groundwater protection Level 1 is applicable (NSW Groundwater Protection Policy, Appendix D), and the relevant requirements have been addressed by this report.

Suitability of groundwater for a stated usage

There is no usage from groundwater resources en route of the pipeline proposed.

Protection of groundwater dependant ecosystems

An assessment can be made by a qualified ecologist, with reference to the groundwater characterisation presented in this report.

Integration of groundwater quality and quantity management.

There is no planned usage of groundwater from aquifers en route of the pipeline.

Consideration of cumulative impacts

The land under consideration is used primarily for agriculture. The incremental increase in impacts to aquifers adjacent to the pipeline due to the construction of the pipeline is considered to be negligible.

Where possible, environmentally degraded areas should be rehabilitated

The aquifer resources under consideration are largely un-utilised. Rehabilitation is not a current requirement for these aquifers.

5.1.2 NSW State Groundwater Dependent Ecosystem Policy (2002)

An assessment can be made by a qualified ecologist, with reference to the groundwater characterisation presented in this report.

5.2 Guidelines

No groundwater actions were relevant in the guidelines referenced in the NSW Office of Water Letter (2011).

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Appendix D

MJM Environmental Report

Cardno/ Orange City Council

Icely Road WTP Process Capacity Review

Final Report

23 May 2012

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Executive Summary

Orange City Council (OCC) is the major potable water provider for the town of Orange.

OCC proposes to undertake the Macquarie Orange Pipeline Project to improve the water security for Orange. The project involves the construction of a pipeline and associated infrastructure to transfer approximately 12 ML/day of water a distance of approximately 37 km from the Macquarie River to the Suma Park Dam at Orange. Water will only be extracted from Macquarie River when sufficient water is available and when the river exceeds a specific water level and Suma Park Dam has sufficient capacity.

Based on a review of the Suma Park Dam and Macquarie River raw water quality and potential blending scenarios, and a review of the Icely Road WTP process, it is recommended that:

- Macquarie River generally has poorer quality raw water compared to Suma Park Dam raw water.
- Icely Road WTP is capable of treating all raw water quality parameters for the new water supply assuming complete mixing and including when entirely sourced from Macquarie River.
- OCC undertake additional testing to verify the water quality parameters in Macquarie River including true colour and soluble iron.
- Complete bench-scale jar testing to verify true colour removal for the plant if true colour levels in Macquarie River are found to be high during typical raw water conditions.
- The current treatment process achieves a minimum log removal of 3 for Cryptosporidium, 6.5 for Giardia, and 10 for viruses.
- The major parameter of concern for the new raw water supply is bromide. OCC should develop and implement a bromide process optimisation strategy for the plant.

Bromide is the major parameter of concern for OCC and should be monitored closely if Macquarie River water is pumped to Suma Park Dam. While there is no ADWG limit for bromide, the chemical is oxidised by ozone to form bromate. Bromate is toxic to humans and is a suspected carcinogen. It is recommended that OCC undertake monthly bromide monitoring in Macquarie River and develop a bromide process optimisation strategy for operation should elevated bromide levels above 0.1 mg/L be experienced.

Icely Road WTP Process Capacity Review

Cardno/ Orange City Council

Final Report

23 May 2012

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1. Introduction

1.1 Purpose of This Report

Orange City Council (OCC) proposes to undertake the Macquarie Orange Pipeline Project (referred to in this report as 'the project'). This report has been prepared to provide a review of potential water quality impacts on Orange City Council's Icely Road Water Treatment Plant (WTP) as an input to the environmental assessment. The environmental assessment is being prepared in accordance with the requirements of Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act).

The report addresses the requirements of the Director-General of the NSW Department of Planning and Infrastructure (the Director-General's Requirements) dated 24 March 2011.

1.2 Project Overview

The project is one step to improving the water security for Orange. It involves construction and operation of infrastructure required to transfer approximately 12 ML/day of water a distance of approximately 37 km from the Macquarie River to the Suma Park Dam at Orange.

The infrastructure required to transfer the water includes an intake and pump stations, an underground pipeline (approximately 37 km in length), an outlet structure, and ancillary infrastructure (power supply).

In summary, the project would involve construction and operation of the following infrastructure:

- 37 km of 375 mm diameter water rising main between the Macquarie River and Suma Park Dam
- an offtake and pump station located at the upper Macquarie River
- three booster pump stations and break tanks along the pipeline route
- power supply to pumps and other infrastructure
- telemetry controls to enable remote operation of the infrastructure including pumps and valves etc
- a discharge structure at the Suma Park Dam.

1.3 Location of the Project

The proposed off-take point would be located north of Long Point on the upper Macquarie River.

The proposed route for the pipeline, shown on Figure 1.1, includes road reserves, including Ophir Rd and Long Point Rd. In some areas the pipeline would need to cross private land. It is proposed that the majority of the pipeline would be underground and would not impact on farming or other land uses.

The majority of the pipeline would be located in the Cabonne local government area (LGA).

The pipeline would discharge to the discharge structure, located at the north of the Suma Park Dam.

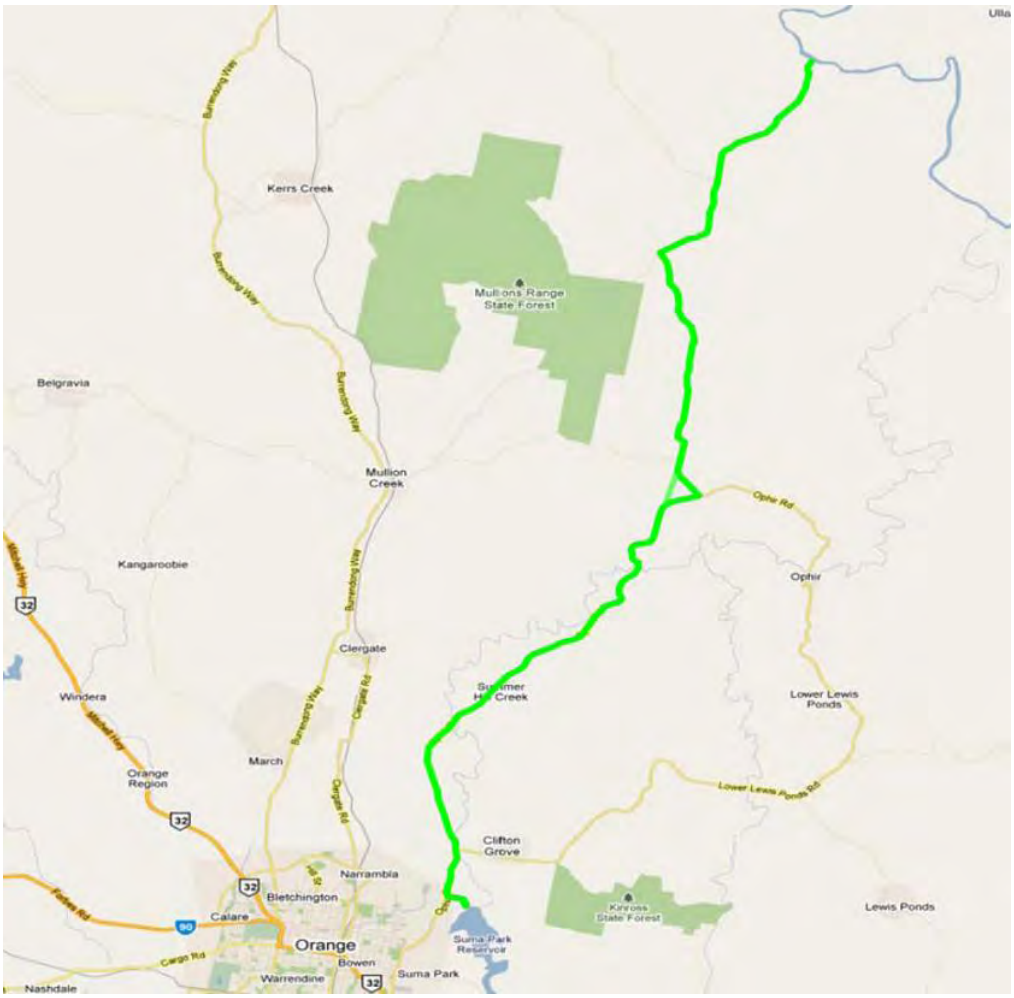

Figure 1.1: Proposed Macquarie Orange pipeline route (Orange Drought Relief Connection Pipeline EA – Part B 2011)

2. Project Objectives

The objective of the Icely Road WTP Process Capacity Review is to provide Cardno/ OCC with recommendations on the capacity of Icely Road WTP to treat Macquarie River raw water to OCC's treated water quality standards.

The scope of works for this project include the following.

- Review Suma Park Dam raw water quality data and determine minimum, average and maximum water quality parameters for the available water quality data
- Review Macquarie River raw water quality data and determine minimum, average and maximum water quality parameters for the available water quality data
- Determine key raw water quality parameters that are likely to be impacted by pumping Macquarie River raw water into Suma Park Dam based on the following blending ratios:
    - 25 % Macquarie River : 75 % Suma Park Dam
    - 50 % Macquarie River : 50 % Suma Park Dam
    - 75 % Macquarie River : 25 % Suma Park Dam
    - 100 % Macquarie River : 0 % Suma Park Dam
- Desk-top Process Review of Icely Road WTP to treat the different raw water blends at the proposed maximum treated water production during drought conditions.

3. Raw Water Quality Review

3.1 Suma Park Dam

A summary of the Suma Park Dam raw water quality data provided by OCC is presented in Table 3.1 for water quality parameters that would potentially impact the water treatment process. The results have been compared to the Australian Drinking Water Guidelines 2011 (ADWG).

