Power and Water Corporation

Darwin to Katherine Transmission Line (DKTL) Substations Condition Assessment Report

Channel Island Power Station Zone Substation

Manton Zone Substation

Batchelor Zone Substation

Pine Creek Zone Substation

Katherine Zone Substation

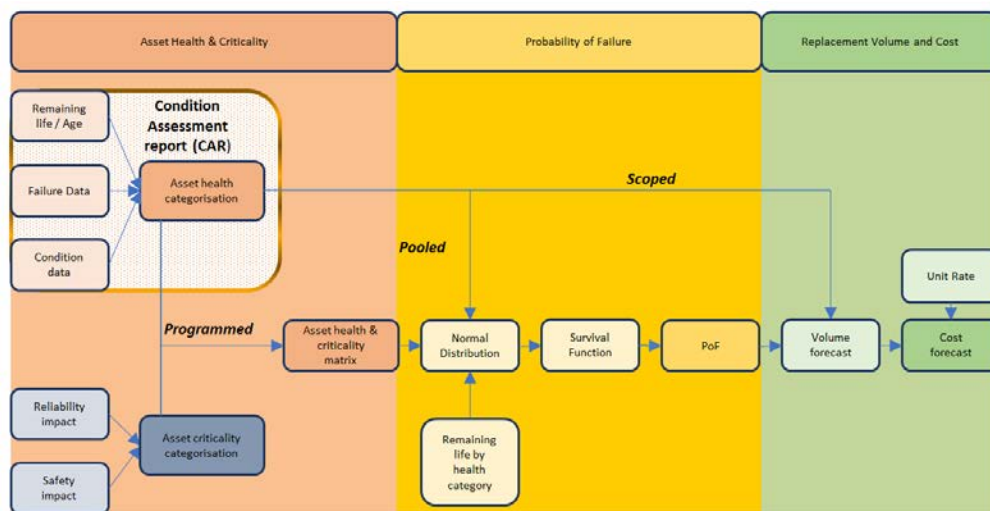| Approved By:	Prepared By:	Issue Date:22 February 2018	Status: Approved
Group Manager Asset Strategy	Condition Monitoring Engineer	Document No.: D2018/92335	Version No: 1.0

Channel Island Substation Condition Assessment Report

TABLE OF CONTENTS

1   Introduction

This condition assessment report (CAR) provides a structured condition assessment of all the assets in a format aligned to the PWC asset hierarchy[1] and applying the condition assessment criteria[2] for each asset class within the Channel Island substation. The CAR collates and summarises information from various PWC data sources that are either in raw data format or conditioned data and is traceable to the source. The following diagram illustrates where the CAR sits within the asset management process within PWC.

Figure 1 - Role of CAR in the PWC asset management process

---

[1] Refer to PWC document D2015/354287 Asset Data Template

[2] Refer to PWC document D2018/65161 for a complete description of the condition assessment methodology.

Approved By:	Prepared By:	Issue Date:22 February 2018	Status: Approved
Group Manager Asset Strategy	Condition Monitoring Engineer	Document No.: D2018/80523	Version No: 1.0

The output of the CAR is an assessment of remaining serviceable life before some form of intervention is required for the asset to continue to provide the service it was designed for. The information within the CAR is used as an input to determine the most effective asset class management plan and by definition the CAR **does not include a criticality assessment**.

2 Summary

The following table and commentary provides a summary of the asset health at the Channel Island substation. Table 1 describes the asset health definitions used in this CAR. A more detailed breakdown of the asset health components and scores can be found in section 5.

Table 1 - Asset health definitions

Code	Definition[3]	Asset Health Rating range
🟥	*Loss of required function within 5 years*	*2.34 - 3*
🟧	*Loss of required function within 5-15 years*	*1.68 – 2.33*
🟩	*New asset / minor degradation (remaining life beyond 15 years)*	*1 – 1.67*

[3] Consistent with PWC Asset health and criticality method D2018/72550

Channel Island Substation Condition Assessment Report

Table 2 - Summary of asset health

Asset Class	Sub Asset	Asset Health Rating
Building structures	*Overall*	1
Civils / earthgrid	*Overall*	1
Protection	*Overall*	*N/A*
	Transmission	1
	Transformer	*N/A*
	AVR	*N/A*
	Distribution	*N/A*
	DDR	*N/A*
HV cable	*Overall*	*N/A*
ZSS TF's	*Overall*	*N/A*
11/22kV indoor switchboard	*Overall*	*N/A*
132kV CB's	*Overall*	*N/A*
	CB 132CI803	1.25
	CB 132CI1302	1.25
	CB 132CI1802	1.25
	CB132CI1803	1.25
	CB 132CI1303	1.25
	CB 132CI604	1.3
	CB 132CI1104	1.25
	CB 132CI1604	1.3
	CB 132CI1105	1.15
	CB 132CI1605	1.3
	CB 132CI802	1.3
	CB 132CI508	1.15
	CB 132CI210	1.25
	CB132CI509	1.05
SCADA	*Overall*	2.14
Comms	*Overall*	1.67
Capacitor banks	*Overall*	N/A
Airconditioning	*Overall*	3
	Airconditioning	3
	Dehumidifier	3
132kV Isolators	*Overall*	1
132kV inst TF's	*Overall*	2
Fire systems	*Overall*	2
Aux TF	*Overall*	*N/A*
LV board	*Overall*	1
DC supplies	*Overall*	2
132kV busbar	*Overall*	2

3 Single Line Diagram
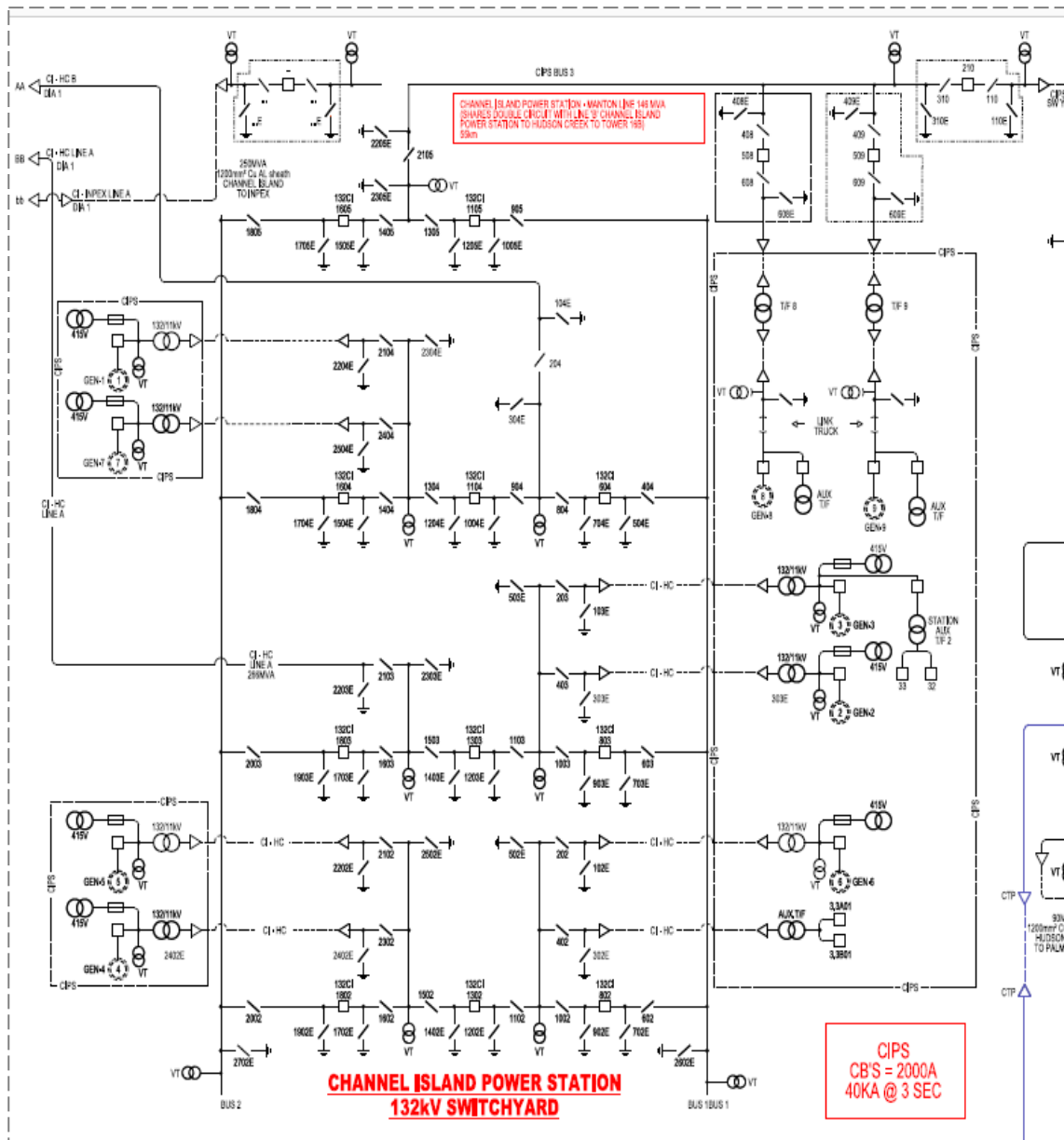
4 Site Overview

The Channel Island substation is an integral part of the Darwin – Katherine 132kV transmission system. Its function is to connect the Channel Island power station to the network. The busbar is configured in a 1.5 CB design reflecting the high security and reliability required in this part of the network. There are two types of CBs installed comprising 11 x Hitachi outdoor GIS type and 3 x ABB PASS outdoor hybrid GIS types. There are 3 x 132kV lines connected to this substation, two to Hudson Creek substation and one to Manton substation. There are no loads connected directly to this substation and therefore no substation transformers or 11kV switchboard.

