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CASE STUDY.

Gladstone Area Water Board.

CRITICAL ASSETS REVIEW.

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PREAMBLE

Gladstone Area Water Board (GAWB) commissioned R2A to undertake a critical infrastructure due diligence review to ensure that all sensible practicable precautions were in place to provide adequate water supplies to GAWB bulk customers.

The review identified critical infrastructure, key threat scenarios and the possible precautionary options. The judgment regarding the balance of the significance of the risk verses the effect required to achieve it, and the subsequent implementation of further precautions is to be completed by others.

The review involved three tasks:

1. Functional boundary analysis to establish the risk context for the review. This examined the credible boundary threats to the critical success factors of GAWB defined as the requirements (quantity and availability) of supply to bulk water customers. This used established techniques from the military intelligence / security community.

2. Zonal vulnerability assessment to identify the critical common mode and common cause failures within the GAWB asset base. This used established techniques from highly protected risk (HPR) underwriters.

3. Raw water system availability modelling for each of the bulk water customers focussing on the possible operating configurations and the identified critical elements in the context of the high-level objectives of GAWB. This used standard reliability engineering tools.

> R2A's review identified critical infrastructure, key threat scenarios and precautionary options.

INTRODUCTION

Gladstone Area Water Board (GAWB) owns and operates bulk treated (potable) and raw (non-potable) water storage and supply system throughout the Gladstone region of Central Queensland. Assets include:

1. Awoonga Dam on the Boyne River and raw water pumping station
2. Gladstone and Yarwun Water Treatment Plants
3. Raw water reservoirs at Gladstone (Fitzsimmons Street – 50Ml and 16Ml) and Toolooa (50Ml)
4. Treated water reservoirs at Boyne Island, East End, Golegumma, South Gladstone, Mt Miller, Gladstone Clearwater and Yarwun Clearwater
5. Delivery pipelines (121km of raw water pipelines and 90km of treated water pipelines).

> GAWB are limited with time available for preventative or corrective maintenance to systems.

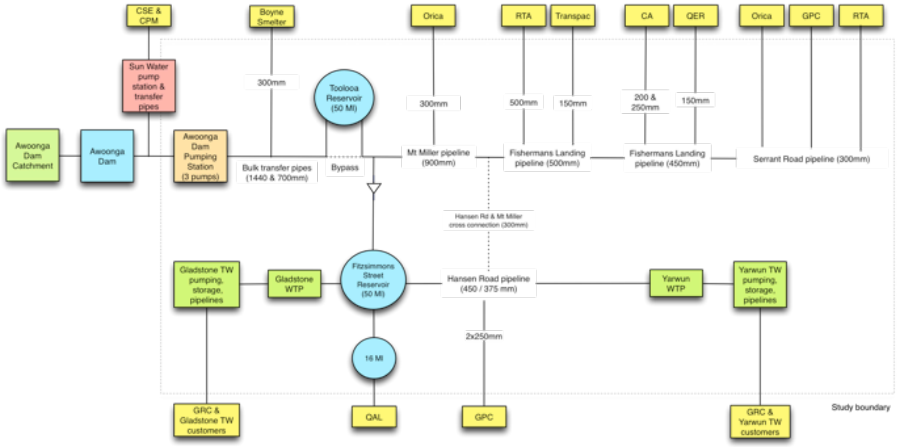
The network arrangements require water to be pumped from Awoonga Dam to Toolooa Reservoir nightly. The water is then distributed throughout the network the following day. Given this arrangement there is limited time available for preventive or corrective maintenance to the system without causing significant interruption to supply.

ANALYSIS

Functional Boundary Analysis & Common Mode Vulnerability Analysis

In order to determine the actual effective availability of the network in the context of all the credible risk issues for each of the critical customers identified, the following boundary analysis was completed.

The context boundary was defined from the Awoonga pumping station to the meter of each critical customer as shown schematically in the diagram below.



