- Excessive conductor movement (sway) from wind which may cause loose connections, strand cracking or conductor wear and tear
- Insufficient conductor tension due to losing tension over time
- A lightning strike causing a flashover

In addition, there are other dominant failure modes for covered conductors or the underground cables on termination poles including:

- Insulation damage can be caused by excessive wind thermally expanding the heart shrink and rubbing on the insulation as it expands
- Partial discharge of the covered or underground cable
- Moisture ingress under the tape which covers the termination ends

Below are images of some these defects; a corroded hv cable tie, flashover or fire damaged cable connector, broken connectors and hot connectors.



Figure 9 Corroded HV tie



Figure 10 Flashover or fire damaged connector



Figure 11 Broken Connector

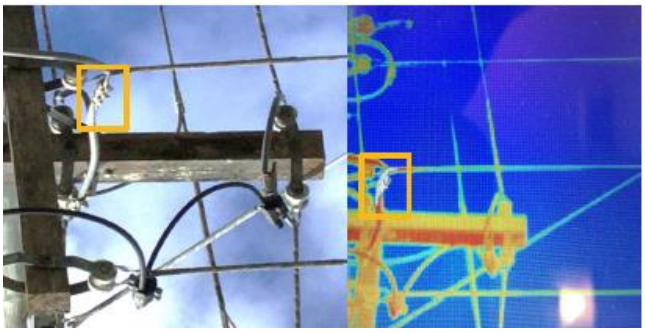


Figure 12 Hot PG Clamp

8.1.5 Cross arms

Cross arms provide physical support for the insulators and conductors and also space the conductors so that minimum phase to phase clearances are maintained. Pacific Hydro utilises only steel galvanised cross arms for its overhead lines even with its wooden poles.

There are a number of issues that may cause cross-arms to fail including:

- Incorrect installation such as incorrect fastening which may cause the king bolt to become loose over time
- Birds using cross arms as a nest
- Wear and tear as the cross-arm ages
- Corrosion from long term exposure to areas near the coast (particularly fastenings)
- Excessive wind which may cause loose connections or steel fatigue
- Leakage current occurring across the cross arm

Below are images of some these defects; a missing king bolt, aged cross arm and corroded steel cross arms.



Figure 13 Missing king bolt



Figure 14 Aged, worn cross arm



Figure 15 Surface rust



Figure 16 Significant rust

8.1.6 Poles and Stays

Pacific Hydro's overhead line poles consist of wood, steel and concrete. There are some lines (mentioned in 6. Site Descriptions) where Pacific Hydro has its conductors and pole top hardware (such as cross arms) located on third party owned poles. These poles are not required to be inspected by Pacific Hydro.

The following table summarises the poles at each of the sites:

Wind Farm Site	Voltage	Pole Material
Portland Wind Energy Project	66kV	Wood Class II H5 CCA treated Black Butt 12kN
Challicum Hills Wind Farm	66kV	Wood Class II H5 CCA treated Black Butt 12kN (2 poles are concrete)
Crowlands Wind Farm	33kV	Galvanised Steel slip joint (600g/m^2) Class II Grade 250 plates and 300 for sections

There are a number of issues that may cause poles to fail including:

- Uneven forces on the poles which may cause the poles to lean
- Vehicles, trees or machinery (such as farm equipment) colliding with poles
- Fire damage (particularly from grass fires)
- Lightning strikes on poles
- Corrosion of steel poles from long term exposure to areas near the coast
- Concrete decay of concrete spun poles
- Termites degrading wood poles and reducing its strength
- Wood pole rot and wood pole splitting
- Pole top cap ill-fitting and not covering the top of the pole

In addition, there are several issues that may cause the stay wires to fail including:

- Corrosion of steel components (particularly below ground) from long term exposure to areas near the coast
- Vehicles, trees or machinery (such as farm equipment) colliding with stays
- Wear and tear of the stay wire or the insulator as they age
- Excess movement of the stay wire caused excessive wind or forces
- Stay wire anchors becoming loose because of incorrect installation or ground movement

Below are images of some these defects; a split pole top, a missing pole top cap, leaning pole, a lightning damaged pole, pole splitting, corrosion and a damaged stay wire.



