APA Group

Murraylink

Asset Management Plan

ML-DO-06

Murraylink

Asset Management Plan

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PROPOSALS FOR AMENDMENT

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1 INTRODUCTION

1.1 Purpose

This document details an Asset Management Plan (AMP) for the Murraylink 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 Murraylink originally commissioned in 2002. The end of economic life date is 2047 for the converters and 2062 for the DC cables.

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 asset management plan 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

Murraylink is a 180 km high voltage direct current (DC) transmission line between Red Cliffs in Victoria and Berri in South Australia. Murraylink can transmit up to 220MW of power between the Victorian and South Australian transmission networks.

The Murraylink transmission line consists of a pair of ±150kV high voltage DC cables buried side by side underground from Berri to Red Cliffs. The cable pair is connected to a single converter station at each end. The converter stations interface the DC cables to the high voltage alternating current (AC) transmission systems in South Australia (132kV) and Victoria (220kV) via a short length of underground high voltage AC cable.

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

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
MI-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 asset management plan (AMP) has been developed for Murraylink as a stand-alone document.

3 DEFINITIONS / ABBREVIATIONS

Term	Definition
AMP	Asset Management Plan
Compliance Plan	A document which defines the obligations and activities required to demonstrate ongoing compliance of the Murraylink Asset to the requirements of the National Electricity Rules and Connection Agreements.
HVAC	Heating, Ventilation and Air Conditioning
HVDC	High Voltage Direct Current
IGBT	Insulated Gate Bipolar Transistor
ISO	International Organization for Standardization
Murraylink Asset	The 220MW HVDC link connecting Red Cliffs in Victoria to Berri in South Australia, including the Red Cliffs Converter Station, the Berri Converter Station, the AC cable between the Red Cliffs Converter Station and the Red Cliffs Terminal Station, the AC cables between the Berri Converter Station and the Monash Substation and the DC cables connecting the two converter stations.
OEM	Original Equipment Manufacturer
PAS55	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 Murraylink which includes a HTML interface, main page titled "Final Plant Documentation Murraylink HVDC Light".

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 PAS55 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

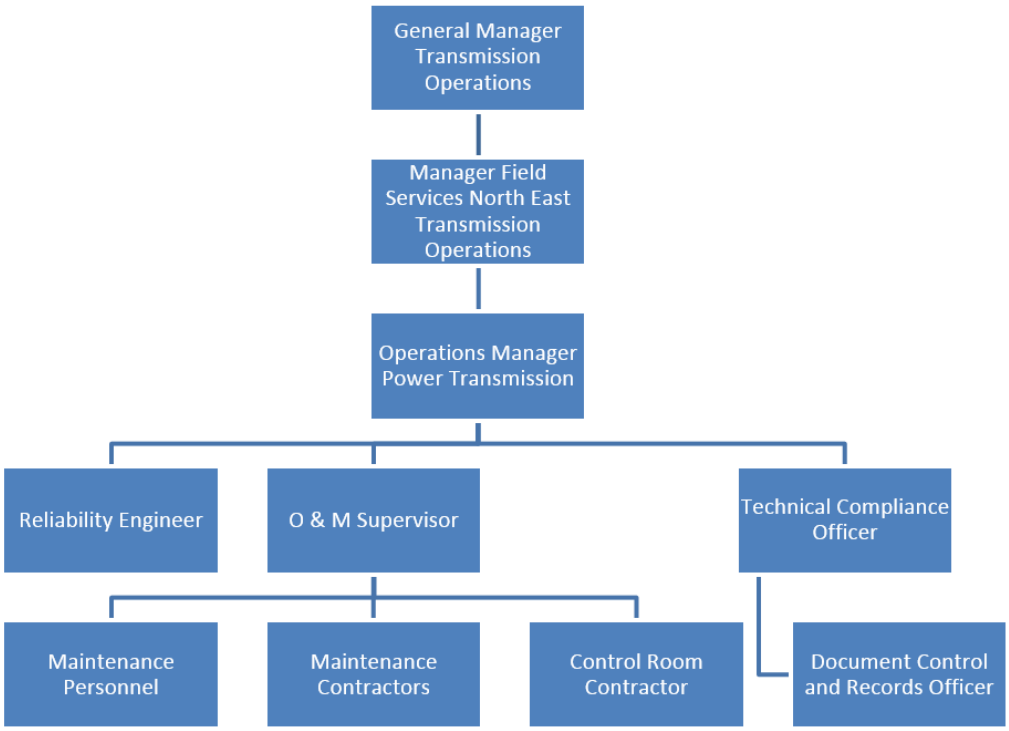
Approval of this AMP is required by APA Group board of directors and other relevant stakeholders especially for commitment to capital improvements, timing and costs.

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 ElectraNet control room, Adelaide. Functions include operating the Murraylink 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 Control Room 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, ElectraNet, SP AusNet and other key stakeholders and regulatory requirement in accordance with the Murraylink Compliance Plans. Engage and manage required legal and professional services associated with regulatory correspondence and compliance.

- Liaison with Third Parties - During normal business hours, the Murraylink Operations staff shall be available to interface AEMO, AER, ElectraNet, SP Ausnet 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 Murraylink and to project manage any improvements or repairs to Murraylink.
- Operating Procedures and Protocols - Develop, maintain and update the required startup, 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 Murraylink with respect to key permits, agreements such connection agreements with AEMO and ElectraNet and SP AusNet and other contracts.
- Budget - Annually prepare and present a Murraylink 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 Murraylink asset and lender requirements.
- Office Administration and Management - Manage and supervise Murraylink Operations office activities, and provide human resource functions such as development of HR policies, employee benefits administration, maintenance of personnel records, and legislative compliance.
- Accounting, Payroll, Financial Reporting - Fulfil accounting requirements for Murraylink 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 Murraylink assets.
- 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 plans.
- 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 asset management plans 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 asset control rooms 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 Murraylink Asset is an HVDC facility that connects the power networks at Red Cliffs (VIC) and Berri (SA) via High Voltage DC cables. The facility consists of the converter stations at Red Cliffs and Berri, the DC cables connecting them and the AC cables, switchgear and converter transformers connecting each converter station to the nearby AC substation (Red Cliffs Terminal Station in Victoria and Monash Substation in South Australia). Murraylink utilises Voltage Source Converter (VSC) technology. The DC cables are buried underground and are approximately 176km in length.