5 Asset Condition Assessment

The following asset condition assessment is based on the current PWC condition assessment criteria for its various asset classes. The supporting test results and values where applicable have been extracted from relevant PWC asset databases and reports.

The three levels of asset health are characterised as follows.

Code	Definition[4]	Asset Health Rating range
	Loss of required function within 5 years	*2.34 - 3*
	Loss of required function within 5-15 years	*1.68 – 2.33*
	New asset / minor degradation (remaining life beyond 15 years)	*1 – 1.67*

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Building structures		*Overall*	1	
		Independent structural report / site inspection report	1	No significant issues.
		Asbestos rating	1	No asbestos on site, D2006/22021
		Age	1	
Civils / earthgrid		*Overall*	1	
		Earthgrid test results	1	Minor remedial work estimated at about $11k. D2017/204690 Substation Earthing Recommendation and Cost Estimation. D2016/330249 FortEng Earthing Report.
		Assessment of switchyard	1	No significant issues.
Protection		*Overall*	*N/A*	Relay Distribution DKTL - D2018/89018

---

[4] Consistent with PWC Asset health and criticality method D2018/72550

Channel Island Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
	Transmission	Overall	1	
		Technology type	1	5 digital all 6 years
		Relay calibration	N/A	
		Failure rate		Future measure
	Transformer	Overall	N/A	
		Technology type	N/A	
		Relay calibration	N/A	
		Failure rate		Future measure
	AVR	Overall	N/A	
		Technology type	N/A	6 digital
		Relay calibration	N/A	
		Failure rate		Future measure
	Distribution	Overall	N/A	
		Technology type	N/A	6 digital
		Relay calibration	N/A	
		Failure rate		Future measure
	DDR	Overall	N/A	
		Technology type	N/A	6 digital
		Relay calibration	N/A	
		Failure rate		Future measure
HV cable		*Overall*	2	132kV cable appears to lack UV stabilisation and the jacket is showing significant degradation and cracking.
ZSS TF's		*Overall*	N/A	
11/22kV indoor switchboard		*Overall*	N/A	

Channel Island Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
132kV CB's		*Overall*	1.34	For all the following asset health parameters and calculation - parameters D2018/13333 HV Circuit Breakers Test Results Health and Criticality – all breakers
	CB 132CI803	Overall	1.25	
		Age	2	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI1302	Overall	1.25	
		Age	2	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI1802	Overall	1.25	
		Age	2	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB132CI1803	Overall	1.25	
		Age	2	

Channel Island Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI1303	Overall	1.25	
		Age	2	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI604	Overall	1.3	
		Age	2	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI1104	Overall	1.25	
		Age	2	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI1604	Overall	1.3	
		Age	2	

Channel Island Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Condition Assessment	1	
		Defect count	2	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI1105	Overall	1.15	
		Age	1	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI1605	Overall	1.3	
		Age	1	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	3	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI802	Overall	1.3	
		Age	2	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132CI508	Overall	1.15	
		Age	1	

Channel Island Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Condition Assessment	1	
		Defect count	2	
		Defect cost	2	
		Insulation technology	1	
		Mechanism technology	1	
	CB 132CI210	Overall	1.25	
		Age	1	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	3	
		Insulation technology	1	
		Mechanism technology	1	
	CB132CI509	Overall	1.05	
		Age	1	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	1	
SCADA		Overall	2.14	D2017/319807
		Age	2.14	
		Failure rate		Future measure
Comms		Overall	1.67	D2017/319807
		Age	1.67	
		Failure rate		Future measure
Capacitor banks		Overall	N/A	
		Age	N/A	
Airconditioning		Overall	3	

Channel Island Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
	Airconditioning	Age	3	
	Dehumidifier	Age	3	
132kV Isolators		*Overall*	1	D2017/230246
		Age	1	
132kV inst TF's		*Overall*	2	D2017/230246
		Age	2	
		Condition Assessment	2	
Fire systems		*Overall*	2	
		Defect cost		Future measure
		Age/Functionality/obsolescence	2	
Aux TF		*Overall*	N/A	
		Age	N/A	
LV board		*Overall*	1	
		Age	1	
DC supplies		*Overall*	2	D2017/230246
		Age	2	
132kV busbar		*Overall*	2	D2017/230246
		Age	2	

Manton Substation Condition Assessment Report

TABLE OF CONTENTS

1 Introduction

This condition assessment report (CAR) provides a structured condition assessment of all the assets in a format aligned to the PWC asset hierarchy[1] and applying the condition assessment criteria[2] for each asset class within Manton substation. The CAR collates and summarises information from various PWC data sources that are either in raw data format or conditioned data and is traceable to the source. The following diagram illustrates where the CAR sits within the asset management process within PWC.

Figure 1 - Role of CAR in the PWC asset management process

---
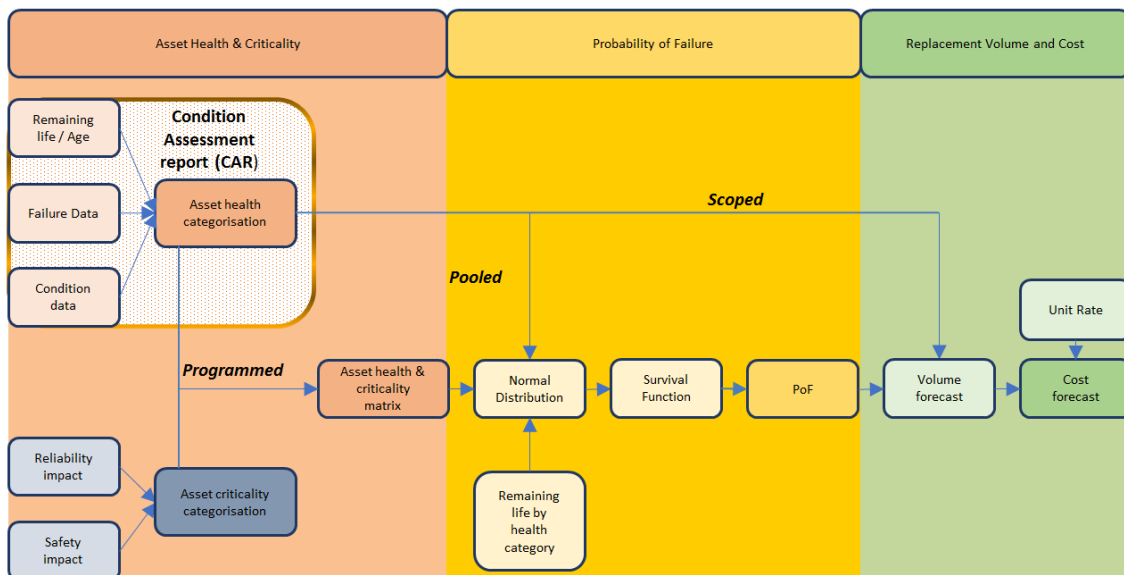
[1] Refer to PWC document D2015/354287 Asset Data Template

[2] Refer to PWC document D2018/65161 for a complete description of the PWC condition   assessment methodology.

Approved By:	Prepared By:	Issue Date:22 February 2018	Status: Approved
Group Manager Asset Strategy	Condition Monitoring Engineer	Document No.: D2018/80527	Version No: 1.0

The output of the CAR is an assessment of remaining serviceable life before some form of intervention is required for the asset to continue to provide the service it was designed for. The information within the CAR is used as an input to determine the most effective asset class management plan and by definition the CAR **does not include a criticality assessment**.

2 Summary

The following table and commentary provides a summary of the asset health at Manton substation. Table 1 describes the asset health definitions used in this CAR. A more detailed breakdown of the asset health components and scores can be found in section 5.