Figure 17 Split at top of pole



Figure 18 Missing pole top cap



Figure 19 Leaning Pole



Figure 20 Lightning damaged pole





Figure 21 Pole Splitting **Figure 22 Steel pole corrosion**



Figure 23 Damaged, loose stay wire

8.1.7 Foundations

The poles contain a below ground section of several metres and are supported by foundations or footings where concrete is installed around its base. Pole foundations are critical to maintaining the pole and overhead line alignment.

There are a number of issues that may cause the foundation to fail including:

- Concrete decay
- Poor drainage causing exposure of the pole base or soil erosion
- Excess wind stress

8.2 Dominant Failure modes

A failure mode describes how a component, equipment, asset or system can fail. It is possible to have several failure modes and several causes that contribute to an event. Dominant failure modes are key failure modes that are most probable to be evident on the component / equipment / asset or system in its current operating context across the network. Dominant failure modes are where the basis of inspection activities should occur at a minimum.

The following table summarises the dominant failure modes for each asset type as well as the symptoms that are most likely to identify this failure modes.

Asset Component	Component Types	Failure type/cause	Symptom/s
Insulators (including for stays)	All types	Incorrect installation	Not properly secured to the pole
		Excess wind stress or tension stress	Loose connections/cracking
		Pin corrosion	Discoloration of the pin

		External flashover or partial discharge causing degradation of insulation	Evidence of lightning strike (arc melts, blackening of materials) or ozone
		Biological agents reduce insulation properties	Discoloration / bio-furial growth (black, green moss)
		Less than the minimum amount of insulator creepage distance	Missing / damaged sheds/disks
Fauna Covers	Fauna Covers (birds)	Incorrect installation	Loosely fitted
		Flashover (animals/vegetation)	Evidence of flashover, blackening of materials
		Age (cracked)	damage or excessive wear
Surge Arresters	Surge Arresters	Incorrect installation	Connectors/ties are loose
		Temporary Overvoltage or moisture ingress causing flashover	Visual damage, blackened areas
		Incorrect earthing arrangements	Loose or missing connections
		Excess energy containment (for silicon metal oxide surge arrestors)	Bulging sides of surge arrestor, punctures and/or charring
Conductors (including stays)	All Bare Conductors	Age	Connectors/ties are loose
		Excessive conductor movement (sway)	Damaged conductor or ties
		Corrosion	Evidence of corrosion or rust (conductor or ties)
		Flashover	Evidence of lightning strike (arc melts, blackening of conductor)
		Age/ excessive conductor movement	Evidence of fretting / strand failure (frail conductor strands)

	Covered or Underground Conductor	Insulation damage	Cracks or annealed insulation
		Excessive wind load causing thermal expansion	Heat shrink damage
		Moisture Ingress under tape over cable termination end	Discolored or ill-fitting tape
Crossarms	Crossarms	Age	Not properly secured to the pole
		Excess wind stress	Evidence of steel fatigue
		corrosion	Evidence of corrosion or rust
		Environment	Wildlife / nesting
Poles	All Pole Types	Uneven forces on the pole	Any lean in poles greater than 10 deg from vertical
		Vehicle, tree or machinery impact	Evidence of structural damage
	Wood	Termites within a depth of 300mm below ground	Evidence of termites within a depth of 300mm below ground
		Fire damage / lightning strike	Charring/pole splitting \ blackened marks
		Degradation	Girth less than 550mm within 200mm above the ground
		Wood Pole rot	Evidence of annulus of at least 50mm
		Wooden pole splitting	Evidence of external decay/ cracks
		Pole top cap loose	Cap is correctly fastened and sealed
	Steel	Age and salinity causing corrosion	The thickness of any corroded area below the ground less than 75% of the sound metal above the ground

	Concrete	Concrete decay	Evidence of concrete decay or exposed metal reo
	Stay	Corrosion below ground	Corrosion / rust
		Vehicle, tree or machinery impact	Evidence of structural damage, wire not under tension
		Stay anchor incorrectly installed / excessive forces	Pole learning / loose fitting
Foundation / Pole Base	Foundation	Concrete decay	Evidence of concrete decay or exposed metal reo
		Excess wind stress leading to pole footing failure	Uneven pole, concrete cracking
		Poor drainage	Water pooling
		Exposure of pole base from subsidence / soil erosion	Uneven ground, pole at less than minimum depth

9. Regulatory Compliance Requirements

There are a number of regulatory compliance and standards that Pacific Hydro are required to meet for inspection activities relating to overhead power lines. These requirements include:

- Electrical Safety Act 1998
- Electricity Safety (Bushfire Mitigation) Regulations 2023 (Statutory Rule Number 40/2023)
- Electricity Safety (Electric Line Clearance) Regulations 2020
- Australian Standards AS7000:2016 Extracts relating to Inspection and Maintenance of Distributors

9.1 Electrical Safety Act 1998

The purpose of the Electricity Safety Act is to outline the requirements for the safety of electrical supply and use, reliability and security of supply and the efficiency of electrical equipment. The act includes provision 113F which states that inspections of private lines are to take place at prescribed times and in accordance with prescribed standards (although its does not prescribe specific times or standards within the act itself).