To summarise the key parameters of the Murraylink Asset:

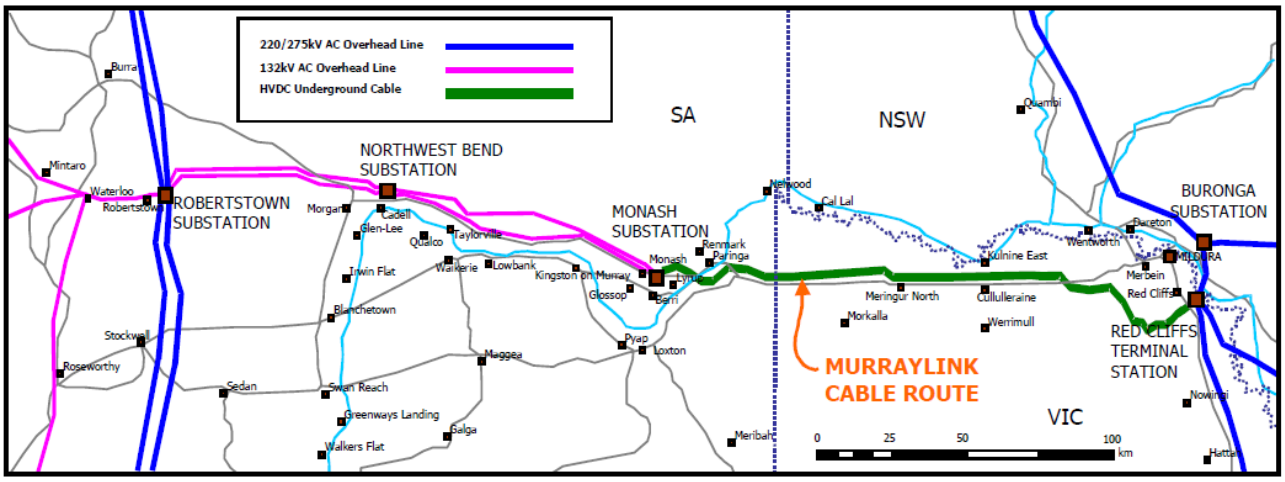
- Bi-directional maximum power flow of 220MW.
- Maximum reactive power generation between +140MVAr and -150MVAr at each end.
- AC connection voltage of 220kV at Red Cliffs and 132kV at Berri.
- DC voltage of ±150kV.

The Murraylink Asset can be divided into six categories:

- AC cable connection between Red Cliffs Terminal Station and the Red Cliffs Converter Station;
- Red Cliffs Converter Station;
- Underground DC Cables;
- Berri Converter Station;
- AC cable connection between Monash Substation and the Berri Converter Station; and
- Remote Operator Workstation (ROWS) and associated telecommunications.

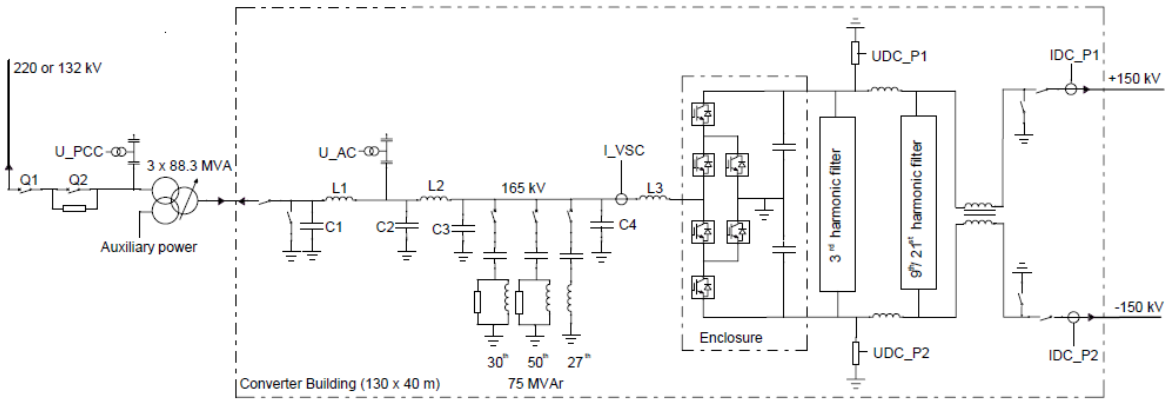
The location of the Red Cliffs Terminal Station and the Monash Substation, as well as the DC cable route, is shown in Figure 2.

Figure 2 - Murraylink Asset Location and DC Cable Route



A simplified single line representation of the Murraylink Asset is provided in Figure 3. This diagram represents either converter station between the connection to the AC cable (either 220kv or 132kV) and the ±150kV DC cables.

Figure 3 - Murraylink 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 MMIS 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. IGBTs and Valve Enclosures
12. High Voltage Cable Easement
13. Control, Protection and Telecommunication Equipment
14. Fire System Equipment
15. HVAC, Valve and Reactor Cooling Systems
16. Auxiliary Power Supply
17. Buildings and Structures

The Murraylink Asset also includes a substantial spare parts holding which are stored in spare parts buildings located at both the Red Cliffs Converter Station and the Berri Converter Station. Those spare parts requiring controlled temperature/environments are stored in a dedicated air conditioned room at each of the converter station sites.

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 Murraylink Asset include:

i. National Electricity (South Australia) Act 1996;
ii. National Electricity (South Australia) Regulations;
iii. National Electricity (Victoria) Act 2005;
iv. National Electricity Rules;
v. Electricity Act 1996 (South Australian Legislation);
vi. Electricity (General) Regulations 2012 under the Electricity Act 1996;
vii. South Australian Electricity Transmission Code Issue No. 7, 1 July 2013;
viii. South Australian Switching Manual Revision 3 August 2012; and,
ix. Victorian Electricity Industry Act 2000;
x. Victorian Electricity Safety Act 1998;
xi. Electricity Safety (Installations) Regulations 2009;
xii. Electricity Safety (Management) Regulations 2009.

7.3 Agreements

The following agreements are applicable to and must be complied with during the operation and maintenance of the Murraylink assets:

- Network Services Agreement with AEMO (formerly VENCorp);
- Connection Agreement with ElectraNet;
- Connection Agreement with SPAusnet (formerly SPI-Powernet).

7.4 Licenses

The Murraylink Transmission Company (MTC) Transmission Licence was issued as at 20 December 1999 and last varied by the Essential Services Commission of South Australia (ESCOSA) on 22 July 2008.

APA has an exemption from holding a Transmission Licence in Victoria.

7.4.1 Standards

7.4.2 Supply Quality Standards

Murraylink has been designed and is operated to meet the standards required by the National Electricity Rules. In addition, connection agreements exist with both ElectraNet and SP AusNet that specify power quality obligations.

Performance quality is monitored against supply quality standards 24 hours a day, 7 days a week at the Murraylink Control Centre in Adelaide.

