Snowy Monaro Villages Water Safety Scoping Study

Final

Snowy Monaro Regional Council

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Executive Summary

The Snowy Monaro Regional Council (SMRC) covers an area of 15,158 square kilometres and has an approximate population of 20,753 (2015 estimate). Of the numerous small villages, the five villages involved in this project have been identified as a priority to investigate and implement additional treatment barriers to improve water safety. The five villages share some common traits, being relatively isolated with small populations and a water supply that receives chlorination as the single treatment barrier. However, each locality has unique challenges to be addressed in improving the water safety and aesthetics

The objective of the Water Safety Scoping Study is to identify one, or more, preferred options to improve water safety at each location. This report meets this objective by providing a concise evaluation that clearly conveys the objectives, design basis and process that was undertaken to determine the preferred options.

The report includes the following sections;

- Section 1 provides an introduction and background to the project
- Section 2 provides the treated water quality targets for the Villages
- Section 3 to 7 provide the water safety scoping study for each Village
- Section 8 provides order of magnitude cost estimates
- Section 9 provides the Conclusions and Recommendations.

A number of reports have been developed as part of the scoping study and provide background detail to support the outcomes of the Scoping Study. The reports and a summary of their content are;

- *Service Area and Demand for Villages Scoping Study Memo, Revision A. from Hunter H2O to Jessica Dunstan (SMRC), 07/09/2020*
  - Provides a summary of available production and consumption data for the villages and compares this to guidance from the water Services Association of Australia as a benchmark.
  - Outlines the existing service area of the villages
  - Provides an estimate for the 2050 demand and hence capacity for treatment infrastructure.
- *Snowy Monaro Villages Water Safety Scoping Study, Source Water Assessment, September 2020, Revision B*
  - A desktop, high level assessment of pathogen risk was completed in line with the Water Services Association of Australia guidance manual (Water Services Association of Australia, September 2015) to nominate a microbiological risk for each source.
  - Chemical and physical hazards were assessed through statistics as well as creating and considering time series charts and summarised for each location and each source.
  - Typical water quality as well as key challenges for each source were nominated
  - A sampling program was provided (included in this report as Appendix B) to better inform the raw water design envelope moving forward.
- *Water Treatment Options Overview, Memo, from Hunter H2O to Jessica Dunstan (SMRC), 23/09/2020*
  - Presents a long list of treatment options for the identified raw water hazards and their strengths and weaknesses
- *Snowy Monaro Villages Water Safety Scoping Study, Options Assessment Report, September 2020, Revision B*
  - Used previous outputs to consider two or three options to improve water safety at each of the villages, compared the associated strengths and weaknesses and selected a preferred option
  - Considered existing assets and available land area to determine a preferred location for siting new treatment infrastructure.

The Water Safety Scoping has combined key outputs from the previous reports and investigations into a single document that clearly conveys the objectives, design basis and process that was undertaken to determine the preferred options to improve water safety. Each Village is presented within a dedicated section of the report, in summary;

Bredbo

To address raw water health and aesthetic hazards it is recommended to construct a new 400kL/day conventional pressurised direct filtration plant, taking water from the existing aeration tower and incorporating UV disinfection as a mutli-barrier approach to chlorine resistant protozoa. The infrastructure would be located on land purchased adjacent to the existing Reservoir site and raw water pumping upgrades will be required.

Kalkite

To address raw water health and aesthetic hazards it is recommended to construct a new 300kL/day membrane filtration plant on land already owned by council between the raw water pumping station and the community. Due to the location and size of the WTP, raw water pumping upgrades will be required. A new dedicated rising main would be constructed to allow for treated water to be sent direct to the existing Reservoirs to improve the consistency of supply to the community and negate the need to construct a dedicated Chlorine contact tank at the new WTP.

Adaminaby

To address raw water health and aesthetic hazards it is recommended to construct a new 500kL/day membrane filtration plant on land already owned by council at the Adaminaby reservoir site. Chlorination and fluoridation equipment at Observation point would be re-located to Adaminaby or abandoned to reduce the requirement to attend the remote pumping station daily. A small number of rural customers would be impacted and receive ‘raw water’ after the change.

Nimmitabel

To address raw water health and aesthetic hazards it is recommended to construct a new 400kL/day membrane filtration plant on land to be purchased adjacent to the Lucan St Bore. The plant would utilise coagulation to address true colour and organics and treat a blend of River and bore water from 80:20 to 50:50 to take advantage of available groundwater yield and supply a consistent level of hardness. Given the raw water catchment UV disinfection would be incorporated as a mutli-barrier approach to chlorine resistant protozoa.

The water will maintain a moderate alkalinity and hardness and there remains the ability to run 100% groundwater during emergency scenarios. Further investigation and community engagement is recommended to determine the frequency and duration of needing to run 100% bore water and the community willingness to pay for hardness reduction during these events.

Eucumbene Cove

It is recommended that a containerised membrane filtration plant is provided to treat water before it enters the existing reservoir. To address water age and chlorine decay issues, tank mixing is recommended with chlorine monitoring of the bulk tank volume with the ability to dose sodium hypochlorite directly to the tank as a ‘top up’ dose.

Recommendations that span across all of the Villages are;

- Incorporate the provided sampling program for routine and event monitoring, to better inform the raw water design envelope and reduce risk for SMRC and Contractors.
- Undertake a fire attack study of the proposed sites to inform the construction materials required of the new assets.
- Confirm the availability of power at each of the sites to inform the construction of the new assets
- Jar Testing:
  - At Bredbo - to determine the effectiveness of coagulation and typical dose rates for conventional filtration.
  - At Nimmitabel - to determine the effectiveness of coagulation and typical dose rates for membrane filtration at carious blend ratios.
  - At Eucumbene Cove - to assess the impact of maintaining a chlorine residual on the water quality, in particular the pH gives the low alkalinity of the water.

- At Kalkite and Adaminaby jar testing is not essential but could be undertaken to consider the advantage, if any, of coagulation against direct membrane filtration without coagulation. Essentially considering the true colour and chlorine decay of the coagulated and direct filtered water.

Finally an order of cost estimation was undertaken using the NSW reference Rates Manual (Department of Primary Industries, Office of Water, 2014) and a comparison based on recent projects with Hunter H2O visibility. The outputs are provided in the table below with a total project cost for the Villages water safety improvement project being estimated to be in the order of $10.5M (NSW reference rate) to $15.5M.

Table EC1: NSW Reference rates and Recent Project Cost Estimate Comparison.

	NSW Reference Rate	Recent Projects Estimate	Comment
Adaminaby (500kL)	$2.93M	$4.09M	Does not include 1000m of new dedicated rising main
Bredbo (400kL)	$2.45M	$3.68M	Land acquisition required
Nimmitabel (400kL)	$2.45M	$3.68M	Land acquisition required Does not include 500m of new rising main to the WTP location
Kalkite (300 kL)	$1.98M	$3.27M	Does not include 1000m of new dedicated rising main
Eucumbene Cove (60kL)	$0.66M	$0.81	Based on 20 foot shipping container solution.

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1 Introduction

1.1 Background

The Snowy Monaro Regional Council (SMRC) covers an area of 15,158 square kilometres and has an approximate population of 20,753 (2015 estimate). Of the numerous small villages, the five villages involved in this project have been identified as a priority to investigate and implement additional treatment barriers to improve water safety.

The five villages share some common traits, being relatively isolated with small populations and a water supply that receives chlorination as the single treatment barrier. However, each locality has unique challenges to be addressed in improving the water safety and aesthetics. An overview of the water supply for the Villages, including previously identified hazards, is included in Table 1-1.

Table 1-1: Village Overview.

Village	Source	Raw Water Cat.	Identified Hazards
Bredbo	Shallow Groundwater under the direct influence of surface water.	4	Iron and possibly free CO_2 and pathogens from direct Murrumbidgee River influence on the bores. Possibility of organics and true colour, in particular, following flooding. Bores impacted by floods and see the turbidity increase above 20 NTU.
Nimmitabel	Bores + Maclaughlin River	4	Lucan St bore has a median total hardness of ~ 300 mg/L as $CaCO_3$ and Alkalinity in excess of 400 mg/L as $CaCO_3$. River water turbidity routinely spikes to 20 and 30 NTU after small amounts of rainfall and includes organics and true colour. Bore water turbidity is low but variable. Source of the variability needs to be confirmed.
Kalkite	Northern end of Lake Jindabyne	3	No history of algae, taste or odour, true colour or significant organics. Water is taken from depth and the turbidity is typically less than 5 NTU with the possibility of turbidity up to 10 NTU. Water is soft with a pH in a good range. Possibility of low oxygen and soluble metals.
Eucumbene Cove	Deep intake Lake Eucumbene (Dam Wall)	3	No history of algae, taste or odour, true colour or significant organics. Water is taken from depth and the turbidity is typically less than 5 NTU. Water is soft with a pH in a good range. Possibility of low oxygen and soluble metals.
Adaminaby	Deep intake Lake Eucumbene (Observation Point)	3	No history of algae, true colour or significant organics. One taste and odour event linked to Tantangara. Water is taken from depth and the turbidity is typically less than 5 NTU. Water is soft with a pH in a good range. Possibility of low oxygen and soluble metals.

Operationally the five villages are located to the north, south and west of Cooma, as shown in Figure 1-1. Whilst the sites appear relatively close to each other, operational travel distances are complicated by a lack of direct routes.

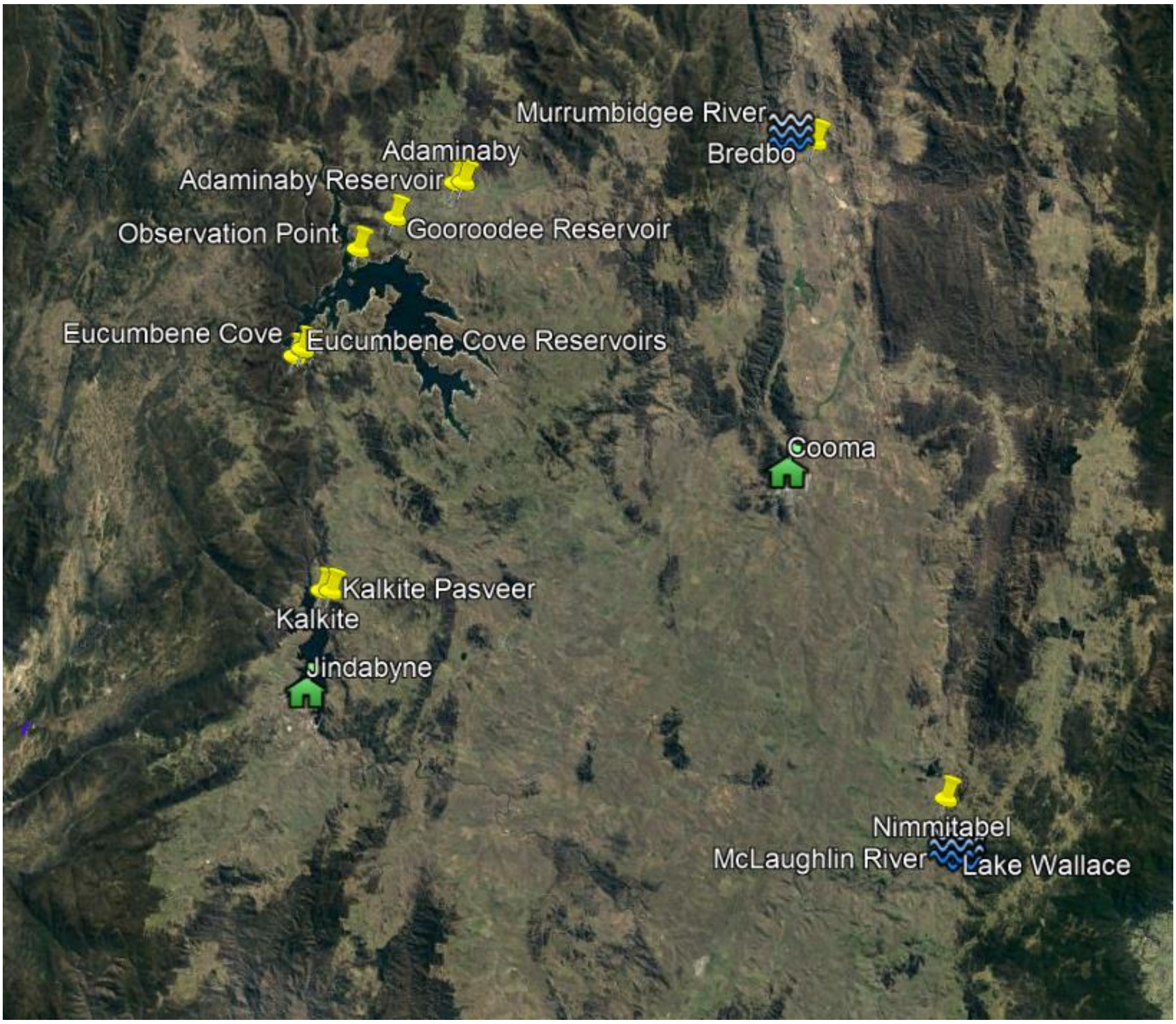


Figure 1-1: Village Location Overview.

1.2 Project Objective

The ultimate objective of the project is to deliver infrastructure and processes that will consistently and reliably deliver water to the residents of the villages that is safe, meets the requirements of legislation, is approved by regulators and is able to be efficiently and effectively operated and maintained by SMRC.

1.2.1 Water Safety Scoping Study Objectives

The objective of the Water Safety Scoping Study is to identify one, or more, preferred options to improve water safety at each location. To successfully meet this objective there is to be a concise evaluation that clearly conveys the objectives, design basis and process that was undertaken to determine the preferred options.

The Water Safety Scoping Study will set the framework for community engagement, SMRC planning and provide the basis to take the project, with DPIE concurrence, into the Concept Design and Business Case phase.

2 Treated Water Quality Targets

2.1 Treated Water Quality

The treated water quality proposed for all of the treatment plants is provided in Table 2-1 as a starting point.

Table 2-1: Preliminary Treated Water Quality Targets.

Parameter	Units	Value and Comment note 1.	ADWG
Turbidity	NTU	• Individual Filter turbidity of <0.15 NTU for 95% of samples. • Individual filter turbidity not to exceed 0.3 NTU for more than 15 minutes consecutively. Individual filter results are to be taken at least every 5 minutes from a continuous online analyser. • Membrane filtered water turbidity of <0.10 NTU for 95% of samples.	Insufficient data for health limit <5 NTU (aesthetic) <1 NTU for Disinfection
		The turbidity targets above are to achieve the highest log credits and are suggested for all sites.	
True colour	Hazen	< 5 Grab sample at the treated water tank outlet	<15 HU (aesthetic)
		True Colour target is valid for Bredbo and Nimmitabel where coagulation is part of the treatment train. For Kalkite, Eucumbene cove and Adaminaby there may not be a need for coagulation (with membrane filtration) and if so the true colour target would be relaxed or removed.	
Total iron	mg/L	< 0.1 Grab sample at the treated water tank outlet	Insufficient data for health limit <0.3 mg/L (aesthetic)
		Required at Bredbo and for other sites this is a typical requirement to ensure that filtration is effective.	
Total manganese	mg/L	Not Applicable	<0.5 mg/L (health) <0.1 mg/L (aesthetic)
		None of the sites have been identified as requiring a barrier to soluble manganese and as such a manganese target will not be incorporated as it would drive risk and the inclusion of additional treatment barriers (pre chlorine, potassium permanganate, oxidation or coated media)	
Total aluminium	mg/L	< 0.1 Grab sample at the treated water tank outlet.	Insufficient data for health limit <0.2 mg/L (aesthetic)
		Standard requirement to ensure that coagulation has been optimised	
pH		6.5 < pH < 8.5 Measured continuously with the free chlorine level	6.5 to 8.5
		Standard requirement to match the ADWG	
Fluoride	mg/L	Fluoride addition for Adaminaby No fluoride addition at any other site	

Free available chlorine	mg/L	1.0 < Free Chlorine < 2.0 90th percentile within 0.3 mg/L of an operator entered free available chlorine set-point at the entry to the treated water tank of between 1 and 4 mg/L.	<5 mg/L Total Chlorine (health)
		At an Option level the intent is that all sites will have online chlorine monitoring on the outlet of the WTP/inlet to the reservoir. At this location the chlorine level can be used to trim the chlorine dose to target a specific level going into the treated water storage and as such the designer can be held responsible for the performance. At Kalkite and Nimmitabel the proposed location of the treatment infrastructure is remote from the treated water storage and 'top up dosing' of the reservoir from the chlorine storage and dosing system in the WTP is not practical. At Bredbo and Adaminaby best practice would be to incorporate reservoir mixing and free chlorine monitoring of the water in/leaving the treated water storage tank with an associated top up dose with a performance requirement. Due to low usage it has been recommended that Eucumbene Cove has a tank mixer and a recirculation loop that measures the free chlorine level in the reservoir to allow for a target level in the reservoir through a chlorine top up dose.	
Chlorine C.t	mg.min/L	Not Applicable	Minimum C.t must be achieved to attain target levels of pathogen inactivation; a free chlorine residual of >0.2 mg/L must be maintained throughout the distribution system; but the total chlorine residual must be kept at <5 mg/L (health)
		Direct feed to the treated water storage tank has been proposed for all of the Villages and the C.t achieved in the reservoir has been calculated in the *Options Assessment Report* (Hunter H2O, September 2020) as sufficient using minimal storage. As such C.t will not be a performance requirement for the Contractor.	
E coli and faecal coliforms	CFU/100mL	No Detects Grab sample at the outlet of the WTP.	N/A
Chlorination Disinfection By-products	Total THM	Not applicable to WTP Contract	< 250µg/L
		Measurements to be taken by SMRC and compared against the targets below, not to be included as part of the D&C contract as the designer is unable to guarantee. < 250µg/L, Chloroacetic acid: 150µg/L, Dichloroacetic acid: 100µg/L, Trichloroacetic acid: 100µg/L	
Alkalinity	mg/L as $CaCO_3$	Alkalinity adjustment is not part of the proposed solution at Bredbo	N/A
		Current position is Bredbo and Nimmitabel – Have sufficient natural alkalinity for use of ACH as a coagulant. Jar testing would be recommended to confirm. Kalkite, Adaminaby and Eucumbene Cove – Sampling required, to confirm level and requirement if coagulation is undertaken.	
Hardness	mg/L as $CaCO_3$	Hardness adjustment is not being considered at any of the Villages. Nimmitabel to have blending of 10% to 50% groundwater	Should not exceed 200 mg/L as $CaCO_3$ to minimise undesirable build-up of scale in hot water systems

Note 1 - For all parameters, except for the chlorine C.t and the filter turbidity, which have their own percentile requirements, the limits presented above represent 95th percentiles for all flows and quality within the raw water design envelope.

3 Bredbo

Table 3-1: Bredbo Summary.

Component	Bredbo – 400 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	74.8	271.9	366.5
Reservoir Capacity	500kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 4 days 2020 PDD ~ 1 day		
Key Water Quality Challenges	The key hazardous event to be overcome, given the demonstrated link of the raw water to surface water, is the increase in turbidity and by inference, pathogen loading, during and following heavy rainfall when the turbidity increases rapidly. Raw water hazards ▪ Turbidity / suspended solids ▪ Pathogens (Category 4 source water) ▪ Iron (soluble and total) ▪ Colour		
Raw Water Quality Uncertainties	Whilst the aeration tower appears to be effective it is recommended to confirm levels of free CO_2 and the typical levels of soluble and total iron for each bore.		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 17% in the reservoir		
Raw Water Pumping	Bore 2 instantaneous capacity is less than required 5.3 L/sec and needs to be investigated to increase capacity or design the treatment infrastructure to suit. Pumping modifications will be required.		
Site location			
Land Acquisition Required?	Yes - Proposed to purchase land adjacent to the existing reservoir site.		
Shortlisted Options Considered	▪ Direct Media Filtration ▪ DAF/F ▪ Direct Membrane Filtration		
Preferred Option	The relatively stable raw water quality from the shallow bores, the availability and relative simplicity of pressure media filters, in combination with UV as a		

	multi barrier approach, means that Direct Media Filtration is the preferred option for Bredbo.
Residuals Management	Sludge Lagoons including an opportunity for local irrigation
UV Disinfection	Recommended due to the preliminary catchment categorisation of 4. “Unprotected Catchment”
Recommendations	In addition to the recommendations of previous reports ▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Coagulation Jar testing ▪ Raw water pumping investigation (Section 3.5.1) ▪ Confirmation and documentation of the design and operation of the aeration tower

3.1 Overview

Bredbo is located 82km south of Canberra and 34km north of Cooma on the Monaro Highway, at the confluence of the Bredbo and Murrumbidgee Rivers.

The town has a population of 352 people (2016 Census) with 110 supply connections (SMRC).

Gravel access road to reservoir location

Aeration tower and reservoir

Bore headworks

View from the bores back to the reservoir

	
Looking up to the bore location from the Murrumbidgee River meander	Reservoir access

Figure 3-1: Overview of Bredbo Infrastructure.

3.2 Service Area

GIS data from SMRC was used to provide an indicative service area for each Village and is presented below in Figure 3-2.