The act also includes provisions 151A and 157 which authorise bushfire mitigation regulations which are discussed in the next section.

9.2 Electricity Safety (Bushfire Mitigation) Regulations 2023 (Statutory Rule Number 40/2023)

The objectives of these regulations is to make provision for:

(a) The preparation of bushfire mitigation plans by specified operators and major electricity companies; and

(b) the inspection of overhead electric lines and supply networks.

To comply with these regulations Pacific Hydro has developed a bushfire mitigation plan Pacific Blue which details how its bushfire mitigations are met in particular:

- Identification of possible ignition sources that could cause a fire, and
- Mitigating or reducing the likelihood and consequence of these through the implementation of effective preventative measures

The prescribed times by when an inspection of overhead private lines is required to be carried out are[1]:

(a) for private electric lines located in hazardous bushfire risk areas, no later than 37 months after the date of the previous inspection carried out by the major electricity company; and

(b) for private electric lines located in other areas, no later than 61 months after the date of the previous inspection carried out by the major electricity company.

The prescribed standards of the act for the inspection of private electric overhead line are[2]:

(a) the insulators and any stay wires are serviceable and are properly secured to the pole or cross-arm; and

(b) the cross-arms are serviceable; and

(c) the conductors and metal ties that secure the conductors to the insulator are serviceable; and

(d) in the case of a line that is horizontally constructed with bare open wire conductors, that a low voltage conductor spreader is fitted to each span of the line; and

Note

Regulation 236(1)(a) of the Electricity Safety (General) Regulations 2019 provides for the fitting of a spreader to each span of a private aerial line that is horizontally constructed with bare open wire conductors.

(e) in the case of a line that has bare open wire conductors, the line complies with the minimum clearance requirements for bare live conductors set out in Table 3.8 of the Australian/New Zealand Wiring Rules; and

(f) in the case of a line that has insulated and unsheathed live conductors—

(i) before 16 December 2023, the line complies with the minimum clearance requirements for insulated and unsheathed live conductors set out in Table 3.8 of the Australian/New Zealand Wiring Rules; and

[1] Electricity Safety (Bushfire Mitigation) Regulations 2023 (Statutory Rule Number 40/2023), Section 10 Prescribed times of inspection

[2] Electricity Safety (Bushfire Mitigation) Regulations 2023 (Statutory Rule Number 40/2023), Section 11 Prescribed standards of inspection

(ii) on or after 16 December 2023, the line complies with the minimum clearance requirements set out in regulation 12(1) and (3); and

(g) in the case of a line that is double insulated or is a neutral-screened cable—

(i) before 16 December 2023, the line complies with the minimum clearance requirements for a neutral-screened cable set out in Table 3.8 of the Australian/New Zealand Wiring Rules; and

(ii) on or after 16 December 2023, the line complies with the minimum clearance requirements set out in regulation 12(2) and (3); and

(h) the insulation is in a serviceable condition; and (i) the poles must not lean more than 10 degrees from the vertical; and

(i) the poles must not lean more than 10 degrees from the vertical; and

(j) in the case of wooden poles other than treated pine poles—

(i) the girth of the pole is greater than 550 mm at any point within 200 mm above the ground; and

(ii) the pole is free from termites to a depth of 300 mm below the surface of the ground; and

(iii) an annulus of at least 50 mm of the wood is free of decay; and (iv) no fruiting fungal bodies are observed; and

(k) in the case of treated pine poles—

(i) the girth of the pole is greater than 450 mm at any point within 200 mm above the ground; and

(ii) the pole is free from termites to a depth of 300 mm below the surface of the ground; and

(iii) the wood is free from external decay; and

(l) in the case of tubular and solid steel poles, the thickness of the metal of the pole in any corroded area below the ground is at least 75% of the sound metal above the ground; and

(m) in the case of concrete poles, the pole—

(i) is free of concrete decay; and

(ii) does not have exposed metal reinforcement; and

(n) the line complies with clause 3 of the Code; and

Note

The Code is the Code of Practice for Electric Line Clearance prescribed under regulation 7 of the Electricity Safety (Electric Line Clearance) Regulations 20205 and set out in Schedules 1 and 2 to those Regulations.

