Regional Water Corp

Risk Assessment
Workshop Summary Paper

Regional Water Corp

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EXECUTIVE SUMMARY

WORKSHOP BACKGROUND

The *Public Health Act 2010* has been passed by Parliament and is expected to commence in 2012. The Act will require drinking water suppliers to establish, and adhere to, a quality assurance program that complies with the associated Regulation. The Regulation requires water suppliers to implement a quality assurance program (or risk-based drinking water management system) consistent with the Framework for the Management of Drinking Water Quality in the *Australian Drinking Water Guidelines 2011.*

NSW Health undertook a pilot program to develop risk based management systems for four water supply schemes. Regional Water Corp (RWC) was one of those schemes.

In developing a management system, water suppliers should undertake a risk assessment from catchment to consumer and develop critical control points (this workshop) to ensure that unsafe water is not released into the distribution systems and that it is protected from contamination during distribution.

WORKSHOP OBJECTIVE:

The objectives of the workshop were to:

- Understand the system from catchment to tap from a water quality perspective;
- Understand and prioritise (assess) the events, hazards and risks to drinking water consumers;
- Identify the control measures in place for addressing the identified events, hazards and risks;
- Identify any additional controls or actions which may be required to improve the risk management of the scheme; and
- Identify critical control points for the scheme.

WORKSHOP OUTLINE:

The outline of the workshop was to:

- Describe the methodology to be used in the workshop;
- Present what was known about water quality risks relating to the source(s);
- Capture knowledge on RWC's water supply system in an integrated fashion;
- Capture participant consensus on risks and appropriate controls;
- Identify critical control points for the scheme.

RISK SUMMARY:

A total of 71 hazardous events was identified for the RWC system with the following 'uncontrolled' or 'maximum' (risks without controls in place) and 'residual' (risks with controls in place) findings (refer to Section 5 for definition of risks). A total of 58 actions was identified to address the risks.

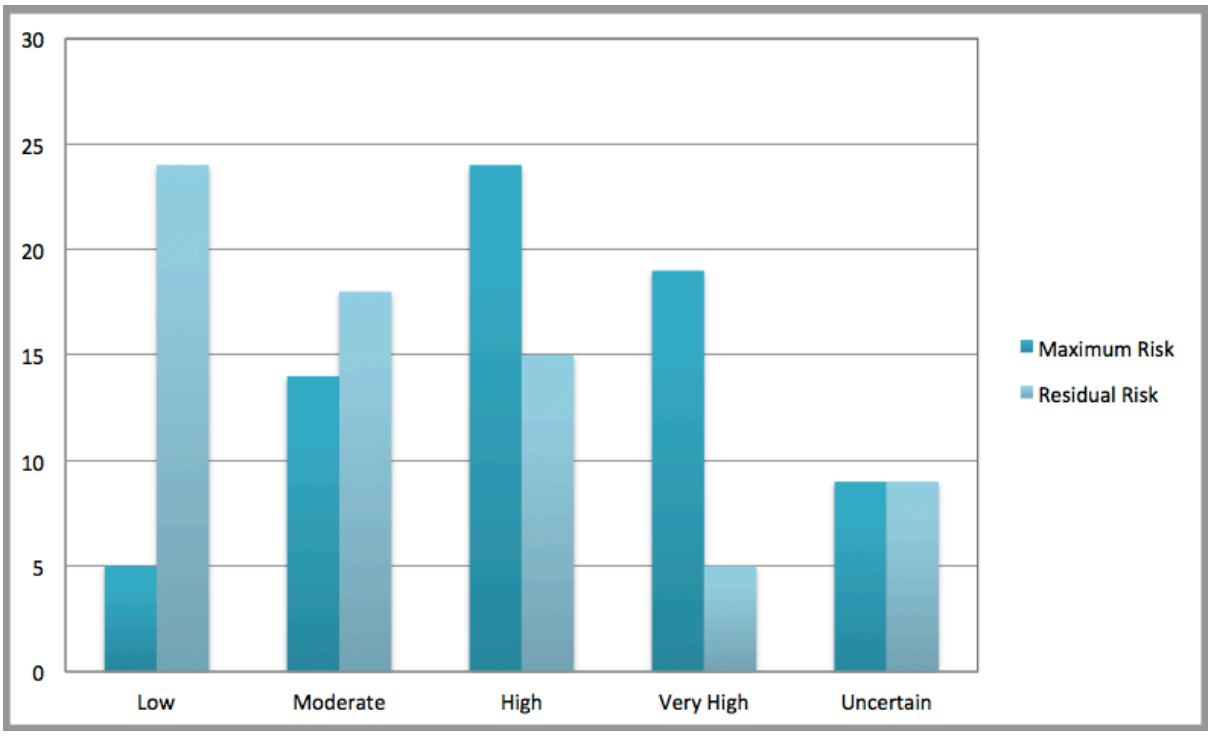
Uncontrolled Risk Summary – No. of risks by location in water supply system

System Components	High	Low	Moderate	Uncertain	Very High	Grand Total
Distribution	5	2	1	2	2	12
Fishers Creek Catchment	2		2	1	5	10
Fishers Creek Dam	3			3		6
Percy Colliery Source	2			2		4
Coagulation	4		2			6
Clarification		1	1			2
Filtration (mono media)			2		2	4
Disinfection (chlorine gas)	1	1			2	4
Post Dosing (stabilisation)	1					1
pH correction	1		1			2

System Components	High	Low	Moderate	Uncertain	Very High	Grand Total
Clearwater Tank					1	1
Raw Water Bypass	1					1
Distribution Reservoirs	1		2		2	5
Chlorine Boosters			1	1	1	3
Fishers River Source					2	2
Non-potable water at Taraville					1	1
Whole of System	3	1	2		1	7
Grand Total	**24**	**5**	**14**	**9**	**19**	**71**

Residual Risk Summary – No. of risks by location in water supply system

System Components	High	Low	Moderate	Uncertain	Very High	Grand Total
Distribution	3	2	3	2	2	12
Fishers Creek Catchment	2	5	2	1		10
Fishers Creek Dam		1	2	3		6
Percy Colliery Source		2		2		4
Coagulation		4	2			6
Clarification		2				2
Filtration (mono media)	1	1	2			4
Disinfection (chlorine gas)	3	1				4
Post Dosing (stabilisation)			1			1
pH correction		1	1			2
Clearwater Tank		1				1
Raw Water Bypass	1					1
Distribution Reservoirs	3		2			5
Chlorine Boosters		1		1	1	3
Fishers River Source	1				1	2
Non-potable water at Taraville					1	1
Whole of System	1	3	3			7
Grand Total	**15**	**24**	**18**	**9**	**5**	**71**



Comparison of Maximum and Residual Risks

CCP SUMMARY:

The following CCPs were identified for the RWC scheme:

1. Plant Inlet (Raw Water Inlet Valve)
2. Filtration (supported by coagulation)
3. Primary Disinfection (outlet of Clearwater tank)
4. Fluoridation (when in place)
5. Distribution Reservoirs (once procedures and monitoring are established)

.

CONTENTS

1 INTRODUCTION

The Australian Drinking Water Guidelines (ADWG) (NHMRC/NRMMC, 2011) set out a holistic approach to drinking water management including understanding where sources of contamination may arise and how contamination may find its way to the consumer. The approach is termed the Framework for the Management of Drinking Water Quality (the Framework).

A significant component of the Framework is understanding and managing the risks to drinking water and forms the basis of this workshop.

The workshop details are provided in Appendix A.

2 WATER QUALITY RISK ASSESSMENT – A BACKGROUND

2.1 ADWG RISK ASSESSMENT COMPONENTS

Element 2 of the ADWG Framework provides the following framework for undertaking a risk assessment on a water supply system. The section where the framework is addressed in this paper, or in the risk workshop as a workshop activity, is shown in brackets.

Water supply system analysis:

- Assemble a team with appropriate knowledge and expertise (Appendix A).
- Construct a flow diagram of the water supply system from catchment to consumer (Section 3.4).
- Assemble pertinent information and document key characteristics of the water supply to be considered (Sections 3 & 4).

Assessment of water quality data:

- Assemble historical data from source waters, treatment plants and finished water supplied to consumers (Appendix B).
- List and examine exceedances (Section 4 and Appendix B).
- Assess data using tools such as control charts and trend analysis to identify trends and potential problems (Appendix B).

Hazard identification and risk assessment:

- Define the approach and methodology to be used for hazard identification and risk assessment (Section 5).
- Identify and document hazards, sources and hazardous events for each component of the water supply system (Workshop Activity – output being the Risk Register).
- Estimate the level of risk for each identified hazard or hazardous event (Workshop Activity – output being the Risk Register).
- Evaluate the major sources of uncertainty associated with each hazard and hazardous event and consider actions to reduce uncertainty (Workshop Activity – output being the Risk Register).
- Determine significant risks and document priorities for risk management (Workshop Activity – output being the Risk Register).

2.2 ADWG CCP COMPONENTS

Element 3 of the ADWG Framework covers assessment of preventive measures, multiple barriers and critical control points.

Preventive measures and multiple barriers:

- Identify existing preventive measures from catchment to consumer for each significant hazard or hazardous event and estimate the residual risk (Workshop Activity – output being the Risk Register).
- Evaluate alternative or additional preventive measures where improvement is required (Workshop Activity – output being the Risk Register).
- Document the preventive measures and strategies into a plan addressing each significant risk (Workshop Activity – output being the Risk Register).

Critical Control Points (Section 6):

- Assess preventive measures from catchment to consumer to identify critical control points.
- Establish mechanisms for operational control (Post Workshop).
- Document the critical control points, critical limits and target criteria (Workshop Activity – output being the identified CCPs in Section 6).

3 System Description

An overview of RWC's water supply system is provided in Table 3-1 and Figure 3-1, and in further detail in the following sections.

Table 3-1. Water supply system – overview description.

SYSTEM COMPONENT	DESCRIPTION
Population Served	The population of approximately 21,000 comprises Regionalville, Wangwall, Starboard, Dalry, Valleyville, Collen, and Barrangaroo. Some part of Sodit and Baconton and Kanval are supplied directly from the Fishers River Water Supply trunk main. Taraville is served by a raw water scheme, this water is not intended for drinking.
Water Source	**Surface water:** Fishers Creek and the Farmers River and Paddymolloy River (via the Farmers River Water Supply Scheme operated by Bulk Water Corp). **Ground water:** None used directly as a source in the council-managed scheme (see below for Percy Colliery groundwater). **Other Water:** Excess treated (chemical dosing, DAF and pH correction) groundwater from Percy Colliery via Percy Colliery Water Transfer Scheme (CWTS) via Fishers Creek.
Water Storage	Fishers Creek Dam (operated by Gollumville City Council). Titania Dam and Paddymolloy Weir (operated by Bulk Water Corporation).
Water Treatment	Raw water from Fishers Creek Dam is treated at the Hokey Pokey Water Treatment Plant as follows: • Soda ash for pH correction • Alum for coagulation and polyelectrolyte (LT20) as a coagulant aid • Flocculation • Clarification (horizontal flow) • Filtration (mono media) • Disinfection (chlorine gas) and stabilization (soda ash) • Fluoridation (step not yet active, project in progress)
Storage After Treatment	Clear water tank then distribution reservoirs at Cleaner St and Candle St.
Distribution of Product	Via pressurised pipes of various diameters (352 km), pumps (30) and tanks (17).
Any Special Controls Required	Booster chlorination (re-chlorination occurs at the Priest Street PS and the outlet of the Wangwall and Tindale Reservoirs). Quality of chemicals, materials etc used in the production and delivery of the product. Manual verification sampling of water from the distribution network. Backflow prevention and trade waste management. Operation and maintenance of all infrastructure to prevent recontamination.

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Figure 3-1. RWC water supply network overview.

3.1 Water Sources

Fishers Creek Dam is RWC's main reservoir (Figure 3-2). Inflows to the dam are from Fishers Creek, which are derived from a small catchment of 11.7km sq (Figure 3-3) and supplemented periodically with treated water from Percy Colliery.

The Fishers Creek catchment is heavily vegetated and is entirely within "Zone No 1 (f)—Rural (Forestry)". Water sourced from catchments of predominantly native vegetation and which are heavily vegetated, is usually of a higher quality than that sourced from agricultural and urbanized catchments.

Rainfall occurs consistently throughout the year with summertime peaks and an average annual rainfall of 820 mm although in recent years the region has been experiencing drought conditions.

Climate change impacts are likely to exacerbate water availability in the region with probable impacts on water quality. While there are various water quality-impacting landuses within the local government area (extractive industries, cropping, agriculture etc), most of those landuses are outside of the catchment area. Only two extractive sites (sand/kaolin) are within the catchment area.

Groundwater pumped from Percy Colliery is treated by LoCoal Corp in a Dissolved Air Flotation (DAF) plant and then transferred through the water transfer system to Fishers Creek upstream of the dam.

There is no formal water quality agreement in place between Percy Colliery (LoCoal Corp) and RWC.

Water can also be sourced from the Farmers River scheme (operated by Bulk Water Corp) via surface water collected in the Paddymolloy Weir and Titania Dam.

Bulk Water Corp's Operating Licence (2008-2013) states that:

> *4.5.1 Bulk Water Corp must use its best endeavours to enter into agreements with its Farmers River Customers during the term of the Licence, in relation to the arrangements to apply to the supply of water by the operation of the Farmers River Scheme.*
>
> *4.5.2 The terms of the arrangements must, as a minimum, include:*
>
> *(a) the standard of the quality of water supplied;*

The agreement in place between Bulk Water Corp and RWC is:

> *Agreement Concerning the Supply of Water from the Famers River Water Supply [the Agreement].*

The Agreement is dated November 2007. Raw water is supplied to RWC from the Farmers River scheme at several points.

