Directlink Joint Venture

Directlink
Revised Revenue Proposal

Attachment 5.1

Directlink
Asset Management Plan

Effective
July 2015 to June 2020

January 2015

APA Group

Energy Infrastructure Investments

[Directlink Excerpt]

Asset Management Plan

2015-2019

Table of Contents

List of Tables

Executive Summary

Background

The Asset Management Plan (AMP) covers the planning period from 1 January 2015 to 31 December 2019 and is updated and reissued on an annual basis.

The AMP identifies the necessary actions required to optimally manage the Energy Infrastructure Investment (EII) assets. A long-term consideration of the integrity of assets is necessary to ensure that they remain fit-for-purpose.

The AMP is written on the basis of the best known information at the time of writing.

Purpose

The purpose of the AMP is:

- To provide a comprehensive understanding of the current management approach relating to the assets, their condition and their utilisation;
- To identify strategic recommendations for future utilisation;
- To provide a platform for approval of work programs by providing discussion of the options available and recommendations; and
- To identify specific issues affecting the assets and the proposed remediation for budget consideration.

Health Safety and Environmental

The objective of this AMP is to ensure that a strong focus on safety and reliability is maintained in relation to the operation and management of the EII assets. In developing the operating and maintenance procedures incorporated within the AMP, the Operator (being APA Operations EII) has considered the approved policies and procedures of the APA Group.

Suitable safety management systems are in place and operating to ensure that the risks relating to the operation of all EII assets are effectively managed to keep risks as low as reasonably possible. The APA HSE Management System is called 'Safeguard' and provides a framework by which the processes relating to EII's HSE activities are written, approved, issued, communicated, implemented and controlled. Additionally, the management system is also subject to review and improvement to ensure objectives and obligations are continually satisfied.

Reviews

The AMP is reviewed each year to ensure that the content is current.

Changes to the assets will inevitably occur during the life of the AMP. Unless there are issues identified that significantly impact the validity of the Plan it is only intended to amend the AMP at each annual review.

The AMP will identify any material changes to budget items for the previous period.

Excluded Items

No costs in respect of the rectification/replacement of the damaged convertor station in respect of system 1 of Directlink, at the Mullumbimby site, have been included in this Asset Management Plan.

Summary of estimated SIB expenditure

The following table shows the estimated expenditure on each asset group for the period CY2015 to CY2019.

Id	Description	Forecast 2014 $000s	2015 $000s	2016 $000s	2017 $000s	2018 $000s	2019 $000s
4	Directlink	2,108	6,907	7,917	3,295	3,735	14,739

Table 1 – Executive summary of SIB for CY2014 to CY2019

1 DIRECTLINK INTERCONNECTOR

1.1 Asset Information

Directlink is a 59 km high voltage direct current (HVDC) transmission system in New South Wales between Bungalora and Mullumbimby. Directlink transfers up to 180MW of power, between the Queensland (QLD) and New South Wales (NSW) transmission networks.

Directlink consists of three independent DC transmission lines each consisting of a pair of HVDC cables, buried in some areas and in others installed in steel troughs. Each cable pair is connected to a single converter station at both Bungalora and Mullumbimby. The converter stations interface to the existing high voltage, AC transmission systems via relatively short lengths of underground, high voltage AC cable at Bungalora (110kV) and overhead high voltage AC cable at Mullumbimby (132kV).

The Australian Energy Market Operator (AEMO) determines the power transmission as a part of their central dispatch process.

1.2 Detailed Asset Management Plan

As part of the documentation review performed by Power Systems Consultants (PSC), to identify gaps and improvements to Good Electricity Industry Practice, a separate Asset Management Plan has been developed specific to the requirements of HVDC assets and is provided at **Appendix D**.

The AMP developed by PSC gives a whole of life view from commissioning of the upgrade and refurbishment works until the estimated end of life and provides a forecast of what is required for maintenance, replacement, overhaul and improvement to achieve economically the expected life.

The remainder of this section relates to those items specific to the period of review, being CY2015 to CY2019.

1.3 Damage to Convertor Station for Pole 3 at Mullumbimby

The convertor station for Pole 3 at Mullumbimby was rendered unsalvageable by a fire in mid-August 2012. The investigation did not conclude a definite cause; however the ongoing partial discharge on the air handling fibreglass is considered a possible contributing factor. As a result, changes are required for phase reactor cooling on all systems. The scope of the changes is yet to be determined and the related costs will be presented to the Energy Infrastructure Investments Pty Ltd (EII) as a separate item for discussion.

Work to replace the system 1 Mullumbimby converter has commenced with an expected completion date of June 2015. Until then, the capacity of Directlink is reduced from 180MW to 120MW. The capital expenditure request and plan for rectifying/replacing the damaged convertor station has not been included in this Asset Management Plan.

1.3.1 Economic Regulation

A draft revenue proposal was submitted to the AER in May 2014. A final decision on the regulatory reset is due in April 2015. The outcomes of the revenue proposal are set out in the tables below.

Year ($millions)	FY2016	FY2017	FY2018	FY2019	FY2020
Return on capital	**10.4**	**10.8**	**11.1**	**11.3**	**11.6**
Regulatory depreciation	**1.7**	**2.0**	**2.2**	**2.5**	**2.8**
Operating expenditure	**5.9**	**5.4**	**5.6**	**5.7**	**5.9**
Efficiency benefit sharing scheme (carryover amounts)	**-**	**-**	**-**	**-**	**-**
Net tax allowance	**0.8**	**0.8**	**0.9**	**0.9**	**1.0**
Annual building block revenue requirement (unsmoothed)	**18.9**	**19.0**	**19.8**	**20.5**	**21.2**

Annual expected Maximum Allowed Revenue (smoothed)	**18.1**	**19.0**	**19.8**	**20.7**	**21.7**
X factor (%)	n/a	**-2.0**	**-2.0**	**-2.0**	**-2.0**

Table 2 – Directlink Revenue Proposal FY2016 to FY2020

1.4 Key performance measures

1.4.1 Supply performance criteria

The Directlink annual performance measures and targets as set by the Australian Energy Market Operator for the last AEMO reporting period and for YTD 2014 are as follows:

Calendar Year Performance Measure and Results	Target 2013	Actual 2013	Target 2014	YTD 2014 (Jan to Jul)
Scheduled circuit availability	99.45%	99.87%	99.45%	91.19%
Forced outage circuit availability in peak periods	99.23%	70.54%	99.23%	79.93%
Forced outage circuit availability in off–peak periods	99.23%	61.91%	99.23%	73.76%

Table 3 – Directlink performance measures

Commentary

Laboratory analysis, to determine whether silicone fluid injection was a successful remediation method, was completed in 2014. Two cable faults occurred in the fluid injected cable samples whereas no cable faults occurred in the non-injected samples. This outcome indicates that cable fluid injection is not a solution to the cable faults. The specialist consultant, leading the investigation, has proposed further laboratory analysis to investigate methods removing moisture from the in service cable so as to prevent cable faults. At this stage, cable replacement is the only viable cable fault remediation method.

1.5 Major Planned Operational expenditure (OPEX)

Year	Description	Budget Month	Actual Month
2014	Annual Maintenance Shutdown	Aug 14	Oct 14

Table 4 – Directlink major operational works preview

1.6 Major Planned Capital Expenditure (CAPEX)

1.6.1 CY2014 Capital works

A reflection on the capital projects for CY2014.

Year	Forecast $000s	Budget $000s	$ Variance	% Variance
2014	2,108	4,126	2,018	48.9

Table 5 – Directlink capital projects review

Commentary

The reduction in capital expenditure relates to the deferral of phase reactor cooling works at Bungalora System 1.

1.6.2 Planned stay in business (SIB) Capital Works

Id	Description	2015 $000s	2016 $000s	2017 $000s	2018 $000s	2019 $000s
1	Phase Reactor Cooling	1,625	2,278	-	-	-
2	Spare IGBTs	407	407	407	407	326
3	Cable replacement program	568	568	568	568	568
4	Spare cable joint kits	388	388	388	388	388
5	Spare valve optic fibres	160	160	160	160	160
6	Security fencing enhancement	-	395	-	-	-
7	Fire suppression	3,518	3,407	-	-	-
8	Sound dampening replacement for ventilation inlet	11	11	11	11	11
9	Cameras	6	-	-	-	-
10	Emergency lighting	-	-	338	-	-
11	Cooling tower sound enclosure panel replacement	40	40	350	41	41
12	Building roof corrosion repair	58	58	55	53	50
13	Zero sequence reactor repair	-	-	749	749	-
14	Safety compliance program	20	72	72	36	-
15	Upgrade industrial computer control system	-	-	-	-	13,070
16	Contingency spares	100	36	40	34	34
17	Refurbishment works	-	18	58	1,215	18
18	Contingent cable relocation	-	73	73	73	73
19	Site lighting improvement	6	6	6	-	-
20	Bungalora hand rails	-	-	20	-	-
	Totals	6,907	7,917	3,295	3,735	14,739

Table 6 – Directlink stay in business proposals

Commentary

As noted earlier, no costs in respect of the rectification/replacement of the damaged convertor station have been included in this Asset Management Plan or the Asset Management Plan at **Appendix D**.

1. Phase reactor cooling

The current reactor cooling systems use fans to circulate air from external to the reactor buildings through the electrical apparatus (unlike Murraylink and other designs that utilise a heat exchanger and circulate chilled water). Apart from being drawn through a filter screen, the air is not currently treated to remove small insects, moisture and dust particles.

This system has led to identified problems where impurities attracted by electrostatic fields are deposited on the insulating fibreglass cooling system parts, which leads to electrical tracking. In order to mitigate this issue, it is proposed to revise the reactor cooling system design as recommended by ABB, to a design developed for the link between the Swedish mainland and the island of Gotland.

The replacement reactor to be constructed at Mullumbimby will use updated cooling arrangements. The cost for CY2015 represents replacement of the system 1 converter station cooling system at Bungalora. The remaining cost in CY2016 represents the cost of cooling system revisions for four remaining reactor stations (two at each of Terranora and Mullumbimby).

2. Spare IGBTs

There are several thousand IGBTs in service at Directlink. IGBTs have a failure rate above that of other HV equipment. There is an on-going need to maintain a level of spare capacitors.

APA analysed the reuse the IGBTs recovered from Mullumbimby System 1 but were unable to gain enough confidence that these reused IGBTs were unaffected in any way by the fire. To ensure compliance with good industry practice, APA have decided not to reuse IGBTs and instead purchase new IGBTs.

3. Cable replacement program

It is proposed to implement and expand the cable replacement program in response to cable faults. The expanded cable replacement program is expected to decrease the rate of cable failure with time and improve the overall reliability of Directlink. The expanded replacement program will consume increased length of spare cable and as such will result in increased cable procurement. The procurement of spare cable has a long time period between order and delivery, therefore the proactive procurement of spare cable will reduce the risk of prolonged plant outages.

4. Spare cable joint kits

It is proposed to maintain an inventory of cable joint kits in preparedness for cable faults. These kits have long lead times between order and delivery which increases the risk of prolonged plant outages. The spare cable joint kits will ensure that repairs can be carried out swiftly reducing the risk of prolonged plant outages.

5. Spare valve optic fibres

An elevated failure rate has led to depletion of spare optic fibres. The progressive replacement of the optic fibre cables is planned.

6. Security fence enhancement

The Directlink Bungalora and Mullumbimby sites have experienced frequent incidents of trespassing, theft and vandalism. An improved security fence is required to mitigate the risk of liability in the event of a trespasser being killed or injured, and the risk of major equipment failure as a consequence of theft or other malicious damage. The Bungalora security fence was upgraded in 2011, due to the highest level of trespass and incident. Mullumbimby is proposed for a fencing upgrade in 2016. The result of increased security at these sites will reduce the likelihood of trespass and incident.

7. Fire suppression

The original ABB design of the Directlink converter stations incorporated fire detection alarms which initiate shutdown of equipment, but did not include a fire suppression system in the reactor buildings.

The failure of a Mullumbimby reactor and the ensuing intense fire that destroyed the converter station in August 2012 has demonstrated that a fire suppression system could have been beneficial. A fire drenching system could have served to limit equipment damage to near the source of ignition of a fire and avoid the total loss of a converter station. Such a system could also obviate any risk of damage to adjacent equipment and property (allowing the link to return to service sooner) or injury to personnel. Fire drenching systems are standard industry practice within substations, used on large electrical equipment such as transformers.

The replacement converter unit to be installed at Mullumbimby during CY2015 will incorporate a fire suppression system, but the existing 5 converter buildings are not so equipped.

8. Sound dampening replacement for ventilation inlet

Considerable rusting has occurred to the sound damping at the inlet of the barn ventilation at both Mullumbimby and Bungalora. This is starting to collapse and will result in the blocking of the ventilation shaft. As system 1 is not operating only 5 dampers are costed to be replaced.

9. Cameras

The inside of the converter buildings has restricted access because of the safety risk associated with the energised high voltage equipment. It is proposed to install a camera system to allow detailed inspection of equipment inside areas of the converter building while the converter building is energised. It is expected that this will reduce the frequency and duration of outages for converter station maintenance and allow rapid internal inspection of the buildings in response to faults.

10. Emergency lighting

Directlink has limited emergency lighting and illuminated exit signs. Additional lighting is required at the converter station sites to allow safe movement of maintenance personnel at night. Current building code specifications and good industry practice require the updating of emergency lighting systems for the safety of personal that work in high voltage buildings and enclosed secure compounds.

11. Cooling tower sound enclosure panel replacement

Corrosion is present in a large number of the panels making up the cooling tower sound enclosure. The corrosion has occurred due to moisture ingress into the sound damping material. These panels require replacing to ensure the integrity of the cooling tower sound enclosure.

12. Building roof corrosion repair

The converter buildings roofs have areas of corrosion. These areas require treating to prevent the corrosion progressing further.

13. Zero sequence reactor repair

A recent audit of Directlink's critical spares identified corrosion in the core laminates of the spare zero sequence reactor. The repair requires replacement of the core. The zero sequence has a long lead time for replacement and a spare is essential to prevent prolonged outages of Directlink.

14. Safety compliance program (working at heights and obstacles)

Recurring activities within the buildings has flagged the need for working at height safety equipment fitted to the inside of the building and cable walkover platforms.

15. Upgrade industrial computer control system

The converter station control system replacement is expected to be in the order of $13M and is planned for the second half of CY2019. As the control system approaches the end of life, the expected high rate of failures and unavailability of spare parts mean the control system must be replaced.

16. Contingency spares

To maintain the high level of plant integrity a contingency for critical spares has been allocated. This amount is surplus to the allowed capital expenditure within the current Access Arrangement.

17. Refurbishment works

The refurbishment works are planned to ensure the ongoing serviceability of a range of ancillary equipment at the converter stations (such as fans, pumps, air conditioners). This equipment is essential to the continued reliable performance of the converter stations. The program contains numerous periodic and one-off items of expenditure.

