Asset Management at Mercury

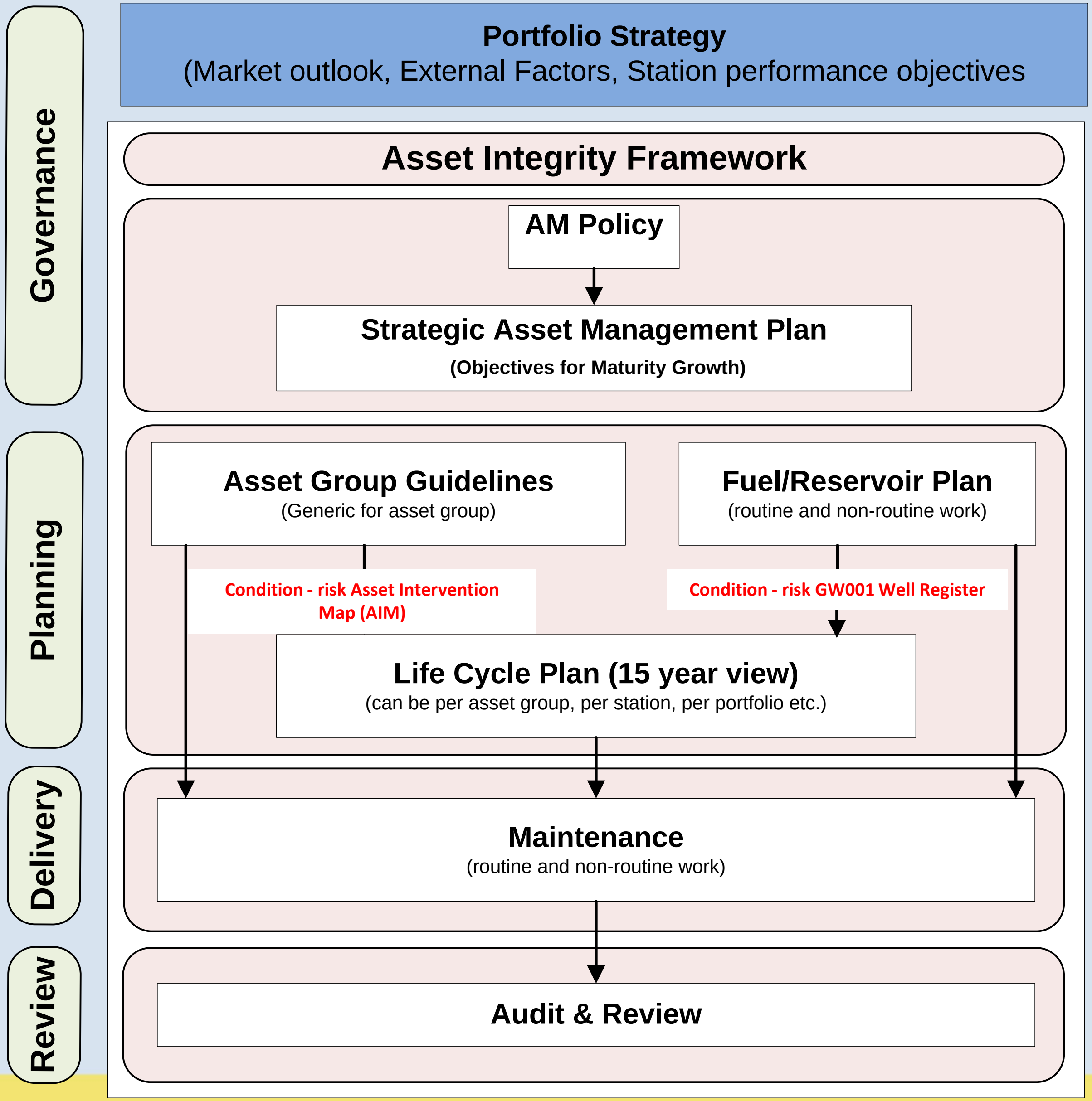
Mathew Hunt
Strategic Asset Planner

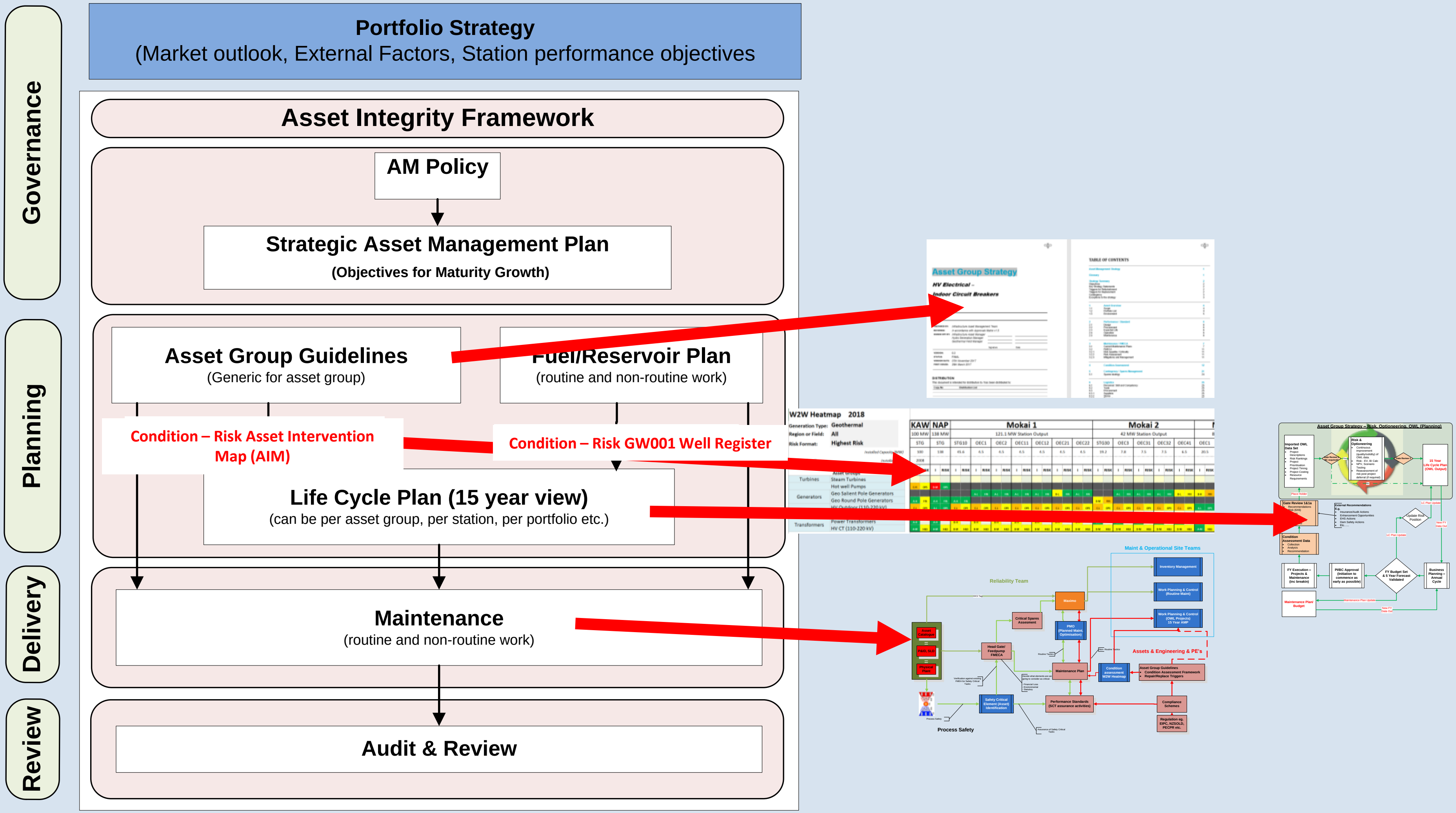
Mercury

21 JUNE 2018

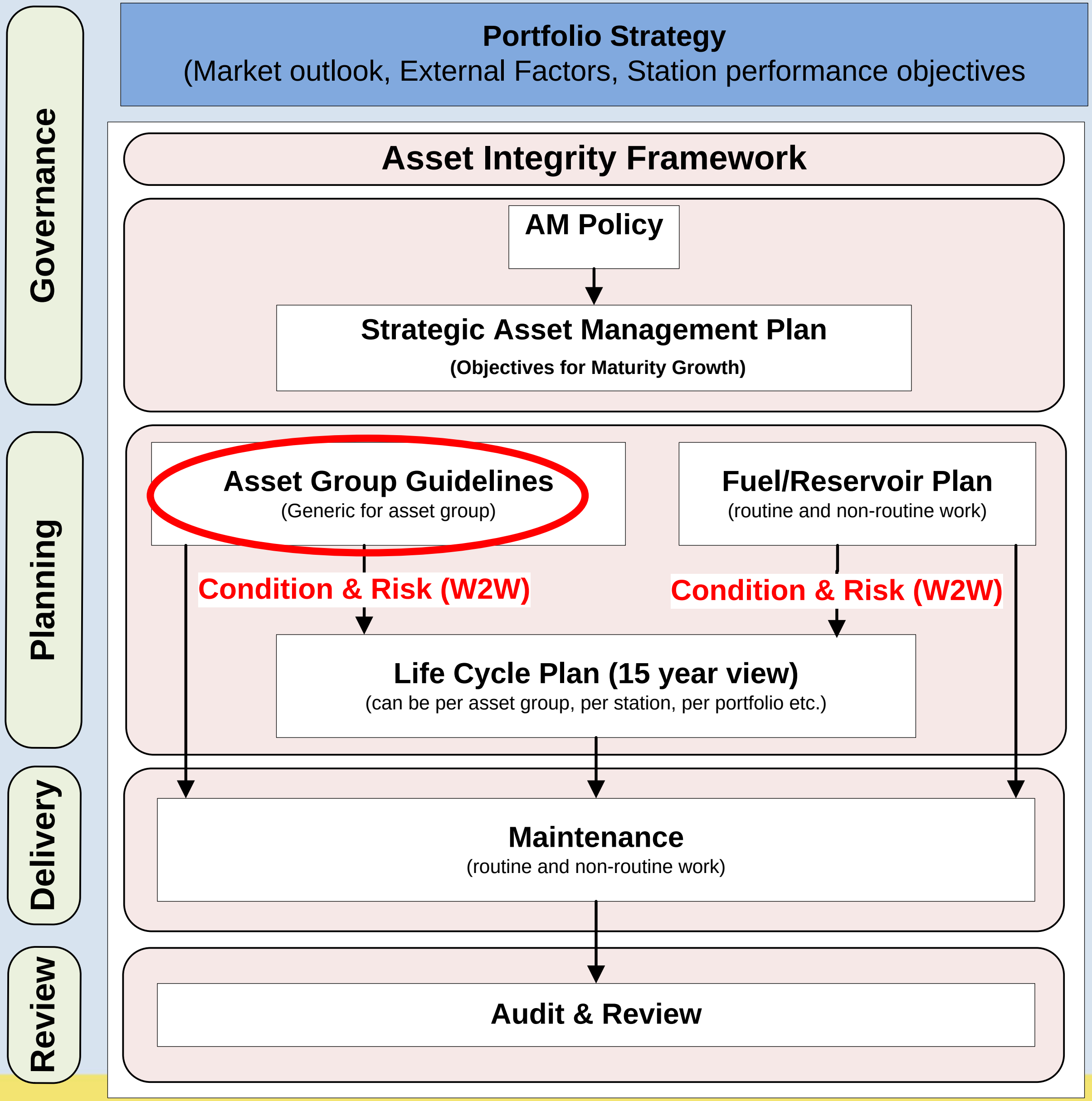
PERSONAL INTRODUCTION

- BE Hons (Mech), University of Canterbury, 2010
- Master Of Maintenance and Reliability Engineering, Federation University (Melbourne, Australia), 2018
- Mercury (then Mighty River Power) in 2013
- For fun, I ride mountain bikes


Governance
Planning
Delivery
Review
Portfolio Strategy
(Market outlook, External Factors, Station performance objectives
Asset Integrity Framework
AM Policy
Strategic Asset Management Plan
(Objectives for Maturity Growth)
Asset Group Guidelines
(Generic for asset group)
Fuel/Reservoir Plan
(routine and non-routine work)
Condition - risk Asset Intervention Map (AIM)
Condition - risk GW001 Well Register
Life Cycle Plan (15 year view)
(can be per asset group, per station, per portfolio etc.)
Maintenance
(routine and non-routine work)
Audit & Review



Governance
Planning
Delivery
Review
Portfolio Strategy
(Market outlook, External Factors, Station performance objectives
Asset Integrity Framework
AM Policy
Strategic Asset Management Plan
(Objectives for Maturity Growth)
Asset Group Guidelines
(Generic for asset group)
Fuel/Reservoir Plan
(routine and non-routine work)
Condition – Risk Asset Intervention Map (AIM)
Condition – Risk GW001 Well Register
Life Cycle Plan (15 year view)
(can be per asset group, per station, per portfolio etc.)
Maintenance
(routine and non-routine work)
Audit & Review
Asset Group Strategy
HV Electrical – Indoor Circuit Breakers
W2W Heatmap 2018
KAW
NAP
Mokai 1
Mokai 2
Maint & Operational Site Teams
Reliability Team
Assets & Engineering & PE's
Process Safety


Governance
Planning
Delivery
Review
Portfolio Strategy
(Market outlook, External Factors, Station performance objectives
Asset Integrity Framework
AM Policy
Strategic Asset Management Plan
(Objectives for Maturity Growth)
Asset Group Guidelines
(Generic for asset group)
Fuel/Reservoir Plan
(routine and non-routine work)
Condition & Risk (W2W)
Condition & Risk (W2W)
Life Cycle Plan (15 year view)
(can be per asset group, per station, per portfolio etc.)
Maintenance
(routine and non-routine work)
Audit & Review

Asset Group Strategy

HV Electrical –

Indoor Circuit Breakers