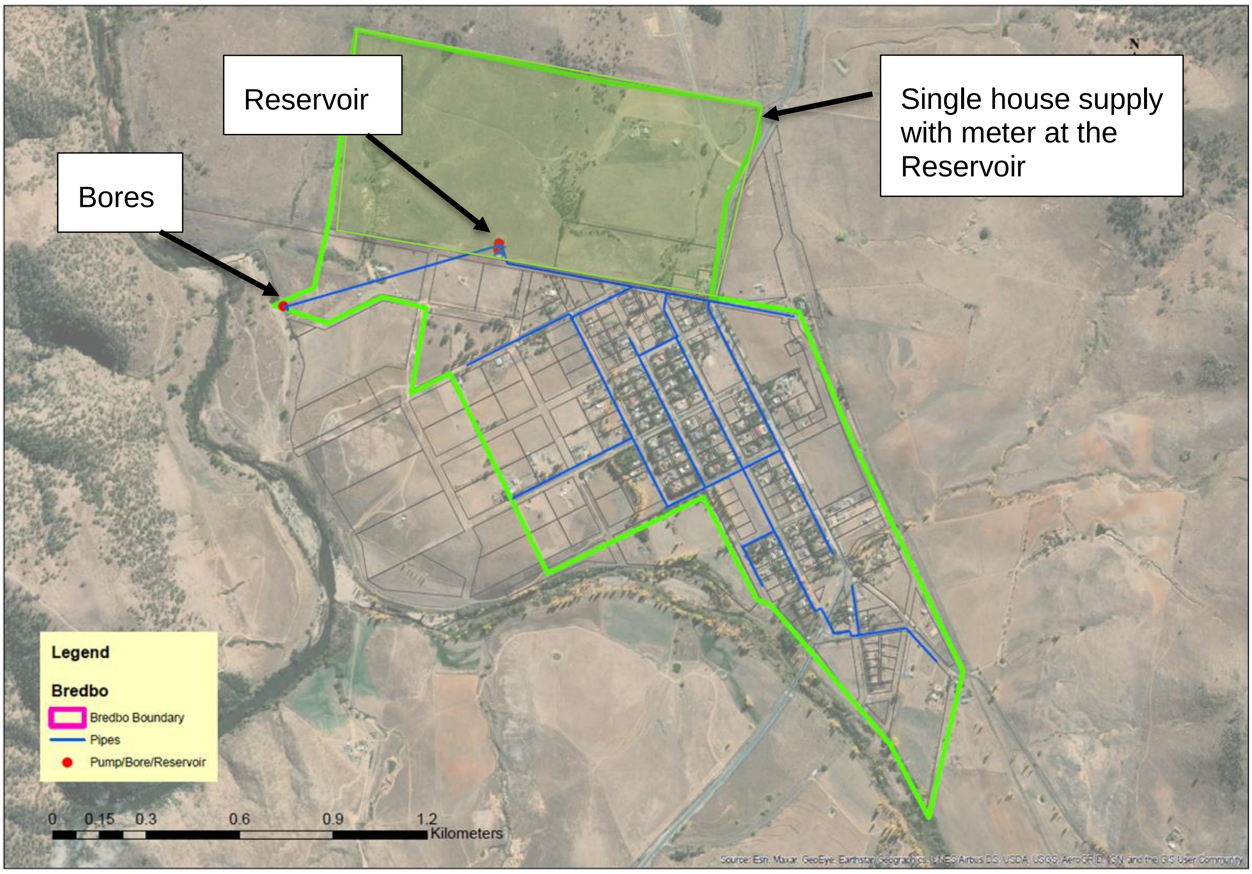


Figure 3-2: Bredbo Service Area.

3.3 Historical and Forecast Demand

Figure 3-3 shows the production of the Bredbo bores over the last 10 years as a time series. Table 3-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

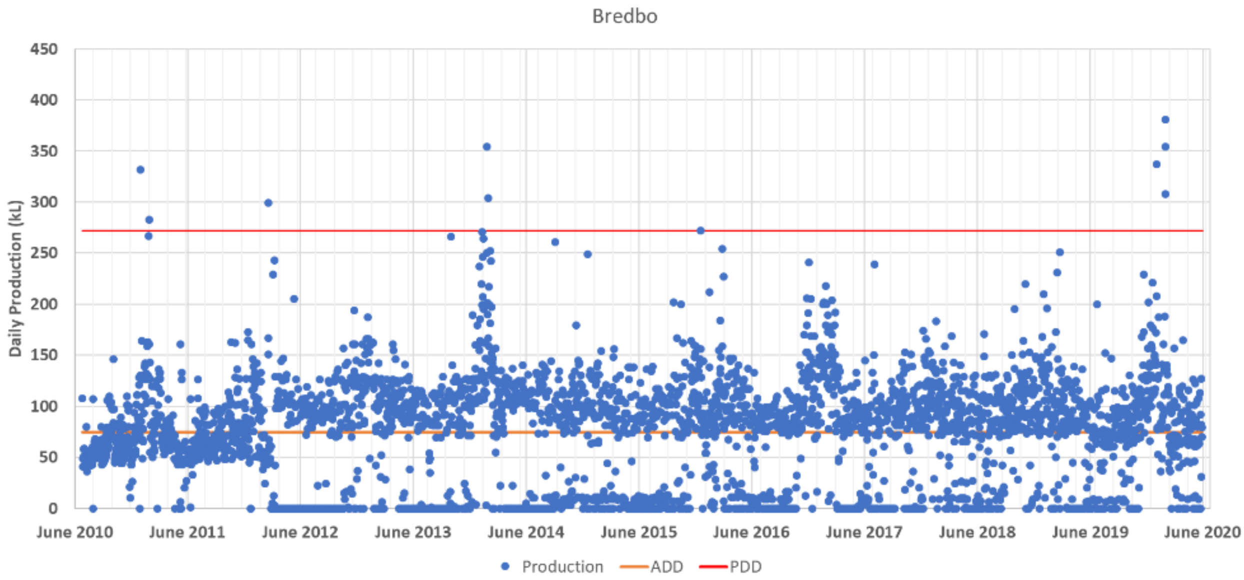


Figure 3-3: Bredbo Daily Production.

Table 3-2: Bredbo Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Bredbo	Groundwater under the direct influence of surface water.	Bore 1 – 460 Bore 2 – 340 Total – 800	272	75	366.5	400

Note 1. 1% annual population growth was adopted for the 2050 projections

3.4 Source Water Assessment

The Bredbo raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

Beyond the day to day challenge, the key hazardous event and challenge to be overcome to improve the water safety of Bredbo, given the demonstrated link of the raw water to surface water, is the increase in turbidity and by inference, pathogen loading, during and following heavy rainfall when the turbidity increases rapidly.

The variability of turbidity associated with the direct connection to surface water is demonstrated in Figure 3-4, Figure 3-5 and Figure 3-6. Whilst the variability is not entirely explained by the river level, the relationship is strong and supports a direct connection to surface water.

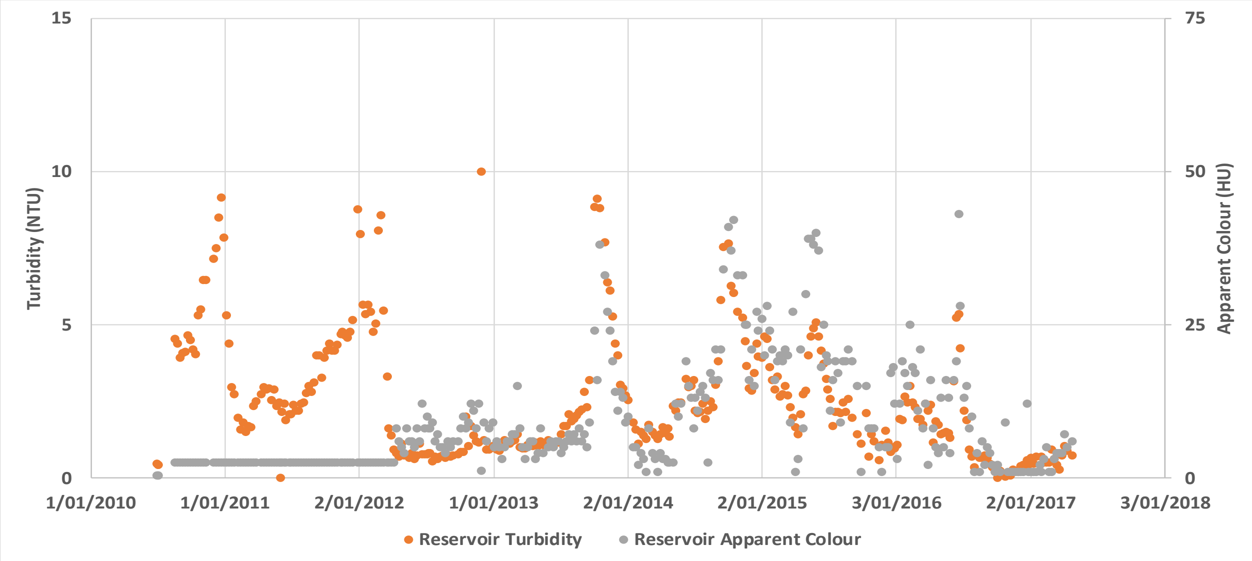


Figure 3-4: Reservoir Water Turbidity and Apparent Colour Data (July 2010 – May 2017).

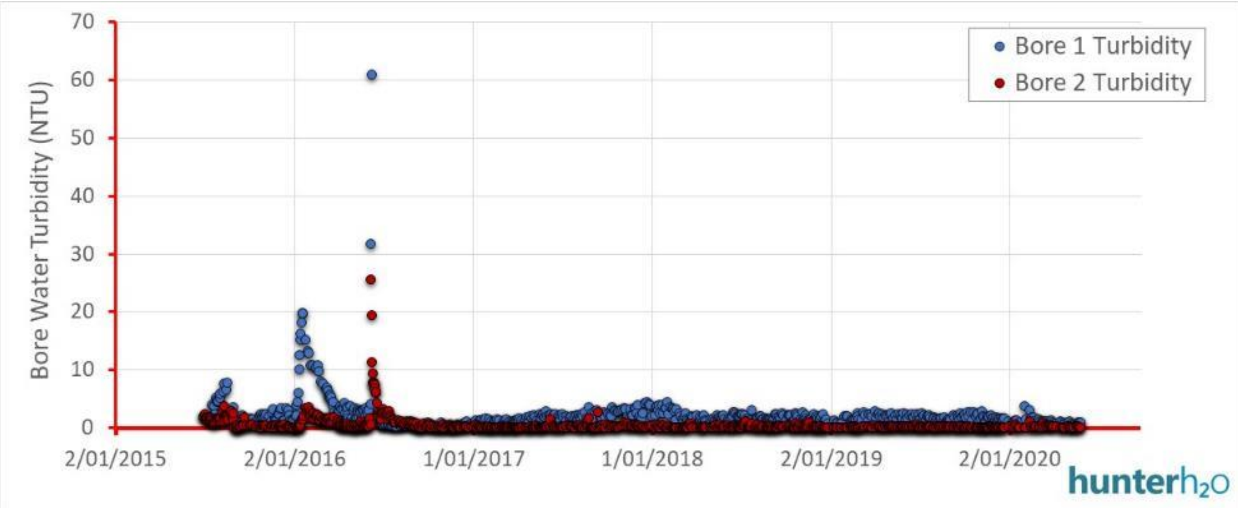


Figure 3-5: Bore Water and Reservoir Water Turbidity Data (July 2015 – May 2020).

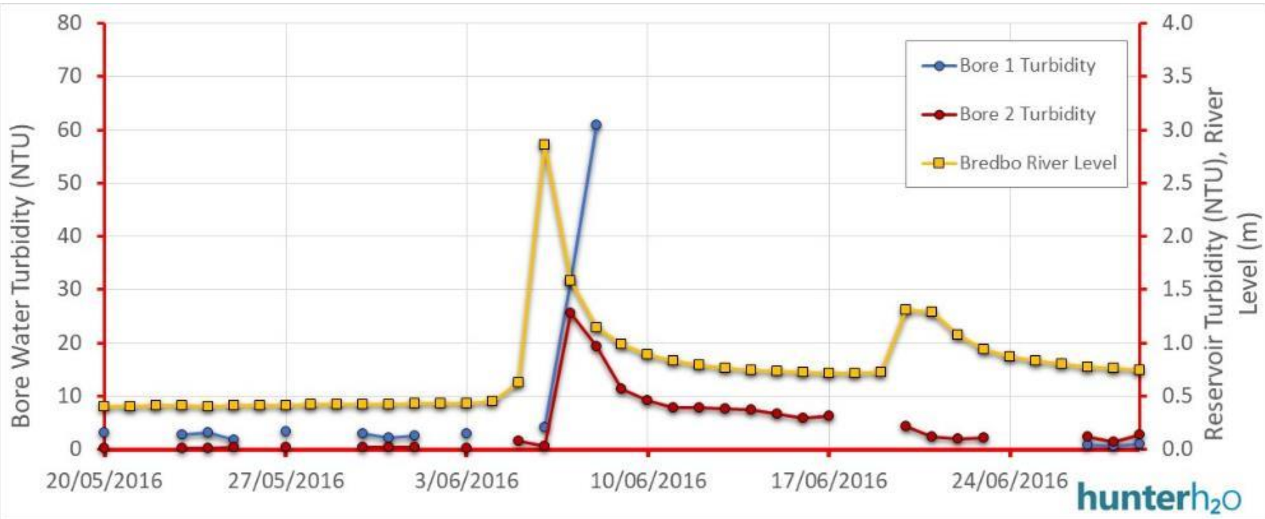


Figure 3-6: Bore Water Turbidity and Bredbo River Level Data During High Turbidity Event in June 2016.

3.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water Assessment (Hunter H2O, 2020). The assessment determined that the Bredbo source was conservatively a Category 4 source (Hunter H2O, 2020).

As a Category 4 source to achieve a target of an additional health burden, from potable water, of less 1×10^{-6} DALY's (Disability Adjusted Life Years) the following log reductions are recommended by the guidance manual and will require a multi barrier approach.

- **6.0 log_{10} reduction in Bacteria**
- **6.0 log_{10} reduction in Viruses and**
- **5.5 log_{10} reduction in Protozoa**

3.4.2 Chemical/Physical

From a review of the available raw water and reservoir water data the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Bredbo.

Turbidity / Suspended Solids

- Both bores are consistently less than 5 NTU but more than 1 NTU
- Bore 1 has a consistently higher turbidity than bore 2
- Turbidity spikes following river level rise and flooding of the Murrumbidgee river meander local to the bores of up to 60 NTU but a more typical a spike has a turbidity of 10 to 20 NTU

Metals

- Soluble iron is present in both bores
  - Unknown ratio of total to soluble iron and effectiveness of current aeration tower.
- No data to nominate if the bores have equivalent levels of total/soluble iron

Colour

- Apparent colour is variable and has been recorded up to 30 HU
- True colour is suspected to be present during periods of increased turbidity due to connection with the river water and surface water organics/colour.

Organics

- No data available, suspected of being low due to low apparent colour
- Increase in organics expected following rain events when the bores are influenced by surface water.

pH and Alkalinity

- Raw water pH is typically less than 7 with the reservoir pH being 7.5 to 8.
  - Stripping of free CO_2 in the aeration tower suspected on being the cause of the pH rising.
  - Some increase through addition of sodium hypochlorite.
- Alkalinity is variable but is sufficient to allow for coagulation if required without impacting stability.

Hardness

- Hardness is reasonable with a historical medium of 65 mg/L as $CaCO_3$

3.4.3 Raw Water Quality Design Envelope

Table 3-3 outlines the preliminary raw water design envelope for the Bredbo WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Bredbo that are recommended to be filled being;

- Dissolved CO_2 presence and removal across the aerator
- The presence of soluble iron and its oxidation across the aerator

- Level of total and dissolved organic carbon, particular as the turbidity increases
- Presence of microbiological contamination in the bores, typically and through events

Table 3-3: Preliminary Raw Water Design Envelope.

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	25
pH		6.5	6.9	7.0	7.5
TDS	mg/L	91	164	306	406
Alkalinity	mg/L as $CaCO_3$	52	97	168	194
Turbidity	NTU	0.4	1.6	15[1.]	61
True Colour	Hazen	0.5	0.5	9.0	32
Calcium	mg/L (Ca)	8.6	17	31	38.4
Magnesium	mg/L (Mg)	4.3	7.0	10.6	10.6
Total Hardness	mg/L $CaCO_3$	42	65	101	101
Total Iron	mg/L	0.02	0.75[1.]	1.50[1.]	2.0[1.]
Soluble Iron	mg/L		0.5[1.]	1.0[1.]	2.0[1.]
Total Mn	mg/L	0.003	0.004	0.008	0.008
Soluble Mn	mg/L				
Free CO_2	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.14	0.17	0.27	0.27

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

3.5 Existing Instructure

The following is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

3.5.1 Raw Water Pumping

Raw water is drawn from two bores in the Murrumbidgee River aquifer on the Murrumbidgee flood plain next to an ephemeral meander of the Murrumbidgee River (Viridis, August 2018). Council is licensed to extract up to 49 ML/year from the two bores.

The bore pump control structure is raised above natural ground and is nominated as RL 701.5 AHD with the bore casings ending around 300mm above natural ground and are at risk of inundation in a large flood event (Figure 3-7).

Figure 3-7: Bore Pump Control Structure (Left) and Bore Headworks.

There are two shallow bores located in the same area that operate alternately at fixed speed. Bore 1 is equipped with a pumping capacity of 5.3 L/sec which matches the proposed treatment infrastructure instantaneous flow. Bore 2 operates at ~74% of the proposed instantaneous flow rate at 3.9 L/s.

For small WTP's the operation is simplified if the WTP operates at a fixed rate and as such it is recommended to investigate;

- the opportunity to run both bores at a 50/50 blend (or other blend) hydraulically and electrically with variable speed drives (VSD) on both bore pumps;
- Confirm the yield available from bore 2 to see if it is able to match the extraction of bore 1 and avoid upgrading to VSD on both pumps.
- Consider raw water storage at the WTP to allow WTP operation at a higher instantaneous rate than bore 2 can supply.
    - For example a 30kL buffer volume would allow for 4 hours operation of Bore 2 before needing to pause and allow the buffer to refill
- Allow for the WTP to operate at different raw water flows based on the bore supplying water at the time.
    - Noting that the plant capacity is reduced to ~ 290 kL/day if only Bore 2 is available at 3.9 L/s

3.5.2 Bredbo Aeration

It is recommended that the aeration tower is maintained in the treatment process to remove free CO_2 (TBC) and oxidise soluble iron.

It is recommended that the design, and operation, of the aeration tower is confirmed and documented in the next stage of the project so that this can be provided to any 3rd party undertaking works.

3.5.3 Reservoir

Key capacity information on the Bredbo Reservoir from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 54% of the reservoir capacity of 500kL
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD is less than 20%
- 60% of the reservoir provides 4 days to repair an issue for the average day demand
- 60% of the reservoir provides 1 day to repair an issue for the PDD
- The Aerator is hydraulically linked to the reservoir

Based on the available information capacity upgrades are not recommended for the Bredbo Reservoir.

Figure 3-8: Bredbo Reservoir and Aeration Tower.

3.5.4 Disinfection

Sodium hypochlorite dosing between the aeration tower and the reservoir is employed for disinfection with the storage and dosing equipment located inside a lined and heated room to avoid the lines freezing (Figure 3-9). The hypo is diluted to extend the life of the product.

The building is in reasonable condition and could be reused in any upgrade with a new dosing system integrated into the WTP control system.

Figure 3-9: Bredbo Hypo Dosing.

3.6 Proposed Site Location

On review of the reservoir location, the infrastructure is located on approximately 1,500m^2 lot DP570008, surrounded by DP 852025. Access is from North Street/Yaouk Street by an easement on an informal gravel road.

In considering water treatment plants in the 200 to 500 kL/day capacity range (Hunter H2O, September 2020) at a scoping level the footprint allowance for Bredbo is suggested as 500 m^2 for process and 1500m^2 for sludge lagoons.

In considering the available lot there are two areas, one to the front and one to the rear of the lot where there is land available for treatment infrastructure. The front area is used for vehicle access, in particular for water trucks to deliver water into the reservoir. The rear area is approximately 13m x 18m (Figure 3-10).

The area to the rear of the lot may be able to be used for a process building and the associated access, parking and tankage, however it would be a very tight fit and not an ideal solution over the medium to long term. In addition, this would constrain residual handling options to collection and irrigation on privately held land. With only one option for the irrigation this would leave SMRC exposed to the whims of the land owner.

As such it is recommended to investigate the purchase of land adjacent to the existing lot to remove constraints around land area and management of residuals. Following the site visit, the area to the west is preferred as it is more level with an indication of the area provided in Figure 3-10.

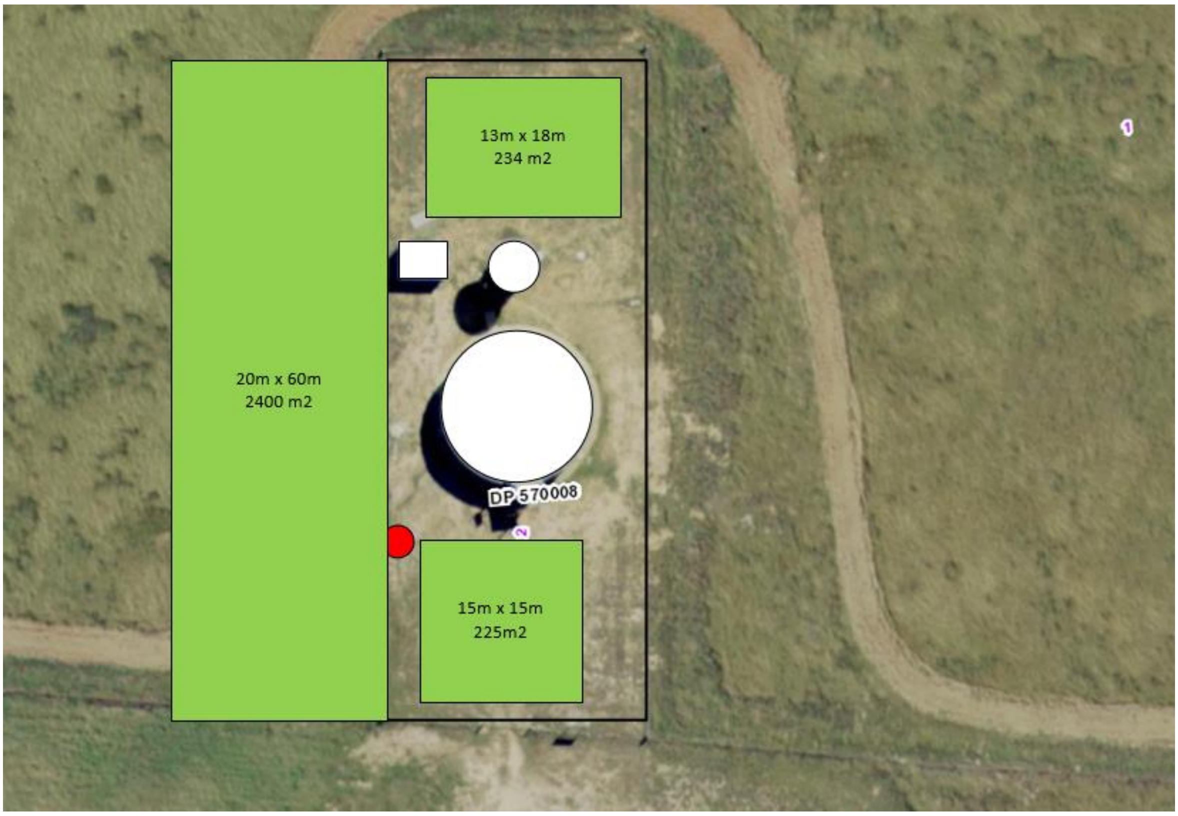


Figure 3-10: Bredbo Reservoir Lot Showing Location Option to the West.