(o) if during an inspection a hazard tree is identified, the hazard tree is notified to the responsible person.

(2) In this regulation, a tree is a hazard tree if a suitably qualified arborist—

(a) has assessed the tree having regard to foreseeable local conditions; and

(b) has determined that the tree, or any part of the tree, is likely to fall onto, or otherwise come into contact with, an electric line.

(3) For the purpose of subregulations (1)(o) and (2), it is irrelevant that the tree is not within, and is not likely to grow into, the minimum clearance space for an electric line span.

(4) In this regulation—

conductor spreader has the same meaning as in the Electricity Safety (General) Regulations 2019;

horizontally constructed has the same meaning as in the Electricity Safety (General) Regulations 2019;

neutral-screened cable has the same meaning as "Cable, neutral-screened" has in the Australian/New Zealand Wiring Rules;

private aerial line has the same meaning as in the Electricity Safety (General) Regulations 2019.

The above requirements are incorporated into the inspection requirements for overhead lines.

9.3 Electrical Line Clearance Requirements

The Electrical Safety (Electric Line Clearance) Regulations prescribed the Code of Practice for Electric Line Clearance as well as standards for vegetation inspections, cutting, removal and protection. Part of the requirement of the regulations and code of practice is to prepare an annual Electric Line Clearance Management Plan.

The inspection requirements for electric line clearances and how they are met are outlined in Pacific Hydro's Electric Line Clearance Management Plan and are not considered by this document.

9.4 Australian Standards Requirements and Guidelines

The Australian Standards AS/NZS 7000:2016 provides electricity network owners, overhead line maintenance service providers or maintainers and private overhead line owners such as Pacific Hydro, an industry standard that outlines design, construction, maintenance and operational requirements.

Inspection and Maintenance activities defined by AS/NZS 7000:2016 include the following:

- Deadline Inspection and/or maintenance – when the line is de-energised or earthed for safe access
- Live Line inspection – provision of a safe access corridor on the structure in inspect components.
- Live Line Maintenance – May include stick or bare hand work either from the structure or insulated elevated work platform or helicopter (which is not approved on Pacific Hydro's owned overhead lines.

The guidelines in Table D3 of AS/NZS 7000:2016 standard, outline recommended inspection periods for timber poles, depending on the durability class, and preservative treatment for the protection against termites.

The standard also states that the recommended frequency of the termite inspection will vary based on different species of timber and field experience – such as asset data history and geographical zone locations. The location of the poles at the 3 sites are considered between Very Low to Moderate hazard according to the Termite Hazard map of Australia (Figure D1) in AS/NZS 7000:2016.