PREPARED BY:	*Infrastructure Asset Management Team*
REVIEWED:	*In accordance with Approvals Matrix v1.5*
SIGNED OFF BY:	*Infrastructure Asset Manager* *Hydro Generation Manager* *Geothermal Field Manager*

Signature Date

VERSION:	0.2
STATUS:	FINAL
VERSION DATE:	*07th November 2017*
FIRST ISSUED:	*29th March 2017*

DISTRIBUTION

This document is intended for distribution to / has been distributed to:

Copy No	Distribution List

TABLE OF CONTENTS

EXCITATION MANAGEMENT STRATEGY SUMMARY

1 Objectives

To provide guidance in the proactive management and timely replacement of all excitation systems, taking into consideration the following:

- Ensure Excitation systems are operated within manufacturer's recommendations and design limits
- Performance targets (steady state and dynamic operational response) are met or exceeded
- Based on obsolescence, spares availability and risk assessment, actively replace excitation systems to reduce the probability of un-repairable hardware and software failures or uneconomic repairs
- Ensure all maintenance including preventative maintenance and condition monitoring routines, are adhered to within the prescribed specifications and schedules
- Ensure all excitation systems procured are capable of meeting current and any planned generator upgrades (where economically viable).
- Ensure that excitation systems meet EIPC[1] requirements.

2 Key Strategy Statements

- The life expectancy of electronic excitation systems is 15-20 years (both digital and analogue) and 10-15 years for PLC based excitation systems
- Life expectancy of existing and the selection of new excitation systems is governed by spares availability, OEM support, environmental conditions, availability of technical skills and ability to meet EIPC requirements
- Standardise excitation systems to a limited number of manufacturers, minimising the number of spares held and resources required without going to a single manufacturer across the whole fleet.

3 Spares Strategy

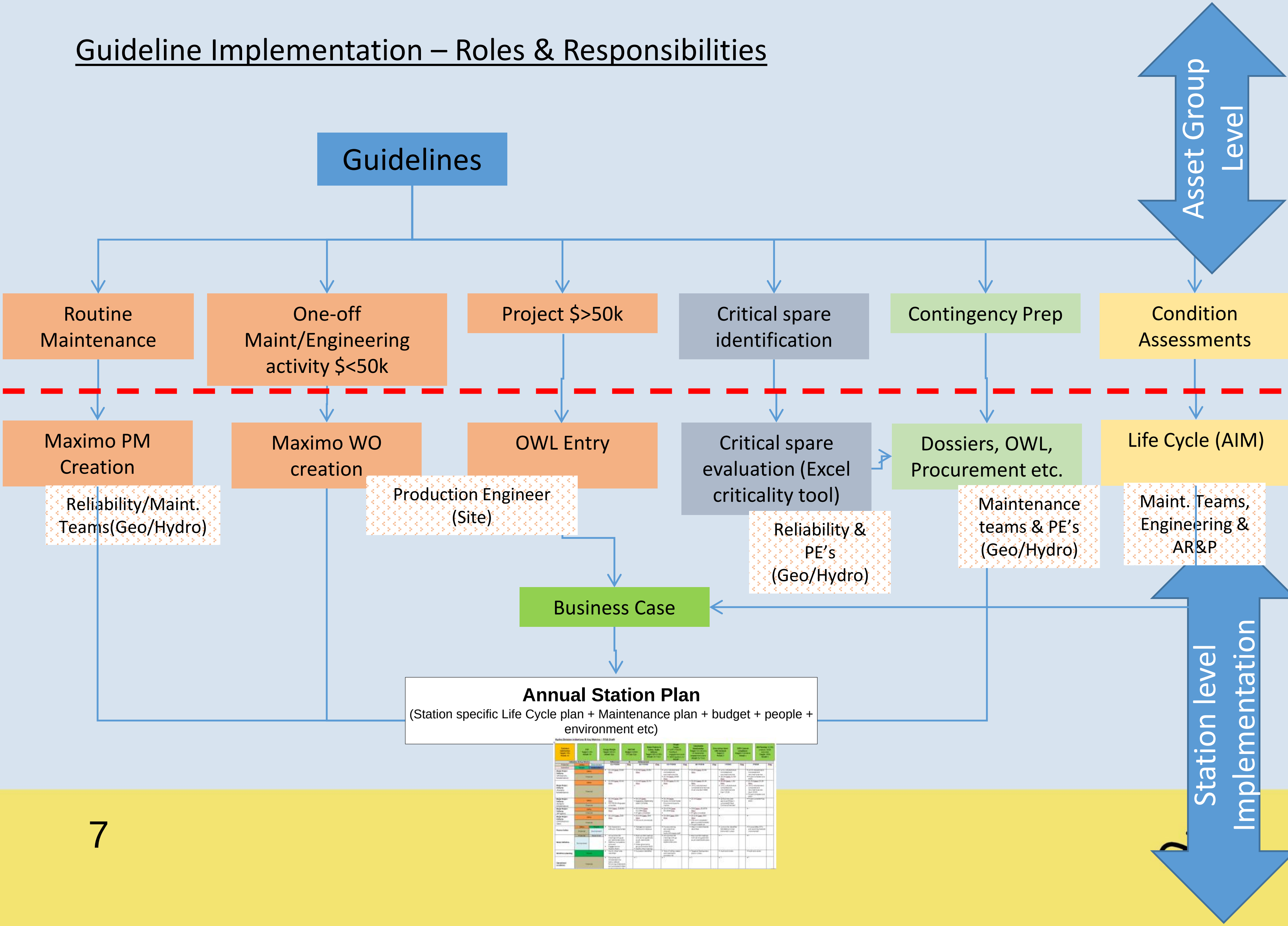
- Set and hold minimum spares (serviceable) stock levels for each excitation system type, as determined by criticality analysis, where it is economically viable.
- Failed components will be repaired or discarded based on economics and future support requirements.
- Spares shall be stored and managed to ensure they are kept in a serviceable state.