As part of the liability provisions of the Agreement, RWC has to acknowledge that it is supplied with microfiltered, chlorinated water and that Bulk Water Corp shall not be obliged to supply water of a higher standard or quality. Further, RWC must treat any water supplied to it to meet the standards set by any national water quality guidelines or any other requirements.

There are no provisions in the agreement for *E. coli* levels (noting that *E. coli* is a surrogate for pathogenic bacterial contaminants), or chlorine residuals, and there is no reference to the Australian Drinking Water Guidelines (See Section 6.1 for additional work required to address this issue).

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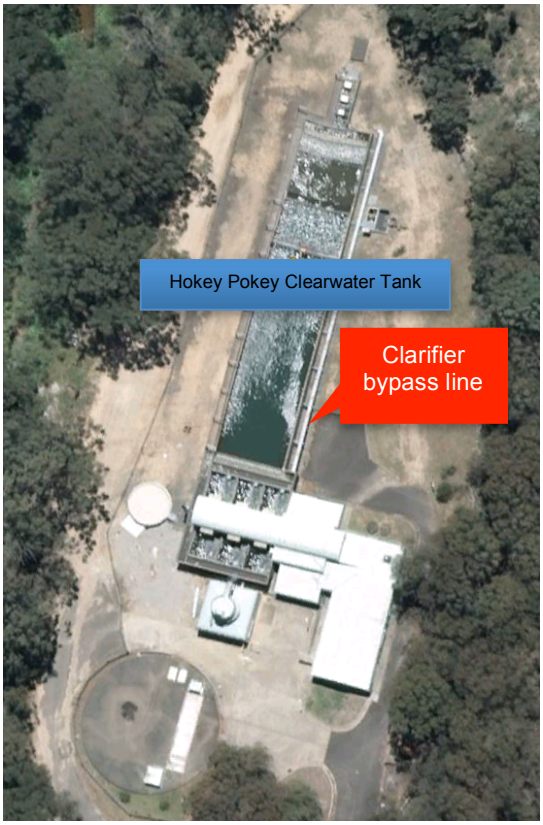
Figure 3-2. Fishers Creek Dam Wall.

3.2 TREATMENT

RWC owns and operates the Hokey Pokey Water Treatment Plant. The treatment steps are listed above in Table 3-1. There is no fluoridation at the plant although provisions are underway to allow for fluoridation to occur in the near future.



Note that the rectangular tank is the clarifier. The clearwater tank is the circular one and it is covered.

There is a raw water bypass provision at the plant, which feeds back into the system at the outlet of the clearwater tank. There is also a clarifier bypass line which can be used to bypass the clarifier when required.

3.3 DISTRIBUTION

RWC's distribution system comprises ca 352 km reticulation ranging from 50 to 500 mm (Table 3-2) 15 distribution reservoirs (Table 3-3) and 16 pumps.

The figures below show the hydraulic profiles of the Farmers River source (Figure 3-4) and the Percy Colliery source (Figure 3-5) and how they interact with the RWC water supply system.

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FIGURE 3-3. FISHERS CREEK CATCHMENT AREA.

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FIGURE 3-4. FARMERS RIVER WATER SUPPLY HYDRAULIC PROFILE.

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FIGURE 3-5. REGIONAL WATER CORP WATER SUPPLY AND PERCY COLLIERY TRANSFER SYSTEM HYDRAULIC PROFILE.

RWC uses an external contractor (Aqualift) to inspect its reservoir assets. A review of the Aqualift reports was undertaken for this workshop and where water quality relevant observations were made, they have been summarised in Table 3-4.

Specifically relevant to this risk workshop, note that bird access, unauthorised access and vandalism has been noted at various of RWC's reservoir assets.

- **Bird access:** Note that bird access of distribution reservoirs has caused waterborne outbreaks in other jurisdictions resulting in illnesses and deaths (Angulo et al, 1997; Clark et al, 1996 and Clark, 2000).
- **Asset integrity:** Ingress into distribution reservoirs (either through leaking seals, open hatches, compromised structure integrity etc) has also resulted in deaths and illness from the water supply (Falco and Williams, 2009; Olinger, 2009).
- **Security:** Vandalism and unauthorised access to distribution reservoirs is also cause for concern in relation to contamination of water (including deliberate and unplanned contamination).

Table 3-2. Reticulation information.

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Table 3-3. Reservoir information (Source: RWC).

Reservoir	Storage Capacity (ML)
Cleaner Street High	3
Cleaner Street Low	4.5
Candle Street New	20
Candle Street Old	6.8
Hokey Pokey WTP	2
South Bigton	2
South Cowenfell	2
Culkin Street	0.3
Barrangaroo	0.2
Wangwall	2.7
Tindale	1.3
Starboard High	1.1
Starboard Low	1
Collen	0.4
Valleyville	4.6
Total	51.9

Table 3-4. Water quality relevant reservoir observations (Source: summarised from Aqualift reports).

Reservoir	Comments
Cleaner St LL	Bird access, dead bird found inside tank, vandalism noted
Collen	The entry hatch cover does not seal around the front edge area and where the ladder stiles used to extend through
Tindale	There is no secure compound around the tank and the ladder door was not locked. Unauthorised access to the tank has most likely been occurring.
Barrangaroo	There is no effective padlock on the entry hatch - the existing lock has been cut and replaced as a dummy lock only.
Starboard HL	There was no padlock on the entry hatch - it is held shut with a nut and bolt. There is a risk of unauthorised access to the tank due to a lack of security up on the tank. Unauthorised access is a possibility and there is no lock on the entry hatch.
Starboard LL	The compound wires have been damaged, and the external ladder and hatch are

Reservoir	Comments
	unlocked. There was deliberate contamination placed inside the tank - a lead acid battery and its charger unit were retrieved. Unauthorised access has occured and there is no lock on the entry hatch.
Dalry	The roof vent has been vandalized, so site security needs to be monitored. The entry hatch cover does not seal around the front where the ladder stiles extend through. Unauthorised personnel have accessed to roof area and the entry hatch cover is not sealed against deliberate contamination events.
Candle St No. 2	There are a number of defects in the security fence, and graffiti on the external walls of the tank. Water and debris is collecting around the platform area, and overflowing into the tank. Water and debris is ponding and overflowing back into the tank, due to the reverse slope on the platform area.
South Bigton	There is no padlock on the entry hatch - the external security is easy to bypass and enter the tank. There were several small birds inside the tank - the bird wire needs to be checked in detail to secure the tank. The bird access area needs to be identified ASAP - the wire mesh under the eaves is the most likely cause.
Wangwall	There were 5 dead birds inside the tank - there is no obvious entry point identified. The bird access area needs to be identified ASAP - maybe a hatch was left open for a period of time.

The towns of Wangwall, Starboard, Tindale, Dalry, Collen and Valleyville are supplied from the Farmers River water supply however, water from this scheme can also be supplied to Barrangaroo and Gollumville as required. Given that the primary source of reticulated water for Gollumville is via the RWC operated system, issues associated with a potential dual source were considered and included (but were not limited to):

- Changes in water chemistry resulting in taste and odour complaints and biofilm disturbance
- Changes in water flow resulting in biofilm sloughing and dirty water events

Another potential source of contamination considered for the RWC distribution system was through cross connections to non-potable supplies.

3.4 Process Flow Diagram

A conceptual flow diagram for the system is shown in Figure 3-6 and for the water treatment plant in Figure 3-7. The purpose of the diagrams is to show key inputs, steps and flow direction. Note that a drought pipeline is slated for supply to Wangwall, Starboard, Tindale, Dalry, Collen and Valleyville, however, while this pipeline was not considered during the risk assessment – it will need to be assessed prior to being commissioned. Procedures and records for the operation of the pipeline will also need to be developed and implemented.

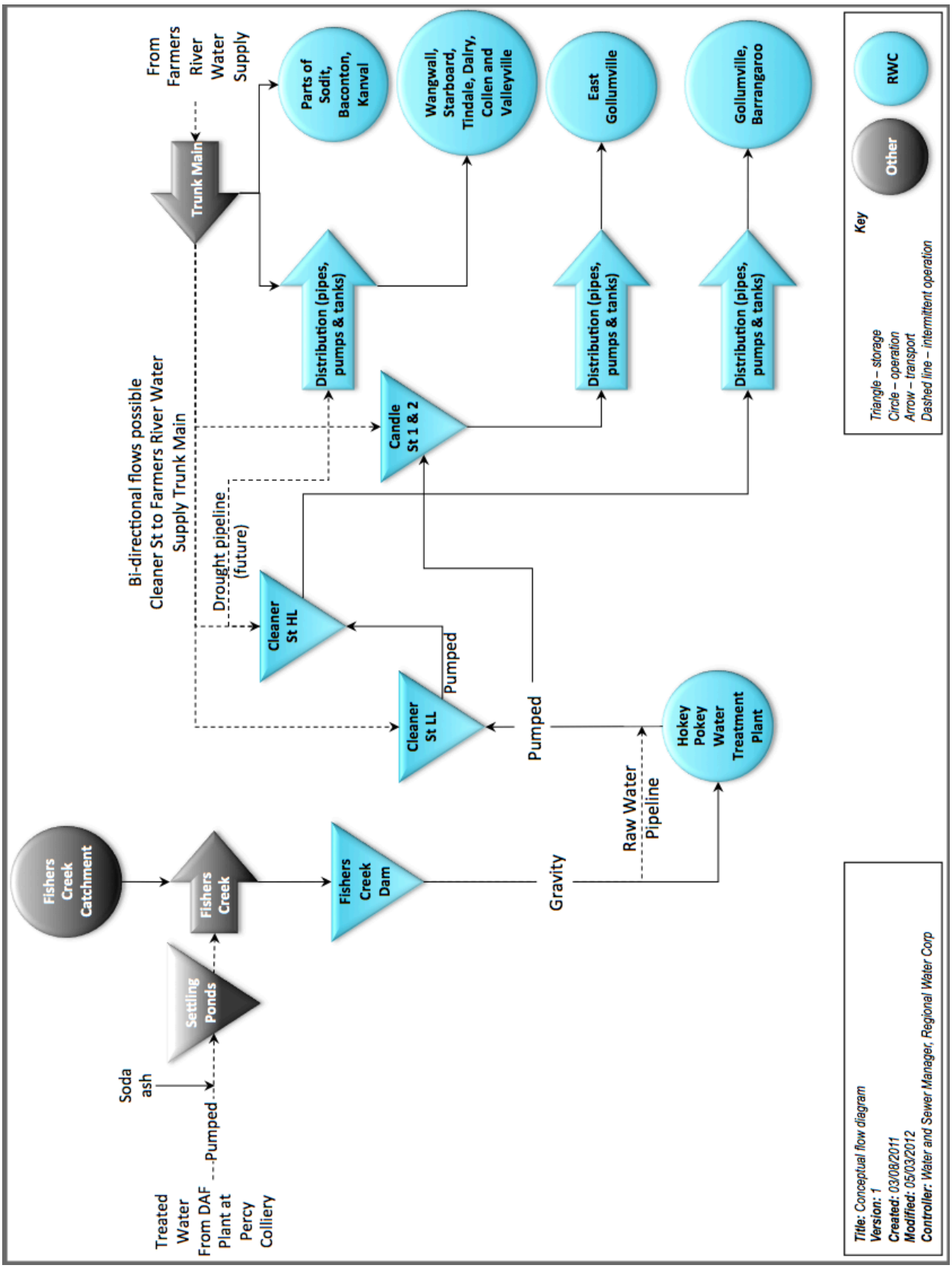

FIGURE 3-6. CONCEPTUAL PROCESS FLOW DIAGRAM OF THE WATER SUPPLY SYSTEM (ACHIEVED BY CONSENSUS AT THE RISK WORKSHOP – SEE FOLLOWING DIAGRAM FOR WATER TREATMENT PROCESS).

