Coastal Shire Council

Risk Assessment Workshop Summary

Coastal River Water Supply Scheme

Version 5.0. Date 29th June 2012.

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EXECUTIVE SUMMARY

BACKGROUND TO RISK ASSESSMENT PROCESS

As part of a pilot program involving four NSW council local water utilities, Coastal Shire Council has partnered with NSW Health and the NSW Office of Water in developing a Drinking Water Management System consistent with the Framework for Management of Drinking Water Quality in the Australian Drinking Water Guidelines 2011 - "the Framework" (NHMRC/NRMMC 2011). The implementation of such a system is required to conform to the *Public Health Act 2010* (NSW) (the Act) (NSW Government 2010) and its supporting regulation (in development). The Act sets out the need for a *Quality Assurance Program* (QAP), which would ideally be consistent with the Framework as a model for best practice.

A key part of the Framework is the water quality risk assessment process. This document summarises the risk assessment process completed by Council through a series of workshops held during September 2011. The process involved the following steps:

- Summarising the water supply system using a system description and process flow diagram.
- Summarising pertinent water quality data.
- Reviewing the above information and assessing risks using a workshop approach.
- Identifying critical control points using a workshop approach.

SUMMARY OF RISKS IDENTIFIED

The workshop risk assessment team identified 43 risks for the Coastal River Water Supply Scheme. The risk distribution of the residual (controlled) risks arising from the risk assessments is shown in the following table. Some 19 actions to address significant risks were identified as part of an Action Plan which is carried into the main Drinking Water Management System (DWMS) document.

Residual (controlled) risk distribution

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Aquifer and borefield				2		2
Balance Tanks				2		2
Borefield Catchment System		4	1	4		9
Chlorination	1	1		1		3
CO_2 dosing				2		2
Collection tank				1		1
Distribution		2		4		6
Fluoridation			1	1		2
Lime dosing				3		3
Rising main				1	1	2
Service reservoirs			1	3		4
Whole of Scheme		2	1	1		4
Whole of System				3		3
Sub-total	1	9	4	28	1	43

1 INTRODUCTION

Coastal Shire Council has partnered with NSW Health and the NSW Office of Water in developing a drinking water quality management plan consistent with the Framework for Management of Drinking Water Quality in the Australian Drinking Water Guidelines 2011 (ADWG) - "the Framework" (Table 1-1 and Figure 1-1) (NHMRC/NRMMC 2011). The document has been developed to conform to the *Public Health Act 2010* (NSW) (the Act) (NSW Government 2010) and its anticipated supporting regulation (in development). The Act sets out the need for a *Quality Assurance Program* (QAP) which would ideally be consistent with the Framework as a model for best practice.

The Framework was developed to guide the design of a structured and systematic approach for the management of drinking water quality and includes twelve elements that are considered good practice for systematic management of drinking water supplies. The Framework is effectively a quality management system that has been developed specifically for the water industry. The framework incorporates a preventive risk management approach from catchment to consumer and includes elements that are analogous to relevant aspects of generic management systems such as:

- Hazard Analysis and Critical Control Point (HACCP);
- Food Safety Management Systems-Requirements for any Organization in the Food Chain (ISO 22000);
- Quality Management Systems (ISO 9001); and
- Risk Management (ISO 31000:2009).

Table 1-1 Framework for Management of Drinking Water Quality (ADWG 2011).

1. Commitment to Drinking Water Quality Management	6. Management of Incidents and Emergencies
Drinking water quality policy	Communication
Regulatory and formal requirements	Incident and emergency response protocols
Engaging stakeholders	7. Employee Awareness and Training
2. Assessment of the Drinking Water Supply System	Employee awareness and involvement
Water supply system analysis	Employee training
Assessment of water quality data	8. Community Involvement and Awareness
Hazard identification and risk assessment	Community consultation
3. Preventive Measures for Drinking Water Quality Management	Communication
Preventive measures and multiple barriers	9. Research and Development
Critical control points	Investigative studies and research monitoring
4. Operational Procedures and Process Control	Validation of processes
Operational procedures	Design of equipment
Operational monitoring	10. Documentation and Reporting
Corrective action	Management of documentation and records
Equipment capability and maintenance	Reporting
Materials and chemicals	11. Evaluation and Audit
5. Verification of Drinking Water Quality	Long-term evaluation of results
Drinking water quality monitoring	Audit of drinking water quality management
Consumer satisfaction	12. Review and Continual Improvement
Short-term evaluation of results	Review by senior executive
Corrective action	Drinking water quality management
	Improvement plan

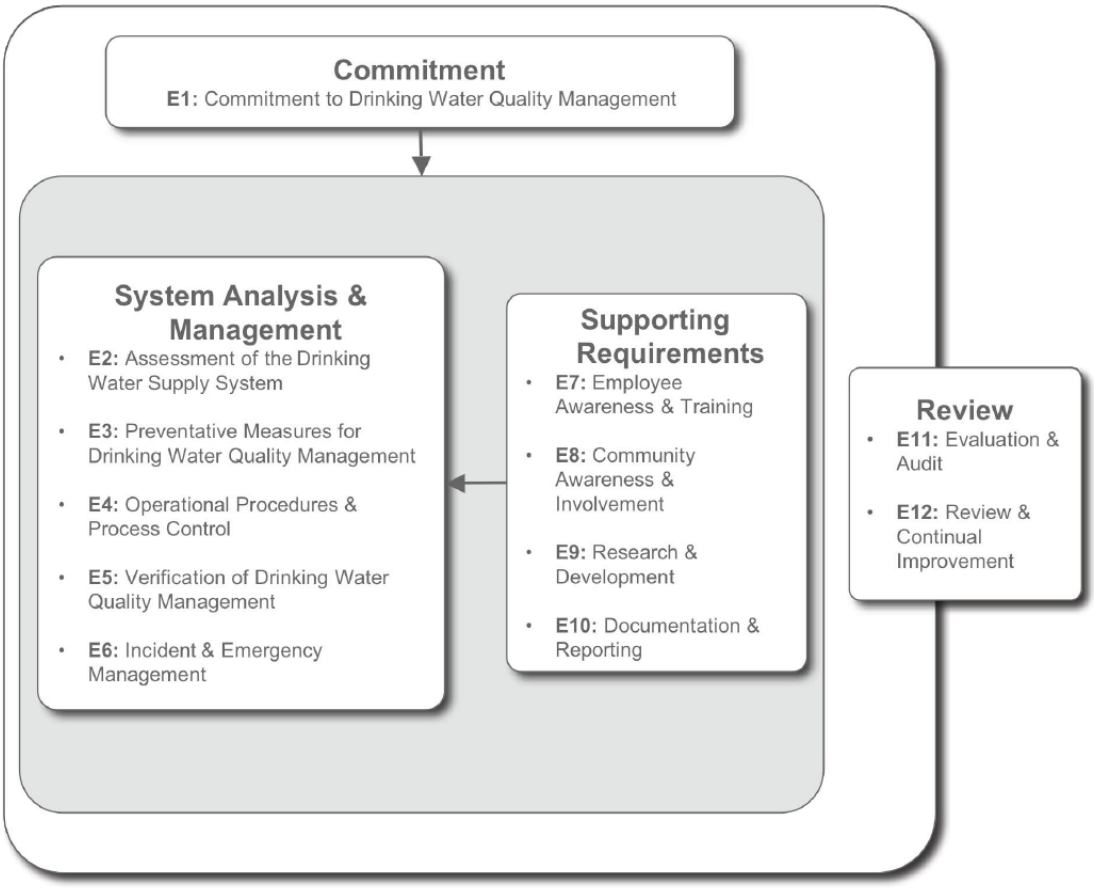


Figure 1-1. Diagrammatic representation of the Framework for Management of Drinking Water Quality (adapted from ADWG, 2011).