18. Contingent cable relocation

The Directlink cables are installed in the coastal area and associated hinterland in north-eastern NSW which is subject to greater development pressures than most other areas. There is thus a strong likelihood that development adjacent to the route of the cables will impact upon their safety, reliability and integrity. The timing of the event is unknown, the total cost has been factored into the Directlink capital expenditure program on the basis of 5 equal annual amounts.

19. Site lighting improvement

Additional lighting is required at the converter station sites to allow maintenance personnel to work safely and effectively at night. The layout sound walls around of the outdoor switchyards and transformers, creates areas of shade where additional lighting is required to allow safe work conditions at night.

20. Bungalora hand rails

The Directlink Bungalora building layout has a safety hazard created by grade of the site. Several common walkways, surrounding the buildings, have a significant drop on one side and no hand rail. This project plans to install additional railings to ensure the safety of staff and contractors traversing the wlakways.

Appendix E outlines the delivery schedule for the CY2014.

1.6.3 Opportunities for growth capital expenditure

Subject to economic regulatory approval the following project are considered opportunities to grow the asset base:

Id	Description	2015 $000s	2016 $000s	2017 $000s	2018 $000s	2019 $000s
	n/a					
	Totals	-	-	-	-	-

Table 7 – Directlink growth capital opportunities

Commentary

No growth capital expenditure was proposed or approved by the regulator within the current Access Arrangement.

Appendix D – Directlink AMP specific to HVDC assets

Appendix E – Directlink Stay in Business Capital CY15

$'000	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	CY15 Total
Revise Phase Reactor Cooling	660,680	964,000	-	-	-	-	-	-	-	-	-	-	1,624,680
Fire Suppression	173,757	74,918	480,141	423,154	110,446	110,446	110,446	357,543	110,446	110,446	1,345,933	110,446	3,518,123
Spare IGBT's	-	-	407,000	-	-	-	-	-	-	-	-	-	407,000
Cable replacement program	-	-	142,000	-	-	142,000	-	-	142,000	-	-	142,000	568,000
Spare cable joint kits	-	-	-	388,000	-	-	-	-	-	-	-	-	388,000
Spare Valve Optic Fibres	-	160,000	-	-	-	-	-	-	-	-	-	-	160,000
Security Fencing Enhancement	-	-	-	-	-	-	-	-	-	-	-	-	-
Sound Dampening Replacement for Ventilation Inlet	-	-	-	-	11,000	-	-	-	-	-	-	-	11,000
Cameras	-	-	6,000	-	-	-	-	-	-	-	-	-	6,000
Site Lighting Improvement	-	-	-	-	-	6,000	-	-	-	-	-	-	6,000
Cooling Tower Sound Enclosure Panel Replacement	-	-	-	-	40,000	-	-	-	-	-	-	-	40,000
Building Roof Corrosion Repair	-	-	-	-	-	-	58,000	-	-	-	-	-	58,000
Zero sequence reactor repair	-	-	-	-	-	-	-	-	-	-	-	-	-
Safety compliance program	-	-	-	-	-	-	-	20,000	-	-	-	-	20,000
Contingency Spares	-	-	25,000	-	-	25,000	-	-	25,000	-	-	25,000	100,000
Directlink Sub Total	834,437	1,198,918	1,060,141	811,154	161,446	283,446	168,446	377,543	277,446	110,446	1,345,933	277,446	6,906,803

DL-DO-06

Directlink

Asset Management Plan

Referenced Documents:

DL-DO-05

DL-OP-06, 18, 19, 23

DL-SP-01, 02

DL-SP-03, 12, 13, 17, 18, 25, 26, 31, 32, 33, 34, 35, 36, 37, 40, 41

Note: all *Italicised text* has specific definitions – refer section 3.0

Date	Rev	Description	Prepared By	Approved By
14/09/07	0	First Issue for Use		
31/03/14	1	GEIP Updates	DC	

QUALITY TEAM MEMBERS:		DATE
Last Revised by:		
EXPERT SOURCES:		
Last Revised by:		
FIELD AND OFFICE REVIEWERS:		
Last Revised by:		
DOCUMENT AND GRAPHICS PREPARERS:		
Last Revised by:		
EXTERNAL PROVIDERS:		
Last Revised by:		
POLICY/STANDARD REVIEWERS:		
Last Revised by:		

DISCLAIMER

APA Group including any of its officers (**"the Releasor"**) may issue the document following ("**the Document**") to any third party (**"the Recipient"**) and in consideration of such issue, the Recipient agrees to the following conditions and acknowledges that:

1. the information and instructions contained in the Document (**"the Information"**) may be updated from time to time by the Releasor;
2. the Recipient must, before using the Information, ensure that the Document has not been updated since the day it was printed, as indicated by the date specified on the Document **("the Print Date")**, or alternatively, obtain a hard copy of all amendments made since the Print Date;
3. the Document contains confidential information and that the Recipient must not under any circumstances release or otherwise make available the Document or all or any part of the Information to any third party except with the prior written consent of the Releasor;
4. while the Releasor believes that the Information may assist the Recipient, the Releasor does not warrant that the Information is accurate in every respect, nor that the Information can be used for any particular purpose; and
5. all intellectual and industrial property rights which exist in or may be derived from the Information, if any, remain the property of the Releasor. In particular, a Recipient will neither obtain nor retain copyright or other intellectual or industrial property rights in the Document or the Information as a consequence of its issue to or use by the Recipient or any other person or entity.

The Releasor disclaims all liability to the Recipient for errors or omissions of any kind whatsoever (whether negligent or otherwise) for any loss, damage or other consequence which may arise as a result of the Recipient's reliance on or use of the Information.

The Recipient agrees to indemnify the Releasor from and against all claims, demands, actions and proceedings brought against the Releasor arising out of or in any way related to the failure of the Recipient to comply with clauses 2 or 3 of this Disclaimer.

PROPOSALS FOR AMENDMENT

This document has been prepared to support APA Group in achieving business objectives by delivering standardised processes. Improvements can be made and feedback on this document is encouraged, and should be directed to the document owner.

PRINTED WORKING COPY CONTROL

The official copy of this document is located on the APA Intranet. Hard copy versions are uncontrolled.

Table of Contents

1 INTRODUCTION

1.1 Purpose

This document details an Asset Management Plan (*AMP*) for the *Directlink* high voltage direct current (*HVDC*) transmission assets owned by Energy Infrastructure Investments and operated by the APA Group.

This plan has been developed from the date of the 1st of January, 2014, with *Directlink* originally commissioned in 2001. The nominal end of life date shall be set as 2047 representing the expected life, financial model base case and financial asset register. An extended end of life has been set at 2060, which represents an achievable target with good practice in operation and maintenance.

The *AMP* is developed to give a whole of life view from commissioning of the upgrade and refurbishment works until the estimated end of life. The *AMP* provides a forecast of what is required for maintenance, replacement, overhaul and improvement to achieve economically the expected life.

The *AMP* is a living document and shall be reviewed and updated annually to capture any changes that shall affect the life of the asset.

1.2 Asset Overview

Directlink is a 59 km *High Voltage DC* transmission system in New South Wales between Bungalora and Mullumbimby. *Directlink* transfers up to 180 MW of power, between the Queensland (QLD) and New South Wales (NSW) transmission networks.

Directlink consists of three independent *DC* transmission lines each consisting of a pair of *High Voltage DC Cables*, buried in some areas and in others installed in steel troughs. Each cable pair is connected to a single converter station at both Bungalora and Mullumbimby. The converter stations interface to the existing high voltage, *AC* transmission systems via relatively short lengths of underground, high voltage *AC* cable at Bungalora (110 kV) and overhead high voltage *AC* cable at Mullumbimby (132 kV).

The Australian Energy Market operator (*AEMO*) determines the power transmission as a part of their central dispatch process.

1.2.1 Damage to Convertor Station for Pole 3 at Mullumbimby

The convertor station for Pole 3 at Mullumbimby was rendered unsalvageable by a fire in mid-August 2012. The investigation did not conclude a definite cause; however the ongoing partial discharge on the air handling fibreglass is considered a possible contributing factor. As a result, changes are required for phase reactor cooling on all systems. The scope of the changes is yet to be determined and the related costs will be presented to the Energy Infrastructure Investments Pty Ltd (EII) as a separate item for discussion.

Work to replace the system 1 Mullumbimby converter is commencing with an expected completion date of June 2015. Until then, the capacity of *Directlink* is reduced from 180 MW to 120 MW. The capital expenditure request and plan for rectifying/replacing the damaged convertor station has not been included in this *AMP*.

2 REFERENCES

Document Number	Title / Description
	Asset Management Policy – APA Group
	Asset Management Strategy – APA Group
PAS 55-1: 2008	Asset Management – Part 1: Specification for the optimized management of physical assets
PAS 55-2: 2008	Asset Management – Part 2: Guidelines for the application of *PAS 55*-1

ISO 9001	Quality Management Systems – Requirements
DL-DO-05	Operations Environmental Management plan
	APA Group's Risk Management Policy
	APA Risk Management Handbook

2.1 Asset Management Policy

APA Group's asset management policy outlines the principles, approach and expectations that govern the organisations approach to asset management. Refer to the asset management policy document for further detail.

2.2 Asset Management Strategy

The APA transmission business has three areas of strategic focus that are linked to APA overall vision and strategy. These are:

- Safety and availability and cost;
- Growth; and
- Seamless service.

APA Group's asset management strategy outlines the strategy and objectives for the management of all APA Group assets. This *AMP* has been developed for *Directlink* as a stand-alone document.

3 DEFINITIONS / *ABB*REVIATIONS

Term	Description
ABB	ABB is a power and automation technologies company that enable utilities to manage electrical supply.
AER	The Australian Energy Regulator (AER) regulates energy markets and networks.
AMP	Asset Management Plan
Australian Energy Market Operator (AEMO)	The Australian Energy Market Operator (AEMO) delivers an array of gas and electricity market, operational, development and planning functions. It manages the National Electricity Market (NEM) and the Victorian gas transmission network.
Compliance Plan	A document which defines the obligations and activities required to demonstrate ongoing compliance of the Directlink Asset to the requirements of the National Electricity Rules and Connection Agreements.
DC	Direct Current
DC Cables	The *DC cable*s that link the Bungalora Converter Station and Mullumbimby Converter Station.
DLSC	Directlink System Control, responsible for control and coordination of all high voltage switching including remote high voltage switching
Directlink / Directlink Asset	Directlink means the 180 MW HVDC transmission system between Bungalora and Mullumbimby in New South Wales. The Directlink transmission system comprises three separate parallel HVDC transmission lines. Each transmission line comprises:

	· a 110 kV converter stations at Bungalora; · a 132 kV converter stations at Mullumbimby; and · a pairs of parallel 80 kV high voltage *DC cable*s
EII	Energy Infrastructure Investments Pty Ltd
Essential Energy	Essential Energy (http://www.essentialenergy.com.au/) is the distribution network operator (historically this entity was known as Northpower
GST	*Galvanised Steel Troughing*
HVAC	Heating, Ventilation and Air Conditioning
HVDC	High Voltage Direct Current
IGBT	Stands for Inverse Gate Bipolar Transistor. The IGBTs are used to switch the DC voltage to produce an AC voltage.
ISO	International Organization for Standardization
Maintenance Connection	Maintenance Connection is a software package used by APA for maintenance and management of its assets. (Maintenance Connection, Inc.)
MAR	Maximum Allowed Revenue as determined by the AER
OEM	Original Equipment Manufacturer
PAS 55	A Publicly Available Specification published by the British Standards Institution (BSI), “Specification for the optimized management of physical assets”.
PlantDocs	A database of design, operation and maintenance documentation provided by the OEM of Directlink which includes a HTML interface, main page titled “Final Plant Documentation Directlink HVDC Light”.
TNSP	Transmission Network Service Provider
Uninterruptible Power Supply (UPS)	A battery backup system designed to provide continuity of supply to equipment during a power outage.
VSC	Voltage Source Converter

4 PREPARATION, APPROVAL AND ASSUMPTIONS

4.1 Preparation

APA has prepared and quality checked this document to *PAS 55* and *ISO* 9001 requirements. Whilst this document is not intended to be *PAS 55* compliance, it is structured in a manner where the key principles of *PAS 55* are followed and so that this plan may be made to be *PAS 55* compliant in the future.

4.2 Approval

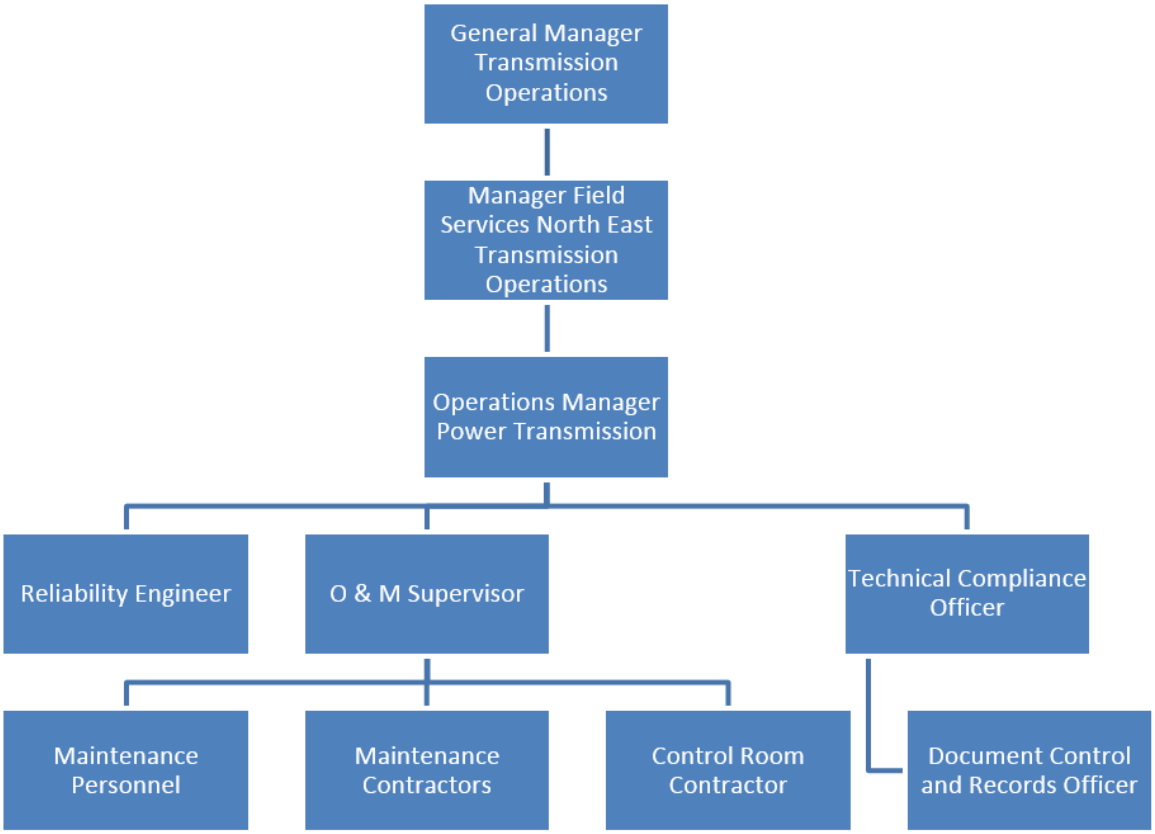
Approval of this *AMP* is required by APA Group board of directors and other relevant stakeholders especially for commitment to capital improvements, timing and costs.