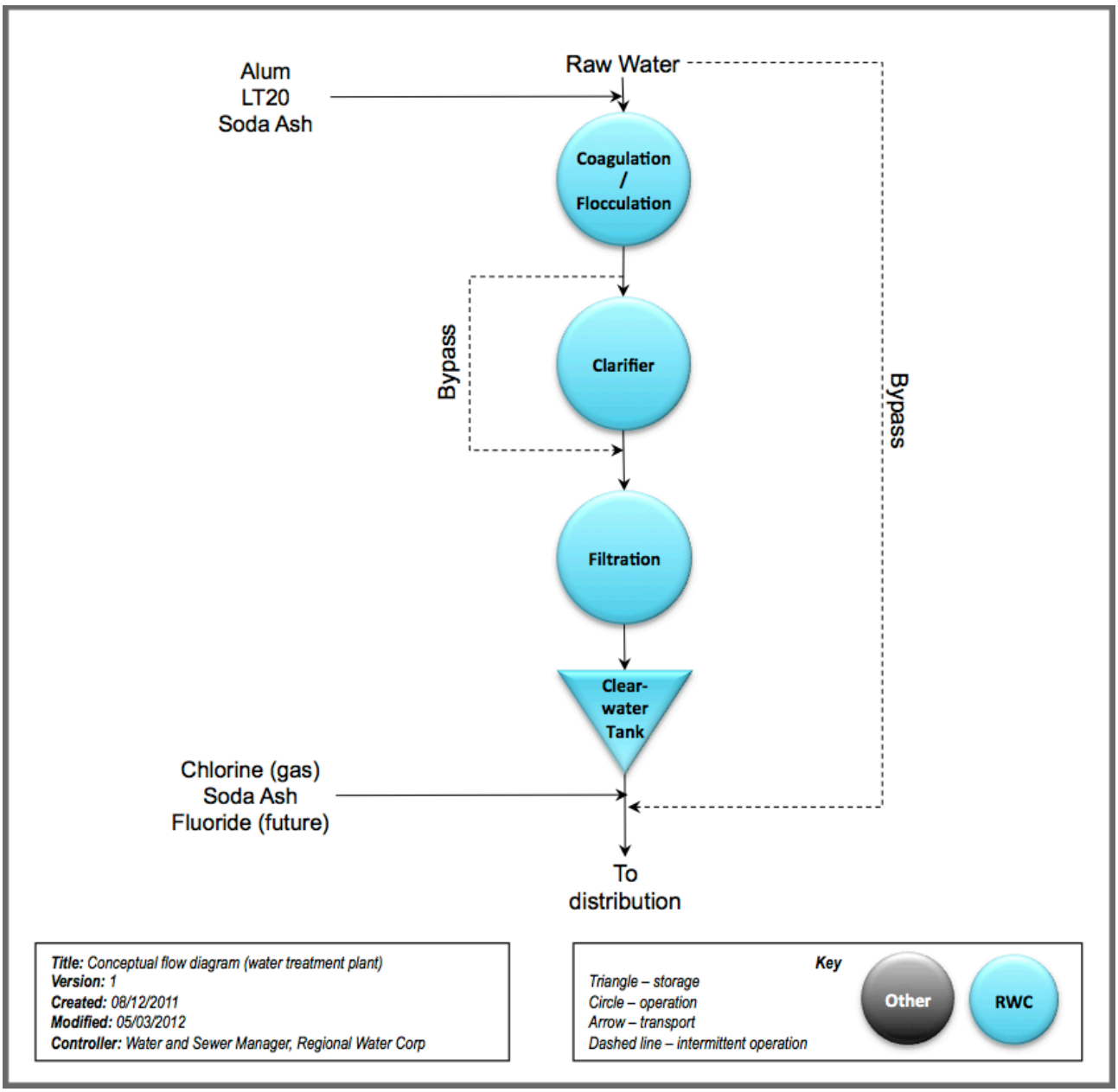

FIGURE 3-7. CONCEPTUAL PROCESS FLOW DIAGRAM OF THE WATER TREATMENT PROCESS AT HOKEY POKEY WATER TREATMENT PLANT.

4 Water Quality Risks

4.1 Risks identified in previous studies

In 2005/06, seven blue green algae (cyanobacteria) alerts occurred (Table 4-1). However, importantly for this risk assessment workshop, all alerts have occurred downstream of Fishers Creek Dam, there have been no alerts at the dam itself.

Table 4-1. Algal Alerts.

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Previous water quality complaints were received by RWC, from Wangwall and Starboard residents (served by the Farmers River Water Supply), in early 2009. The complaints were investigated by the NSW Health Population Health Unit, RWC and Bulk Water Corp. Results indicated that while the Paddymolloy treatment plant was effective in complying with Australian Drinking Water Guideline levels, levels of manganese, aluminium and iron recurred in supply mains and reticulation lines downstream of the plant. Chlorine levels leaving the plant were also found to be too low to maintain an effective chlorine residual throughout the system.

4.2 Risks identified through water quality analysis

Water quality data were sourced from RWC and the NSW Health (Water Quality Database). To allow statistical formulae to handle the full body of data, non-detects were transformed to half the detection limit and values above the upper dynamic range of the assay to twice the upper limit.

Graphs of the water quality parameters can be found in Appendix B. The water quality parameters are summarised in Table 4-2, Table 4-3, Table 4-4, and Table 4-5 below.

Gollumville Hokey Pokey Water Quality

Water quality data was extracted from the NSW Health verification monitoring database for testing carried out in the Gollumville reticulation supplied by Hokey Pokey WTP over the period 1-1-2001 to 31-7-2011. Water was tested for 38 quality parameters. An analysis of the results against the Australian Drinking Water Guidelines 2011 is provided in the tables below. Table 4-2 provides statistics for common parameters, and Table 4-3 provides descriptions for all parameters where any exceedences were recorded.

Table 4-2. Summary of water quality data for Gollumville reticulation supplied from Hokey Pokey WTP (NSW Health Data).

Parameter	Units	Samples	Min	5th %ile	Mean	95th %ile	Max	ADWG Value	Exceedances
pH		145	5	6.50	7.86	9.00	9.50	6.5 - 8.5	34
True Colour	HU	118	1	0.50	1.22	3.40	11.00	15	0
Turbidity	NTU	142	0.1	0.05	0.43	1.19	8.00	5 (aesthetic)	2
								1 (desirable for disinfection)	8
Iron	mg/L	126	0.01	0.01	0.06	0.16	2.11	0.3	1
Manganese	mg/L	141	0.005	0.00	0.02	0.09	0.52	0.5 (health)	1
								0.1 (aesthetic)	7
Aluminium	mg/L	126	0.01	0.01	0.13	0.56	1.50	0.2	16
Nickel	mg/L	128	0.01	0.01	0.02	0.05	0.22	0.02	21
Thermotolerant Coliforms	cfu/mL	102	0	0.00	0.23	0.00	15.00	0	4
E. coli	cfu/mL	746	0	0.00	0.00	0.00	1.00	0	2
Total Hardness	(mg/L as $CaCO_3$)	126	0.099	3.70	28.30	49.30	95.30	200	0

TABLE 4-3. WATER QUALITY ISSUES FOR GOLLUMVILLE RETICULATION SUPPLIED FROM HOKEY POKEY WTP.

Issue	Frequency	Comment
pH	Occasionally	pH was outside the guideline range on 35 occasions from 1255 samples, the most recent exceedence in 2009.
E. coli	Rarely	2 positive detects for *E. coli* were found from 821 samples, the most recent in 2003.
Turbidity	Rarely	2 exceedences were found for turbidity in 2004 and 2005, plus 8 exceedences of the desirable limit for disinfection
Free chlorine	Rarely	1 exceedence was found for free chlorine in 2009.
Aluminium	Occasionally	16 exceedences for aluminium were found from 126 samples, occurring consistently across the sampling period.
Iron	Rarely	3 exceedences were found for iron, the most recent in 2009.
Nickel	Occasionally	21 exceedences for nickel were found from 128 samples, during a period from 2004 – 2006.
Total Hardness	Often	60 – 200 mg/L is described as good quality water in the ADWG 2011. While there were no exceedences of 200 mg/L, hardness is often lower than the recommended minimum of 60 mg/L, at which the water can be described as soft but possibly corrosive.

Gollumville Villages Farmers River Water Quality

Water quality data was extracted from the NSW Health verification monitoring database for testing carried out in Gollumville Villages supplied by Farmers River Water Supply over the period 1-1-2001 to 31-7-2011. Water was tested for 37 quality parameters. An analysis of the results against the Australian Drinking Water Guidelines 2011 is provided in the tables below. Table 4-4 provides statistics for common parameters, and Table 4-5 provides descriptions for all parameters where any exceedences were recorded.

TABLE 4-4. SUMMARY OF WATER QUALITY DATA FOR GOLLUMVILLE VILLAGES SUPPLIED FROM FARMERS RIVER WATER SUPPLY (NSW HEALTH DATA).

Parameter	Units	No. Samples	Min	5th %ile	Mean	95th %ile	Max	ADWG Value	Exceedances
pH		87	6.5	6.8	7.28	7.97	8.5	6.5 - 8.5	0
True Colour	HU	68	1	1	6.89	14.20	17.7	15	2
Turbidity	NTU	87	0.1	0.1	2.17	8.56	22.2	5 (aesthetic)	10
								1 (desirable for disinfection)	40
Iron	mg/L	73	0.01	0.01	0.13	0.39	1.02	0.3	6
Manganese	mg/L	85	0.005	0.003	0.09	0.21	2.43	0.5 (health)	3
								0.1 (aesthetic)	12
Thermotolerant Coliforms	cfu/mL	140	0	0	0.67	2.05	35	0	14
E. coli	cfu/mL	1291	0	0	0.48	0	78	0	52
Total Hardness	(mg/L as $CaCO_3$)	78	5.4	23.86	29.36	35.03	41.5	200	0

TABLE 4-5. WATER QUALITY ISSUES FOR GOLLUMVILLE VILLAGES SUPPLIED FROM FARMERS RIVER WATER SUPPLY.

Issue	Frequency	Comment
E. coli	Occasionally	59 positive detects for *E. coli* were found from 1410 samples, the most recent in 2009.
Turbidity	Occasionally	10 exceedences of the aesthetic guideline and 40 exeedences of the recommended limit for disinfection were found.
Iodine	Rarely	1 exceedence for iodine was found in 2002.
Iron	Occasionally	6 exceedences were found for iron from 73 samples
Lead	Rarely	1 exceedence for lead was found in 2011.
Manganese	Rarely	3 exceedences were found for manganese from 85 samples
True Colour	Rarely	2 minor exceedences were found for true colour from 68 samples.
Total Hardness	Always	60 – 200 mg/L is described as good quality water in the ADWG 2011. While there were no exceedences of 200 mg/L, hardness is always lower than the recommended minimum of 60 mg/L, at which the water can be described as soft but possibly corrosive.

5 RISK ASSESSMENT PROCESS

5.1 RISK ASSESSMENT

Events and hazards were identified for each process step. Risks posed by each of the events were assessed. Participants were asked to identify the:

Hazardous event A hazardous event is one that introduces contaminants (hazards) to the water.

For this risk assessment the hazardous event will be for the level of contamination to be unacceptable for treatment through the downstream processes. Examples of a hazardous event might be:

- cyanobacterial bloom resulting in toxins that cannot be removed by downstream processes
- distribution reservoir contamination by vermin resulting in pathogens in the distribution system

Hazard A hazard is a physical, chemical, biological or radiological agent in the water with the potential to cause an adverse effect.

Examples of hazards might be:

- Human-infectious pathogens and nutrients from failing septic tanks
- Particles and nutrients from land clearing practices

Controls in place Controls are practices and equipment that reduce the hazard or the hazardous event:

Examples of controls include:

- Catchment management programs to reduce nutrients in the river thereby reducing cyanobacterial blooms
- A water treatment plant
- A backflow prevention program

Controlled Risk This was assessed by identifying the likelihood and consequence of the hazardous event occurring with the control in place (residual risk). The risks were assessed as Likelihood (Table 5-1) x Consequence (Table 5-2).

A risk assessment matrix (ADWG, 2011) was used to assess the identified risks (Table 5-3).

Maximum Risk Likelihood and consequence of the hazardous event occurring if the controls were to fail or without the controls in place.

The results were captured during the workshop via an Excel® spreadsheet.

TABLE 5-1. LIKELIHOOD TABLE (ADWG, 2011).

Level	Descriptor	Example description
A	Almost certain	Is expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Might occur or should occur at some time
D	Unlikely	Could occur at some time
E	Rare	May occur only in exceptional circumstances

TABLE 5-2. CONSEQUENCE TABLE (ADWG, 2011).

Level	Descriptor	Example description
1	Insignificant	Insignificant impact, little disruption to normal operation, low increase in normal operation costs
2	Minor	Minor impact for small population, some manageable operation disruption, some increase in operating costs
3	Moderate	Minor impact for large population, significant modification to normal operation but manageable, operation costs increased, increased monitoring
4	Major	Major impact for small population, systems significantly compromised and abnormal operation if at all, high level of monitoring required
5	Catastrophic	Major impact for large population, complete failure of systems

TABLE 5-3. RISK MATRIX (ADWG, 2011).

Likelihood	Consequences				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very high	Very high	Very high
B (likely)	Moderate	High	High	Very high	Very high
C (possible)	Low	Moderate	High	Very high	Very high
D (unlikely)	Low	Low	Moderate	High	Very high
E (rare)	Low	Low	Moderate	High	High

5.2 SUMMARY

A total of 71 hazardous events were identified for the Gollumville system. All events have been captured within an Excel®-based Risk Register. Note that 'uncertainty' was captured along with any other comments, in the 'Basis/Notes' section of the Risk Register. The register will be reviewed at a set frequency and/or on system changes. The Risk Register, as determined at this workshop, is presented in Appendix C.

Risks remaining high after controls were assessed are as follows:

- Soft water in the source water
- First flush rain event introducing contaminants into catchment waterways
- Short circuiting of filters leading to breakthroughs
- Underdosing of chlorine (inc equipment failure or running out) leading to chlorine sensitive pathogen survival in finished water (primary kill)
- High pH in the water causing issues such as skin rashes and reduced disinfection efficiency
- Underdosing of chlorine resulting in lack of chlorine residuals in distribution system

- Raw water can be connected into the distribution system downstream of the clearwater tank resulting in undisinfected water being supplied to customers
- Low chlorine residuals resulting in the potential for water quality failure
- Malicious contamination leading to water contamination
- Reservoirs are not routinely maintained or checked resulting in water quality contamination eg gutter blockage and overflow, vermin access
- Receipt of non-conforming water into Gollumville's distribution system resulting in water quality issues
- Aging infrastructure leading to ingress and water quality issues
- Reduced velocities in the main resulting in conditions that favour biofilm formation and sediment accumulation
- Mains break or perforation (air valves etc) leading to water quality issues
- Disgruntled employees or contractors leading to malicious damage resulting in poor water quality (note that employees and contractors understand the system so would know where to act to cause most damage e.g. altering SCADA, contaminating clearwater tank etc)

Risks reduced from Very High to Low with controls in place are as follows:

- Recreational activities in the catchment (illegal) including 4WD, camping
- Recreational activities in the catchment (illegal)
- Ingress into clear water tank through integrity issues and potentially flood inundation from creek

Risks reduced from High to Low with controls in place are as follows:

- Reservoir turnover leading to water quality issues
- Receipt of high levels of metals (Fe and Mn) from Percy source above ADWG values
- Receipt of high levels of metals (Ni) from Percy Colliery source above ADWG values
- Over and underdosing of coagulant
- Rapid change in raw water turbidity resulting in inability to treat
- Bushfire taking out the plant

A total of 56 actions was identified in the workshop (with two added post workshop to take the total to 58) to address the identified risks. An Action Plan has been developed and is presented in Appendix D.