3.7 Shortlisted Options

Following a consideration of barriers available to manage the identified raw water hazards for Bredbo, the following three treatment trains were shortlisted for further assessment and comparison.

- Option 1 – Direct Media Filtration
- Option 2 – DAF/F
- Option 3 – Direct Membrane Filtration (MF or UF)

The existing aerator will be retained to be part of the treatment process for iron removal (and CO_2 reduction). Confirmation of condition and design is required during the next phase of the project.

3.7.1 Comparison of Options Against Health Based Targets

Table 3-4 presents the LRV removal expectation for the shortlisted options. The pathogen removal credits are taken from the WSAA guideline (WSAA 2015) and for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

None of the options reaches the best practice benchmark for a Category 4 with all having some level of shortfall. Noting that the assessment of a Category 4 raw water was conservative and based on a desktop assessment that concluded a direct connection to surface water and the presence of microbiological hazards.

Based on industry best practice UV disinfection is recommended for all options to provide a multi barrier approach.

Table 3-4: LRV Expectation for the Shortlisted Options.

	Log Reduction Values			
	Bacteria	Virus	*Cryptosporidium*	Process Critical Limits
Required Treatment (Category 4 Source)	**6.0**	**6.0**	**5.5**	
Option 1				
Direct Filtration	1.0	1.0	2.5 – 3.5	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***5.0***	***5.0***	***2.5 – 3.5***	
Shortfall or Excess Log Removal	***1.0***	***1.0***	***2.0 to 3.0***	Shortfall can be addressed by UV
Option 2				
DAFF	2.0	2.0	3.0 – 4.0	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***6.0***	***6.0***	***3.0 – 4.0***	
Shortfall or Excess Log Removal	***0***	***0***	***1.5 to 2.5***	Shortfall can be addressed by UV
Option 3				
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***5.0***	***4.0***	
Shortfall or Excess Log Removal	***2.0***	***0***	***1.5***	Shortfall can be addressed by UV

3.7.2 Common Elements

3.7.2.1 Residuals Handling

The preferred option for residuals handling is to utilise two sludge lagoons for balancing instantaneous flows and capturing, and ultimately drying, solids. Supernatant will then be returned to the WTP or irrigated locally.

As a backup, to allow for the lagoon level to be lowered, irrigation of council or private land should be considered as during Winter only in the order of 5kL/day can be returned through the WTP whilst meeting the good practice target of returning less than 10% as an instantaneous flow. Suitable irrigation locations would need to be identified and confirmed in the concept design.

3.7.2.2 UV Treatment Barrier

Based on the assessment of the source as being a Category 4, UV is recommended to ensure a multi barrier approach to chlorine resistant protozoa. Hence regardless of the process train a UV system is recommended.

3.7.2.3 Chlorine Disinfection

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided with any new treatment infrastructure.

3.7.2.4 Aeration

The existing aerator will be retained but will require modification to divert water from the aerator to the new infrastructure.

3.7.2.5 Fire Risk

The site is close to town and surrounded by open grassland, hence the fire attack level is expected to be low.

Recommend a fire attack study be completed to inform the materials and construction methods for the WTP.

3.7.2.6 Power Availability

Site power is delivered via overhead lines and available capacity will need to be confirmed during the next phase.

3.7.3 Option 1 – Direct Media Filtration

Raw water would be pumped to the WTP from one or both bores at a constant rate to the existing aeration unit. From the aerator collection well the water will be pumped through a bank of media filters, receiving a coagulant (likely ACH to have minimal impact on the pH) and coagulation/flocculation time in an empty pressure media filter prior to filtration.

Depending on the raw water pH and the selected coagulant, pH correction (through acid or alkali dosing) may be required prior to coagulant dosing to achieve the optimal coagulation pH range. Filtered water would then pass through a UV unit prior to chlorination and entry into the treated water storage reservoir.

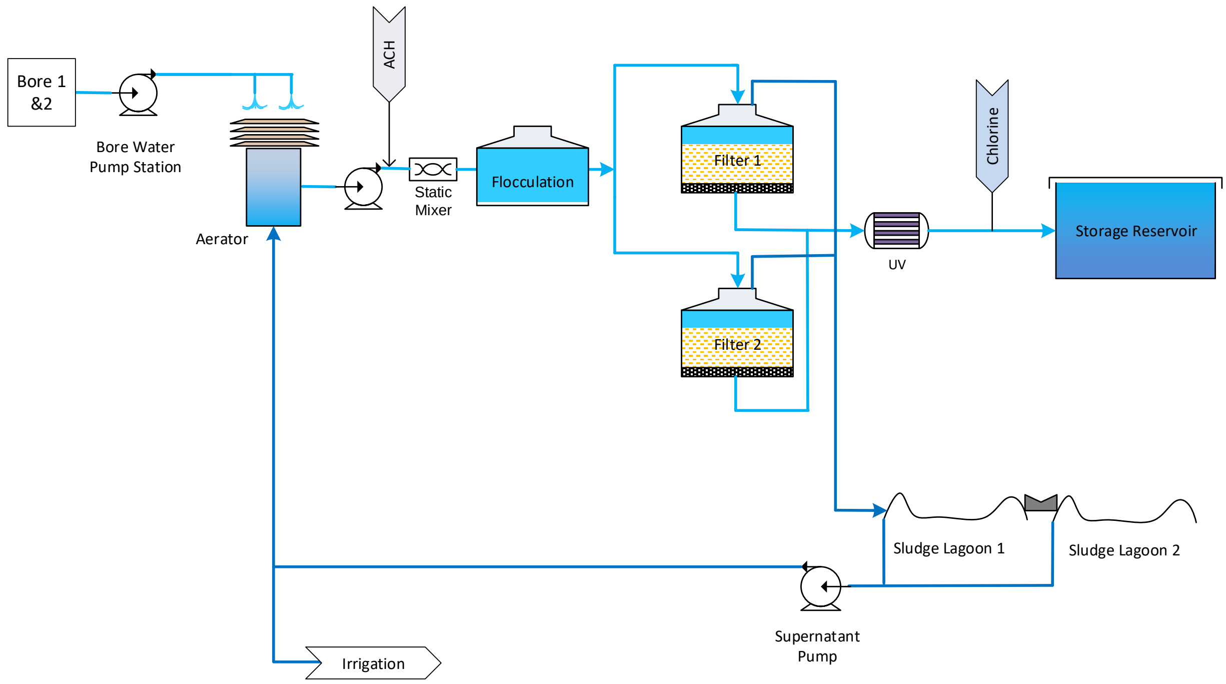


Figure 3-11: Schematic of the Bredbo Direct Media Filtration WTP.

The key elements of Option 1 are:

1. Aeration
   i. Oxidation of soluble metals and stripping of free CO_2 from the groundwater in the existing aerator.
2. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
      a. High level estimate for coagulant usage is less than 500L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.
3. Pressure media filtration
   i. Water pumped from the aerator collection well through the process and into the reservoir
   ii. Filtration rate of less than 10 m^3/hr per m^2 of surface area (m/hr)
   iii. In the order of 2.5m^2 of filtration surface area provided in 2 to 5 individual pressure media filters
4. Sludge lagoons, At a yearly production of 33 ML (90 kL/day)
   i. An estimated TSS of 20 mg/L (conservative)
   ii. There is a production of 21.8m^3 of 3% TSS sludge
   iii. Provide 2 lagoons, each at least 15m long and 5m wide
   iv. Supernatant pump station to return supernatant to the outlet of the aerator
5. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2 to target protozoa
6. Chlorine disinfection with C.t in the reservoir

3.7.4 Option 2 – DAFF or DAF followed by Filtration

Raw water would be pumped to the WTP from one or both bores at a constant rate to the existing aeration unit. From the aerator collection well the water will be dosed with a coagulant, ACH, and transferred to a coagulation/flocculation tank at a constant rate. The coagulated and flocculated water will then enters the DAFF cell and is contacted with small microbubbles, released from solution, following the introduction of an air saturated water stream, which attach to flocs as they rise to the surface. The clarified water is either removed from underneath the DAF (in the case of a straight DAF process) or passes directly onto the filter under the DAF (in the case of an in-filter DAF or DAF on filter process – commonly referred to as a DAFF process). The float is removed periodically using a mechanical scraping mechanism or a temporary flooding process and is assisted via water sprays to separate the float from the walls.

The saturated air stream is prepared by pumping clarifier or filtered water into a high pressure saturator where air is introduced. Under these high pressure conditions, the water becomes saturated with air. The air saturated water is then returned to the DAF injection system and bubbles are released via a pressure drop provided from a dispersion valve. This pressure drop releases the micro bubbles from the water and allows them to contact with the flocs and a float is formed.

Depending on the raw water pH and the selected coagulant, pH correction (through acid or alkali dosing) may be required prior to coagulant dosing to achieve the optimal coagulation pH range.

Filtered water would then pass through a UV unit prior to chlorination and entry into the treated water storage reservoir.

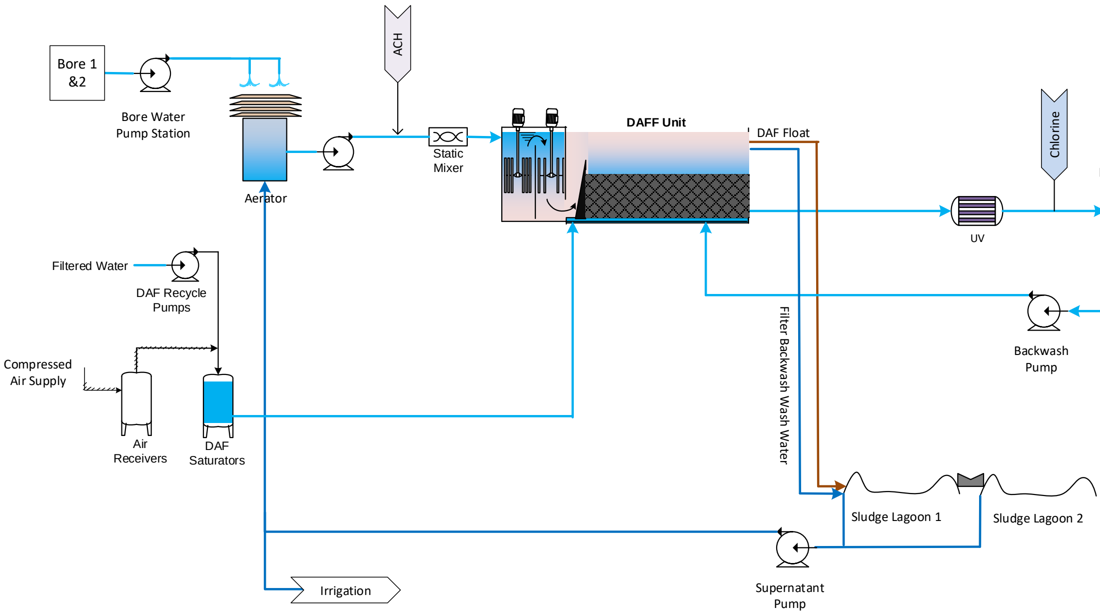


Figure 3-12: Schematic of the Bredbo DAFF WTP.

The key elements of Option 2 are:

1. Aeration
   i. Oxidation of soluble metals and stripping of free CO_2 from the groundwater in the existing aerator.
2. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   iii. High level estimate for coagulant usage is less than 500L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.
3. Floatation
   i. Floatation of the flocculated water through contacting with microbubbles with the maximum recycle rate of 15% and loading rate of 10 m/h.
   ii. In the order of 2.2 m^2 of DAF surface area provided in 2 to 5 individual DAF as a straight DAF process or as DAFF process.
4. Gravity Media filtration
   i. Filtration of the clarified water through passing onto the media filter under the DAF or in separate gravity media filters
   ii. Filtration rate of 10 m^3/hr per m^2 of surface area (m/hr)

iii. In the order of 2.2 m^2 of filtration surface area provided in 2 to 5 individual gravity media filters or underneath the DAF units.

5. Sludge lagoons
   i. At a yearly production of 33 ML (90 kL/day)
   ii. An estimated TSS of 20 mg/L (conservative)
   iii. There is a production of 21.8m^3 of 3% TSS sludge
   iv. Provide 2 lagoons, each at least 15m long and 5m wide
   v. Supernatant pump station to return supernatant to the outlet of the aerator
6. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
7. Chlorine disinfection

3.7.5 Option 3 – Membrane Filtration

Raw water would be pumped to the WTP from one or both bores at a constant rate to the existing aeration unit. From the aerator collection well the water will be dosed with a coagulant, ACH, and transferred to a coagulation/flocculation tank at a constant rate.

The coagulated and flocculated water will then be pumped through a strainer, a membrane filter, a UV unit and be dosed with chlorine prior to entering the clear water tank.

Membrane fouling through solids accumulation and adsorption of dissolved contaminants (including iron and manganese) will occur. Regular backwashing, every 30 to 60 minutes, is required to remove accumulated particles, with chemical cleaning undertaken monthly.

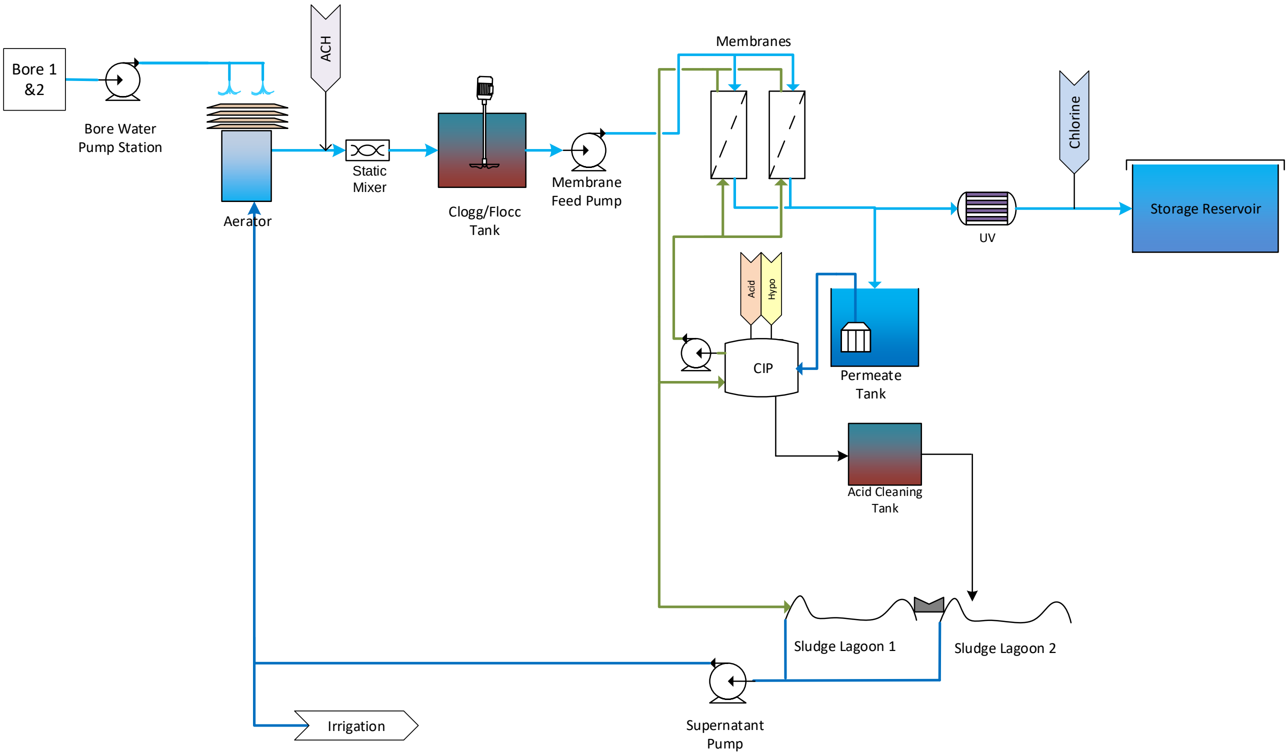


Figure 3-13: Schematic of the Bredbo Membrane Filtration WTP.

The Key elements of Option 3 are:

1. Aeration
   i. Oxidation of soluble metals and stripping of free CO_2 from the groundwater in the existing aerator.
2. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered

   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   iii. High level estimate for coagulant usage is less than 500L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.
3. Membrane filtration
   i. Membrane feed pumps take water from the coagulation/flocculation tank and push it through strainers and the membrane all the way to the treated water storage reservoir
   ii. Due to the low temperature and to minimise chemical cleaning the flux would be limited to a value of < 35 $l/m^2/hour$
   iii. In the order of $550m^2$ of filtration surface area provided by 10 to 20 membrane filtration modules.
   iv. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500mg/L to manage organic and biological fouling.
   v. Tankage (or a separate lagoon) required for the collection and storage of citric acid cleaning solution for pump out and transport to Cooma WWTW.
4. Sludge lagoons – As per option 1
5. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
6. Chlorine disinfection

3.7.5.1 Membrane Chemical Cleaning

Chemical cleaning residuals can be a challenge at small remote. Strategies for managing chemical cleaning for small membrane WTP's include.

- Specification of minimum use of chemicals, for example chemical cleaning interval of at least 6 weeks with no intermittent "maintenance" or "enhanced" chemical cleaning.
- Collection of all cleaning waste in a single tank and transfer to a regional WWTW by a pump out truck sizing the tank to ensure a minimum of truck movements
- Collection of cleaning waste in a dedicated lagoon and allowing for evaporation and removal when required.
- Collection and neutralisation of sodium hypochlorite cleaning waste and recycle through the sludge lagoons back to the plant feed at a low rate
  - Nut suitable for citric acid or phosphorous based cleaners which need to be treated separately.

3.8 Preferred Option

The strengths and weaknesses of the shortlisted options have been compared and scored in Table 3-5;

- 1 is given for an option that has the most weaknesses
- 2 is given for an option that has both strengths and weaknesses
- 3 is given for an option that demonstrates strengths that align with the requirements of the location.

The simplified scoring suggests that Option 1, direct media filtration and Option 3, direct membrane filtration are comparable solutions across the criteria selected with a score of 16 and 15 respectively.

In considering these options the relatively stable raw water quality from the shallow bores, the availability and relative simplicity of pressure media filters, in combination with UV as a multi barrier approach means that Option 1, direct media filtration, is the preferred option for Bredbo.

It is recommended that jar testing is undertaken to confirm that good filtered water quality is able to be obtained by using a coagulant (no polymer) and without pH correction. This will reduce uncertainty and risk for the Contractor and should reduce the risk value that they use in any offer.

Table 3-5: Bredbo Comparison of Key Strengths and Weaknesses.

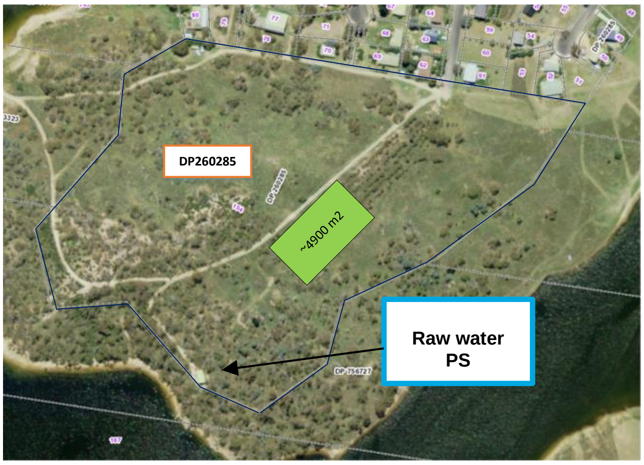
	Option 1 Direct Media Filtration	Option 2 DAF/F	Option 3 Direct Membrane Filtration
Total Score	**16**	**12**	**15**
Footprint	Relatively small and compact	Relatively small and compact	Filtration unit is the smallest of the options but there are requirements for additional tankage and strainers which evens out the footprint.
	2	**2**	**2**
Water Quality/Quantity Typical	Easily able to manage the typical water quality	Easily able to manage the typical water quality. Quick to start so can be run for short periods on/off.	Easily able to manage the typical water quality. No coagulant required which simplifies operation. Automatic test to demonstrate integrity of membrane. No issue with multiple start/stop operation.
	Typically not as 'deep' as gravity filters which can reduce run times with early breakthrough. Cant 'see' the process to confirm the condition of the filtration media and confirm the backwash process.	DAF not typically required for typical Bredbo raw water turbidity, so wasted.	Coagulant utilised to remove organics. If no coagulant is used then backwash water not able to be returned, would need to be irrigated.
	2	**2**	**3**
Water Quality/Quantity during "Events" (For Bredbo this is a rapid increase in turbidity from ~2 NTU to 30 NTU)	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes.	Consistent filter run times and backwashing frequency regardless of the raw water quality with the pre-clarification of the DAF. Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. *Could treat River water under most scenarios.*	Membranes are a barrier and quality (pathogens and TSS) will not be affected by raw water quality change. Can't get 'breakthrough' of turbidity.
	Will require adjustment of coagulation dose to ensure that there is no turbidity breakthrough during a change in raw water quality. Extra backwashing required with increasing turbidity and a reduction in throughput. Can quickly reach a point where the backwashing produces more water than can be returned to the raw water (>10%).	DAFF treatment requires optimisation of the upstream coagulation chemistry (coagulant dose) when the water quality changes. Polymer may be required.	Given historical maximum turbidity, events do not pose a significant operational concern. If close to needing a chemical clean, increased solids can trigger a CIP and halt production.
	1	**1**	**3**
Control and Monitoring	Simple to understand and monitor headloss and filtered water turbidity remotely.	Simple to understand and monitor headloss and filtered water turbidity remotely.	Basis of control and monitoring as per conventional filtration. Can stop and start numerous times and not impact the quality.