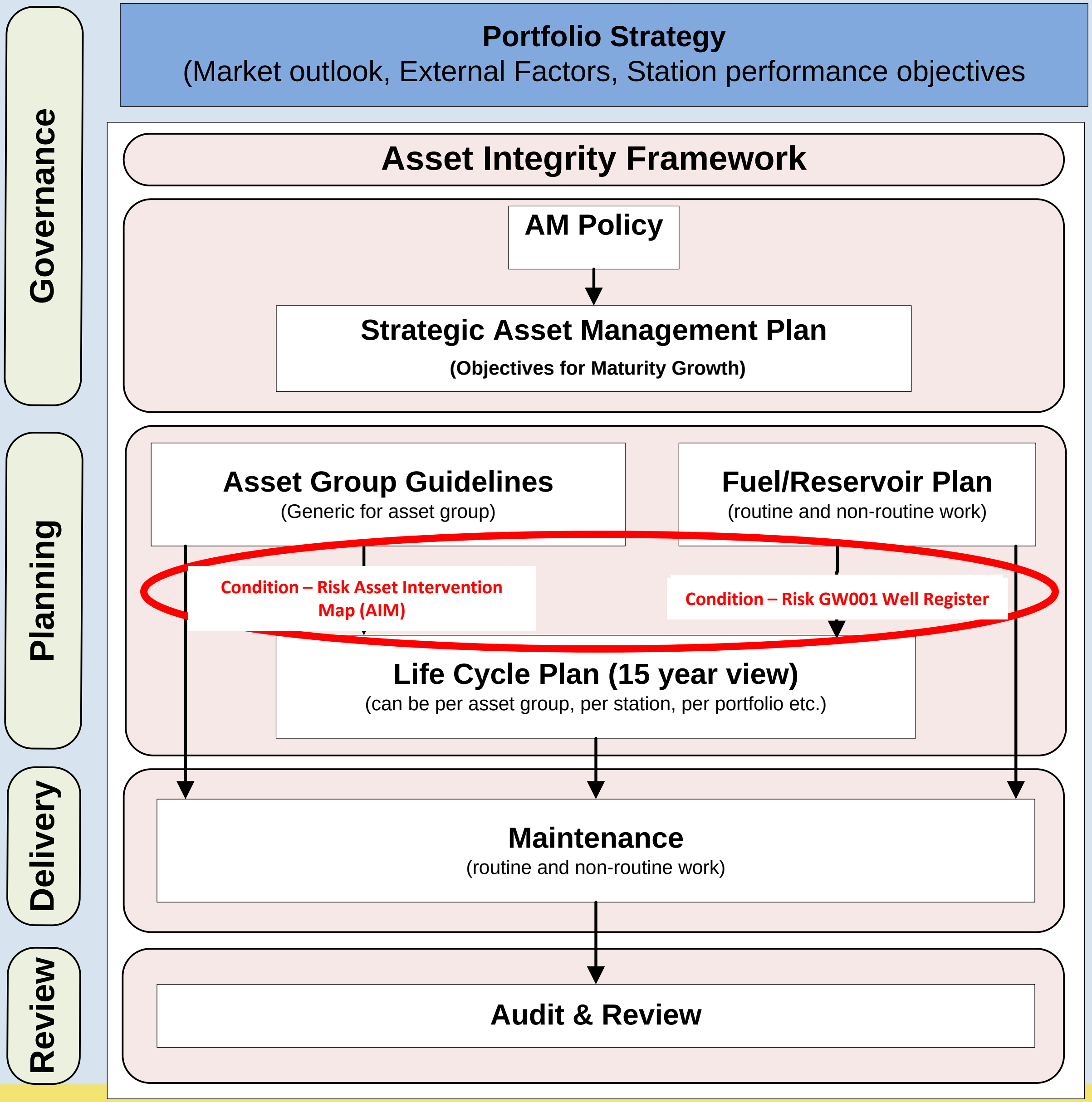
4 Excitation Replacement Triggers

Excitation systems will be proactively replaced, with due consideration to risk, when any one of the following occur;

Two "strategies/guidelines" two different maturity levels

Guideline Implementation – Roles & Responsibilities





Governance
Planning
Delivery
Review
Portfolio Strategy
(Market outlook, External Factors, Station performance objectives
Asset Integrity Framework
AM Policy
Strategic Asset Management Plan
(Objectives for Maturity Growth)
Asset Group Guidelines
(Generic for asset group)
Fuel/Reservoir Plan
(routine and non-routine work)
Condition – Risk Asset Intervention Map (AIM)
Condition – Risk GW001 Well Register
Life Cycle Plan (15 year view)
(can be per asset group, per station, per portfolio etc.)
Maintenance
(routine and non-routine work)
Audit & Review

Condition – Risk Heatmap (Asset Intervention Map)

Generation Type

Hydro

Risk Format

Highest Risk

Installed Capacity (MW)

Installed Year

Asset Groups

		Aratiatia					
		90 MW Station Output					
		1		2		3	
	Installed Capacity (MW)	30		30		30	
	Installed Year	1964		1964		1964	
Asset Groups		I	RISK	I	RISK	I	RISK
Water Passages	Intake Gates	D-H	FIN	B-M	FIN	D-H	FIN
	Penstocks	C-H	H&S	C-H	H&S	C-H	H&S
	Scroll Case	C-M	H&S	C-M	H&S	C-M	H&S
	Draft Tube	C-L	OPS	C-L	OPS	C-L	OPS
Turbines	Hydro Turbines	B-M	OPS	A-H	OPS	B-H	OPS
Governors	Hyrdo Governors	A-H	OPS	A-H	OPS	A-H	OPS
Generators	Excitation	B-M	FIN	A-H	FIN	B-M	FIN
	Hydro Generators	C-M	FIN	A-H	FIN	C-M	FIN
	Hydro Bearings	X-L	OPS	A-H	OPS	X-L	OPS
Circuit Breakers	HV Outdoor (110-220 kV)	A-H	COM	A-H	OPS	A-H	OPS
	HV Indoor (3.3-11 kV)						
	Transformers	C-M	OPS	C-M	OPS	B-H	OPS

		Ohakuri							
		112 MW Station Output							
		1		2		3		4	
	Installed Capacity (MW)	28		28		28		28	
	Installed Year	1961		1961		1961		1961	
Asset Groups		I	RISK	I	RISK	I	RISK	I	RISK
Water Passages	Intake Gates	B-M	FIN	B-M	FIN	B-M	FIN	B-M	FIN
	Penstocks	B-M	H&S	B-M	H&S	B-M	H&S	B-M	H&S
	Scroll Case	A-H	H&S	A-M	H&S	A-H	H&S	A-M	H&S
	Draft Tube	A-H	OPS	A-M	OPS	A-H	OPS	A-M	OPS
Turbines	Hydro Turbines	A-H	OPS	A-M	OPS	A-H	OPS	A-M	OPS
Governors	Hyrdo Governors	A-M	OPS	A-M	OPS	A-M	OPS	A-M	OPS
Generators	Excitation	A-H	FIN	A-H	FIN	A-H	FIN	A-H	FIN
	Hydro Generators	A-H	FIN	A-H	FIN	A-H	FIN	A-H	FIN
	Hydro Bearings	A-M	OPS	A-M	OPS	A-M	OPS	A-M	OPS
Circuit Breakers	HV Outdoor (110-220 kV)	C-H	OPS	C-H	OPS	C-H	OPS	C-H	OPS
	HV Indoor (3.3-11 kV)								
	Transformers	D-H	OPS	C-M	OPS	B-H	OPS	B-L	OPS

		Atiamuri							
		84 MW Station Output							
		1		2		3		4	
	Installed Capacity (MW)	21		21		21		21	
	Installed Year	1958		1958		1958		1958	
Asset Groups		I	RISK	I	RISK	I	RISK	I	RISK
Water Passages	Intake Gates	A-H	FIN	A-H	FIN	A-H	FIN	A-H	FIN
	Penstocks	B-M	H&S	B-M	H&S	B-M	H&S	B-M	H&S
	Scroll Case	D-H	H&S	C-H	H&S	D-H	H&S	C-H	H&S
	Draft Tube	D-H	OPS	C-H	OPS	D-H	OPS	C-H	OPS
Turbines	Hydro Turbines	D-H	FIN	C-H	FIN	D-H	FIN	C-H	FIN
Governors	Hyrdo Governors	B-L	OPS	B-H	OPS	A-H	OPS	A-H	OPS
Generators	Excitation	D-M	FIN	D-M	FIN	D-M	FIN	D-M	FIN
	Hydro Generators	X-L	OPS	C-H	OPS	C-H	OPS	X-L	OPS
	Hydro Bearings	D-H	OPS	D-H	OPS	D-H	OPS	D-H	OPS
Circuit Breakers	HV Outdoor (110-220 kV)	B-H	OPS	B-H	OPS	B-H	OPS	B-H	OPS
	HV Indoor (3.3-11 kV)								
	Transformers	B-H	OPS	B-H	OPS	B-H	OPS	B-H	OPS

The Heatmap represents the overall Intervention period and Critical Risk for each asset type (portfolio) and/or Station.