Table 1 - Asset health definitions

Code	Definition[3]	Asset Health Rating range
🟥	*Loss of required function within 5 years*	*2.34 - 3*
🟧	*Loss of required function within 5-15 years*	*1.68 – 2.33*
🟩	*New asset / minor degradation (remaining life beyond 15 years)*	*1 – 1.67*

---

[3] Consistent with PWC Asset health and criticality method D2018/72550

Manton Substation Condition Assessment Report

Table 2 - Summary of asset health

Asset Class	Sub Asset	Asset Health Rating
Building structures	*Overall*	1
Civils / earthgrid	*Overall*	1
Protection	*Overall*	N/A
	Transmission	**2.75**
	Transformer	1
	AVR	**3**
	Distribution	1
HV cable	*Overall*	2
ZSS TF's	*Overall*	1
	TF1	1
22kV indoor switchboard	*Overall*	1
	Siemens Simoprime	1
132kV CB's	*Overall*	1.65
	CB 132MT01	1.65
	CB 132MT02	1.65
	CB 132MT03	1.65
	CB 132MT04	1.65
SCADA	*Overall*	2.25
Comms	*Overall*	1.5
Capacitor banks	*Overall*	1
Airconditioning	*Overall*	1.5
	Airconditioning	2
	Dehumidifier	1
132kV Isolators	*Overall*	1
132kV inst TF's	*Overall*	1.12
Fire systems	*Overall*	2
Aux TF	*Overall*	1
LV board	*Overall*	1
DC supplies	*Overall*	1
132kV busbar	*Overall*	2

The following additional commentary is provided to complement the above summary in relation to significant asset classes by exception.

Protection / SCADA (RTU)

The following is a summary of the protection system related issues at Pine Creek substation.

Secondary system	Issues
AVR relay	Transformer tap change in the transmission and sub-transmission system is performed automatically or in remote manual control mode by the power system controller to manage voltage regulation. The transformers along the DA-KA transmission line are fitted with Email/RMS 2V161H auto voltage regulating (AVR) relays. This relay is no longer supported by the OEM and has proven to be unreliable in the past with an increasing failure rate. An obsolete Gould PLC unit performs the tap-change control function, which is also no longer supported by the OEM. Both relays are operating beyond their design life. PWC has commenced a relay replacement function for RMS 2V161H AVR across other ZSS sites.
Line protection relay	The line protection system between Channel Island, Manton, Pine Creek and Katherine Zone Substations currently comprises of obsolete protection relays GEC Quadramho SHPN101, ABB Rel511 and ABB Razfe protection relays. These relays have surpassed their expected asset design life, are no longer supported by the manufacturer and with spares unavailable.
Auto reclose	The auto-reclose function is typically employed for overhead lines to enable automatic reclose of circuit breakers following non-critical outages (momentary spurious outages caused by flying animals, trees and branches, etc.). Currently this function is performed by Gould PLC units. These relays have surpassed their expected asset design life, are no longer supported by the manufacturer and with spares unavailable.
CB management relay	The circuit breaker (CB) management protection relays for each of the circuit breakers at Manton, Pine Creek and Katherine Zone Substations consists of aged, outdated and inefficient electro-mechanical relays. For example, at Pine Creek, the circuit breaker management function is currently performed by four relays operating beyond their design life and exposed to failure; in modern protection schemes this function is undertaken by one Intelligent Electronic Device (IED) protection relay. The relay technology is no longer supported by the manufacturer, and spare relays are no longer available. Whilst repairs may be possible by making use of components from salvaged relays, the risk of failure of other components continues to increase.

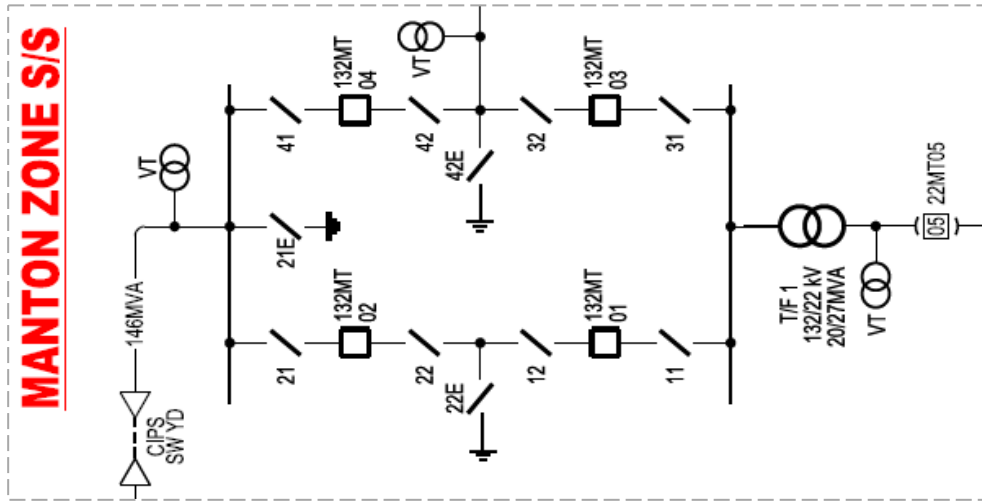| Secondary system	Issues
RTU	Current substation design philosophy incorporates duplicate/redundant RTUs for increased reliability, however, the existing installation at MT and PC ZSSs only include single RTUs which does not meet PWC's design philosophy. The RTUs installed at both sites are C2025 modules which are over 30 years old and no longer in production and unsupported by the manufacturer. Additionally, spare parts are becoming difficult to source.
Substation Lan	Substation LANs are not currently installed at substation sites on this transmission line, which does not meet PWC's design philosophy, and inhibits any remote access to the protection relays from the major centres like Darwin. The response time required to investigate faults and system events is therefore extended due to lengthy travel times involved in attending site.

3 Site Overview

Manton 132kV substation is part of the Darwin – Katherine 132kV system. There is an incoming 132kV line from Channel Island and outgoing to Pine Creek Substation. The 132kV bus feeds a single 132kV/22kV power transformer which supplies a 22kV indoor switchboard. The 22kV distribution system supplies part of the rural areas around Darwin.
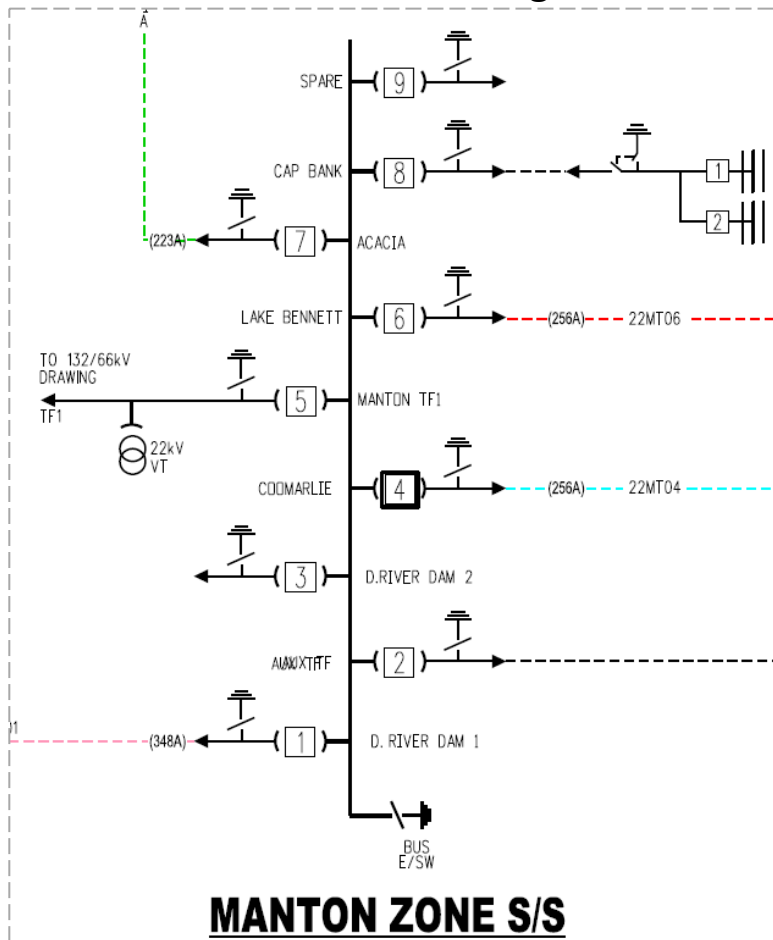
4 Single Line Diagram

132kV Outdoor Switchyard

22kV Indoor Switchgear

5 Asset Condition Assessment

The following asset condition assessment is based on the current PWC condition assessment criteria for its various asset classes. The supporting test results and values where applicable have been extracted from relevant PWC asset databases and reports.

The three levels of asset health are characterised as follows.