Table 3.1: Suma Park Dam raw water quality data

Water Quality Parameter	Units	Number of Samples	Minimum	Average	Maximum	95%ile	ADWG value[2]
pH	pH unit	14	6.71	7.60	8.30	8.11	6.5 to 8.5 (A)
Turbidity	NTU	14	0.2	**4.4**	**17.0**	**11.9**	<1 (H) <5 (A)
Suspended Solids	mg/L	9	2.0	7.0	26.0	19.2	-
Colour (True)	HU	8	1.0	9.1	15.0	14.3	15 (A)
Total Organic Carbon (TOC)	mg/L	8	4.0	6.3	7.0	7.0	-
E. coli[2]	CFU/ 100 mL	10	**1.0**	**25.8**	**68.0**	**60.8**	<1 (H)
S. coliphages	PFU/ 100 mL	9	**1.0**	**45.1**	**180.0**	**137.3**	<1 (H)
C. perfringens	CFU/ 100 mL	12	**2.0**	**6.0**	**30.0**	**20.9**	<1 (H)
Aluminium (soluble)	mg/L	2	**0.42**	**0.42**	**0.42**	**0.42**	<0.2 (A)
Manganese (soluble)	mg/L	3	0.0010	0.0015	0.0020	0.0020	<0.1 (A) <0.5 (H)
Aluminium (total)	mg/L	9	0.02	0.15	**0.88**	**0.61**	<0.2 (A)
Iron (total)	mg/L	12	0.03	0.21	**0.88**	**0.63**	<0.3 (A)
Manganese (total)	mg/L	13	0.01	**0.15**	**0.60**	**0.58**	<0.1 (A) <0.5 (H)
Alkalinity	mg/L $CaCO_3$	8	60.3	78.6	86.0	85.3	-
Calcium	mg/L	9	10.8	13.6	17.0	16.2	-
Magnesium	mg/L	9	8.0	9.4	11.0	10.6	-
Total Hardness	mg/L $CaCO_3$	9	59.8	72.8	87.8	84.2	200 (A)
TDS	mg/L	9	80.0	113.3	144.0	142.8	500 (A)
Chloride	mg/L	9	7.0	7.4	8.2	8.1	250 (A)
Sulphate	mg/L	9	6.00	7.00	8.00	7.95	250 (A)
Fluoride	mg/L	8	0.06	0.09	0.11	0.11	1.5 (H)
Bromide	mg/L	11	0.010	0.040	0.050	0.047	-

[1] Australian Drinking Water Guidelines 2011,(A) – Aesthetic based guideline, (H) – Health Based Guideline
[2] The highest *E. Coli* levels measured were 40,000 and 140,000 CFU/100 mL on 8th February 2010 and 24th November 2009. However they appear to be outliers rather than representative raw water quality data and were excluded from the calculations.
Bold and underlined figures exceed the ADWG

Based on the available water quality data, raw water from Suma Park Dam is described as having low to moderate turbidity and colour levels, moderate TOC levels, moderate metals levels, and moderately hard.

It is noted that there is a low degree of certainty for the average value for aluminium (soluble) as there are only two values for this parameter.

3.2 Macquarie River

A summary of the Macquarie River raw water quality data provided by OCC is presented in Table 3.2 for water quality parameters that would potentially impact on the water treatment process.

Table 3.2: Macquarie River raw water quality data

Water Quality Parameter	Units	Number of Samples	Minimum	Average	Maximum	95%ile	ADWG value[1]
pH	pH unit	15	6.6	7.9	**8.7**	8.4	6.5 to 8.5 (A)
Turbidity	NTU	15	**3.1**	**10.0**	**31.9**	**27.5**	<1 (H) <5 (A)
Suspended Solids	mg/L	15	4.0	15.5	39.0	32.0	-
Colour (True)	HU	1	**45**	**45**	**45**	**45**	15 (A)
Total Organic Carbon (TOC)	mg/L	15	3	6.13	10	10	-
E. Coli	CFU/ 100 mL	15	**1.0**	**72.8**	**500.0**	**283.0**	<1 (H)
S. coliphages	PFU/ 100 mL	14	0.5	**80.6**	**470.0**	**281.5**	<1 (H)
C. perfringens	CFU/ 100 mL	14	0.5	**11.1**	**30.0**	**29.4**	<1 (H)
Aluminium (soluble)	mg/L	13	0.02	0.14	**0.38**	**0.34**	<0.2 (A)
Manganese (soluble)	mg/L	6	0.008	0.030	0.045	0.043	<0.1 (A) <0.5 (H)
Aluminium (total)	mg/L	15	0.09	**0.53**	**1.56**	**1.42**	<0.2 (A)
Iron (total)	mg/L	15	0.25	**0.81**	**1.77**	**1.73**	<0.3 (A)
Manganese (total)	mg/L	15	0.02	0.06	**0.18**	**0.12**	<0.1 (A) <0.5 (H)
Alkalinity	mg/L $CaCO_3$	1	125.0	125.0	125.0	125.0	-
Calcium	mg/L	1	26.0	26.0	26.0	26.0	-
Magnesium	mg/L	1	12.0	12.0	12.0	12.0	-
Total Hardness	mg/L $CaCO_3$	1	114.4	114.4	114.4	114.4	200 (A)
TDS	mg/L	15	132.0	200.9	318.0	273.2	500 (A)
Chloride	mg/L	1	59.5	59.50	59.5	59.5	250 (A)
Sulphate	mg/L	1	44.4	44.40	44.4	44.4	250 (A)
Fluoride	mg/L	1	0.24	0.24	0.24	0.24	1.5 (H)
Bromide	mg/L	15	0.020	0.087	0.163	0.155	-

[1] Australian Drinking Water Guidelines,(A) – Aesthetic based guideline, (H) – Health Based Guideline
Bold and underlined figures exceed the ADWG

Based on the above water quality data, raw water from Macquarie River is described as having moderate turbidity and colour levels, moderate TOC levels, low to moderate aluminium and iron levels, and is moderately hard. Fluoride levels are moderate, as are the *E. Coli* and *S. Coliphage* levels.

The maximum turbidity recorded was 31.9 NTU and is attributed to high flow events (>1,000 ML/day). Appendix B of the Macquarie River Source and Ploughmans Valley North Orange Development – Water Quality Risk Assessment 2011 contains a graph comparing turbidity and suspended solids to flow.

It is noted that there is a low degree of certainty in the average values for a number of water quality parameters including true colour, alkalinity, calcium, magnesium, total hardness, chloride, sulphate and fluoride as there are only single value provided for these parameters.

It is our understanding that OCC is continuing to monitor raw water quality data from Macquarie River.

3.3 Comparison

The following comparisons are made of the water quality characteristics of the new raw water source (Macquarie River) against the existing raw water source (Suma Park Dam):

- Macquarie River generally has poorer quality raw water compared to Suma Park Dam raw water
- Turbidity, suspended solids, true colour and total dissolved solids (TDS) levels are higher for Macquarie River than Suma Park Dam
- Total organic carbon (TOC) levels are relatively similar between the two raw water sources
- Iron (total) is higher for Macquarie River than Suma Park Dam
- Suma Park Dam raw water alkalinity and hardness is lower than Macquarie River.

The following parameters are considered to have a potential impact on the Icely Road WTP process and will be assessed, based on one or more exceedances of the water quality limits specified in the ADWG 2011:

- pH
- Turbidity
- Suspended solids
- True colour
- E. coli
- *S. coliphages*
- *C. perfringens*
- Aluminium (soluble)
- Aluminium (total)
- Iron (total)
- Manganese (total)

Bromide is also assessed due to the potential for bromate to formation as a by-product of the ozonation process at Icely WTP.

3.4 Raw Water Quality Data and Quality Assurance

In completing this assessment of potential water quality impacts on the WTP resulting from the proposed project, MJM has relied upon water quality data and other information supplied by OCC.

MJM has assumed that the data provided is accurate and suitable and complete.

All statements, conclusions and recommendations in this report that are based on the water quality data are reliant on the accuracy and completeness of the data supplied. MJM will not be liable for any incorrect conclusions should any water quality data be incorrect, withheld or misinterpreted.

Pathogens, virus, algae, algal toxins and taste and odour compounds were not measured by OCC at the time of writing this report. Therefore MJM Environmental has not commented on the removal of these water quality parameters.

4. Raw Water Blending Scenarios

To assess the impact of the new raw water source on the water treatment plant process, it is necessary to develop a number of scenarios that describe the characteristics of the new raw water supply. The new raw water supply will be a blend of raw water from the existing source (Suma Park Dam) and the new source (Macquarie River), and the ratio of Dam to River water is not fixed.

As part of this assessment it was proposed that the following blending scenarios would be investigated:

- 25 % Macquarie River : 75 % Suma Park Dam
- 50 % Macquarie River : 50 % Suma Park Dam
- 75 % Macquarie River : 25 % Suma Park Dam
- 100 % Macquarie River : 0 % Suma Park Dam

A water quality mass balance was carried out to investigate the above blending scenarios. The results are presented in Table 4.1.