	Option 1 Direct Media Filtration	Option 2 DAF/F	Option 3 Direct Membrane Filtration
Total Score	**16**	**12**	**15**
	With multiple filters acting as one filter troubleshooting a problem with one filter can be difficult. Multiport valves can be problematic to trouble shoot. Rapidly changing raw water quality will require attendance to allow for optimising the process.	DAF not as common as settling processes and so support can be a little harder to receive. Optimising DAF Float requires a ‘feel’ for the process and can be difficult for a new Operator. Rapidly changing raw water quality will require attendance to allow for optimising the process.	Lots of different sequences to understand when troubleshooting. “Black box” control and monitoring of a proprietary system. Need to monitor over the long term to pick up slow building problems that can fall over the cliff.
	3	**1**	**2**
Ease of Maintenance	The use of multiple filters improves redundancy and maintainability. Commonly available components can be maintained in house.	Fairly standard mechanical kit and can be maintained in house. A typical media filter will only require media replacement every 10 – 20 years.	Ancillary equipment is standard and can be maintained in house.
	Need to ensure that access is provided around the filter and to the top of the filter for media removal and replacement. Repairing a broken lateral or issue inside a pressure media filter is nearly impossible insitu.	Likely to be a single process train, so whole plant offline when maintenance required on the DAF/F. Due to height of the system access for maintenance can be difficult.	Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks. Valves are often at awkward heights and locations due to the systems being proprietary. Typically have a third party engagement to manage membranes which has a cost. Typically involve some proprietary kit needing external assistance (e.g. membrane repair).
	3	**2**	**2**
Residuals Handling	Can keep instantaneous backwash flow down by having numerous filters in parallel.	Consistently high recovery and stable backwash water volumes as filter backwashing remains constant with increasing raw water turbidity. DAF float generally breaks up when travelling to the next process and settles well.	Small volume every 30 – 45 minutes
	For 1 or 2 filters the instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant.	For a single filter the instantaneous backwash rate is ~ 5 times the plant flow rate and can be a large power draw compared to the remainder of plant. DAF float is not always easily settled however typically with some mixing when the float is removed on its way to a sludge lagoon the float settles well.	Typically slightly lower first pass recovery than conventional at ~ 95%. Need to manage cleaning chemical residuals. Typically collection and transport to a WWTW with associated costs. If coagulant is not used then solids will not settle and residuals will need to be irrigated.
	2	**3**	**1**
Environmental Impact	Need access to the top of the filters to load and remove media.	Would be housed indoor.	Coagulant not required to achieve low turbidity.

	Option 1 Direct Media Filtration	Option 2 DAF/F	Option 3 Direct Membrane Filtration
Total Score	**16**	**12**	**15**
Physical Visual Noise Energy	Quiet operation, backwashing can be scheduled for 'business' hours as typically once a day. Low energy and chemical use		
	Coagulant is required introducing aluminium to the backwash water and limiting reuse potential.	Tall building required. Coagulant is required introducing aluminium to the backwash water and limiting reuse potential. ***Continuous operation of the recycle pumps and compressor make this the highest base load noise option.*** Recycle of 15% of the water at 600kPa principal energy demand along with compressed air requirement.	Has to backwash every 30 - 45 minutes which makes more noise at night (supplier dependent). Membranes have a 7 – 10 year life and will end up in landfill. Uses more chemicals with hypo and citric acid required for chemical cleaning. However, practically small volumes.
	3	**1**	**2**

4 Kalkite

Table 4-1: Kalkite Summary.

Component	Kalkite – 300 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	54.7	198.8	268
Reservoir Capacity	448kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 5 days 2020 PDD ~ 1.4 day		
Key Water Quality Challenges	The key hazardous event to be overcome is the increase in turbidity and by inference, pathogen loading, during and following heavy rainfall when the turbidity increases rapidly. Raw water hazards ▪ Turbidity / suspended solids ▪ Pathogens (Category 3 source water) ▪ Soluble metals with sources taken from depth		
Raw Water Quality Uncertainties	▪ Alkalinity ▪ Level of organics and true colour ▪ The presence or absence of total and soluble iron		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 14% in the reservoir		
Raw Water Pumping	The existing pumping station has a large excess capacity above the required instantaneous flow rate of 4 L/sec to treat 316 kL raw water over 22 hours. To this end either a raw water storage will be required, or the pumps may need to be reduced in size to better match the treatment requirements.		
Site location			
Land Acquisition Required?	No		
Shortlisted Options Considered	▪ Direct Media Filtration (with Coagulant) ▪ Direct Membrane Filtration (MF or UF with or without coagulant)		
Preferred Option	The relative stability of the water, lack of true colour and available land for evaporation of cleaning residuals, means that Direct Membrane Filtration is the preferred option for Kalkite.		

Residuals Management	Sludge Lagoons including an opportunity for irrigate locally
UV Disinfection	Not recommended due to the preliminary catchment categorisation of 3. “Poorly Protected Catchment”
Recommendations	In addition to the recommendations of previous reports ▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Options and concept design of a dedicated rising main to the Reservoir ▪ Full condition assessment of the reservoirs

4.1 Overview

Kalkite is situated on the Banks of Lake Jindabyne on Glebe Point and north of Taylors Inlet. It is around 10.5km upstream of the dam wall and 5.5km from the upper limits of the Lake, where the Eucumbene river enters.

The town has a population of 214 people (2016 Census) with 147 supply connections (SMRC).

Raw Water Intake Location

Raw Water Intake Pipeline

Chlorination and lift pump building

Storage Reservoirs (top right)

Figure 4-1: Overview of Kalkite Infrastructure.

4.2 Service Area

GIS data from SMRC was used to provide an indicative service area for each Village and is presented below in Figure 4-2.

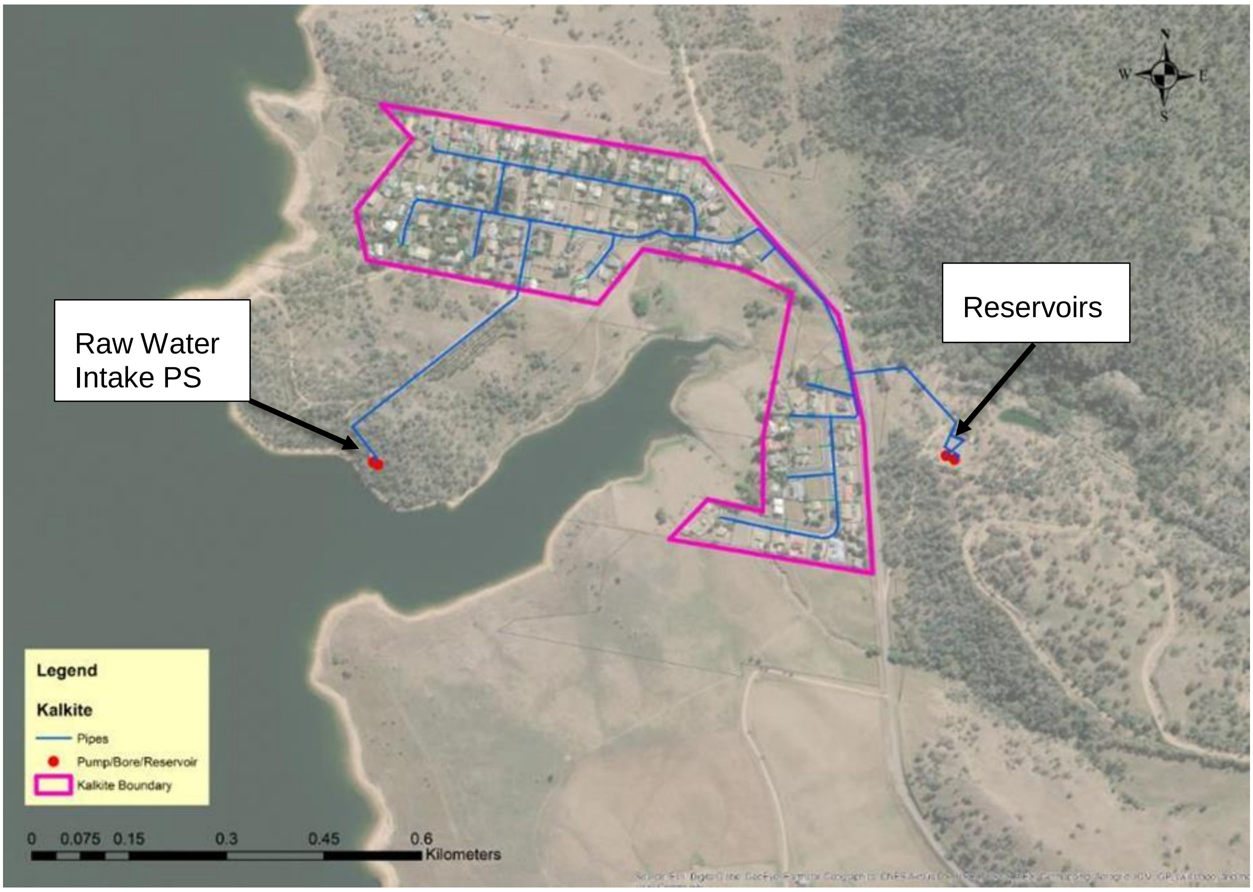


Figure 4-2: Kalkite Service Area.

4.3 Historical and Forecast Demand

Figure 4-3 shows the annual consumption for Kalkite. Table 4-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

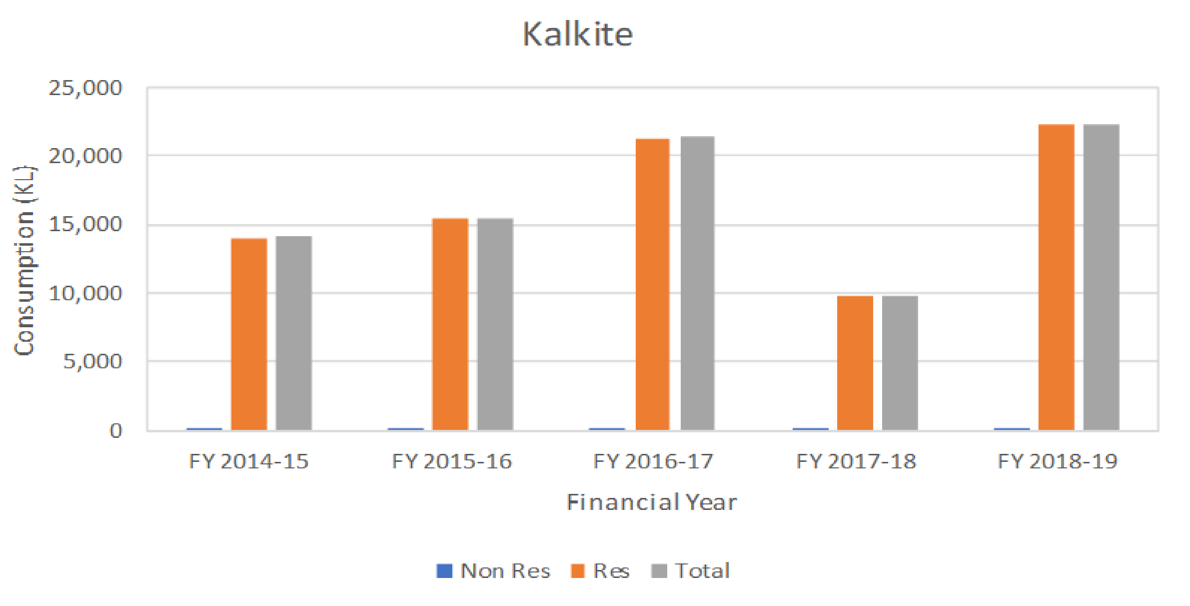


Figure 4-3: Kalkite Consumption Data.

Table 4-2: Kalkite Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Kalkite	Northern end of Lake Jindabyne	1,800	198.8	54.7	268.0	300

Note 1. 1% annual population growth was adopted for the 2050 projections

4.4 Source Water Assessment

The Kalkite raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

Beyond the day to day challenge of low levels of suspended solids and pathogens, the key hazardous event and challenge to be overcome to improve the water safety of Kalkite is turbidity and by inference, pathogen loading, during and following a rapid increase in the lake level caused by heavy rainfall. During such an event the treatment process will be challenged with only a moderate turbidity, however this may be 5 to 10 times the typical challenge.

In addition, it remains possible that when the lake is at a high level the intake, being deep in the lake, may be accessing deoxygenated water with the possibility of soluble metals being present, principally iron and manganese. Whilst there is no evidence historically of this occurring it remains a risk due to the intake design being at a fixed point.

The variability of the raw water and reservoir turbidity with rainfall is demonstrated in Figure 4-4.

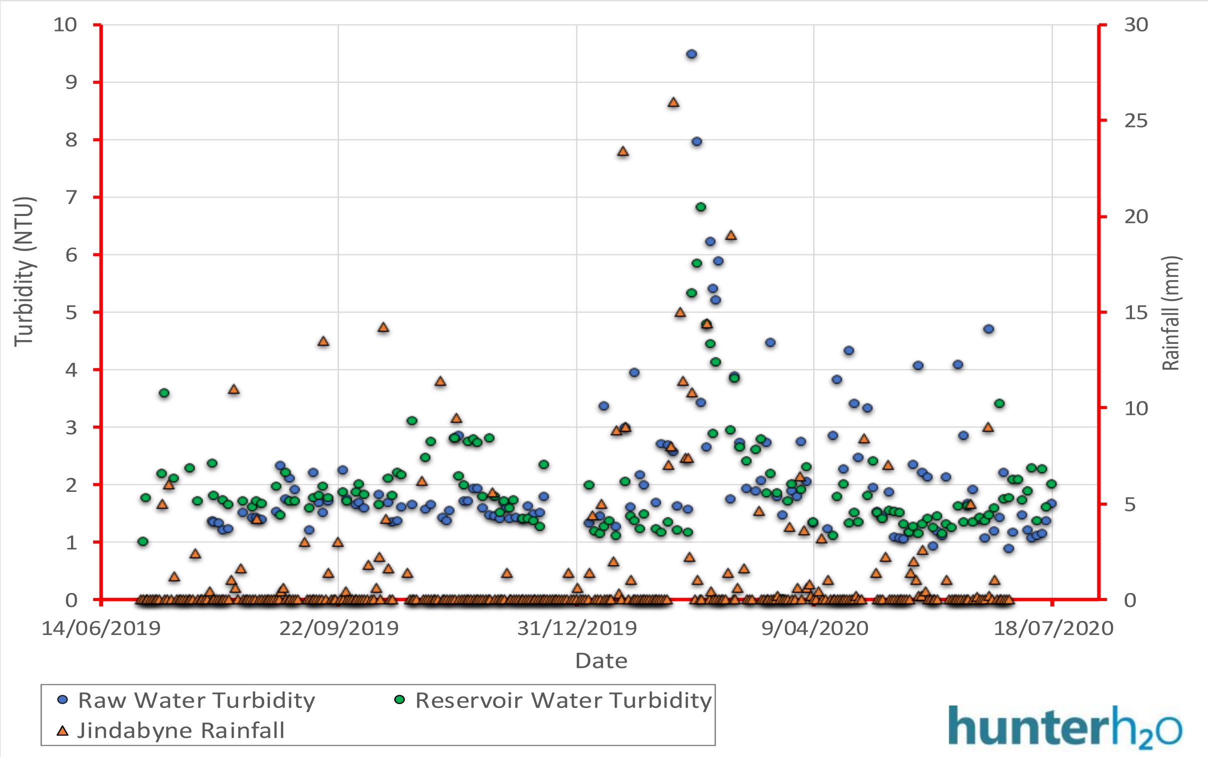


Figure 4-4: Raw Water (before chlorination) and Reservoir Water (after chlorination) Turbidity and Jindabyne Rainfall Data (July 2019– July 2020).

4.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water Assessment (Hunter H2O, 2020). The assessment determined that the Kalkite source was conservatively a Category 3 source (Hunter H2O, 2020).

As a Category 3 source, to achieve a target of an additional health burden, from potable water, of less $1x10^{-6}$ DALY's (Disability Adjusted Life Years) would require the following log reductions (Water Services Association of Australia, September 2015).

- **5.0 log_{10} reduction in Bacteria**
- **4.0 log_{10} reduction in Viruses and**
- **3.5 log_{10} reduction in Protozoa**

4.4.2 Chemical/Physical

From a review of the available raw water and reservoir water data the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Kalkite.

Turbidity / Suspended Solids

- With a limited data set the raw water turbidity is typically low, being more than 1 NTU but less than 10 NTU
  - It is expected that at times the turbidity would be more than 10, say following a large filling event but unlikely to exceed 25 NTU.
  - The intake location is at a fixed depth and unlikely to be impacted by wind stirring up sediment on the lake margins.
- Lake Jindabyne is used as part of the Snowy Hydro scheme and the level may rise and fall due to scheme operation or climatic conditions.
  - There is insufficient data to describe, beyond doubt, the impact of the level rising and falling.

Metals

- Soluble metals are a risk with sources taken from depth where the water can lack oxygen and insoluble iron and manganese can be dissolved.
  - Available data suggests that iron, manganese and aluminium are not a major raw water hazard.
  - Whilst iron and manganese cannot be ruled out there is no data to suggest they are a hazard.

Post Workshop, the Kalkite intake was confirmed as having a minimum operating level of 896.1m which equates to a Lake Jindabyne level of ~43%. The 100% level of Lake Jindabyne is 911m placing the intake at a maximum depth of 15.1m. The minimum and maximum level over the period 2000 through 2020 is indicated on Figure 4-5 *with the last 5 years having a similar variation from ~52% through to 88%.*

With a maximum depth of 15m there remains an opportunity for low oxygen and soluble metals in the Kalkite raw water, however it remains that there is no reported history (operational or network samples) of soluble metal at Kalkite and it remains a low risk.

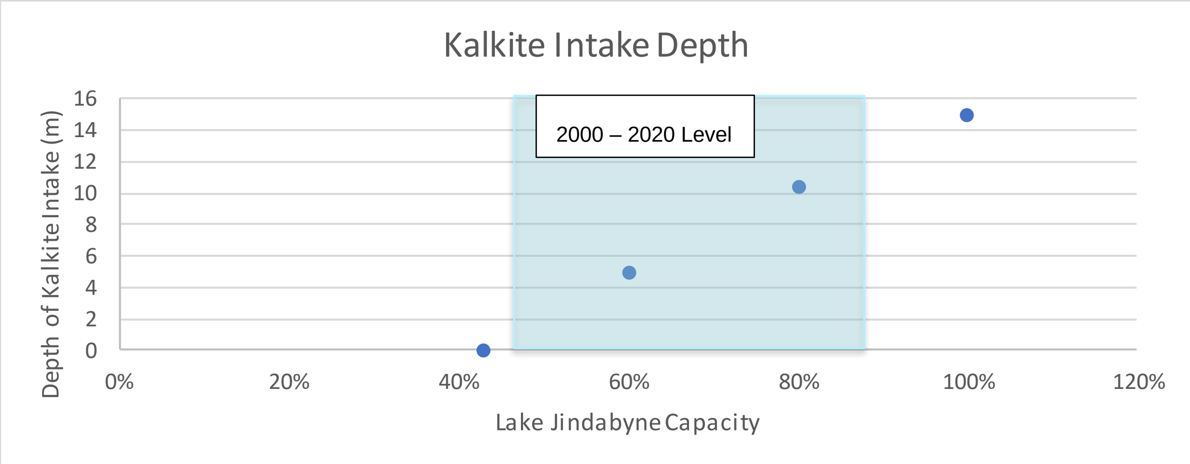


Figure 4-5 Kalkite intake depth variation with lake level

Colour

- Available true colour data suggests that the true colour of the raw and chlorinated water is below the ADWG target of 15 HU.
- Whilst 15 HU is the ADWG value, as Kalkite is a tourism destination, a best practice target of < 5 HU may be more appropriate to ensure community and visitor satisfaction.

Organics

- There was a single data point available for total organic carbon of 2.2 mg/L which is in keeping with the low true colour of the water source.

pH and Alkalinity

- The raw water pH is typically between 7 and 8.
  - There was a high degree of variation in pH for a large and relatively stable raw water source which should be investigated
- The raw water alkalinity is unknown and needs to be confirmed to allow for the consideration of coagulation.

Hardness

- The total hardness is low with the average of 13.9 mg/L as $CaCO_3$.

4.4.3 Raw Water Quality Design Envelope

Table 4-3 outlines the preliminary raw water design envelope for the Kalkite WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Kalkite that are recommended to be filled being;

- Alkalinity
- True colour to identify the coagulation requirements
- The presence or absence of total and soluble iron
- Level of total and dissolved organic carbon

Table 4-3: Preliminary Raw Water Design Envelope.