Code	Definition[4]	Asset Health Rating range
🟥	*Loss of required function within 5 years*	*2.34 - 3*
🟧	*Loss of required function within 5-15 years*	*1.68 – 2.33*
🟩	*New asset / minor degradation (remaining life beyond 15 years)*	*1 – 1.67*

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Building structures		*Overall*	1	
		Independent structural report / site inspection report	1	No known major issues
		Asbestos rating	1	No Asbestos.
		Age	1	The building was established in 2012.
Civils / earthgrid		*Overall*	1	
		Earthgrid test results	1	
		Assessment of switchyard	1	No significant issues.
Protection		*Overall*	N/A	Relay Distribution DKTL - D2018/89018
	Transmission	Overall	2.75	
		Technology type	2.75	8 static – 29 years 8 digital – 4 x 12 years, 4 x 29 years
		Relay calibration	N/A	

---

[4] Consistent with PWC Asset health and criticality method D2018/72550

Manton Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Failure rate		Future measure
	Transformer	Overall	1	
		Technology type	1	2 digital – 4 years
		Relay calibration	N/A	
		Failure rate		Future measure
	AVR	Overall	3	
		Technology type	3	1 static – 29 years
		Relay calibration	N/A	
		Failure rate		Future measure
	Distribution	Overall	1	
		Technology type	1	1 static – 4 years 11 digital – 4 years
		Relay calibration	N/A	
		Failure rate		Future measure
HV cable		***Overall***	2	
		Construction technology / design / installation	2	
ZSS TF's		***Overall***	1	
	TF1	Overall	1	
		Degree of polymerisation	1	D2018/84957
		Oil Analysis	1	TxAnalyser' platform
		Age	1	D2017/230246
22kV indoor switchboard		***Overall***	1	
	Siemens Simoprime with 3AH 11kV CBs	Overall	1	
		Age	1	D2018/39291 Asset Age Profile Charts

Manton Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Functional / Safety / operational issues	1	None
		Partial Discharge		Future measure
132kV CB's		*Overall*	1.5	For all the following asset health parameters and calculation - parameters D2018/13333 HV Circuit Breakers Test Results Health and Criticality – all breakers
	CB 132MT01	Overall	1.5	D2018/13333 HV Circuit Breaker Results
		Age	2	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	3	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132MT02	Overall	1.5	D2018/13333 HV Circuit Breaker Results
		Age	2	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	3	
		Insulation technology	1	
		Mechanism technology	2	
	CB 132MT03	Overall	1.4	D2018/13333 HV Circuit Breaker Results
		Age	2	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	2	
		Insulation technology	1	

Manton Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Mechanism technology	2	
	CB 132MT04	Overall	1.5	D2018/13333 HV Circuit Breaker Results
		Age	2	
		Condition Assessment	1	
		Defect count	2	
		Defect cost	3	
		Insulation technology	1	
		Mechanism technology	2	
SCADA		*Overall*	*2.25*	D2017/319807
		Age	2.25	
		Failure rate		
Comms		*Overall*	*1.5*	D2017/319807
		Age	1.5	
		Failure rate		
Capacitor banks		*Overall*	*1*	D2018/39291 Asset Age Profile Charts
		Age	1	
Airconditioning		*Overall*	*1.5*	
	Airconditioning	Age	2	
	Dehumidifier	Age	1	
132kV Isolators		*Overall*	*1*	D2018/39291 Asset Age Profile Charts
		Age	1	
132kV inst TF's		*Overall*	*1.12*	D2018/39291 Asset Age Profile Charts
		Age	1	
		Condition Assessment	1.4	TxAnalyser output
Fire systems		*Overall*	*2*	
		Defect cost		Future measure
		Age/Functionality/obsolescence	2	

Manton Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Aux TF		*Overall*	1	D2013/288593 Zone Substation Asset Verification
		Age	1	
LV board		*Overall*	1	
		Age	1	
DC supplies		*Overall*	1	D2013/288593 Zone Substation Asset Verification
		Age	1	
132kV busbar		*Overall*	2	D2018/39291 Asset Age Profile Charts
		Age	2	

PowerWater

POWER AND WATER CORPORATION

Batchelor Zone Substation Condition Assessment Report

TABLE OF CONTENTS

1   Introduction

This condition assessment report (CAR) provides a structured condition assessment of all the assets in a format aligned to the PWC asset hierarchy[1] and applying the condition assessment criteria[2] for each asset class within the Batchelor ZSS. The CAR collates and summarises information from various PWC data sources that are either in raw data format or conditioned data and is traceable to the source. The following diagram illustrates where the CAR sits within the asset management process within PWC.

Figure 1 - Role of CAR in the PWC asset management process

---
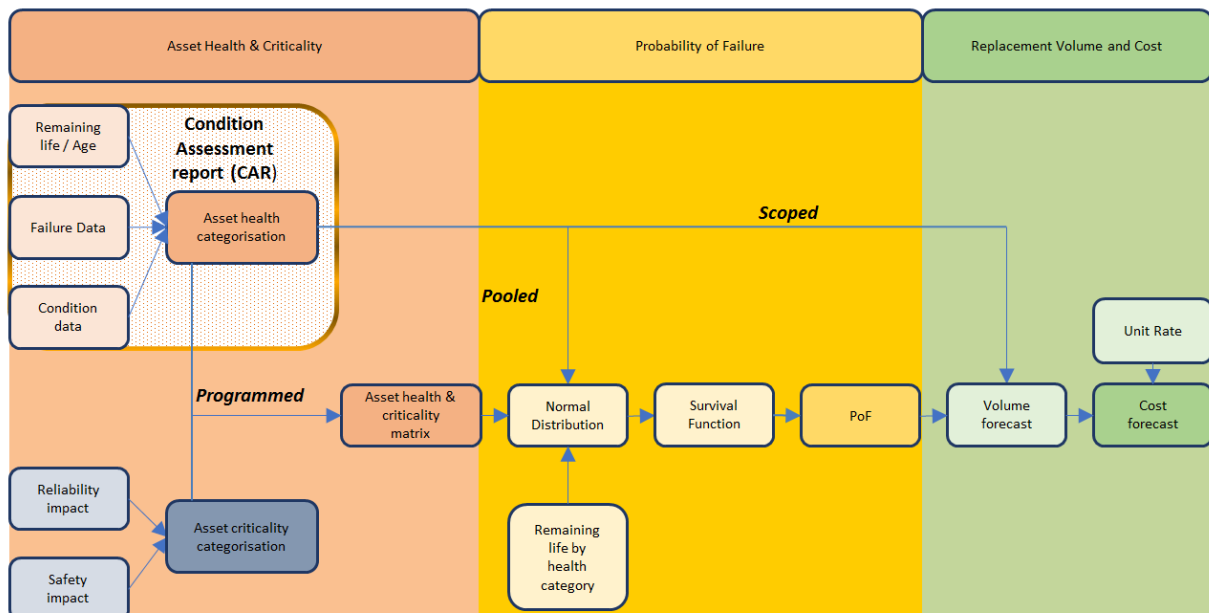
[1] Refer to PWC D2015/354287 Asset Data Template
[2] Refer to PWC document D2018/65161 for a complete description of the PWC condition assessment methodology.

Approved By:	Prepared By:	Issue Date:22 February 2018	Status: Approved
Group Manager Asset Strategy	Condition Monitoring Engineer	Document No.: D2018/80520	Version No: 1.0

The output of the CAR is an assessment of remaining serviceable life before some form of intervention is required for the asset to continue to provide the service it was designed for. The information within the CAR is used as an input to determine the most effective asset class management plan and by definition the CAR **does not include a criticality assessment**.

2 Summary

The following table and commentary provides a summary of the asset health at Batchelor substation. Table 1 describes the asset health definitions used in this CAR. A more detailed breakdown of the asset health components and scores can be found in section 5.

Table 1 - Asset health definitions

Code	Definition[3]	Asset Health Rating range
	Loss of required function within 5 years	*2.34 - 3*
	Loss of required function within 5-15 years	*1.68 – 2.33*
	New asset / minor degradation (remaining life beyond 15 years)	*1 – 1.67*

---

[3] Consistent with PWC Asset health and criticality method D2018/72550

Batchelor Substation Condition Assessment Report

Table 2 - Summary of asset health

Asset Class	Sub Asset	Asset Health Rating
Building structures	*Overall*	1
Civils / earthgrid	*Overall*	1
Protection	*Overall*	N/A
	Transmission	1
	Transformer	1
	AVR	1
	Distribution	1
	DDR	1
HV cable	*Overall*	2.3
ZSS TF's	*Overall*	1
	TF1	1
22kV indoor switchboard	*Overall*	1
	ABB 22kV Switchboard	1
132kV CB's	*Overall*	1
	CB 132BA101	1
SCADA	*Overall*	2
Comms	*Overall*	1.5
Capacitor banks	*Overall*	N/A
Airconditioning	*Overall*	1
	Airconditioning	1
	Dehumidifier	N/A
132kV Isolators	*Overall*	1
132kV inst TF's	*Overall*	1.1
Fire systems	*Overall*	2
Aux TF	*Overall*	1
LV board	*Overall*	1
DC supplies	*Overall*	2
132kV busbar	*Overall*	1

PowerWater
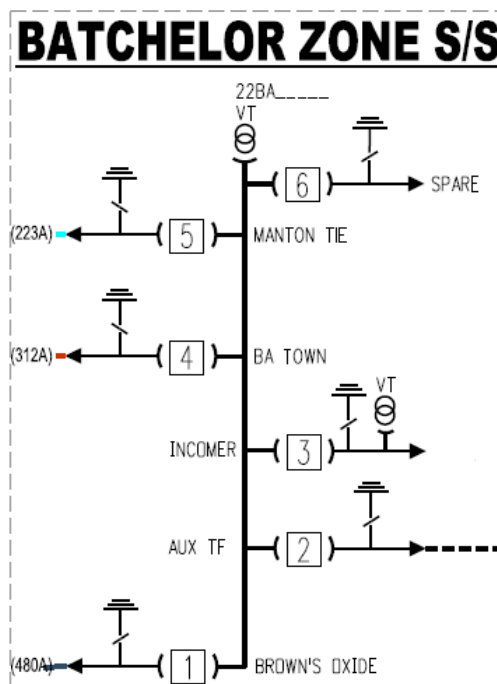
3   Site Overview

Batchelor 132kV substation is part of the Darwin – Katherine 132kV system. The substation is supplied by a tee off the 132kV line between Manton and Pine Creek. There is a single 132kV/22kV power transformer which supplies a 22kV indoor switchboard. The 22kV distribution system supplies Brown's Oxide mine and Batchelor township.