5 ASSET MANAGEMENT RESOURCES

5.1 APA Asset Management Structure

Figure 1 shows team structure for the APA asset management team in relation to the *HVDC* assets.

Figure 1 – APA Asset Management Team Structure - *HVDC* Assets



5.2 Functions and Obligations of the APA Asset Management Team

Basic functional requirements/obligations of the APA Asset management team include:

- Manning 24/7 Control Centre - An operator shall be on duty 24 hours a day, 7 days a week in the APA control centre in Dandenong, Victoria. Functions include operating the *Directlink Asset*, monitoring the performance and interaction with *AC* network system operators, monitoring of site facilities including fire and security systems, maintaining operational records, and monitoring and controlling access to both converter sites for staff and visitors.
- Regular Maintenance and Inspections - Provide regular maintenance and inspections as recommended by *ABB* and equipment suppliers. This will include general weekly, monthly, annually etc., inspections on transformers, primary equipment, auxiliary systems (power, air conditioning, *UPS* systems, fire, and security systems), cooling systems and control and protection systems.
- Emergency Call Out and Operations - A staff member for first response is available 24/7 who will coordinate the response activities to either converter station site or the Directlink System Control (*DLSC*) in the event of an emergency or incident, either related to the facility equipment and auxiliary systems, or in response to an alarm. Where switching operations are required or where deemed by the specific job, two persons may be required at the site.
- Manage Cable Repairs in Accordance with Cable Repair Procedures - Personnel shall respond to any cable system failures and initiate and manage the fault investigation, fault location and repair process in accordance with the Cable Repair Procedures.
- Compliance - Implement necessary procedures, processes and documentation to demonstrate compliance with *AER*, *Essential Energy* and other key stakeholders and regulatory requirement

in accordance with the *Directlink Compliance Plan*s. Engage and manage required legal and professional services associated with regulatory correspondence and compliance.

- Liaison with Third Parties - During normal business hours, the *Directlink* operations staff shall be available to interface *AEMO*, *AER*, *Essential Energy* and other third parties as may be required.
- Scheduled Outages and Annual Maintenance - Schedule, plan, engage contractors, and supervise the execution of any scheduled outages and annual maintenance required. This includes the management of the spares parts, tools and safety equipment inventory and the ordering of required replacements and the updating and management of the short term and long term maintenance plans.
- Engineering and/or Project Improvements - Undertake investigations and engineering for incidents and other technical issues identified during operation of *Directlink* and to project manage any improvements or repairs to *Directlink*.
- Operating Procedures and Protocols - Develop, maintain and update the required start-up, operating, shutdown, repair, maintenance and overhaul procedures, including electrical safety, switching and tagging procedures and testing/repair procedures. This includes all required procedures and protocols with third parties such as the interconnected utility companies, *AEMO*, etc...
- Operation and Maintenance Records - Maintain all required records and operating logs required by the lenders and/or required as recommended by the equipment manufacturer. This also includes records associated with system events, access permitting. Relay testing and instrument calibration.
- Reporting - Prepare the monthly management reports and quarterly board papers for presentation at Management Committee meetings and Board of Managers meetings.
- Maintenance of Permits, Agreements and Contractors - Manage the obligations of *Directlink* with respect to key permits, agreements such connection agreements with *Essential Energy* and other contracts.
- Budget - Annually prepare and present a *Directlink Asset* operations and maintenance budget for approval. Manage the budget over the course of the financial year and report deviations per the associated policies and procedures.
- Insurance - Ensure that all required insurance policies such as property insurance, liability insurance, workers compensation etc. are bound and premiums and deductibles adequately meet both the risk profile associated with the *Directlink Asset* and lender requirements.
- Office Administration and Management - Manage and supervise *Directlink* operations office activities, and provide human resource functions such as development of human resource policies, employee benefits administration, maintenance of personnel records, and legislative compliance.
- Accounting, Payroll, Financial Reporting - Fulfil accounting requirements for *Directlink* operations and in accordance with applicable policies, namely billing, payroll, audit support, budget analysis, tax filing support, and general administrative functions and reporting of a financial nature.

5.3 Authority and Responsibilities

The responsibilities of the senior personnel of the APA Asset Management team are detailed below:

5.3.1 Operations Manager Power Transmission

The Operations Manager Power Transmission is responsible for:

- Electricity Transmission Revenue Regulation Compliance.
- Electricity Transmission Technical Regulation Compliance.
- High Voltage Safety.
- Site Safety.
- Asset Management.

- Risk Management.
- Technical Support.
- Effective Delivery to Customers.
- Effective Management and Leadership.

5.3.2 Operations and Maintenance Supervisor

The Operations and Maintenance Supervisor is responsible for:

- Ensuring all high voltage switching activities are performed safely by suitably qualified and authorized personnel.
- Actively work to increase public safety awareness of the hazard presented by the underground cables.
- Work with customers and team members to identify opportunities to improve the operational performance and reduce costs of the assets.
- Monitor work/testing which may affect the supply of energy to the customers.
- Participate in planned and unplanned maintenance work to ensure the reliable operation of the assets.
- Supervise to ensure personnel and contractors complete their work to an acceptable standard.
- Maintain and review records for all assets and easements.
- Maintain and review the risk register for the *Directlink Asset*s.
- Provide on-call maintenance and operations support, on a rostered basis, via telephone and remote computer access.
- Attend asset sites for emergencies and maintenance periods to supervise personnel onsite and provide technical support.
- Assist with compiling reports as required by regulations and for all safety, maintenance and operations incidents and events.
- Ensure all asset operations and maintenance is in accordance with the requirements of the regulatory *Compliance Plan*s.
- Ensure all responsibilities are executed within budget constraints and in accordance with APA guidelines and procedures.
- Comply with APA Group's HS&E Policy and procedures.
- Take reasonable care to act and behave in a manner that promotes care and diligence to yourself and others in the workplace.
- Comply with reasonable instructions from any authorised representative of the company concerning health, safety and environment matters.
- Actively participate in the Emergency Response procedures.
- Attend HS&E training as directed.
- Participate in identifying, assessing and control HS&E systems and procedures.
- Report any accident/injury/hazard and/or act on reports received in the workplace using the appropriate systems.

5.3.3 Reliability Engineer

The Reliability Engineer is responsible for:

- Analysis of maintenance activities to determine future maintenance needs.
- Monitoring of operations and maintenance data to identify abnormal operating or equipment conditions.

- Review and improve equipment condition monitoring activities to determine future maintenance needs.
- Maintain accurate measurement of assets performance.
- Review and update work instructions, operational procedures, operating forms and safety procedures specific to the assets.
- Ensure operational compliance with *AMP* and budgets.
- Identify improvement opportunities and implement changes within the approved budget restraints.
- Provide electrical engineering and technical support for the assets as required.
- Provide technical training as required.
- Liaise with *DLSC* to interpret operational alarms and diagnose malfunctions of the assets.
- Liaise with on-call maintenance personnel to assist diagnosis of equipment failures.
- Attend asset sites for emergencies and maintenance periods to supervise contractors onsite and provide technical support.
- Prepare technical incident reports as required.
- Prepare accident / incident reports for all safety incidents that related to the assets.
- Immediately report breaches of regulatory obligations.
- Prepare operations incident reports as required.
- Contribute to the preparation of capital and operating budgets.
- Ensure all responsibilities are executed within budget restraints and in accordance with APA guidelines and procedures.
- Ensure assets are operated in accordance with operations plans and agreements.
- Ensure accurate recording of operations activities and communications.
- Provide operations support for the assets as required.
- Provide operations training as required
- Comply with APA Group's HS&E Policy and procedures.
- Take reasonable care to act and behave in a manner that promotes care and diligence to yourself and others in the workplace.
- Comply with reasonable instructions from any authorised representative of the company concerning health, safety and environment matters.
- Actively participate in the emergency response procedures.
- Attend HS&E training as directed.
- Participate in identifying, assessing and control HS&E systems and procedures.
- Report any accident/injury/hazard and/or act on reports received in the workplace using the appropriate systems.

6 SUMMARY OF ASSETS

The *Directlink Asset* is an *HVDC* facility that connects the power networks at Mullumbimby (NSW)) and Terranora (NSW) via *High Voltage DC Cables*. The facility consists of the three converter stations at each site at Mullumbimby and Bungalora, the *DC Cables* connecting them and the *AC* cables, busbar, switchgear and converter transformers connecting each converter station to the nearby *AC* substation (*MUL - Mullumbimby Converter Station)* and *BLA - Bungalora Converter Station*). *Directlink* utilises Voltage Source Converter (*VSC*) technology. The *DC Cables* are either buried underground or installed in galvanised steel troughing (*GST*) along the route which is 59 km in length.

The *Directlink Asset* is comprises of three parallel *HVDC* links, each delivering 56 MW at the receiving end converter station. Each *DC* link operates independent of the others. There are three pairs of *DC Cables* connecting their respective converter stations, labelled System 1, System 2 and System 3.

- Bi-directional maximum power flow of 168 MW delivered.
- Maximum reactive power generation of each converter between +35 MVAr and -55 MVAr at each end.
- *AC* connection voltage of 110 kV at Bungalora and 132 kV at Mullumbimby.
- *DC* voltage of ±80 kV.

The *Directlink Asset* can be divided into six categories:

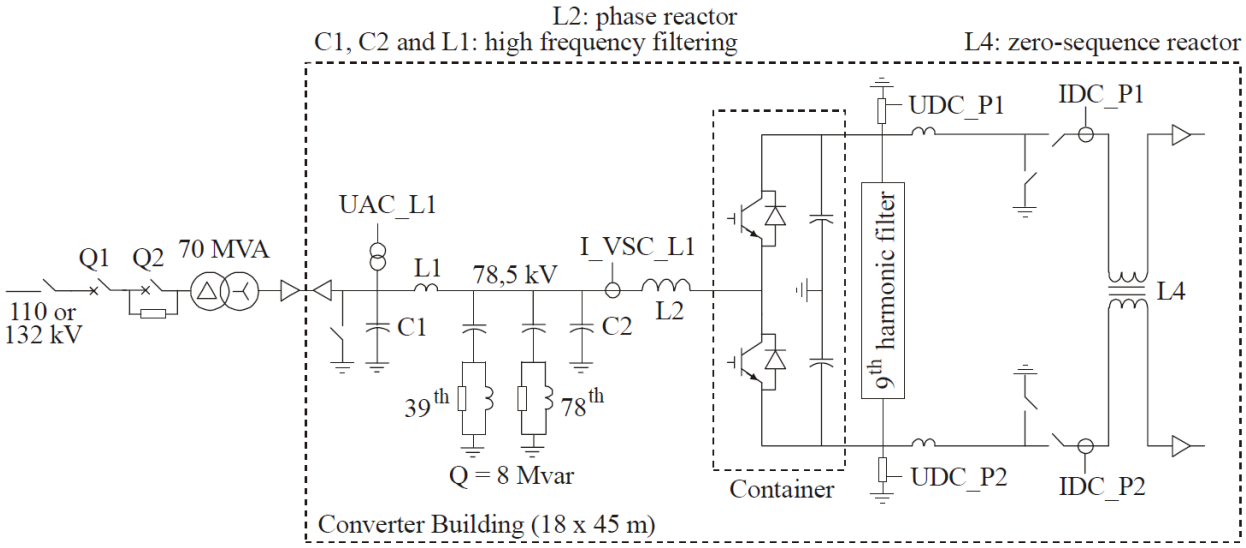
- *AC* cable connection between Terranora Substation and the *BLA*;
- *BLA*;
- Underground *DC Cables*;
- *MUL*;
- Strung bus connection between Mullumbimby Substation and the *MUL*; and
- Remote operator Workstation (ROWS) and associated telecommunications.

A high level location map is provided in Figure 2.

Figure 2 - *Directlink Asset* Location and *DC* Cable Route

A simplified single line representation of the *Directlink Asset* is provided in Figure 3. This diagram represents one of the three converter stations, at either end, between the connection to the *AC* cable (either 110 kV or 132 kV) and the ±80 kV *DC Cables*.

Figure 3 - *Directlink* Simplified Single Line Diagram



Within each of the two converter stations, there are a number of sub-systems and major equipment categories, which are summarised in Appendix 2. These category titles are used within APA's *Maintenance Connection* system.

Based on the full list of asset categories provided in Appendix 2, 17 Asset Classes have been identified and on which individual asset maintenance strategies are developed and maintained. These are listed below.

1. Circuit Breakers
2. Disconnectors and Earth Switches
3. Power Transformers
4. Phase Reactors
5. Filter Reactors (including Zero Sequence and *DC* Smoothing)
6. Capacitors
7. Filter Resistors
8. Surge Arresters
9. Current and Voltage Transformers
10. Wall Bushings
11. *IGBT*s and Valve Enclosures
12. High Voltage Cables
13. Control, Protection and Telecommunication Equipment
14. Fire System Equipment
15. *HVAC*, Valve Cooling Systems
16. Auxiliary Power Supply
17. Buildings and Structures

The *Directlink Asset* also includes a substantial spare parts holding which are stored in a spare parts building located at both the *BLA and MUL*. Large spare parts are stored at an off-site warehouse facility used by the APA Group in Eagle Farm, Brisbane. Those spare parts requiring controlled temperature/environments are stored in the air conditioned valve cooling rooms at each site.

7 COMPLIANCE

7.1 Applicable Regulations

Applicable regulations are reviewed routinely by APA.

No material changes to the Acts, legislation or licence have been recorded since the last review of this *AMP*.

7.2 Legislation

The relevant legislation that applies to the *Directlink Asset* include:

1. Electricity Supply Act 1995;
2. Electricity Supply (General) Regulation 2001
3. Electricity Supply (Safety and Network Management) Regulation 2008;
4. National Electricity (New South Wales) Act 1997;
5. National Electricity Rules;
6. New South Wales - Occupational Health and Safety Act 2000, and
7. New South Wales - Occupational Health and Safety Regulation 2001.