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	25
pH		7.1	7.4	8.2	8.8
TDS	mg/L	20	25	41	41
Alkalinity	mg/L as $CaCO_3$	15[1.]	20[1.]	30[1.]	30[1.]
Turbidity	NTU	1.1	1.7	10[1.]	15[1.]
True Colour	Hazen	2	3.5[1.]	10[1.]	20[1.]
Calcium	mg/L (Ca)	2.9	4.6	5.9	5.9
Magnesium	mg/L (Mg)	0.5	0.7	1.0	1.0
Total Hardness	mg/L $CaCO_3$	9.9	14.2	18.2	18.2
Total Iron	mg/L	0.04	0.1[1.]	0.2[1.]	0.2[1.]
Soluble Iron	mg/L	0.02	0.1[1.]	0.1[1.]	0.1[1.]
Total Mn	mg/L	0.003	0.003	0.019	0.019
Soluble Mn	mg/L				
Free CO_2	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.05	0.05	0.05	0.05

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

4.5 Existing Instructure

The following is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

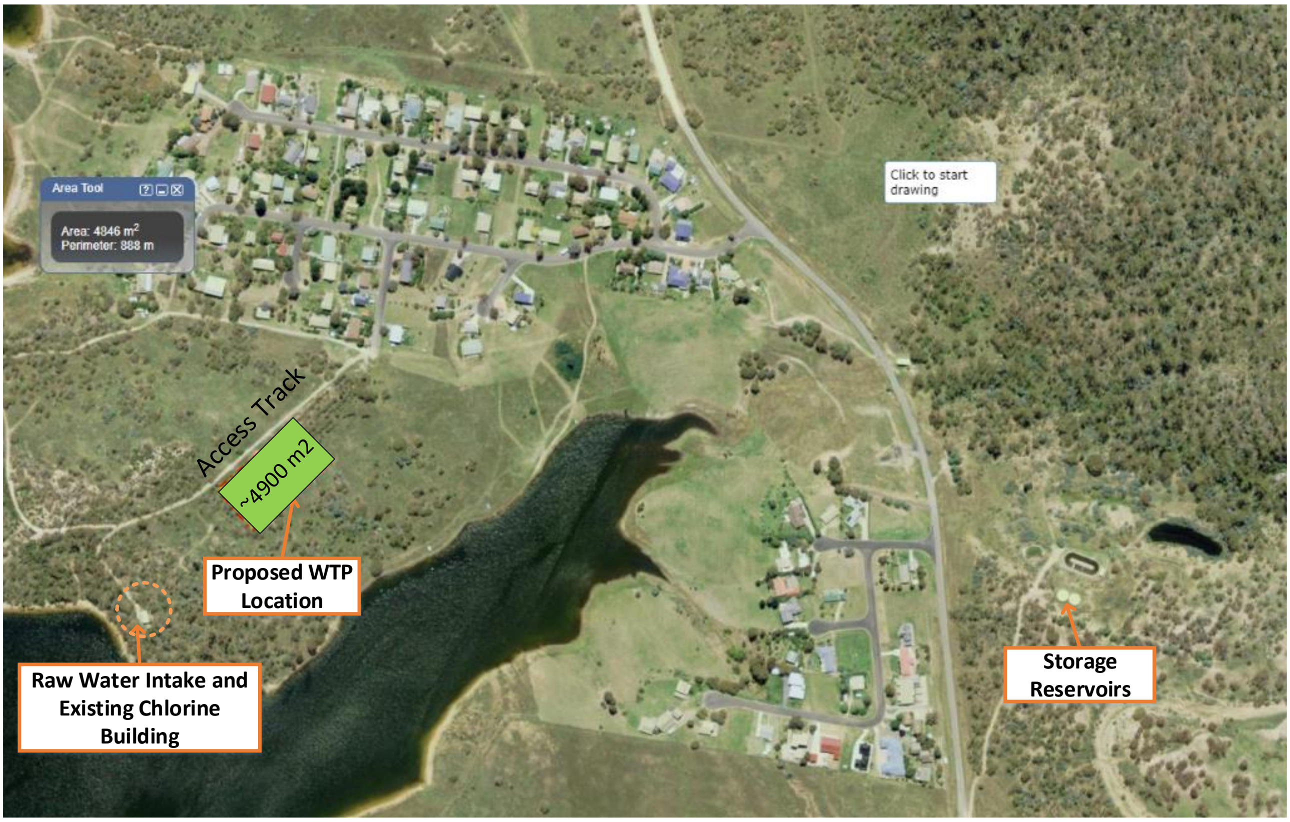


Figure 4-6: Kalkite Overview.

4.5.1 Raw Water Pumping

Kalkite raw water is drawn from Lake Jindabyne by submersible pumps (incline mounted bore pumps) local to Kalkite to a balance tank with the volume of 26 kL. Lift pumps then transfer water to the town reservoirs.

	
Raw Water Balance Tank local to pumping station	Raw Water Intake Pipelines

Figure 4-7: Raw Water Intake Pipeline and Balance Tank.

The lake lift pumps have a capacity of ~ 1200 kL/day (14.2 L/s) with the lift pumps being slightly less at around 860 kL/day (10.1 L/s). In comparing the raw water flow requirements of the proposed WTP, the existing pumping station has a large excess capacity above the required instantaneous flow rate of 4 L/sec to treat 316 kL raw water over 22 hours. To this end the raw water pumps may need to be reduced in size to better match the treatment requirements, or storage will be required at the treatment plant.

4.5.2 Combined Rising Main

The rising main from the point of chlorination at Kalkite pumping station acts as a feed to the storage reservoirs and also as a distribution main. As such when the reservoir is filling the residents along the main receive an elevated chlorine residual and a water that has not has a C.t of 15 mg.min/L.

This is managed on the ground through pumping at night when demand is low but exposes SMRC to customer complaints of variable and high chlorine, and reduced water safety.

It is recommended that any upgrade includes for a dedicated rising main.

4.5.3 Reservoir

Key capacity information on the Kalkite Reservoirs from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 44% of the reservoir capacity of 448kL (2×224 kL)
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD is less than 20%
- 60% of the reservoir provides about 5 days to repair an issue for the average day demand
- 60% of the reservoir provides 1.4 day to repair an issue for the PDD

Based on the available information capacity upgrades are not recommended for Kalkite Reservoirs however, a full condition assessment is recommended.

Figure 4-8: Kalkite Reservoirs above the Kalkite STP.

4.5.4 Disinfection

Chlorine dosing at Kalkite pumping station is employed for disinfection with the storage and dosing equipment located inside a room at the raw water pumping station (Figure 4-9).

As the existing chlorination system is located at the water intake pumping station, it is not suitable to be reused for the new WTP.

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided with any new treatment infrastructure.

Figure 4-9: Chlorine Dosing System Room.

4.6 Proposed Site Location

In considering water treatment plants in the 200 to 500 kL/day capacity range (Hunter H2O, September 2020) at a scoping level, the footprint allowance for Kalkite is 500 m^2 for process and 1500 m^2 for sludge lagoons.

The location of the existing infrastructure and the surrounding area was investigated during the site visit to identify a possible location for the future Kalkite WTP. The area near the storage reservoirs is very steep and is not a reasonable option for the WTP.

On review of the raw water intake infrastructure location, the infrastructure is located on lot DP260285. Along the road from the raw water intake infrastructure to the town, there is a reasonably large and level area within the same lot owned by council. The area is relatively flat and is proposed for the WTP location. Access is off Lantana Drive Road (Figure 4-10 and Figure 4-11) and would need to be formalised.

A smaller site could be achieved through utilising membrane filtration without coagulation, a smaller lagoon and irrigation of the surrounding land area if the soil profile and flora would support this.

A dedicated rising main from the new WTP with an approximate 1 km length would be incorporated into the scope of the project to transfer the treated water from the WTP to the storage reservoirs without going direct to consumers and causing issues with variable and high chlorine and requiring a dedicated CCT at the WTP.

An initial estimate for the Rising main would be 1100m of DN100, noting that this may be through residential streets and the ground up to the reservoirs will be difficult for construction of a new pipeline.

Figure 4-10: Location of the Proposed Kalkite WTP Site.

Figure 4-11: Typical vegetation around the proposed Kalkite WTP Area.

4.7 Shortlisted Options

Following a consideration of barriers available to manage the identified raw water hazards for Kalkite, the following treatment trains were shortlisted for further assessment and comparison (Hunter H2O, September 2020).

- Option 1 – Direct Media Filtration (with Coagulant)
- Option 2 – Direct Membrane Filtration (MF or UF with or without coagulant)

4.7.1 Comparison of Options Against Health Based Targets

Table 4-4 presents the LRV removal expectation for the shortlisted options. The pathogen removal credits are taken from the WSAA guideline (WSAA 2015) and for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

Table 4-4: LRV Expectation for the Shortlisted Options.

	Log Reduction Values			
	Bacteria	**Virus**	***Cryptosporidium***	**Process Critical Limits**
Required Treatment (Category 3 Source)	**5.0**	**4.0**	**3.5**	
Option 1				
Direct Filtration	1.0	1.0	2.5 – 3.5	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***5.0***	***5.0***	***2.5 – 3.5***	
Shortfall or Excess Log Removal	***0.0***	***1.0***	***1.0 to 0***	Shortfall can be addressed by UV
Option 2				
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***6.0***	***4.0***	
Shortfall or Excess Log Removal	***3.0***	***2.0***	***0.5***	

4.7.2 Common Elements

4.7.2.1 Residuals Handling

As there is available land at the proposed WTP site, the preferred option for residuals handling at Kalkite is to construct two sludge lagoons for balancing instantaneous flows and capturing, and ultimately drying solids. Supernatant will then be returned to the WTP.

If membrane filtration is utilised without coagulant, then storage/balancing of the Washwater with irrigation is a viable option. Suitable irrigation locations would need to be identified and confirmed in the concept design.

4.7.2.2 Chlorine Disinfection

The existing chlorination system is located at the water intake pumping station and is not suitable for the new WTP.

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided with any new treatment infrastructure.

4.7.2.3 Fire Risk

Recommend a fire attack study be completed to inform the materials and construction methods for the WTP.

4.7.2.4 Power Availability

Site power to operate existing infrastructure is delivered via overhead lines and available capacity will need to be confirmed during the next phase.

4.7.3 Option 1 – Direct Media Filtration

The raw water submersible pumps are too large and they would be replaced with smaller pumps capable of delivering water to the new WTP coagulation/flocculation tank, receiving a coagulant, likely ACH due to low alkalinity water. Flocculated water would then be pumped through a bank of media filters.

With small doses of a coagulant that does not consume much alkalinity, such as ACH, pH correction is not expected to be required.

Filtered water would be chlorinated and enter a treated water balance tank and lift pumps would transfer the water to the reservoirs via a dedicated rising main.

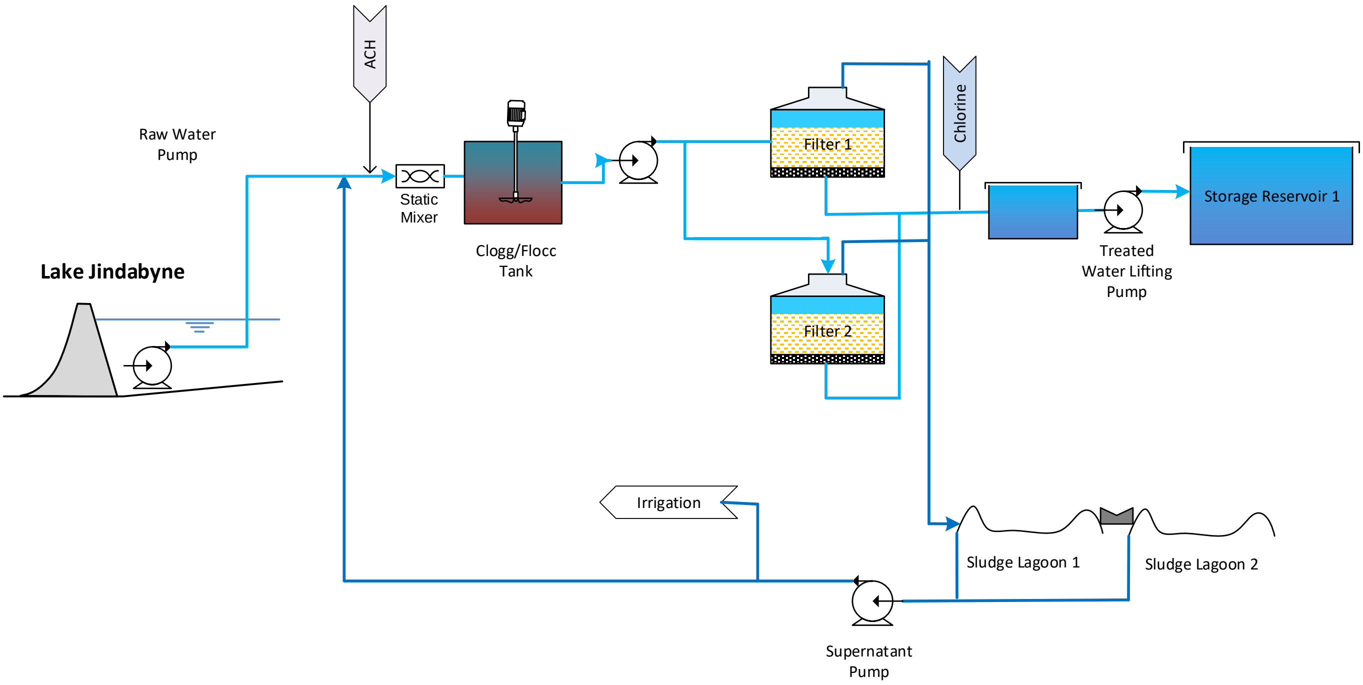


Figure 4-12: Schematic of the Kalkite Direct Media Filtration WTP.

The key elements of Option 1 are:

1. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered

ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
iii. High level estimate for coagulant usage is less than 200 L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank every couple of months.

2. Pressure media filtration
   i. Filtration rate of less than 10 m^3/hr per m^2 of surface area (m/hr)
   ii. In the order of 1.8 m^2 of filtration surface area provided in 2 to 5 individual pressure media filters
3. Sludge lagoons
   i. At a yearly production of 20 ML (66 kL/day)
   ii. An estimated TSS of 15 mg/L (conservative)
   iii. There is a production of 10 m^3 of 3% TSS sludge
   iv. Provide 2 lagoons, each with a base area of at least 20m^2
   v. Supernatant pump station to return supernatant to the inlet of the filters or irrigation
4. Chlorine disinfection
5. High Lift pumps to transfer water direct to the reservoir through a new dedicated rising main

4.7.4 Option 2 – Membrane Filtration

The raw water submersible pumps are too large and would be replaced with smaller pumps capable of delivering water to a new WTP balance tank. From the balance tank water would be pumped through strainers and on to and through the membranes.

Whilst coagulant could be utilised, an advantage of membrane filtration is that a coagulant is not required to achieve turbidity targets.

Based on historical data if coagulant is not used then no pH correction will be required.

Membrane filtered water would be chlorinated and then pass into a treated water balance tank and lift pumps would transfer the water to the reservoirs.

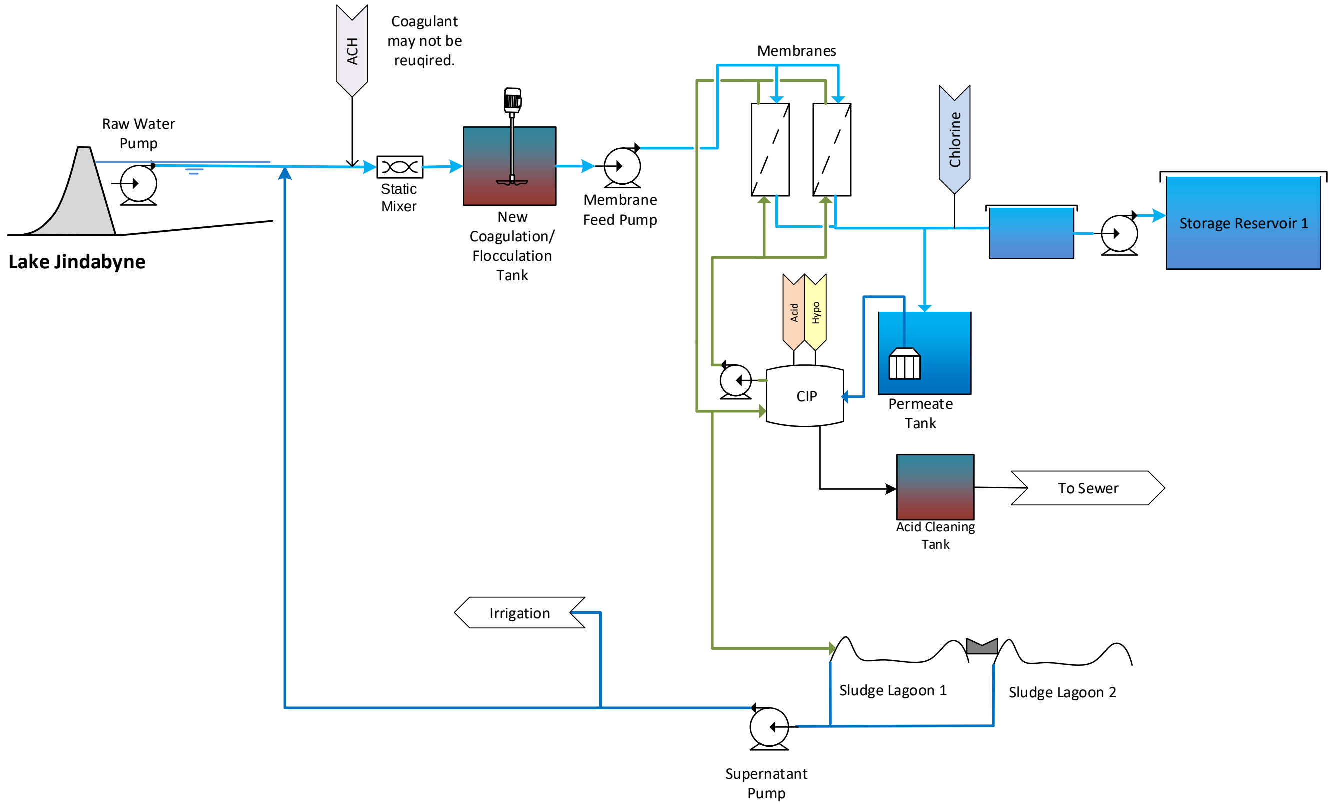


Figure 4-13: Schematic of the Kalkite Membrane Filtration WTP.

The Key elements of Option 2 are:

IF coagulant is selected to reduce colour and organics.

1. Coagulation and flocculation
   i. Only if deemed as required by the Contractor Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   iii. High level estimate for coagulant usage is less than 400 L/annum allowing for delivery of 15 L packages with small pumped transfer into a 100 L to 200 L tank.

Without coagulant;

2. Membrane filtration
   i. Membrane feed pumps take water from a balance tank (coagulation/flocculation tank) and push it through strainers and the membrane all the way to the treated water balance tank.
   ii. Due to the low temperature and to minimise chemical cleaning, the flux would be limited to a value of < 35 $l/m^2/hour$.
   iii. In the order of 400 m^2 of filtration surface area provided by 6 to 12 membrane filtration modules.
   iv. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500 mg/L to manage organic and biological fouling.
   v. Small evaporation lagoon for citric acid cleaning waste
3. Sludge lagoons – As per option 1 where coagulant is utilised
   i. Irrigation opportunities would be improved through the absence of a coagulant
4. Chlorine disinfection
5. High Lift pumps to transfer water direct to the reservoir through a new dedicated rising main

4.7.4.1 Membrane Chemical Cleaning

Whilst a sewer is available for chemical cleaning waste products this is not supported by DPIE with a preference for collection and evaporation of cleaning residuals that cannot be recycled. Strategies to minimise waste include;

- Specification of minimum use of chemicals, for example chemical cleaning interval of at least 6 weeks with no intermittent “maintenance” or “enhanced” chemical cleaning.
- Collection and neutralisation of sodium hypochlorite cleaning waste and recycle through the sludge lagoons back to the plant feed at a low rate
  - Not suitable for citric acid or phosphorous based cleaners.

4.8 Preferred Option

The strengths and weaknesses of the shortlisted options have been compared and scored in Table 4-5;

- 1 is given for an option that has the most weaknesses
- 2 is given for an option that has both strengths and weaknesses
- 3 is given for an option that demonstrates strengths that align with the requirements of the location.

In considering the strengths and weaknesses of the shortlisted options, both membrane filtration and direct media filtration are considered suitable alternatives for Kalkite (score of 16 and 17 respectively), given a good specification is utilised and prosecuted that has clear minimum requirements.

On balance, to provide a single preferred option, given the opportunity for water quality to change, a lack of true colour requiring coagulant, available land area for irrigation and cleaning residual collection and evaporation, the simplified scoring suggests that Option 2 – Membrane Filtration with a score of 17 is preferred for Kalkite.

Table 4-5: Kalkite Comparison of Key Strengths and Weaknesses.

	Option 1 Direct Media Filtration	Option 2 Direct Membrane Filtration
Total Score	**16**	**17**
Footprint	Relatively small and compact	Filtration unit is smaller option but there are requirements for additional tankage and strainers which evens out the footprint.
	2	**2**
Water Quality/Quantity Typical	Easily able to manage typical water quality May naturally build up biology to manage taste and odour.	Easily able to manage typical water quality. No coagulant required which simplifies operation. Automatic test to demonstrate integrity of membrane. No issue with multiple start/stop operation.
	Typically, not as 'deep' as gravity filters which can reduce run times with early breakthrough. Cant 'see' the process to confirm the condition of the filtration media and confirm the backwash process.	Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks.
	2	**3**
Water Quality/Quantity during "Events" (For Kalkite this is a moderate to rapid increase in turbidity from 2 NTU to 10 NTU)	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. Based on historic water quality an "Event" is a small additional solids load that should not impact operation.	Membranes are a barrier and quality (pathogens and TSS) will not be affected by raw water quality change. Can't get 'breakthrough' of turbidity. Based on historic water quality an "Event" is a small additional solids load that should not impact operation.
	Cannot deal with soluble metals. Will require adjustment of coagulation dose to ensure that there is no turbidity breakthrough during a change in raw water quality. Backwashing increased and may overload sludge lagoons Will not treat soluble metals Will not treat taste and odour	If close to needing a chemical clean then increased solids can trigger a CIP and halt production. Will not treat soluble metals Will not treat taste and odour Will not reduce true colour
	2	**3**
Control and Monitoring	Simple to understand and monitor headloss and filtered water turbidity remotely.	Basis of control and monitoring as per conventional filtration. Can stop and start numerous times and not impact the quality.
	With multiple filters acting as one filter troubleshooting a problem with one filter can be difficult. Multiport valves can be problematic to trouble shoot.	Lots of different sequences to understand when troubleshooting. "Black box" control and monitoring of a proprietary system. Similar concept to conventional but lots of nuances. Need to monitor over the long term to pick up slow building problems that can fall over the cliff.