1.1 STRUCTURE OF THE DOCUMENT

This document summarises the implementation of parts of Elements 2 to 3 of the Framework and is structured in accordance with relevant components of the ADWG.

2 ELEMENT 2 - ASSESSMENT OF THE DRINKING WATER SUPPLY SYSTEM

Element 2 has three components:

- Water supply system analysis;
- Assessment of water quality data; and
- Hazard identification and risk assessment.

2.1 WATER SUPPLY SYSTEM ANALYSIS

Prior to completing the workshop, the system was described as recommended by the ADWG Framework.

Actions

- Assemble a team with appropriate knowledge and expertise.
- Construct a flow diagram of the water supply system from catchment to consumer.
- Assemble pertinent information and document key characteristics of the water supply to be considered.
- Periodically review the water supply system analysis.

2.1.1 Team with appropriate knowledge and expertise

Coastal Shire Council undertook a water quality risk assessment process for its water supply system on 27th and 28th September 2011. Coastal Shire Council staff and external specialists have been involved in assessing and documenting risks to drinking water quality and constitute the Risk Assessment Team (Table 2-1).

Table 2-1. Risk Assessment Team

Organisation	***Position***
Coastal Shire Council	Manager Water & Sewerage
	Water & Sewerage Engineer
	Water & Sewerage Supervisor
	Water Leader/Operator
	Water Operator
NSW Department of Health	Area Health Service Public Health Unit Environmental Health
	NSW Health Water Unit representative
Office of Water	Regional representative
	Inspector for the area
	Head Office representative
Independent technical consultant	Water engineering consultant involved in assisting Council develop procedures to support the DWMS
Water quality management system consultant	Facilitation and water quality risk assessment consultant to independently facilitate the workshop and assist Council develop the DWMS (team of two used)

2.1.2 Flow diagram of the water supply system from catchment to consumer

A conceptual flow diagram for the system is shown in Figure 2-1. The purpose of this diagram is to show key inputs, steps and flow direction.

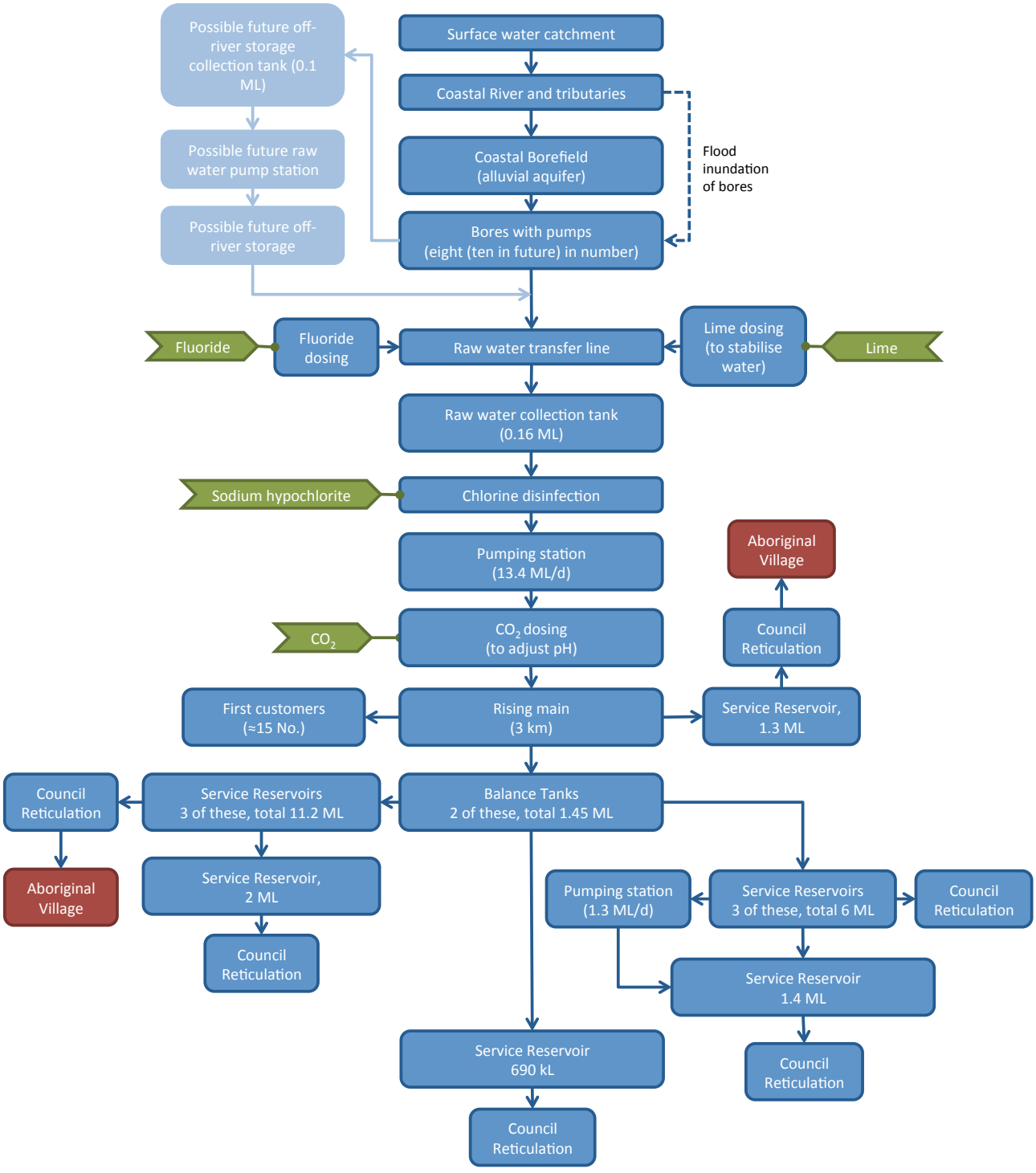


Figure 2-1. Conceptual process flow diagram of the Coastal NSW water supply system.

2.1.3 Pertinent information and key characteristics of the water supply to be considered

This section summarises the Coastal District Water Supply (CDWS) scheme. An overview of the scheme is given in Table 2-2 and in further detail in the Drinking Water Management System document, provided separately.

Table 2-2. Water supply system – overview description.