Bulk Water Transfer Functional Schematic

The following vulnerability assessment was then completed identifying the critical success factors (defined as the requirements of GAWB's bulk customers) and the external (boundary) credible threats.

		GAWB Delivery Critical Success Factors									
		Boyne Smelter	Cement Australia	Gladstone Port Corp.	Orica	QAL	QER	RTA	Transpacific	GRC	CSE & CPM
	Raw water (Ml pa)	650	230	580	1,120	10,775	10	3,700	25	-	-
	Treated water (Ml pa)	80	40	-	570	6	-	515	-	9,000	-
	Credible Threats										
1	Dam failure (earthquake, flood)	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2	Bushfire (catchment)	x	x	x	x	x	x	x	x	x	x
3	Power failure (cyclone/storm, supply failure, switchyard failure)	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4	Regulatory changes incl. reduced allocation	x	x	x	x	x	x	x	x	x	x
5	Inundation / flood (tailwater)	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6	Industrial issues incl. contractors esp treated water	xxx	xxx	-	xxx	xxx	-	xxx	-	xxx	-
7	External comms failure eg backup comms, telephone, modems	x	x	x	x	x	x	x	x	x	x
8	Drought	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
9	Contamination	x	x	x	x	x	x	x	x	x	x
10	Sabotage / Terrorism	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
11	Sun Water infrastructure failure	xx	xx	xx	xx	xx	xx	xx	xx	xx	xxx

Boundary Vulnerability Assessment

Where: xxx Credible critical potential vulnerability that must be (seen to be) addressed.

xx Moderate potential vulnerability.

x Minor potential vulnerability.

\- No noticeable vulnerability.

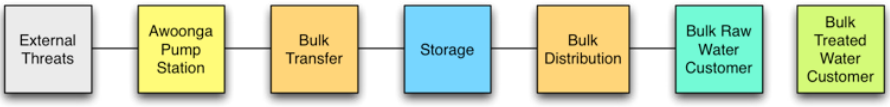
For each credible issue which was identified as being capable of creating critical outcomes (xxx), a further analysis was undertaken to test for reasonable practicable precautions with the intention of ensuring that reasonable practicable precautions are in place based on the balance of the significance of the risk vs the effort required to reduce it.

> Further analysis is undertaken to ensure reasonable practicable precautions are in place.

AVAILABILITY MODELLING

Bulk Water Transfer System Availability Modelling

The following schematic represents the key elements for the delivery of bulk water to GAWB customers.



Availability estimates for the model were based on GAWB and general industry experience.

External Threats:
This describes incidents that can affect the whole GAWB water supply chain. These were identified during the context vulnerability assessment and include drought, dam failure and power supply failure.

Awoonga Pump Station Threats:
The pump station at Awoonga has three pumps (duty, standby and backup) all capable of pumping the full bulk water requirement. However, a number of common mode failures were identified that take out all of the pumps at the same time, including: wooden power pole failure; storm or cyclone resulting in power supply impact; grouped cable fire; fire / explosion in pumpwell, VFD building or HV switch room; and pump well flood. It was also noted that there is a single point failure associated with the underground pipeline from the pump station to the bulk transfer pipes on the other side of the spillway.

Bulk Water Transfer:
From the pump station the water can be transferred to the storage reservoirs either via the 1440mm underground or 700mm above ground pipeline. The two pipes run parallel along the road and three common mode failures were identified that could affect both pipes including transfer SCADA failure; washaway (one pipe washes out the other); and malicious damage.

> Availability estimates for the model were based on GAWB and general industry experience.

Storage:
Effectively bulk water is transferred to the two 50Ml storage reservoirs at Toolooa and Fitzsimmons St. before being distributed to the bulk water customers. Either of the reservoirs can feed all bulk water customers, therefore making the storage system redundant.