Within the Heatmap, users are able to access the details of that intervention or risk rating including its underlying condition score in the Asset's Condition Assessment by clicking on an individual cell.

Condition – Risk Heatmap (Asset Intervention Map)

Legend:

Intervention

A	Intervene > 10 Years
B	Intervene 5-10 Years
C	Intervene 2-5 Years
D	Intervene < 2 Years
X	Intervene ASAP

Evidence

L	Low Evidence	Gut feel, anecdotal or incomplete data OR old condition assessment.
M	Medium Evidence	Quantitative data, may be incomplete OR slightly dated condition assessment.
H	High Evidence	Observed failure; funtional testing; formal, recent condition assessment

I	RISK
B-H	H&S

Colour

Symbol

Risk Priority Level
1
2
3
4
5

Risk Type

H&S	Health & Safety
COM	Legal/Compliance
PEO	People
OPS	Operational
REO	Reputation
FIN	Financial + BI

W2W Map 2018

Generation Type

Hydro

Risk Format

Highest Risk

		Aratiatia					
		90 MW Station Output					
		1		2		3	
	Installed Capacity (MW)	30		30		30	
	Installed Year	1964		1964		1964	
	Asset Groups	I	RISK	I	RISK	I	RISK
Water Passages	Intake Gates	D-H	FIN	B-M	FIN	D-H	FIN
Water Passages	Penstocks	C-H	H&S	C-H	H&S	C-H	H&S
Water Passages	Scroll Case	C-M	H&S	C-M	H&S	C-M	H&S
Water Passages	Draft Tube	C-L	OPS	C-L	OPS	C-L	OPS
Turbines	Hydro Turbines	B-M	OPS	A-H	OPS	B-H	OPS
Governors	Hyrdo Governors	A-H	OPS	A-H	OPS	A-H	OPS
Generators	Excitation	B-M	FIN	A-H	FIN	B-M	FIN
Generators	Hydro Generators	C-M	FIN	A-H	FIN	C-M	FIN
Generators	Hydro Bearings	X-L	OPS	A-H	OPS	X-L	OPS
Circuit Breakers	HV Outdoor (110-220 kV)	A-H	COM	A-H	OPS	A-H	OPS
Circuit Breakers	HV Indoor (3.3-11 kV)						
Transformers	Transformers	C-M	OPS	C-M	OPS	B-H	OPS

		Ohakuri							
		112 MW Station Output							
		1		2		3		4	
	Installed Capacity (MW)	28		28		28		28	
	Installed Year	1961		1961		1961		1961	
	Asset Groups	I	RISK	I	RISK	I	RISK	I	RISK
Water Passages	Intake Gates	B-M	FIN	B-M	FIN	B-M	FIN	B-M	FIN
Water Passages	Penstocks	B-M	H&S	B-M	H&S	B-M	H&S	B-M	H&S
Water Passages	Scroll Case	A-H	H&S	A-M	H&S	A-H	H&S	A-M	H&S
Water Passages	Draft Tube	A-H	OPS	A-M	OPS	A-H	OPS	A-M	OPS
Turbines	Hydro Turbines	A-H	OPS	A-M	OPS	A-H	OPS	A-M	OPS
Governors	Hyrdo Governors	A-M	OPS	A-M	OPS	A-M	OPS	A-M	OPS
Generators	Excitation	A-H	FIN	A-H	FIN	A-H	FIN	A-H	FIN
Generators	Hydro Generators	A-H	FIN	A-H	FIN	A-H	FIN	A-H	FIN
Generators	Hydro Bearings	A-M	OPS	A-M	OPS	A-M	OPS	A-M	OPS
Circuit Breakers	HV Outdoor (110-220 kV)	C-H	OPS	C-H	OPS	C-H	OPS	C-H	OPS
Circuit Breakers	HV Indoor (3.3-11 kV)								
Transformers	Transformers	D-H	OPS	C-M	OPS	B-H	OPS	B-L	OPS

		Atiamuri							
		84 MW Station Output							
		1		2		3		4	
	Installed Capacity (MW)	21		21		21		21	
	Installed Year	1958		1958		1958		1958	
	Asset Groups	I	RISK	I	RISK	I	RISK	I	RISK
Water Passages	Intake Gates	A-H	FIN	A-H	FIN	A-H	FIN	A-H	FIN
Water Passages	Penstocks	B-M	H&S	B-M	H&S	B-M	H&S	B-M	H&S
Water Passages	Scroll Case	D-H	H&S	C-H	H&S	D-H	H&S	C-H	H&S
Water Passages	Draft Tube	D-H	OPS	C-H	OPS	D-H	OPS	C-H	OPS
Turbines	Hydro Turbines	D-H	FIN	C-H	FIN	D-H	FIN	C-H	FIN
Governors	Hyrdo Governors	B-L	OPS	B-H	OPS	A-H	OPS	A-H	OPS
Generators	Excitation	D-M	FIN	D-M	FIN	D-M	FIN	D-M	FIN
Generators	Hydro Generators	X-L	OPS	C-H	OPS	C-H	OPS	X-L	OPS
Generators	Hydro Bearings	D-H	OPS	D-H	OPS	D-H	OPS	D-H	OPS
Circuit Breakers	HV Outdoor (110-220 kV)	B-H	OPS	B-H	OPS	B-H	OPS	B-H	OPS
Circuit Breakers	HV Indoor (3.3-11 kV)								
Transformers	Transformers	B-H	OPS	B-H	OPS	B-H	OPS	B-H	OPS

Condition – Risk Heatmap (Asset Intervention Map)

KAW Hotwell Pumps

KAW A

INTERVENTION	**C-H**	**Intervene 2-5 Years; High Evidence (**	Comments Impeller has 2 years remaining service life according to the strategies estimated 12 year service life. Substantial cavitation damage was found in the January 2018 inspection, which was repaired at the time. The impellers should be replaced within the next 4 years.
CRITICAL RISK	**OPS**	**Significant Consequence; Unlikely Probability (OPERATIONAL)**	The most likely failures could be recovered from within a week (provided spares are available). The plant would operate at 0%-50% generation capacity over this time. KAG production is ~100MW at $80/MWH a days generation is worth around ~$192,000. Some spares have high valvues ($250k for an impeller, $350k for a motor.) Its likely any failure will result in financila impact >$750k but <$7.5m

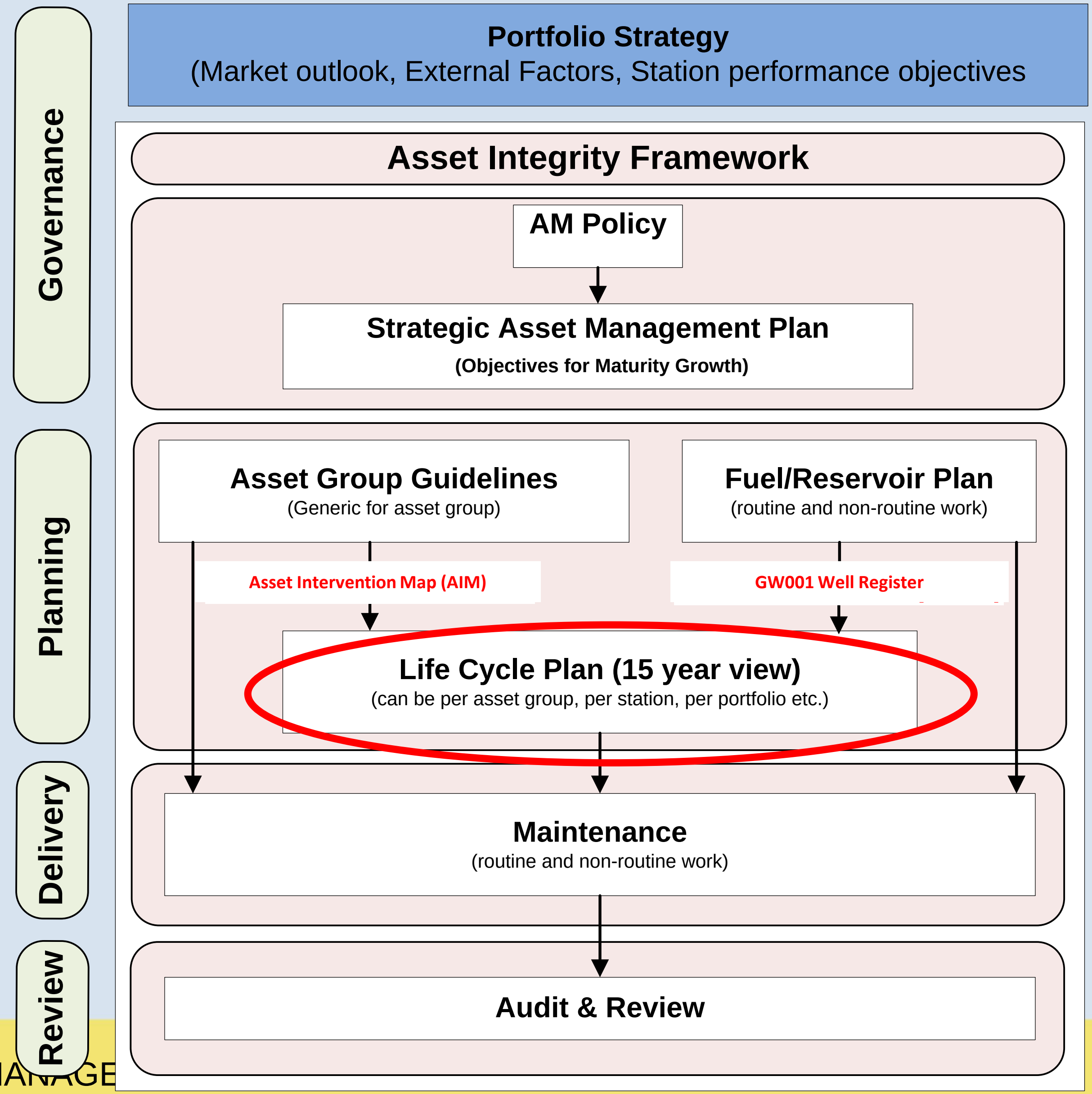
Return Calculated Rating | **Edit Assessment**