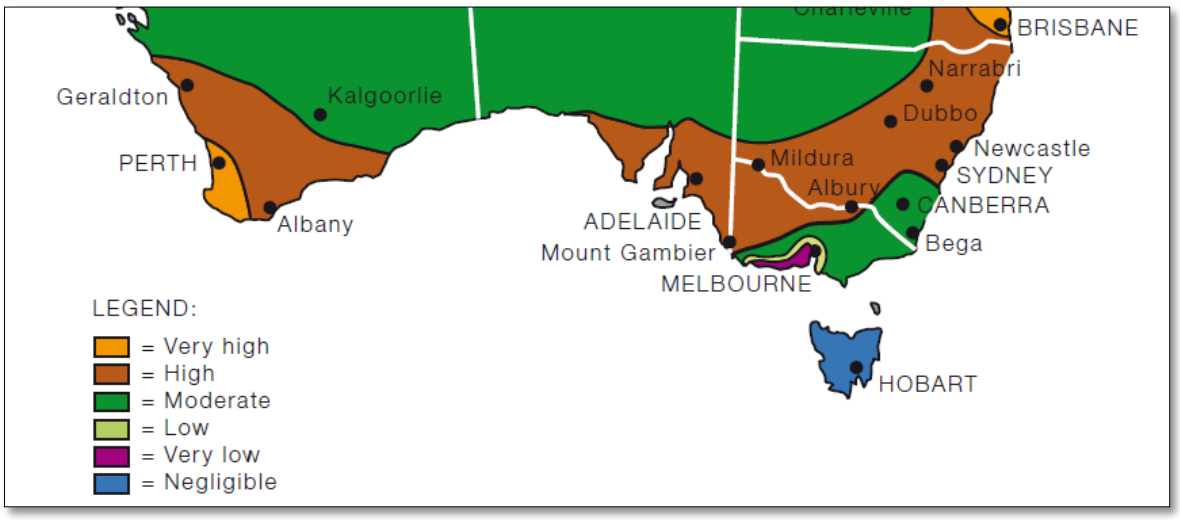


Figure 24 AS/NZ 7000:2016 Termite Hazard Map

It outlines the first inspection (10 – 20 years depending on timber pole specification) followed by a periodic inspection of every 3 - 6 years (36 – 72 Months) there-after (regardless of timber pole specification).

10. Planned Inspection Activities

Pacific Hydro's planned overhead line inspections are based on both: identifying dominant defect symptoms before asset failures occur and meeting regulatory compliance requirements.

The overhead line planned inspection strategy includes;

- A scheduled three-year asset inspection of each overhead line.
- Annual Vegetation Inspection (and clearance works) for the overhead lines/spans as per the requirements of the Pacific Hydro Electric Line Management Clearance Plan – PHA.OPS.08.011. The requirements for vegetation inspections are not covered by this procedure.
- Every 12 years (or fourth cycle) undertake a below ground and invasive inspection of each pole.

The management of outcomes and further actions identified through inspection activities are conducted in accordance with PHA.OPS.09.005 Maintenance Management Procedure.

10.1 Scheduled 3 Year Asset Inspections

The scheduled inspection of each line includes inspection of all overhead line asset components simultaneously rather than separate inspections for different components. The pole forms the basis by which the functional location of each component is identified. Therefore, before carrying inspections of individual components the pole number should be identified and recorded, see figure 25 below for an example of the pole number. The purpose of this inspection is to identify and record defects through an assessment of the asset component's condition, serviceability and functionality.



Figure 26 Pole Number and ID Photo Example (from Portland Wind Farm)

10.2 Invasive Inspections (12 yearly)

Planned invasive inspections are to be conducted every 4 inspections (or 12 years). Below ground inspections of poles are conducted to determine the residual pole strength, identify drainage, moisture or rotting issues or the presence of termites. Drilling into wooden poles or NDT scan wooden poles is to be completed above ground and/or below in addition to the below ground inspection. The inspections are carried out by either the dig and drill method or where no-destructive testing is required than Woodscan (for wooden poles) may be used. The following table outlined the depth required for below ground inspections.

Inspection Zone	Pole Type	Area Inspected
General below ground inspection	Wood	To 300mm below ground level
	Concrete	No below ground inspection. Only inspect to ground level
	Steel	To 200mm below ground level
Drill or NDT scan inspection	Wood	50 to 150mm @ 20º angle below ground with an 13mm auger @<300rpm to inspection for internal rot and or termite infestation. Polesaver rod shall be used to treat the pole after inspection. Drill location should be perpendicular to the loading of the pole. l

11. Non-Scheduled or Outcome instigated Activities

Some typical non-scheduled preventative/predictive strategies also used are:

- Thermographic patrol inspections – for more quantitative investigation of components likely to experience overheating or hot spot detection for potential known or higher risk failure points in the network.
- Insulator Washing conducted on an as needed basis that may be triggered but an inspection or visual patrol observation or local weather conditions
- Auto reclose functionality is currently suppressed on the power lines and the lines are part of the procedure to inspect prior to re-energising after fault diagnosis and rectification.

12. Completed Inspection Reporting Requirements

At the conclusion of the inspection of each overhead line the asset inspector will be required to submit a completed inspection report. In addition, Asset Inspectors will be required to identify defects as per Pacific Hydro Defects Reporting Procedure – PHA.OPS.09.002.

Pacific Hydro has adopted a four-level classification for defects that determines the timeframes by which the defect is to be addressed. The Asset Inspector is required to identify the defect classification level. The four levels are summarised in the table below:

Condition of the assessed item	Priority allocation
The item is assessed to pose an immediate supply reliability, fire or public safety risk.	Priority 1
The item is assessed as not assessed an immediate supply reliability, fire or public safety risk, however is likely to become one within 42 days to 2 years.	Priority 42
The item is assessed as not assessed an immediate supply reliability, fire or public safety risk, however is likely to become one within 2 years to 3 years.	Priority 2
This item is not a priority 1, 42 or 2 but may require attention before the next inspection (3 years)	Priority 3

Appendix A includes the acceptance criteria for the allocations for each of the failure modes.