SYSTEM COMPONENT	DETAILS
Population Served (2007 estimate)	Town 1 992 Town 2 2,705 Town 3 5,984 Town 4 1,486 Town 5 1804 Rural area 1,069 Total 13,040
Water Source	Open rural residential, grazing and horticultural catchments supplying the Bores, pumping from an alluvial aquifer borefield (eight bores) on Coastal River upstream of the tidal limit with a capacity of 23.4 ML/d.
Raw Water Storage	Alluvial aquifer
Water Treatment	Coastal Water Treatment Plant: • 0.16 ML collection tank • Lime dosing • Carbon dioxide dosing • Fluoride dosing • Chlorine dosing with sodium hypochlorite dosed on automatic feedback loop
Storage After Treatment	• 13.4 ML/d pumping station • 3 km of 450 mm MSCL rising main • Two balance tanks to the east of the site with combined capacity of 1.45 ML.
Distribution of Product	• Gravitates from the treatment plant balance tanks to the first set of service reservoirs (three, combined capacity 11.2 ML), or a second set of three reservoirs (three, combined capacity 6.0 ML). • 1.3 ML/d capacity booster pump station downstream of the service reservoir supplies a secondary reservoir (1.4 ML capacity) during periods of high demand. All other times the secondary reservoir service area is served via gravity flow. • Water gravitates from the main service reservoirs to additional service reservoirs (2.0 ML capacity). • An off-take from the main balance tank rising main serves an additional service reservoir (1.3 ML reservoir). • A 690 kL concrete reservoir serves a rural residential estate. • There are two aboriginal villages at that are serviced by council (covered in separate plans).
Any Special Controls Required	Avoidance of inundated bores following flood events and cleaning of bores after those events Peak tourism periods

2.2 ASSESSMENT OF WATER QUALITY DATA

Actions

- Assemble historical data from source waters, treatment plants and finished water supplied to consumers (over time and following specific events).
- List and examine exceedances.
- Assess data using tools such as control charts and trend analysis to identify trends and potential problems.

2.2.1 Historical data from source waters, treatment plants and finished water supplied to consumers (over time and following specific events)

Water quality information was collected from the raw water, treatment plant and finished water supplied to consumers. Raw water and treated water data is electronically recorded daily on the plant water quality spreadsheets and analysed monthly for trends. These results are reported in the Council operations section monthly, quarterly and annual reports. Historical summaries are given in Appendix A and Table 2-3, below.

2.2.2 List and examine exceedances

Finished water supplied to consumers is collected and analysed as part of the NSW Health Drinking Water Monitoring Program. Health-related water quality exceedances are reported to the council and local Public Health Unit by telephone and fax and are recorded in the NSW Drinking Water Database. Summaries of exceedances are given in Appendix A and Table 2-3 and Table 2-4, below.

2.2.3 Assessment of data using tools such as control charts and trend analysis to identify trends and potential problems

Time series plots and statistical tables of water quality are given in Appendix A. Water quality data were sourced from Council and via the NSW Drinking Water 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. The water quality parameters are summarised in Table 2-3 and Table 2-4, below.

Table 2-3. Summary of water quality data (NSW Drinking Water Monitoring Program Data for treated water between 23 January 2001 and 13 September 2011).

Parameters	Number of Samples	Minimum	Mean	95%ile	Maximum	ADWG guideline value	No. of exceedances
pH	545	6.5	7.5	8.1	8.8	6.5 - 8.5	3
True Colour (HU)	100	1.0	0.7	1.8	3.0	15	0
Turbidity (NTU)	442	0.16	0.9	2.2	36.7	1 (desirable*) 5 (aesthetic)	68 4
Iron (mg/L)	111	0.01	0.14	0.14	5.87	0.3	2
Manganese (mg/L)	135	0.006	0.006	0.005	0.385	0.1 (aesthetic) 0.5 (health)	1 0
Total coliforms (CFU or MPN/100 ml)	1214	0	1	0	> 200	N/A	41 > 1
***E. coli* (CFU or MPN/100 ml)**	1214	0	0	0	> 200	0	5
Total Hardness (mg/L as $CaCO_3$)	111	23	48	60	129	200	0
Fluoride	132	0.10	0.87	1.10	1.31	0.9 - 1.1 (operational) 1.5 (health)	60 0

**this guideline value is the desirable turbidity at the point of disinfection and can be exceeded further into the reticulation system.*

Table 2-4. Water quality issues based on water quality data.

Issue	Frequency	Comment
pH	Rarely	pH hasn't been outside the guideline values since around 2004
Turbidity	Regularly	Raw turbidity regularly exceeds 1 NTU Reticulated turbidity historically exceeds 5 NTU at times
E. coli	Rarely	*E. coli* has only rarely been above the guideline value and not for many years
Fluoride	Often	Fluoride is often below the desirable operational target

2.3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

Actions

- Define the approach and methodology to be used for the hazard identification and risk assessment.
- Identify and document hazards sources and hazardous events for each component of the water supply system.
- Estimate the level of risk for each identified hazard or hazardous event.
- Evaluate the major sources of uncertainly associated with each hazard and hazardous event and consider actions to reduce uncertainty.
- Determine significant risks and document priorities for risk management.
- Periodically review and update the hazard identification and risk assessment to incorporate any changes.

1.1.1.1 APPROACH AND METHODOLOGY

The approach and methodology used to assess risk followed the example given in the ADWG. A workshop process was used to complete the risk assessment. A preliminary set of hazard and risk scenarios were provided in the workshop to provide participants with worked examples and to help facilitate discussion. Participants then added to these identified risks. The results were captured during the workshop via an Excel® spreadsheet (Appendix B). The risk assessment workshop was conducted on 27th and 28th September 2011 at Council's offices.

1.1.1.2 IDENTIFY AND DOCUMENT HAZARDS SOURCES AND HAZARDOUS EVENTS

Hazardous events and hazards were identified for each process step as shown in Appendix B. The workshop objectives included understanding and prioritising (assessing) the events, hazards and risks to drinking water consumers. Key terms used in the risk assessment were as given in the ADWG:

Hazard A biological, chemical, physical or radiological agent that has the potential to cause harm.

[Examples of hazards might be:

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

Hazardous events An incident or situation that can lead to the presence of a hazard (what can happen and how)

[Examples of a hazardous events might be:

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

The hazards identified as exceedances were considered in the risk assessment. In addition, during 2011 a preliminary risk assessment was drafted, but not completed, for the proposed future upgrade with the off-river storage. Key risks relevant to the current scheme that were noted in the risk assessment included turbidity during floods and inundation of the bores during floods.

1.1.1.3 ESTIMATE THE LEVEL OF RISK

Riskposed by each of the events were assessed, through a consideration of likelihood and consequence, as per the ADWG example, reproduced here for ease of reference. Likelihood (Table 2-5) x Consequence (Table 2-6) was assessed with the risk assessment matrix being used to assess risks (Table 2-7). This

approach is illustrated in the risk assessment worksheet (Appendix B). Risk was defined as given in the ADWG:

Risk	The likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the severity of the consequences
Maximum Risk	Risk assessed in the absence of preventive measures
Residual Risk	Risk assessed after consideration of existing preventive measures

Table 2-5. 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 2-6. 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 2-7. 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

1.1.1.4 EVALUATION OF THE MAJOR SOURCES OF UNCERTAINLY

Uncertainty was not explicitly assessed, but follow up actions were recorded where risks were considered to need additional information to improve their assessment. In addition, the basis for risk scoring was recorded in the risk assessment worksheets (Appendix B).

1.1.1.5 DETERMINE SIGNIFICANT RISKS AND DOCUMENT PRIORITIES

Significant risks were those that were not "low". Significant risks were considered further to determine the controls in place, and their effectiveness.

In total, 43 risks were identified. A detailed breakdown of the identified risks is given in Appendix B. A summary of the risks identified and their distribution is given for the residual (controlled) (Table 2-8) and maximum (uncontrolled) (Table 2-9) situations.

Table 2-8. Residual (controlled) risk distribution.

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Aquifer and borefield				2		2
Balance Tanks				2		2
Catchment System		4	1	4		9
Chlorination	1	1		1		3
CO_2 dosing				2		2
Collection tank				1		1
Distribution		2		4		6
Fluoridation			1	1		2
Lime dosing				3		3
Rising main				1	1	2
Service reservoirs			1	3		4
Whole of Scheme		2	1	1		4
Whole of System				3		3
Sub-total	1	9	4	28	1	43

Table 2-9. Maximum (uncontrolled) risk distribution.