An overall summary of the uncontrolled (‘maximum’) and controlled (‘residual’) risks is presented in tabular and graphical form below (Table 5-4, Table 5-5 and Figure 5-1).

TABLE 5-4. RESIDUAL RISK SUMMARY

System Components	High	Low	Moderate	Uncertain	Very High	Grand Total
Distribution	3	2	3	2	2	12
Fishers Creek Catchment	2	5	2	1		10
Fishers Creek Dam		1	2	3		6
Percy Colliery Source		2		2		4
Coagulation		4	2			6
Clarification		2				2
Filtration (mono media)	1	1	2			4
Disinfection (chlorine gas)	3	1				4
Post Dosing (stabilisation)			1			1
pH correction		1	1			2
Clearwater Tank		1				1
Raw Water Bypass	1					1
Distribution Reservoirs	3		2			5
Chlorine Boosters		1		1	1	3
Farmers River Source	1				1	2
Non-potable water at Taraville					1	1
Whole of System	1	3	3			7
Grand Total	**15**	**24**	**18**	**9**	**5**	**71**

TABLE 5-5. UNCONTROLLED RISK SUMMARY

System Components	High	Low	Moderate	Uncertain	Very High	Grand Total
Distribution	5	2	1	2	2	12
Fishers Creek Catchment	2		2	1	5	10
Fishers Creek Dam	3			3		6
Percy Colliery Source	2			2		4
Coagulation	4		2			6
Clarification		1	1			2
Filtration (mono media)			2		2	4
Disinfection (chlorine gas)	1	1			2	4
Post Dosing (stabilisation)	1					1
pH correction	1		1			2
Clearwater Tank					1	1
Raw Water Bypass	1					1
Distribution Reservoirs	1		2		2	5
Chlorine Boosters			1	1	1	3
Farmers River Source					2	2
Non-potable water at Taraville					1	1
Whole of System	3	1	2		1	7
Grand Total	**24**	**5**	**14**	**9**	**19**	**71**

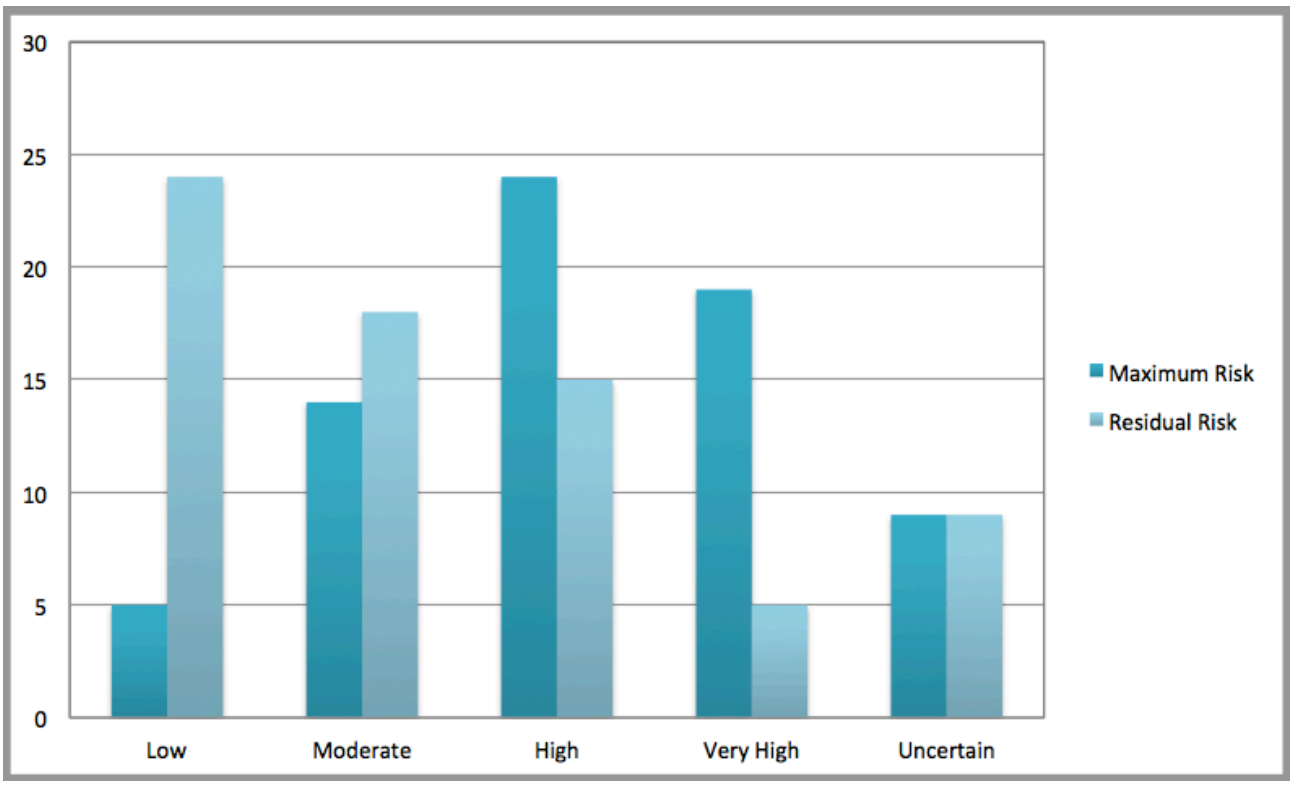


FIGURE 5-1. GRAPHICAL REPRESENTATION OF RISKS (X AXIS – RISK RATING; Y – AXIS – NUMBER OF RISKS IDENTIFIED).

6 CRITICAL CONTROL POINT IDENTIFICATION

Critical control points are the operational core of the drinking water management system. CCPs are covered under Element 3 of the Framework. In the Framework, CCPs are defined as:

"…..an activity, procedure or process at which control can be applied and which is essential to prevent a hazard or reduce it to an acceptable level."

For a point to be considered critical it must:

- Control hazards that represent a significant risk and require elimination or reduction to assure supply of safe drinking water.
- Have a parameter (surrogate) that can be measured in a timely manner for the hazardous event
- Be able to have a correction applied in response to a deviation in the process

The key risks from the risk assessment were reviewed and the critical control points were identified.

The points in the Gollumville system identified as critical control points (or future critical control points) were (see also Table 6-1):

1. Plant Inlet (Raw Water Inlet Valve)
2. Filtration (supported by coagulation)
3. Primary Disinfection (outlet of Clearwater tank)
4. Fluoridation (when in place)
5. Distribution Reservoirs (once procedures and monitoring are established)

TABLE 6-1. CRITICAL CONTROL POINT WORKSHOP OUTCOMES.

Critical Control Point	Controls	Parameter	Operating Target	Adjustment Limit	Critical Limit	Comments
Plant Inlet (Inlet Valve)	Pathogens/Turbidity	Turbidity (currently not online, sample taken to lab)	Operating range		Design limit	
Coagulation (Operational Point)	pH	pH	6.4	<6 >7	Remains at <5 >7.5 after adjustment	Operational not critical control point Monitoring of Al residual
Filtration	Pathogens	Turbidity	0.3 NTU	0.5 NTU	1 NTU	
Primary Disinfection (outlet of CWT)	Chlorine sensitive pathogens	Free chlorine residual (manual measurements)	1.7 mg/L	<1.5mg/L	1.2 mg/L	Limits are set on ability to maintain a distribution chlorine residual. Consider having online telemetered measurement. The limit of 1.2 mg/L is subject to review and may need to be amended to ensure that an appropriate chlorine residual (0.2 mg/L) reaches consumers.
Primary Disinfection (outlet of CWT)	Chlorine sensitive pathogens	pH	7.8-8.2	<7 >8.5	Remains at >8.5 after adjustment	Consider changing pH monitoring point to inlet of CWT.
Fluoridation	Fluoride	Fluoride				To be established once fluoridation is online (see below Section 6.1)
Distribution Reservoirs	Pathogens	Free chlorine residual	Zone specific			FCl currently measured in the distribution system not at the reservoir. Could consider having a monitoring point directly downstream of the reservoirs. Sampling points to be reviewed for appropriateness.
Distribution	Pathogens	Vermin-proofed	Is vermin	Evidence of	Breach not	

Critical Control Point	Controls	Parameter	Operating Target	Adjustment Limit	Critical Limit	Comments
Reservoirs			proof	breaches	rectified	
Distribution Reservoirs	Pathogens	Secure and leak-proof	Is secure	Evidence on breach	Breach not rectified	

The critical limits will be considered further as the critical control points are refined during development and implementation.

6.1 Areas of additional work to support CCP development

Distribution

Note that while distribution reservoirs were considered by the team as needing to be assigned as critical control points, the monitoring and procedures supporting this system component are currently not well developed and will need to be reviewed before the distribution reservoirs can be assigned as a critical control point.

Fluoridation

While fluoridation is not currently in place at the Hokey Pokey Water Treatment Plant, fluoridation will be assigned as a critical control point once in operation.

Farmers River WS/Gollumville System Interface Points

Discussion was had by the group around the Farmers River WS handover points and whether they could/should be assigned as critical control points. Given that there is currently no monitoring or procedures in place at the handover points, the consensus was that these points in the system should be reviewed in terms of the legal water quality agreement and the procedures/monitoring, and then reassessed at a later date. See Actions 13 to 16, 37, 38, 41 and 45 relating to issues associated with receipt of water from other sources.

7 REFERENCES

References which specifically identify this water supply system have been removed.

ADWG (2011) NHMRC/NRMMC (National Health and Medical Research Council/ Natural Resource Management Ministerial Council) Australian Drinking Water Guidelines (ADWG) National Water Quality Management Strategy. ISBN Online: 1864965118.

Angulo, F.J., Tippen, S., Sharp, D.J., Payne, B.J., Collier, C., Hill, J.E., Barrett, T.J., Clark, R,M., Geldreich, E.E., Donnell, H.D. and Swerdlow, D.L. (1997) A community waterborne outbreak of salmonellosis and the effectiveness of a boil water order. American Journal of Public Health 87(4): 580-584.

Clark, R. (2000) Water quality modelling case studies. In: Water distribution systems handbook. Ed. Mays, L.W. McGraw Hill New York.

Clark, R.M., Geldreich, E.E., Fox, K.R., Rice, E.W., Johnson, C.H., Goodrich, J.A., Barnick, J.A., Abdesaken, F. (1996) Tracking a *Salmonella* serovar *typhimurium* outbreak in Gideon, Missouri: Role of contaminant propagation modelling. Aqua - Journal of Water Supply: Research and Technology [AQUA J. WATER SUPPLY TECHNOL.]. Vol. 45, no. 4, pp. 171-183

Falco, R. and Williams, S.I. (2009) Waterborne *Salmonella* outbreak in Alamosa, Colorado March and April 2008. Outbreak identification response, and investigation. Safe Drinking Water Program Water Quality Control Division. Colorado Department of Public Health and Environment. http://www.cdphe.state.co.us/wq/drinkingwater/pdf/AlamosaInvestRpt.pdf.

Olinger, D. (2009) Tainted water still burdens town. Denver Post 22 March 2009. http://www.denverpost.com/ci_11968436.

APPENDIX A WORKSHOP DETAILS

WORKSHOP AGENDA

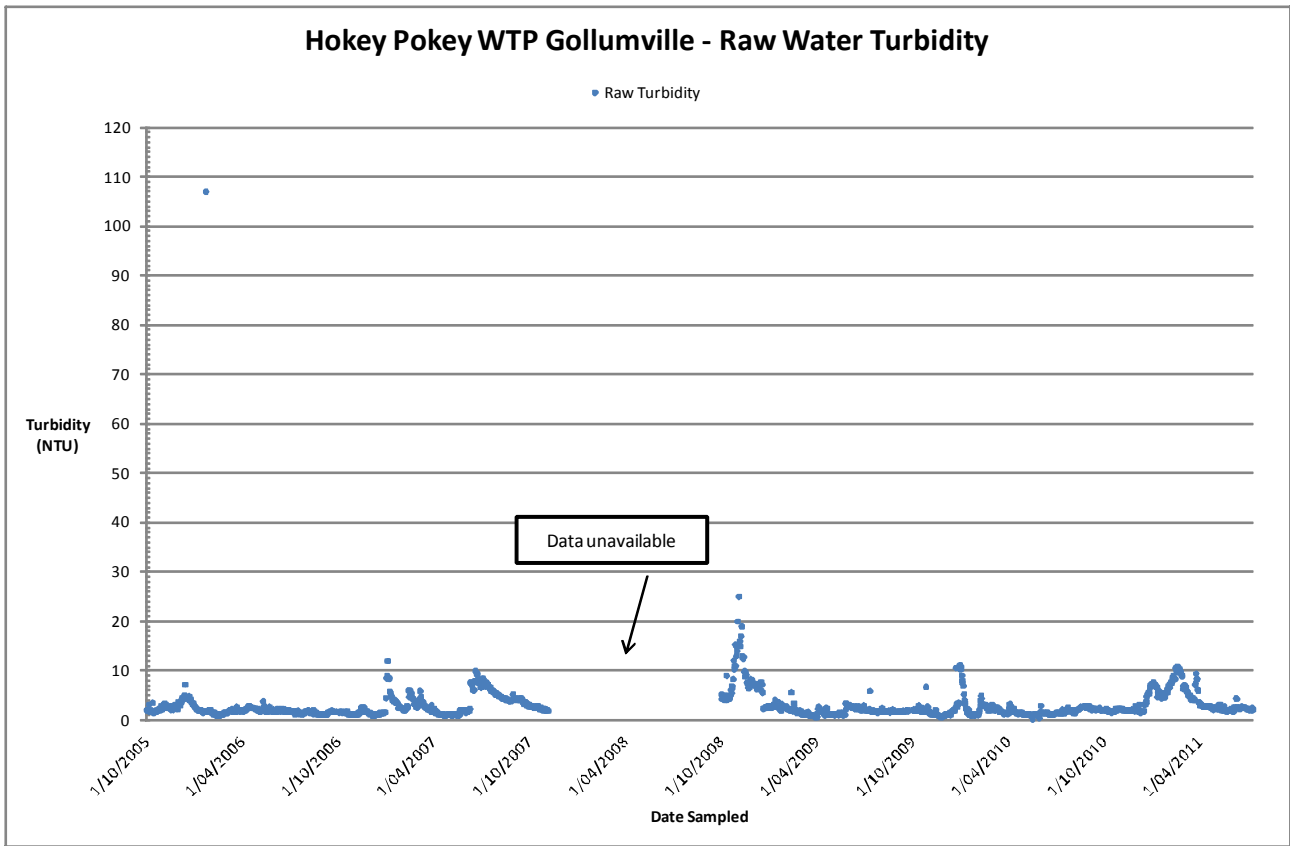
Item	Description
Date/Time:	1 September 2011 / 08:30 am for a 9:00 am start to 5:00 pm
Venue	Council Chambers, Regional Water Corp, 180 Mort Street, Gollumville NSW 2790
Contacts:	Removed for de-identification purposes.