7.4.3 Supply Reliability Standards

Supply reliability standards are service standards set by ElectraNet, SP AusNet and the Australian Energy Regulator (AER) in their decision on the Murraylink Application for Conversion and Revenue Cap. They are detailed in Section 8.1.

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
    - Market impact

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 - Murraylink 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 Murraylink assets are service standards set by ElectraNet, SPAusNet and the Australian Energy Regulator (AER) in their final decision on the 2013 Murraylink transmission revenue determination.

The AER determination outlines financial bonus/penalty in terms of cap and collar as outlined in Table 2 and Table 3. The bonus/penalties are set as a proportion of MAR which is the AER determined maximum allowed revenue.

The market impact parameter relates to whether Murraylink causes a cost constraint on the network, due to its inability to respond to requested dispatch targets.

Table 2 - Murraylink Availability AER Targets

Parameter	Collar	Target	Cap	Weighting (% of MAR)
Planned circuit availability (%)	99.04	99.17	99.38	0.4
Forced peak circuit availability (%)	98.90	99.48	100.0	0.4
Forced off–peak circuit availability (%)	98.84	99.34	99.94	0.2

Table 3 - Murraylink AER Market Impact Targets

Parameter	Target	Cap	Weighting (% of MAR)
Market impact parameter	782.3	0	2.0

Internally set availability and reliability targets are outlined in Table 4 and Table 5.

Table 4 - Murraylink SRMTMP Targets

Target Availability (Inclusive of all planned, peak forced and off-peak forced outages)	98.03%
Target Unplanned Interruptions	<= 5 per annum
Compliance with the Safety, Reliability, Maintenance and Technical Management Plan Target Compliance Level	<1 breach per annum

Table 5 - Murraylink EII Targets

Minimum Total System Availability	98.00%
Maximum Power not transferred to daily targets	5.00%
Minimum Planned maintenance to schedule	95.00%

8.1.3 Reporting

Murraylink reports internally each month on its performance against the requirements set by ElectraNet, and SP AusNet and also the targets set by the AER. Annual reports are submitted to the AER on performance targets, set by the AER Decision on the Murraylink application for Conversion and Revenue Cap. These results are publically available from the AER web site.

An EII Monthly operations report is prepared at operating business unit level and compiled at National Operations level and submitted to EII.

8.2 Operations and Maintenance Strategy

This section summarises the overall strategy implemented by APA for the operation and maintenance of the Murraylink 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 control room staffed by fully trained operators located in Adelaide, South Australia.

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

8.2.2 Maintenance

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

i. 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;

ii. Diligently undertake the maintenance services to provide maximum availability and maintain Murraylink assets in good condition, in accordance with the requirements of Murraylink procedures, good electricity industry practices and applicable laws;

iii. Schedule and co-ordinate Maintenance Services in advance and re-schedule planned outages accommodating requests from AEMO or any Transmission Network Service Provider (TNSP);

iv. Take suitable action to avoid collateral damages to any other asset owned or operated by Murraylink and any electrical infrastructure or asset of a TNSP or any other person;

v. Ensure sufficient trained and competent personnel are available to undertake the maintenance.

In general, APA asset management staff apply preventative maintenance practices to the Murraylink 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 Murraylink asset and access to the live main circuit components is scheduled to coincide with times where the dispatch across Murraylink is expected to be low. This typically results in such major planned maintenance occurring in the autumn and spring periods. The scheduled dates for such maintenance is coordinated with AEMO and SPAusnet. 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 Murraylink asset is monitored and dispatched on a 24/7 basis from the ElectraNet control room in Adelaide, SA.

The Murraylink 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 response roster where the remote control 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 Murraylink. 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 Murraylink asset include:

- Spare parts storage shed, located at the Red Cliffs Converter Station.
- Controlled temperature spare parts storage room, located at the Red Cliffs Converter Station.

- Spare parts storage shed, located at the Berri Converter Station.
- Controlled temperature spare parts storage room, located at the Berri Converter Station.

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 (ML-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 Murraylink assets. These are:

- ML-OP-23 - Emergency Response Plan.
- ML-DO-04 - Operations Environmental Management plan.
- ML-SP-01 - Response to a Serious Electrical Accident.
- ML-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 Murraylink assets including:

- Bush fire; and
- Flooding of the Murray River.

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

Murraylink manages environmental considerations through the Operations Environmental Management plan (ML-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 Murraylink including an outline of the route and location of each component. This section also has a brief description of the environmental resources found along Murraylink;

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 Murraylink assets are addressed in detail in various Murraylink operational documents. Table 6 summarises the training, awareness and competence regime undertaken by APA in the management of the Murraylink asset.

Table 6 - Murraylink 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
Murraylink Induction	Internal	Vic and SA	OMP, OME, OMS, ETP	18 Months
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
Murraylink High Voltage Switching Operator - Initial Course	External	Vic and SA	OMP, OME, OMS, ETP	3 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
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	Abbreviation
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 Murraylink 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 *"Final Plant Documentation Murraylink HVDC Light".*
- A spare parts and special tools register is held by APA group *'ML_SparePartList'*. 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 MMIS.

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 Murraylink 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, 3ph/1pol live tank circuit breakers rated for normal voltages of 132kVat Berri and 220kV at Red Cliffs. 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 2018.

9.1.1.1.1 Circuit Breaker Maintenance

Monthly visual inspections are performed by APA staff in accordance with work instruction ML-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.

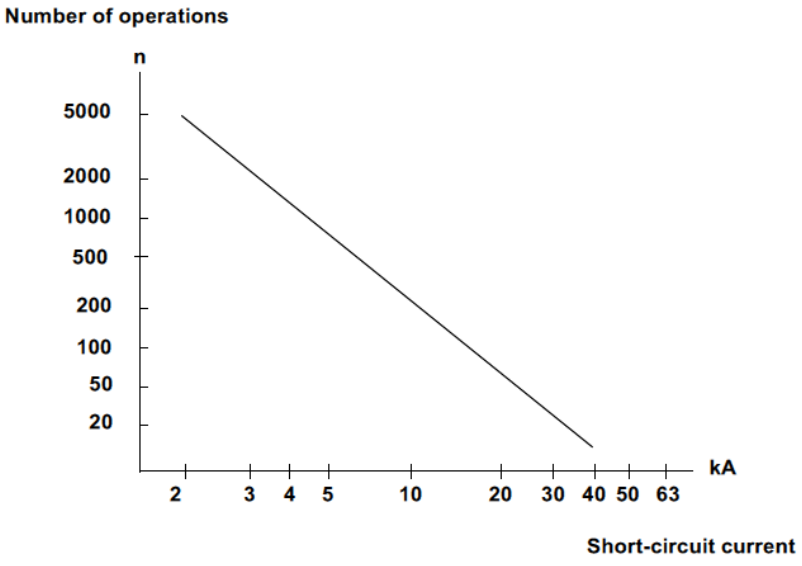
Periodic maintenance shall be carried out at operation intervals specified in Table 8.