Table 4.1: Water quality mass balance results based on average water quality data

Water Quality Parameter	Units	Blending Scenarios (Macquarie River %: Suma Park Dam %)				ADWG value[2]
		25%:75%	50%:50%	75%:25%	100%:0%	
pH	pH unit	7.68	7.76	7.85	7.93	6.5 to 8.5 (A)
Turbidity	NTU	**5.8**	**7.2**	**8.6**	**10.0**	<1 (H) <5 (A)
Suspended Solids	mg/L	9.1	11.3	13.4	15.5	-
Colour (True)	HU	**18.1**	**27.1**	**36.0**	**45.0**	15 (A)
Total Organic Carbon (TOC)	mg/L	6.2	6.2	6.2	6.1	-
E. coli	CFU/ 100 mL	**37.5**	**49.3**	**61.1**	**72.8**	<1 (H)
S. coliphages	PFU/ 100 mL	**54.0**	**62.9**	**71.7**	**80.6**	<1 (H)
C. perfringens	CFU/ 100 mL	**7.3**	**8.6**	**9.9**	**11.1**	<1 (H)
Aluminium (soluble)	mg/L	0.19	0.17	0.14	0.12	<0.2 (A)
Manganese (soluble)	mg/L	0.0034	0.0054	0.0075	0.0095	<0.1 (A) <0.5 (H)
Aluminium (total)	mg/L	**0.23**	**0.33**	**0. 41**	**0.53**	<0.2 (A)
Iron (total)	mg/L	**0.34**	**0.50**	**0.66**	**0.81**	<0.3 (A)
Manganese (total)	mg/L	**0.130**	**0.110**	0.082	0.057	<0.1 (A) <0.5 (H)
Alkalinity	mg/L $CaCO_3$	90.2	101.8	113.4	125.0	-
Calcium	mg/L	16.7	19.8	22.9	26.0	-
Magnesium	mg/L	10.1	10.7	11.4	12.0	-
Total Hardness	mg/L $CaCO_3$	83.2	93.6	104.0	114.4	200 (A)
TDS	mg/L	135.2	157.1	179.0	200.9	500 (A)
Chloride	mg/L	20.5	33.5	46.5	59.5	250 (A)
Sulphate	mg/L	16.4	25.7	35.1	44.4	250 (A)
Fluoride	mg/L	0.13	0.17	0.20	0.24	1.5 (H)

Bromide	mg/L	0.05	0.06	0.08	0.09	-
Nitrogen (total)	mg/L	0.85	0.83	0.81	0.79	-
Phosphorus (total)	mg/L	0.05	0.05	0.04	0.04	-

According to the mass balance results the water quality parameters of concern including turbidity, colour, alkalinity, hardness, iron, *C. perfringens* and oil and grease increase as Suma Park Dam comprises of a greater proportion of Macquarie River water. *E. coli* concentrations decrease as more Macquarie River water is pumped into Suma Park Dam.

The levels of total nitrogen and total phosphorous are relatively similar in Suma Park Dam raw water and Macquarie River raw water under average water quality conditions. It is recommended that OCC continue to monitor the nutrient levels and algae levels in Suma Park Dam.

The following parameters exceeded the ADWG values for at least one of the blending scenarios:

- Turbidity
- True colour
- *E. coli*
- *S. coliphages*
- *C. perfringens*
- Aluminium (total)
- Iron (total)
- Manganese (total)

Because these parameters exceed ADWG guidelines for the various blending scenarios the review of key impacts in Section 8 will focus on the above parameters along with other water quality parameters of concern.

5. Icely Road WTP Overview

5.1 Overview

A process flow diagram describing the configuration of Icely Road WTP is presented in Figure 5.1.

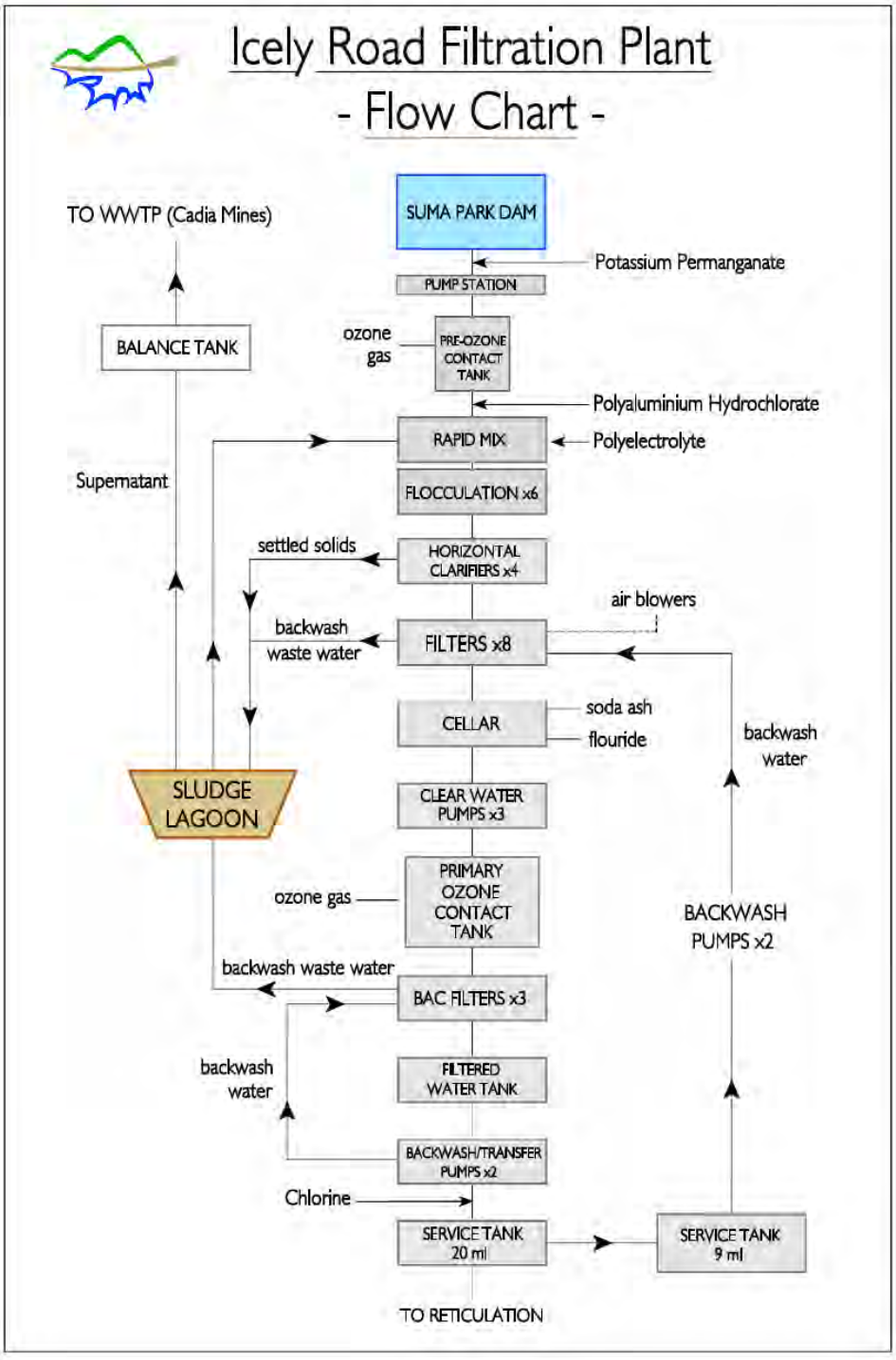

Figure 5.1: Treated water production process flow diagram[1]

[1] Sourced from Orange City Council website on 11 November 2011 at http://www.orange.nsw.gov.au/client_images/851564.pdf. Diagram provided for information only and may be incorrect or out of date.

5.2 General

Icely Road WTP is located in Orange, NSW, 2800 on the western end of Icely Road. Raw water is pumped to Icely Road WTP from the Suma Park Dam via the Suma Park pump station. As the raw water passes through the pump station it is dosed with potassium permanganate to promote oxidation of soluble manganese which is followed by pre-ozonation.

Aluminium chlorohydrate is then dosed as the coagulant in the inlet pipe to initiate the coagulation process.

The raw water then enters the flash mixer where it is dosed with polymer to aid in flocculation. The water flows through the flocculation tank to four horizontal sedimentation tanks where it undergoes sedimentation. Eight gravity filters are then used to remove the remaining floc and particles. The filtered water is fed through a single water channel to a clear water tank. At this stage soda ash is dosed for pH correction and fluoride for dental health.

The filtered water then enters the primary ozonation tank where it undergoes further ozonation to oxidise organics, bacteria, viruses and parasites. The ozonated water is then filtered through three biologically activated carbon (BAC) filters which then flows into a 20 ML storage reservoir where it is dosed with chlorine at the inlet. From the storage tank the treated water is gravity fed into the town reticulation system.

5.3 Design Capacity

The design capacity of Icely WTP is currently 525 L/s (instantaneous) and 38 ML/d (daily).

5.4 Chemical Dosing

Chemicals dosed as part of the existing water treatment process at Icely Road WTP include:

- Potassium permanganate to oxidise manganese
- Ozone to oxidise organics and for disinfection
- Aluminium chlorohydrate for flocculation
- Polyacrylamide to aid flocculation
- Soda ash for pH correction
- Sodium silicofluoride for dental health
- Chlorine gas for disinfection

5.5 Operations and Maintenance

Icely Road WTP operates typically 8 hours a day, 365 days a year.

5.6 Future Augmentation

In the year of 2009 the city of Orange had less than two years supply of water. As a result the city was placed on Level 5 Water restrictions. To provide water security to the city, OCC propose to supplement Suma Park Dam with water from the Macquarie River by means of a new pipeline.

5.7 Water Quality Objectives

The treated water quality targets set by OCC are shown in Table 5.1. All other parameters are to meet ADWG limits.