13. Document History

The following table lists the changes made to this document:

Version	Date	Amended by	Comments
0.0	*4/10/2021*	*Daniel Choi* *Senior Operations Engineer*	*Initial Release*
1.0	3/10/2023	*Yuriy Odarenko* *Senior Operations Engineer*	Used New Pacific Blue Template
2.0	8/10/2023	*Yuriy Odarenko* *Senior Operations Engineer*	*Updated to Electricity Safety (Bushfire Mitigation) Regulations 2023 (Statutory Rule Number 40/2023)*

14. Appendices

14.1 Appendix A – Failure Mode Symptoms and Acceptance Criteria

The following table contains the acceptance criteria for each asset component as well the prioritisation level which would apply to a symptom.

Asset Component	Component Types	Failure type/cause	Symptom	Acceptable limit	Priority 1	Priority 42	Priority 2	Priority 3
Insulators (including for stays)	All types	Incorrect installation	Not properly secured to the pole	Must be present, installed correctly and secure	Insulator not present or secured to pole (not serviceable)	More than ONE loose connection or missing fastener component identified. (Limited serviceability)	One loose connection or missing fastener component (serviceable)	Loose connection but functionally secure until the next inspection (3yr)
		Excess wind stress or tension stress	Loose connections/cracking	Connections are secure and no signs of cracks		More than ONE loose connection or missing fastener component or CRACK identified. (Limited serviceability)	One loose connection or missing fastener component (serviceable)	Loose connection or only hairline CRACKS witnessed but functionally secure until the next inspection (3yr)
		Pin corrosion	Discolouration of the pin	No signs of discolouration			Evidence of discolouration / corrosion requiring corrective action before the next inspection (2-3 years)	
		External flashover or partial discharge causing	Evidence of lightning strike (arc melts,	No signs of burns/flash	Clear evidence of discolouration /burns on		Minor disclouration / burns evident and not requiring corrective action	

		degradation of insulation	blackening of materials) or ozone	marks / discolouration	more than 50 % of insulators		before next inspection (2-3 years)	
		Biological agents reduce insulation properties	Discolouration / biofurial growth (black, green moss)	No signs of discolouration or fungal growth	Clear evidence of discolouration from biological agent on more than 50 % coverage (non-serviceable)		Less than 50% coverage, identified as biological agent evident (serviceable)	
		Less than the minimum amount of insulator creepage distance	Missing / damaged sheds/disks	No missing or damaged sheds	Missing insulator or shed (non-serviceable)	Damage to insulator which would reduce the creepage distance	Minor damage to insulator not requiring corrective action before the next inspection (2-3 years)	
Fauna Covers	Fauna Covers (birds)	Incorrect installation	Loosely fitted	Must be Present, installed correctly and secure		Not Present or correctly secured to pole	Present but MORE than ONE loose connection or missing connection fastener component	Present but only ONE loose connection or missing connection fastener component
		Flashover (animals/vegetation)	Evidence of flashover, blackening of materials	No signs of burns/flash marks			Blackened marks / burns evident, but functional	
		Age (cracked)	Signs of damage or excessive wear	No signs of damage				Damage evident to fauna covers

Surge Arresters	Surge Arresters	Incorrect installation	Connectors/ties are loose	Must be installed correctly and secure	Surge Arrestor not secured to pole	More than one loose connection or missing connection fastener component	One loose connection or missing fastener component	Loose connection but functionally secure until the next inspection (3yr)
		Temporary Overvoltage or moisture ingress causing flashover	Visual damage, blackened areas	No signs of moisture ingress	Significant evidence of discolouration /burns - more than 50 %		Less than 50% discolouration / burns	
		Incorrect earthing arrangements	Loose or missing connections	No evidence of loose or missing connections	Missing earthing connection	More than one loose connection or missing connection bolt	One loose connection or missing fastener component	Loose connection but functionally secure until the next inspection (3yr)
		Excess energy containment (for silicon metal oxide surge arrestors)	Bulging sides of surge arrestor	Surge Arrestor appears to be in normal condition		Bulging/charring of surge arrestor		
Conductors (including stays)	All Bare Conductors	Age	Connectors/ties are loose	Must be installed correctly and secure	Insulator not secured to pole	More than one loose connection or missing connection fastener component	One loose connection or missing fastener component	Loose connection but functionally secure until the next inspection (3yr)
		Excessive conductor movement (sway)	Damaged conductor or ties	Must be secure and free from	<80% of the original material	HV ties are loose with signs of excessive aluminium oxide (black mud) and		Minor damage evident with small signs of aluminium oxide (black