Process step	Very High	High	Moderate	Low	Unrated	Sub-total
Aquifer and borefield	1	1				2
Balance Tanks	1		1			2
Catchment System	4	3	1	1		9
Chlorination	2			1		3
CO_2 dosing		1	1			2
Collection tank		1				1
Distribution	1	2	1	2		6
Fluoridation		1		1		2
Lime dosing		2		1		3
Rising main				1	1	2
Service reservoirs	1	1	1	1		4
Whole of Scheme	1	2	1			4
Whole of System				3		3
Sub-total	11	14	6	11	1	43

1.1.1.6 PERIODICALLY REVIEW AND UPDATE

The information contained within this document is current at the time of writing. The information will need to be periodically reviewed and updated. The information will be formally reviewed annually and updated in response to significant system changes.

3 ELEMENT 3 - PREVENTIVE MEASURES FOR DRINKING WATER QUALITY MANAGEMENT

3.1 PREVENTIVE MEASURES AND MULTIPLE BARRIERS

Actions

- Identify existing preventive measures from catchment to consumer for each significant hazard or hazardous event and estimate the residual risk.
- Evaluate alternative or additional preventive measures where improvement is required.
- Document the preventive measures and strategies into a plan addressing each significant risk.

3.1.1 Identify existing preventive measures from catchment to consumer for each significant hazard or hazardous event and estimate the residual risk.

Preventive measures were defined as suggested in the ADWG and the term 'controls' or 'control measures' was used interchangeably with 'preventive measures'. In outline, the definition used was as follows:

Preventive measures

Processes that reduce the hazard or the hazardous event:

Examples of preventive measures include:

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

The residual risk was then assessed, as shown in Appendix B.

3.1.2 Evaluate alternative or additional preventive measures where improvement is required.

The preventive measures for the water supply system explicitly encompassed within the risk assessment have been considered adequate to control the risks. Improvement processes and other follow up actions were recorded where risks were considered to need additional mitigation (Appendix B).

3.1.3 Document the preventive measures and strategies into a plan addressing each significant risk.

The preventive measures and strategies for addressing the significant risks are summarised in the following section that deals with Critical Control Points.

3.2 CRITICAL CONTROL POINTS

Actions

- Assess preventive measures from catchment to consumer to identify critical control points.
- Establish mechanisms for operational control.
- Document critical control points, critical limits and target criteria.

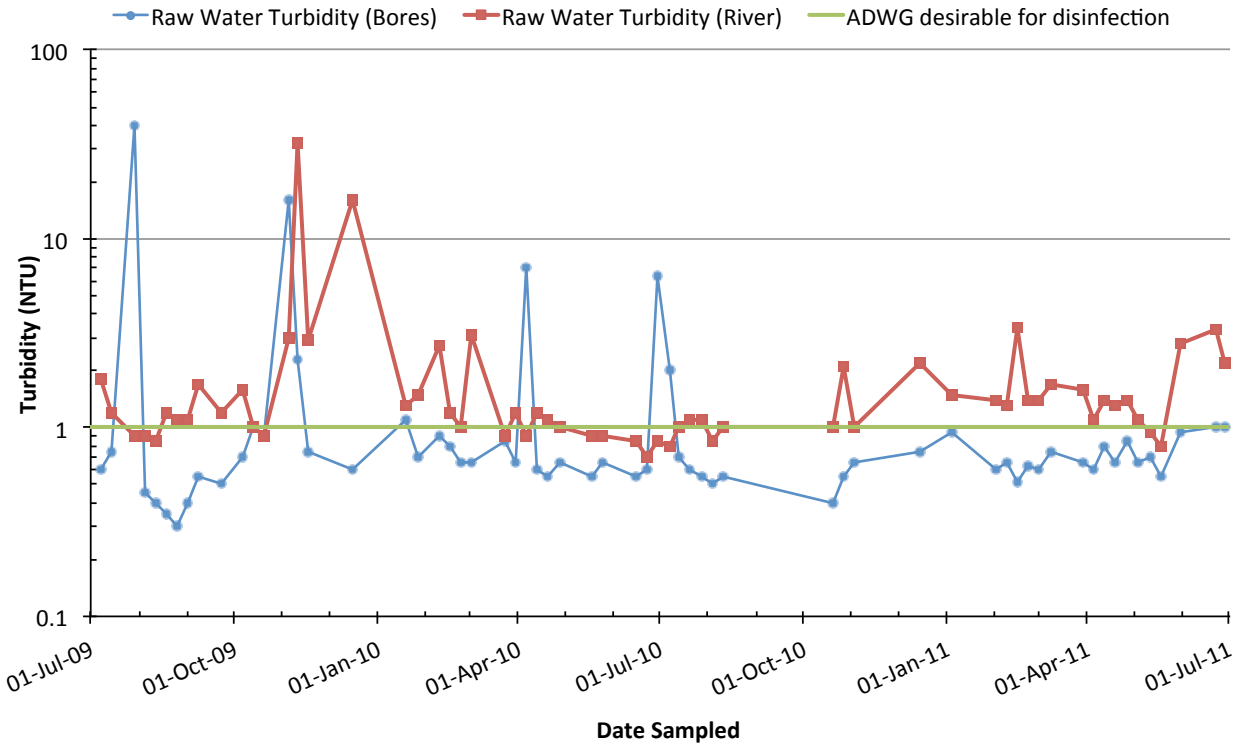
3.2.1 Assess preventive measures from catchment to consumer to identify critical control points

Critical control points were selected as follows, based on their necessity to manage significant risks:

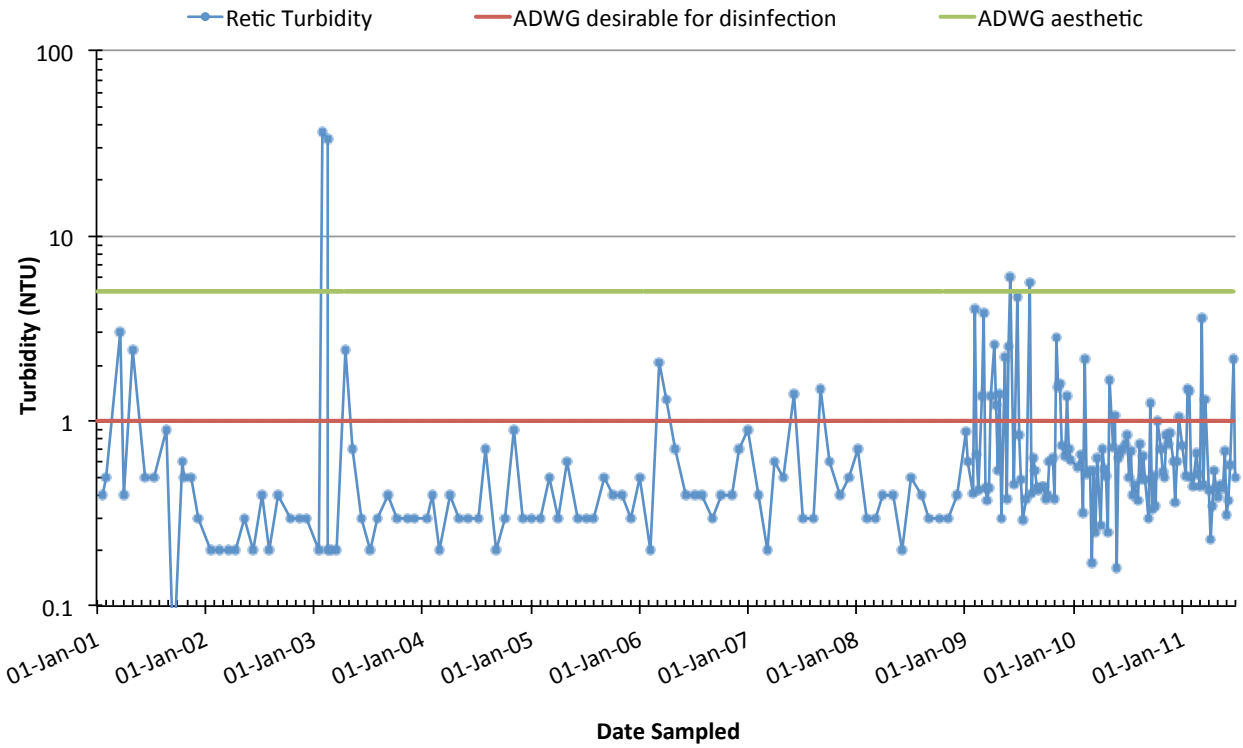
- 1. Raw water abstraction
- 2. Well head protection
- 3. Chlorine disinfection
- 4. Fluoride dosing
- 5. Distribution reservoirs
- 5. Reticulation
- 6. Customer connections