Distribution System:
The distribution system delivers bulk water to customers from the two storage reservoirs and is made up of various length underground pipes. An average fault rate per kilometre per year based on GAWB experience of unplanned failures, which was then used to estimate the failure rate for each delivery pipeline. It was noted during the review that pipes are not usually expected to fail catastrophically and minor failures can usually be repaired without significant interruptions to water delivery.

Water Treatment:
In addition to providing bulk raw water, GAWB is also responsible for the provision of some bulk treated water. GAWB have two water treatment plants, one at Gladstone and the other at Yarwun which are operated by the Gladstone Regional Council.

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Two availability models were developed for the treated water, one each for Gladstone and Yarwun. Elements modelled included common mode failures to the water treatment plant, the treatment process, pumping, storage and customer delivery system.

> Two availability models were developed and include common mode failures, processes, storage and delivery systems.

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SUMMARY OF RESULTS

The following table summarises the modelling results for bulk customers in days unavailable for each of the high-level functional elements.

CUSTOMER	EXTERNAL THREATS	AWOONGA PS	BULK TRANSFER	STORAGE	BULK DISTRIBUTION	RAW WATER UNAVAILABILITY	TREATED WATER UNAVAILABILITY
Boyne Smelter	4.65	1.0908	0.019	0.0127	0.0075	5.78	6.17
Cement Aust., Boat Creek	4.65	1.0908	0.019	0.0127	0.2205	6.02	6.77
Cement Aust., East End	4.65	1.0908	0.019	0.0127	0.2205	6.02	7.28
Gladstone Port Corp., Hansen Rd	4.65	1.0908	0.019	0.0127	0.0375	5.81	
Gladstone Port Corp., Serrant Rd	4.65	1.0908	0.019	0.0127	0.2206	6.03	
Gladstone Water Treatment Plant	4.65	1.0908	0.019	0.0127	0.0125	5.76	
Orica (Mt Miller)	4.65	1.0908	0.019	0.0127	0.2203	6.00	6.73
Orica, Serrant Rd	4.65	1.0908	0.019	0.0127	0.2206	6.03	
Queensland Aluminium	4.65	1.0908	0.019	0.0127	0.0025	5.77	6.17
Queensland Energy Resources	4.65	1.0908	0.019	0.0127	0.2205	6.02	
Rio Tinto Aust., Refinery	4.65	1.0908	0.019	0.0127	0.2204	6.01	6.73
Rio Tinto Aust., RMA	4.65	1.0908	0.019	0.0127	0.2206	6.03	6.85
Transpacific	4.65	1.0908	0.019	0.0127	0.2204	6.01	
Yarwun Water Treatment Plant	4.65	1.0908	0.019	0.0127	0.375	5.81	

As can be seen in the table, the majority of the total days unavailable for bulk raw water is related to external threats and the common mode failures at the Awoonga pump station. Most of these items are characterised as unlikely but have significant downtime consequences. In turn the unavailability numbers for treated water is driven by the unavailability of bulk raw water to the treatment plants.

For example, based on the modelling Queensland Aluminium Ltd, on average will not have raw water available 5.77 days per annum. 4.65 of these days are a result of the external threats identified and 1.09 days associated with the threats identified at Awoonga Pump Station.

> The majority of unavailability relates to external threats and common mode failures.

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PRECAUTIONARY REVIEW

From a criticality viewpoint, there are a number of external threats and common mode failures that will interrupt supply for an extended period of time. These are shown in the table below.