				movement and damage		show movement, or evidence of major conductor damage		mud) to conductor but functional until next inspection (3yr)
		Corrosion	Evidence of corrosion or rust (conductor or ties)	No signs of corrosion	<80% of the original material	Significant corrosion (large area or multiple locations e.g. greater than 10% of surface area visible) - risk of conductor failure	Evidence of rust no greater than 10% total surface area	No evidence of corrosion, but steel exposure (paint/coating deterioration) - functional until next inspection (2-3 years)
		Flashover	Evidence of lightning strike (arc melts, blackening of conductor)	No signs of burns/flash marks		Significant evidence of discolouration / blackening of conductors (in multiple locations)	Minor discolouration / blackening requiring corrective action before the next inspection (2-3 years)	Minor discolouration / blackening requiring corrective action at the next inspection (3 years)
		Age/ excessive conductor movement	Evidence of fretting / strand failure (frayed conductor strands)	No signs of fretting, strand failure or signs of movement		Multiple locations (per span) of fretting or damage to strands	Evidence of fretting / span damage requiring corrective action before the next inspection (2-3 years)	
	Covered or Underground Conductor	Insulation damage	Cracks or annealed insulation	No sights of annealed or cracked insulator damage		Annealed or cracked insulator damage		

		Excessive wind load causing thermal expansion	Heat shrink damage	Heat shrink correctly not damaged and correctly covering termination end		Evidence of deteriorated or damage to Heat shrink		
		Moisture Ingress under tape over cable termination end	Discolored or ill-fitting tape	Correct fitting tape		Discolored/Signs of partial discharge ozone or ill-fitting tape		
Crossarms	Crossarms	Age	Not properly secured to the pole	Must be secure and all hardware present	Crossarms not properly secured to pole (non-serviceable)	More than ONE loose connection or missing connection fastener component with uneven crossarm support	ONE loose connection or missing fastener component and uneven cross arm support	Loose connection or fastener component, slight uneven crossarm but functionally secure until the next inspection (3yr)
		Excess wind stress	Evidence of steel fatigue	No evidence of cracks/bent arms or early signs of fatigue	Crossarms not properly secured to pole due to steel fatigue (non-serviceable)	Significant steel fatigue on cross arm and braces	Some visible evidence of steel fatigue	
		Corrosion	Evidence of corrosion or rust	No signs of corrosion		Significant rust / corrosion on more than 50% coverage	Less than 50% coverage of rust	Minor surface corrosion not requiring corrective action before

								the next inspection
		Environment	Wildlife / nesting	No signs of wildlife/nesting		Nesting at the pole top / crossarm area plus blackening	Nesting at the pole top / crossarm area	
Poles	All Poles Types	Uneven forces on the pole	Any lean in poles greater than 10 deg from vertical	Less than 10 degrees from vertical		Greater than 10 degrees	Greater than 5 degrees	
		Vehicle, tree or machinery impact	Evidence of structural damage	No signs of structural damage	Major damage (pole uneven / missing sections of pole). In danger of falling (non-serviceable)		Some visible damage requiring corrective action (removal/relocation) b	
	Wood	Termites within a depth of 300mm below ground	Evidence of termites within a depth of 300mm below ground	No evidence within depth of 300mm below ground level		Evidence of current termite infestation (e.g. larvae) and damage to pole evident from 300mm of ground surface upwards.	Evidence of previous termites infestation (small holes) requiring corrective action (removal / relocation) before the next inspection (2-3 years)	
		Fire damage / lightning strike	Charring/pole splitting \ blackened marks	No evidence of fire / lightning damage	major damage to structural integrity or significant blackened of	Large cracking / splitting - could cause loss of structural integrity	Moderate cracks/splitting	Minor cracks/splitting