Further detail on the critical control points and other preventive measures is given in the Drinking Water Management System document, provided separately.

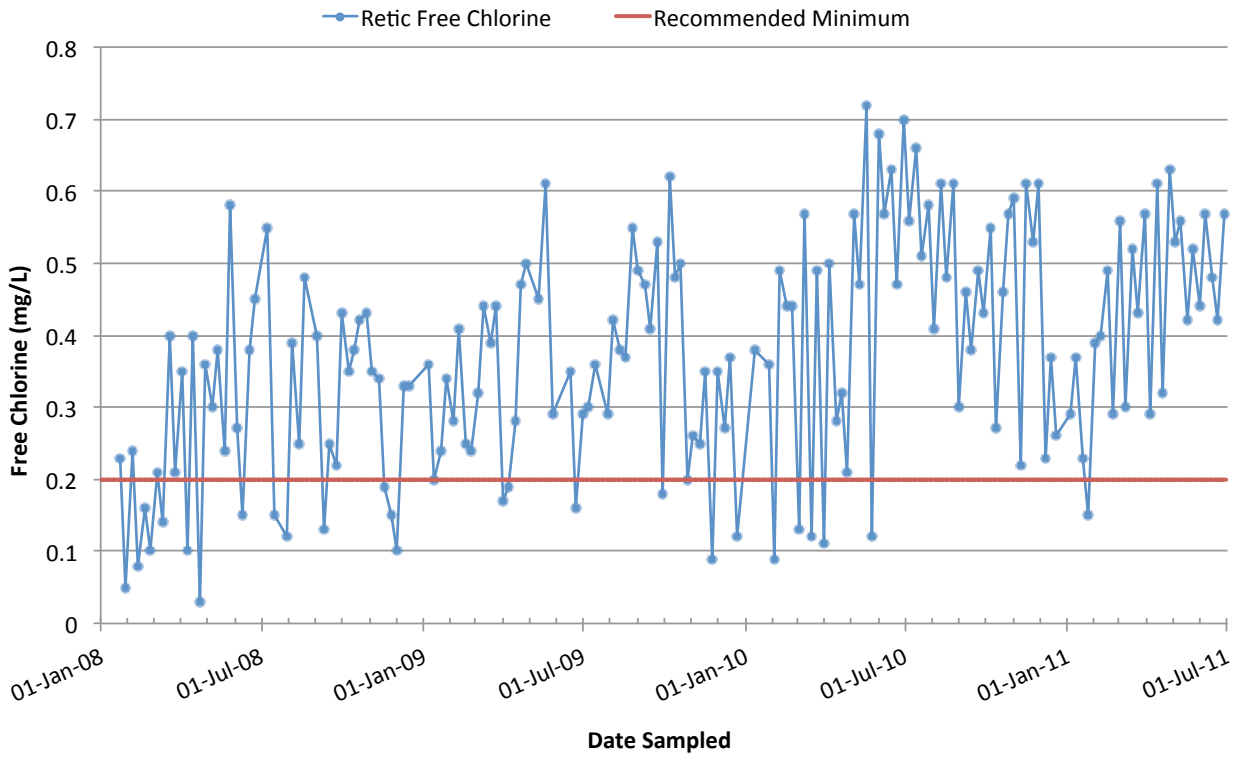
APPENDIX A. WATER QUALITY DATA TIME SERIES.