Table 5.1: Treated water quality targets

Parameter	Units	ADWG		Target	Maximum	Trigger Level
		Health	Aesthetic			
pH		-	6.5 – 8.5	7.6 – 7.8	7.5 – 8.0	Outside range for 1 hour
Turbidity	NTU	1	5	0.15	0.3	>0.3
Total Alkalinity	mg/L $CaCO_3$	-	-	80 - 120	-	-
Aluminium	mg/L	0.2	-	≤0.1	0.2	>0.2

Manganese (Soluble)	mg/L	>0.5	0.1	<0.02	0.02	>0.02
Iron (Total)	mg/L	-	0.3	≤0.05	0.1	>0.1
Fluoride	mg/L	>1.5	0.7 - 1	0.9 – 1.1	1.2	>1.2
Chlorine	mg/L	5	-	1.35	0.5 – 1.5	<0.5
E. coli or thermotolerant coliforms	no./100 mL	0	1	None detected		If any detected

6. Icely Road WTP Process Design Summary

The process design summary sheet for Icely Road WTP is presented in Table 6.1. The data used to develop the the process design summary is attached as Appendix A.

Table 6.1: Icely Road WTP Process Design Summary

Design Parameters	Units	Value
Design Flows		
Raw Water Daily Consumption		
Maximum	ML/d	38
Typical	ML/d	10
Raw Water Instantaneous Flow		
Maximum	L/s	525
Minimum	L/s	350
Treated Water Daily Production		
Maximum	ML/d	38
Typical	ML/d	10
Filtered Water Instantaneous Flow		
Maximum	L/s	525
Minimum	L/s	350
Treated Water Instantaneous Flow		
Maximum	L/s	525
Minimum	L/s	350
Plant Runtime	h	8
Plant Turndown Ratio		1.5
Process Description	Oxidation (potassium permanganate), pre-ozonation, coagulant dosing (PACl), coagulant aid dosing (polyacrylamide), flocculation, clarification, dual media filtration, pH correction (soda ash), fluoridation (sodium silicofluoride), primary ozonation, BAC filtration, filtered water storage and pumping, disinfection (Cl_2).	
Raw Water Inlet Works		
Raw water source	-	Suma Park Dam
Raw water pipework	-	600 mm MSCL main from reservoir
Raw water pump station	-	Suma Park Pumping Station
Raw water control	-	Submersible pump with variable drive speed
Raw water flow rate		
Maximum	L/s	450
Minimum	L/s	300
Oxidation		
Chemical agent used		Potassium permanganate (1% $KMnO_4$ w/w)
Typical Dose Range	mg/L	0 - 130
Dosing point		Raw water main

Design Parameters	Units	Value
Detention time at maximum flow rate	min	18.3
Coagulant Dosing		
Coagulant type		Polyaluminium chloride (PACL)
Typical dose range	mg/L	20 - 40
Dosing point		After pre-oxidation
Polymer Dosing (Coagulant Aid)		
Polymer Type		Polyacrylamide (Magnafloc LT20)
Typical dose range	mg/L	0.05 - 1
Dosing point		Flash mixer
Flash mixing chamber		
Tank volume	m^3	8.18
Mechanical flash mixer		
Type	-	Vertical shaft/ impeller/ no baffles
Velocity gradient	s^{-1}	215
Flocculation		
Number of tanks/compartments		6
Dimensions: length x width x depth	m	4.049 x 3.45 x 3.45
Detention time at design max flow rate	min	9.2
Number mechanical flocculators		5
Sedimentation		
Type		Horizontal clarifiers – high rate
Number of tanks		4
Design surface loading rate at max flow rate	m/h	2.1
Ozone Generation		
Oxygen supply	-	PSA Oxygen Generator
Oxygen output	L/s	11 @ 90% purity
Number of oxygen generators	-	3 (Duty/duty/duty)
Ozone output	kg/h	3
Number of ozonators	-	3 (Duty/duty/duty)
Total ozone dose at design max flow rate	mg/L	4.8
Pre-Ozonation		
Number of contactors	-	1
Contact tank volume	m^3	30
Baffling factor	-	0.7
Typical ozone dose	mg/L	1
Typical ozone residual	mg/L	0
Contact time at design max flow rate	min	1
Minimum CT	mg/L-min	0
Filtration		
Filter beds/ vessels		
Type		Gravity

Design Parameters	Units	Value
Number of filters		8
Area dimensions: length x width	m	5.4 x 4.2
Area per filter	m^2	22.68
Total filter area	m^2	181.44
Filtration rate	m/h	11.6 (max)
Backwash rate during backwash	m/h	54
Filter media		
Filter coal:		
Depth	mm	460
Effective size	mm	1.0 – 1.1
Uniformity Coefficient		1.4
Filter sand		
Depth	mm	225
Effective size	mm	0.5
Uniformity Coefficient		1.6
Gravel layer 1: Effective size	mm	2-3
Gravel layer 2: Effective size	mm	3-6
Gravel layer 3: Effective size	mm	6-12
Gravel layer 4: Effective size	mm	12-24
Backwashing		
Sequence		• Air scour • High rate water wash
Number of Air Scour Blowers	No.	2 off (duty/ standby)
Backwash pumps		
Number		2 off (duty/standby)
Capacity each pump	m^3/h	1,296
Backwash water source		9 ML tank
Filtered Water Storage		
Filtered water tank		
Tank volume	m^3	350
Detention time at design max flow rate	min	12
Clear water pumps		
Number of pumps		3 off (duty/standby/standby)
Capacity of each pump	L/s	420
Alkali Dosing		
Chemical agent used		Soda ash
Typical dose range	mg/L	12 - 46
Fluoridation		
Fluoridating agent		Sodium silicofluoride
Typical Dose	mg/L	1.2
Primary Ozonation		

Design Parameters	Units	Value
Number of contactors	-	3
Contact tank volume	m^3	450
Baffling factor	-	0.7
Typical ozone dose	mg/L	3
Typical ozone residual	mg/L	0.19
Contact time at design max flow rate	min	14.3
Minimum CT	mg/L-min	1.9
BAC Filtration		
Filter beds/ vessels		
Type		Gravity
Number of filters		3
Area dimensions: length x width	m	8.5 x 4
Area per filter	m^2	34
Total filter area	m^2	102
Filtration rate	m/h	18.5
Filtered Water Storage		
Filtered water tank		
Tank volume	m^3	9,000
Detention time at design max flow rate	min	286
Clear water pumps		
Number of pumps		2 off (duty/standby/standby)
Capacity of each pump	L/s	420
Disinfection		
Chemical agent used		Chlorine gas
Typical residual	mg/L	1.35
Service Tank 1		
Tank volume	m^3	20,000
Baffling factor	-	0.1
Detention time at design max flow rate	min	2286
Minimum CT	mg/L-min	63
Wastewater Handling		
Sludge lagoons		
Type		High rate
Number of lagoons		2
Dimensions at base: length x width	m	110 x 35[1]
Dimensions at crest: length x width	m	110 x 35[1]
Total depth	m	1.6
Operating height	m	1.6
Supernatant return pumps		
Number of pumps		2
Capacity of each pump	L/s	20

[1] Dimensions of lagoons were estimated from an aerial photograph (Google Maps 2012)

7. Water Quality Impacts Assessment

A treatment matrix was generated to outline the water treatment processes at the plant which are involved in or have the ability to remove the water quality parameters of concern. The treatment matrix is shown in Table 7.1.

Table 7.1: Water treatment matrix

Parameter	Potassium Permanganate	Pre-ozonation	Coagulation	Flocculation	Clarification	Gravity Filtration	pH Correction	Fluoridation	Primary Ozonation	Biologically Activated Carbon Filtration	Chlorination
pH							✓				
Turbidity			✓	✓	✓	✓				✓	
Total Suspended Solids			✓	✓	✓	✓				✓	
Colour	✓	✓	✓	✓	✓	✓			✓	✓	
E. coli		✓			✓	✓			✓	✓	✓
S. coliphages		✓			✓	✓			✓	✓	✓
C. perfringens		✓			✓	✓			✓	✓	✓
Aluminium			✓	✓	✓	✓				✓	
Manganese	✓	✓							✓		
Iron	✓	✓							✓		
Bromide											

8. Summary of Key Impacts

8.1 pH

Suma Park Dam has an average pH of 7.6 whilst Macquarie River has an average of 7.93. As the pH levels are similar between the two water sources, the addition of water from the Macquarie River to the Suma Park Dam will have little effect on the current pH correction process at the WTP. A slight decrease in the pots-filtration soda ash dose may be required to produce treated water with pH values which meet OCC's water quality targets.

8.2 Turbidity

Average turbidity levels in Suma Park Dam (4.4 NTU) are below the average Macquarie River turbidity level (10.0 NTU). Water quality mass balance results predict that turbidity will increase slightly as more Macquarie River water is pumped into Suma Park Dam.

The maximum raw water turbidity recorded in Macquarie River was 31.9 NTU which is higher than the maximum value of 17 NTU recorded for Suma Dam. OCC can reduce the risk of high turbidity in Macquarie River impacting Suma Park Dam by not pumping during periods of poor water quality. The management of raw water pumping protocols by OCC will ensure that raw water containing high levels of turbidity will not be pumped into Suma Dam.

Polyaluminium chloride (PACl) is dosed for coagulation at a typical dose range of 20 to 40 mg/L. This dose range is sufficient to effectively agglomerate suspended and dissolved contaminants into floc particles for the Macquarie River raw water quality. The typical useage of PACl may increase as Macquarie River water is blended into Suma Park Park.

A polyelectrolyte is dosed as a settling aid to enhance the floc formation and subsequent settling process.