7.3 Agreements

The following agreements are applicable to and must be complied with during the operation and maintenance of the *Directlink Asset*s:

- Connection Agreement with *Essential Energy*

7.4 Licenses

No licence is required to operate *Directlink*. As a transmission line in NSW *Directlink* must comply with the Network Management Plan developed in accordance with the requirements of the NSW Electricity Supply (Safety and Network Management) Regulation 2008.

7.4.1 Standards

7.4.2 Supply Quality Standards

Directlink has been designed and is operated to meet the standards required by the National Electricity Rules. In addition, a connection agreement exists between APA and *Essential Energy*, specifying power quality obligations.

Performance quality is monitored against supply quality standards 24 hours a day, 7 days a week, at the *Directlink* control centre, APA Dandenong.

7.4.3 Supply Reliability Standards

Supply reliability standards are service standards set by *Essential Energy* and the *AER* in their decision on the *Directlink* Application for Conversion and Revenue Cap, they are detailed in Appendix C (3) of the decision.

8 OPERATIONS AND MAINTENANCE STRATEGY

8.1 Service Levels

The operating strategy has been developed to allow the asset to achieve the required service levels. These are:

- Safety;
- Environment

- Supply Reliability Standards including:
  - Availability
  - Interruptions

8.1.1 Safety and Environment

Safety and environment performance targets are to achieve no lost time or medical treatment incidents as shown in Table 1.

Table 1 - *Directlink* Safety and Environment Targets

Lost Time Injury (LTI) Incidents	Nil
Medical Treatment Injury (MTI) Incidents	Nil
Environmental Incidents	Nil

8.1.2 Supply Reliability Standards

The supply reliability standards for the *Directlink Asset*s are service standards set by *Essential Energy* the *AER* in their final decision on the 2013 *Directlink* transmission revenue determination.

The *AER* determination outlines financial bonus/penalty in terms of cap and collar as outlined in Table 2 and **Error! Reference source not found.**. The bonus/penalties are set as a proportion of maximum allowed revenue (*MAR)* which is determined by the *AER*.

Table 2 - *Directlink* Availability *AER* Targets

Parameter	Collar	Target	Cap	Weighting (% of *MAR*)
Scheduled circuit availability	98.90%	99.45%	100%	0.3
Forced outage circuit availability peak periods	98.47%	99.23%	100%	0.35
Forced outage circuit availability off–peak periods	98.47%	99.23%	100%	0.35

Internally set availability and reliability targets are outlined in Table 3 and Table 4.

Table 3 - *Directlink* Network Management Plan (NMP) Targets

Performance Measure	Target
Scheduled circuit availability	99.45%
Forced outage circuit availability in peak periods	99.23%
Forced outage circuit availability in off–peak periods	99.23%

Table 4 - *Directlink* EII Targets

Performance Measure	Target
Minimum Total System Availability	91.00%
Maximum Power not transferred to daily targets	5.00%
Minimum Planned maintenance to schedule	95.00%

8.1.3 Reporting

Directlink reports internally each month on its performance against the requirements set by *Essential Energy* and the targets set by the *AER*. Annual reports are submitted to the *AER* on performance targets set by the *AER* decision on the *Directlink* application for conversion and revenue cap. These results are publically available from the *AER* web site.

EII monthly operations report is prepared at operating business unit level and compiled at national operations level and submitted to EII.

8.1.4 Performance

The *Directlink* annual performance for the last *AEMO* reporting period (Calendar Year 2012) and for YTD 2013 are presented in Table 5:

Table 5 *Directlink* Performance Measures

Calendar Year Performance Measure and Results	Target 2012	2012	Target 2013	YTD 2013
Scheduled circuit availability	99.45%	98.56%	99.45%	99.91%
Forced outage circuit availability in peak periods	99.23%	86.87%	99.23%	96.64%
Forced outage circuit availability in off–peak periods	99.23%	93.43%	99.23%	95.83%

A reduced rate of cable failure resulted in an improved availability in 2012. Laboratory analysis of cable fault samples was undertaken early in 2012. The further laboratory analysis is planned for late 2013 to determine whether silicone fluid injection will be a successful remediation method.

8.2 Operations and Maintenance Strategy

This section summarises the overall strategy implemented by APA for the operation and maintenance of the *Directlink Asset* to achieve the Service Standards described in 8.1.

8.2.1 Remote Operations

Operational control is manned 24 hours a day, 7 days a week from a remote *DLSC* staffed by fully trained operators.

Directlink receives dispatch targets from *AEMO* on a five-minute basis, in a manner similar to scheduled generation plant. *Directlink* dispatch (both direction and magnitude) is optimally determined by *AEMO's* Scheduling, Pricing and Dispatch (SPD) software.

8.2.2 Maintenance

Maintenance work for the *Directlink Asset* is undertaken by a combination of APA staff and contractors under the guidance of APA asset management staff. The aim of this *AMP* is to ensure that the maintenance work is in accordance with the following objectives:

1. Ensure that all personnel act, and plan for action, in a manner that will not put any property or any person at risk of damage or injury;
2. Diligently undertake the maintenance services to provide maximum availability and maintain *Directlink Assets* in good condition, in accordance with the requirements of *Directlink* procedures, good electricity industry practices and applicable laws;
3. Schedule and co-ordinate Maintenance Services in advance and re-schedule planned outages accommodating requests from *AEMO* or any Transmission Network Service Provider (*TNSP*);
4. Take suitable action to avoid collateral damages to any other asset owned or operated by *Directlink* and any electrical infrastructure or asset of a *TNSP* or any other person;
5. Ensure sufficient trained and competent personnel are available to undertake the maintenance.

In general, APA asset management staff apply preventative maintenance practices to the *Directlink Asset*, where maintenance is primarily driven by the condition or duty of equipment, determined during regular scheduled inspections. The effectiveness of this preventative maintenance strategy will be enhanced by the installation of remotely controlled cameras within the energised parts of the converter buildings which is currently proposed.

A plan is in place to introduce more predictive maintenance strategies with an intention to implement a data historian as part of an upcoming control system upgrade.

Routine maintenance shall take place weekly, monthly and annually as required by the Maintenance Plan (Appendix 1). Where redundant systems allow, maintenance shall be performed during normal operations (no required outage) in accordance with manufacturer recommendations.

Maintenance is planned in advance to ensure that the integrity of supply is secured and that the asset has high availability. However, unplanned maintenance is dealt with on a case by case basis and depending on the urgency of the requirement. If the requirement is urgent, such as the safety of personnel or the public is at risk or there is a high likelihood of damage to and/or outage of the plant and equipment, this will be acted on immediately. In less urgent cases, the unplanned maintenance requirement will be scheduled for either a more suitable time in the future or the next planned maintenance activity.

Major planned maintenance requiring the shutdown of the *Directlink Asset* and access to the live main circuit components is scheduled to coincide with times where the dispatch across *Directlink* is expected to be low. This typically results in such major planned maintenance occurring in July and August. The scheduled dates for such maintenance is coordinated with *AEMO* and *Essential Energy*. Such maintenance includes the inspection, maintenance, and cleaning of equipment in areas that are high voltage energized when operating and/or the replacement of high voltage components that have failed or require replacement due to condition.

8.2.3 Site Manning Strategy

The *Directlink Asset* is monitored and dispatched on a 24/7 basis from the DLSC.

The *Directlink Asset* sites are not permanently manned. Instead, these sites are manned on an ad hoc basis, with trained staff and contractors available to undertake the routine inspections and maintenance and to attend the sites in an emergency.

A call centre number is provided at the site gates and on the cable markers to allow members of the public to contact APA asset management if required.

8.2.4 Site First Response

APA operate a first roster, where the DLSC centre is provided a single telephone number to contact the rostered APA first response person. The first response person assumes responsibility for investigating and resolving any issues affecting the operation of *Directlink*. Depending on the severity of the event or issue, persons up the chain of APA asset management are contacted.

8.2.5 Maintenance Facilities

Facilities which are used for the operations and maintenance of the *Directlink Asset* include:

- Spare parts storage shed, located at the *BLA*.
- Controlled temperature spare parts storage is within in the valve cooling room
- Large spare parts are stored at APA warehouse in Eagle Farm, Brisbane

8.2.6 Contractor Support

Aside from the responsibilities of the APA asset management staff, other personnel and resource requirements will be satisfied through the engagement of contractors either through support contracts or engaged on an ad-hoc basis as required. Examples of where other personnel will be required include during scheduled shutdown maintenance, overhauls and emergency repairs for both the converter station and the high voltage cables.

Currently, APA asset management have contractors engaged on a regular basis for the following activities:

- Fire system maintenance;

- *HVAC* maintenance;
- High voltage cable repair;
- Transformer maintenance; and
- Large scale repairs, replacements or maintenance shutdowns where additional staff are required.

8.2.7 High Voltage Switching

The APA asset management team have implemented and continue to maintain formal high voltage switching procedures (DL-OP-06). These are written to align with the Victorian "Code of Practice on Electrical Safety for Work on or Near High Voltage Apparatus" often known as the "Blue Book". The document outlines the roles and responsibilities during HV switching, and covers the process of applying for high voltage outages, developing and implementing switching sheets, undertaking switching operations safely and ensuring safe access through the implementation of a high voltage access permit system. Training and competency of persons undertaking the various roles and responsibilities involved in HV switching is also covered by the HV switching procedures and are summarised in section 8.5 of this *AMP*.

8.3 Contingency Planning

There are currently two key documents related to the management of emergencies and major failures of the *Directlink Asset*s. These are:

- DL-OP-23 - Emergency Response Plan.
- DL-DO-05 - Operations Environmental Management plan.
- DL-SP-01 - Response to a Serious Electrical Accident.
- DL-SP-02- Response to a Serious Electrical Accident – Downstream.

In addition to these procedures, which deal primarily with the safety and environmental issues associated with an emergency incident and the subsequent management, reporting and investigation of the incident, APA are currently developing emergency plans for the replacement of major items of plant in the event of failure. The intent of these plans is to ensure that a process can be immediately implemented to prevent delays to the commencement of repair and replacement and to ensure any required engineering or planning has been done before the event has occurred. The major items of plant for which these plans are being developed include:

- Power transformers;
- Phase reactors;
- Zero sequence reactor; and
- High voltage cables.

APA have implemented or are developing emergency plans to respond to natural events that threaten to affect the *Directlink Asset*s including:

- Bush fire; and
- Flooding

The purpose of this contingency planning is to minimise outages and/or downtime caused by these events and therefore to maximise reliability.

8.4 Environmental Planning

Directlink manages environmental considerations through the Operations Environmental Management Plan (DL-DO-05). This plan is managed by the National APA Heritage, Environment and Lands Department and is reviewed annually. The general structure includes:

i. A description of the main components of *Directlink* including an outline of the route and location of each component. This section also has a brief description of the environmental resources found along *Directlink*;

ii. A description of APA's environmental emergency response procedures;

iii. The environmental management strategies that are employed to minimise and mitigate against environmental impacts; and,

iv. A description of monitoring, measurement and evaluation processes including incident reporting and notification.

8.5 Training, Awareness and Competence

The training and competency requirements of APA staff and contractors for the operation and maintenance of the *Directlink Asset*s are addressed in detail in various *Directlink* operational documents. Table 6 summarises the training, awareness and competence regime undertaken by APA in the management of the *Directlink Asset*.

Table 6 - *Directlink Asset* - Training Requirements

Training	Source	Jurisdiction	Participants	Frequency
Construction Industry Induction	External	National	OMP, OME, OMS, ETP	Once
APA Induction	Internal	National	OMP, OME, OMS, ETP	Once
Directlink Induction	Internal	NSW	OMP, OME, OMS, ETP	18 Months
Toowoomba Hospital Induction	Internal	Qld	OMP, OME, OMS	2 years
Daandine Power Station Induction	External	Qld	OMP, OME, OMS	Ad hoc as required
X41 Power station Induction	External	Qld	OMP, OME, OMS	Ad hoc as required
Confined Space Access	External	NSW, Vic and SA	OME, OMS, ETP	2 years
Directlink High Voltage Switching operator - Initial Course	External	NSW	OMP, OME, OMS, ETP	3 years
High Voltage Switching operator - Practical Assessment		NSW, Vic and SA	OMP, OME, OMS, ETP	3 years
APA Safety System Training	Internal	National	OMP, OME, OMS, ETP	Once
APA Oracle Finance System Training	Internal	National	OMP, OME, OMS, ETP	Once
APA Permit Issue Officer Training	Internal	National	OME, OMS, ETP	Once
APA Maintenance Connection Training	Internal	National	OMP, OME, OMS, ETP	Once
Electrical License Renewal Training	External	Qld	OMS, ETP	5 years
Mach2 Control System Training	Internal	National	OME, OMS, ETP	Once
CB Maintenance Training	External	National	OME, OMS, ETP	Once
Low Voltage Rescue Training	External	National	OMP, OME, OMS, ETP	1 Year

Training	Source	Jurisdiction	Participants	Frequency
First Aid training	External	National	OMP, OME, OMS, ETP	1 Year
Resuscitation Training	External	National	OMP, OME, OMS, ETP	1 Year
Working at Heights	External	National	OME, OMS, ETP	2 years
Elevated Work Platform	External	National	ETP	2 years
Basic Rigging	External	National	ETP	2 years
Excavation Training	Internal	National	ETP	2 years
Forklift Training	External	National	ETP	2 years

Participant	*ABB*reviation
Operations Manager - Power Transmission & Generation	OMP
Operations and Maintenance Engineer - Power Transmission & Generation	OME
Operations Supervisor - Power Transmission & Generation	OMS
Electrical Technician - Power Transmission	ETP

9 LIFE CYCLE ASSET MANAGEMENT PLAN

9.1 Maintenance Strategies for Individual Asset Classes

Work instructions have been developed by APA group for routine preventative maintenance based on the *OEM*'s recommendations. Based on age the majority of equipment is beyond warranty periods, hence strict compliance with the *OEM*'s recommendations is no longer required. Where practical APA have modified work instructions to suit maintenance strategies. The order of precedence for asset maintenance instructions is as follows:

- APA group work instructions
- *OEM*'s instructions

Where a conflict exists in the performance of a maintenance task seek clarification from the APA Operations Manager Power Transmission.

Individual strategies for maintenance by asset class have been developed as listed in Table 7. Information available from the *OEM* of each asset is identified in the table below.

Based on age the *Directlink Assets* are in the sustaining maintenance phase of the asset lifecycle. The asset maintenance strategies for each asset class should be selected to match this sustaining phase.

APA Group intend on improving asset maintenance strategies to incorporate further condition based maintenance. Further investment in data collection and monitoring is planned such as:

- Installation of a data historian system for the collection and trending of data;
- Installation of a camera system for detection and event diagnostics; and
- A failure reporting, analysis, and corrective action system (FRACAS) is being developed to gather data that will support improvements in reliability.