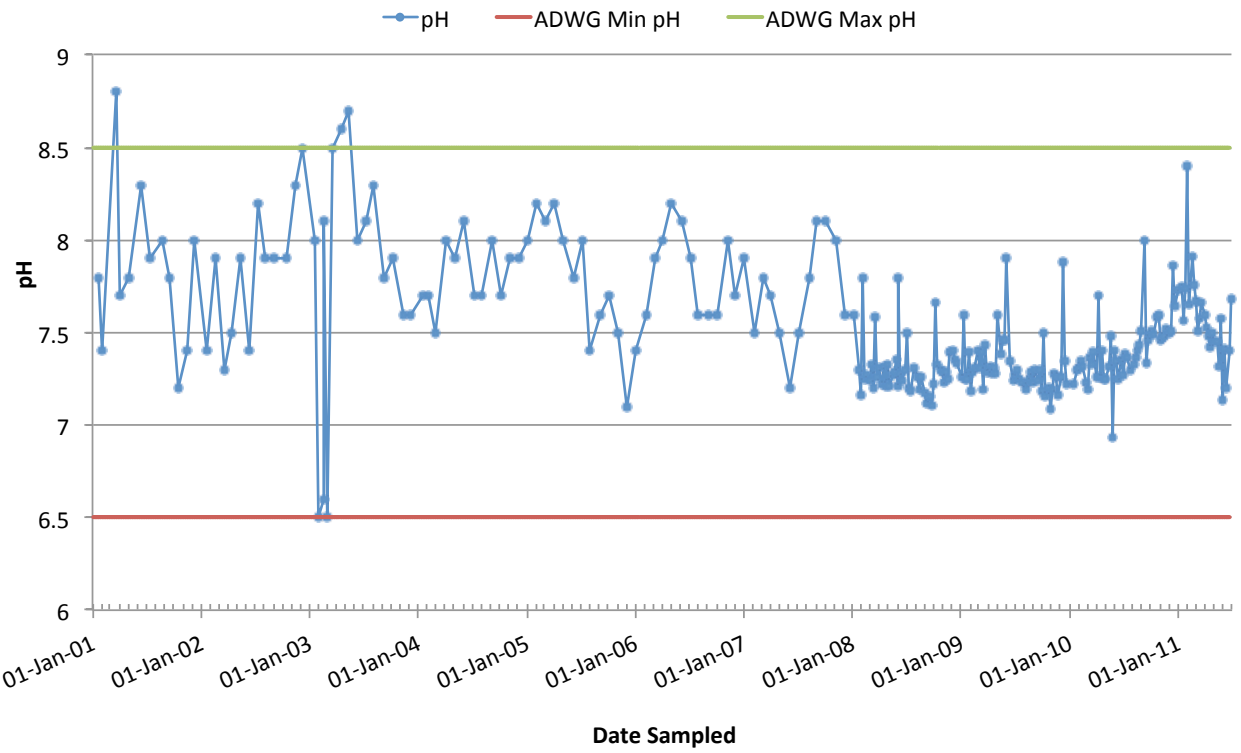
Raw water turbidity



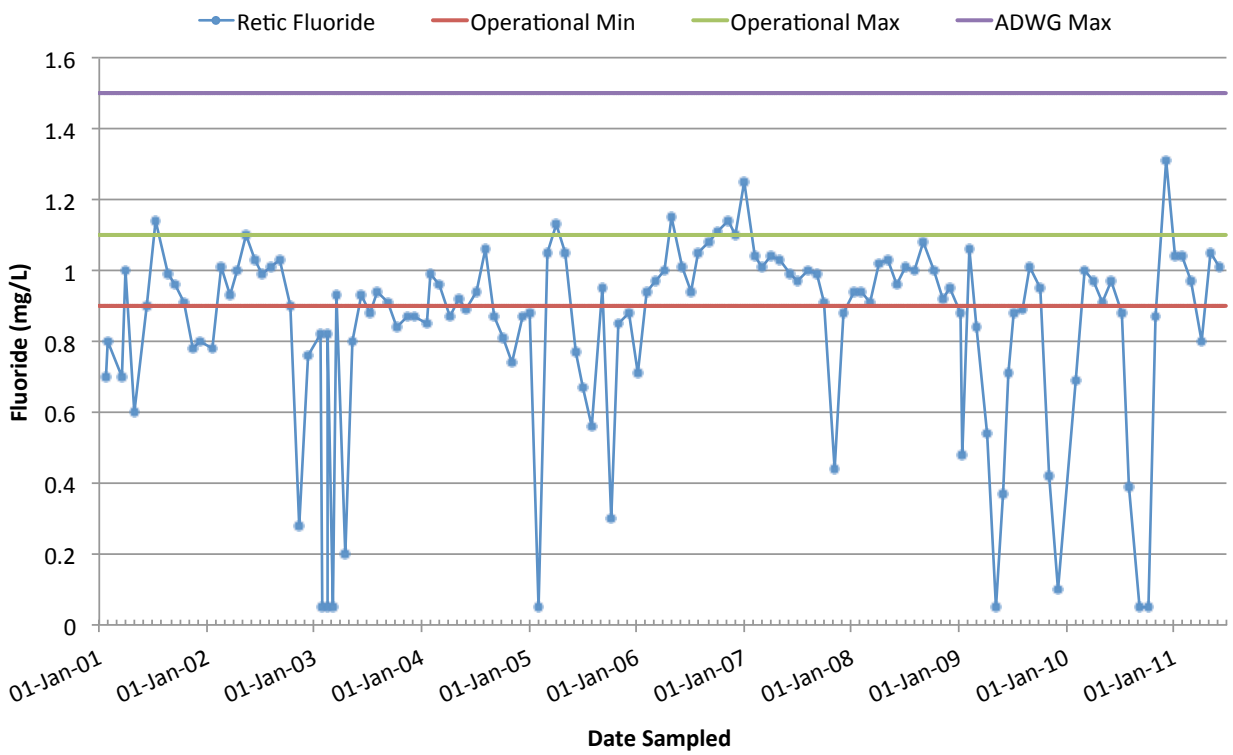
Treated water turbidity in the reticulation system



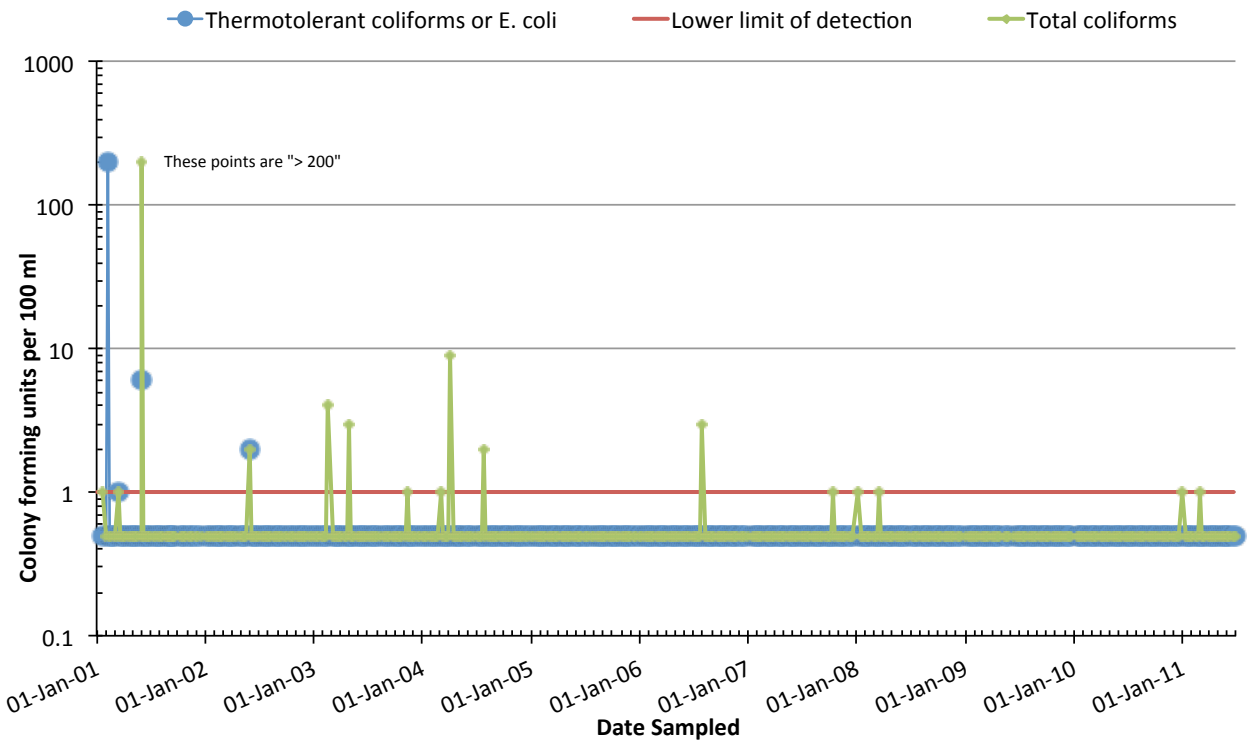
Treated water chlorine in the reticulation system



Treated water in the reticulation system



Treated water fluoride in the reticulation system



Treated water microbial indicators in the reticulation system

APPENDIX B. RISK ASSESSMENT WORKSHEET.