Flocculation occurs in six mechanical flocculation tanks with a total flocculation time of 9.2 minutes at maximum plant flow, which is adequate for floc formation under all raw water quality scenarios modelled.

The floc particles are removed via four horizontal sedimentation tanks operating at maximum settling rate of 2.1 m/h at maximum plant design flow. The settling rate is considered slightly above the preferred loading rate of 1.5 m/h but is considered acceptable for Icely WTP given that the filtration processes consists of dual media filters.

The existing sedimentation process is a very robust treatment process for turbidity removal and has the capability treat raw water turbidities up to 500 NTU provided the front-end process chemistry is optimised. The sedimentation process can be expected to remove up to 90% of the turbidity under optimised conditions.

The WTP uses eight open gravity type granular media high rate filters with a maximum design filtration rate is 11.6 m/h at maximum plant design flow.

The dual-media beds consist of coarse anthracite (coal) and silica sand. The coarse anthracite allows a high filtration rate and draws floc particles deeper into the filer bed which increases the storage of solids and results in longer filter runs times. The calculated L/d ratio for the filter media is of 888, which is slightly less than the optimum of at least > 1000. However the current L/d ratio produces treated water quality which meets the treated water quality turbidity target of 0.15 NTU. Therefore OCC can expect the same level of performance from Icely WTP if the plant is required to treat Macquarie River raw water which is pumped into Suma Dam.

In summary, Icely WTP has the capability to treat the potential changes in raw water turbidity levels as a result of Macquarie River raw water being pumped into Suma Dam. The change in raw water turbidity will have minimal impact on the treatment process provided the process is optimised during these conditions. It should be noted that as raw water turbidity increases the ozone demand will increase and the beneficial effects of pre-ozonation can be expected reduce. The coagulant dose rates will also have to be increased with increasing turbidity however there is adequate dosing capacity at the plant.

8.3 Colour (True)

Average true colour is significantly different between Suma Park Dam (9.1 HU) and Macquarie River (45 HU). However this is only based on one data set and was measured during typical raw water conditions.

Due to the high level of true colour measured in the one sample it is recommend that OCC undertake further monitoring of true colour levels in Macquarie River.

The four blending scenarios calculated in the mass balance showed that true colour would increase significantly at all mixing ratios.

The current treatment process has multiple true colour removal processes including pre-ozonation, coagulation and post-filtration ozonation prior to BAC filtration. Potassium permanganate will also provide colour oxidation when dosed for soluble manganese removal. Disinfection using chlorine would also provide colour removal by oxidation in the event of colour breakthrough at the plant.

The main impact of increased true colour levels are as follows:

- Front-end pre-ozonation is unlikely to remove all the true colour as the ozone dose is only 1 mg/L
- Higher doses of PACl will be required to remove all the true colour
- There may be an increase in ozone demand in the post-filtration ozonation stage if true colour breakthrough occurs after the conventional treatment process under un-optimised conditions.

The existing treatment process can be expected to remove the higher levels of true colour. However it is recommended that additional monitoring be undertaken of Macquarie River raw water to verify true colour levels. In the event that true colour levels are found to be high under typical raw water conditions bench-scale jar tests should be undertaken to confirm true colour removal for the plant.

8.4 *Escherichia Coli*

Macquarie River recorded a relatively higher average *E. Coli* level (73 CFU/100 mL) compared to Suma Park Dam (26 CFU/100 mL). Mass balance calculations show increases in *E. coli* levels corresponding with higher proportions of Macquarie River water.

The current treatment process and ozone BAC will effectively remove *E. Coli* from the Macquarie River water. The combination of the ozonation process and chlorine disinfection process is particularly effective against *E. Coli*.

8.5 *Somatic coliphages*

Average *somatic coliphage* levels for Suma Park Dam (45 PFU/100 mL) are lower than Macquarie River (81 PFU/100 mL). Based on the mass balance calculations an increase in S. coliphage levels would occur when Macquarie River water is pumped into Suma Park Dam.

The treatment processes used to remove *E. Coli* is also effective in removing *Somatic coliphages*. The current treatment processes can be expected to treat the *Somatic coliphage* levels recorded in Macquarie River.

8.6 *Clostridium perfringens*

Suma Park Dam had an average *C. perfringens* concentration of 6 CFU/100 mL whilst Macquarie River had an average of 11 CFU/100 mL.

Clostridium perfringens are treated by the same processes that remove *E. Coli* and s*omatic coliphages*. These processes including ozonation, clarification, gravity filtration, BAC filtration and chlorination are adequate in treating the *clostridium perfringen* levels in Macquarie River.

8.7 Aluminium

Suma Park Dam and Macquarie River had average total aluminium concentrations of 0.15 mg/L and 0.53 mg/L respectively. Average soluble aluminium concentration is 0.14 mg/L for Macquarie River, indicating that the larger portion of the aluminium is insoluble. The average level in Suma Park Dam is uncertain as there is only one sample point, taken during a dirty water event. It is recommended that OCC undertake additional testing to verify the form of aluminium present in Suma Park Dam raw water.

The conventional treatment process is capable of removing the low levels of aluminium typically found in surface waters including the higher level detected in Macquarie River.

8.8 Manganese

Suma Park Dam has an average total manganese concentration of 0.15 mg/L, which is above the Macquarie River an average concentration of 0.06 mg/L.

Raw water manganese levels in Macquarie River raw water is mostly insoluble and does not present a treatment challenge for the plant as insoluble manganese is readily removed by conventional treatment.

8.9 Iron

Suma Park Dam recorded an average total iron concentration of 0.21 mg/L. The average iron concentration of Macquarie River is higher with an average of 0.81 mg/L being recorded.

OCC has not measured both the total and soluble iron levels in Macquarie River. However give that soluble iron is readily oxidised with oxygen it is expected to be mostly in the insoluble form. It is recommended that OCC undertake additional testing to verify the form of iron present in Macquarie River raw water.

The conventional treatment process is capable of removing the low levels of iron typically found in surface waters including the higher level detected in Macquarie River. Oxidation by potassium permanganate and ozone will also assist in the removal of dissolved iron if it were to occur in the raw water.

8.10 Bromide

Suma Park Dam and Macquarie River have an average bromide concentration of 0.04 and 0.087 mg/L respectively. Bromide is a chemical parameter of concern for OCC and should be monitored closely if Macquarie River water is pumped to Suma Park Dam. While there is no ADWG limit for bromide, the chemical is oxidised by ozone to form bromate. Bromate is toxic to humans and is a suspected carcinogen. The ADWG limit for Bromate is 0.02 mg/L, and the ADWG states that bromate levels of up to 0.09 mg/L have been detected in ozonated water.

The issues paper written by City Water Technology for OCC in 2010, recommended that bromide levels above 0.1 mg/L at the WTP intake should trigger further investigation into the source of bromide (Suma Park Dam Inlet, Blackmans Swamp Creek harvesting scheme patch ponds and bores).

It is recommended that OCC undertake monthly bromide monitoring in Macquarie River. OCC is currently investigating the use of an online bromide meter for Icely WTP and proposed Macquarie River extraction point.

It is recommended that OCC continue developing the bromide process optimisation strategy for operation should elevated bromide levels above 0.1 mg/L be experienced. The optimisation strategy could incorporate modification of the treatment process including the following:

- Reduce pH, by utilising alum in lieu of PACl
- Reduce ozone dose
- Reduce ozone contact time by operating plant at higher flow rates
- Reduce organics through enhanced coagulation

9. Icely Road WTP Log Removal

The following is an assessment of the log removal credits that would be achieved by Icely Road WTP. These are the minimum log removals that would be achieved by the process, as the log removals were determined for the plant operating at maximum design flow, therefore the contact time (CT) for disinfection by ozone and chlorine would be at their minimum.

Table 9.1: Minimum log removal credits achieved at Icely Road WTP for Cryptosporidium, Giardia and viruses

Process	Cryptosporidium	Giardia	Virus
Conventional	3 log removal[1] 4 log can be achieved if individual filter effluent turbidity ≤ 0.15 NTU in at least 95% of measurements each month in each filter and no greater than 0.3 NTU in two consecutive measurements in any filter	2.5 log removal[2] Combined filter effluent turbidity < 0.5 NTU in at least 95% of measurements each month and maximum turbidity of < 5 NTU with measurements taken every four hours	2 log removal[2] Combined filter effluent turbidity < 0.5 NTU in at least 95% of measurements each month and maximum turbidity of < 5 NTU with measurements taken every four hours
Ozone	0.5 log removal at 20°C[3] < 0.25 log removal at 10°C[3]	3 log removal at all temperatures[3]	4 log removal at all temperatures[4]
Chlorination	Not effective disinfection[5]	2.5 log at pH 7.5 and 20°C[6] 1 log at pH 7.5 and 10°C[6] 2 log at pH 8 and 20°C[6] 1 log at pH 8 and 10°C[6]	4 log removal at all temperatures[7]
Total Log Credit	**3 log removal minimum**	**6.5 log removal minimum**	**10 log removal minimum**

References

1. USEPA LT2ESWTR, January 2006, Federal Register 40 CFR Parts 9, 141, and 142, p678
2. USEPA SWTR, June 1989, Federal Register 40 CFR Parts 141 and 142, p27511
3. USEPA LT2ESWTR Toolbox Guidance Manual p11-3
4. AWWA M20 – Water Chlorination/ Chloramination Practices and Principals, p142
5. ADWG 2011
6. AWWA M20 – Water Chlorination/ Chloramination Practices and Principals, p139
7. AWWA M20 – Water Chlorination/ Chloramination Practices and Principals, p141

The minimum log removals presented in Table 9.1 will provide adequate treatment and log removal of pathogens, viruses and bacteria for both Suma Park Dam raw water and Macquarie River raw water. It should be noted that the actual log removals will be greater under typical operating conditions. OCC's ongoing optimisation of Icely WTP will ensure that the plant achieves the nominated minimum log removals pathogens, viruses and bacteria.