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	(redacted)
C	Overhaul	30 years or 10,000 On-Off or ΣnI^2=20,000	(redacted)	(redacted)

In Figure 4 the criteria for preventative maintenance/overhaul based on fault-trip events is outlined. ABB recommends to perform preventative maintenance once ΣnI2=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 converter station.
- Operating devices – A single operating device of each type is held at one converter station.
- Pre-insertion resistor – A single spare is held at each site.

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:

- Vertical type disconnectors - Jakobson and Electro, Mark 40.
- Earth switches - Jakobson and Electro, G60.

9.1.2.1 Maintenance and Timing

The maintenance of disconnectors and earth switches shall be performed by trade qualified personnel in accordance with APA work instruction ML-WI-20 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:

- Disconnector phase – A single pole for each disconnector type is held at each converter station.
- Insulators – 3 replacement insulators of each type is held for each disconnector type at the converter station.
- Motor drive mechanisms – A disconnector motor drive mechanism is held at each converter station.

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 4 single phase units (1 spare) each having 3 windings. The transformers at Red Cliffs are configured for 220kV/165kV/22kV and at Berri they are configured 132kV/165kV/22kV.

The transformer oil cooling system comprises of 2 fans and formed sheet metal radiator fins. The cooling is 2 stage, 62 MVA ONAN, 89 MVA ONAF.

9.1.3.1 Maintenance and Timing

Power transformer maintenance is performed generally in accordance with section 7 of ABB's Operation and Maintenance Manual *"089M001-4 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 ML-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 *089M001-4 Rev.00* and includes:

- Insulated oil sampling and lab testing
- Bushings inspection and cleaning (in accordance with 2750-515-12 & 41)
- Insulation resistance measurement
- Accessories general overhaul

Long term recommended maintenance includes on-load tap changer diverter switches (in accordance with 1ZSE5492-124en Rev. 05 & 1ZSE5492-125en Rev. 02) and maintenance of paint and welds.

9.1.3.2 Spares Strategy

A full spare single phase converter transformer is installed in-situ at each converter station for replacement in the event of a failure. In the event of failure the incoming and outgoing connections will be disconnected and re-terminated to bring into service the spare transformer.

Instructions for the assembly and replacement of equipment is outlined in PlantDoc including:

- Power transformers - 089M001-4 Rev. 00
- Transformer bushings - 2750515-12en Rev. 07 & 2750515-41en Rev. 04
- On-load tap changers - 1ZSE5492-124en Rev. 05 & 1ZSE5492-125en Rev. 02
- Safety valves - VS-150 Rev. 00
- Fans - L-WAL001-05/99-D/GB Rev. 00

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
- 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 ML-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 30bar water spray applied from 200mm 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 each converter station.
- Phase reactor – a single spare phase reactor is held at each site.
- Insulators – spare insulators for each reactor type are held at each converter station.

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

Filter LV Capacitors

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 ML-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 ML-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 each converter station.
- Insulators – spare insulators for each capacitor type are held at each converter station.

Replacement will be performed by APA staff or approved contractors

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

9.1.6 Filter Resistors

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

- AC filter resistors
- DC filter resistor
- HF damping circuit

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 ML-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 each converter station.

Replacement will be performed by APA staff or approved contractors.

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

9.1.7 Surge Arresters

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

- Metallic Screen Arresters
- DC Filter Arresters
- DC Bus Arresters
- Surge Current Limiting Devices
- 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 ML-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 each converter station.

Replacement will be performed by APA staff or approved Contractors

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

9.1.8 Current Transformers

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

- Outdoor post type current transformer
- Hall effect current transducers
- DC cable screen current transformers
- Digital optical current transducers

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 ML-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 - ML-WI-31
- DC Cable Screen Current Transformers - ML-WI-33
- Digital Optical Current Transducers

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 each 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 ML-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 each type is held at each converter station.

Replacement will be performed by APA staff or approved Contractors

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

9.1.10 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 of each type is held at each converter station.

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 IGBTs and Valve Enclosures

The Murraylink Asset consists of a number of valve enclosures which contain stacks of IGBTs. The IGBTs 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 ML-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 Murraylink 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 IGBTs 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 ML-WI-12.

Replacement of failed IGBT's shall be performed by trained personnel in accordance with APA group work instruction ML-WI-13 and ABB maintenance instruction 1JNL100043-619.

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 IGBTs (i.e. the system will trip if the sixth IGBT in that valve fails).

Whilst replacement of IGBTs will occur during the annual shut down maintenance period, it is possible that other outages may be required to replace IGBTs if the number of failed IGBTs 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 (51 IGBTs 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:

- Heat sinks
- 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 Reactor Cooling Systems

The Murraylink Asset includes two separate water cooling systems:

1. The Valve Cooling System – pumps and regulates the temperature of de-ionised water through the IGBTs; and
2. The Reactor Cooling System - pumps and regulates the temperature of de-ionised water through the water-cooled phase reactors.

In addition, HVAC (Heating, Ventilation and Air Conditioning) plant is included in this asset class due to similarities in rotating plant and equipment and in the maintenance requirements and skills required to perform the maintenance.

9.1.12.1 Maintenance and Timing

Valve and reactor 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 - ML-WI-17,
- Nitrogen bottle change out and oxygen content checking in accordance with ML-WI-18
- Three month cooling system maintenance - ML-WI-19
- De-energised maintenance inspections - ML-WI-20
- Valve cooling - Swede Water maintenance instructions 8-5630-200
- Air cooled condenser - Swede Water maintenance instructions 8-1000-195/E
- Air blast cooler - ABB O&M instructions K1017143A & K1017146A
- Charging Rectifier – Kraft instructions 9-1578
- Frequency Converters – ABB hardware manuals

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

- Cooling pumps
- De-aeration 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 and reactor 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:

- 6 monthly in accordance with ML-WI-24

- Fan coil maintenance
- Expansion vessel maintenance
- Annually in accordance with ML-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 Murraylink Asset are connected by a pair of high voltage DC cables. These cables are buried underground (mostly direct buried with conduits at service and river undercrossings) for the entire 176km route length. An easement 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 underground 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 is performed on a monthly basis. 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.

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.