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
						Likelihood	Consequence	Risk	Likelihood	Consequence	Risk		
1	Borefield Catchment System	Pathogens from rural and agricultural faecal inputs reaching the bores when bores are not inundated	Chlorine-resistant pathogens e.g. *Cryptosporidium*	- Physical removal via alluvial aquifer - LEP development controls: no subdivisions or intensive agriculture (linked to wellhead protection plan) - Septic systems to be registered and inspected annually on a risk-based priority	Council	E	4	High	C	4	Very High	Only limited stock: only one dairy, mostly beef grazing. Some cattle have access to the river. No historical reports of health consequences from NSW Health bulletin. Bores estimated at tens of m from the main river channel, some down to around 15 m.	
2	Borefield Catchment System	Pathogens from rural and agricultural faecal inputs reaching the bores when bores are not inundated	Chlorine-sensitive pathogens e.g. *E. coli* and viruses	- Physical removal via alluvial aquifer - Chlorine - LEP development controls: no subdivisions or intensive agriculture (linked to wellhead protection plan) - Septic systems to be registered and inspected annually on a risk-based priority	Council	E	4	High	C	4	Very High	The chlorine dosing system has been reliable. The residuals and microbial indicators suggest that disinfection is effective.	
3	Borefield Catchment System	Pathogens from rural and agricultural faecal inputs reaching the bores when bores are inundated via backflow into drainage line and gaps in the well capping	Chlorine-resistant pathogens e.g. *Cryptosporidium*	- Avoid use of the three highest risk bores when potentially inundated - Flush and clean bores after floods - LEP development controls: no subdivisions or intensive agriculture (linked to wellhead protection plan) - Septic systems to be registered and inspected annually on a risk-based priority	Council	E	4	High	A	4	Very High	Concern relates to ability to shut off bores prior to inundation. Risk as ranked is as low as reasonably practical (ALARP)	Review some sort of warning system such as river level to enable early shut-off of bores. Review turbidity monitoring of bores to pick up inundation. Include bore sealing in capital works improvements. Start daily testing of Tb against a 1 NTU target value at the combined water.

No.	Process Step	Hazardous events (how can the hazard be introduced)?	Hazards (contaminants)	What preventive measures are currently in place (controls)	Responsibility to manage risk	Residual			Maximum			Notes on the basis of risk scoring	Follow-up actions to reduce risks or risk assessment uncertainties
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4	Borefield Catchment System	Pathogens from rural and agricultural faecal inputs reaching the bores when bores are inundated via backflow into drainage line and gaps in the well capping	Chlorine-sensitive pathogens e.g. *E. coli* and viruses	- Avoid use of the three highest risk bores when potentially inundated - Flush and clean bores after floods - Chlorine - LEP development controls: no subdivisions or intensive agriculture (linked to wellhead protection plan) - Septic systems to be registered and inspected annually on a risk-based priority	Council	E	4	High	A	4	Very High		
5	Borefield Catchment System	Spills occurring in catchment on roads or on properties	Chemicals (various)	- Hazardous material controls on transport vehicles (state/national requirements) - Removal in Aquifer		E	2	Low	E	2	Low	No major highways in the catchment. Spills would be rare. System has a high volume.	
6	Borefield Catchment System	Pesticides above ADWG health values in the raw water offtake from agricultural activity such as stock dips, horticulture	Pesticides	- Pesticides Act 1997 (OEH) - Landholders pesticide management actions - LEP development controls: no subdivisions or intensive agriculture (linked to wellhead protection plan?)	OEH	E	2	Low	C	3	High	Monthly pesticide monitoring for one year in the two nearby aboriginal community retic systems hasn't detected pesticides above ADWG guideline values. Experience with pesticide testing across the state hasn't identified significant problems.	
7	Borefield Catchment System	Nutrients that create adverse water quality downstream arising from landuse	Nutrients and algal by products	- Often high flows in river - Physical removal via alluvial aquifer	N/A	E	2	Low	E	3	Moderate		
8	Borefield Catchment System	Polluting activities directly adjacent to the well heads, e.g. biosolids dumping, fertilizer spreading, manure spreading etc.	Chemicals Pathogens	- Bore caps are elevated so that direct water entry into the bore can only occur during flood conditions - Well head is on raised built up platform - Steel cased bore - Bores in concrete pit	Council	E	3	Moderate	C	3	High	The lowest bore cap is about 300 to 400 mm above the ground, most bore caps are around 1 m above the ground.	Include bore sealing in capital works improvements.
9	Borefield Catchment System	Erosion creating elevated turbidities	Turbidity	- Landcare activities within the catchment. - Removal by aquifer. - LEP development controls: no subdivisions or intensive agriculture (linked to wellhead protection plan?)	Land-holders Council	D	2	Low	B	3	High	System isn't fenced and banks aren't stabilised to facilitate fencing.	Review bank stabilisation work options.

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10	Aquifer and borefield	Hydraulic short-circuiting of contaminants through aquifer to bores e.g. due to rapid pumping	Pathogens	- Bores distant from watercourse by an estimated 15 m or more - Downstream treatment by chlorine	Council	E	2	Low	B	4	Very High	The risk is likely to rise over time if not mitigated.	Review erosion of aquifer buffer between river and bore. Consider stabilisation works.
11	Aquifer and borefield	Short-circuiting of contaminants through to bores due to well casing failure	Pathogens	- Well head is on raised built up platform - Steel cased bore - Bores in concrete pit - Chlorination	Council	D	2	Low	C	3	High	The assets are relatively stable and don't readily fail	
12	Lime dosing	Under-dosing of lime creating asset management issues	Insufficient hardness	- Lime dosing is flow paced - Inspection of dosing system to check for blockages	Council	E	2	Low	C	3	High	Water is very soft and can corrode copper pipes and leaded-brass fittings Effect would occur only very gradually	CCPP is not measured. 45 to 55 mg/L Ca hardness is a target or rule of thumb for this system.
13	Lime dosing	No dosing of lime creating asset management issues	Insufficient hardness	- Lime dosing is flow paced - Inspection of dosing system to check for blockages - Cement lining of pipes would tend to stabilise the water in this system until the cement was gone	Council	E	2	Low	C	3	High	Water is very soft and can corrode copper pipes and leaded-brass fittings Effect would occur only very gradually	CCPP is not measured. 45 to 55 mg/L Ca hardness is a target or rule of thumb for this system.
14	Lime dosing	Over-dosing of lime to create operational problems	Too much Ca	- Lime dosing is flow paced - Inspection of dosing system to check pump function - CO_2 is automatically dosed to bring back pH into specification using on line pH monitoring	Council	E	1	Low	C	1	Low	The outcome is operational rather than health issues	
15	CO_2dosing	No dosing or under-dosing leading to elevated pH	Pathogens (loss of chlorine efficiency)	- CO_2 is automatically dosed to adjust pH. - CO_2 is regularly topped up. - Maintenance of system - Reduce lime dosing if CO_2dosing failed to ensure pH is within safe limits (informal) - Daily inspection, check testing and regular calibration of on line pH meter - Dilution in downstream storage would mitigate a short process failure	Council	D	2	Low	C	3	High	pH could reach above 10 if CO_2 didn't trim it back. To date the CO_2 hasn't run out as the contractor fills it regularly at a suitable interval Only historical failure was linked to lightning strikes	Formalise current procedures to reduce lime dosing if CO_2 dosing fails to ensure pH is within safe levels.