10. Recommendations

Based on a review of the Suma Park Dam and Macquarie River raw water quality and potential blending scenarios, followed by a review of the Icely Road WTP process, it is recommended that:

- Macquarie River is generally poorer raw water quality compared to Suma Park Dam. It is recommended that OCC should consider and design the pumping protocols to ensure that large quantities of poor quality raw water are not pumped into Suma Dam. The primary water quality parameters of concern are turbidity and bromide.
- Icely Road WTP is capable of treating raw water from Macquarie River that will be pumped into Suma Dam assuming complete mixing and including when entirely sourced from Macquarie River.
- It is recommended that OCC undertake additional testing to verify the following water quality parameters in Macquarie River:
    - True colour
    - Soluble iron
- Complete bench-scale jar testing to verify true colour removal for the plant if true colour levels in Macquarie River are found to be high during typical raw water conditions.
- The current treatment process achieves a minimum log removal of 3 for Cryptosporidium, 6.5 for Giardia, and 10 for viruses.
- The major parameter of concern for the new raw water supply is bromide. OCC should develop and implement a bromate process optimisation strategy for the plant.

11. Glossary

ITEM	DEFINITION
Units	
°C	Degree Celsius
d	Day
g	Gram
h	Hour
HP	Horsepower
HU	Hazen Unit
km	Kilometre
kPa	Kilopascal
kW	Kilowatts
L	Litres
m	Metres
mg	Milligram
mg/L	Milligram per Litre
min	Minutes
mL	Millilitre
ML	Megalitres
mm	Millimetre
NTU	Nephelometric Turbidity Unit
org	Organism
PCU	Platinum Cobalt Unit
s	Second
y	Year
µg	Microgram

Symbol

d	Diameter
G	Velocity Gradient
Gt	Mixing Energy
L	Length
k	Decay rate
K	Headloss coefficient
t	Time

Chemicals

$CaCO_3$	Calcium Carbonate
Cl_2	Chlorine Gas
CO_2	Carbon Dioxide

Acronyms

ACH	Aluminium Chlorohydrate
ADWG	Australian Drinking Water Guidelines
AWWA	American Water Works Association
CCPP	Calcium Carbonate Precipitation Potential
CWS	Clear Water Storage (Tank)
DAF	Dissolved Air Flotation
DAFF	In-Filter Dissolved Air Flotation
DOC	Dissolved Organic Carbon
ES	Effective Size
ET	Equivalent Tenement
HACCP	Hazard Analysis and Critical Control Point

LSI	Langelier Saturation Index
NPV	Net Present Value
OCC	Orange City Council
PAC	Powdered Activated Carbon
PID/P&ID	Pipework and Instrumentation Diagram
PLC	Programmable Logic Controller
RO	Reverse Osmosis
RTW	Rothberg, Tamburini & Windsor
SCADA	Supervisory Control And Data Acquisition
T&O	Taste and Odour
TDS	Total Dissolved Solids
THM	Trihalomethane
TOC	Total Organic Carbon
UC	Uniformity Coefficient
UFRV	Unit Filter Run Volume
USEPA	United States Environmental Protection Agency
UV	Ultra Violet (Light)
VSD	Variable Speed Drive
WHO	World Health Organisation
WFP	Water Filtration Plant
WPS	Water Pump Station
WR	Water Reservoir
WTP	Water Treatment Plant

Appendix A – Process Design Summary

Cardno/ Orange CC

Icely Road WTP Process Design Summary

Draft Report

4 April 2012

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Icely Road WTP Process Design Summary

Cardno/ Orange CC

Draft Report

4 April 2012

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Table of Contents

1. Introduction

Orange City Council (OCC) is constructing a new 37 km pipeline from the Macquarie River to Suma Park Dam, to provide a new raw water source that will assist in securing the water supply for the city of Orange in NSW.

Cardno Pty Ltd has been engaged by OCC to undertake detailed design of the Macquarie Pipeline. As part of the engagement Cardno is required to complete a water quality risk assessment on the new raw water source including an assessment of the impact to OCC's treated water quality standards. Cardno engaged MJM Environmental (MJM) to complete a review of potential water quality impacts on OCC's Icely Road Water Treatment Plant (WTP).

As part of the review MJM is required to complete a process design summary of the WTP.

The process design summarises are based on the NSW Water Directorate Operations and Maintenance Templates. Should OCC decide to use these O&M Templates for Icley WTP they can be easily incorporated into the manual in the future.

2. Process Design Summary

The following tables present the various water treatment processes carried out at the WTP and the design parameters and values for each process. For MJM to complete a process design summary of the WTP the following process tables are to be forwarded to the person/s responsible for the operation of each process and the design values inserted.

The process tables include the following:

- Oxidation ($KMnO_4$)
- Pre-Ozone
- Coagulation and Flocculation
- Clarification
- Dual Media Filtration
- pH Correction
- Fluoridation
- Post-Ozone
- BAC Filtration
- Filtered Water Storage and Pumping
- Disinfection
- Chemical Dosing Systems
    - Potassium Permanganate
    - Ozone
    - Coagulant (PACl)
    - Polymer
    - Soda Ash
    - Fluoride
    - Chlorine Gas

2.1 Oxidation ($KMnO_4$)

Component	Parameter	Value	Units
Flow Rates			
Flash mixing/ coagulation	Design process maximum flow rate (instantaneous)	315	L/s
	Design hydraulic maximum flow rate (instantaneous)	315	L/s
Process Components			
Potassium Permanganate Oxidation	Chemical agent used	$KMnO_4$ 1%	
	Typical dose range	0 < X > 130	Mg/L
	Dosing point	Raw water main	
	Signal for flow pacing dosing	Manual	
	Signals for dosing start/ stop	Raw water flow	
	For details of dosing system see:	Prominent	
Pipe	Pipe volume	N/A	m^3
	Detention time at maximum flow rate	18.3	min

2.2 Pre-Ozone

(Data already provided by OCC)

2.3 Coagulation and Flocculation

Component	Parameter	Value	Units
Flow Rates			
Flash mixing/ coagulation	Design process maximum flow rate (instantaneous)	315	L/s
	Design hydraulic maximum flow rate (instantaneous)	315	L/s
Process Components			
Coagulant dosing	Chemical agent used	ACH	-
	Typical dose range	20 – 40	mg/L
	Dosing point	Before Pre-oxidation	-
	Signal for flow pacing dosing	No feedback/ Raw water flow	-
	For details of dosing system see:	OCC	-
Polymer dosing	Chemical agent used	LT20	-
	Typical dose range	0.05 – 1	mg/L
	Dosing point	Flash mixer	-
	Signal for flow pacing dosing	Raw water flow	-
	For details of dosing system see:	OCC	-
Flash mixing chamber	Tank dimensions: width	1.545 X 1.535	m
	Tank depth	3.45	m
	Tank volume	8.18	m^3
	Detention time at design max flow rate	0.54	min
Mechanical flash mixer	Type	Vertical shaft/impeller/no baffles	-
	Speed range	80 – 130	rpm
	Velocity gradient	215	s^{-1}
Flocculation tank	Number of tanks/compartments	6	-
	Dimensions: length x width x depth	4.049 X 3.45 X 3.45	m

Component	Parameter	Value	Units
	Tank volume	48.2	m^3
	Detention time at design max flow rate	9.2	min
Mechanical flocculators	Number	5	-
	Type	N/A	-
	Speed range	N/A	rpm
Polymer dosing	Chemical agent used	N/A	-
	Typical dose range	N/A	mg/L
	Dosing point	N/A	-
	Signal for flow pacing dosing	N/A	-
	For details of dosing system see:	N/A	-

2.4 Sedimentation

Component	Parameter	Value	Units
Flow Rates			
Sedimentation	Design process maximum flow rate (instantaneous)	450	L/s
	Design process minimum flow rate (instantaneous)	450	L/s
	Design hydraulic maximum flow rate (instantaneous)	450	L/s
Process Components			
Sedimentation Tanks	Type	Horizontal clarifiers – high rate	-
	Number of tanks	4	-
	Maximum flow rate per tank	112.5	L/s
	Dimensions	9.2 x 23.8	m
	Area (total)	219	m^2
	Area (settling zone)	219	m^2
	Design surface loading rate at max flow rate	2.1	m/h
	Volume (total)	761.8	m^3
	Volume (flocculation zone)	761.8	m^3
	Detention time at design max flow rate (total)	24	min
	Detention time at design max flow rate (flocculation zone)	24	min
Inlet	Type	Weir	-
Settled water collection system	Type	Saw tooth weir	-
Sludge rake/scraper	Type	Horizontal rake	
	Drive speed	2.5	m/min
Sludge hoppers/ sump	Type	Sump	-
	Number per clarifier	6	-
	Volume each hopper/ sump	N/A	m^3
Desludge valves	Type	Knife gate	-
	Number per clarifier/ hopper	3	-
	Size (nominal bore diameter)	150	mm
Desludge discharge pit	Type	In-ground/rectangular/ concrete	-
	Volume	N/A	m^3