The following documentation is referred to in the asset maintenance strategies:

- APA operating procedures and work instructions.
- *OEM* plant documentation including operation and maintenance within *ABB PlantDocs* which uses a HTML interface, main page titled “Plant Documentation *Directlink* – 2006-05-30”.
- A spare parts and special tools register is held by APA group “*Directlink* Spares”. APA spare parts and special tools are held generally in accordance with the *OEM*’s recommendations outlined in *PlantDocs*.

- For a listing of maintenance activities, timing and generation of work orders refer to the preventative maintenance assets listing in *Maintenance Connection*.

Further description of maintenance strategies for asset classes are described in the following sections. This section focusses on main assets and does not describe all maintenance activities that are performed by *Directlink* operations personnel.

For a further summary of assets, maintenance intervals, procedure documentation and personnel requirements refer to the table in Appendix 2.

Table 7 - Asset Class Information

Asset Class	Maintenance		Documentation			Spares	Asset Health
	Routine	Condition Based	Manufacturer	Work Instruction	Response Plan		
Circuit Breakers	√	√	√	√		√	
Disconnector Earth Switches	√		√	√		√	
Power Transformers	√	√	√	√		√	
Reactors	√		√	√		√	
Capacitors	√	√	√	√		√	
Filter Resistors	√		√	√		√	
Surge Arresters	√		√	√		√	
Current Transformers	√		√	√		√	
Voltage Transformers	√		√	√		√	
Wall Bushings	√		√			√	
IGBT Valves	√		√	√		√	
HVAC, Valve and Reactor Cooling Systems	√		√	√		√	
High Voltage Cable						√	
Control, Protection and Telecommunication Equipment						√	
Fire Systems	√		√	√		√	
Auxiliary Power	√		√	√		√	
Buildings & Structures						√	

9.1.1 Circuit Breakers

The HV circuit breaker type installed within the yards are SF6, *ABB* LTB type, 3 ph/1 pol live tank circuit breakers rated for normal voltages of 132 kV at Mullumbimby and 110 kV at Bungalora. The asset maintenance strategy for the circuit breakers asset class covers the following:

- *AC* circuit breakers

- *AC* bypass breaker
- *AC* filter breakers
- Pre insertion resistors

The circuit breakers are non-redundant and critical to the electrical protection of the assets.

9.1.1.1 Maintenance and Timing

Circuit breaker design life is 30 years between major overhauls. Minor preventative maintenance overhauls are recommended after 15 years, 10,000 on-off operations or a combination of trip on-load/fault events. Routine maintenance consists of monthly and annual de-energised visual inspections.

Historical operations indicate that preventative maintenance will be performed based on age rather than operation; hence the minor preventative maintenance will be due in 2015.

9.1.1.1.1 Circuit Breaker Maintenance

Monthly visual inspections are performed by APA staff in accordance with work instruction DL-WI-17. The inspection consists of:

- Inspect device for external contamination. (Clean by wiping with a clean, dry, lint free rag, if required only if de-energised). This includes the pre-insertion resistors.
- Inspect the drain plugs and ventilation openings in the operating mechanism cabinets. Replace if required.
- Check operation of the heater by adjusting the thermostat to above ambient temperature. Return thermostat to original setting (20°C).
- Record the operation counter located in the rear of the mechanism box.
- Record the SF6 gas pressure on all 3 units.
- Check the mechanism boxes for signs of moisture and dust ingress. Record observations.
- For the pre-insertion resistors, check for signs of failure or damage including:
  - venting duct plastic cover blown off;
  - cracks in the porcelain if porcelain insulation is used;
  - soot marks on the porcelain if porcelain insulation is used; and
  - soot marks inside the venting duct.

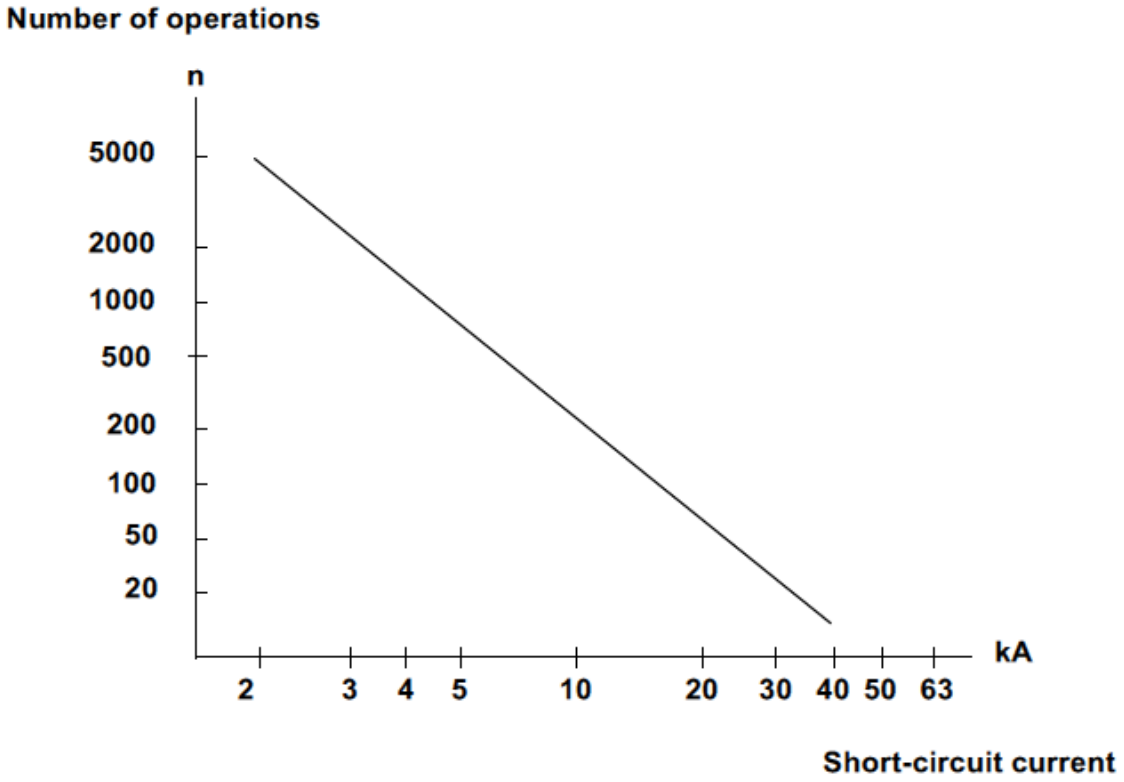
Periodic maintenance shall be carried out at operation intervals specified in Table 8.

Table 8 - Circuit Breaker Maintenance

Circuit Breaker Maintenance				
	Maintenance Type	Inspection Interval	Maintenance Environment	Maintenance Personnel
A	Visual Inspection	1-2 years	In-situ	No special training
B	Preventative Maintenance	15 years or ΣnI^2=20,000	Indoor	Authorised *ABB* personnel
C	Overhaul	30 years or 10,000 On-Off or ΣnI^2=20,000	*ABB* approved workshop	Authorised *ABB* personnel

In Figure 4 the criteria for preventative maintenance/overhaul based on fault-trip events is outlined. *ABB* recommends to perform preventative maintenance once Σnl2=20,000 (where n= number of events and I= short circuit current in kA).

Figure 4 - Circuit Breaker Preventative Maintenance Evaluation



Preventative maintenance tasks are outlined in 1HSB425409-101 and include removal, degassing and detailed inspection and testing in a controlled indoor environment by authorised service personnel.

Overhaul of equipment shall be performed by authorised service personnel at the workshop.

9.1.1.1.2 Circuit Breaker Spring Loaded Operating Mechanisms

Preventive maintenance and overhaul of spring loaded operating mechanisms shall be carried out at regular intervals in accordance with *ABB* recommendations including:

- Visual inspection at 1-2 year's intervals.
- Lubrication after 15 years or 2,000 mechanical On-Off operations.
- Preventive maintenance after 15 years or 5,000 mechanical On-Off operations.
- Overhaul after 30 years or 10,000 mechanical On-Off operations.

Overhaul and repair work may only be carried out by authorised service personnel.

9.1.1.2 Spares Strategy

Spares are held as follows:

- Circuit breaker – A single pole for each live tank circuit breaker type is held at each the Mullumbimby station storage facility, as well as trip coils, gas density gauges and gaskets.
- Operating devices – A single operating device is held at the *MUL* store.

Replacement shall be performed by approved contractors. Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

9.1.2 Disconnectors and Earth Switches

The asset maintenance strategy for the disconnectors and earth switches asset class covers the following:

- Horizontal centre break type disconnectors -
  - *AC* type - *ABB* TD-HLA-052
  - *DC* type – *ABB* TD-HLA-058
- Earth switches - *ABB* type NSA

9.1.2.1 Maintenance and Timing

Monthly Energised checks are performed in accordance with DL-WI-17 including:

- Check operation of the heater by touching the heater shield located at the bottom left of the mechanism box.
- Check for signs of moisture or dust ingress into the mechanism box.

The maintenance of disconnectors and earth switches shall be performed by trade qualified personnel as follows:

- Inspection of contacts and current-carrying parts is recommended every 2-3 years.
- Motor drive mechanisms every 6 years in accordance with manufacturers recommendations.

9.1.2.2 Spares Strategy

Spares are held as follows:

- Contact arms – two, 3 ph sets of contact arms are held at the *MUL* store.
- Drive mechanisms – A *DC* motor drive mechanism and an *AC* manual drive mechanism is held at the Mullumbimby store.

Replacement shall be performed by approved contractors.

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

9.1.3 Power Transformers

The converter transformers consist of a single, three phase unit, Dy1n, 70 MVA ONAF at each converter station, 110 kV/78.5 kV at Bungalora and 137 kV/78.5 kV at Mullumbimby.

9.1.3.1 Maintenance and Timing

Power transformer maintenance is performed generally in accordance with *ABB*'s Operation and Maintenance Manual *"000169568 Rev. 00".* Inspection and maintenance activities are typically carried out as per the recommended durations for monthly, annual and long term maintenance. All maintenance of transformers shall be performed by trade qualified personnel.

Monthly energised inspections are as outlined in document DL-WI-17 including:

- Oil Temperatures
- Winding Temperatures
- Oil Levels
- Silica Gel Condition
- Cooling Fans
- Pressure Relief Valve
- On Load Tap Changer (OLTC)
- Buchholz Relay
- Surge Diverters

- Control Cubicle
- General Transformer Condition.

Annual maintenance shall be performed in accordance with *ABB* operation and maintenance manual *000169568 Rev. 00* and includes:

- Insulated oil sampling and lab testing
- Bushings inspection and cleaning
- Insulation resistance measurement
- Accessories general overhaul

Long term recommended maintenance includes overhauls based on condition assessment and maintenance of paint and welds.

9.1.3.2 Spares Strategy

One spare transformer is held at Bungalora which can be tapped at either 132 kV or 110 kV.

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

As the power transformers are a critical main circuit item and can be both complex and time consuming to replace, an emergency replacement plan is under development by APA Group.

9.1.4 Reactors

The asset maintenance strategy for the reactors asset class covers the following:

- *AC* filter reactors
- *AC* PLC filter reactors
- *DC* smoothing reactors
- Zero sequence smoothing reactors
- *DC* Filter reactors
- Phase reactors

9.1.4.1 Maintenance and Timing

Routine annual reactor inspections are performed by trade qualified personnel in accordance with APA work instruction DL-WI-29. The following activities are performed:

- Check if the arms of the top/bottom spiders have become loose from the winding.
- Check if the spider ties have become loose.
- Check the top and bottom of the winding for possible abnormalities such as carbonization, arcing marks, tracking marks, etc. If such marks are found, notify APT. Do not re-energise until the manufacturer has been notified.
- Check the inside and outside surface of the reactor winding for possible tracking marks. If such marks are found, notify APT. Do not re-energise until the manufacturer has been notified.
- Check whether all bolts are securely fastened. If several bolts are found to be loose, retighten all bolts
- Check the performance of the ground wires (tightness of bolting, corrosion, etc.)
- Check the surface of the reactors and insulators for contamination. Clean reactors and insulators if necessary. Cleaning using soft nylon brush or clean lint free tissues and 30 bar water spray applied from 200 mm distance.
- Check the status of the protective paint of the reactor. Local imperfections or paint peeling should be touched-up according to *OEM* specification.
- Check the top of the winding and the cooling ducts for foreign objects and remove them.

Note that a separate APA work instruction is under development for the maintenance of the phase reactors.

9.1.4.2 Spares Strategy

Spares are held as follows:

- Filter and smoothing reactors – a spare reactor of each type is held at the *MUL* store.
- Phase reactor – a single spare phase reactor is typically held, however a spare is not currently in stock
- Insulators – spare insulators for each reactor type are held at the *MUL* store.

As the phase reactors and the zero sequence reactors are a critical main circuit item and can be both complex and time consuming to replace, an emergency replacement plan is under development by APA Group.

Replacement will be performed by APA staff or approved Contractors

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

9.1.5 Capacitors

The asset maintenance strategy for the capacitors asset class covers the following:

- *DC* capacitors
- *DC* filter capacitors
- *AC* filter capacitors
- *AC* filter tuning unit

9.1.5.1 Maintenance and Timing

The *OEM* recommends annual inspection and capacitance measurement every three years. To optimise capacitor inspections APA perform capacitance measurement annually and rotate so that all capacitors are measured within a three year timeframe.

All inspections shall be performed under the supervision of trade qualified personnel.

Annual inspection procedures are described in APA work instruction DL-WI-30 and consist of:

- Perform a visual inspection looking for pollution, damage to the finish, leaking capacitor units, etc.
- Clean insulators and bushings.
- Replace all leaking capacitors. The capacitance difference between the faulty and replacement units should not differ by more than ±1 unit.

Three yearly measurement of capacitance is described in APA work instruction DL-WI-38 and consists of:

- Measure the capacitance of all units.
- Replace all capacitors where measured capacitance deviates more than 10% from the commissioned value. The capacitance difference between the faulty and replacement units should not differ by more than ±1 unit.

9.1.5.2 Spares Strategy

Spares are held as follows:

- Capacitors – spare capacitor units of each type is held at the *MUL* store.
- Insulators – spare insulators for each capacitor type are held at the *MUL* store.

Replacement will be performed by APA staff or approved contractors

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

9.1.6 Filter Resistors

The asset maintenance strategy for the filter resistor asset class covers the following:

- *AC* filter resistors
- *DC* filter resistor
- PLC filter resistor

9.1.6.1 Maintenance and Timing

Annual de-energised inspections of filter resistors are performed by trade qualified personnel as outlined in APA work instruction DL-WI-35 including:

- Inspect device for external contamination. Clean if necessary. Clean the insulators by wiping with a clean, dry, lint free cloth. Clean the resistor webs by blowing with compressed air.
- Check all connections of the resistor webs to their busbars are tight.
- Check all electrical connections are tight.
- Check the enclosure surface inside and outside for surface damage.

9.1.6.2 Spares Strategy

Spare resistors for each type are held at the *MUL* store.