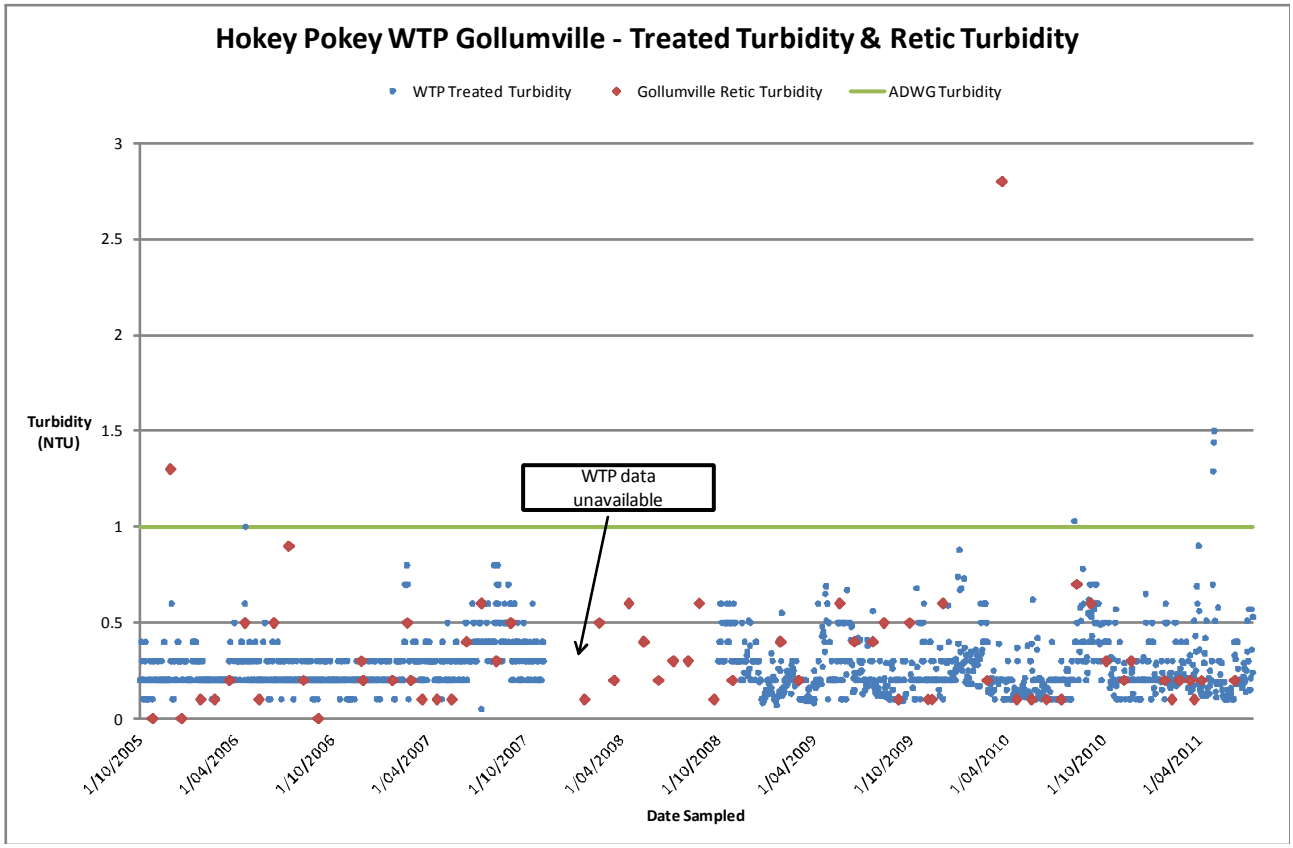
Time	Session	Item	Person
8:45 – 9:00	Arrival	Arrival and tea/coffee	Removed for de-identification purposes
9:00 – 9:05	Welcome	Introduction roundtable	
9:05 – 9:10	Introduction	Overview of project	
9:10 – 09:30	System Description	Scope of workshop Description of the water supply system including catchment description, water quality data analysis and presentation of flow diagram	
09:30 – 9:50	Flow Diagram	Workshop to confirm flow diagram	
9:50 – 10:15	Workshop Overview	Workshop methodology	
10:15 – 10:30	Break	*Morning tea*	
10:15 – 12:30	Risk Assessment	Workshop events, hazards, risks and controls	
12:30 – 13:00	Break	*Lunch*	
13:00 – 15:00	Risk Assessment	Continued	
14:30 – 14:45	Break	*Afternoon tea*	
14:45 – 16:00	Risk Assessment	Continued	
16:00-16:50	Critical Control Points	Review CCPs Assign critical limits where possible	
16:50 – 17:00	Close	Workshop close and next steps	

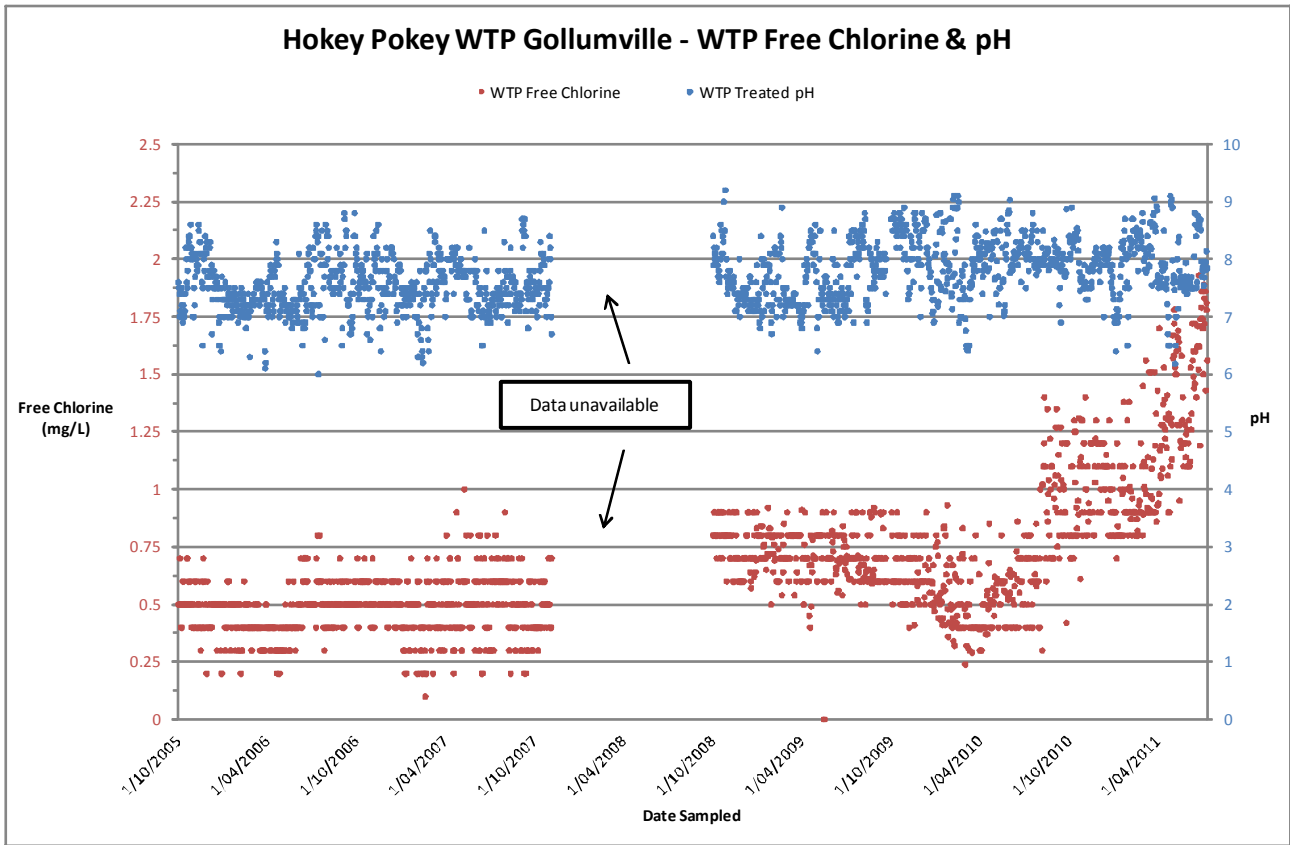
WORKSHOP PARTICIPANTS

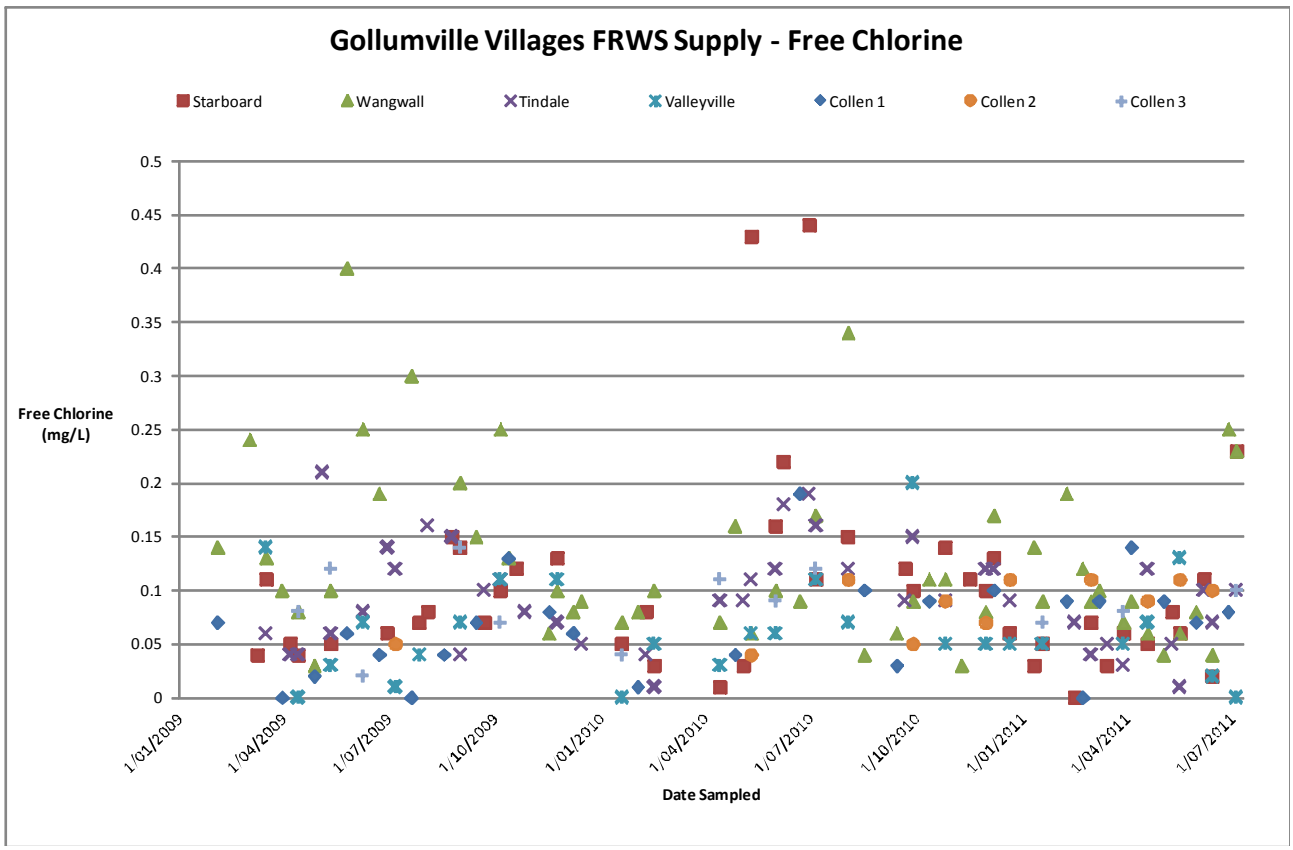
Removed for de-identification purposes, should ordinarily include a scanned sign-in sheet of the workshop participants.