	Option 1 Direct Media Filtration	Option 2 Direct Membrane Filtration
Total Score	**16**	**17**
		Post dosing is stop start every 30 – 45 minutes when there is a backwash, and this can complicate monitoring of post treatment.
	3	**2**
Ease of Maintenance	The use of multiple filters improves redundancy and maintainability. Commonly available components can be maintained in house	Ancillary equipment is standard and can be maintained in house
	Need to ensure that access is provided around the filter and to the top of the filter for media removal and replacement. Repairing a broken lateral or issue inside a pressure media filter is nearly impossible on site.	Valves are often at awkward heights and locations due to the systems being proprietary. Typically have a third party engagement to manage membranes which has an associated cost. Typically involve some proprietary kit needing external assistance (e.g. membrane repair)
	3	**2**
Residuals Handling	Can keep instantaneous backwash flow down by having numerous filters in parallel	Small volume every 30 – 45 minutes Coagulant may not be required, reducing residuals and allowing for irrigation of backwash water.
	For 1 or 2 filters the instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant. Sludge lagoons required and the associated management of drying solids.	Typically slightly lower first pass recovery than conventional at ~ 95% If coagulant is not used then solids will not settle and residuals will need to be irrigated or returned to the lake.
	2	**3**
Environmental Impact Physical Visual Noise Energy	Quiet operation, backwashing can be scheduled for ‘business’ hours as typically once a day.	Coagulant not required to achieve low turbidity. With irrigation the visual impact would be lower than for a plant with coagulation and sludge lagoons.
	Coagulant is required introducing aluminium to the backwash water and limiting reuse potential.	Has to backwash every 30 - 45 minutes which makes more noise at night. Membranes have a 7 – 10 year life and will end up in landfill. Uses hypo (can be recycled) and citric acid for chemical cleaning. Volumes are practically small and manageable.
	2	**2**

5 Adaminaby

Table 5-1: Adaminaby Summary

Component	Adaminaby – 500 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	98.5	358.1	482.6
Reservoir Capacity	450kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 2.75 days 2020 PDD ~ 0.75 day		
Key Water Quality Challenges	Raw water hazards ▪ Turbidity / suspended solids ▪ Pathogens (Category 3 source water) ▪ pH		
Raw Water Quality Uncertainties	▪ The level of organic material ▪ Level of alkalinity ▪ Soluble metals		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 25% in the reservoir		
Raw Water Pumping	The existing pumping station has sufficient capacity to provide the instantaneous flow of ~14 L/sec, more than twice of the required instantaneous flow rate of 6.6 L/sec to treat 526 kL raw water over 22 hours.		
Preferred Site location			
Land Acquisition Required?	No		
Shortlisted Options Considered	▪ Direct Media Filtration (with Coagulant) ▪ Direct Membrane Filtration (MF or UF)		
Preferred Option	The relative stability of the water, lack of true colour and land area available for collection and evaporation of cleaning residuals that cannot be recycled means that Direct Membrane Filtration is the preferred option for Adaminaby.		
Residuals Management	Sludge Lagoons including an opportunity for irrigate locally		
UV Disinfection	Not recommended due to the preliminary catchment categorisation of 3. “Poorly Protected Catchment”		
Recommendations	In addition to the recommendations of previous reports ▪ Confirmation of the intent to continue fluoridation at Adaminaby		

	▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Jar testing to investigate the benefit of coagulation

5.1 Overview

Adaminaby is located 52km to the NW of Cooma along the Snowy Mountains Highway. Adaminaby draws water from Observation point in a narrowing to the northern end of Lake Eucumbene.

The town has a population of 301 people (2016 Census) with 267 supply connections (SMRC).

Gravel access road to Adaminaby reservoir

Adaminaby reservoir

Gooroodee Reservoir, accessed through private property

Gravel road to Observation point

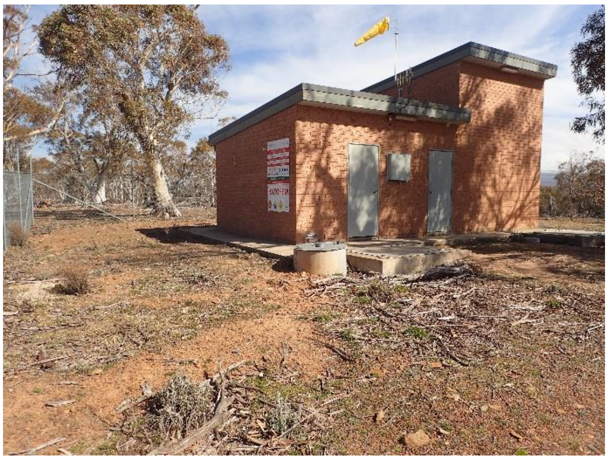
 Bore pump well head	 Chlorine gas dosing system
 Sodium flouride dosing system	 Chemical Building

Figure 5-1: Overview of Adaminaby Infrastructure.

5.2 Service Area

GIS data from SMRC was used to provide an indicative service area for Adaminaby and is presented below in Figure 5-2.

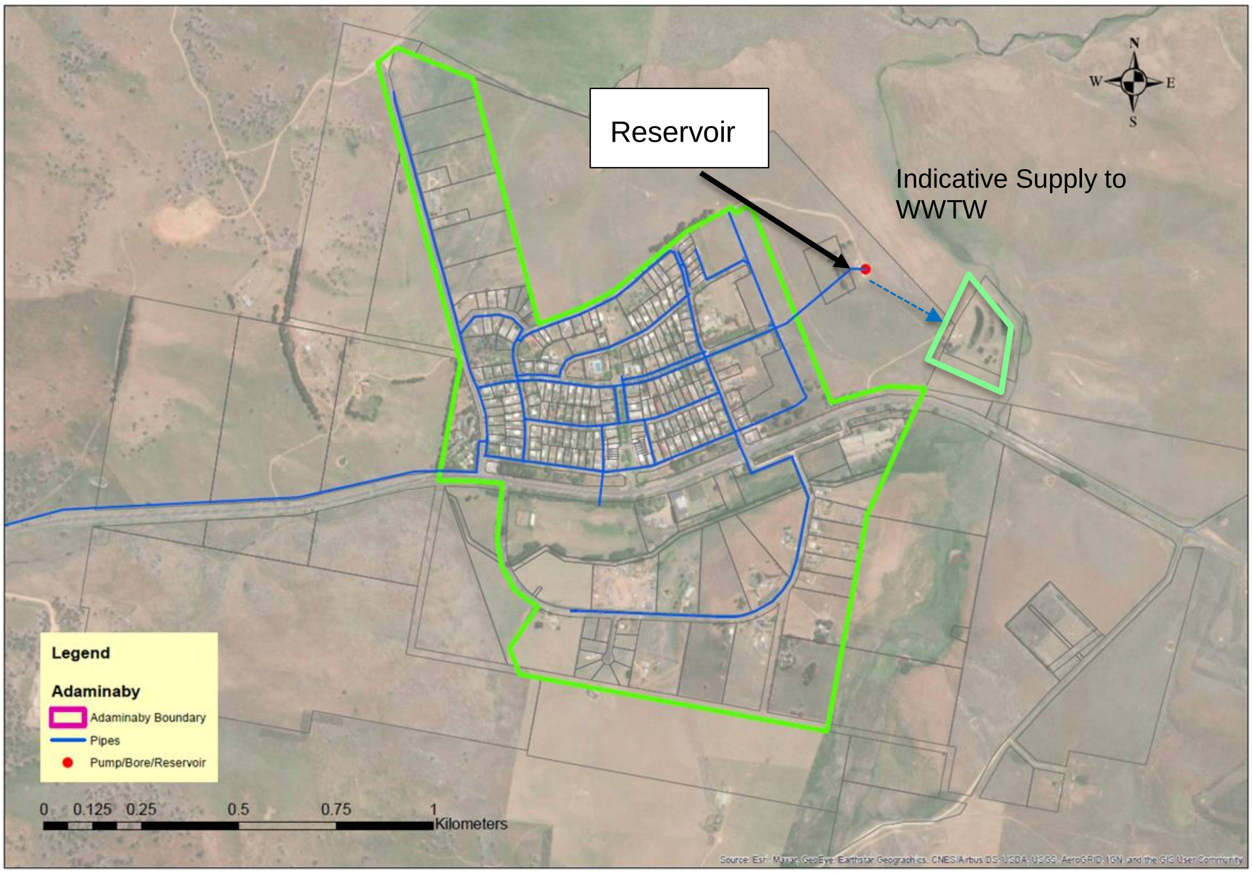


Figure 5-2: Adaminaby Service Area.

5.3 Historical and Forecast Demand

Figure 5-3 shows the annual consumption for Adaminaby. Table 5-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

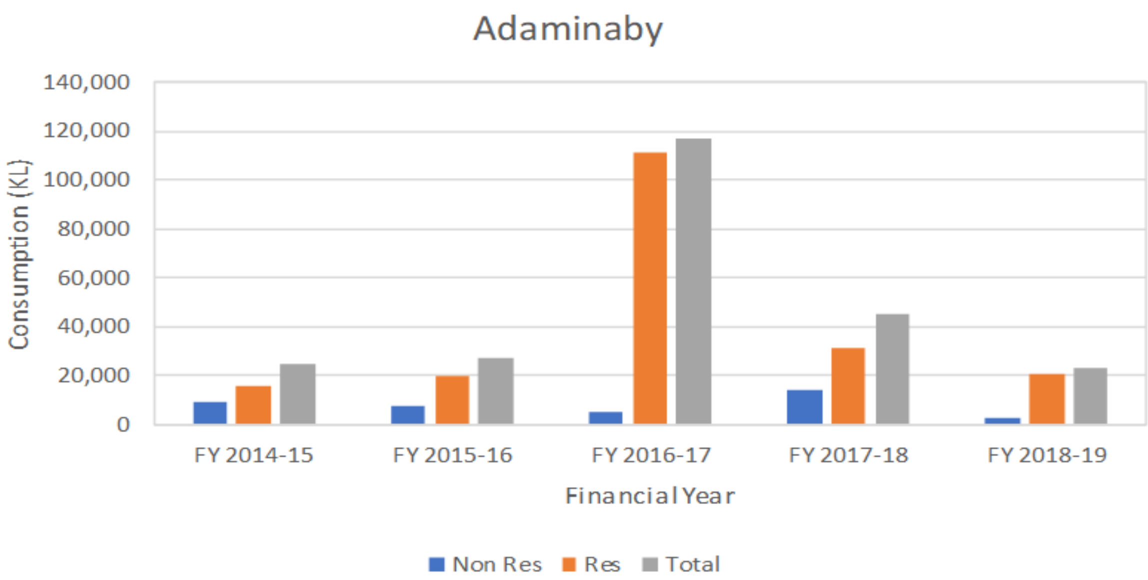


Figure 5-3: Adaminaby Consumption Data.

Table 5-2: Adaminaby Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Adaminaby	Lake Eucumbene (Observation Point)	1,200	358.1	98.5	482.6	500

Note 1. 1% annual population growth was adopted for the 2050 projections.

5.4 Source Water Assessment

The Adaminaby raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

Beyond the day to day challenge of low levels of suspended solids (Figure 5-4) and pathogens, the key hazardous event and challenge to be overcome to improve the water safety of Adaminaby is turbidity and by inference, pathogen loading, during and following a rapid increase in the lake level caused by heavy rainfall. During such an event the treatment process will be challenged with only a moderate turbidity, however this may be 5 to 10 times the typical challenge.

In addition, it remains possible that when the lake is at a high level the intake, being deep in the lake, may be accessing deoxygenated water with the possibility of soluble metals being present, principally iron and manganese. Whilst there is no evidence historically of this occurring it remains a risk due to the intake design being at a fixed point.

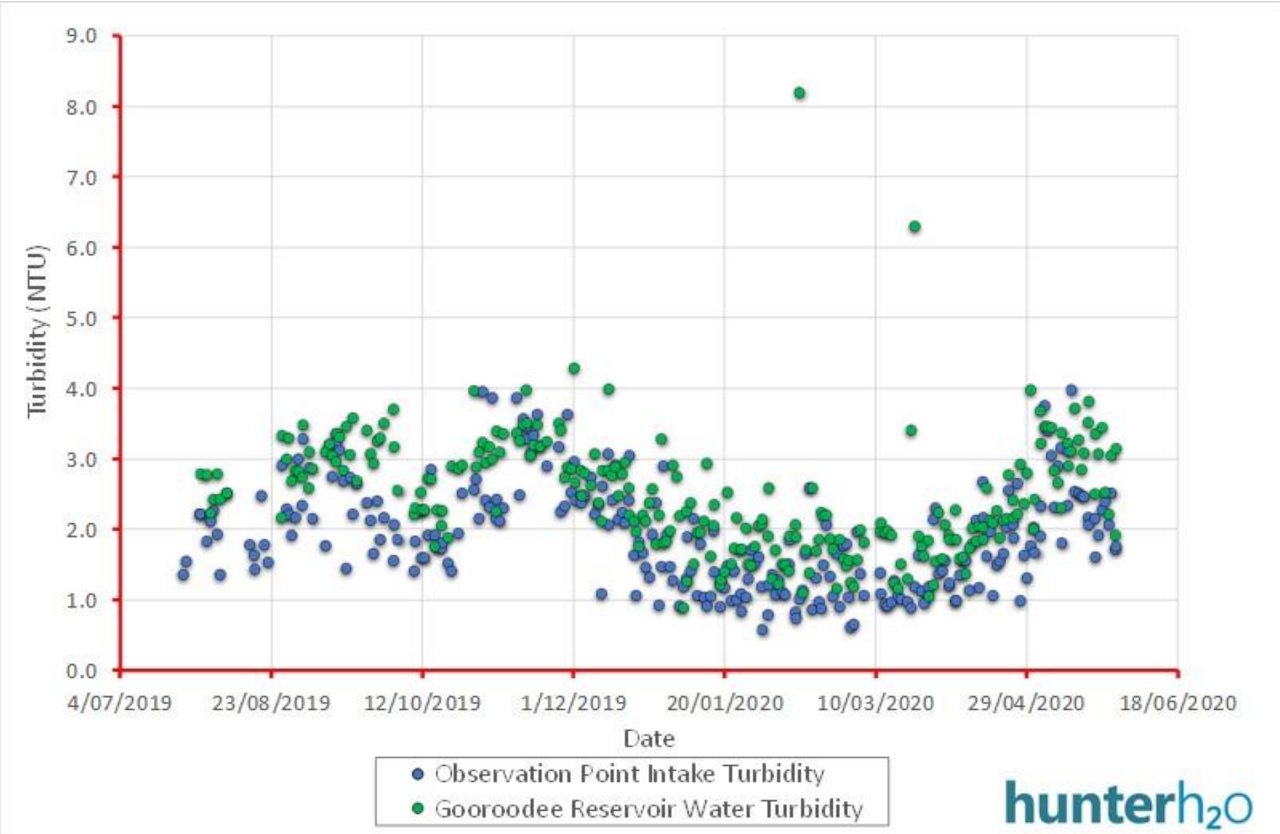


Figure 5-4 Observation Point and Gooroodee Turbidity

5.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water Assessment (Hunter H2O, 2020). The assessment determined that the Adaminaby source was conservatively a Category 3 source (Hunter H2O, 2020).

As a Category 3 source to achieve a target of an additional health burden, from potable water, of less $1x10^{-6}$ DALY's (Disability Adjusted Life Years) the following log reductions are recommended by the guidance manual and will require a multi barrier approach.

- **5.0 log_{10} reduction in Bacteria**
- **4.0 log_{10} reduction in Viruses and**
- **3.5 log_{10} reduction in Protozoa**

5.4.2 Chemical/Physical

From a review of the available raw water data the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Adaminaby.

Turbidity / Suspended Solids

- The raw water turbidity is low but still above the target for disinfection of less than 1NTU.

Colour

- The true colour from the reticulation is typically low with a maximum of 7 HU
  - This is above the best practice target of 5 HU
- Data from the lake in 2011 showed increased colour with one result of 45 HU which is out of character.
- There is not enough information to say definitively that the colour is always below 15 HU.
- The free chlorine residual data for the reticulation network shows a low chlorine demand, which may be an indication of the low level of organic material in the raw water.

Organics

- There is no data available to nominate a level of organic material.

pH and Alkalinity

- Reticulation data suggests a mean and median of ~ 7.1
  - pH measured onsite has been variable with unexplained step changes in recorded pH.
- The water is very soft and whilst it is expected that the water has a very low alkalinity, there is insufficient data to make a definitive statement.

Hardness

- The raw water total hardness results from the reticulation of Adaminaby were in the range of 6.9 to 11.8 mg/L as $CaCO_3$ making it a soft water.
- Hardness appears similar to Kalkite, which is downstream and so from the same catchment

5.4.3 Raw Water Quality Design Envelope

Table 5-3 outlines the preliminary raw water design envelope for the Adaminaby WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Adaminaby that are recommended to be filled being;

- Alkalinity
- True colour to identify the coagulation requirements
- The presence or absence of soluble iron
- Level of total and dissolved organic carbon

Table 5-3: Preliminary Raw Water Design Envelope.

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	5
pH		6.5	6.9	7.7	8.0[1.]
TDS	mg/L	12	17.5	32	32
Alkalinity	mg/L as $CaCO_3$	15[1.]	20[1.]	40[1.]	70[1.]
Turbidity	NTU	0.9	3[1.]	10[1.]	15[1.]
True Colour	Hazen	0.5	2	15[1.]	45[1.]
Calcium	mg/L (Ca)	2.2	2.6	3.5	3.5
Magnesium	mg/L (Mg)	0.67	0.76	0.95	0.95
Total Hardness	mg/L $CaCO_3$	9.1	9.7	11.7	11.7
Total Iron	mg/L	0.04	0.07	0.2[1.]	0.5[1.]
Soluble Iron	mg/L		0.05[1.]	0.2[1.]	0.3[1.]
Total Mn	mg/L	0.0025	0.005	0.011	0.011
Soluble Mn	mg/L				
Free CO_2	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.9	1.0	1.0	1.1

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

5.5 Existing Instructure

The following information is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

5.5.1 Raw Water Pumping

An intake pumping station (~14 L/s) at Observation Point supplies Adaminaby with water, first dropping into Gooroodee Reservoir before flowing by gravity via 13.7 km pipeline to Adaminaby Reservoir. Council is licensed to extract up to 102 ML/year from Lake Eucumbene. This is a yearly average day of 279 kL/day compared to the current ADD of ~ 100 kL/day.

The water supply system has a design capacity of 1.2 ML/d. In comparing the raw water flow requirements of the proposed WTP, the existing pumping station has sufficient capacity to provide the instantaneous flow of

~14 L/sec, more than twice of the required instantaneous flow rate of 6.6 L/sec to treat 526 kL raw water over 22 hours.

5.5.2 Reservoir

Key capacity information on the Adaminaby Reservoir from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 80% of the reservoir capacity of 450kL.
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD 25%.
- 60% of the reservoir provides 2.75 days to repair an issue for the average day demand
- 60% of the reservoir provides 0.75 day to repair an issue for the PDD

Based on the available information capacity upgrades are not recommended for the Adaminaby Reservoir.

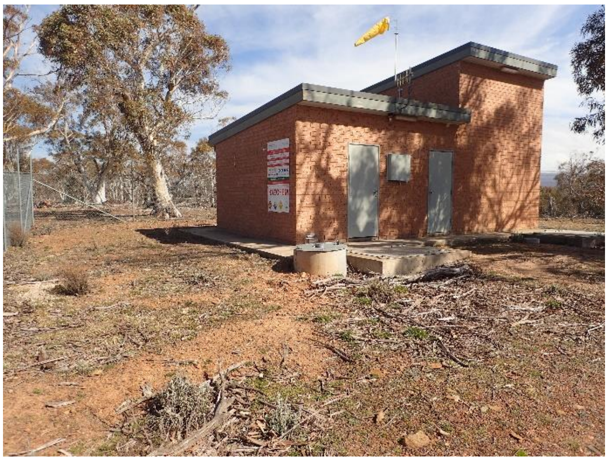
Figure 5-5: Adaminaby Reservoir.

5.5.3 Disinfection and Fluoridation

Chlorine gas dosing and fluoride dosing at raw water intake is employed for disinfection and fluoridation with dosing system located inside a room at raw water intake location (Figure 5-6).

The existing chlorine and fluoride dosing systems and building are in a good condition and can be used for the future dosing if the WTP to be constructed at the raw water and chemical building location.

However, if the WTP is constructed at another location, then to align with the other Village treatment plants sodium hypochlorite would be preferred. In addition, during the next phase of delivery, the long-term application of fluoridation is recommended to be investigated consider, specifically, if location of treatment infrastructure is at Adaminaby.



Chemical building at raw water intake

Chlorine gas dosing system

Fluoride dosing system

Figure 5-6: Adaminaby Chlorine Dosing System.

5.6 Proposed Site Location

In considering water treatment plants in the 200 to 500 kL/day capacity range, at a scoping level, the footprint allowance for Adaminaby is 500 m^2 for process and 1500m^2 for sludge lagoons.

Figure 5-7 shows the location of the existing raw water infrastructure, Gooroodee Reservoir, Adaminaby reservoir and old Adaminaby.

For Adaminaby WTP, there are three options for the site location with the site (Option 2) at Adaminaby being selected as the most appropriate.:

1. At raw water intake and chemical building location:
    a. The raw water infrastructure is located on lot DP552374 (Figure 5-8) and is surrounded by a moderate amount of relatively flat land. There is access to power at this site due to the requirements of the bore pumps to transfer water to Gooroodee Reservoir.
    b. The main benefit of construction of the WTP near to the existing infrastructure is that, the existing chlorine and fluoridation dosing systems and building are in a good condition and can be used for the future dosing. From the site visit, the land could be suitable for the new WTP.

c. Raw water pumps would be replaced, and new ground mounted lift pumps would be installed. With a combined power draw equivalent or less than to the existing pumps given a reduced capacity.

2. At Adaminaby Reservoir location:

   a. On review of the Adaminaby Reservoir location, the infrastructure is located on approximately 1.3 ha lot DP729876. Access is able from Chalker street by an easement on a gravel road.

   b. In considering the available lot, there are two areas, one on the left side and one on the right side of the lot which are available for treatment infrastructure. As can be seen in Figure 5-8, the approximate area of these two areas are sufficient for the treatment process units and sludge lagoons.

   c. This site has the advantage that it is easier to access for Operators and has access to sewer. In addition, the 'common' land around the site may be suitable for irrigation which can be considered as one of the options for managing liquid residuals (filter backwash water).

   d. For this site, a new dedicated raw water rising main of about 1200m, following York St from Lette St, would be required.

3. Near Old Adaminaby:

   a. A location close to Old Adaminaby may also be suitable with a number of flat areas available.

   b. This location would have the same benefit of Option 1 in allowing Old Adaminaby to be put onto potable water but has the advantage of keeping the infrastructure in a more accessible location as compared to Observation Point.

Figure 5-7: Location of the Raw Water Intake Infrastructure, Gooroodee Reservoir, Adaminaby Storage Reservoir and Old Adaminaby.