Assessment Date: **Jan-18**

Inspection Type: **Biennial Shut**

Intervention Assessment

Pump Component	Estimated Replacement Lifecycle	Maintenance Lifecycle	Original Install Date	Date Replaced or Maintained	Age Since Overhaul (yrs)	Time Until Intervention (yrs)	Comments	Adjusted Time Until Intervention (yrs)	Level of Evidence	Intervention Rating
Impeller/Suction bowl	12	8	Jan-08	Jan-08	10.0	2.0	Impeller has 2 years remaining service life according to the strategies estimated 12 year service life. Substantial cavitation damage was found in the January 2018 inspection, which was repaired at the time. The impellers should be replaced within the next 4 years.	4.0	High	C-H
Motor	25	8	Jan-08	Jan-18	0.0	8.0	Motor was overhauled in Jan 2018 with new bearings installed. The electrical tests indicate that the rotor and stator are in good condition. It should be electrically tested in 4 years time but will last another 10 years until a routine overhaul is required.	10.0	High	B-H
Bearings, Seals, Shafts and Consumables	8	8	Jan-08	Jan-18	0.0	8.0	Labyrinth bush was found to be heavily worn at Jan 2018 inspection. The labyrinth bush housing was found to be out of round and oversize, going from an interfereance fit to a clearance one, so the bush was reinstalled with liberal quantities of Loctite to hold in place. At the next overhaul opportunity consideration should be given to rebuilding and		High	B-H
Remainder of Pump (Discharge Bowl, column pipes etc.)	25	8	Jan-08	Jan-08	10.0	15.0	Inspected in 2018. Good condition. For outage reports and further evidence of condition see: \\mrp.net.nz\data\Departments\Generation Asset Strategy\Asset Specialist (mechancical)		High	A-H


Governance
Planning
Delivery
Review
Portfolio Strategy
(Market outlook, External Factors, Station performance objectives
Asset Integrity Framework
AM Policy
Strategic Asset Management Plan
(Objectives for Maturity Growth)
Asset Group Guidelines
(Generic for asset group)
Fuel/Reservoir Plan
(routine and non-routine work)
Asset Intervention Map (AIM)
GW001 Well Register
Life Cycle Plan (15 year view)
(can be per asset group, per station, per portfolio etc.)
Maintenance
(routine and non-routine work)
Audit & Review

Life Cycle Plan - Operations Work List (OWL)

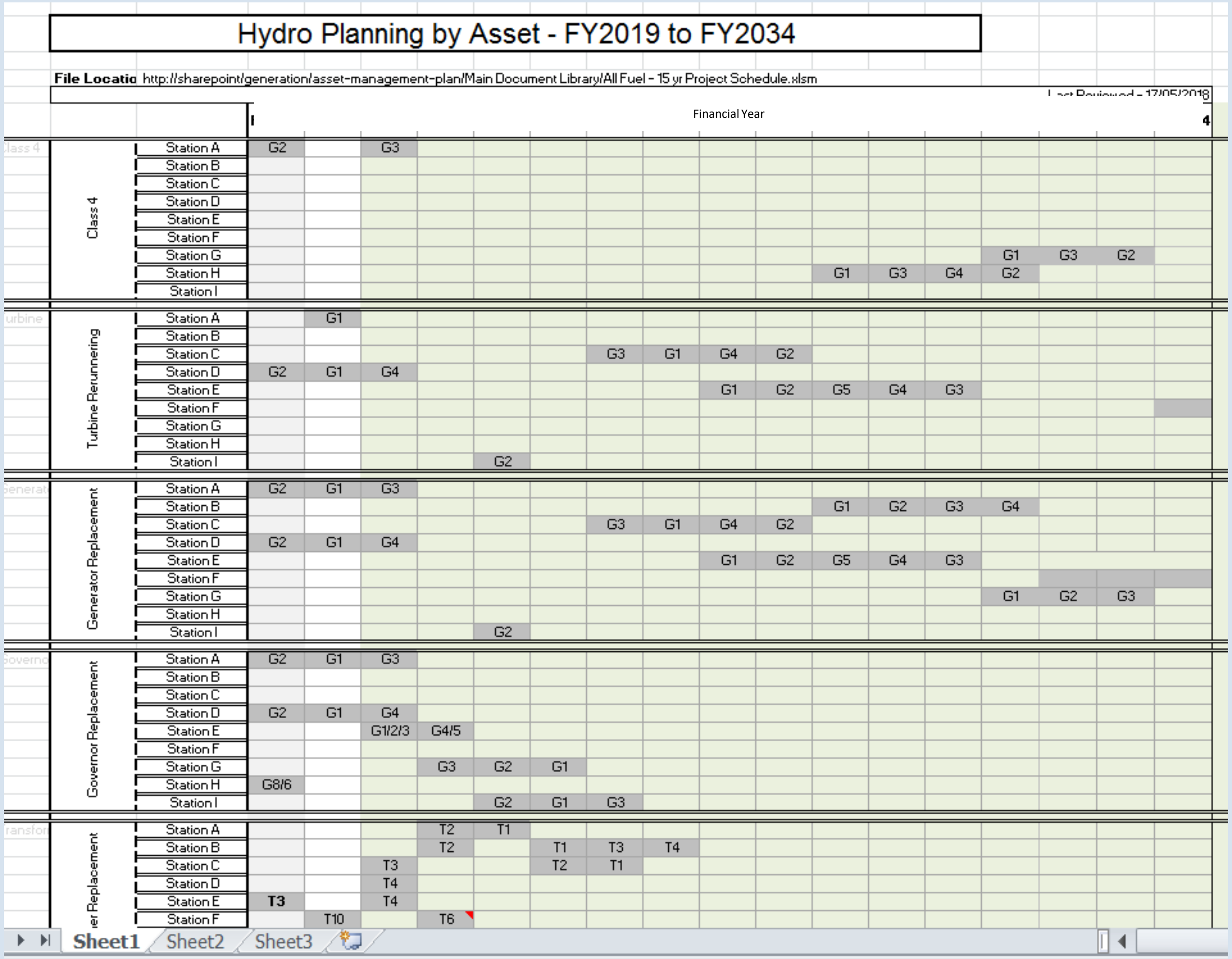
Project Name	Opr Project State	Opr FY19 Budg	Opr PI Status	Opr BC Status	Initial Spe	Owner	Opr Fuel Type	Opr Station	Opr Unit
ARA and ATI UPS and Battery Bank Replacem	Initiated	Included in Maintenance		Not Started	FY19	Jarrad Bowler	Hydro	ARA, ATI	Multi Units
ARA Aratiatia Rehabilitation	Site Works in Progress	Prepared	Approved	Approved	FY17	James Ravenscroft	Hydro	ARA	All Units
ARA Cable Room Fire Protection	Initiated				Zero Fcst	Jarrad Bowler	Hydro	ARA	
ARA G1 Penstock Spot Paint	Risk Defined				FY27	Andrew King	Hydro	ARA	Balance of Plant
ARA G2 Penstock Spot Paint	Risk Defined				FY26	Andrew King	Hydro	ARA	Balance of Plant
ARA G3 Penstock Spot Paint	Risk Defined		Not Started	Not Started	FY28	Andrew King	Hydro	ARA	Balance of Plant
ARA intake gate frames painting	Initiated		Not Started	Not Started	FY20	Jarrad Bowler	Hydro	ARA	All Units
ARA Roof Painting	Initiated		Not Started	Not Started	FY19	Liz McKellar	Hydro	ATI	All Units
ARA Spare headgate refurbishment	Initiated				Zero Fcst	Jarrad Bowler	Hydro	ARA	
ARA spillway winchgear maintenance	Initiated		Not Started	Not Started	FY19	Jarrad Bowler	Hydro	ARA	Hydro
ARA Surge Chamber lift replacement	Initiated				FY20	Andrew King	Hydro	ARA	Hydro>G1
ARA T2 Transformer Replacement	Initiated		Not Started	In Progress	Zero Fcst	Glen Tuining	Hydro	ARA	Hydro>G2
ARA Vegetation Mangement	Initiated		Not Started	Not Started	FY19	Jarrad Bowler	Hydro	ARA	Balance of Plant
ARA Vibration instrumentation Upgrade	Initiated				FY19	Rob Munn	Hydro	ARA	Balance of Plant
ARI - T5 Transformer Mid-Life Refurbishment	Initiated		Not Started	Not Started	FY21	Melissa Ling	Hydro	ARI	Hydro
ARI - T6 Transformer Mid-Life Refurbishment	Initiated		Not Started	Not Started	FY20	Melissa Ling	Hydro	ARI	Hydro
ARI - T7 Transformer Mid-Life Refurbishment	Initiated		Not Started	Not Started	FY21	Melissa Ling	Hydro	ARI	Hydro
ARI 11kv Structure replacement	Initiated	Prepared	Not Started	Not Started	FY19	David Derecourt	Hydro	ARI	Balance of Plant
ARI Class 4 programme	Initiated		Not Started	Not Started	FY22	Matt Clarke	Hydro	ARI	Multi Units
ARI Dam Abutment Bank Stabilisation	Initiated		Not Started	Not Started	FY19	David Derecourt	Hydro	ARI	Balance of Plant
ARI Dam Foundation Performance Review	Planning Works in Progress	Prepared	Not Started	Not Started	FY18	Geoff Higgins	Hydro	ARI	Balance of Plant
ARI Full Flow Headgate Testing	Initiated	Included in Maintenan	Not Started	Not Started	FY19	Nathan Lewis	Hydro	ARI	All Units
ARI Full Flow Headgate Testing Equip Procure	Planning Works in Progress	Prepared	Not Started	Not Started	FY19	Nathan Lewis	Hydro	ARI	All Units
ARI G1 Penstock Spot Paint	Risk Defined	Prepared	Not Started	Not Started	FY19	Matt Clarke	Hydro	ARI	Balance of Plant
ARI G2 Penstock Full Blast and Paint Int	TBC		Not Started	Not Started	FY20	Colin Steed	Hydro	ARI	Balance of Plant
ARI G3 Penstock Full Blast and Paint Int	TBC				FY20	Colin Steed	Hydro	ARI	Balance of Plant
ARI G4 Penstock Spot Paint	Planning Works in Progress		Not Started	Not Started	FY28	Matt Clarke	Hydro	ARI	Balance of Plant
ARI G5 - G8 oil cooler water box and bundle re	Initiated		Not Started	Not Started	FY19	Matt Clarke	Hydro	ARI	All Units
ARI G5 Penstock Spot Paint	Risk Defined				FY21	Colin Steed	Hydro	ARI	Balance of Plant
ARI G6 Penstock Full Blast and Paint Int	TBC		Not Started	Not Started	FY26	Matt Clarke	Hydro	ARI	Balance of Plant
ARI G7 Penstock Spot Paint	Planning Works in Progress		Not Started	Not Started	FY20	Colin Steed	Hydro	ARI	Balance of Plant
ARI G8 Penstock Spot Paint	Planning Works in Progress		Not Started	Not Started	FY21	Colin Steed	Hydro	ARI	Balance of Plant
ARI G8 Rivet Repairs	Planning Works in Progress	Prepared	Not Started	Not Started	FY19	Colin Steed	Hydro	ARI	Hydro>G8
ARI Governor Upgrade	Planning Works in Progress	Prepared to Omit		Approved	FY17	Bede Geoghegan	Hydro	ARI	Multi Units
ARI Headgate hoist winch to hydraulic conver	Approved in AMP		Not Started	Not Started	FY19	David Derecourt	Hydro	ARI	Multi Units