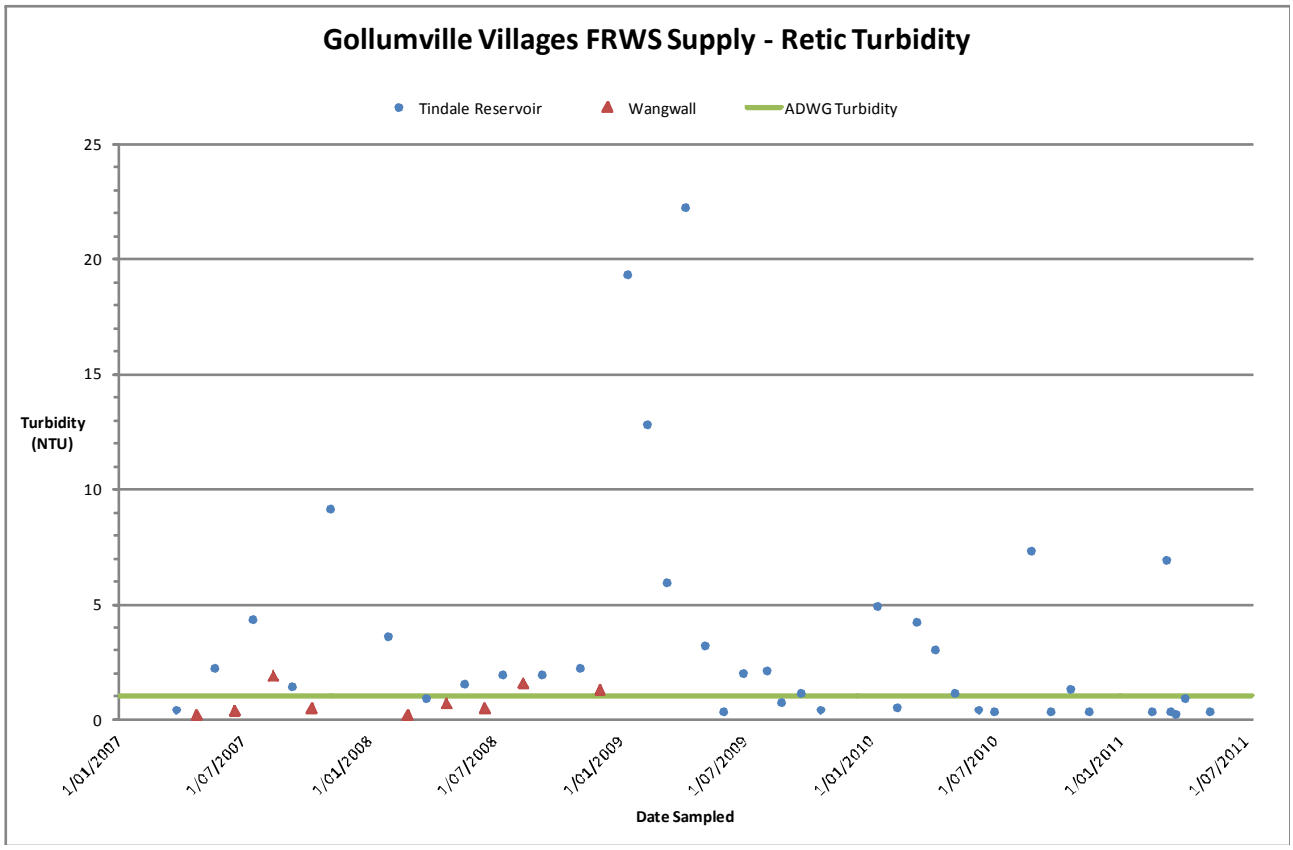
APPENDIX B WATER QUALITY DATA

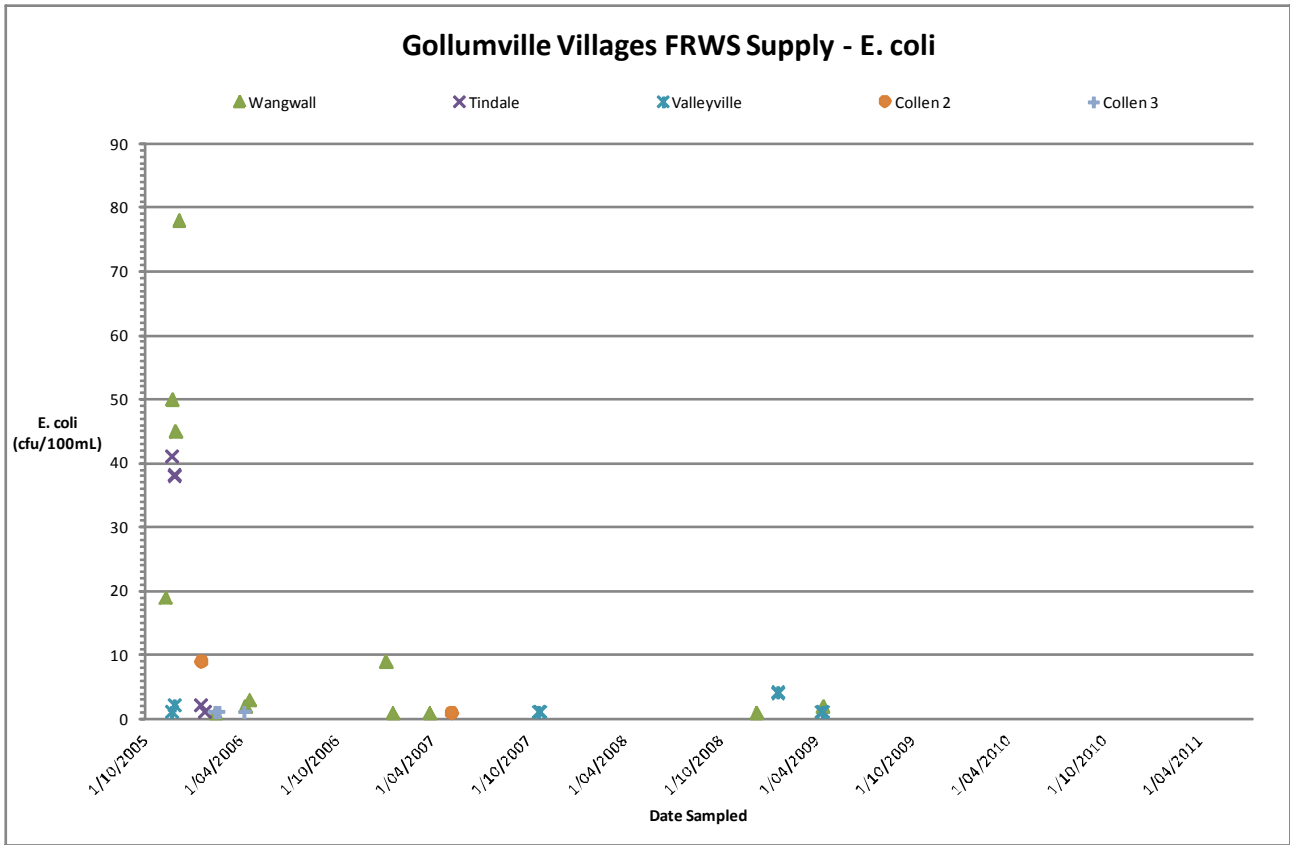





Hokey Pokey WTP Gollumville - WTP Free Chlorine & pH
WTP Free Chlorine
WTP Treated pH
Free Chlorine (mg/L)
pH
Data unavailable
Date Sampled
1/10/2005
1/04/2006
1/10/2006
1/04/2007
1/10/2007
1/04/2008
1/10/2008
1/04/2009
1/10/2009
1/04/2010
1/10/2010
1/04/2011


Gollumville Villages FRWS Supply - Free Chlorine
Starboard
Wangwall
Tindale
Valleyville
Collen 1
Collen 2
Collen 3
Free Chlorine (mg/L)
Date Sampled
1/01/2009
1/04/2009
1/07/2009
1/10/2009
1/01/2010
1/04/2010
1/07/2010
1/10/2010
1/01/2011
1/04/2011
1/07/2011


Gollumville Villages FRWS Supply - Retic Turbidity
Tindale Reservoir
Wangwall
ADWG Turbidity
25
20
15
10
5
0
Turbidity (NTU)
1/01/2007
1/07/2007
1/01/2008
1/07/2008
1/01/2009
1/07/2009
1/01/2010
1/07/2010
1/01/2011
1/07/2011
Date Sampled


Gollumville Villages FRWS Supply - E. coli
Wangwall
Tindale
Valleyville
Collen 2
Collen 3
90
80
70
60
50
40
30
20
10
0
E. coli (cfu/100mL)
1/10/2005
1/04/2006
1/10/2006
1/04/2007
1/10/2007
1/04/2008
1/10/2008
1/04/2009
1/10/2009
1/04/2010
1/10/2010
1/04/2011
Date Sampled

APPENDIX C WORKSHOP RISK REGISTER

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Responsibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
FC1	Fishers Creek Catchment	Soft water in the source water		None	RWC	A	2	High	A	2	High	
FC2	Fishers Creek Catchment	Rainfall following bushfire or grassfire resulting in run off into the catchment	Fire retardants, ash, Turbidity Tastes and odours	WTP, Dam, natural environment, alternative supply	RWC	C	2	Moderate	C	4	Very High	Operational issues associated with changing over to Farmers River supply
FC3	Fishers Creek Catchment	First flush rain event introducing contaminants into catchment waterways	Nutrients, BGA, Toxins, Tastes and Odours Turbidity DBP pre-cursors	WTP, Dam, natural environment, alternative supply	RWC	B	2	High	B	4	Very High	Risk based on need to adjust operation when first flushes occur
FC4	Fishers Creek Catchment	Accidents and spills on catchment roads into water causing water quality issues	Pathogens	No roads close to rivers, reasonably closed catchment, emergency service response, WTP, reservoir detention and dilution, alternative supply	RWC, SES, emergency services	E	1	Low	E	4	High	A lot of 4WD activity in the catchment. Logging trucks use the catchment.
FC5	Fishers Creek Catchment	Accidents and spills on catchment roads into water causing water quality issues	Hydrocarbons Various chemicals	No roads close to rivers, reasonably closed catchment, emergency service response, WTP (not designed for hydrocarbon etc removal), reservoir detention and dilution, alternative supply	RWC, SES, emergency services	D	2	Low	D	3	Moderate	
FC6	Fishers Creek Catchment	Legal and illegal motorcycle track in head of catchment and 4WD causing erosion	Turbidity, DBP pre-cursors	WTP, Dam, natural environment, some restricted access, planning	RWC, State Forests	C	1	Low	C	2	Moderate	

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
				powers								
FC7	Fishers Creek Catchment	Overloading of Motorcycle club septic system overflowing leading to pathogens in catchment	Pathogens	WTP, Dam, natural environment, inspection powers, onsite sewage management policy	RWC, Leaseholder	B	1	Moderate	B	4	Very High	Know that systems in other parts of the LGA are failing so likely that this one might be. Risk assessment based on more likely to overflow during an event at the club.
FC8	Fishers Creek Catchment	Recreational activities in the catchment (illegal) including 4WD, camping	Crypto	Powers under PEOA and Sect 632 LGA, filtration, dam (dentention, dilution), travel time	RWC	E	1	Low	C	4	Very High	Signs of camping, fires toileting is known in the catchment. Rangers work 5/7 1 sign in catchment
FC9	Fishers Creek Catchment	Recreational activities in the catchment (illegal)	Chlorine sensitive pathogens	Powers under PEOA and Sect 632 LGA, chlorine disinfection, dam (dentention, dilution), travel time	RWC	E	1	Low	C	4	Very High	Signs of camping, fires toileting is known in the catchment. Rangers work 5/7 1 sign in catchment
FC10	Fishers Creek Catchment	Illegal dumping in the catchment leading to water quality issues	Various (most likely to be chemicals, can be pathogens from pumpouts)	Powers under PEOA, chlorine disinfection, dam (dentention, dilution), travel time, OEH surveillance, rangers (5/7)	RWC, OEH, SCA, State Forests			Uncertain			Uncertain	Increased incidence of illegal dumping noted since environment levy for dumping introduced.
FCD1	Fishers Creek Dam	Reservoir turnover leading to water quality issues	Mn, Fe, taste and odours, turbidity	WTP, alternative supply, raw water monitoring at the head of the plant, level of offtake	RWC	E	2	Low	E	4	High	Has occurred in the past.
FCD2	Fishers Creek Dam	Deliberate contamination of the reservoir	Various (most likely to be chemicals)	WTP, alternative supply, dilution, raw water monitoring at the head of the plant	RWC	E	3	Moderate	E	4	High	Car has been found previously in the dam.