Replacement will be performed by APA staff or approved contractors.

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

9.1.7 Surge Arresters

The asset maintenance strategy for the surge arrester asset class covers the following:

- *DC* filter arresters
- *DC* bus arresters
- Power transformer neutral arrester
- *AC* filter arresters
- *AC* filter bus arresters
- *AC* bus arresters
- *AC* cable termination arresters

9.1.7.1 Maintenance and Timing

Annual de-energised inspection of arresters are performed by trade qualified personnel and are outlined in APA work instruction DL-WI-34 including:

- Inspect device for external contamination. If required, clean by wiping with a clean, dry, lint free cloth.
- Check all electrical connections are tight.
- Inspect device for signs of failure. If the device has failed it will need to be replaced. Signs of include:
  - venting duct plastic cover blown off;
  - cracks in the porcelain if porcelain insulation is used;
  - soot marks on the porcelain if porcelain insulation is used;
  - soot marks inside the venting duct;
  - signs of burning or heating in the silicone if silicone insulation is used.

9.1.7.2 Spares Strategy

A single spare surge arrester of each type is held at the *MUL* store.

Replacement will be performed by APA staff or approved Contractors

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

9.1.8 Current Transformers

The asset maintenance strategy for the current transformers asset class covers the following:

- Outdoor post type *AC* current transformer
- Hall effect current transformers
- *DC cable* screen current transformers

9.1.8.1 Maintenance and Timing

Outdoor post type current transformers shall be maintained by trade qualified personnel in accordance with APA work instruction DL-WI-32 which outlines annual inspections and five yearly maintenance.

Annual de-energised inspections shall include:

- Check for cracks or damage to the resin surface of the current transformer.
- Check the secondary terminal box is sealed and free from contamination.
- Check all electrical connections are tight.
- Check the condition of cover plates and flange sealings.

Five year maintenance activities shall consist of cleaning the current transformers and applying a thin coat of silicone.

Current transformer equipment shall be maintained by trade qualified personnel in accordance with APA work instructions:

- Hall Effect Current Transducers - DL-WI-31
- *DC* Cable Screen Current Transformers - DL-WI-33

Annual de-energised inspections shall be performed as follows:

- Remove dust from current transducer by wiping with a clean, dry cloth.
- Check tightness of primary bar connections and all other connections.

9.1.8.2 Spares Strategy

Typically a single current transformer of each type is held at either converter station

Replacement will be performed by APA staff or approved Contractors.

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

9.1.9 Voltage Transformers

The asset maintenance strategy for the voltage transformers asset class covers the following:

- Capacitance voltage transformers

9.1.9.1 Maintenance and Timing

Capacitive voltage transformers shall be maintained by trade qualified personnel in accordance with APA work instruction DL-WI-37:

- Inspect device for external contamination. Clean by wiping with a clean, dry, lint free rag, if required.
- Check for cracks and other damage to the insulators.

- Check for oil leaks from both the capacitors and the transformer.
- Check the oil level in the transformer. Oil level should be in the middle of the oil level gauge.

9.1.9.2 Spares Strategy

A single voltage transformer of is held at the *MUL* store.

Replacement will be performed by APA staff or approved Contractors

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

9.1.10 Wall Bushings

The wall bushings are SF6 insulated.

9.1.10.1 Maintenance and Timing

Recommended annual maintenance of wall bushings consists of:

- Checking that density monitors and pressure gauges are working as expected.
- supervision of SF6 to ensure that gas pressure does not drop below nominal insulating density
- Thermo-vision infrared scanning to ensure the normal bushing temperature rise at rated current is 20-30K above ambient.

9.1.10.2 Spares Strategy

A single wall bushing is held at the *MUL* store.

Replacement will be performed by APA staff or approved Contractors

Instructions for the assembly and replacement of equipment is outlined in *ABB PlantDoc*.

9.1.11 *IGBT*s and Valve Enclosures

The *Directlink Asset* consists of a number of valve enclosures which contain stacks of *IGBT*s. The *IGBT*s are connected in series electrically for each valve and are cooling via a valve cooling circuit.

9.1.11.1 Maintenance and Timing

Annual *IGBT* valve maintenance shall be performed by approved personnel (APA staff or contractors) in accordance with APA work instruction DL-WI-26 and *ABB* maintenance instruction *1JNL100053-678* which includes:

- Reduced Light Test (energised and blocked)
- Visual Inspection.
- Replace Faulty *IGBT* Positions.
- Leakage Current Test.
- Switching and Communication Tests.
- Cleaning and Pre-energisation checks.

Annual maintenance shall be performed with the *Directlink Asset* de-energised and earthed.

APA group work instructions for the preparation of the converter stations and valve enclosures for access for maintenance shall be followed.

The required equipment for the annual maintenance and replacement of the *IGBT*s are specified in the *ABB* maintenance instruction *1JNL100053-678* and includes:

- Set of tools for changing faulty *IGBT* positions.
- *IGBT* Position tester LTIB 800/1300.
- Test probes.

- Resistor box.
- Multimeter.
- SN8, Light Power measuring equipment.
- Extractor and pliers for the light guide.
- Reference Light Guide.

For maintenance testing access to the IPM log files is required in accordance with APA group work instruction DL-WI-12.

Replacement of failed *IGBT*'s shall be performed by trained personnel in accordance with APA group work instruction DL-WI-13 and *ABB* maintenance instruction 1JNL100026-087.

9.1.11.2 Spares Strategy

The contract/design requirement for *IGBT* failure is 0.5% per annum. Each valve has an in-service redundancy of five *IGBT*s (i.e. the system will trip if the sixth *IGBT* in that valve fails).

Whilst replacement of *IGBT*s will occur during the annual shut down maintenance period, it is possible that other outages may be required to replace *IGBT*s if the number of failed *IGBT*s in one or more valves gets close to the in-service redundancy.

The spares holding is accordance with the *OEM* recommendations for routine maintenance and replacement (21 *IGBT*s per site).

Sufficient spares is held at each converter station for typically one year of operation. Spares are ordered as they are used.

Multiple spares for O-rings and insulating rods are also held.

For other equipment, typically a single replacement part of each type is held at each converter station for items such as:

- Shields
- Pipes of each type
- Light guides

Instructions for the assembly and replacement of equipment is outlined in *PlantDoc*.

Special tools for routine replacement work are also held at each converter station.

9.1.12 *HVAC*, Valve and Cooling Systems

The *Directlink Asset* includes a valve cooling system – pumps and regulates the temperature of de-ionised water through the *IGBT*s; and *HVAC* (Heating, Ventilation and Air Conditioning) plant. Due to similarities in rotating plant and equipment the maintenance requirements and skills required are the same.

9.1.12.1 Maintenance and Timing

Valve cooling system inspections and maintenance shall be performed on a monthly, 3 monthly and annual basis. All maintenance shall be performed by performed or supervised by trade qualified personnel.

Valve and reactor cooling systems shall be maintained in accordance with APA group work instructions and manuals provided by *PlantDocs* including:

- Monthly energised inspections - DL-WI-17,
- Nitrogen bottle change out and oxygen content checking in accordance with DL-WI-18

Monthly energised valve and reactor cooling system inspections shall be performed in accordance with APA group work instruction DL-WI-17 and shall include:

- Cooling pumps
- De-*AER*ation of ion exchange vessels

- Check nitrogen levels
- Cooling tower checks
- Cooling instrument checks
- Valve & Reactor cooling checks

Three monthly maintenance of reactor and valve cooling equipment includes:

- Checking pump operation
- Lubrication & grease changes for pumps

De-energised valve cooling system inspections are performed, typically annually, to check for leaks, oxygen levels evidence of water or flashover and integrity of equipment within the:

- Valve enclosure
- Reactor room; and
- HF damper circuit.

HVAC systems inspections and maintenance is performed by APA operations staff as follows:

- Fan coil maintenance
- Expansion vessel maintenance
- Annually in accordance with DL-WI-25
- Ventilation fan maintenance
- Humidity control system maintenance

HVAC design, operation, maintenance information can be found in *PlantDocs*.

9.1.12.2 Spares Strategy

Spares are generally held in accordance with the *OEM* recommendations for routine maintenance and breakdown. Some common spares are held between converter stations.

Special tools for routine replacement work are also held at each converter station.

9.1.13 High Voltage Cables

The converter stations of the *Directlink Asset* are connected by three pairs of *High Voltage DC Cables*. These cables are buried underground, with a significant portion of the route above ground in Galvanised Steel Trough (*GST*). An easement of 59 km route length is provided along the cable route which needs to be inspected and maintained.

9.1.13.1 Maintenance and Timing

The *DC Cables* are buried or enclosed in *GST* for the entire length of the cable route and therefore cannot be inspected on a regular basis. No maintenance is performed on the underground cables, except to inspect the route easements and to respond to cable failures. This is considered good electricity industry practice.

The routine inspection of easements is performed by APA staff monthly. This comprises monthly inspections of selected parts of the cable route. The overall strategy is to ensure that the whole route is inspected over the course of the year.

This inspection covers:

- An inspection of vegetation along the *DC cable* easement; and
- An inspection of the presence of and condition of cable location signs and markers.
- An inspection of the condition of the *GST*

Any required vegetation control will be initiated on completion of the inspection and issued to the vegetation contractor. Any missing or badly damaged cable location signs and markers are to be replaced.

Cable repair is performed by an APA approved contractor in the event of a cable fault or failure.

There are no procedures for the repair of the cables, other than the manufacturer technical data and cable joint instructions. APA Group are developing *HVDC cable* repair procedures to ensure a quality control approach is applied to the repair.

DL-OP-19 covers the requirements for undertaking works adjacent to and in the vicinity of the *DC cable* route.

Any issues identified with the *GST* will be identified and works for repair arranged.

9.1.13.2 Spares Strategy

Common spares and special tools are held at Bungalora for cable repair, jointing and termination. Spares include:

- Spare *AC* & *DC* Cable lengths;
- Spare *AC* and *DC cable* terminations; and
- Spare *AC* and *DC cable* joint kits.

Satisfactory lengths and numbers of each are held to ensure cable repairs can be completed urgently. There is allowance for multiple failures to occur before replacements arrive.

Special equipment is held at the Bungalora sites to locate cable faults and to undertake repairs. This includes:

- Hipotronics Cable Fault Locator and Test Set
- Hipotronics TDR 1100L
- Cable stands, work benches, water resistors etc. for the repair and testing of the cables.

9.1.14 Control, Protection and Telecommunication Equipment

Priority for asset management is given to software systems required for the continuing operation of *Directlink*.

Software systems maintenance activities include:

- Maintenance and backup of master software code
- Weekly storage of information such as alarm and trip events
- Annual backup of the software code.

Changes to software code is performed and documented in accordance with APA procedures.

Industrial hardware control systems are replaced typically over a 10-15 year period as the equipment becomes superseded and more difficult to maintain. An upgrade of the industrial hardware system is planned for 2016.

Workstation hardware items such as computers, screens, laptops, and printers are considered to be consumable items and routinely replaced on average every 5 years.

Routine maintenance activities for control and protection equipment is mainly focussed on cooling and ventilation equipment. Maintenance is performed as follows:

- Weekly or monthly visual inspection of equipment
- Maintenance/cleaning of fans and filters is performed every 6 months
- Replacement of fans typically every 5 years.

9.1.14.1 Spares Strategy

Spares are held at each converter station primarily for maintenance/replacement in the event of breakdown.

The spare parts for the control and protection system is stored in the controlled temperature spare parts rooms located across from the local control room in each converter station. The spare parts typically comprise:

- A MACH 2 main computer (currently nil spare);
- Power supply cards;
- CPU and I/O boards/cards;
- Circuit breakers and relays;
- Fan units;
- Computer peripherals; and
- Cables, connectors and fibre optic leads.

9.1.15 Fire System Equipment

The asset maintenance strategy for the fire system equipment asset class covers the following:

- Fire Indicator Panel – NT Scandinavian Fireman's Panel
- Fire detection and alarm system installed by Wormald
- Fire detection system – VESDA Laser Plus

9.1.15.1 Maintenance and Timing

Fire system maintenance consists of:

- Weekly functional testing performed by operation staff
- Monthly system tests by operation staff
- Annual testing by a competent services/maintenance company.

The fire detection maintenance activities for the above inspection regime is outlined in:

- FIP Maintenance is recommended in "wfs-NTF-GB2202 Rev. 00 "
- VESDA system recommended maintenance of the is outlined in "Wfs-VLP-GB3115 Rev. 00 - VESDA Laser Plus, System Design Manual"

9.1.15.2 Spares Strategy

Spares are held at each converter station primarily for maintenance/replacement in the event of breakdown.

Spare parts required would be provided by the fire services contractor.

9.1.16 Auxiliary Power Supply

The auxiliary power supply system comprises:

- Auxiliary power transformer
- Distribution Boards
- *UPS* system

9.1.16.1 Maintenance & Timing

The *UPS* systems are designed to be maintenance free and shall be kept free of dust and dirt to maintain proper operation of the heat sink equipment.

Battery maintenance is performed in accordance with the *OEM*'s instructions.

The auxiliary power transformer is maintained on an ad hoc basis. APA Group is currently developing a work instruction specifically for the maintenance of auxiliary power equipment including the auxiliary power transformers.

The *UPS* system shall be maintained as follows:

- 6 monthly checking of battery systems
- Annual inspection includes checking of equipment including
  - Charging voltage
  - Measuring instrument
  - Alarm circuits
  - Fans & filters
- Replacement of cooling fans every 5 years.

9.1.16.2 Spares Strategy

Spares are held at each converter station primarily for maintenance/replacement in the event of breakdown.

The commonly held spares for auxiliary power include:

- Various contactors, relays, MCBs
- Safety switches;
- Fuses; and
- Relays.

9.1.17 Buildings and Structures

The following routine maintenance of buildings and structures is performed:

- Emergency lighting routine tests every 6 months and include the AC switchyard lighting maintenance – if installed.
- Potable fire extinguishers are tested every 6 months
- Functional test of emergency stop and trip buttons performed annually

Ad-hoc maintenance of building fitting and fixtures is performed as identified for normal wear and tear of equipment.

Compliance inspection and testing of buildings, installation and site facilities is performed in accordance with legislative requirements including:

- Earth grid testing – APA Group are currently developing a procedure for the ongoing earth grid testing to comply with requirements.

9.1.17.1 Spares Strategy

Spares are held at each converter station primarily for maintenance/replacement in the event of breakdown.

9.2 Spares Holding, Special Tools & Purchasing

A spare parts and special tools register is held by APA group *'Directlink Spares*. APA spare parts and special tools are held generally in accordance with *ABB* recommendations outlined in *PlantDocs*.

Annual inspection is performed on spare parts and special tools to ensure they are stored appropriately and in suitable condition for service. Calibration of testing devices is performed prior to use or as recommended by manufacturer.