9.1.13.2 Spares Strategy

Common spares and special tools are held at the Red Cliffs Converter Station for cable repair, jointing and termination. Spares include:

- Spare 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 sites to locate cable faults and to undertake repairs. This includes:

- Hipotronics Cable Fault Locator and Test Set (2 off)
- Hipotronics TDR 1100L (2 off)

- 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 Murraylink.

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 control room in each converter station. The spare parts typically comprise:

- A MACH 2 main computer;
- 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 - Tyco F4000
- Fire detection and alarm system installed by Wormald
- Fire detection system – Vesda Laser Plus
- Fire suppression system - Intergen

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 *"LT0117-2002-04-19 Rev. 00 "*
- Fire gas suppression system preventative maintenance is recommended in accordance with Wormald document *"gas-suppr-sys-Murraylink Rev. 00"*
- Fire detection and alarm system preventative maintenance is recommended in accordance with Wormald document "*Fire-detec-alarm-sys-Murraylink Rev. 00"*
- Vesda system recommended maintenance of the is outlined in *"Wfs-VLP-GB3100 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 smoke detectors are held in storage. Other 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
- Rectifier
- Inverter
- Battery

9.1.16.1 Maintenance & Timing

The inverter 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 rectifier 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

- Voltage, time-block and Wisch relays.

9.1.17 Buildings and Structures

The following routine maintenance of buildings and structures is performed:

- Emergency lighting routine tests every 6 months
- 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 *'ML_SparePartList'*. 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 Capital Works

Planned capital works consist of projects to sustain and improve the operation of the Murraylink HVDC link. Planned capital works for Murraylink are outlined in Table 9 for further detail refer to Appendix 4

Table 9 - Murraylink Improvement Proposals

ID	Description	Yr	Purpose
1	NSW runback - Capital contribution	15/16	Recommission scheme to relieve constraints on the AC network
2	Positive building ventilation	14/15	To stop dust ingress into buildings
3	Security fences	14/15	Upgrade of security fence at Berri 2014 Red Cliffs 2015
4	Additional chillers - Compressor	14	To prevent limitations on Murraylink during high ambient temperature
5	Earth switches	14	Safety improvement for maintenance
6	Critical spares	N/A	Continuing maintenance and repair

7	Berri water tank		Required for cooling system
8	Cable relocation	N/A	Contingent cost allocation
9	FRACAS system	14	For improvements for condition based maintenance

9.5 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 10 - Murraylink Growth Capital Opportunities

Id	Description		Trigger
1	Black start capability		AER approval
2	Contingent reduction of converter losses		Converter loss limit enforced
3	Contingent duplication of DC link		AEMO Acceptance
4	Contingent duplication of transmission lines		

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 Murraylink assets 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 Murraylink 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 Murraylink 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 Murraylink assets, 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 Murraylink assets, 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 PAS55.

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 (redacted)

Murraylink - Asset Maintenance Schedule

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

Rev A

Equipment Type	Identifier	Maintenance Interval														Personnel	Energised/ Operating	Action	ML O&M Procedure	Manufacturer Doc
		wkly	1 mth	3 mth	4 mth	6 mth	1 yr	2 yr	3 yr	5 yr	6 yr	7 yr	10 yr	15 yr	30 yr					
Circuit Breakers																				
AC Filter Breaker (3ph/1 pole)	Q(1,2,3)						R		X		X					Q,H	no/no	Inspection	ML-WI-20	1HSB425409-101en 1HSB525409-101en
														X		2H	no/no	Preventative Maintenance		
															X	2H	no/no	Overhaul		
AC Circuit Breaker (3 ph / 1 pole)	Q1						R		X		X					Q,H	no/no	Inspection	ML-WI-17	1HSB425409-101en 1HSB435409-100en 1HSB535409-100en 1HSB525409-101en
														X		2H	no/no	Preventative Maintenance		
															X	2H	no/no	Overhaul		
AC By-Pass Breaker (3 ph / 1 or 3 pole)	Q2						R		X		X					Q,H	no/no	Inspection	ML-WI-17	1HSB425409-101en 1HSB435409-100en 1HSB515409-100en 1HSB525409-101en
														X		2H	no/no	Preventative Maintenance		
															X	2H	no/no	Overhaul		
Disconnector Earth Switches																				
DC Disconnector and Earth Switch	Q(11,21)							X								H	no/no	Inspection	ML-WI-20	MA97009 MA97010 5275 826E-23
											X					H	no/no	Motor Drive Mechanism		
AC Disconnector and Earth Switch	Q(11,21)							X								H	no/no	Inspection		MA97009 MA97010 5275 826E-23
											X					H	no/no	Motor Drive Mechanism		

Equipment Type	Identifier	Maintenance Interval														Personnel	Energised/ Operating	Action	ML O&M Procedure	Manufacturer Doc
		wkly	1 mth	3 mth	4 mth	6 mth	1 yr	2 yr	3 yr	5 yr	6 yr	7 yr	10 yr	15 yr	30 yr					
AC Disconnector	Q11							X								Q,H	no/no	Inspection		MA97009 5275 826E-23
											X					Q,H	no/no	Motor Drive Mechanism		
Power Transformers																				
Power Transformer (1 ph). Including 2 x Current Transformers	T1		X		R							X				Q,H	Yes/Yes	General, Oil	ML-WI-17 Section1. 3	089M001-4 Rev. 00 - ABB Operation and Maintenance Manual. Section 7 2750515-12en Rev. 07 2750515-41en Rev. 04 1ZSE5492-124en Rev. 05 1ZSE5492-125en Rev. 02 VS-150 Rev. 00 L-WAL001-05/99-D/GB Rev. 00
							X									Q,H	no/no	Oil, Bushings, Resistance, Accessories		
Reactors																				
Zero Sequence Smoothing Reactor	L1						R	R								Q	no/no	Inspection	ML-WI-29	2ZSE 460 022-BRD
DC Filter Reactor	L(2,3)						X									Q, H	no/no	General	ML-WI-29	MI-43180-88RC MI-43180-88B
DC Smoothing Reactor	L1						X									Q	no/no	General	ML-WI-29	MI-43180-88RC MI-43180-88B
Converter reactor (1ph)	L1						X									H	no/no	Inspection	ML-WI-29	1ZSE 937003-6E_00-03-29
DC Filter reactor	L2						X												ML-WI-29	MI-43180-88RC/B
										R						Q	no/no	General		
AC Filter Reactor	Z(11,12,13) -L1						X			R						Q,H	no/no	General	ML-WI-29	MI-43180-88RC MI-43180-88B
AC PLC Filter Reactor	L(1,2)						X			R						Q,H	no/no	General	ML-WI-29	MI-201.01.0427
Capacitors																				
Filter LV Capacitor	C3						X									Q	no/no	Inspection	ML-WI-30 ML-WI-38	SECAP B-003/4.en SECAP B-003/TDHLA-011
									X							Q, H	no/no	Capacitance Measurement		
DC Filter Capacitor	C(1,2)						X									Q	no/no	Inspection	ML-WI-30 ML-WI-38	SECAP B-003/4.en SECAP B-003/TDHLA-011
									X							Q, H	no/no	Capacitance Measurement		
DC capacitor	C(1,2)						X		X										ML-WI-39	TI-028 Rev. 01