					pole (more than a meter long)	& blackening of pole		
		Degradation	Girth less than 550mm within 200mm above the ground	Girth GREATER than 550mm within 200mm above ground level		Girth LESS than 550mm within 200mm above ground level		
		Wood Pole rot	Evidence of annulus of at least 50mm	No signs of rot or decay		Evidence of decay for an annulus GREATER than 50mm	Evidence of decay for an annulus LESS than 50mm	
		Wooden pole splitting	Evidence of external decay/ cracks	No signs of cracking/splits	major damage to structural integrity	Large cracking / splitting - could cause loss of structural integrity	Moderate cracks/splitting	Minor cracks/splitting
		Pole top cap loose	Cap is correctly fastened and sealed	Pole cap covers top of pole and no evidence of gaps / moisture under the cap		Pole cap missing		Pole cap loose or damaged
	Steel	Age and salinity causing corrosion	The thickness of any corroded area below the ground less than 75% of the sound metal above the ground	The thickness of any corroded area below the ground less than 75% of the sound		The thickness of any corroded area below the ground less than 75% of the sound metal above the ground		Evidence of corrosion not requiring corrective action before the next inspection (3 years)

				metal above the ground				
	Concrete	Concrete decay	Evidence of concrete decay or exposed metal reo	No early evidence of concrete decay / exposed reo		Significant concrete decay (large cracks or exposed reo/metal)		Some minor concrete cracking
	Stay	Corrosion of steel components below ground	Corrosion / rust	No signs of corrosion or rust		Significant rust / corrosion on more than 50% coverage or multiple locations	Less than 50% coverage of rust	Minor surface corrosion not requiring corrective action before the next inspection
		Vehicle, tree or machinery impact	Evidence of structural damage, wire not under tension	No evidence of structural damage. Wire is under correct level of tension.	Wire not under tension or stay damaged and likely to fail (Not Serviceable)	Wire not under tension or stay damaged and likely to fail (Serviceable)		Evidence of damage / collision
		Stay anchor incorrectly installed / excessive forces	Pole learning / loose fitting	Installed correctly, not loose, hardware present and secure, pole is not leaning	Stay wire loose or pole leaning (GREATER than 10 degrees) - Not serviceable	Stay wire loose or pole leaning (less than 10 degrees) - Not serviceable	Stay wire connections / bolts not installed correctly or not tight (serviceable)	
Foundation / Pole Base	Foundation	Concrete decay	Evidence of concrete decay or exposed metal reo	No early evidence of concrete		Significant concrete decay		Some concrete cracking

				decay / exposed reo		(large cracks or exposed reo)		
		Excess wind stress leading to pole footing failure	Uneven pole, concrete cracking	Pole should be upright, no signs of cracks, damage or defects to structural integrity of foundation.	Leaning pole or significant concrete cracks GREATER than 10 degrees	Leaning pole or significant concrete cracks less than 10 degrees		Some concrete cracking, no leaning of pole (less than 5 degrees)
		Poor drainage	Water pooling	No evidence of water pooling			Moisture at base of pole	
		Exposure of pole base from subsidence / soil erosion	Uneven ground, pole at less than minimum depth	Pole at correct depth, no evidence of soil erosion		Pole at less than minimum depth	Soil erosion	

It should be noted that not all symptoms will have a prioritisation for all four levels. The following table explains why some symptoms may have a blank prioritisation level.

Priority 1	**Priority 42**	**Priority 2**	**Priority 3**
Symptom does not breach any statutory or regulatory requirements No safety or priority 1 risk imposed (e.g. not able to pose an immediate supply reliability or fire or public safety risk and wouldn't ever typically be rated Priority 1 Poor condition is covered by another failure mode for Priority1 e.g. acceptable limit for insulator is 'Connections are secure and no signs of cracks' but found in worst state possible (completely disconnected), this is already covered under a more appropriate failure mode ' Insulator not secured to pole'	Priority 42 may be blank as the failure mode in question is likely to be either worst case (not present, or urgent for repairs as Priority 1) or Priority 2 and/or Priority 3. These are failures that if aren't typically highly critical in terms of impact wouldn't likely be required to be performed within the next 2 years.	Blank if only one other priority would suit the acceptance criteria. Lower priority assigned where rectification of issues can be delayed for corrective work at 2 or more years	Blank if only one other priority would suit the acceptance criteria. Lower priority assigned where rectification of issues can be delayed for corrective work at 3 or more years at the next pole inspection