4   Single Line Diagram

132kV Outdoor Switchyard

22kV Indoor Switchgear

5 Asset Condition Assessment

The following asset condition assessment is based on the current PWC condition assessment criteria for its various asset classes. The supporting test results and values where applicable have been extracted from relevant PWC asset databases and reports.

The three levels of asset health are characterised as follows.

Code	Definition[4]	Asset Health Rating range
🟥	*Loss of required function within 5 years*	*2.34 - 3*
🟧	*Loss of required function within 5-15 years*	*1.68 – 2.33*
🟩	*New asset / minor degradation (remaining life beyond 15 years)*	*1 – 1.67*

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Building structures		**Overall**	1	
		Independent structural report / site inspection report	1	No significant issues.
		Asbestos rating	1	No asbestos
		Age	1	The building was established in 2006
Civils / earthgrid		**Overall**	1	
		Earthgrid test results	1	Minor remedial work estimated at about $20k. D2017/204690 Substation Earthing Recommendation and Cost Estimation. D2016/330243 FortEng Earthing Report.
		Assessment of switchyard	1	No significant issues.
Protection		**Overall**	**N/A**	Relay Distribution DKTL - D2018/89018
	Transmission	Overall	1	
		Technology type	1	Digital = 4 Static = 3 All 9 years old

---

[4] Consistent with PWC Asset health and criticality method D2018/72550

Batchelor Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Relay calibration	N/A	
		Failure rate		Future measure
	Transformer	Overall	1	
		Technology type	1	Digital = 1 Static = All 9 years old
		Relay calibration	N/A	
		Failure rate		Future measure
	AVR	Overall	1	
		Technology type	1	Digital = 0 Static = 1 9 years old
		Relay calibration	N/A	
		Failure rate		Future measure
	Distribution	Overall	1	
		Technology type	1	Digital = 5 Static = 1 All 9 years old
		Relay calibration	N/A	
		Failure rate		Future measure
	DDR	Overall	1	
		Technology type	1	Digital = 1 Static = 0 9 years old
		Relay calibration	N/A	
		Failure rate		Future measure
HV cable		Overall	2.3	
		Construction technology / design / installation	2.3	
ZSS TF's		Overall	1	
	TF1	Overall	1	

Batchelor Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Degree of polymerisation	1	D2018/84957
		Oil Analysis	1	TxAnalyser' platform
		Age	1	D2017/230246
22kV indoor switchboard		*Overall*	1	
	ABB 22kV Switchboard	Overall	1	
		Age	1	
		Functional / Safety / operational issues	1	None, under unrestricted areas D2018/26731
		Partial Discharge		Future measure
132kV CB's		*Overall*	1	For all the following asset health parameters and calculation - parameters D2018/13333 HV Circuit Breakers Test Results Health and Criticality – all breakers
	CB 132BA101	Overall	1	D2018/13333 HV Circuit Breaker Results
		Age	1	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	1	
SCADA		*Overall*	2	D2017/319807
		Age	2	
		Failure rate		Future measure
Comms		*Overall*	1.5	D2017/319807
		Age	1.5	
		Failure rate		Future measure
Capacitor banks		*Overall*	N/A	
		Age	N/A	

PowerWater

Batchelor Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Airconditioning		*Overall*	1	
	Airconditioning	Age	1	
	Dehumidifier	Age	N/A	
132kV Isolators		*Overall*	1	
		Age	1	D2018/39291 Asset Age Profile Charts
132kV inst TF's		*Overall*	*1.1*	
		Age	1	
		Condition Assessment	1.33	
Fire systems		*Overall*	2	
		Defect cost		Future measure
		Age/Functionality/obsolescence	2	
Aux TF		*Overall*	1	
		Age	1	D2013/288593 Zone Substation Asset Verification
LV board		*Overall*	1	
		Age	1	
DC supplies		*Overall*	2	
		Age	2	D2013/288593 Zone Substation Asset Verification
132kV busbar		*Overall*	1	
		Age	1	D2018/39291 Asset Age Profile Charts

Pine Creek 132kV Substation Condition Assessment Report

TABLE OF CONTENTS

1 Introduction

This condition assessment report (CAR) provides a structured condition assessment of all the assets in a format aligned to the PWC asset hierarchy[1] and applying the condition assessment criteria[2] for each asset class within the Pine Creek 132kV substation. The CAR collates and summarises information from various PWC data sources that are either in raw data format or conditioned data and is traceable to the source. The following diagram illustrates where the CAR sits within the asset management process within PWC.

Figure 1 - Role of CAR in the PWC asset management process

---
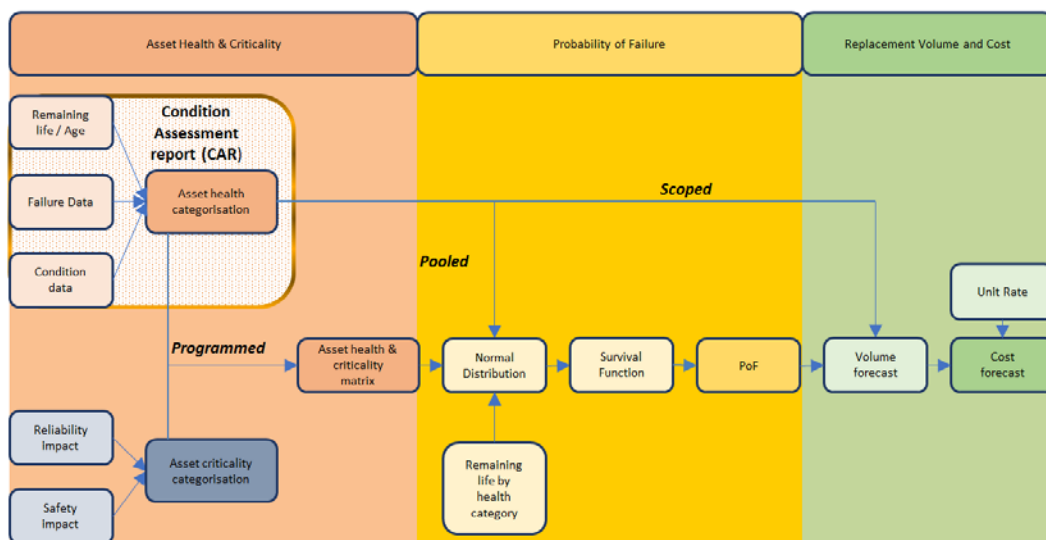
[1] Refer to PWC D2015/354287 Asset Data Template

[2] Refer to PWC document D2018/65161 for a complete description of the PWC condition assessment methodology.

Approved By:	Prepared By:	Issue Date:22 February 2018	Status: Approved
Group Manager Asset Strategy	Condition Monitoring Engineer	Document No.: D2018/80530	Version No: 1.0

The output of the CAR is an assessment of remaining serviceable life before some form of intervention is required for the asset to continue to provide the service it was designed for. The information within the CAR is used as an input to determine the most effective asset class managent plan and by definition the CAR **does not include a criticality assessment**.

2 Summary

The following table and commentary provides a summary of the asset health at the Pine Creek 132kV substation. Table 1 describes the asset health definitions used in this CAR. A more detailed breakdown of the asset health components and scores can be found in section 5.

Table 1 - Asset health definitions

Code	Definition[3]	Asset Health Rating range
	Loss of required function within 5 years	*2.34 - 3*
	Loss of required function within 5-15 years	*1.68 – 2.33*
	New asset / minor degradation (remaining life beyond 15 years)	*1 – 1.67*

---

[3] Consistent with Asset health and criticality method D2018/72550

Pine Creek 132kV Substation Condition Assessment Report

Table 2 - Summary of asset health

Asset Class	Sub Asset	Asset Health Rating
Building structures	*Overall*	*1*
Civils / earthgrid	*Overall*	*1*
Protection	*Overall*	*N/A*
	Transmission	*2.89*
	Transformer	*3*
	DDR	*3*
	Transmission-Tx 66/22kV	*3*
	Distribution 66/22kV	*3*
HV cable	*Overall*	*N/A*
132/66kV TF	*Overall*	*2.2*
	TF1	*2.2*
11/22kV indoor switchboard	*Overall*	*N/A*
66kV CB's	*Overall*	*1.65*
	CB 66PK01	*1.65*
132kV CB's	*Overall*	*1*
	CB 132PK01	*1*
	CB 132PK03	*1*
SCADA	*Overall*	*2.5*
Comms	*Overall*	*1.83*
Capacitor banks	*Overall*	*N/A*
Airconditioning	*Overall*	*3*
	Airconditioning	*3*
	Dehumidifier	*N/A*
66kV Isolators	*Overall*	*2*
66kV inst TF's	*Overall*	*1.85*
132kV Isolators	*Overall*	*2*
132kV inst TF's	*Overall*	*2.25*
Fire systems	*Overall*	*2*
Aux TF	*Overall*	*2.25*
LV board	*Overall*	*2*
DC supplies	*Overall*	*2*
66kV busbar	*Overall*	*2*
132kV busbar	*Overall*	*2*

The following additional commentary is provided to complement the above summary in relation to significant asset classes by exception.