2.5 Dual Media Filtration

Component	Parameter	Value	Units
Flow Rates			
Filtration	Design process maximum flow rate (instantaneous)	450	L/s
	Design process minimum flow rate (instantaneous)	450	L/s
	Design hydraulic maximum flow rate (instantaneous)	450	L/s
Process Components			
Filter inlet distribution channel/ pipe	Dimensions: length x width x depth	5.35 x 4.4 x 3.45	m
	Channel volume	81.2	m^3
	Detention time at design max flow rate	3	min
	Method of flow distribution between filters	Concrete channel	-
Filter beds/ vessels	Type	Gravity	-
	Number of filters	8	-
	Area dimensions: length x width	5.4 x 4.2	m
	Area per filter	22.68	m^2
	Total filter area	181.44	m^2
	Filtration rate	11.6 (max)	m/h
	Backwash rate during backwash	54	m/h
	Filter bed available headloss	2.5 (Max)	m H_2O
Filter bed/ vessel Underdrains	Type	Laterals	-
Filter media	Filter coal: Effective size / depth Uniformity Coefficient	460 1.0 – 1.1 1.4	mm
	Filter sand: Effective size / depth Uniformity Coefficient	225 0.5 1.6	mm
	Gravel layer 1: Effective size / depth	2-3	mm
	Gravel layer 2: Effective size / depth	3-6	mm
	Gravel layer 3: Effective size / depth	6-12	mm
	Gravel layer 4: Effective size / depth	12-24	mm
Polymer dosing	Process function	N/A	-
	Chemical agent used	N/A	-
	Typical dose range	N/A	mg/L
	Dosing point	N/A	-
	Signal for flow pacing dosing	N/A	-
	Signals for dosing start/ stop	N/A	-
	For details of dosing system see:	N/A	-
Filter backwash triggers	Headloss: Typical backwash trigger setpoint	2.5	m
	Turbidity: Typical backwash trigger setpoint	-	NTU
	Time: Typical backwash trigger setpoint	40	hours
	Filter water level: Typical backwash trigger setpoint	-	-
Backwash phases	Air scour: Typical rate setpoint	58.5	m/h
	Combined air and water: Typical rate setpoints for air/ water	-	m/h
	Water wash: Typical flow setpoint	240 L/s	m/h
Air scour blowers	Number	2 (duty/standby)	-
	Capacity each blower	58.5	m^3/h

Component	Parameter	Value	Units
Backwash pumps	Number	2 (duty/standby)	-
	Capacity each pump	N/A	m^3/h
	Backwash water source	9 ML tank	-

2.6 Filtered Water Storage (Cellar)

Component	Parameter	Value	Units
Flow Rates			
Filtered water tank (Cellar) inflow	Design process maximum flow rate (instantaneous)	450	L/s
	Design process minimum flow rate (instantaneous)	450	L/s
	Design hydraulic maximum flow rate (instantaneous)	450	L/s
Clear water pump station and main	Design process maximum flow rate (instantaneous)	420	L/s
	Design process minimum flow rate (instantaneous)	420	L/s
	Design hydraulic maximum flow rate (instantaneous)	420	L/s
Process Components			
Filtered water tank (Cellar)	Dimensions: length x width x depth	20 x 7 x 2.5	m
	Tank volume	350	m^3
	Baffling arrangement	N/A	-
	Detention time at design max flow rate	12	min
	Chemical dosing points on inlet pipe to clear water tank	SSF & SA	-
	Height of bottom water level above tank floor	0.75	m
	Height of overflow above tank floor	2.3	m
Clear water pumps	Number of pumps	3 (duty/standby/standby)	-
	Pump manufacturer, model	Kelly & Lewis	-
	Capacity of pumps (each pump)	420	L/s
	Treated water feed to pumps	Yes	-

2.7 pH Correction

Component	Parameter	Value	Units
Flow Rates			
pH/ alkalinity adjustment	Design process maximum flow rate (instantaneous)	315	L/s
	Design process minimum flow rate (instantaneous)	315	L/s
	Design hydraulic maximum flow rate (instantaneous)	315	L/s
Process Components			
Pre-coagulation alkali dosing	Chemical agent used	Soda ash	-
	Typical dose range	12 – 46	mg/L
	Dosing point	In cellar	-
	Signal for flow pacing dosing	CW flow	-
	Signals for dosing start/ stop	CW flow	-
	For details of dosing system see:	OCC	-
Pre-coagulation inline mixer	Mixer type	Screw feeder	-
	Mixer location	Batching tank	-
Post-coagulation inline mixer	Mixer type	N/A	-
	Mixer location	N/A	-

2.8 Fluoridation

Component	Parameter	Value	Units
Flow Rates			
Fluoridation	Design process maximum flow rate (instantaneous)	315	L/s
	Design process minimum flow rate (instantaneous)	315	L/s
	Design hydraulic maximum flow rate (instantaneous)	315	L/s
Process Components			
Fluoride dosing	Chemical agent used	SSF	-
	Typical dose range	1.2 mg/L	mg/L
	Dosing point	Into cellar	-

2.9 Post-Ozone

(Data already provided by OCC)

2.10 BAC Filtration

Component	Parameter	Value	Units
Flow Rates			
Filtration	Design process maximum flow rate (instantaneous)	315	L/s
	Design process minimum flow rate (instantaneous)	315	L/s
	Design hydraulic maximum flow rate (instantaneous)	315	L/s
Process Components			
Filter inlet distribution channel/ pipe	Dimensions: length x width x depth	8.5 X 4.0 X 5.0	m
	Channel volume	170	m^3
	Detention time at design max flow rate	9	min
	Method of flow distribution between filters	Pipes/tank/weir	-
Filter beds/ vessels	Type	Gravity	-
	Number of filters	3	-
	Area dimensions: length x width	8.5 x 4	m
	Area per filter	34	m^2
	Total filter area	102	m^2
	Filtration rate	18.5	m/h
	Filtration rate during backwash	27.8	m/h
	Filter bed available headloss	1.7 m	m H_2O
Filter bed/ vessel Underdrains	Type	Laterals (51)	-
Filter media	Filter coal: Effective size / depth Uniformity Coefficient	460 1.0-1.1 1.4	mm
	Filter sand: Effective size / depth Uniformity Coefficient	225 0.5 1.6	mm
	Gravel layer 1: Effective size / depth	2-3	mm
	Gravel layer 2: Effective size / depth	3-6	mm
	Gravel layer 3: Effective size / depth	6-12	mm
	Gravel layer 3: Effective size / depth	12-24	mm
Filter backwash triggers	Headloss: Typical backwash trigger setpoint	-	m
	Turbidity: Typical backwash trigger setpoint	-	NTU
	Time: Typical backwash trigger setpoint	Manual 72	hours
	Filter water level: Typical backwash trigger setpoint	-	-
Backwash phases	Air scour: Typical rate setpoint	N/A	m/h
	Combined air and water: Typical rate setpoints for air/ water	90 L/s	m/h
	Water wash: Typical flow setpoint	200 L/s	m/h
Air scour blowers	Number	2 (Duty/Standby)	-
	Capacity each blower	N/A	m^3/h
Backwash pumps	Number	2 (Duty/Standby)	-
	Capacity each pump	455 L/s	m^3/h
	Backwash water source	CW Storage Tank	-

2.11 Filtered Water Storage and Pumping

Component	Parameter	Value	Units
Flow Rates			
Filtered water tank inflow	Design process maximum flow rate (instantaneous)	450	L/s
	Design process minimum flow rate (instantaneous)	450	L/s
	Design hydraulic maximum flow rate (instantaneous)	450	L/s
Transfer pump station and main	Design process maximum flow rate (instantaneous)	420	L/s
	Design process minimum flow rate (instantaneous)	420	L/s
	Design hydraulic maximum flow rate (instantaneous)	420	L/s
Backwash pump station and main	Design process maximum flow rate (instantaneous)	420	L/s
	Design process minimum flow rate (instantaneous)	420	L/s
	Design hydraulic maximum flow rate (instantaneous)	420	L/s
Process Components			
Filtered water tank	Dimensions: length x width	5.1 x 11.2	m
	Tank volume	N/A	m^3
	Baffling arrangement	-	-
	Detention time at design max flow rate	N/A	min
	Chemical dosing points on inlet pipe to clear water tank	None	-
	Height of bottom water level above tank floor	N/A	m
	Height of overflow above tank floor	N/A	m
Transfer pumps	Number of pumps	2 (Duty/Standby)	-
	Pump manufacturer, model	Malcom/Thompson	-
	Capacity of pumps (each pump)	4.55	L/s
	Treated water feed to pumps	N/A	-

2.12 Disinfection

Component	Parameter	Value	Units
Flow Rates			
Disinfection	Design process maximum flow rate (instantaneous)	315	L/s
	Design process minimum flow rate (instantaneous)	315	L/s
	Design hydraulic maximum flow rate (instantaneous)	315	L/s
Process Components			
Chlorine dosing	Chemical agent used	Chlorine Gas	-
	Typical dose range	1.35	mg/L
	Dosing point	CW pipework	-

2.13 Service Tank 1

Component	Parameter	Value	Units
Process Components			
Service tank	Dimensions: length x width x depth	N/A	m
	Tank volume	20 M/L	m^3
	Baffling arrangement	None	-
	Detention time at design max flow rate	N/A	min
	Chemical dosing points on inlet pipe to clear water tank	Chlorine	-
	Height of bottom water level above tank floor	55% atm	m
	Height of overflow above tank floor	N/A	m
Treated water mains (to town reservoir)	Length of mains	5 to closest reservoir	km
	Diameter (ID) of mains	700	mm
	Chemical dosing points on treated water main	None	-