Project Name	Opr Asset Type	Opr Project Description (WHAT)	Opr Issue Description (WHY)	Opr Project Benefit	Opr Business D	Opr S	Opr S	Opr Fu
ARA and ATI UPS and Battery Bank Replacem	Station Services				Risk Reduction	Opex		
ARA Aratiatia Rehabilitation	AMP Project, Class 4, Generators,	Replacement of 3 generators, 3 governors, 1 turbine	Generators at end of life; turbine for minimum flow		Risk Reduction	Both	Class A	No
ARA Cable Room Fire Protection					Risk Reduction	Undefined		
ARA G1 Penstock Spot Paint	Hydraulic Passages		Condition based intervention		Risk Reduction	Opex	ROM	
ARA G2 Penstock Spot Paint	Hydraulic Passages		Condition based intervention		Risk Reduction	Capex	ROM	
ARA G3 Penstock Spot Paint	Hydraulic Passages		Condition based intervention		Risk Reduction	Opex	ROM	No
ARA intake gate frames painting	Dam Safety Assurance Programme	Blast and paint of the frames of all intake gates during surge chamber dewatering during annual station shutdown	Corrosion of gate frame, fracture of frame components, failure of the intake gates to close		Risk Reduction	Opex	ROM	No
ARA Roof Painting	Buildings	Carry out roof repairs and Painting to avoid full replacement	maintenance required to avoid full failure and replacement or leaks which cause asset		Risk Reduction	Opex	ROM	No
ARA Spare headgate refurbishment					Risk Reduction	Undefined		
ARA spillway winchgear maintenance	Dam Safety Assurance Programme	ARA winch gear need removing rams new gears required, gears are blast and paint etc.	Warns equipment in need of refurbishment		Risk Reduction	Opex	ROM	No
ARA Surge Chamber lift replacement	Other	ARA - Station lift upgrade	New station lift (surge chamber). Lift components are old with little spares available and hard to maintain to reliable		Risk Reduction	Capex	Class A	
ARA T2 Transformer Replacement	Transformers				Risk Reduction	Undefined		No
ARA Vegetation Mangement	Civil Infrastructure - General	Carry out removal of large vegetation from the ARA surge tank	large vegetation limits the ability to see deformation post earthquake. Large trees also risk instability due to root jacking and		Risk Reduction	Opex	ROM	No
ARA Vibration instrumentation Upgrade		Replacing obsolete system. Some spares are available.	Without vibration monitoring, units would not be recommended to be operated remotely. Also part of protection system		Risk Reduction	Undefined		
ARI - T5 Transformer Mid-Life Refurbishment	Transformers	Transformer overhauls at Bunnythorpe workshop including detanking, inspection, cleaning, dryout, tightening, testing. Also requires cooler replacement due to galvanic corrosion on tube plates	Mid-Life Refurb to prolong Asset Life as per tx asset strategy		Risk Reduction	Opex	ROM	No
ARI - T6 Transformer Mid-Life Refurbishment	Transformers	Transformer overhauls at Bunnythorpe workshop including detanking, inspection, cleaning, dryout, tightening, testing	Mid-Life Refurb to prolong Asset Life		Risk Reduction	Opex	ROM	No
ARI - T7 Transformer Mid-Life Refurbishment	Transformers	Transformer overhauls at Bunnythorpe workshop including detanking, inspection, cleaning, dryout, tightening, testing	Mid-Life Refurb to prolong Asset Life		Risk Reduction	Opex	ROM	No
ARI 11kv Structure replacement	Station Services: Electrical	11Kv wooden structure is beyond usable life and/or at risk of failure - Level project to start and design in FY18 - ER 17-361	This has been an issue / project since 2010? and keeps getting deferred.		Risk Reduction	Capex	ROM	
ARI Class 4 programme	Hydro Turbines	Class 4 programme for 7 units (G7 excluded due to FY2012 overhaul) - copied into OWL from SAP	Alignment to Class 4 strategy		Risk Reduction	Opex	ROM	No
ARI Dam Abutment Bank Stabilisation	Dam Safety Assurance Programme	Installation of stabilisation rock on chase & debris capture on left & right abutment - Requires gated approach Subject to risk assessment by civil team FY18	Bank stabilisation & rock fall place's serious H&S risks (Death) for staff access dam bars for routine weekly & monthly inspections		Risk Reduction	Capex	ROM	No
ARI Dam Foundation Performance Review	Civil Infrastructure - General, Dam	Performance assessment of the ARI dam foundation	Arapuni Dam instrumentation is exhibiting a changing and ongoing trend from precedent levels within the Dam foundation particularly at the left abutment. Expert opinion indicates a performance assessment is recommended to analyse and understand		Risk Reduction	Opex	ROM	No
ARI Full Flow Headgate Testing	Gates and Screens and Stoplogs	ARI full flow headgate testing	Headgate performance and closing margin as per Engineering recommendation email "Line Items for Inclusion in OWL" Fri 4/12/2016		Risk Reduction	Opex	ROM	No
ARI Full Flow Headgate Testing Equip Procure	Gates and Screens and Stoplogs	Procure testing equipment for headgate	Headgate performance and closing margin		Risk Reduction	Capex	ROM	No
ARI G1 Penstock Spot Paint	Hydraulic Passages		Condition based intervention		Risk Reduction	Opex	ROM	No
ARI G2 Penstock Full Blast and Paint Int	Hydraulic Passages				Risk Reduction	Opex	ROM	No
ARI G3 Penstock Full Blast and Paint Int	Hydraulic Passages				Risk Reduction	Opex	ROM	
ARI G4 Penstock Spot Paint	Hydraulic Passages		Condition based intervention		Risk Reduction	Opex	ROM	No
ARI G5 - G8 oil cooler water box and bundle re	Cooling Systems	replace ARI G5, 6, 7 Thrust and guide bearing shell and tube oil coolers bundles and top and bottom water boxes	bundles and water boxes are at end of life and failures are starting to take place due to Stress corrosion cracking, erosion and		Risk Reduction	Capex	ROM	No
ARI G5 Penstock Spot Paint	Hydraulic Passages		Condition based intervention		Risk Reduction	Opex	ROM	
ARI G6 Penstock Full Blast and Paint Int	Hydraulic Passages				Risk Reduction	Opex	ROM	No
ARI G7 Penstock Spot Paint	Hydraulic Passages		Condition based intervention		Risk Reduction	Opex	ROM	No
ARI G8 Penstock Spot Paint	Hydraulic Passages		Condition based intervention		Risk Reduction	Opex	ROM	No
ARI G8 Rivet Repairs	Hydraulic Passages	Engineering to determine optimum time to complete rivet repairs in penstock and scroll case.	Risk of penstock or scroll case failure		Risk Reduction	Opex		No
ARI Governor Upgrade	Governors	replacement of ARI governors	Obsolescence of parts		Risk Reduction	Opex		
ARI Headgate hoist winch to hydraulic conver	Gates and Screens and Stoplogs	Replacement of the original wire rope hoists	The Arapuni intake gate hoists suffer from		Risk Reduction	Undefined	ROM	