Figure 5-8: Proposed WTP Site Locations.

5.7 Shortlisted Options

Following a consideration of barriers available to manage the identified raw water hazards for Adaminaby, the following treatment trains were shortlisted for further assessment and comparison.

- Option 1 – Direct Media Filtration
- Option 2 – Direct Membrane Filtration (MF or UF)

5.7.1 Comparison of Options Against Health Based Targets

Table 5-4 presents the LRV removal expectation for the shortlisted options. The pathogen removal credits are taken from the WSAA guideline (WSAA 2015) and for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

Table 5-4: LRV Expectation for the Shortlisted Options.

	Log Reduction Values			
	Bacteria	**Virus**	***Cryptosporidium***	**Process Critical Limits**
Required Treatment (Category 3 Source)	**5.0**	**4.0**	**3.5**	
Option 1				
Direct Filtration	1.0	1.0	2.5 – 3.5	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***5.0***	***5.0***	***2.5 – 3.5***	
Shortfall or Excess Log Removal	***0***	***1.0***	***1.0 to 0***	Shortfall can be addressed by UV
Option 2				
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***6.0***	***4.0***	
Shortfall or Excess Log Removal	***3.0***	***2.0***	***0.5***	

5.7.2 Common Elements

5.7.2.1 Residuals Handling

The preferred option for residuals handling is to utilise two sludge lagoons for balancing instantaneous flows and capturing, and ultimately drying, solids. Supernatant will then be returned to the WTP.

As a backup, to allow for the lagoon level to be lowered, irrigation of council or private land should be considered. Suitable irrigation locations would need to be identified and confirmed in the concept design.

5.7.2.2 Chlorine Disinfection

Whilst the existing gas chlorine system is in a good condition liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) for the other sites and for consistency it is thought that a new plant would utilise sodium hypochlorite.

5.7.2.3 Fluoridation

The fluoridation system could be moved or a new system provided at the Adaminaby site..

5.7.2.4 Power Availability

Site power is delivered via overhead lines and available capacity will need to be confirmed during the next phase.

5.7.3 Option 1 – Direct Media Filtration (WTP Location at Adaminaby)

Raw water would gravity feed from the Gooroodee Reservoir through a flow control valve at a constant rate to a raw water coagulation/flocculation and balance tank. Flocculated water would then be pumped through a bank of media filters and continue past a chlorination point into the reservoir.

With low alkalinity water the coagulant dosing regimen needs to be confirmed to determine if pH correction is required pre, post or both pre and post dosing. (jar testing recommended)

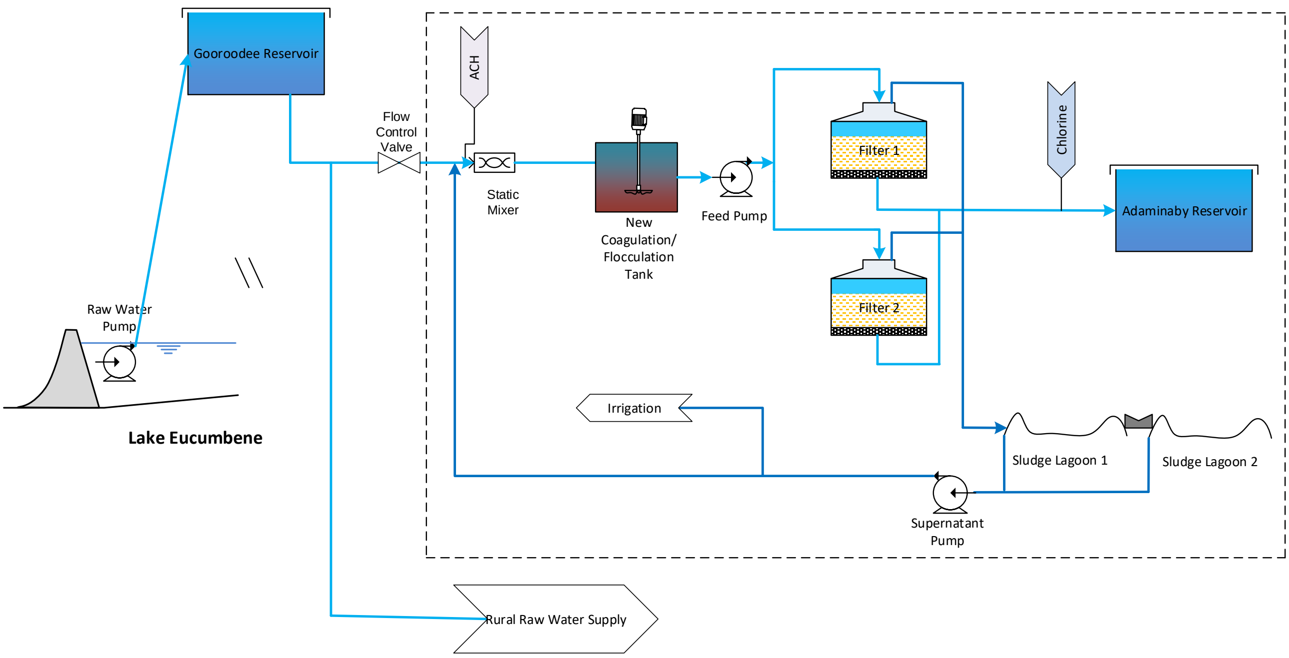


Figure 5-9: Schematic of the Adaminaby Direct Media Filtration WTP.

The key elements of Option 1 are:

1. Flow Control valve and dedicated raw water main to the Adaminaby Reservoir location.
2. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   iii. High level estimate for coagulant usage is less than 700 L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.
3. Pressure media filtration
   i. Filtration rate of less than 10 m^3/hr per m^2 of surface area (m/hr)
   ii. In the order of 3 m^2 of filtration surface area provided in 2 to 5 individual pressure media filters
4. Sludge lagoons
   i. At a yearly production of 43ML (~ 120 kL/day)
   ii. An estimated TSS of 20 mg/L (conservative)
   iii. There is a production of 28.8 m^3 of 3% TSS sludge
   iv. Provide 2 lagoons, each at least 45m^2 base area each
   v. Supernatant pump station to return supernatant to the inlet of the filters
5. Chlorine disinfection

5.7.4 Option 2 – Membrane Filtration

Raw water would gravity feed from the Gooroodee Reservoir through a flow control valve at a constant rate to a raw water coagulation/flocculation and balance tank.

Flocculated water would then be pumped through the membrane and continue past a chlorination point into the reservoir.

With low alkalinity water the coagulant dosing regimen needs to be confirmed to determine if pH correction is required pre, post or both pre and post dosing. (jar testing recommended)

Membrane fouling through solids accumulation and adsorption of dissolved contaminants (including iron and manganese) will occur. Regular backwashing, every 30 to 60 minutes, is required to remove accumulated particles, with chemical cleaning undertaken monthly.

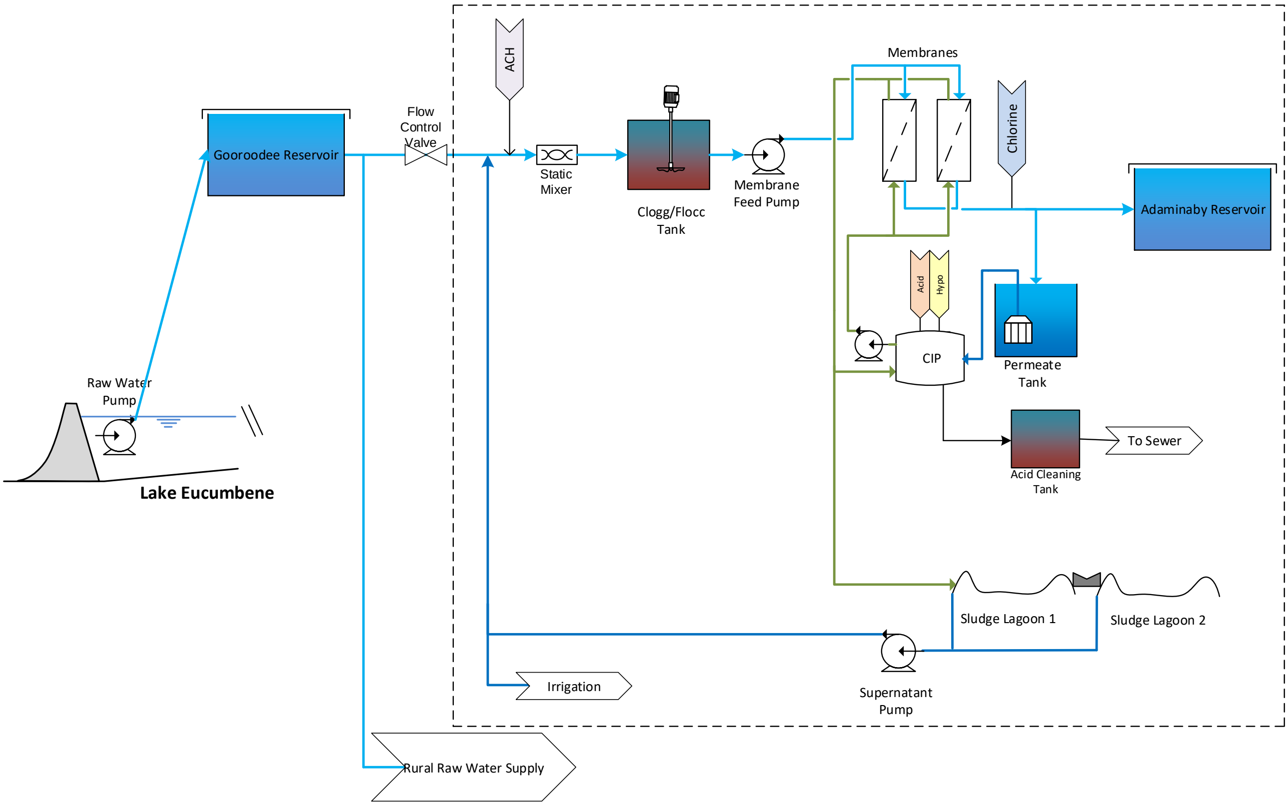


Figure 5-10: Schematic of the Adaminaby Membrane Filtration WTP.

The Key elements of Option 2 are:

1. Control valve and dedicated raw water rising main to the WTP site

IF coagulant is selected to reduce colour and organics.

2. Coagulation and flocculation
   iv. Only if deemed as required by the Contractor, addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   v. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   vi. High level estimate for coagulant usage is less than 400 L/annum allowing for delivery of 15 L packages with small pumped transfer into a 100 L to 200 L tank.

Without coagulant;

3. Membrane filtration
   vi. Membrane feed pumps take water from a balance tank (coagulation/flocculation tank) and push it through strainers and the membrane all the way to the treated water balance tank.
   vii. Due to the low temperature and to minimise chemical cleaning, the flux would be limited to a value of < 35 l/m^2/hour.

viii. In the order of 400 m^2 of filtration surface area provided by 6 to 12 membrane filtration modules.
ix. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500 mg/L to manage organic and biological fouling.

4. Membrane filtration
   i. Membrane feed pumps take water from the coagulation/flocculation tank and push it through strainers and the membrane all the way to the treated water storage reservoir
   ii. Due to the low temperature and to minimise chemical cleaning the flux would be limited to a value of < 35 l/m^2/hour
   iii. In the order of 700 m^2 of filtration surface area provided by 15 to 25 membrane filtration modules.
   iv. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500mg/L to manage organic and biological fouling.
2. Sludge lagoons – As per option 1 where coagulant is utilised
   i. Irrigation opportunities would be improved through the absence of a coagulant
5. Chlorine disinfection

5.7.4.1 Membrane Chemical Cleaning

Whilst a sewer is available for chemical cleaning waste products this is not supported by DPIE with a preference for collection and evaporation of cleaning residuals that cannot be recycled. Strategies to minimise waste include;

- Specification of minimum use of chemicals, for example chemical cleaning interval of at least 6 weeks with no intermittent “maintenance” or “enhanced” chemical cleaning.
- Collection and neutralisation of sodium hypochlorite cleaning waste and recycle through the sludge lagoons back to the plant feed at a low rate
  - Not suitable for citric acid or phosphorous based cleaners.

5.8 Preferred Option

The strengths and weaknesses of the shortlisted options for Adaminaby have been compared and scored in Table 5-5;

- 1 is given for an option that has the most weaknesses
- 2 is given for an option that has both strengths and weaknesses
- 3 is given for an option that demonstrates strengths that align with the requirements of the location.

In considering the strengths and weaknesses of the shortlisted options, both membrane filtration and direct media filtration are considered suitable alternatives for Adaminaby given a good specification is utilised and prosecuted that has clear minimum requirements.

On balance, to provide a single preferred option, given a lack of true colour requiring coagulant, available land area for irrigation and cleaning residuals management, the simplified scoring suggests that Option 2 – Membrane Filtration with a score of 17 is preferred for Adaminaby.

Table 5-5: Adaminaby Comparison of Key Strengths and Weaknesses.

	Option 1 Direct Media Filtration	Option 2 Direct Membrane Filtration
Total Score	**16**	**17**
Footprint	Relatively small and compact	Filtration unit is smaller option but there are requirements for additional tankage and strainers which evens out the footprint.
	2	**2**
Water Quality/Quantity Typical	Easily able to manage the typical water quality	Easily able to manage the typical water quality. No coagulant required which simplifies operation. Automatic test to demonstrate integrity of membrane. No issue with multiple start/stop operation.
	Typically, not as 'deep' as gravity filters which can reduce run times with early breakthrough. Cant 'see' the process to confirm the condition of the filtration media and confirm the backwash process.	Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks.
	2	**3**
Water Quality/Quantity during "Events" (For Adaminaby this is a rapid increase in turbidity from below 1 NTU to less than 10 NTU)	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. Based on historic water quality an "Event" is a small additional solids load that should not impact operation.	Membranes are a barrier and quality (pathogens and TSS) will not be affected by raw water quality change. Can't get 'breakthrough' of turbidity. Based on historic water quality an "Event" is a small additional solids load that should not impact operation.
	Cannot deal with soluble metals. Will require adjustment of coagulation dose to ensure that there is no turbidity breakthrough during a change in raw water quality. Backwashing increased and may overload sludge lagoons Will not treat soluble metals Will not treat taste and odour	If close to needing a chemical clean then increased solids can trigger a CIP and halt production. Will not treat soluble metals Will not treat taste and odour Will not reduce true colour
	2	**3**
Control and Monitoring	Simple to understand and monitor headloss and filtered water turbidity remotely.	Basis of control and monitoring as per conventional filtration. Can stop and start numerous times and not impact the quality.
	With multiple filters acting as one filter troubleshooting a problem with one filter can be difficult. Multiport valves can be problematic to trouble shoot.	Lots of different sequences to understand when troubleshooting. "Black box" control and monitoring of a proprietary system. Similar concept to conventional but lots of nuances. Need to monitor over the long term to pick up slow building problems that can fall over the cliff.

	Option 1 Direct Media Filtration	Option 2 Direct Membrane Filtration
Total Score	**16**	**17**
		Post dosing is stop start every 30 – 45 minutes when there is a backwash, and this can complicate monitoring of post treatment.
	3	**2**
Ease of Maintenance	The use of multiple filters improves redundancy and maintainability. Commonly available components can be maintained in house	Ancillary equipment is standard and can be maintained in house
	Need to ensure that access is provided around the filter and to the top of the filter for media removal and replacement. Repairing a broken lateral or issue inside a pressure media filter is nearly impossible on site.	Valves are often at awkward heights and locations due to the systems being proprietary. Typically have a third party engagement to manage membranes which has an associated cost. Typically involve some proprietary kit needing external assistance (e.g. membrane repair)
	3	**2**
Residuals Handling	Can keep instantaneous backwash flow down by having numerous filters in parallel	Small volume every 30 – 45 minutes Coagulant may not be required, reducing residuals and allowing for irrigation of backwash water.
	For 1 or 2 filters the instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant. Sludge lagoons required and the associated management of drying solids.	Typically slightly lower first pass recovery than conventional at ~ 95% If coagulant is not used then solids will not settle and residuals will need to be irrigated or returned to the lake.
	2	**3**
Environmental Impact Physical Visual Noise Energy	Quiet operation, backwashing can be scheduled for 'business' hours as typically once a day. Low energy and chemical use	Coagulant not required to achieve low turbidity. With irrigation the visual impact would be lower than for a plant with coagulation and sludge lagoons.
	Coagulant is required introducing aluminium to the backwash water and limiting reuse potential.	Has to backwash every 30 - 45 minutes which makes more noise at night (supplier dependent). Membranes have a 7 – 10 year life and will end up in landfill. Uses more chemicals with hypo and citric acid required for chemical cleaning. However, practically small volumes.
	2	**2**

6 Nimmitabel

Table 6-1: Nimmitabel Summary

Component	Nimmitabel – 400 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	86.5	279.7	377
Reservoir Capacity	580kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 4 days 2020 PDD ~ 1.2 day		
Key Water Quality Challenges	Raw water hazards ▪ Turbidity / suspended solids ▪ Colour ▪ Organics ▪ Pathogens (Category 4 source water) ▪ Bore Water Hardness ▪ Algae		
Raw Water Quality Uncertainties	▪ Level of TDS and alkalinity in Lake William Bore ▪ True colour and organics level in the Maclaughlin River ▪ Level of calcium and magnesium in Lake William Bore ▪ The presence of soluble iron in all sources ▪ Presence of microbiological contamination, typically and through events		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 15% in the reservoir		
Raw Water Pumping	The existing Maclaughlin River pump operates at twice the required future demand (~11 L/sec), with Lucan St. bore and Lake William Bore unable to meet the proposed instantaneous flow rate at 47% and 11% of the proposed instantaneous flow rate at 2.5 L/s and 0.6 L/s.		
Preferred Site location			
Land Acquisition Required?	Yes - Proposed to purchase land for the site at Lucan St. Bore.		
Shortlisted Options Considered	▪ Option 1 – Direct Membrane Filtration (MF or UF) ▪ Option 2 – DAF/F ▪ Option 3 – Inclined Plate Settler/ Media Filtration ▪ Hardness Reduction of bore water when 100% bore water supply		

Preferred Option	Given the historical 95th turbidity percentile of less than 15 NTU, with rapid increase and decrease that may be difficult for a clarification process to manage, Option 1 – Membrane Filtration is preferred for Nimmitabel.
Residuals Management	Sludge Lagoons including an opportunity for irrigate locally
UV Disinfection	Recommended due to the preliminary catchment categorisation of 4. "Unprotected Catchment"
Recommendations	In addition to the recommendations of previous reports ▪ Engage with the community to determine the willingness to pay for hardness reduction when 100% bore water is used. ▪ Groundwater investigation to determine the cause of fluctuating turbidity from the bores ▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Coagulation jar testing of various percentage blends of River and ground water, including event based jar testing with elevated colour, organics and turbidity.

6.1 Overview

Nimmitabel is located 37km SE of Cooma on the Monaro Highway. The town has a population of 320 people (2016 Census) with 181 supply connections (SMRC).

Maclaughlin River Water intake

Mclaughlin River water intake and pumping station

Figure 6-1: Overview of Nimmitabel Location and Infrastructure.

6.2 Service Area

GIS data from SMRC was used to provide an indicative service area for each Village and is presented below in Figure 6-2.

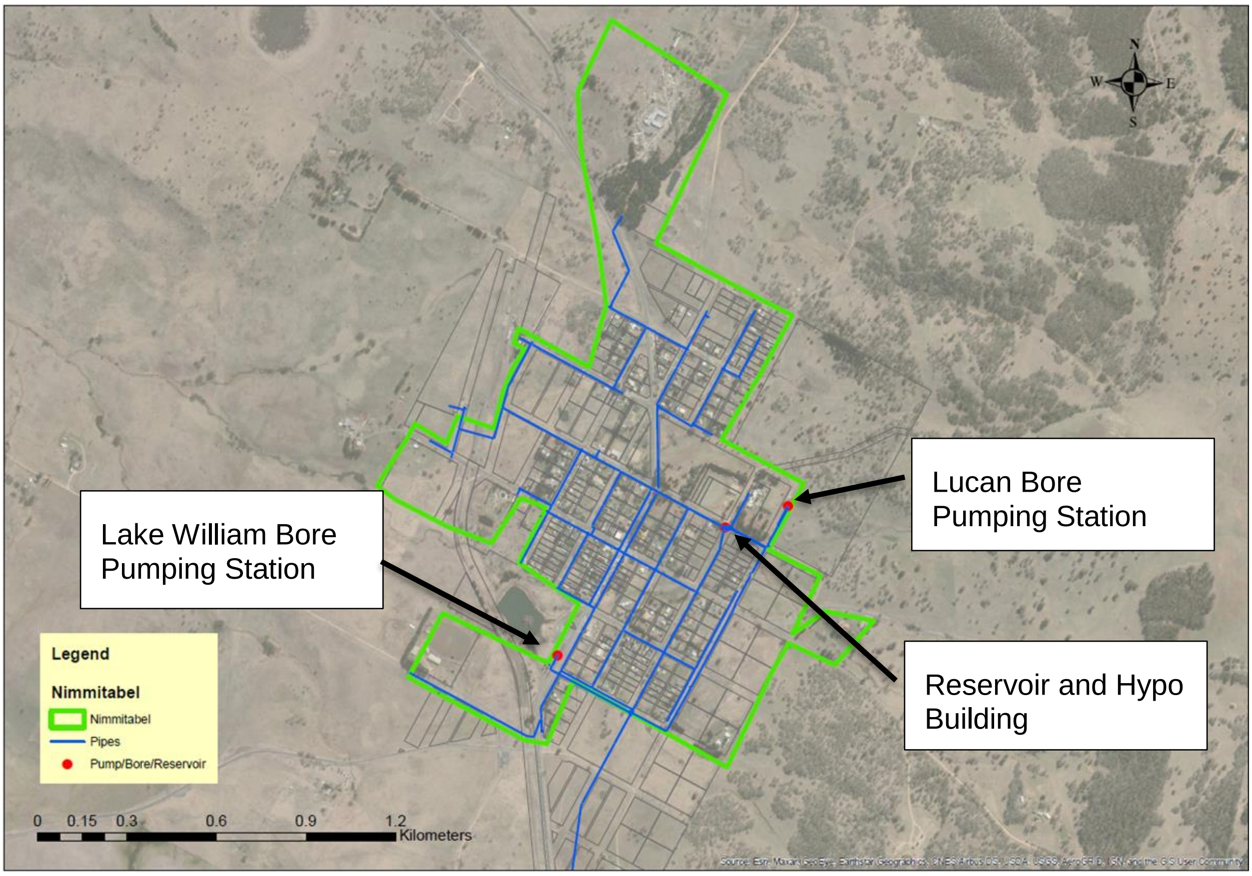


Figure 6-2: Nimmitabel Service Area.