Purchasing of consumables is performed by APA asset management as required.

9.3 Maintenance Records & Asset Condition

A maintenance log shall be reviewed updated and signed off during each inspection with records scanned and sent to APA asset management team.

Records go into APA's FMECA and FRACAS data systems.

9.4 Planned Operational Expenditure

Directlink major planned operational expenditure occurs typically around July and August in accordance with planned major maintenance listed in Table 9.

Table 9 - *Directlink* Major Operational Works

Yr	Id	Description	Budget Month	Actual Month
2011	1	Annual Maintenance Shutdown	July 2013	July 2013
2011	2	Annual Valve and Reactor cooling maintenance	Aug 2013	Aug 2013

9.5 Planned Capital Works

Planned capital works consist of projects to sustain and improve the operation of the *Directlink HVDC* link. Planned capital works for *Directlink* are outlined in Table 10 for further detail refer to Appendix 4

Table 10 - *Directlink* Improvement Proposals Includes Margin

ID	Description	Yr	Purpose
1	Revise Phase Reactor Cooling	14	Eliminate condensation
2	Control System Spares	-	Ongoing maintenance
3	*UPS* Batteries	-	Ongoing maintenance
4	Upgrade Industrial computer control system	15	Planned upgrade
5	Spare capacitors	-	Ongoing maintenance
6	Spare *IGBT*s	14	Maintain spares holding
7	Spare Cable	14	Maintain spares holding
8	Spare cable joints (maintain inventory)	14/16	Maintain spares holding
9	Contingency Spares	-	Ongoing maintenance
10	Spare valve optic fibres	-	Ongoing maintenance
11	Security fencing enhancement (1 site)	16	Mullumbimby fence upgrade to prevent trespass
12	Contingent relocation of cables	15/16	Contingency due to non-exclusive road access rights
13	Cable Switch Yard	16	Proposed project for switching cable circuits between converters
14	Cable fluid injection assessment & trial (R&D / engineering) Cost benefit & risk v replacement.	14/15	Proposed project to improve cable reliability
15	Fire Suppression	16	To minimise losses due to a fire
16	Temperature regulation of valve cooling water	14	For outage conditions

ID	Description	Yr	Purpose
17	Sound Dampening Replacement for Ventilation Inlet	14	Integrity repair works
18	Test Equipment	14	To improve maintenance response and condition assessment
19	Cameras	14/16	To improve maintenance response and condition assessment
20	Site Lighting Improvement	14/15	Personnel safety
21	Valve Control logic changes.	14	Automated testing to minimise labour requirements
22	Failure Analysis software.	14	Improve condition based maintenance
23	Cooling Tower Sound Enclosure Panel Replacement	16	Integrity repair works
24	Building Roof Corrosion Repair	14	Integrity repair works
25	Bungalora Storm Water Drainage Repair	14	Integrity repair works
26	Bungalora Hand Rails	14	Personnel safety

9.5.1 Commentary

Directlink capital expense was less than forecasted in 2013 due to a reduced rate of cable failure that allowed the purchase of new cable joints to be deferred. A significant number of *IGBT*s are likely to be recovered from the fire damaged system 1 converter at Mullumbimby, deferring the need to purchase replacement *IGBT*s. Capital budgeted for the Phase reactor temperature control is being allocated to modify the arrangement of the air handling. Cable fluid injection will be trialled in the second half of the year. *ABB* have not responded to date on our request for a quote to modify the valve control logic for *IGBT* reduced light testing.

9.6 Opportunities for Growth Capital Expenditure (CY2014)

Subject to economic regulatory approval the following projects are considered opportunities to grow the asset base for further detail refer to Appendix 4.

Table 11 - *Directlink* Growth Capital Opportunities

Id	Description	Trigger
1	Phase reactor replacement	*AER* approval
2	Cable Fluid injection	Outcome of Testing

10 RISK MANAGEMENT

A register of integrity risks (refer to Appendix 3) has been developed to identify any threats to the integrity of the operations and maintenance of the *Directlink Asset*s and to the ability of the asset to achieve the Service Levels detailed in section 8.1 of this *AMP*.

The register is routinely reviewed and updated to ensure the continued safe and reliable operation of *Directlink* and achievement of the Service Levels.

The register has been developed in accordance with APA Group's Risk Management Policy to ensure that:

i. Appropriate systems are in place to identify all material risks that affect or could affect the integrity of the *Directlink Assets*;

ii. The impacts of identified risks are understood and appropriate mitigation measures are in place to control exposures to those risks; and

iii. Appropriate responsibilities are delegated to control the identified risk effectively.

In assessing the risks associated with the *Directlink Asset*s, the processes set out in the APA Risk Management Handbook will apply. Where assessing conflicting risks and mitigation measures, an imminent risk to the health, safety and the environment (HS&E) must always be addressed with priority. Outside of HS&E, asset management decisions shall prioritise on the basis of maintaining high availability and maximising the life of the asset.

The register covers all components of the *Directlink Asset*s, including the converter stations and *AC* and *DC Cables*.

11 IMPROVEMENT PROGRAM

APA Group will continue to review and revise this *AMP* on an annual basis or where an issue is raised that warrants a review.

In terms of planned improvement, APA Group intends for this *AMP* to develop into an asset management system that is fully compliant with *PAS 55*.

The APA Operations Manager Power Transmission is responsible for ensuring that an annual review is performed and that a program of continued improvement of this *AMP* is implemented.

Appendix 1 – Maintenance Plan

Directlink - Asset Maintenance Schedule - Year 1 (2001)

Notes: X = Planned maintenance interval
R = Recommended maintenance interval (by manufacturer)
ABB = *ABB* approved personnel
Q = Qualified trade personnel
H = Helper

Rev A - Draft For Comment

		Maintenance Interval																	
Equipment Type	**Identifier**	wkly	1mth	3mth	4mth	6mth	1yr	2yr	3yr	5yr	6yr	7yr	10yr	15yr	30yr	Duration (h)	Personnel	Energised/ Operating	Action	DL O&M Procedure	Manufacturer Doc
Circuit Breakers																					
AC Filter Breaker (3 ph / 1 pole)	Q(1,2,3)						R		X		X						Q,H	no/no	Inspection	DL-WI-17	1HSB425409-101en 1HSB435409-100en 1HSB535409-100en 1HSB525409-101en 1HSB425409-200en 1HSB425409-202en
														X			*ABB*,2H	no/no	Preventative Maintenance		
															X		*ABB*,2H	no/no	Overhaul		
AC Circuit Breaker (3 ph / 1 pole)	Q1						R		X		X						Q,H	no/no	Inspection		
														X			*ABB*,2H	no/no	Preventative Maintenance		
															X		*ABB*,2H	no/no	Overhaul		
AC By-Pass Breaker (3 ph / 1 or 3 pole)	Q2						R		X		X						Q,H	no/no	Inspection		
														X			*ABB*,2H	no/no	Preventative Maintenance		
															X		*ABB*,2H	no/no	Overhaul		
Disconnector Earth Switches																					
DC Disconnector and Earth Switch								X									*ABB*, H	no/no	Inspection	DL-WI-17 *ML-WI-20*	5275 826E-24 Rev. 00 5309 869E-1 5409 506E Rev. 14
											X						*ABB*, H	no/no	Motor Drive Mechanism		
AC Disconnector and Earth Switch	Q(11,21)							X									*ABB*, H	no/no	Inspection		
											X						*ABB*, H	no/no	Motor Drive Mechanism		
AC Disconnector								X									Q,H	no/no	Inspection		
											X						Q,H	no/no	Motor Drive Mechanism		

Equipment Type	Identifier	wkly	1mth	3mth	4mth	6mth	1yr	2yr	3yr	5yr	6yr	7yr	10yr	15yr	30yr	Duration (h)	Personnel	Energised/ Operating	Action	DL O&M Procedure	Manufacturer Doc
Power Transformers																					
Power Transformer Including 2 x Current Transformers and Cable End	T1		X		R												Q,H	Yes/Yes	General, Oil	DL-WI-17	1ZBA676002-1 Rev. 00 1ZSE6480-101en Rev. 02 000169568MI Rev. 00 2750515-12en Rev. 05 RENZMANN-01 Rev. 00 SESWG_A-2370E Rev. 01 TECNOPROGET-1 Rev. 00 TL503-405 Rev. 00
							X										Q,H	no/no	Oil, Bushings, Resistance, Accessories		
																	ABB, Q	no/no	Transformer Overhaul		
Reactors																					
Zero Sequence Smoothing Reactor	L1						R	R									Q	no/no	Inspection	DI-WI-29	Cannot Locate
DC Filter Reactor	L2						X										Q, H	no/no	General	DI-WI-29	MI-201.01.0050 Rev. 00
DC Smoothing Reactor	L1						X										Q	no/no	General	DI-WI-29	MI-99.01.0163 Rev. 00
Converter reactor (1ph)	L1						X										H	no/no	Inspection	DI-WI-29	11-98 Rev. 00 (Fans Only)
AC Filter Reactor	Z11.L1, Z12.L1						X			R							Q,H	no/no	General	DL-WI-29	MI-99.01.0162 Rev. 00
AC PLC Filter Reactor	L(1,2)						X			R							Q,H	no/no	General	DL-WI-29	MI-99.01.0200 Rev. 00
Capacitors																					
DC Filter Capacitor	C(1,2)						X										Q	no/no	Inspection	DL-WI-30 DL-WI-38	SECAP-B-003_TD-HLA-011 Rev. 01 1HSE96001-1E HENF600012
									X								Q, H	no/no	Capacitance Measurement		
DC capacitor	C(1,2)						X										Q	no/no	Inspection		
									X								Q, 2H	no/no	Capacitance Measurement		
AC Filter Capacitor	Z11.C1, Z12.C1						X										Q,H	no/no	Inspection		
									X								Q,H	no/no	Capacitance Measurement		
AC PLC Filter Capacitor	C(1,2,3,4)						X		X								Q,H	no/no	Inspection		
AC PLC Filter Tuning Unit	Z(1,2)									X							Q	no/no	Inspection		
Filter Resistors																					
AC Filter Resistor	Z(11,12)-R1						X	R									H	no/no	Inspection	DL-WI-35	F9535_1.DOC Rev. 00
Pre Insertion Resistor	R1						X										Q	no/no	Inspection		
PLC Filter Resistors	Z1, Z2						X														HENF600012
Surge Arresters																					

Equipment Type	Identifier	wkly	1mth	3mth	4mth	6mth	1yr	2yr	3yr	5yr	6yr	7yr	10yr	15yr	30yr	Duration (h)	Personnel	Energised/ Operating	Action	DL O&M Procedure	Manufacturer Doc
Metallic Screen Arrester	F(1,2)						X										Q	no/no	Inspection	DL-WI-34	HAAR 490 800
Surge Arrester	F1						X										Q	no/no	Inspection	DL-WI-17 DL-WI-34	XL 300 021-242 Rev. 01
AC Filter Bus Arrester	F1						X										Q	no/no	Inspection	DL-WI-34	XL 300 021-242 Rev. 01
Spark Gap	F11						X										Q	no/no	Inspection	DL-WI-34	1JNL100027-641 Rev. 00 1JNL100027-640 Rev. 01
DC Bus Arrester	F(1,2)						X										Q	no/no	Inspection	DL-WI-34	XL 300 021-242 Rev. 01
Current Transformers																					
DC filter current transformer	T1						R										H	no/no	Inspection	DL-WI-32	EKM Mm-0001.98
AC Current Transformer (LEM)	T11, T12, T21, T22						X										Q	no/no	Inspection	DL-WI-33	Cannot Locate
AC Filter Ground CT	Z11.T1, Z12.T1						R										H	no/no	Inspection	DL-WI-32	EKM Mm-0001.98
DC measuring device (LEM)	T11, T12						X										Q	no/no	Inspection	DL-WI-31	LB2000-S/SP5 Rev. 00
DC measuring device (Rogowski)	T1, T2, T3						X										Q	no/no	Inspection	Dl-WI-28	PEM Rev. 00
Voltage Transformers																					
Capacitive Voltage Transformer	T11						X						X				Q	no/no	Inspection	DL-WI-37	EKH WB-15.97 Rev. 00
Capacitive Voltage Transformer	T11						X						X				Q	no/no	Inspection		
Direct voltage divider	U1						X	X									Q, H	no/no	Inspection	DL-WI-36	F9837_1.DOC Rev. 02
Wall Bushings																					
Wall bushing	X1						R		X								Q	no/no	Inspection		2770501-8 Rev. 00
***IGBT* Valves**																					
IGBT valve groups	V1, V2						X										*ABB*, 2xH	no/no	RSM	DL-OP-06 DL-WI-26	1JNL100026-087 - PDF - Rev. 02 (*IGBT* Replacement) 1JNL100033-472 - PDF - Rev. 00 (Maintenance) 1JNL100053-678

Equipment Type	Identifier	wkly	1mth	3mth	4mth	6mth	1yr	2yr	3yr	5yr	6yr	7yr	10yr	15yr	30yr	Duration (h)	Personnel	Energised/ Operating	Action	DL O&M Procedure	Manufacturer Doc
***HVAC*, Valve and Transformer Cooling Systems**																					
Valve & Transformer Cooling System																					
Valve Cooling System - Monthly system check			X														Q,H	yes/yes	System Check Water Leakage, Noise, Oxygen measuring valve	DL-WI-17	8-5599-203 (Swede Water) 8-1000-150/E 8-1000-182/E
Valve Cooling System - 3 Monthly system check				X													Q,H	yes/yes	Main Pump Units	*ML-WI-19* Section 2.2	8-5599-203 (Swede Water) 8-1000-150/E 8-1000-182/E
Pump Motors							X										Q,H	yes/yes	Inspection		8-1000-150/E
Air Blast Coolers	E1 - E7			X				X									Q,H	yes/yes	Inspection	DL-WI-17	8-1000-195/E
Pressure regulator, relief valve and safety valve	F1						X										Q,H	yes/yes	Inspection		8-1000-104/E
Strainer and filters	Z1,Z2						X										Q,H	yes/yes	Inspection		8-5599-203 8-1000-087/E
Ion-Exchange Vessel	C2, C3						X			X							Q,H	yes/yes	Inspection		8-5599-203 8-9900-002
Meters - Pt100 element - Conductivity meters - Oxygen content sensor - Pressure transmitter							X										Q,H	yes/yes	Inspection		8-1000-212/E 8-5599-203 8-1000-016/E
Function checks - Flanged joints for tightness - Hand operated valves - 2 and 3 way remote control valves - Level switches - Solenoid valves							X										Q,H	no/no	General Check		8-5630-200 Rev. 01 8-9900-011
Nitrogen Bubbling Facility																				DL-WI-17 DL-WI-18	
***HVAC* & Dehumidifiers**																					
Dehumidifier							X													DL-WI-25	HMH-FEB-96 Rev. 00 TGB-1008 Rev. 00
Split System Air Conditioners				R		X	X														PSA012B375 Rev. 00
High Voltage Cable																					
DC Cable, Terminations and Joints																				DL-OP-18	None
Easement Management																				DL-OP-18	None
Fault Detection and Cable Repair																				DL-WI-40 DL-WI-41	None