Process Flow Chart | UserGuide | Report Parameters | Data | Resourcing Report | Team Overview Report | Station Charts

Ready 40%

Life Cycle Plan - Operations Work List (OWL)



Hydro Planning by Asset - FY2019 to FY2034

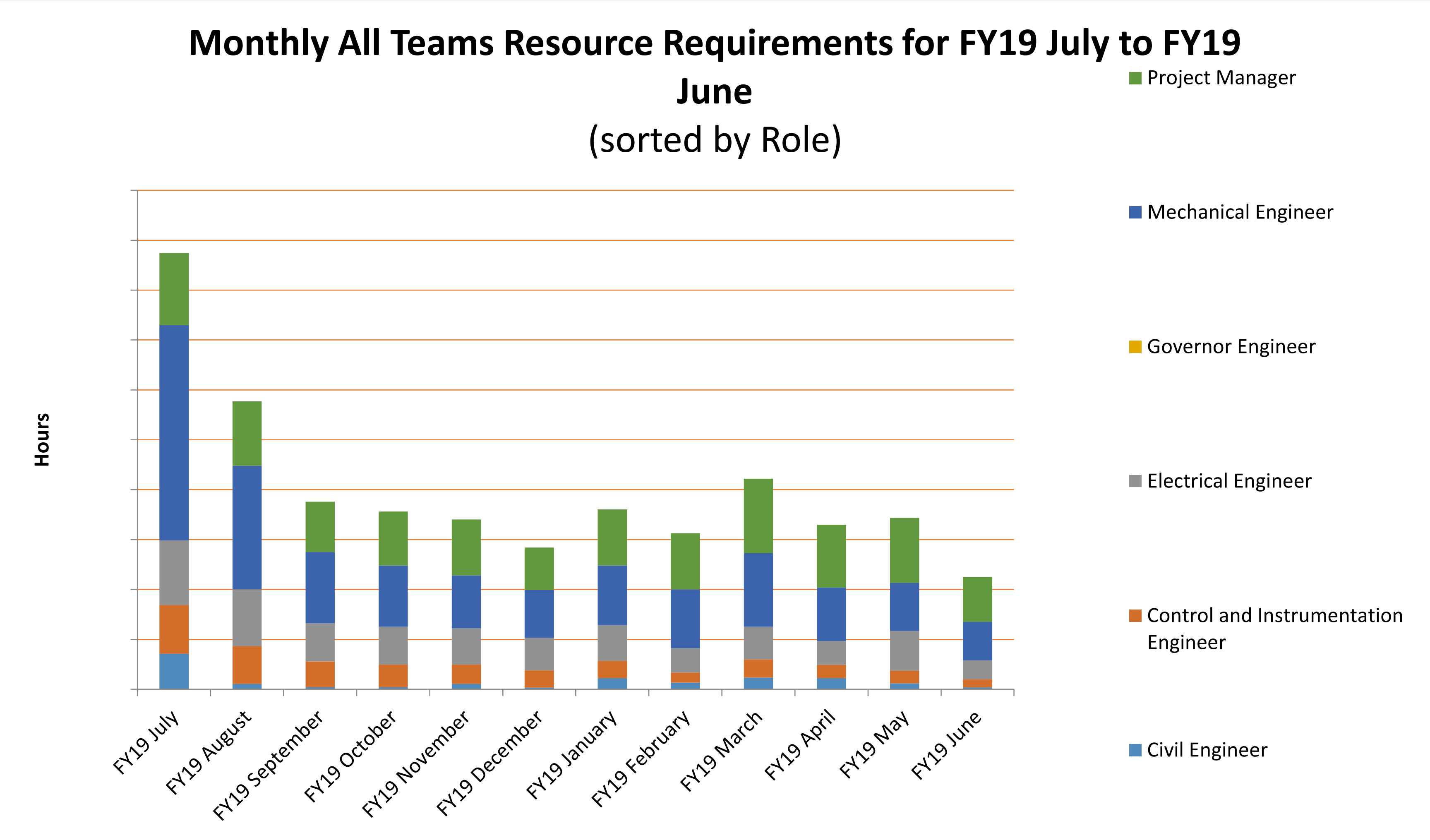
File Location http://sharepoint/generation/asset-management-plan/Main Document Library/All Fuel - 15 yr Project Schedule.xlsm

Last Reviewed - 17/05/2018

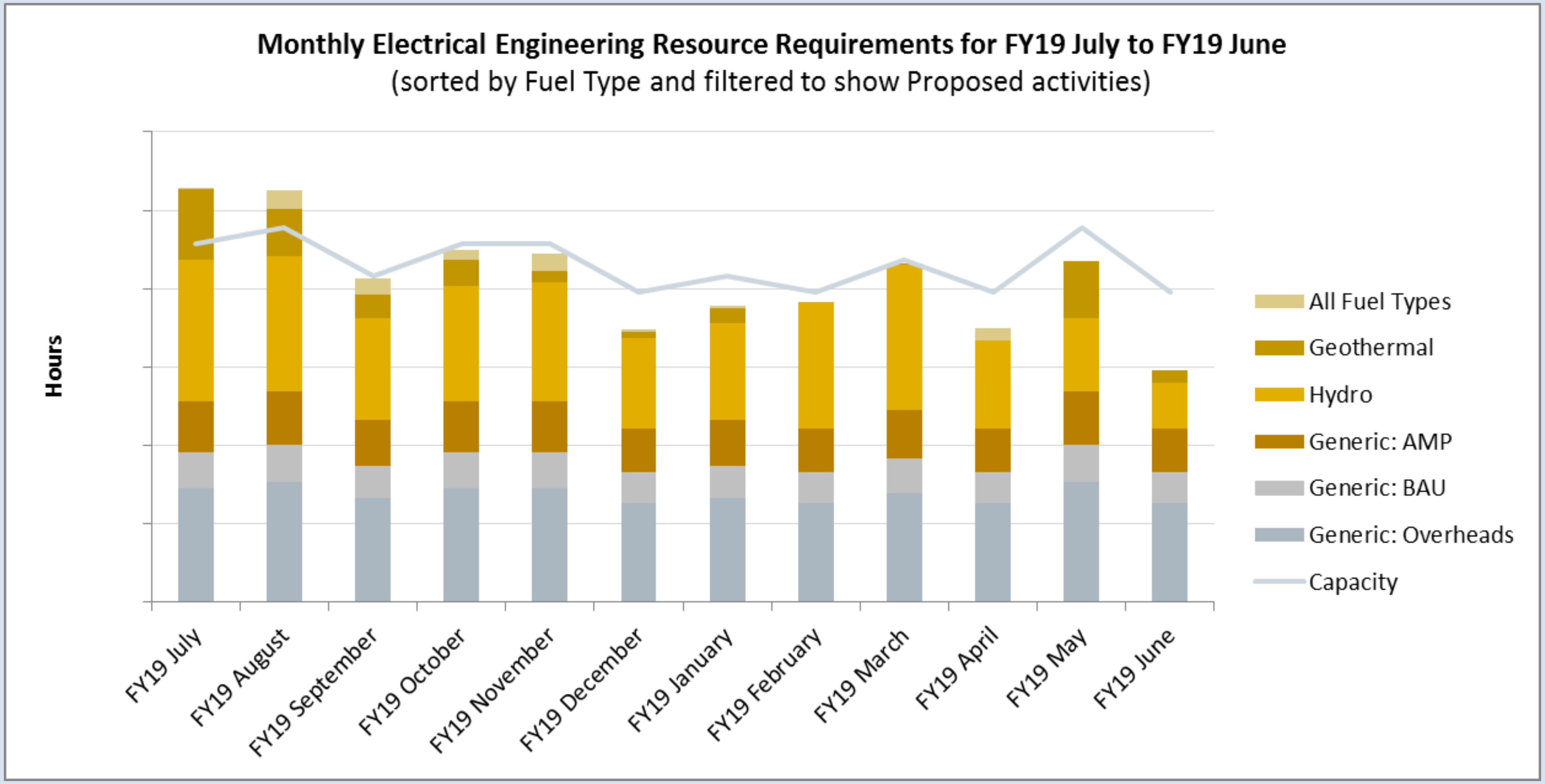
Category	Station	Financial Year																
Class 4	Station A	G2		G3														
	Station B																	
	Station C																	
	Station D																	
	Station E																	
	Station F																	
	Station G														G1	G3	G2	
	Station H											G1	G3	G4	G2			
	Station I																	
Turbine Rerunnering	Station A		G1															
	Station B																	
	Station C							G3	G1	G4	G2							
	Station D	G2	G1	G4														
	Station E									G1	G2	G5	G4	G3				
	Station F																	
	Station G																	
	Station H																	
	Station I					G2												
Generator Replacement	Station A	G2	G1	G3														
	Station B											G1	G2	G3	G4			
	Station C							G3	G1	G4	G2							
	Station D	G2	G1	G4														
	Station E									G1	G2	G5	G4	G3				
	Station F																	
	Station G														G1	G2	G3	
	Station H																	
	Station I					G2												
Governor Replacement	Station A	G2	G1	G3														
	Station B																	
	Station C																	
	Station D	G2	G1	G4														
	Station E			G1/2/3	G4/5													
	Station F																	
	Station G				G3	G2	G1											
	Station H	G8/6																
	Station I					G2	G1	G3										
Transformer Replacement	Station A				T2	T1												
	Station B				T2		T1	T3	T4									
	Station C			T3			T2	T1										
	Station D			T4														
	Station E	**T3**		T4														
	Station F		T10		T6													