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16	CO_2dosing	Over-dosing CO_2leading to low pH and asset issues	Low pH	- Daily inspection, check testing and regular calibration of on line pH meter - Dilution in downstream storage would mitigate a short process failure	Council	E	2	Low	C	2	Moderate	No record of this happening at this site	
17	Fluoridation	Failure of dosing or under-dosing	Compliance	- Daily check testing - Compliance of fluoridation code of practice - Certified operators - Dosing is flow-paced	Council	C	2	Moderate	C	3	High	This occurs occasionally for short periods due to equipment failure. The equipment is 27 to 28 years old.	Seek funding to replace equipment by writing to the Fluoridation Committee noting that the plant is becoming aged and unreliable and should be replaced
18	Fluoridation	Over-dosing	Fluoride	- Daily check testing - Compliance of fluoridation code of practice - Certified operators - Plant designed to be unable to physically overdose to acutely hazardous levels - Dosing is flow-paced	Council	E	2	Low	D	2	Low	Dosing is currently close to capacity so the plant isn't physically capable of dosing much above guideline values unless the system doses on no flow. There are three interlocked flow switches to control dosing on flow.	High level fluoride alarm telemetry being set up currently. Develop a chart of flow rate vs dosage setting to calibrate the dosing process.
19	Collection tank	Ingress of vermin faecal matter	Pathogens	- Chlorination downstream - Physical barriers aluminium roofed concrete tank with locked hatch - Inspected daily	Council	D	1	Low	C	3	High		
20	Chlorination	Failure of sodium hypochlorite dosing system	Pathogens	- Daily checks -Spot dosing of reservoirs - On line monitoring residual controlled - Ordering management to avoid running out of hypo	Council	C	4	Very High	B	4	Very High	Chemical supply comes from Brisbane and in the past chemical has run out and have had to get chlorine from other utilities or the swimming pool	Install dual pumps on dosing system
21	Chlorination	Under-dosing	Pathogens	- Usually discard aged hypo when new delivery arrives - Order stocks frequently to maintain strength - Daily checks - On line monitoring residual controlled - Weekly retic monitoring	Council	E	4	High	B	4	Very High	Residuals and microbial indicators suggest the chlorine is currently effective	

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22	Chlorination	Over-dosing	Chlorine	- Daily checks - On line monitoring residual controlled - Weekly retic monitoring	Council	E	1	Low	D	2	Low	The system has a very low chlorine demand so there are unlikely to be significant disinfection by-products. Dosing at below 0.8 mg/L leads to around 0.4 mg/L towards the end of the system. Some recent sampling in the area for the aboriginal community supplies fed by the scheme has shown disinfection by-products that are typically below 10 µg/L and often below detection limits.	
23	Rising main	Customer draw off prior to adequate CT (concentration x contact time)	Pathogens		Council							There are estimated to be around 15 customers taking water from the rising main and two customers in particular that are the closest. Contact time is unknown.	Review contact time to first customer then rank the risk
24	Rising main	Backflow/cross connection leading to water contamination of rising main water	Various	- Rising main is pressurised when pumps are running - Supply to dairy has an RPZ - Customers have dual check valve water meters	Council Customer	D	2	Low	D	2	Low		Advise property owners of their obligations relating to backflow prevention
25	Balance Tanks	Ingress of vermin faecal matter	Bacteria	- Stainless steel vermin-proofed aluminium roofed concrete above-ground tanks with locked access ladders of the order 4 to 5 m height - Residual disinfectant - Internal overflows that are not vermin-meshed - chlorine is tested daily so sites are visited daily	Council	D	1	Low	C	4	Very High	Reservoirs are not common inlet-outlet designs. Chlorine is tested daily so sites are visited daily	Vermin-proof the overflows if necessary

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26	Balance Tanks	Access to reservoirs by unauthorised personnel	Various	- Aluminium roofed concrete above-ground tanks with locked access ladders of the order 4 to 5 m height - Reservoirs taken off line and drained and cleaned by council staff at intervals every few years (informal frequency) - Chlorine is tested daily so sites are visited daily	Council	E	2	Low	C	2	Moderate	Problems of the past have been mitigated through the locked access ladder arrangement	
27	Service reservoirs	Ingress of vermin faecal matter	Bacteria	- All reservoirs are roofed with good access - Pumping rules preventing high chlorine demand water into the system Aqualift has a schedule to do a full inspection of the reservoir every four years and repair issues they find - Quarterly inspections by water operations staff. There is a standard inspection form. - Good chlorine residual control generally above 0.4 mg/L	Council	C	1	Low	C	4	Very High	Based on good chlorine residual in the reservoirs.	
28	Service reservoirs	Access to reservoirs by unauthorised personnel	Various	- Locked hatches - Quarterly inspection	Council	E	2	Low	C	2	Moderate	Some evidence of unauthorised access on roofs but not into the reservoirs	
29	Service reservoirs	Water age	Taste and odour, potentially pathogens	- Chlorine residual - No common inlet/outlet reservoirs	Council	E	1	Low	E	1	Low	Have to keep the head up to the reservoirs to prevent issues	
30	Service reservoirs	Introduction of contaminants to the reservoirs by the operation of other utilities (mobile phone installations) e.g. birds nesting, mobile phone installations allowing contaminants into the reservoir.	Pathogens, contaminants	- They are not given a key - Informal review process for the installation work - Quarterly inspection - Independent third party inspections (every four years)	Council	D	3	Moderate	D	4	High		Consider a procedure to check the installation work to ensure contamination has not arisen (possibly bring the standard check forward).
31	Distribution	Mains breaks & splits or perforation leading to ingress	Pathogens	- Informal procedure consistent with good practice - pumping the water out of the hole, trenching etc. - Flushing after the break	Council	D	2	Low	C	3	High		
32	Distribution	Air valves in pits drawing in water following a pipe break	Pathogens	- Gravity fed system - Air valves at the top of hills	Council	E	1	Low	E	1	Low		

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33	Distribution	Backflow/cross connection leading to water contamination events	Various	- Backflow prevention policy based plumbing code AS3500 and NSW plumbing guidelines - Residential users have backflow prevention built into the meter - Stage rollout of annual reporting and inspections	Council - Health and Building	D	4	High	C	4	Very High	Highest risk one are Hospital. There are not high hazard sites in the scheme area.	Continue rolling out the implementation of the backflow prevention program.
34	Distribution	Dead end in reticulation systems leading to stagnation	Taste and odour	- Are currently rolling out an active flushing program	Council	C	1	Low	C	2	Moderate		Continue the flushing program
35	Distribution	Use of fire hydrants stirring up the system and causing water quality incidents	Sediment	- Mains and tank cleaning	Council	B	2	High	B	2	High	This occurs with training for both the RFS and Fire brigade.	Consider discussions with fire fighters regarding timing and locations
36	Distribution	Water carters contaminating the scheme through backflow	Pathogens, chemicals	- Two locations individually metered and keyed - Gravity supplied from reservoir - no chance of backflow prevention	Council	E	1	Low	E	1	Low	This risk as been designed out	
37	Whole of Scheme	Malicious contamination leading to water contamination	Various		Council	E	5	High	E	5	High	Managed under incident and emergency response plan	
38	Whole of Scheme	Power failure	Various	- Pumped system (from source water) - Generators could be sourced if required	Council	E	4	High	E	4	High	48 hours unrestricted supply 4 ranked for operationally issues	
39	Whole of Scheme	Failure of telemetry monitoring devices	Various	- Manual backup	Council	D	2	Low	D	3	Moderate	-Common during storms	
40	Whole of Scheme	Human error	Various	- Suitably trained operators (e.g. fluoride) - On going training	Council	D	3	Moderate	A	5	Very High	Contractors used for calibration and electrical switchboard. Contractors are not left alone at the plant.	This risk should be re-scored with the new telemetry coming in.
41	Whole of System	Chemical quality contamination	Various	- Purchasing procedures (from Orica) as part of Hunter Procurement - Operators on site when deliveries are occurring (except CO_2)	Council	E	1	Low	E	1	Low		
42	Whole of System	Materials not fit for contact with water	Various	- Pipe purchases through Hunter Procurement. - Pipe fitting purchased from reputable suppliers (e.g. Tyco) to meet Australian Standards 4020	Council	E	1	Low	E	1	Low		

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43	Whole of System	Loss of trained operators and external services due to sickness or leave or leaving the sector, etc.	Various	- Good work environment (quality of life)	Council	D	2	Low	D	2	Low		