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Responsibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
FCD 3	Fishers Creek Dam	Short circuiting of reservoir	Turbidity Pathogens	WTP, alternative supply, dilution, raw water monitoring at the head of the plant	RWC			Uncertain			Uncertain	Unclear whether short circuiting occurs.
FCD 4	Fishers Creek Dam	Cross contamination of dam (farm dams etc) with helicopter access to fight fires	Algae, pathogens	WTP, alternative supply, dilution				Uncertain			Uncertain	
FCD 5	Fishers Creek Dam	Illegal recreational activities in the dam (swimming, dog access etc)	Pathogen, turbidity, taste and odours	WTP, dilution, dam inspections	RWC	A	1	Moderate	A	2	High	Occurs mostly in summer. Only a few numbers of people at a time.
FCD 6	Fishers Creek Dam	High levels of metals coming in from upstream sources	Metals	Dam, dilution	RWC			Uncertain			Uncertain	
CCS 1	Percy Colliery Source	Receipt of poor quality water into Fishers Creek Dam	Hydrocarbons	Formal agreement to supply water, informal operating protocol. New Water Committee has been formed to discuss water quality issues. Dilution in the dam but less in drought.	RWC			Uncertain			Uncertain	No formal water quality agreement in place with LoCoal Corp. Proposal being considered to put water directly into the dam at the dam wall. - variability in water quality anyway. Inconsistency in the volume of water received from Percy on a daily basis. Hydrocarbons are perceived as a problem in the community.
CCS 2	Percy Colliery Source	Receipt of high levels of metals from Percy source above ADWG values	Fe, Mn	Formal agreement to supply water, informal operating protocol. New Water Committee has been formed to discuss water	CC	C	1	Low	C	3	High	Metals have been found to be an issue. Rarely have a failure at the plant in Fe and Mn. Settling ponds will disappear with the new proposal.

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
				quality issues. Dilution in the dam but less in drought. WTP. Shandy with alternative supply. Settling ponds.								
CCS 3	Percy Colliery Source	Receipt of high levels of metals from Percy source above ADWG values	Ni	Formal agreement to supply water, informal operating protocol. New Water Committee has been formed to discuss water quality issues. Dilution in the dam but less in drought. Shandy with alternative supply. Settling ponds.	CC	C	1	Low	C	3	High	Ni has been an issue in the past (2005) but doesn't seem to have been much of an issue since introduction of the DAF plant at LoCoal Corp. Settling ponds will disappear with the new proposal.
CCS 4	Percy Colliery Source	Short circuiting of Percy inputs	Various	Consider this event in the pipeline proposal.				Uncertain			Uncertain	No formal water quality agreement in place with LoCoal Corp. Proposal being considered to put water directly into the dam at the dam wall.
pH1	pH correction	Under or no dosing of soda ash causing pH lower than optimal for coagulation	Pathogen, turbidity, Al, pH, Fe, Mn	Operator monitoring at number 1 weir, manual control over the dosing, O&M on equipment, calibration of testing equipment, operator training, observation of clarifier for colour change	RWC	C	2	Moderate	B	3	High	Monitoring is not continuous

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
				and check of hopper and quantity								
pH2	pH correction	Overdosing of soda ash causing pH higher than optimal for coagulation	Pathogen, turbidity, Al, pH, Fe, Mn	Operator monitoring at number 1 weir, manual control over the dosing, O&M on equipment, calibration of testing equipment, operator training, observation of clarifier for colour change and check of hopper and quantity	RWC	D	2	Low	D	3	Moderate	Monitoring is not continuous
Coag1	Coagulation	Underdosing of coagulant leading to failure to achieve flocculation	Turbidity Pathogen, Fe, Mn	Operator monitoring by observation, manual control over the dosing, O&M on equipment, calibration of testing equipment, operator training (and experience), observation of clarifier for colour change and daily jar testing, filters	RWC	C	2	Moderate	C	3	High	
Coag2	Coagulation	Overdosing of coagulant	Aluminium	Operator monitoring by observation, manual control over the dosing, O&M on equipment, calibration of testing equipment, operator	RWC	C	2	Moderate	B	3	High	Some Al noted in retic. Risk ranked more on community perception issue than health issue.

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
				training (and experience), observation of clarifier for colour change and daily jar testing, filters								
Coag3	Coagulation	Over and underdosing of coagulant	Colour (DOC), DBPs	Operator monitoring by observation, manual control over the dosing, O&M on equipment, calibration of testing equipment, operator training (and experience), observation of clarifier for colour change and daily jar testing, filters	RWC	C	1	Low	C	3	High	Colour has not >10 in the last years.
Coag4	Coagulation	Mechanical/equipment failure/maintenance of flocculators leading to water quality issues	Turbidity Pathogens	Operator monitoring by observation, O&M on equipment, operator training (and experience), observation of clarifier for colour change and daily jar testing, filters. Redundancy (2 can operate instead of 3). Alternative SUPPLY source.	RWC	D	2	Low	D	3	Moderate	Difficult to source replacement parts for the flocculators. Stability and low turbidity of the water means the uncontrolled risk is only a 3
Coag5	Coagulation	Raw water is too 'clean' causing flocculation to be less than optimum	Turbidity Pathogens	Operator monitoring by observation, operator training	RWC	D	1	Low	D	3	Moderate	Rated as a 3 for uncontrolled risks due to downstream impacts

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
				(and experience), daily jar testing, filters								
Coag6	Coagulation	Rapid change in raw water turbidity resulting in inability to treat	Turbidity Pathogens	Operator monitoring by observation, manual control over the dosing, O&M on equipment, calibration of testing equipment, operator training (and experience), observation of clarifier for colour change, filters, plant shutdown followed by jar test (and daily jar testing) monitor rainfall.	RWC	E	2	Low	E	4	High	Turbidity has only been above 10 NTU once in 5 years (related to bushfire?)
Clar 1	Clarification	Failure to clarify properly leading to water quality issues at the filter	Turbidity Pathogens	Automatic desludging, desludging valves, alternative supply	RWC	D	1	Low	D	2	Low	
Clar 2	Clarification	Bypass of the clarifier (during maintenace)	Turbidity Pathogens	Sand filters (direct filtration), controlled operation	RWC	E	2	Low	E	3	Moderate	Informal procedure to change over
F1	Filtration (mono media)	Short circuiting of filters leading to breakthroughs	Turbidity Pathogens	Backwash on headloss, filter run times, Operator monitoring by observation, manual control over the dosing, O&M on equipment, calibration of testing equipment, operator training (and experience), plant	RWC	C	3	High	B	4	Very High	

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
				shutdown followed by jar test (and daily jar testing), chlorination for chlorine sensitive pathogens								
F2	Filtration (mono media)	Poor filter performance e.g. filter nozzles, filter media loss, high loads in water, aborted backwash	Turbidity Pathogens	Backwash on headloss, filter run times, Operator monitoring by observation, manual control over the dosing, O&M on equipment, calibration of testing equipment, operator training (and experience), plant shutdown followed by jar test (and daily jar testing), chlorination for chlorine sensitive pathogens, plant shutdown on some failures.	RWC	C	2	Moderate	B	4	Very High	
F3	Filtration (mono media)	Filter ripening issues leading to pathogen breakthrough	Turbidity Pathogens	Disinfection for chlorine sensitive pathogens	RWC	D	1	Low	C	2	Moderate	
F4	Filtration (mono media)	Filter ripening issues leading to pathogen breakthrough	Crypto	No controls	RWC	C	2	Moderate	C	2	Moderate	Crypotosporidum is not considered a high risk in this water
Dis1	Disinfection (chlorine gas)	Overdosing of chlorine leading to high levels in finished water	T&O DBPs Chlorine	Operator training, Sampling, O&M, Dosing controls, customer complaint monitoring	RWC	E	2	Low	E	2	Low	

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
Dis2	Disinfection (chlorine gas)	Underdosing of chlorine (inc equipment failure or running out) leading to chlorine senstive pathogen survival in finished water (primary kill)	Turbidity Pathogens	Operator training, sampling at plant (daily) and in reticulation (weekly by RWC), O&M, Dosing controls, public health survellience (collected by Council ranges). Duty/stand by on chlorination bottles.	RWC	D	4	High	C	4	Very High	No telemetered chlorine monitoring
Dis3	Disinfection (chlorine gas)	High pH in the water causing issues such as skin rashes and reduced disinfection efficiency	Pathogens	Operator training, post dosing, wind down upstream dosing	RWC	B	2	High	B	2	High	pH range should be 7.8 - 8.2. Occurs a few times a year in higher range.
Dis4	Disinfection (chlorine gas)	Underdosing of chlorine resulting in lack of chlorine residuals in distribution system	Pathogens	Operator training, sampling at plant (daily) and in reticulation (weekly by RWC), O&M, Dosing controls, public health survellience (collected by Council rangers). Duty/stand by on chlorination bottles, NSW Health monitoring	RWC	A	2	High	A	4	Very High	
PD1	Post Dosing (stablisation)	Overdosing of Soda ash	high pH	Operator training, manual testing	RWC	C	2	Moderate	B	2	High	Can be >9 leaving the plant
CWT1	Clearwater Tank	Ingress into tank through integrity issues and potentially flood inundation from creek	Pathogens	Aqualift contractor checks and reports, chlorine residual, temporary bunding available (sand bags),	RWC	D	2	Low	C	4	Very High	

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
				alternative supply								
RW B1	Raw Water Bypass	Raw water can be connected into the distribution system downstream of the clearwater tank resulting in undisinfected water being supplied to customers	Pathogens	No handle on the valve	RWC	E	4	High	D	4	High	The bypass was designed as an emergency measure in the event of WTP failure to at least allow water to enter the distribution system. There is no SOP currently in place for managing the bypass. Raw water connections have been known to cause outbreaks in other systems.
DR1	Distribution Reservoirs	Low chlorine residuals resulting in the potential for water quality failure	Pathogens	Weekly testing, frequency of refill, closed reservoirs	RWC	B	3	High	B	3	High	Currently don't shock dose reservoirs. Candle St is the biggest and lowest turnover.
DR2	Distribution Reservoirs	Seasonal changes in water demand leading to water quality issues	Taste & odour, pathogens	Weekly testing, NSW Health monitoring, customer complaint monitoring	RWC	C	2	Moderate	C	2	Moderate	Assessment based more on complaints.
DR3	Distribution Reservoirs	Low turnover leading to water quality issues (common inlet outlet?)	Taste & odour, pathogens	Weekly testing, NSW Health monitoring, customer complaint monitoring	RWC	C	2	Moderate	C	2	Moderate	Cleaner LL, South Bigton, Barrangaroo are common inlet outlet reservoirs.
DR4	Distribution Reservoirs	Malicious contamination leading to water contamination	Various	Some security measures, Aqualift, facilities maintenance checks	RWC	C	3	High	B	5	Very High	A lead-acid battery and its charger were found at Starboard LL and removed by Aqualift.

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
DR5	Distribution Reservoirs	Reservoirs are not routinely maintained or checked resulting in water quality contamination eg gutter blockage and overflow, vermin access	Pathogens, turbidity, taste and odours	Aqualift contractor checks and reports, NSW Health testing	RWC	C	3	High	B	5	Very High	Bird access of distribution reservoirs has caused waterborne outbreaks in other jurisdictions resulting in illnesses and deaths. Dead birds were found inside Cleaner St LL, South Bigton and Wangwall.
CB1	Chlorine Boosters	Overdosing of chlorine leading to high levels in distribution water	DBPs, Taste and odour	Automatic control, flow paced, reticulation testing, customer complaints	RWC	D	2	Low	C	2	Moderate	Re-chlorination occurs at the Priest Street PS and the outlet of the Wangwall and Tindale Reservoirs
CB2	Chlorine Boosters	Underdosing of chlorine leading to low levels in distribution water	Pathogens	Automatic control, flow paced, reticulation testing, reservoir maintenance	RWC	C	4	Very High	B	4	Very High	Re-chlorination occurs at the Priest Street PS and the outlet of the Wangwall and Tindale Reservoirs. Priest Street supplies the hospital and therefore a vulnerable population.
CB3	Chlorine Boosters	Low turnover of hypochlorite leading to reduction of chlorine strength	Pathogens	Purchasing and storage				Uncertain			Uncertain	
FRS 1	Farmers River Source	Receipt of non-conforming water into Gollumville's distribution system resulting in water quality issues	Various	Agreement Concerning the Supply of Water from the Farmers River Water Supply	RWC/SW	C	3	High	B	5	Very High	E. coli is not listed as a parameter in the agreement. RWC has participated in a recent (August 2011) risk workshop with alternative supply from Farmers River.
FRS 2	Farmers River Source	Lack of maintenance of chlorine residual in water supplied from alternative	Pathogens	Agreement Concerning the Supply of Water from the		A	4	Very High	A	4	Very High	Agreement doesn't cover chlorine residual.