2.14 Service Tank 2

Component	Parameter	Value	Units
Process Components			
Service tank	Dimensions: length x width x depth	N/A	m
	Tank volume	9 ML	m^3
	Baffling arrangement	N/A	-
	Detention time at design max flow rate	N/A	min
	Chemical dosing points on inlet pipe to clear water tank	N/A	-
	Height of bottom water level above tank floor	N/A	m
	Height of overflow above tank floor	N/A	m

2.15 Wastewater Handling

Component	Parameter	Value	Units
Flow Rates			
Wastewater inflow	Dual media filtration backwash flow rate (instantaneous)	360	L/s
	BAC filtration backwash flow rate (instantaneous)	360	L/s
	Clarifier desludge flow rate (instantaneous)	3.5	L/s
Supernatant return pump station and main	Design process maximum flow rate (instantaneous)	40	L/s
	Design process minimum flow rate (instantaneous)	40	L/s
	Design hydraulic maximum flow rate (instantaneous)	40	L/s
Process Components			
Sludge lagoons	Type	High rate	
	Number of lagoons	2	
	Dimensions at base: length x width	110 x 35[1]	m
	Dimensions at crest: length x width	110 x 35[1]	m
	Total depth	1.6 m	m

Component	Parameter	Value	Units
	Operating height	1.6 m	-
	Lagoon volume	N/A	m^3
	Baffling arrangement	N/A	-
	Chemical dosing points on inlet pipe	N/A	-
Supernatant return pumps	Number of pumps	2	-
	Pump manufacturer, model	N/A	-
	Capacity of pumps (each pump)	20	L/s
	Supernatant recycle point(s)	Flash mixer	-

[1] Dimensions of lagoons estimated from aerial photographs (Google 2012)

2.16 Chemical Dosing Systems

2.16.1. Potassium Permanganate

Component	Parameter	Value	Units
Chemical	Type of chemical or brand name	Potassium Permanganate	-
Chemical delivery and unloading	Delivery/ storage method	20 L Drums	-
	Effective storage capacity	200	kg
	Unloading equipment	Manual	-
Dust extraction system	Type	None	-
	Location	N/A	
Chemical storage silo/ hopper	No. of silos/ hoppers/ pallet storage space	None	-
	Silo/ hopper/ bags effective storage capacity	N/A	t
	Silo/ hopper level sensor type	N/A	-
	Silo/ hopper low/ high level switch type	N/A	-
Chemical dosing	No. of metering screw feeders: duty + standby	N/A	-
	Type and model of screw feeders	N/A	-
	Capacity range of screw feeders	N/A	kg/h
	Screw feeder turndown	N/A	-
Dilution tanks	No. of solution/ slurry tanks: duty + standby	1	-
	Solution/ slurry tank effective volume	2000	L
	Solution/ slurry tank mixer type	Mechanical Verticle Shaft	-
Transfer system	No. of transfer pumps/ eductors: duty + standby	1	-
	Type and model of transfer pumps/ eductors	52C4 (Prominent)	-
	Capacity of transfer pumps/ eductors	130	L/h
Dilution/ carry water	Source	Town Water/ CW	-
	Capacity	Under system pressure	L/h
	Normal operating gauge pressure	Reticulation	kPa

2.16.2. Ozone

(Data already provided by OCC)

2.16.3. Coagulant (PACl)

Component	Parameter	Value	Units
Chemical	Type of chemical or brand name	PACL	-
Chemical delivery	Delivery method	Tanker	-
	Delivery location	Site	-
	Fill point fittings	50mm Camlock	-
Chemical storage	No. of storage tanks	2	-
	Tank material	Fibreglass	-
	Tank effective storage volume	38	kL
	Tank depth to fill level	300	mm
	Tank level sensor type	Laser level sensor	-
	Tank depth to low level switch	N/A	mm
	Tank depth to high level alarm switch	N/A	mm
Storage tank bund	Bund capacity	110%	m^3
	Bund sump pump capacity	N/A	L/h
Chemical dosing	No. of dosing pumps: duty + standby	2	-
	Type and model of dosing pumps	Prominent – Sigmas	-
	Capacity range of dosing pumps	65	L/h
	Dosing pump turndown	10:1[1]	-
Calibration tube	Material	PVC	-
	Size	1	L
	Graduation volumes	N/A	mL
Dilution/ carry water	Source	FW Cellar	-
	Capacity	3,240	L/h
	Normal operating gauge pressure	5 m (head)	kPa

[1] Assumed to be 10:1

2.16.4. Polymer

Component	Parameter	Value	Units
Chemical	Type of chemical or brand name	LT20	-
Chemical delivery and unloading	Delivery/ storage method	1 x pallet 25	-
	Effective storage capacity	1 x pallet	kg
	Unloading equipment	Forklift	-
Dust extraction system	Type	N/A	-
	Location	N/A	
Chemical storage silo/ hopper	No. of silos/ hoppers/ pallet storage space	N/A	-
	Silo/ hopper/ bags effective storage capacity	N/A	t
	Silo/ hopper level sensor type	N/A	-
	Silo/ hopper low/ high level switch type	N/A	-
Chemical dosing	No. of metering screw feeders: duty + standby	N/A	-
	Type and model of screw feeders	N/A	-
	Capacity range of screw feeders	N/A	kg/h
	Screw feeder turndown	N/A	-

Component	Parameter	Value	Units
Dilution tanks	No. of solution/ slurry tanks: duty + standby	2	-
	Solution/ slurry tank effective volume	3500(mix) 1600 (dosing)	L
	Solution/ slurry tank mixer type	Mechanical	-
Transfer system	No. of dosing pumps: duty + standby	2	-
	Type and model of dosing pumps	Ajax	-
	Capacity of transfer pumps	120	L/h
Dilution/ carry water	Source	FW Cellar	-
	Capacity	N/A	L/h
	Normal operating gauge pressure	N/A	kPa

2.16.5. Soda Ash

Component	Parameter	Value	Units
Chemical	Type of chemical or brand name	Soda Ash	-
Chemical delivery and unloading	Delivery/ storage method	Truck	-
	Effective storage capacity	20,000	kg
	Unloading equipment	Forklift/crane	-
Dust extraction system	Type	Exhaust fan	-
	Location	Above hopper	
Chemical storage silo/ hopper	No. of silos/ hoppers/ pallet storage space	1 hopper	-
	Silo/ hopper/ bags effective storage capacity	4	t
	Silo/ hopper level sensor type	None	-
	Silo/ hopper low/ high level switch type	N/A	-
Chemical dosing	No. of metering screw feeders: duty + standby	1	-
	Type and model of screw feeders	Volumetric	-
	Capacity range of screw feeders	0<x>2	kg/h
	Screw feeder turndown	Gearbox	-
Dilution tanks	No. of solution/ slurry tanks: duty + standby	1	-
	Solution/ slurry tank effective volume	227	L
	Solution/ slurry tank mixer type	Mechanical	-
Transfer system	No. of transfer pumps/ eductors: duty + standby	None	-
	Type and model of transfer pumps/ eductors	Gravity	-
	Capacity of transfer pumps/ eductors	-	L/h
Dilution/ carry water	Source	FW Cellar	-
	Capacity	1,800	L/h
	Normal operating gauge pressure	-	kPa

2.16.6. Fluoride

Component	Parameter	Value	Units
Chemical	Type of chemical or brand name	Sodium silicofluoride	-
Chemical delivery and unloading	Delivery/ storage method	Truck	-
	Effective storage capacity	4000	kg

Component	Parameter	Value	Units
	Unloading equipment	Forklift	-
Dust extraction system	Type	Yes	-
	Location	In room/ sealed room	
Chemical storage silo/ hopper	No. of silos/ hoppers/ pallet storage space	1 hopper	-
	Silo/ hopper/ bags effective storage capacity	0.1	t
	Silo/ hopper level sensor type	N/A	-
	Silo/ hopper low/ high level switch type	N/A	-
Chemical dosing	No. of metering screw feeders: duty + standby	1	-
	Type and model of screw feeders	Volumetric	-
	Capacity range of screw feeders	5.6	kg/h
	Screw feeder turndown	N/A	-
Dilution tanks	No. of solution/ slurry tanks: duty + standby	1	-
	Solution/ slurry tank effective volume	240	L
	Solution/ slurry tank mixer type	Mechanical verticle shaft	-
Transfer system	No. of transfer pumps/ eductors: duty + standby	N/A	-
	Type and model of transfer pumps/ eductors	Gravity	-
	Capacity of transfer pumps/ eductors	N/A	L/h
Dilution/ carry water	Source	FW Cellar	-
	Capacity	600	L/h
	Normal operating gauge pressure	N/A	kPa

2.16.7. Chlorine Gas

Component	Parameter	Value	Units
Chemical	Type of chemical or brand name	N/A	-
Chemical delivery	Delivery method	920 kg drum	-
	Unloading mechanism	Forklift	-
Chemical storage	No. of cylinders/ drums/ storage vessels	2 Duty/ 2 Standby	-
	Total storage amount	3,680	kg
	Storage measurement system	N/A	-
Chemical dosing	No. of injectors/ dosing systems	2 Injectors	-
	Type and model of injectors/ dosing systems	Aquamet	-
	Capacity range of injectors/ dosing systems	0<x>16.7 kg/h	g/h
Booster/ injector water	Source	FW Cellar	-
	Capacity	14,400	L/h
	Normal operating gauge pressure	740	kPa
Flow meters/ rotameters	No. of flow meters/ rotameters	1 per system	-
	Type	N/A	-
	Range	10,000	g/h
Gas leak detectors and exhaust fans	Storage room leak detector type	N/A	-
	Dosing room leak detector type	N/A	-

Component	Parameter	Value	Units
	Dosing room exhaust fan capacity	N/A	m^3/min