Equipment Type	Identifier	wkly	1mth	3mth	4mth	6mth	1yr	2yr	3yr	5yr	6yr	7yr	10yr	15yr	30yr	Duration (h)	Personnel	Energised/ Operating	Action	DL O&M Procedure	Manufacturer Doc
Control, Protection and Telecommunication Equipment																					
FLK-Units	V23																				
Main Computer	U25																				
PCP IO Equipment	A5																				
230/110 *AC*/*DC* Converter	B29																				
LOWS																					
ROWS																					
Maintenance PC																					
LAN Switch																					
GPS Clock																					
Antenna																					
Fire Systems																					
NT Fire Panel		R	X			X	X	X													WFS-NTF-GB2202 Section 5
VESDA	AL.A2		X			X	X	X													WFS-VLP-GB3100 Rev. 00 - Maintenance section
Auxiliary Power Equipment																					
Auxiliary Power Supply Transformer							X														
Cooling Pump MCC Units																					
240VAC Distribution Board	SA3.G7																				
415VAC Main Incomer	SA2.G6																				
415VAC Distribution Board	SA2.G7																				
UPS System A and B (Exide Prestige 2500VA)	1.U32					X															
UPS System SCE (Exide Prestige 1500VA)	5					X															
UPS for *DC* Disconnector (Powerware 2000VA)	WP1.*UPS*, WP2.*UPS*					X															

Equipment Type	Identifier	wkly	1mth	3mth	4mth	6mth	1yr	2yr	3yr	5yr	6yr	7yr	10yr	15yr	30yr	Duration (h)	Personnel	Energised/ Operating	Action	DL O&M Procedure	Manufacturer Doc
Buildings & Structures																					
Emergency Lighting						X															
AC Switchyard Lighting						X															
Safety Equipment																					
LV Rescue Kit			X																	DL-WI-17	
Fire Extinguisher			X			X														DL-WI-17	
Fire Hose																					
Eye Wash Station																					
Spill Kit																					
Converter Station - General																					
Maintenance and Testing of Earthing Systems																				None	N/A
Pre-Energisation Inspection - Valve Containers																				DL-WI-03	N/A
Pre-Energisation Inspection - Converter Building																				N/A	N/A
Pre-Energisation Inspection - Phase Reactors																				N/A	N/A

Appendix 2 - Asset Categories

- Mach 2 Converter Station Control System;
  - Mach 2 Valve Cooling Control & Protection;
  - Mach 2 *AC* Control & Protection;
  - Mach 2 Remote Control Interface;
  - Mach 2 Valve Control;
  - Mach 2 Reactor Cooling Control & Protection;
- Auxiliary Power Supply
  - Station Service Power System;
  - Uninterruptable *DC* and *AC* Supply;
  - Auxiliary Power Transformer;
  - Reactor Cooling Motor Control Centre;
  - Valve Cooling Motor Control Centre;
- Valve Cooling System
  - Valve Cooling Water Pumping & Control Equipment;
  - Valve Cooling Water Cooling Towers;
  - Water De-ionisation Vessel;
  - Valve Cooling Pump;
  - Semi-Automatic Discharge Unit for Nitrogen;
- Fire System Equipment
  - Aspirating Fire Detection System;
  - Conventional Fire Detection System;
  - Fire Alarm System;
  - Portable Fire Extinguishers;
- *HVAC*
  - *HVAC* Service Enclosure;
  - *HVAC* Valve Enclosure;
- *AC* Cable System
  - *AC* Cable Terminal Surge Arrestor;
- Phase Reactors
  - Phase Converter Reactor;
- Valve Group
  - *DC* Capacitor;
  - *DC* Filter Reactor;
  - *DC* Filter Current Transformer;
  - *DC* Current Transformer Rogowski;
  - Valve
  - High Freq Damping Circuit;
  - Wall Bushing;
- *DC* Filter Yard

  - *DC* Filter Low Voltage Capacitor;
  - *DC* Filter Surge Arrestor;
  - *DC* Filter Cable Metallic Screen Surge Arrestor;
  - Zero Sequence Smoothing Reactor;
  - *DC* Filter Current Transformer;
  - *DC* Bus Arrestor;
  - Air Gap for Surge Limiting Device;
  - *DC* Smoothing Reactor;
  - *DC* Disconnector;
  - *DC* Earthing Switch;
  - *DC* Current Transformer;
  - *DC* Voltage Divider;
- *AC* Switchyard and Power Transformer Area
  - *AC* Bus Surge Arrestor;
  - Cable Screen Surge Arrestor;
  - Power Transformer Neutral Surge Arrestor;
  - *AC* Circuit Breaker;
  - *AC* Disconnector;
  - *AC* By-Pass Circuit Breaker;
  - Pre-Insertion Resistor;
  - Power Transformer;
- *AC* Filter Yard
  - Capacitive Voltage Transformer;
  - *AC* PLC Noise Filter Capacitor;
  - *AC* Filter Bus Surge Arrestor;
  - *AC* PLC Noise Filter Reactor;
  - *AC* Filter Circuit Breaker
  - *AC* Filter Disconnector;
  - *AC* Filter Earthing Switch;
  - *AC* Current Transformer;
  - *AC* PLC Noise Filter Capacitive Turning Unit;
  - *AC* Filter Capacitor;
  - *AC* Filter Reactor;
  - *AC* Filter Current Transformer;
  - *AC* Filter Resistor;
  - *AC* Filter Optical Unbalance Current Transformer;
- Auxiliary Buildings;
- Communications Equipment & Infrastructure;
- Small Plant & Safety Equipment
- Civil Systems
- SCADA Equipment

Appendix 3 – Integrity Risk Register

Appendix 4 – Asset Maintenance Works

1. Planned Capital Works

The planned capital works consist of projects to sustain and improve the operation of the *Directlink HVDC* link and are described in the following sections.

The capital expenditure request and plan for rectifying/replacing the damaged convertor station has not been included in this *AMP*.

1.1 Revise Phase Reactors Cooling

The *Directlink* phase reactors are air cooled with the cooling fan running continuously when the converter is in operation. During periods when the converter is lightly loaded, the reactor generates minimal heat and continuous operation of the cooling fan can cause condensation in the reactor. The condensation is considered to be the primary cause of the partial discharge in the reactor. The project will investigate the cooling requirements for the phase reactor and implement a solution that eliminates condensation.

1.2 Control System spares

To maintain an appropriate level of control systems spares required for operations.

1.3 *UPS* Batteries

To maintain *UPS* batteries required for operations.

1.4 Upgrade industrial computer control system

The *Directlink* converters have an industrial computer integrated into their control system. The motherboards used in the industrial computers are out of manufacture and all spares have been used. Should a motherboard develop a fault, second-hand motherboards will need to be sourced as replacements. The proposed solution is to replace the motherboards with a current model. It is intended to spread this change out over the next five years, therefore reducing the impact financially to the business.

1.5 Spare capacitors

There are several hundred capacitors in service at *Directlink*. Capacitors have been identified as an item that has a failure rate above that of other HV equipment. The is an on-going need to maintain a level of spare capacitors.

1.6 Spare *IGBT*s

There are several thousand *IGBT*s in service at *Directlink*. *IGBT*s have a failure rate above that of other HV equipment. There is an on-going need to maintain a level of spare capacitors. A large number of *IGBT*s have been salvaged from the fire damaged Mullumbimby System 1. These *IGBT*s will need to be cleaned and tested before becoming spares remaining operating systems.

1.7 Spare cable

It is proposed to purchase additional cable. This elevated rate of failure decreases the plant reliability and increases the risk of prolonged plant outages. Currently there are limited supplies of spare cable at *Directlink*. These cables have a long time period between order and delivery. The spare cable will reduce the risk of prolonged plant outages.

1.8 Spare cable joint kits Replenish critical spares

It is proposed to purchase and maintain an inventory of cable joint kits in preparedness for cable faults. Currently there are limited supplies of spare cable joint kits at *Directlink*. These kits have long lead times between order and delivery which increases the risk of prolonged plant outages. The spare cable joint kits will ensure that repairs can be carried out swiftly reducing the risk of prolonged plant outages.

Cable injection trials (see 16) may ultimately lead to a reduction in the level of inventory being held and purchasing would reflect the replenishment of the desired inventory level rather than a particular budgetary value.

1.9 Contingency spares

To maintain the high level of plant integrity a contingency for critical spares has been allocated.

1.10 Spare valve optic fibres

An elevated failure rate has led to depletion of spare optic fibres. Spare optic fibre cable and optic fibre connectors were purchased in 2012. Future optic fibres will be assembled from the purchased components as required throughout the 2013.

1.11 Security fence

The *Directlink* Bungalora and Mullumbimby sites have experienced frequent incidents of trespassing, theft and vandalism. An improved security fence is required to mitigate the risk of liability in the event of a trespasser being killed or injured, and the risk of major equipment failure as a consequence of theft or other malicious damage. The Bungalora security fence was upgraded in 2011, due to the highest level of trespass and incident. Mullumbimby is proposed for a fencing upgrade in 2016. The result of increased security at these sites will reduce the likelihood of trespass and incident.

1.12 Contingent relocation of cables

The *Directlink* cable may require relocation to make way for potential developments along the cable route in the future. The *Directlink* cables have non-exclusive rights to occupy road reserves under section 45 of the Electricity Supply Act in New South Wales; however sections of the route pass along a disused rail corridor which has the potential to be re-established. In the event that some future development is planned for an area where the cables are installed along the rail corridor *Directlink* may be required to relocate the cables which would involve significant difficulty due to the poor access. The budget allocated is a provisional allowance to deal with such development. The scope and likelihood of the relocation works will not be known until such development is proposed.

1.13 New Switchyard /Busbar arrangement

Currently each *Directlink* system is dedicated to a pair of cables. It is proposed to install a gas insulated switch gear and busbar arrangement to allow the converter stations to be switched between different cables, thereby maximising availability and reliability of plant. This proposal will require review of the cost/benefit prior to any development.

1.14 Cable fluid injection assessment & trial

Discussions are underway with a North American based company supplying HV cable remediation by fluid injection. In order to select an appropriate fluid, further assessment of the cable faults is required. It is proposed to engage the fluid injection company to review the results of the investigations undertaken to date and to examine samples of failed cables. Should the consultant determine a remediation technique that appears viable it would be recommended to the Board before implementation?

1.15 Fire Suppression

A fire suppression system will remove the risk of a total loss of a converter building in the event of a fire. The costs of a fire suppression system were put in 2016 to allow possible recovery under the next revenue period. Earlier installation of a fire suppression system may be required if the ongoing fire risk is determined to be high.

1.16 Valve Cooling Control Logic Changes.

The incidence of *IGBT* failure shortly after start up can be reduced by maintaining the *IGBT*s at operating temperature during plant shutdown. Currently the valve cooling control system regulates cooling water temperature to 20ºC. It is proposed to have *ABB* undertake an engineering review and control logic changes to add a second cooling water temperature regulation set point. The second temperature seta point will maintain the operating temperature of the *IGBT*s when the converter

station is shutdown. The cost estimate includes an engineering review and implementation by *ABB* as a separate project.

1.17 Sound Dampening Replacement for Ventilation Inlet

Considerable rusting has occurred to the sound damping at the inlet of the barn ventilation at both Mullumbimby and Bungalora. This is starting to collapse and will result in the blocking of the ventilation shaft. As system 1 is not operating we with require 4 dampers to be replaced at $5000 per damper.

1.18 Test Equipment

It has been identified that there is a need to have test gear on site to enable adequate maintenance to be conducted. The test equipment includes the following items:

a. micro-ohm meter – this is necessary to measure the resistance of high current connections that have been disturbed during maintenance. It can also be used to test the grounding network. Current model being looked at is the 6250 at $4190.00 + *GST*.
b. Thermal imaging camera - this is necessary to allow routine monitoring of high current connection during operation. Current model being looked at is the 6250 at $4190.00 + *GST*.

1.19 Cameras

The inside of the converter buildings has restricted access because of the safety risk associated with the energised high voltage equipment. It is proposed to install a camera system to allow detailed inspection of equipment inside areas of the converter building while the converter building is energised. It is expected that this will reduce the frequency and duration of outages for converter station maintenance and allow rapid internal inspection of the buildings in response to faults.

1.20 Improved site lighting to meet OHS requirements

Additional lighting is required at the converter station sites to allow safe movement of maintenance personnel at night.

1.21 VCU Control logic change

Currently the each of the 5400 *IGBT*s has to be manually tested to determine the performance of the optic fibre triggering system. The software change will enable an automated test with no labour required.

1.22 Software for Collection and Analysis of Failure Data

Due the age of the *HVDC* systems we are entering the stage of the failure trend that will see a greater increase in the rate equipment failure. Over the next 20 years of operation a the ability to handle the maintenance and replacement of equipment in a suitable timeframe will rest on the ability to trend the failures and make informed decisions. The success rests primarily on the way in which failure data is collected and accessed. Due to the limited staff operating a number of assets it is seen as essential to use software to help record, track and analysis this data.

1.23 Cooling Tower Sound Enclosure Panel Replacement

Corrosion is present in a large number of the panels making up the cooling tower sound enclosure. The corrosion has occurred due to moisture ingress into the sound damping material. These panels require replacing to ensure the integrity of the sooling tower sound enclosure.

1.24 Building Roof Corrosion Repair

The roofs of the converter buildings are developing some areas of corrosion. These areas require treating to prevent the corrosion progressing further.

1.25 Bungalora Storm Water Drainage Repair

The Bungalora site has high rates of storm water run-off. The stormwater run-off has eroded of the shoulder drains of the site access road. This has created a hazard for vehicles and is undermining the bitumen.

1.26 Bungalora Hand Rails

The Bungalora site has a number of different levels with steps and retaining walls installed to allow access around the site. The hand rails will be extended to remove the hazard created by the lack of hand rails on the stairs and some higher parts of the retaining walls.

2. Opportunities for Growth Capital Expenditure (CY2014)

Subject to economic regulatory approval the following projects are considered opportunities to grow the asset base

2.1 Phase reactor replacement

The current design of the phase reactors at *Directlink* is prone to partial discharge burning. The burning results in the higher maintenance costs and reduced availability. These issues can be eliminated by installing reactors designed to prevent partial discharge.

2.2 Cable Fluid Injection

Cable fluid injection is being tested on the *Directlink* cables in a laboratory during 2013. If found to be successful at mitigating the effects of moisture in the cable, a limited trial will be conducted on in-service cable during 2014. Following The trial section of cable know to be water affected will be injected as part of project works.