Equipment Type	Identifier	Maintenance Interval														Personnel	Energised/ Operating	Action	ML O&M Procedure	Manufacturer Doc
		wkly	1 mth	3 mth	4 mth	6 mth	1 yr	2 yr	3 yr	5 yr	6 yr	7 yr	10 yr	15 yr	30 yr					
DC capacitor	C(1,2)						X									Q	no/no	Inspection	ML-WI-30 ML-WI-38	SECAP B-003/4.en SECAP B-003/TD-HLA-011
									X							Q, 2H	no/no	Capacitance Measurement		
AC Filter Capacitor	Z(11,12,13) -C1						X									Q,H	no/no	Inspection	ML-WI-30 ML-WI-38	SECAP B-003/4. en SECAP B-003/TDHLA-011
									X							Q,H	no/no	Capacitance Measurement		
AC PLC Filter Capacitor	C(1,2,3,4)						X		X							Q,H	no/no	Inspection	ML-WI-30 ML-WI-38	SECAP C18.en 1HSE96001-1en
AC PLC Filter Tuning Unit	Z(1,2)									X						Q	no/no	Inspection		MI-201.01.0427 - incorrect document listed? It appears it should be HENF600012 Rev. 01
Filter Resistors																				
AC Filter Resistor	Z(11,12)-R1						X	R								H	no/no	Inspection	ML-WI-35	F9547_1.DOC
Pre Insertion Resistor	R2						X									Q	no/no	Inspection	ML-WI-35	XL300 021-760
HF damping circuit	Z(1,2,3,4,5)						X												ML-WI-27	None
HF damping circuit	Z(1,2)						X									Q	no/no	Inspection	ML-WI-27	None
Surge Arresters																				
Metallic Screen Arrester	F(3,4)						X									Q	no/no	Inspection	ML-WI-34	CH-HS133987E
DC Filter Arrester	F(1,2)						X									Q	no/no	Inspection	ML-WI-34	SESWG/A2375E SESWG/A2527en
Surge Current Limiting Device	R1						X									Q	no/no	Inspection	ML-WI-34	XL300 021-760
DC Bus Arrester	F(1,2)						X									Q	no/no	Inspection	ML-WI-34	SESWG/A2375E SESWG/A2527en
Air Gap for Surge Limiting Device	F11						X									Q	no/no	Inspection	ML-WI-34	
AC Filter Bus Arrester	F1						X									Q	no/no	Inspection	ML-WI-34	SESWG/A2375E SESWG/A2527E
AC Filter Arrester	Z(11,12,13) -F1						X									Q	no/no	Inspection	ML-WI-34	SESWG/A2375E SESWG/A2527E
AC Bus Arrester	F1						X									Q	no/no	Inspection	ML-WI-34	SESWG/A2375E
Power Transformer Neutral Arrester	F3						X									Q	no/no	Inspection	ML-WI-34	SESWG/A2375E
AC Cable Termination Arrester	F1						X									Q	no/no	Inspection	ML-WI-34	SESWG/A 2375E
Current Transformers																				
DC Cable Screen Current Transformer	T(3,4)						X									H	no/no	Inspection	ML-WI-33	EKM Mm-0001.98
DC Filter Current Transformer	T(1,2)						R	R								H	no/no	Inspection	ML-WI-32	EKM Mm-0001.98
DC filter current transformer	T1						R									H	no/no	Inspection	ML-WI-32	EKM Mm-0001.98
AC Current Transformer (LEM)	T1						X									Q	no/no	Inspection	ML-WI-31	DOSSTECH/200s45e (LT2000-S/SP45-1)
AC Filter Current Transformer	Z(11,12,13) -T1						R									H	no/no	Inspection	ML-WI-32	EKM Mm-0001.98

Equipment Type	Identifier	Maintenance Interval														Personnel	Energised/ Operating	Action	ML O&M Procedure	Manufacturer Doc
		wkly	1 mth	3 mth	4 mth	6 mth	1 yr	2 yr	3 yr	5 yr	6 yr	7 yr	10 yr	15 yr	30 yr					
Opto Unbalance Current Transformer	Z(11,12,13) -T2						X									Q	no/no	Inspection	ML-WI-40	1HSE33600-29
DC measuring device (LEM)	T(1,2)						X									Q	no/no	Inspection	ML-WI-31	DOSSTECH/200s45e (LT2000-S/SP45-1)
DC measuring device (Rogowski)	T3						X												ML-WI-28	IRF15XD12-4-1300-2
DC derivative measuring device	T(1,2,4,5)						X												ML-WI-28	IRF15XD12-4-1300-2
DC measuring device (Rogowski)	T3						X									Q	no/no	Inspection	ML-WI-28	IRF03XD12-4-600-2
Voltage Transformers																				
Capacitive Voltage Transformer	T11						X						X			Q	no/no	Inspection	ML-WI-37	1HSE96001-26en
Capacitive Voltage Transformer	T11						X						X			Q	no/no	Inspection	ML-WI-37	1HSE96001-26en
Direct voltage divider	U1						X	X								Q, H	no/no	Inspection	ML-WI-36	MI-1STKI05201 F9607-2.DOC
Wall Bushings																				
Wall bushing	X1						R		X							Q	no/no	Inspection		2770 501-8 en
IGBT Valves																				
IGBT valve groups	V(1,2,3,4,5, 6)						X									2xH	no/no	RSM	ML-WI-26 ML-WI-03 ML-WI-12 ML-WI-13	1JNL100053-678 1JNL100043-619 01PT0148 Rev. 00
HVAC, Valve and Reactor Cooling Systems																				
Valve Cooling System																				
Valve Cooling System - Monthly system check			X													Q,H	yes/yes	System Check Water Leakage, Noise, Oxygen measuring valve	ML-WI-17 Section 1.4 ML-WI-20 Section 3 ML-WI-18 Section 2.3	8-5630-200 Rev. 01 Section 7 8-5630-200 Rev. 01 Section 10 K1017146A Rev. 00 - Air blast coolers 8-1000-150/E - Cooling pump 8-1000-182/E - Pump motor
Valve Cooling System - 3 Monthly system check				X												Q,H	yes/yes	Main Pump Units	ML-WI-19 Section 2.2	8-5630-200 Rev. 01 Section 7 8-1000-150/E K1017146A Rev. 00
Pump Motors							X									Q,H	yes/yes	Inspection		8-1000-150/E
Air Blast Coolers				X				X								Q,H	yes/yes	Inspection		K1017146A Rev. 00
Pressure regulator, relief valve and safety valve							X									Q,H	yes/yes	Inspection		8-5630-200 Rev. 01 Section 2.7
Strainer and filters							X									Q,H	yes/yes	Inspection		8-5630-200 Rev. 01 Section 13
Ion-Exchange Vessel							X			X						Q,H	yes/yes	Inspection		8-5630-200 Rev. 01 Section 9