Protection / SCADA (RTU)

The following is a summary of the protection system related issues at Pine Creek substation.

Secondary system	Issues
Sychronisation	(i) The tone signalling units, which facilitate communication between the power station and substation, have previously malfunctioned and have recently been repaired. However, the units are no longer supported by the OEM and given the age, are prone to failure making them unreliable[4]; and (ii) The synchronisation system and PLC is now obsolete and has been superseded by a new design. This system has become increasingly unreliable in its operation, causing local outages. There are no spare units available, and the manufacturer has declined to repair existing units.
Grid / Island Protection	The grid/island detection, located at Pine Creek Power Station, is currently performed by an Allen Bradley PLC (type AB SLC 502 PLC) which is due to be discontinued in 2017. These devices are operating beyond their design life, and there is insufficient knowledge within PWC to maintain the ladder logic used in the PLC for these functions.
AVR relay	Transformer tap change in the transmission and sub-transmission system is performed automatically or in remote manual control mode by the power system controller to manage voltage regulation. The transformers along the DA-KA transmission line are fitted with Email/RMS 2V161H auto voltage regulating (AVR) relays. This relay is no longer supported by the OEM and has proven to be unreliable in the past with an increasing failure rate. An obsolete Gould PLC unit performs the tap-change control function, which is also no longer supported by the OEM. Both relays are operating beyond their design life. PWC has commenced a relay replacement function for RMS 2V161H AVR across other ZSS sites.
Transformer Protection Relay	The existing transformer protection relays at Pine Creek Switching Station are outdated and are operating beyond their design life. After detection of several defects, the same relay has been replaced at Katherine 132kV Zone Substation.

---

[4] Email "Review of Syncheck Settings in Power Network" dated 08/09/2016 sent by W. Chan. Trim reference D2016/410770

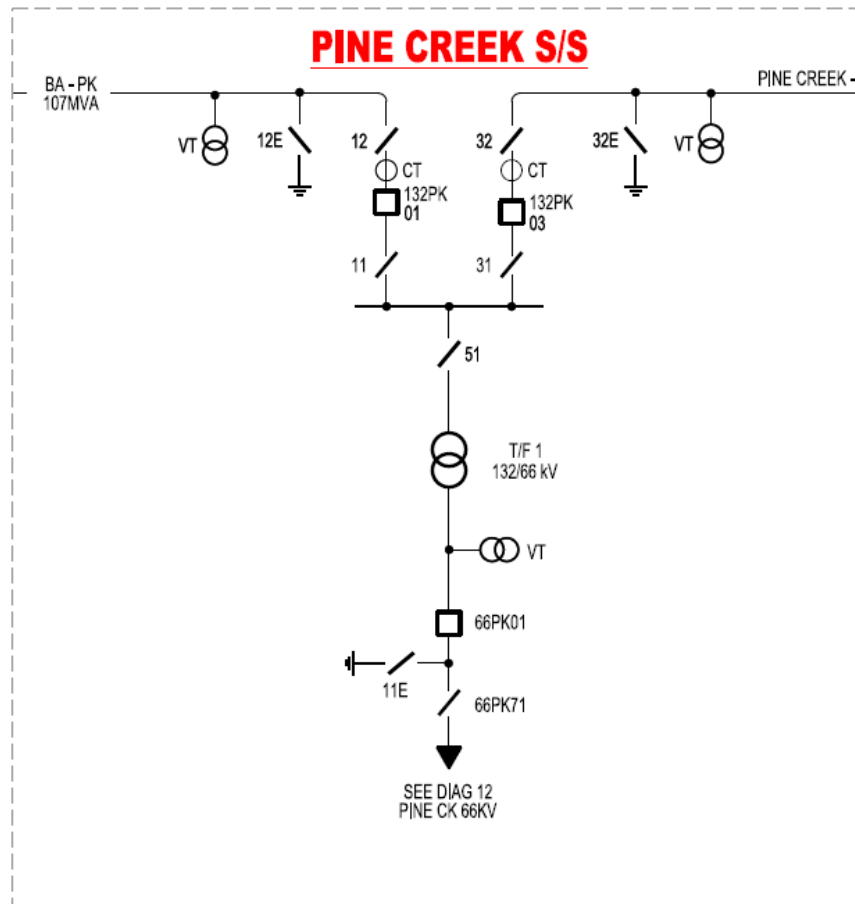# Pine Creek 132kV Substation Condition Assessment Report

Secondary system	Issues
Line protection relay	The line protection system between Channel Island, Manton, Pine Creek and Katherine Zone Substations currently comprises of obsolete protection relays GEC Quadramho SHPN101, ABB Rel511 and ABB Razfe protection relays. These relays have surpassed their expected asset design life, are no longer supported by the manufacturer and with spares unavailable.
Auto reclose	The auto-reclose function is typically employed for overhead lines to enable automatic reclose of circuit breakers following non-critical outages (momentary spurious outages caused by flying animals, trees and branches, etc.). Currently this function is performed by Gould PLC units. These relays have surpassed their expected asset design life, are no longer supported by the manufacturer and with spares unavailable.
CB management relay	The circuit breaker (CB) management protection relays for each of the circuit breakers at Manton, Pine Creek and Katherine Zone Substations consists of aged, outdated and inefficient electro-mechanical relays. For example, at Pine Creek, the circuit breaker management function is currently performed by four relays operating beyond their design life and exposed to failure; in modern protection schemes this function is undertaken by one Intelligent Electronic Device (IED) protection relay. The relay technology is no longer supported by the manufacturer, and spare relays are no longer available. Whilst repairs may be possible by making use of components from salvaged relays, the risk of failure of other components continues to increase.
RTU	Current substation design philosophy incorporates duplicate/redundant RTUs for increased reliability, however, the existing installation at MT and PC ZSSs only include single RTUs which does not meet PWC's design philosophy. The RTUs installed at both sites are C2025 modules which are over 30 years old and no longer in production and unsupported by the manufacturer. Additionally, spare parts are becoming difficult to source.
Substation Lan	Substation LANs are not currently installed at substation sites on this transmission line, which does not meet PWC's design philosophy, and inhibits any remote access to the protection relays from the major centres like Darwin. The response time required to investigate faults and system events is therefore extended due to lengthy travel times involved in attending site.

Pine Creek 132kV Substation Condition Assessment Report

3 Site Overview

Pine Creek 132kV substation is part of the Darwin – Katherine 132kV system. It also radially supplies the Pine Creek ZSS and the radial 66kV sub transmission system.

4 Single Line Diagram

5 Asset Condition Assessment

The following asset condition assessment is based on the current PWC condition assessment criteria for its various asset classes. The supporting test results and values where applicable have been extracted from relevant PWC asset databases and reports.

The three levels of asset health are characterised as follows.

Code	Definition[5]	Asset Health Rating range
	Loss of required function within 5 years	2.34 - 3
	Loss of required function within 5-15 years	1.68 – 2.33
	New asset / minor degradation (remaining life beyond 15 years)	1 – 1.67

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Building structures		Overall	1	
		Independent structural report / site inspection report	1	No structural issues.
		Asbestos rating	1	No asbestos D2006/21921, D2006/21922, D2006/21920
		Age	1	
Civils / earthgrid		Overall	1	
		Earthgrid test results	1	D2015/1899 no major earthing issues.
		Assessment of switchyard	1	No significant issues.
Protection		Overall	N/A	Relay Distribution DKTL - D2018/89018
	Transmission	Overall	2.89	

---

[5] Consistent with PWC Asset health and criticality method D2018/72550

Pine Creek 132kV Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Technology type	**2.89**	11 Static – 23 years 8 Digital – 2 x 12 years, 6 x 23 years
		Relay calibration	**N/A**	
		Failure rate		Future measure
	Transformer	Overall	**3**	
		Technology type	**3**	2 Static 1 Digital all 23 years
		Relay calibration	**N/A**	
		Failure rate		Future measure
	DDR	Overall	**3**	
		Technology type	**3**	1 Digital 32 years
		Relay calibration	**N/A**	
		Failure rate		Future measure
	Transmission-Tx 66/22kV	Overall	**3**	
		Technology type	**3**	13 Static 3 Digital all 23 years
		Relay calibration	**N/A**	
		Failure rate		Future measure
	Distribution 66/22kV	Overall		
		Technology type	**3**	9 Static 2 Digital all 23 years
		Relay calibration	**N/A**	
		Failure rate		Future measure
HV cable		**Overall**	**N/A**	