EXTERNAL THREAT / COMMON MODE FAILURE	CRITICALITY (DAYS DURATION)
Sabotage / terrorism	1000
Dam failure	1000
Drought (single catchment)	36
Sunwater infrastructure failure	14
Inundation (tail water)	14
Fire / explosion in HV Switch room	14
Pump well flood (broken pipe)	14
Fire / explosion in VFD building	14
Fire / explosion in pump well	14
Loss of surge tank	14
Corrosion / erosion of spillway pipe	14
Fire / explosion at Gladstone Water Treatment Plant	14
Sabotage / terrorism at Gladstone Water Treatment Plant	14
Fire / explosion at Yarwun Water Treatment Plant	14
Sabotage / terrorism at Yarwun Water Treatment Plant	14
Rail bridge failure (over Callipe River)	10
Power supply failure (grid loss)	7
Wash away of main transfer pipe to storage	7
Malicious damage of main transfer pipe	7
Group cable fire	5
Wooden pole failure at Awoonga	3
Storm or cyclone (power supply interruption)	3
Pole collapse into cutting	3
Lightning strike (control system)	3

The provision of a 2 week + off-line storage facility and associated pumping station will address supply interruptions associated with failures of 14 days and less. Such failures include Sunwater infrastructure failure, inundation of the Awoonga Pump Station, fire / explosion in various key buildings including the pump well, HV switch room, VFD building and water treatment plants (see section 6.0 for the full list). This significantly reduces the network's current criticality for all lesser critical threats and improves the average availability of bulk water to GAWB customers by approximately 2 days per annum (see table below).

CUSTOMER	EXTERNAL THREATS	AWOONGA PS	BULK TRANSFER	STORAGE	BULK DISTRIBUTION	RAW WATER UNAVAILABILITY	TREATED WATER UNAVAILABILITY
Boyne Smelter	3.71	0	0	0.0127	0.0075	3.74	4.13
Cement Aust., Boat Creek	3.71	1.0908	0.019	0.0127	0.2205	3.98	4.74
Cement Aust., East End	3.71	1.0908	0.019	0.0127	0.2205	3.98	5.25
Gladstone Port Corp., Hansen Rd	3.71	1.0908	0.019	0.0127	0.0375	3.77	
Gladstone Port Corp., Serrant Rd	3.71	1.0908	0.019	0.0127	0.2206	3.99	
Gladstone Water Treatment Plant	3.71	1.0908	0.019	0.0127	0.0125	3.72	
Orica (Mt Miller)	3.71	1.0908	0.019	0.0127	0.2203	3.97	4.70
Orica, Serrant Rd	3.71	1.0908	0.019	0.0127	0.2206	4.00	
Queensland Aluminium	3.71	1.0908	0.019	0.0127	0.0025	3.74	4.13
Queensland Energy Resources	3.71	1.0908	0.019	0.0127		3.98	
Rio Tinto Aust., Refinery	3.71	1.0908	0.019	0.0127	0.22050.2204	3.98	4.70
Rio Tinto Aust., RMA	3.71	1.0908	0.019	0.0127	0.2206	3.99	4.74
Transpacific	3.71	1.0908	0.019	0.0127	0.2204	3.98	
Yarwun Water Treatment Plant	3.71	1.0908	0.019	0.0127	0.0375	3.77	

CONCLUSION

During discussions with the GAWB stakeholders, a number of generic precautions emerged to address these concerns. From a criticality viewpoint, there are a number of external threats and common mode failures that will interrupt supply for an extended period of time especially drought, dam break and the like. The provision of an alternate independent water supply such as the Gladstone - Fitzroy pipeline or a desalination plant will address all of these identified long-term threat scenarios.

> Precautions were identified to address long-term threat scenarios.

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WHERE TO NEXT

> Talk to R2A about your next project.

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- Contact R2A to organise a briefing for your executive management team.
- Book an In-House Course or Private Briefing.
- Buy a copy of the 9th edition R2A text: Risk & Reliability: Engineering Due Diligence. Order online.
- Receive R2A's email newsletter.
- Attend the two day Engineering Due Diligence Workshop presented by Richard Robinson.
- Attend the one day Defensible Risk Management Techniques course presented by Richard Robinson on behalf of Engineering Education Australia.
- Enrol in the postgraduate unit 'Introduction to Risk and Due Diligence' Postgraduate Unit at Swinburne University, also presented by R2A.

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