Equipment Type	Identifier	Maintenance Interval														Personnel	Energised/ Operating	Action	ML O&M Procedure	Manufacturer Doc
		wkly	1 mth	3 mth	4 mth	6 mth	1 yr	2 yr	3 yr	5 yr	6 yr	7 yr	10 yr	15 yr	30 yr					
Meters - Pt100 element - Conductivity meters - Oxygen content sensor - Pressure transmitter							X									Q,H	yes/yes	Inspection		8-5630-200 Rev. 01
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
Converter Reactor Cooling System																				
Reactor Cooling System - Monthly system check			X																ML-WI-17 Section 1.5 ML-WI-20 Section 4.1	8-5634-200 Rev. 01 Section 7 K1017143A Rev. 00 - Air blast coolers
Reactor Cooling System - 3 Monthly system check				X															ML-WI-19 Section 2.3	8-5634-200 Rev. 01 Section 7 8-1000-150/E K1017143A Rev. 00
Pump Motors							X													8-1000-150/E
Air Blast Coolers				X				X												K1017143A Rev. 00
Pressure regulator, relief valve and safety valve							X													8-5634-200
Strainer and filters							X													8-5634-200
Ion-Exchange Vessel							X			X										8-5634-200
Meters - Pt100 element - Conductivity meters - Oxygen content sensor - Pressure transmitter							X													8-5634-200
Function checks - Flanged joints for tightness - Hand operated valves - 2 and 3 way remote control valves - Level switches - Solenoid valves							X													8-5634-200
HVAC & Dehumidifiers																				
Valve Dehumidifier				R		R	X													TGB-1008 Rev. 00
Valve Humidity Control System							X												ML-WI-25	TGB-1026 Rev. 00

Equipment Type	Identifier	Maintenance Interval														Personnel	Energised/ Operating	Action	ML O&M Procedure	Manufacturer Doc
		wkly	1 mth	3 mth	4 mth	6 mth	1 yr	2 yr	3 yr	5 yr	6 yr	7 yr	10 yr	15 yr	30 yr					
HVAC				R		X	X												ML-WI-24 ML-WI-25	VHVH-M. Rev. 00 AJ8363A Rev. 03 Kanalfläkt3 Rev. 00
HVAC Liquid Chiller+126:106:130		R	R				X													13435-76 Rev. 00 Sections 14 and 15
High Voltage Cable																				
DC Cable, Terminations and Joints																			ML-OP-19	1JNL100045-732 - PDF - Rev. 00 - DC transmission cable TD-HLB02-097B 4290.4951-01 Rev. 00 - Prefabricerad Joint for 150 kV Extruded DC Land Cable
Easement Management																			ML-OP-19	None
Fault Detection and Cable Repair																			DL-WI-41	None
Control, Protection and Telecommunication Equipment																				
FLK-Units																				
Main Computer																				
PCP IO Equipment																				
LOWS																				
ROWS																				
Maintenance PC																				
LAN Switch																				
GPS Clock																				
Antenna																				
Fire Systems																				
Fire Detection Controller		R	X			X	X	X												WFS-NT Rev. 00 LT0117-2002-04-19 Rev. 00
VESDA			X			X	X	X												WFS-VLP-GB3100 Rev. 00 WFS-VLP-GB3115 Rev. 00
Gaseous Fire Suppression System			X			X	X	X												F-9312-9 Rev. 00 gas-suppr-sys-Murraylink Rev. 00
Auxiliary Power Equipment																				
Valve and Reactor Cooling MCC Units							X													

Equipment Type	Identifier	Maintenance Interval														Personnel	Energised/ Operating	Action	ML O&M Procedure	Manufacturer Doc
		wkly	1 mth	3 mth	4 mth	6 mth	1 yr	2 yr	3 yr	5 yr	6 yr	7 yr	10 yr	15 yr	30 yr					
Auxiliary Power Supply Battery						X	X												ML-WI-42 NOT ISSUED	MK00011GB Rev. 00
Auxiliary Power Supply Charging Rectifier							X			X									ML-WI-42 NOT ISSUED	9-1571 Rev. 02
Auxiliary Power Supply Inverter																			ML-WI-42 NOT ISSUED	9-1578 Rev. 03
Auxiliary Power Supply Transformer							X													
Buildings & Structures																				
Emergency Lighting						X														
AC Switchyard Lighting																				
Safety Equipment																				
LV Rescue Kit			X																ML-WI-17	
Fire Extinguisher			X			X													ML-WI-17	
Fire Hose																				
Eye Wash Station																				
Spill Kit																				

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 and Reactor Cooling System
    - Valve Cooling Water Pumping & Control Equipment;
    - Valve Cooling Water Cooling Towers;
    - Reactor Cooling Water Pumping & Control Equipment;
    - Reactor Cooling Water Cooling Towers;
    - Water De-ionisation Vessel;
    - Valve Cooling Pump;
    - Semi Automatic Discharge Unit for Nitrogen;
    - Reactor Cooling Pump;
- Fire System Equipment
    - Aspirating Fire Detection System;
    - Conventional Fire Detection System;
    - Fire Alarm System;
    - Gas Fire Suppression System;
    - Portable Fire Extinguishers;
- HVAC
    - HVAC Air Cooled Liquid Chiller;
    - HVAC Control Enclosure;
    - HVAC Reactor Cooling Enclosure;
    - 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 Risks

Appendix 4 – Asset Maintenance Budget

1. Planned Capital Works

Error! Reference source not found. The planned capital works consist of projects to sustain and improve he operation of the Murraylink HVDC link and are described in the following sections.

1.1 SW Runback Scheme

To enhance Murraylink's role in the national electricity market, the NSW runback scheme should be recommissioned to relieve constraints from the AC network. The NSW Runback scheme has been disabled since the withdrawal of the telecommunication service to the remote substations. Additionally, substantial augmentations have been made to the NSW transmission network since the scheme was originally designed. These augmentations will require new network studies to determine the required setting of the scheme.