Pine Creek 132kV Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
132/66kV TF		*Overall*	**2.2**	
	TF1	Overall	**2.2**	
		Degree of polymerisation	**2**	D2018/84957
		Oil Analysis	**2**	TxAnalyser Output
		Age	**3**	D2017/230246
11/22kV indoor switchboard		*Overall*	**N/A**	
66kV CB's		*Overall*	**1.65**	For all the following asset health parameters and calculation - parameters D2018/13333 HV Circuit Breakers Test Results Health and Criticality – all breakers
	CB 66PK01	Overall	**1.65**	
		Age	**1**	
		Condition Assessment	**2**	
		Defect count	**2**	
		Defect cost	**2**	
		Insulation technology	**1**	
		Mechanism technology	**1**	
132kV CB's		*Overall*	**1**	For all the following asset health parameters and calculation - parameters D2018/13333 HV Circuit Breakers Test Results Health and Criticality – all breakers
	CB 132PK01	Overall	**1**	
		Age	**1**	
		Condition Assessment	**1**	
		Defect count	**1**	
		Defect cost	**1**	
		Insulation technology	**1**	

PowerWater

POWER AND WATER CORPORATION

Pine Creek 132kV Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Mechanism technology	1	
	CB 132PK03	Overall	1	
		Age	1	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	1	
SCADA		*Overall*	2.5	D2017/319807
		Age	2.5	
		Failure rate		Future measure
Comms		*Overall*	1.83	D2017/319807
		Age	1.83	
		Failure rate		Future measure
Capacitor banks		*Overall*	*N/A*	
Airconditioning		*Overall*	*3*	D2017/230246
	Airconditioning	Age	3	
	Dehumidifier	Age	*N/A*	
66kV Isolators		*Overall*	*2*	D2017/230246
		Age	2	
66kV inst TF's		*Overall*	*1.85*	
		Age	2	D2017/230246
		Condition Asessement	1.5	TxAnalyser
132kV Isolators		*Overall*	*2*	D2017/230246
		Age	2	
132kV inst TF's		*Overall*	*2.25*	
		Age	2.57	D2017/230246
		Condition Asessement	1.5	TxAnalyser

Pine Creek 132kV Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Fire systems		*Overall*	*2*	
		Defect cost		Future measure
		Age/Functionality/obsolescence	2	
Aux TF		*Overall*	*1*	D2017/230246
		Age	1	
LV board		*Overall*	*2*	D2017/230246
		Age	2	
DC supplies		*Overall*	*2*	D2017/230246
		Age	2	
66kV busbar		*Overall*	*2*	D2017/230246
		Age	2	
132kV busbar		*Overall*	*2*	D2017/230246
		Age	2	

Katherine Substation Condition Assessment Report

TABLE OF CONTENTS

Introduction

This condition assessment report (CAR) provides a structured condition assessment of all the assets in a format aligned to the PWC asset hierarchy[1] and applying the condition assessment criteria[2] for each asset class within the Katherine substation. The CAR collates and summarises information from various PWC data sources that are either in raw data format or conditioned data and is traceable to the source. The following diagram illustrates where the CAR sits within the asset management process within PWC.

Figure 1 - Role of CAR in the PWC asset management process

---
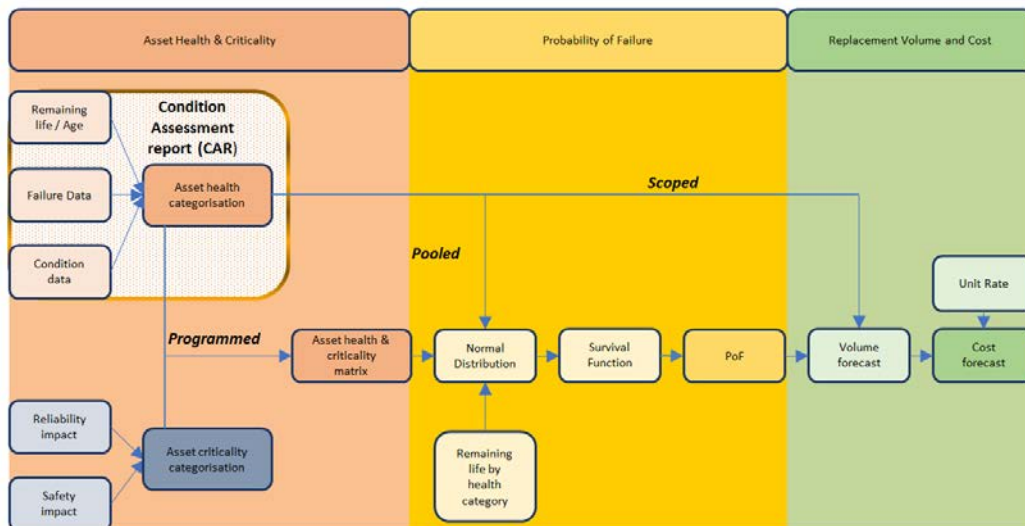
[1] Refer to PWC document D2015/354287 Asset Data Template

[2] Refer to PWC document D2018/65161 for a complete description of the PWC condition assessment methodology.

Approved By:	Prepared By:	Issue Date:22 February 2018	Status: Approved
Group Manager Asset Strategy	Condition Monitoring Engineer	Document No.: D2018/80524	Version No: 1.0

The output of the CAR is an assessment of remaining serviceable life before some form of intervention is required for the asset to continue to provide the service it was designed for. The information within the CAR is used as an input to determine the most effective asset class management plan and by definition the CAR **does not include a criticality assessment**.

1 Summary

The following table and commentary provides a summary of the asset health at the Katherine substation. Table 1 describes the asset health definitions used in this CAR. A more detailed breakdown of the asset health components and scores can be found in section 5.

Table 1 - Asset health definitions

Code	Definition[3]	Asset Health Rating range
	Loss of required function within 5 years	*2.34 - 3*
	Loss of required function within 5-15 years	*1.68 – 2.33*
	New asset / minor degradation (remaining life beyond 15 years)	*1 – 1.67*

---

[3] Consistent with PWC Asset health and criticality method D2018/72550

Katherine Substation Condition Assessment Report

Table 2 - Summary of asset health

Asset Class	Sub Asset	Asset Health Rating
Building structures	*Overall*	1
Civils / earthgrid	*Overall*	1
Protection	*Overall*	N/A
	Transmission	2.71
	Transmission/DDR	3
	Transformer	1
	AVR	3
	Distribution	1
	Distribution/DDR	1
HV cable	*Overall*	3
ZSS TF's	*Overall*	1.35
	TF1	1
	TF2	1.7
22kV indoor switchboard	*Overall*	1
	Siemens Simoprime	1
132kV CB's	*Overall*	1
	CB 132KA01	1
	CB 132KA02	1
SCADA	*Overall*	2.33
Comms	*Overall*	1.67
Capacitor banks	*Overall*	1
Airconditioning	*Overall*	2.5
	Airconditioning	2
	Dehumidifier	3
132kV Isolators	*Overall*	3
132kV inst TF's	*Overall*	1.14
Fire systems	*Overall*	2
Aux TF	*Overall*	1
LV board	*Overall*	1
DC supplies	*Overall*	2.36
132kV busbar	*Overall*	3

The following additional commentary is provided to complement the above summary in relation to significant asset classes by exception.

Protection

The following table is a summary of the protection system related issues at Katherine substation.

Secondary system	Issues
Synchronisation	(i) The tone signalling units, which facilitate communication between the power station and substation, have previously malfunctioned and have recently been repaired. However, the units are no longer supported by the OEM and given the age, are prone to failure making them unreliable[4]; and (ii) The synchronisation system and PLC is now obsolete and has been superseded by a new design. This system has become increasingly unreliable in its operation, causing local outages. There are no spare units available, and the manufacturer has declined to repair existing units.
AVR relay	Transformer tap change in the transmission and sub-transmission system is performed automatically or in remote manual control mode by the power system controller to manage voltage regulation. The transformers along the DA-KA transmission line are fitted with Email/RMS 2V161H auto voltage regulating (AVR) relays. This relay is no longer supported by the OEM and has proven to be unreliable in the past with an increasing failure rate. An obsolete Gould PLC unit performs the tap-change control function, which is also no longer supported by the OEM. Both relays are operating beyond their design life. PWC has commenced a relay replacement function for RMS 2V161H AVR across other ZSS sites.
Line protection relay	The line protection system between Channel Island, Manton, Pine Creek and Katherine Zone Substations currently comprises of obsolete protection relays GEC Quadramho SHPN101, ABB Rel511 and ABB Razfe protection relays. These relays have surpassed their expected asset design life, are no longer supported by the manufacturer and with spares unavailable.
Auto reclose	The auto-reclose function is typically employed for overhead lines to enable automatic reclose of circuit breakers following non-critical outages (momentary spurious outages caused by flying animals, trees and branches, etc.). Currently this function is performed by Gould PLC units. These relays have surpassed their expected asset design life, are no longer supported by the manufacturer and with spares unavailable.
CB management relay	The circuit breaker (CB) management protection relays for each of the circuit breakers at Manton, Pine Creek and Katherine Zone Substations consists of aged, outdated and inefficient electro-mechanical relays. For example, at Pine Creek, the circuit breaker management function is currently performed by four relays operating beyond their design life and exposed to failure; in modern protection schemes this function is undertaken by one Intelligent Electronic Device (IED) protection relay. The relay technology is no longer supported by the manufacturer, and spare relays are no longer available. Whilst repairs may be possible by making use of