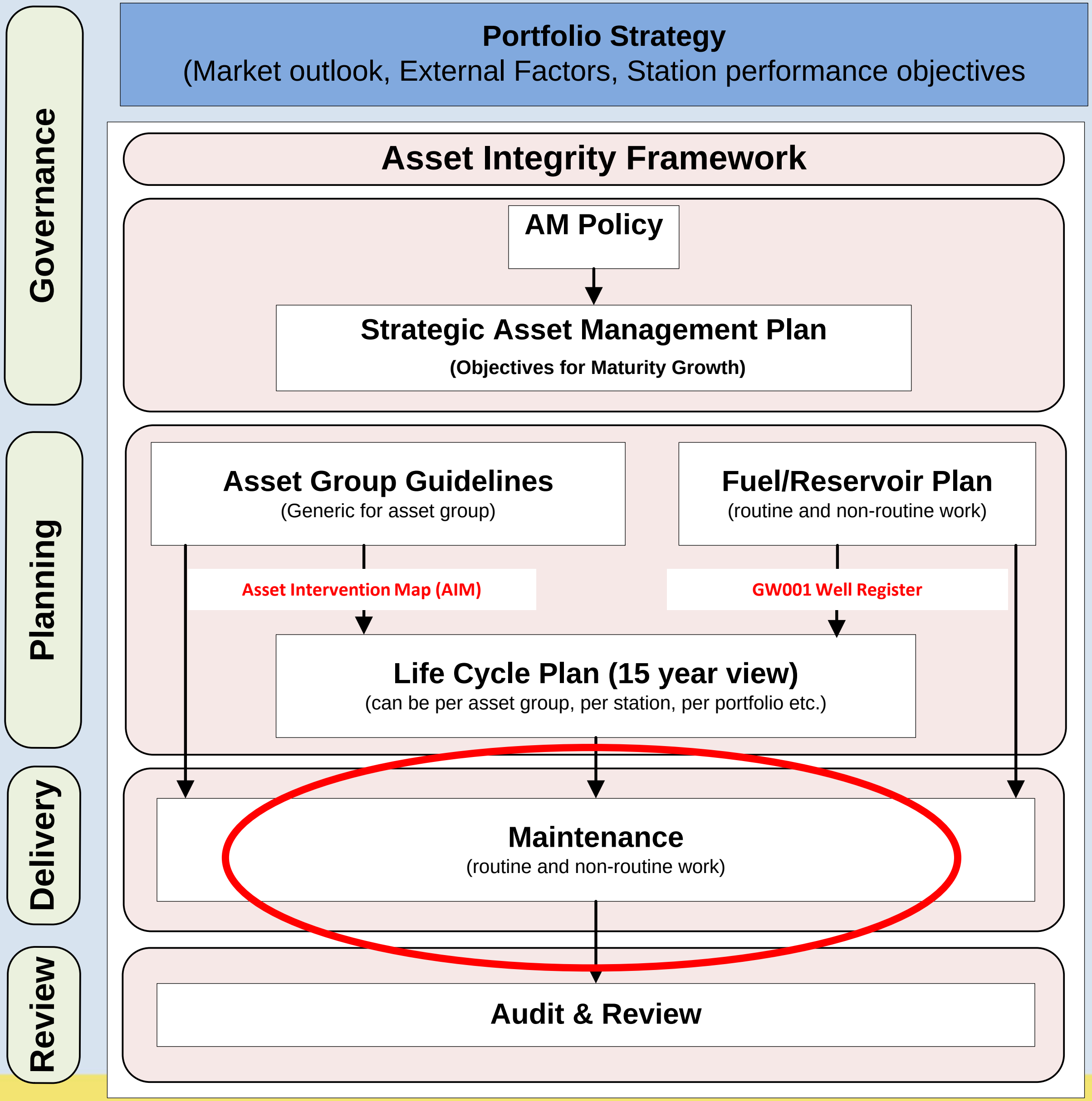
Sheet1 Sheet2 Sheet3

<u>Operations Work List (OWL)</u>



Operations Work List (OWL)




Governance
Planning
Delivery
Review
Portfolio Strategy
(Market outlook, External Factors, Station performance objectives
Asset Integrity Framework
AM Policy
Strategic Asset Management Plan
(Objectives for Maturity Growth)
Asset Group Guidelines
(Generic for asset group)
Fuel/Reservoir Plan
(routine and non-routine work)
Asset Intervention Map (AIM)
GW001 Well Register
Life Cycle Plan (15 year view)
(can be per asset group, per station, per portfolio etc.)
Maintenance
(routine and non-routine work)
Audit & Review

Maintenance Management – Maximo, Eclipse and Asset Cataloguing

- Maximo is used as the companies computerised maintenance management system
- PM tasks are informed by the asset group guidelines:
  - FMECA studies
  - Compliance requirements (Geothermal Regulations, PECPR, EIPC etc.)
- Current challenge with Maintenance management is lack of consistency (Maximo, Eclipse, Drawings etc.)
  - Unreliable OEM drawings
  - Assets exist physically but not on drawings, in maximo or in eclipse & Vice versa
  - Typo's and language used (e.g vaporizer, vaporiser, vaporizor, vapouriser)
  - Inconsistancy within sites and across the business

Maintenance Management – Maximo, Eclipse and Asset Cataloguing

- Development of the Asset Catalogue Standard
  - KKS Location Coding system adapted for use at Mercury
  - It provides standard rules that establish asset location code and description uniformity across Mercury (Geo, Hydro and Southdown)
  - Asset Catalog Standard reviewed and endorsed by representatives from across the business
  - Common terminology to be utilized, excess data moved to appropriate fields in Maximo, typos and spelling corrected.
  - Will be applied in conjunction with the Asset Tagging Standard to ensure that equipment on site is appropriately labeled.

DATA EXAMPLE

Current Maximo Data

Asset Number	Asset Description	Location	Location Description	DCS Tag	Official Number
1005134	OEC3 Preheater (M&I A1140102)	MOK03/HAB53/AC001	OEC3 Preheater (M&I A1140102)	A1140102	A1140102
1002885	OEC11 LH Preheater (M&I 143073)	MOK11/HAB51/AC001	OEC11 LH Preheater (M&I 143073)	11-H-1101A	11-H-1101A
1002886	OEC11 RH Preheater (M&I 143071)	MOK11/HAB52/AC001	OEC11 RH Preheater (M&I 143071)	11-H-1101B	11-H-1101B
350874	OEC-1 Preheater HE-9102C ON# A1121008	NTM01/LGD51/AC001	OEC-1 Preheater HE-9102C ON# A1121008	1-HE-9102C	
350875	OEC-1 Preheater HE-9102B ON# A1121008	NTM01/LGD52/AC001	OEC-1 Preheater HE-9102B ON# A1121008	1-HE-9102B	
350876	OEC-1 Preheater HE-9102A ON# A1121007	NTM01/LGD54/AC001	OEC-1 Preheater HE-9102A ON# A1121007	1-HE-9102A	
1002932	OEC01 Preheater	RKA01/HAB50/AC001	OEC01 Preheater	MI 166040	MI 166040
1000152	OEC21 Preheater	RKA21/HAB50/AC001	OEC21 Preheater	H-1101	MI 144119

Asset Catalogue Standard Implemented Maximo Data

Asset Number	Asset Description	Location	Location Description	DCS Tag	Official Number
1005134	Heat Exchanger; Shell and Tube; Horizontal	MOK03/HAB53/AC001	OEC03 Preheater		MI A1140102
1002885	Heat Exchanger; Shell and Tube; Horizontal	MOK11/HAB51/AC001	OEC11 LH Preheater	11-H-1101A	MI 143073
1002886	Heat Exchanger; Shell and Tube; Horizontal	MOK11/HAB52/AC001	OEC11 RH Preheater	11-H-1101B	MI 143071
350874	Heat Exchanger; Shell and Tube; Horizontal	NTM01/HAB51/AC001	OEC01 Preheater C	01-HE-9102C	MI A1121008
350875	Heat Exchanger; Shell and Tube; Horizontal	NTM01/HAB52/AC001	OEC01 Preheater B	01-HE-9102B	MI A1121008
350876	Heat Exchanger; Shell and Tube; Horizontal	NTM01/HAB54/AC001	OEC01 Preheater A	01-HE-9102A	MI A1121007
1002932	Heat Exchanger; Shell and Tube; Horizontal	RKA01/HAB50/AC001	OEC01 Preheater		MI 166040
1000152	Heat Exchanger; Shell and Tube; Horizontal	RKA21/HAB50/AC001	OEC21 Preheater	21-H-1101	MI 144119

Questions?

TM