1.2 Building Ventilation Changes

The existing converter station building ventilation system causes contamination of the high voltage equipment installed inside the building. The converter buildings have exhaust fans installed on their roofs that extract air from the buildings. The air extraction causes a negative pressure differential between the inside and outside of the building. Debris, dust and insects are drawn into the converter buildings by the pressure difference, where they settle on the high voltage equipment, increasing the risk of an electrical flashover and increasing maintenance costs to clean inside the building annually.

1.3 Perimeter Fence Security

To maintain a high level of security, protecting the public and trespassers, the perimeter fences at Berri and Red Cliffs will require an upgrade in CY15. Upgrading the fence maintains a high level of facility security and will significantly reduce the incidence of theft, injury, and malicious damage by trespassers. Similar action to upgrade security fencing has, or is being undertaken by other network businesses. The proposed solution is to upgrade to weld mesh and the budget estimate reflects that the Murraylink converters are housed inside large compounds. This has been scheduled to CY14, minimising costs.

1.4 Install Additional Air Conditioning Chillers

During summer, the performance of the air conditioning chillers is critical to the operation of Murraylink. The converter stations are operated by a distributed control system which malfunctions if low ambient temperatures are not maintained in the control enclosures. Control system malfunctions, due to high ambient temperatures, result in outages of Murraylink and increased control system maintenance costs. The proposed solution is to install additional chillers and water pumps, in CY14, to secure the air conditioning system against the failure of a single chiller.

1.5 Install Fixed Earthing Switches

The cable terminations for the transformer primary and secondary connections at both Berri and Red Cliffs are 7m above the ground. Applying portable earths to these cable terminations requires significant manual effort to clamp the earth cable onto the conductor. On the execution of this task (annually) there is a risk of injury to the switching operator as he tightens the earth clamp at the end of the 5m long operating stick with 7m of heavy earth cable hanging from the clamp. This is currently being managed using PPE and careful application of manual handling controls. It is proposed to install fixed earthing switches to enable efficient and safe application of earth leads to eliminate the risk, however the site is physically restricted and the solution will require careful design. The work was proposed in the capital plan to the AER for 2015 but has now been brought forward to 2014 by which time a suitable design and resources can be coordinated.

1.6 Contingency Spares

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

1.7 Berri Water Storage

Additional water storage at the Berri converter station is required to improve the maintenance of the cooling systems.

1.8 Cable Relocation

The Murraylink cable may require relocation to make way for potential developments, or road realignment, along the cable route in the future. The Murraylink cables have non-exclusive rights to occupy road reserves under section 93(1)(d) of the Electricity Industry Act and a licence with Vic Roads in Victoria; and under section 47 the Electricity Act in South Australia. In the event that some future development is planned for an

area where the cables are installed, Murraylink is likely to be required to relocate or otherwise protect the cables from damage. This proposal is contingent on a future development that requires the relocation of the Murraylink cables.

1.9 FRACAS

A failure reporting, analysis, and corrective action system is being developed to gather data that will support improvements in the reliability of Murraylink.

Refurbish Rotating Auxiliary Equipment

The reliable performance of ancillary equipment is necessary for the security of the link. The motors and contactors associated with valve cooling systems, reactor cooling systems and chilled water systems have a service life much shorter than the primary equipment. This equipment has been in service for a decade and the refurbishment of several items is planned to ensure the continued reliable operation of the link.

Corrosion

Elements of the chilled water piping will require replacement with age. External corrosion of the piping occurs due to exposure to the outdoor environment. Internal corrosion of the piping occurs due to contact with the chilled water. The reliable operation of the chilled water circuit requires the integrity of the chilled water pipes to be maintained.

Insulated Gate Bipolar Transistor (IGBT) Replacement

It is necessary to maintain a sufficient number of spare IGBTs for the expected rate of failure. Long lead time for delivery of replacement spare IGBTs necessitates maintaining a level of spares.

Capacitor Spares Replacement

There are a total of 300 capacitor cans that make up the harmonic filters at the Berri and Red Cliffs converter stations. As a consequence, it is necessary to maintain a sufficient number of spare capacitor cans to cater for several failures per year.

Chilled Water Piping Lagging

The lagging associated with the chilled water piping deteriorates with exposure to solar radiation and the elements and requires periodic replacement.

Control System End of Life Replacement

The Murraylink control system consists of a variety of computerised components and software. As the components and software age, it becomes more expensive to support and maintain the system. The proposed solution is to replace the control system components and software in CY16, to ensure the control system remains maintainable. The budget estimate of $767k will be confirmed in subsequent AMPs.

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 Black Start Capability

Black start capability refers to "islanded" operating capability. Islanded operating capability is the ability to operate and supply an electricity network that is separated from any frequency controlling generators. Currently Murraylink is controlled to transfer a constant active power, varied only by changing the active power set point. Murraylink has no capability to vary the active power to control a constant frequency.

In the event that a remote AC network outage causes Murraylink to be separated from all frequency controlling generators, the frequency of the AC network connected to Murraylink will deviate and the Murraylink frequency protection will trip the converter station. Murraylink has received several enquiries, in recent years, about the capability to assist in restoring the AC network after a black system event. In the next AER review, consideration will be given to include a submission to implement black start capability at Murraylink. If approved by the AER, this expenditure will be added to the asset base as a recoverable prudent expenditure.

2.2 Contingent Reduction of Converter Losses

Future carbon pricing may focus attention on transmission system losses and Murraylink may be required to take action to reduce transmission losses.

A significant cause of transmission losses is the switching of the valve IGBTs. The switching losses may be reduced by utilising an improved switching pattern for the IGBTs. The proposed solution is to change the switching pattern for the IGBTs and retune the AC and DC filter banks for the resultant harmonics. This proposal is contingent on a requirement to reduce transmission losses.

2.3 Contingent Duplication and Extension of Murraylink Transmission Line

Duplication of Murraylink will enable greater export of renewable energy from South Australia. South Australia has extensive wind energy resources; however development is currently constrained by limited transmission capacity between South Australia, Victoria and New South Wales. The proposed solution is to:

- duplicate Murraylink with a 400MW DC transmission line between Hallet in South Australia and Buronga in New South Wales; and
- extend Murraylink, between Berri and Hallet in South Australia, and between Red Cliffs and Shepparton in Victoria, to remove AC transmission network constraints that limit the South Australian export capability of Murraylink.

This proposal is contingent on AEMO acceptance, RIT-T demonstration of the cost-benefit, EII Board approval, AER regulatory approval of the contingent project and sufficient commercial arrangements from wind generators to make the investment necessary to reinforce the South Australian interconnection capacity.