---

[4] Email "Review of Syncheck Settings in Power Network" dated 08/09/2016 sent by W. Chan. Trim reference D2016/410770

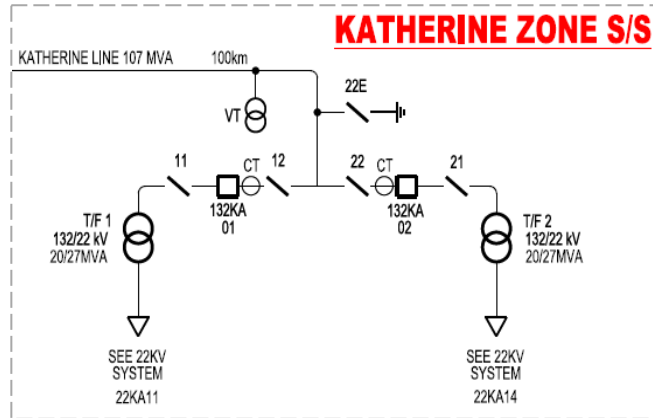| Secondary system	Issues
	components from salvaged relays, the risk of failure of other components continues to increase.
Substation Lan	Substation LANs are not currently installed at substation sites on this transmission line, which does not meet PWC's design philosophy, and inhibits any remote access to the protection relays from the major centres like Darwin. The response time required to investigate faults and system events is therefore extended due to lengthy travel times involved in attending site.

2 Site Overview

The Katherine Zone Substation was established in 1975 and is at one end of the Darwin – Katherine 132kV system. The substation is supplied by a radial single circuit 132kV overhead line. The Katherine area load is supplied via 2 x 27MVA 132/22kV TF's further supplying a 22kV indoor switchboard. 22kV load supplies Katherine town and surrounding areas.
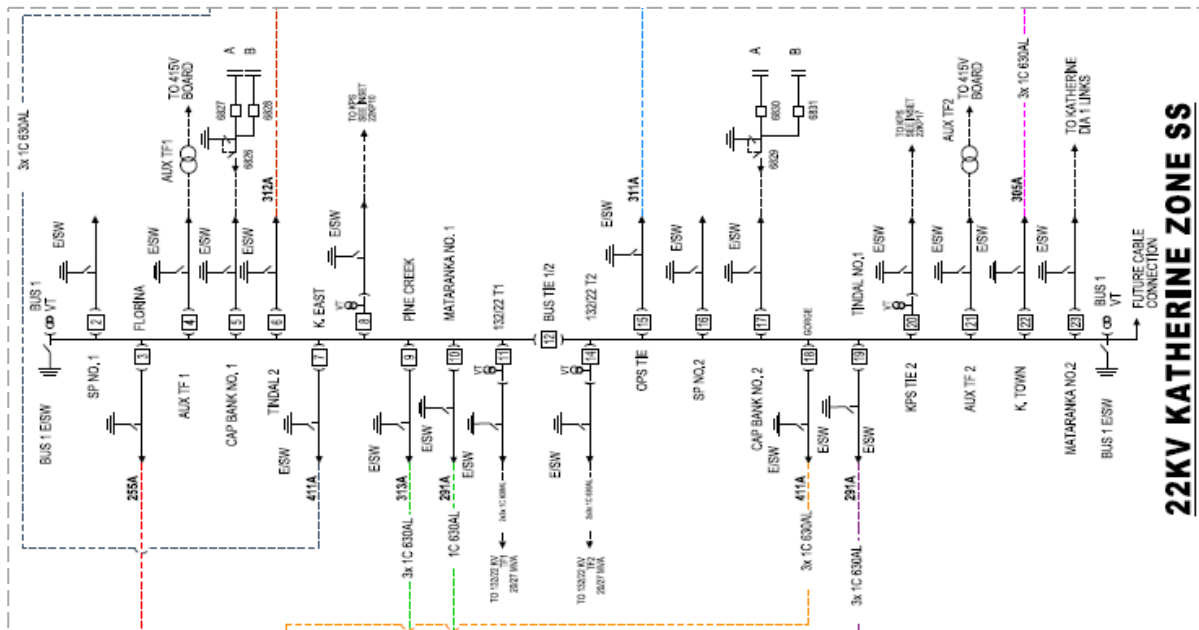
3 Single Line Diagram

132kV Outdoor Switchyard

22kV Indoor Switchgear

4 Asset Condition Assessment

The following asset condition assessment is based on the current PWC condition assessment criteria for its various asset classes. The supporting test results and values where applicable have been extracted from relevant PWC asset databases and reports.

The three levels of asset health are characterised as follows.

Code	Definition[5]	Asset Health Rating range
	Loss of required function within 5 years	*2.34 - 3*
	Loss of required function within 5-15 years	*1.68 – 2.33*
	New asset / minor degradation (remaining life beyond 15 years)	*1 – 1.67*

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Building structures		*Overall*	1	
		Independent structural report / site inspection report	1	No major known issues
		Asbestos rating	1	No Asbestos.
		Age	1	The building was established in 2010.
Civils / earthgrid		*Overall*	1	
		Earthgrid test results	1	Minor remedial works outlined in D2014/280679
		Assessment of switchyard	1	No significant issues.
Protection		*Overall*	N/A	Relay Distribution DKTL - D2018/89018
	Transmission	Overall	2.71	
		Technology type	2.71	5 static – 4 x 28 years, 1 x 14 years 2 digital – 1 x 28 years, 1 x 12 years

---

[5] Consistent with PWC Asset health and criticality method D2018/72550

Katherine Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Relay calibration	N/A	
		Failure rate		Future measure
	Transmission/DDR	Overall	3	
		Technology type	3	1 x Digital – 32 years
		Relay calibration	N/A	
		Failure rate		Future measure
	Transformer	Overall		
		Technology type	1	6 x Digital – 5 years
		Relay calibration	N/A	
		Failure rate		Future measure
	AVR	Overall		
		Technology type	3	2 x Static – both 28 years
		Relay calibration	N/A	
		Failure rate		Future measure
	Distribution	Overall		
		Technology type	1	2 x Static – 5 years 29 x Digital – 5 years
		Relay calibration	N/A	
		Failure rate		Future measure
	Distribution/DDR	Overall		
		Technology type	1	1 x Digital – 4 years
		Relay calibration	N/A	
		Failure rate		Future measure
HV cable		Overall	3	
		Construction technology / design / installation	3	
ZSS TF's		Overall	1.35	
	TF1	Overall	1	

Katherine Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Degree of polymerisation	1	
		Oil Analysis	1	Output from 'TxAnalyser' platform
		Age	1	D2013/288593 Zone Substation Asset Verification
	TF2	Overall	1.7	
		Degree of polymerisation	2	
		Oil Analysis	1	Output from 'TxAnalyser' platform
		Age	1	D2013/288593 Zone Substation Asset Verification
22kV indoor switchboard		*Overall*	N/A	
	Siemens Simoprime	Overall	1	D2018/39291 Asset Age Profile Charts
		Age	1	
		Functional / Safety / operational issues	1	None
		Partial Discharge		Future measure
132kV CB's		*Overall*	N/A	For all the following asset health parameters and calculation - parameters D2018/13333 HV Circuit Breakers Test Results Health and Criticality – all breakers
	CB 132KA01	Overall	1	D2018/13333 HV Circuit Breaker Results
		Age	1	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	

Katherine Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
		Mechanism technology	1	
	CB 132KA02	Overall	1	D2018/13333 HV Circuit Breaker Results
		Age	1	
		Condition Assessment	1	
		Defect count	1	
		Defect cost	1	
		Insulation technology	1	
		Mechanism technology	1	
SCADA		*Overall*	2.33	D2017/319807
		Age	2.33	
		Failure rate		Future measure
Comms		*Overall*	1.67	D2017/319807
		Age	1.67	
		Failure rate		Future measure
Capacitor banks		*Overall*	1	
		Age	1	D2018/39291 Asset Age Profile Charts
Airconditioning		*Overall*	2.5	
	Airconditioning	Age	2	
	Dehumidifier	Age	3	
132kV Isolators		*Overall*	3	
		Age	3	D2018/39291 Asset Age Profile Charts
132kV inst TF's		*Overall*	1.14	
		Age	1	
		Condition Assessment	1.47	Tx Analyser
Fire systems		*Overall*	2	
		Defect cost		Future measure
		Age/Functionality/obsolescence	2	D2018/39291 Asset Age Profile Charts

PowerWater

Katherine Substation Condition Assessment Report

Asset Class	Sub Asset	Remaining serviceable life criteria	Asset Health Rating	Comments / Source
Aux TF		*Overall*	1	
		Age	1	D2013/288593 Zone Substation Asset Verification
LV board		*Overall*	1	
		Age	1	
DC supplies		*Overall*	2.36	
		Age	2.36	D2013/288593 Zone Substation Asset Verification
132kV busbar		*Overall*	3	
		Age	3	D2018/39291 Asset Age Profile Charts

PowerWater

POWER AND WATER CORPORATION