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
		supply		Farmers River Water Supply								
D1	Distribution	Aging infrastructure leading to ingress and water quality issues	Pathogens	Mains replacement program, monitoring, chlorine residual	RWC	B	2	High	A	2	High	
D2	Distribution	Reduced velocities in the main resulting in conditions that favour biofilm formation and sediment accumulation	Biofilms causing taste & odour problems, dirty water turbidity	Flushing as required - not programmed, chlorine residual, monitoring	RWC	B	2	High	A	2	High	
D3	Distribution	Mains break or perforation (air valves etc) leading to water quality issues	Pathogens	Air valves are all underground, chlorine residual	RWC	B	2	High	B	2	High	
D4	Distribution	Unsanitary repairs that lead to water quality issues	Pathogens	No formalised procedures, rely on experience of team, chlorine residual	RWC	D	3	Moderate	B	3	High	
D5	Distribution	Reverse flow sloughing biofilm leading to water quality complaints	Biofilms causing taste & odour problems, dirty water, turbidity	No formalised procedures, rely on experience of team, chlorine residual, customer complaints	RWC	C	2	Moderate	C	3	High	Complaints rather than health issue.
D6	Distribution	Plug flow leading to water stagnation issues in some areas	Taste & odour problems, dirty water, turbidity					Uncertain			Uncertain	
D7	Distribution	Backflow/cross connection leading to water contamination events	Various	DA Process, trade waste policy, some checking, capture of rainwater tank installations, section 68 approval for devices	RWC	C	4	Very High	C	4	Very High	
D8	Distribution	Dead end in reticulation systems leading to stagnation and water quality issues	Taste and odour, pathogens	Flushing, no dead ends in new developments	RWC	A	1	Moderate	A	1	Moderate	
D9	Distribution	Cast iron internals	Fe	Mains replaceme	RWC	C	1	Low	C	1	Low	

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
		corrode leading to water quality issues		nt program, monitoring, chlorine residual								
D10	Distribution	Cross-contamination from non-quarantining of sewer and water equipment eg CCTV during mains work	Pathogens	No formal checking, dedicated crews for water and sewer	RWC			Uncertain			Uncertain	
D11	Distribution	Use of fire hydrants stirring up the system and causing water quality incidents	Pathogens, chemicals	Testing of hydrants, positive pressure	RWC	D	2	Low	D	2	Low	
D12	Distribution	Illegal connections resulting in introduction of unknown hazards	Various	Some customer education, water balance	RWC	C	4	Very High	C	4	Very High	Large amount of non-revenue water noted in the system.
NPW1	Non-potable water at Taraville	Water being consumed as if it were potable	Pathogens	Information provided when first connected	RWC	A	4	Very High	A	4	Very High	Customers not consistently told that the water is non-potable
WOS1	Whole of System	Bushfire taking out Hokey Pokey Water Treatment Plant	All	Alternative supply. Maintain buffer around the plant.	RWC	E	2	Low	E	5	High	
WOS2	Whole of System	Incorrect or reduced quality of chemicals or wrong specification of chemicals resulting in overdosing , underdosing or contamination	Chemicals	General Purchasing and Procurement Policy Chemicals purchased from Orica Certificate of compliance supplied with every chemical batch	RWC	D	3	Moderate	C	3	High	
WOS3	Whole of System	Incorrect or reduced quality of materials resulting in potential for water quality contamination	Various	General Purchasing and Procurement Policy, review materials and specify what is to be used	RWC	D	2	Low	C	2	Moderate	
WOS4	Whole of System	Power failure resulting in non-conforming water	Various	UPS, distribution system backup	RWC	C	1	Low	E	1	Low	Booster stations - dosing would stop but there would be gravity flow still continuing.

No.	Process Step	How can the hazard be introduced? (hazards/ causes)	Contaminants (hazards)	Control measures currently in place	Respon-sibility to manage risk	L	C	Controlled Risk Score	L	C	Uncontrolled Risk Score	Basis/ Notes
WOS5	Whole of System	Disgruntled employees or contractors leading to malicious damage resulting in poor water quality (note that employees and contractors understand the system so would know where to act to cause most damage e.g. altering SCADA, contaminating clearwater tank etc)	Various		RWC	E	5	High	E	5	High	
WOS6	Whole of System	Failure of critical monitoring devices resulting in inability to pick up water quality issues	Various	Annual ABB Instrumentation contract calibration Meters calibrated monthly as per manufacturer's instructions	RWC	D	3	Moderate	C	4	Very High	
WOS7	Whole of System	Chemicals are delivered to incorrect storage resulting in process contamination or incorrect dosage	Chemicals, pathogens	Operators on site for each delivery, specific fittings	RWC	E	3	Moderate	D	3	Moderate	
WOS8	Whole of System	Operator training is not kept up to date resulting in potential for water contamination through incorrect operation of the water supply system	Various	Operator training (including lab skills, risk management and incident investigation, fluoridation of public water supplies, Water Operator Training Course)	RWC	E	3	Moderate	C	3	High	

APPENDIX D ACTION PLAN

Note that where specific procedures have been identified, these are presented in the right hand column and will be developed in conjunction with NSW Public Works (NSW PW).

Action No.	Event	Risk No.	Follow-up Actions	Responsibility	Procedure
A1	Rainfall following bushfire or grassfire resulting in run off into the catchment Bushfire taking out Hokey Pokey Water Treatment Plant	FC2, WOS1	Review procedures for bushfires in Emergency Response Plan including how Hokey Pokey WTP is managed.	RWC / NSW PW	Incident response plan (template to be developed by NSW PW)
A2	Accidents and spills on catchment roads into water causing water quality issues	FC4, FC5	Consider having an agreement in place with emergency services in the event that something happens in the water supply catchment.	RWC	
A4	Legal and illegal motorcycle track in head of catchment and 4WD causing erosion Recreational activities in the catchment (illegal) including 4WD, camping Recreational activities in the catchment (illegal)	FC6, FC8, FC9	Consider signage in the catchment (sect 632 LGA) to indicate that the catchment is used as a water supply catchment and to report any contamination to RWC.	RWC	
A5	Overloading of Motorcycle club septic system overflowing leading to pathogens in catchment	FC7	Review how the septic is managed at the club.	RWC	
A6	Recreational activities in the catchment (illegal)	FC9	Consider a review of the water quality monitoring program for catchment (to tap).	RWC / NSW PW	Drinking Water Monitoring Program (template to be developed by NSW Public Works)
A7	Illegal dumping in the catchment leading to water quality issues	FC10	Improve interagency communication.	RWC	Incident response plan (template to be developed by NSW PW)
A8	Illegal dumping in the catchment leading to water quality issues	FC10	Improve council departmental communication.	RWC	Clarifier bypass procedure
A9	Deliberate contamination of the reservoir	FCD2	Review Business Continuity Plan and Emergency Response Plan to cover water and sewer.	RWC / NSW PW	Incident response plan (template to be developed by NSW PW)
A10	Short circuiting of reservoir	FCD3	Review raw water quality data and inflows to reservoir (mm rain) to see if a relationship can be established.	RWC	
A11	Cross contamination of dam (farm dams etc) with helicopter access to fight fires	FCD4	Review procedures for bushfires in Emergency Response Plan.	RWC / NSW PW	Incident response plan (template to be developed by NSW PW)

Action No.	Event	Risk No.	Follow-up Actions	Responsibility	Procedure
A12	High levels of metals coming in from upstream sources	FCD6	Review raw water monitoring program.	RWC	
A13	Receipt of poor quality water into Fishers Creek Dam	CCS1	Formalise agreement with LoCoal Corp re water quality and communication protocols if treatment fails at LoCoal Corp.	RWC	
A14	Receipt of poor quality water into Fishers Creek Dam	CCS1	Review pipeline location for input of Percy Colliery Source in new configuration.	RWC	
A15	Receipt of poor quality water into Fishers Creek Dam	CCS1	Review water quality results that LoCoal Corp has to report on as part of its Environment Protection Licence.	RWC	
A16	Receipt of poor quality water into Fishers Creek Dam	CCS1	Check hydrocarbons in the Percy Colliery Source water to better assess risk.	RWC	
A17	Under or no dosing of soda ash causing pH lower than optimal for coagulation Overdosing of soda ash causing pH higher than optimal for coagulation	pH1, pH2	Consider moving to online, telemetered monitoring.	RWC	
A18	Rapid change in raw water turbidity resulting in inability to treat	Coag6	Consider online monitoring of raw water (turbidity, EC pH) with telemetery.	RWC	
A19	Bypass of the clarifier (during maintenance)	Clar2	Develop a formalised procedure for this process.	RWC	
A20	Short circuiting of filters leading to breakthroughs	F1	Review the need for individual filter turbidity meters.	RWC	
A21	Short circuiting of filters leading to breakthroughs Filter ripening issues leading to pathogen breakthrough	F1, F4	Consider undertaking individual filter monitoring once the media has been changed.	RWC	
A22	Poor filter performance e.g. filter nozzles, filter media loss, high loads in water, aborted backwash	F2	Develop a procedure for observation of the filters.	NSW PW	Filter inspection and backwash procedure
A23	Filter ripening issues leading to pathogen breakthrough	F4	Review the need for filter to waste.	RWC	
A24	Filter ripening issues leading to pathogen breakthrough	F4	Review the need for a water quality monitoring program for Cryptosporidium in the catchment.	RWC	
A25	Overdosing of chlorine leading to high levels in finished water	Dis1	Consider improving the chlorine dosing system.	RWC	
A26	Overdosing of chlorine leading to high levels in finished water	Dis1	Confirm the CT for the plant.	RWC	
A27	Underdosing of chlorine (inc equipment failure or running out) leading to chlorine senstive pathogen survival in finished water (primary kill)	Dis2	Consider an on-line chlorine residual analyser with telemetry.	RWC	
A28	Underdosing of chlorine (inc equipment failure or running out) leading to chlorine senstive pathogen survival in finished water (primary kill)	Dis2	Review chlorination procedures (plant shut down on chlorine failure etc).	NSW PW	CCP response procedures
A29	Underdosing of chlorine (inc equipment failure or running out) leading to chlorine senstive pathogen survival in finished water (primary kill)	Dis2	Formalise current procedures for managing chlorination and testing.	NSW PW	CCP response procedures
A30	High pH in the water causing issues such as skin rashes and reduced disinfection efficiency	Dis3	Review how pH is monitored and where.	RWC	
A31	High pH in the water causing issues such as skin rashes and reduced disinfection efficiency	Dis3	Consider whether stabilisation of water is needed.	RWC	
A32	Underdosing of chlorine resulting in lack of chlorine residuals in distribution system	Dis4	Review reticulation monitoring plan for location and frequency.	RWC	
A33	Overdosing of Soda ash	PD1	Review reasons for pH increases	RWC	

Action No.	Event	Risk No.	Follow-up Actions	Responsibility	Procedure
			including plant and reticulation issues.		
A34	Raw water can be connected into the distribution system downstream of the clearwater tank resulting in undisinfected water being supplied to customers	RWB1	Develop SOP for managing the bypass including the O&M of the bypass infrastructure.	RWC	
A35	Low chlorine residuals resulting in the potential for water quality failure	DR1	Consider shock dosing of reservoirs.	NSW PW	Reservoir shock dosing procedure
A36	Low chlorine residuals resulting in the potential for water quality failure Reservoirs are not routinely maintained or checked resulting in water quality contamination eg gutter blockage and overflow, vermin access	DR1, DR5	Consider having reservoir inspection procedures and checklists.	NSW PW	Reservoir inspection checklist
A37	Low turnover leading to water quality issues (common inlet outlet?)	DR3	Review asset ownership between RWC and Bulk Water Corp.	RWC	
A38	Low turnover leading to water quality issues (common inlet outlet?)	DR3	Make sure asset agreements are in place between RWC and Bulk Water Corp.	RWC	
A39	Malicious contamination leading to water contamination	DR4	Consider undertaking a security vulnerability assessment on all assets.	RWC	
A40	Low turnover of hypochlorite leading to reduction of chlorine strength	CB3	Actions required for appropriate storage of chemicals.	RWC	
A41	Receipt of non-conforming water into Gollumville's distribution system resulting in water quality issues	FRS1	Agreement between RWC and Bulk Water Corp needs to be reviewed and tightened in terms at least water quality to meet ADWG levels, communication protocols in case of non-conformance, chlorine residual adequacy in the water supplied to Dalry and Wangwall and Fe and Mn management.	RWC	
A42	Aging infrastructure leading to ingress and water quality issues	D1	Adequacy of asset replacement program to be considered.	RWC	
A43	Aging infrastructure leading to ingress and water quality issues	D1	Asset management and asset condition assessment are not being done and need to be reviewed.	RWC	
A44	Mains break or perforation (air valves etc) leading to water quality issues Unsanitary repairs that lead to water quality issues	D3, D4	Formalise mains repair procedures including review of ADWG guidance.	RWC	Mains break and repair procedure
A45	Reverse flow sloughing biofilm leading to water quality complaints	D5	Formalise procedures relating to switching between water supplies (Farmers River WS/RWC).	RWC	Water Source changeover procedure
A46	Plug flow leading to water stagnation issues in some areas	D6	Review system for examination and management of reticulation water age issue.	RWC	
A47	Backflow/cross connection leading to water contamination events	D7	Ensure that a register is in place for all backflow devices installed and checking frequencies.	RWC	
A48	Dead end in reticulation systems leading to stagnation and water quality issues	D8	Procedure required for flushing.	RWC	Reticulation flushing procedure
A49	Dead end in reticulation systems leading to stagnation and water quality issues	D8	Review areas of dead ends to see if they can be reticulated.	RWC	
A50	Cast iron internals corrode leading to water quality issues	D9	Need to include cast iron mains in asset management program when developed.	RWC	
A51	Cross-contamination from non-quarantining of sewer and water equipment eg CCTV during mains work	D10	Review how contractors check their equipment.	RWC	
A52	Illegal connections resulting in introduction of unknown hazards	D12	Consider undertaking a more in depth system modelling to better understand	RWC	

Action No.	Event	Risk No.	Follow-up Actions	Responsibility	Procedure
			water balance.		
A53	Water being consumed as if it were potable	NPW1	Review how the potable water system is dealt with in terms of communication and education (see guidance from NSW Health).	RWC	
A54	Incorrect or reduced quality of chemicals or wrong specification of chemicals resulting in overdosing , underdosing or contamination	WOS2	Need to review how chemicals are dealt with in council.	NSW PW	Chemical receiving and QA procedure
A55	Disgruntled employees or contractors leading to malicious damage resulting in poor water quality (note that employees and contractors understand the system so would know where to act to cause most damage e.g. altering SCADA, contaminating clearwater tank etc)	WOS5	Review how contractors and outgoing staff are managed.	RWC	Employee exit procedure
A56	Failure of critical monitoring devices resulting in inability to pick up water quality issues	WOS6	Develop calibration records (being done).	RWC / NSW PW	Instrument calibration record (template to be developed by NSW PW)
A57	Various operations	Added Post Workshop	Develop a list of SOPs for WTP and Retic operations	RWC / NSW PW	SOPs (list and some SOPs to be developed by NSW PW)
A58	Critical Control Point Management	Added Post Workshop	Develop flowchart for CCP management	Public Works	CCP response procedures