6.3 Historical and Forecast Demand

Figure 6-3 shows the production of Nimmitabel over the last 11 years as a time series. Table 6-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

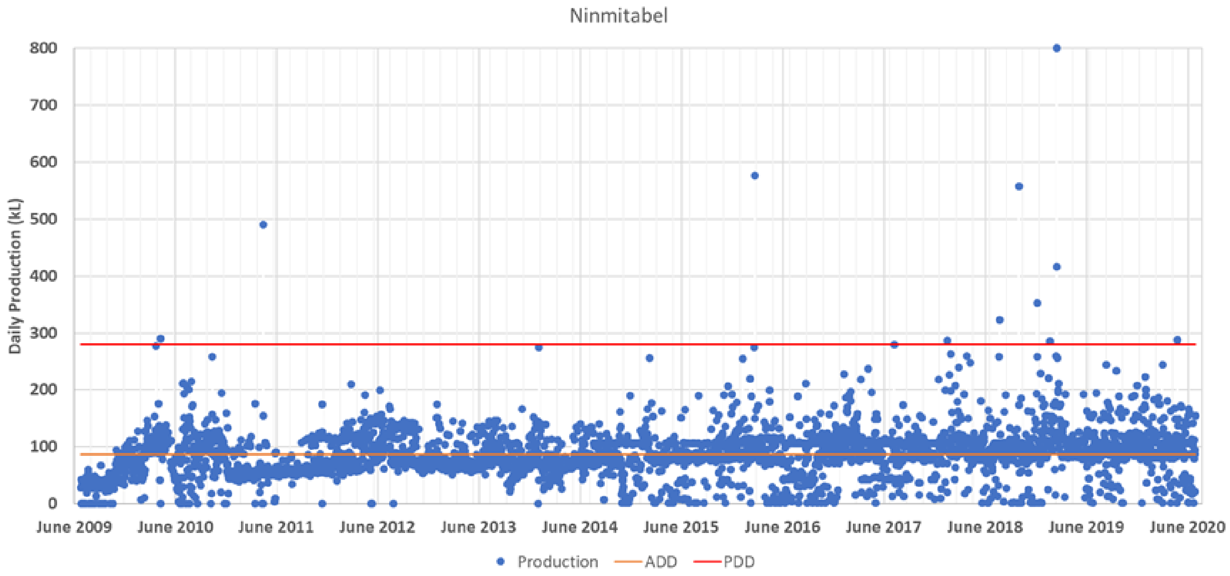


Figure 6-3: Nimmitabel Daily Production.

Table 6-2: Nimmitabel Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Nimmitabel	Bores + McLaughlin River + Lake Wallace (Pigring Creek)	River – 950 LS Bore – 200 LW Bore – 50	279.7	86.5	377.0	400

Note 1. 1% annual population growth was adopted for the 2050 projections

6.4 Source Water Assessment

The Nimmitabel raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

Beyond the day to day challenge of moderate turbidity and colour, the key challenge to be overcome to improve the water safety of Nimmitabel is turbidity and by inference, pathogen loading, during and following heavy rainfall when the Maclaughlin River turbidity increases rapidly (Figure 6-4), which requires mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level. As is shown in Figure 6-5, a relationship exists between the river water turbidity and apparent colour.

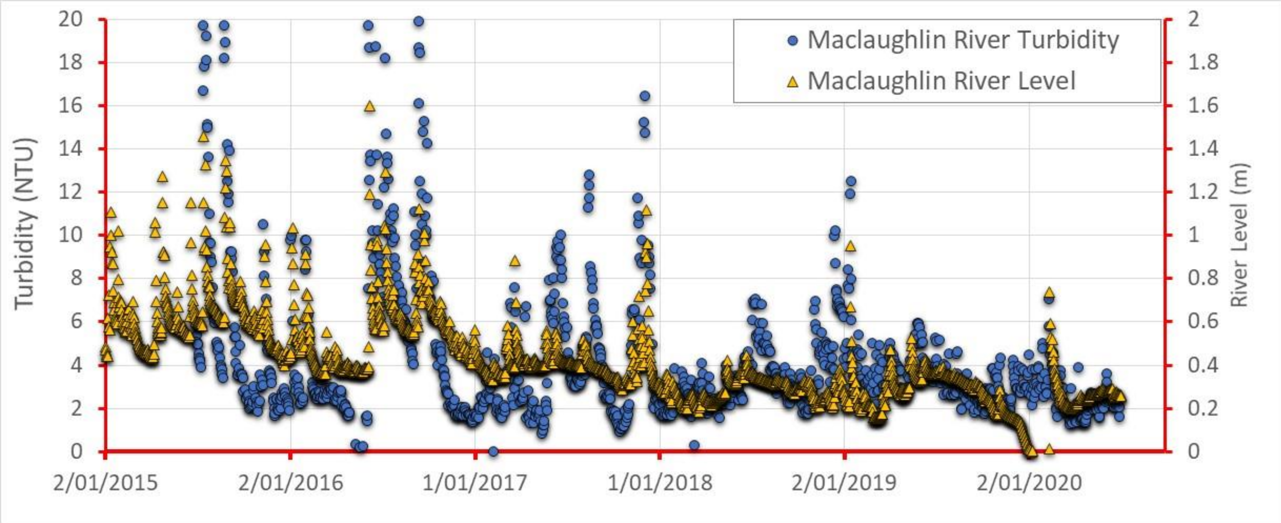


Figure 6-4: Maclaughlin River Turbidity and River Level Data (July 2015 – June 2020).

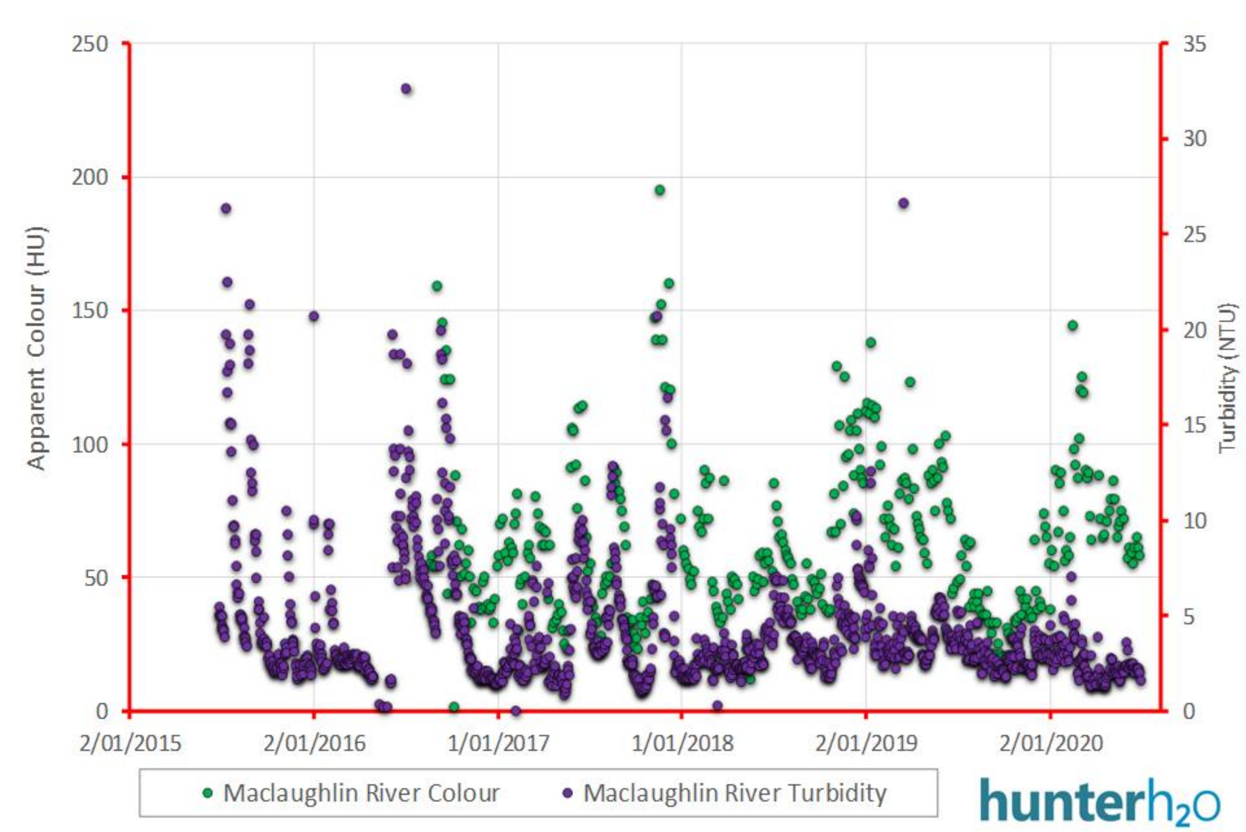


Figure 6-5: Maclaughlin River Water Apparent Colour and turbidity.

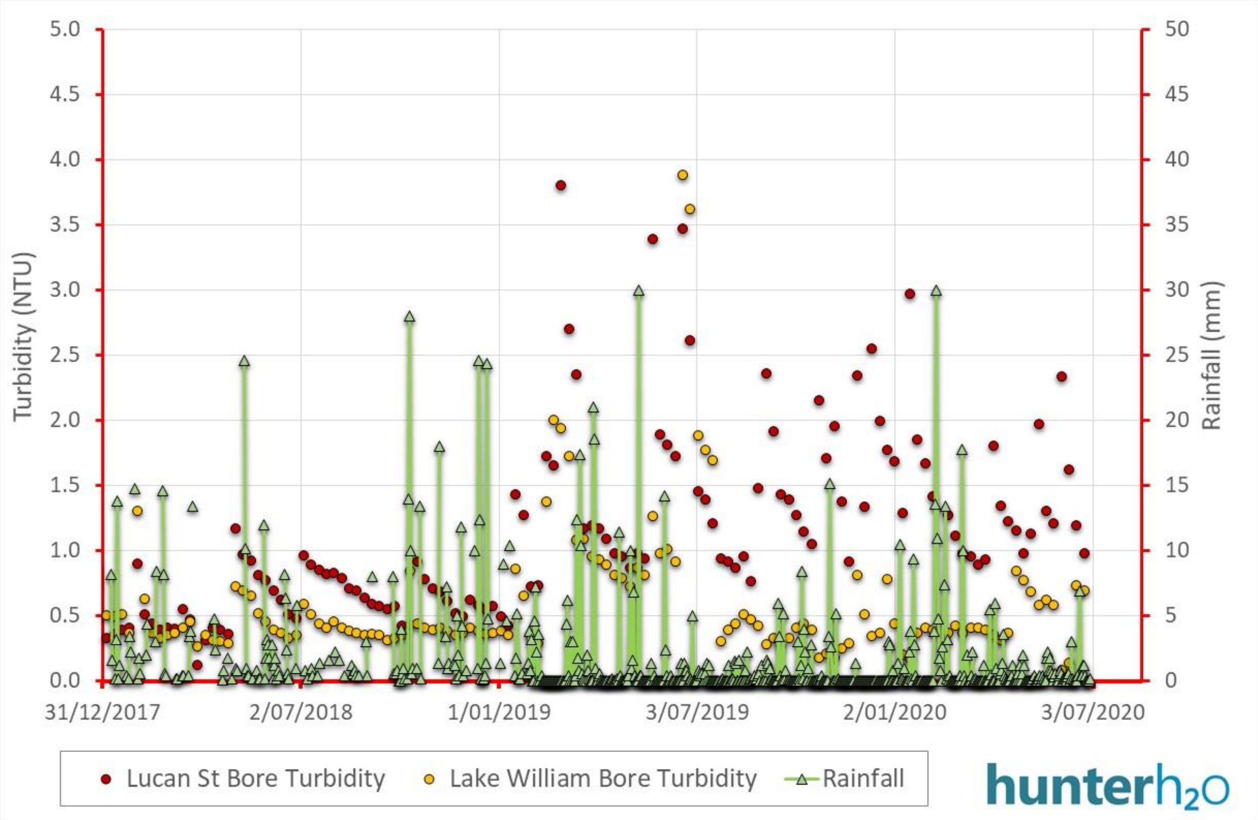


Figure 6-6: Lucan St Bore and Williams Bore Turbidity and Rainfall Data (Jan 2017 – June 2020).

6.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water Assessment (Hunter H2O, 2020). The assessment determined that the Nimmitabel sources ware conservatively a Category 4 source (Hunter H2O, 2020).

As a Category 4 source to achieve a target of an additional health burden, from potable water, of less $1x10^{-6}$ DALY's (Disability Adjusted Life Years) the following log reductions are recommended by the guidance manual and will require a multi barrier approach.

- **6.0 log_{10} reduction in Bacteria**
- **6.0 log_{10} reduction in Viruses and**
- **5.5 log_{10} reduction in Protozoa**

6.4.2 Chemical/Physical

From a review of the available raw water and reservoir water data, the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Nimmitabel.

Turbidity / Suspended Solids

- Maclaughlin River water is consistently more than 5 NTU.
- River water turbidity spikes following rainfall and a river level rise up to more than 30 NTU
  - a more typical a spike sees the turbidity rise to 20 NTU.
- The Lucan St bore is typically less than 2 NTU but can be up to 5NTU.
  - There is no certainty on why the bore turbidity varies so much and an investigation is recommended.
- The Lake William bore is typically less than 0.5 NTU but has been measured up to 4 NTU.

Metals

- There is a limited data set from the reticulation monitoring available from FASS over a period of 2000-2020 (37 samples).
    - Iron had an average of 0.28 mg/L and a maximum of 1.64 mg/L
    - Aluminium had an average of 0.20 and a maximum of 0.67 mg/L
- Not known if the bores have equivalent levels of total/soluble iron.
- Given the shallow surface water source it is expected that these metals were all total and not soluble however it is recommended that this is confirmed for each source.

Colour

- Apparent colour is high and variable in the Maclaughlin River being consistently more than 50 HU and exceeding 100 HU routinely.
    - It is suspected that true colour in the river will be variable and from network monitoring it is suspected to be in the range of 15 to 50 HU.
- Whilst it is expected to be low, there is no information on colour in the groundwater source.

Organics

- Organics data is not available for the River however, given the apparent colour organics are expected and jar testing at various blends is recommended to determine typical doses, organics levels and effectiveness of coagulation
- It would be expected that the bores are low in organics.
    - Data is required to demonstrate

pH and Alkalinity

- The pH of the individual sources is within the ADWG range of 6.5 to 8.5
- The alkalinity of the River is a median of 53 mg/L as $CaCO^3$ and is sufficient for typical levels of coagulation
- The alkalinity of the bores is high with a median of 390 mg/L as $CaCO^3$
- The alkalinity of a blended supply will be in the order of 100 to 200 mg/L as $CaCO^3$

Hardness

- The estimated typical total hardness of the Lucan St bore water is in the order of 300 mg/L as $CaCO^3$. This aligns reasonably with a FASS maximum of 370 mg/L as $CaCO^3$.
    - Lucan St bore calcium has a median calcium hardness of 162.5 mg/L as $CaCO^3$.
    - No magnesium results are available except for FASS database with a maximum of 47 mg/L attributed to a period when bores were run exclusively, with a hardness contribution of ~ 190 mg/L as $CaCO^3$.
- At the historical blend ratio of 60:40 the hardness of ~ 135 mg/L as $CaCO_3$, whilst elevated, is in a good range and softening is not required.
    - A blend using more River water could also be used to reduce the hardness further (70:30 giving a hardness of ~ 100 mg/L as $CaCO^3$). However, during drought, if the river is not available there will be a noticeable increase in hardness that will be noticeable by some residents.

Algae

- Given the shallow and low flowing nature of the River, Algae remains a risk.

6.4.3 Raw Water Quality Design Envelope

Table 6-3 outlines the preliminary raw water design envelope for the Nimmitabel WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Nimmitabel that are recommended to be filled being;

- Level of TDS and alkalinity in Lake William Bore
- True colour and organics level in the Maclaughlin River
- Level of calcium and magnesium in Lake William Bore
- The presence of soluble iron in all sources
- Presence of microbiological contamination, typically and through events

Table 6-3: Preliminary Raw Water Design Envelope.

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	25
pH		6.6	7.4	7.7	8.1
TDS	mg/L	81	156	247	393
Alkalinity River	mg/L as $CaCO_3$	25	53	116	134
Alkalinity Bores	mg/L as $CaCO_3$	280	390	460	515
Turbidity	NTU	0.2[2.]	5[1.]	15[1.]	40[1.]
True Colour	Hazen	5[1.]	15[1.]	30[1.]	70[1.]
Calcium River	mg/L (Ca)	5.1	9.7	19.5	64.7
Calcium Bores	mg/L (Ca)	47	69	83	100[1.]
Magnesium	mg/L (Mg)	1.81[3.]	12.97[3.]	28.4[3.]	46.93
Bore	mg/L (Mg)	10[1.]	30[1.]	80[1.]	100[1.]
Total Hardness[3.]	mg/L $CaCO_3$	19.7	126.1	226.8	373
Total Hardness Bores	mg/L $CaCO_3$	150[1.]	220[1.]	320[1.]	373[1.]
Total Iron	mg/L	0.02	0.6[1.]	1.20[1.]	2.0[1.]
Soluble Iron	mg/L	0.02	0.4[1.]	0.8[1.]	2.0[1.]
Total Mn	mg/L	0.0025	0.007	0.023	0.029
Soluble Mn	mg/L				
Free CO_2	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.05	0.05	0.19	0.79

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

6.5 Existing Instructure

The following information is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

6.5.1 Raw Water Pumping

Nimmitabel raw water is drawn from a weir pool on the Maclaughlin River with the ability to maintain the level in the weir through releases from Lake Wallace down the River if required. Further, water is supplied from 2 bores, the Lucan St Bore and the Lake William Bore.

A summary of the supply is:

- Maclaughlin River
    - Weir constructed in 1968
    - Licence to draw 68 ML/year (Yearly average of 186kL/day)
    - Pumping station constructed in 2005
- Lake Wallace (Pigring Creek)
    - Lake Capacity of ~320 ML
    - Outlet depth is able to be adjusted
    - Used during drought when the River ceases to flow
    - Releases into Pigring creek and travels around 2.5km down the Maclaughlin River to the weir pool
- Bores (bore construction logs not available)
    - Located in lower fractured rock aquifers
    - Noted as experiencing elevated levels of iron, carbon dioxide and hydrogen sulphide
        - Hydrogen sulphide and associated smell not raised as an issue.
    - Lucan St Bore (47 ML/year license)
        - Constructed 1996
        - Capacity 1 to 2.5 L/s (NSW Public Works, 2012)
        - Wellhead not integral and vermin could enter
    - Lake William bore (19 ML/year license)
        - Low flow and rarely utilised
        - Constructed 1996
        - Wellhead not integral and vermin could enter

Post Workshop – There is a third bore, referred to as the "School Bore" which supplies water into the outlet of the Lucan St bore when it is operated. The quality of the water and condition of the bore are unknown and should be investigated.

In comparing the raw water flow requirements of the proposed WTP, the existing Maclaughlin River pump operates at twice the required future demand (~11 L/sec), with Lucan St. bore and Lake William Bore unable to meet the proposed instantaneous flow rate at 47% and 11% of the proposed instantaneous flow rate at 2.5 L/s and 0.6 L/s respectively.

Maclaughlin River Water intake

Mclaughlin River raw water intake and pumping station

 Maclaughlin River raw water pumping	 Maclaughlin River weir
 Lake William Bore water intake	 Lucan Street Bore water intake

Figure 6-7: Nimmitabel Raw Water Intake and Pumping Infrastructure.

6.5.2 Reservoir

Key capacity information on the Nimmitabel Reservoir from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 48% of the reservoir capacity of 580kL
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD is less than 20%
- 60% of the reservoir provides 4 days to repair an issue for the average day demand
- 60% of the reservoir provides 1.2 day to repair an issue for the PDD

Based on the available information capacity upgrades are not recommended for the Nimmitabel Reservoir.

Figure 6-8: Nimmitabel Reservoir.

6.5.3 Disinfection

Sodium hypochlorite dosing at the reservoir site is employed for disinfection with the storage and dosing equipment located inside a lined and heated room to avoid the lines freezing (Figure 6-9).

The building is in reasonable condition however there is limited opportunity to co-lo ate treatment infrastructure to allow for reuse of the building. However, there would be an opportunity to use the system for 'top up' dosing in combination with a sample instrumentation, a small recycle and tank mixing.

Figure 6-9: Nimmitabel Hypo Storage and Dosing.

6.6 Proposed Site Location

Figure 6-10 shows the location of the Maclaughlin River, Lake Wallace, Lucan Bore, Lake William Bore and storage reservoir.

In considering water treatment plants in the 200 to 500 kL/day capacity range at a scoping level the footprint allowance for Nimmitabel is 500 m^2 for process and 1500 m^2 for sludge lagoons.

Three options for the location of the Nimmitabel WTP were identified:

1. At Lake Wallace with the bore water receiving chlorination only.
2. At Lucan Bore location and near the reservoir with all water sources receiving treatment
3. At Nimmitabel STP site location

Considering the first option, if there was sufficient evidence to verify that the bore water is from a confined aquifer, then there is an opportunity to locate a treatment plant at Lake Wallace with the bore water receiving chlorination and at worst chlorination and UV. A conservative position has been taken that assumes that the ground water is under the influence of surface water and requires equivalent treatment to the Maclaughlin River water. This constrains the location of the treatment infrastructure to a location where all of the raw water is available.

From the review of the location of the raw water pumping stations and water storage reservoir, as shown in Figure 6-10, the proposed locations for Nimmitabel WTP is near the reservoir and the area near the Lucan St Bore.

On review of the Lucan Bore location, where private land next to the Lucan Bore infrastructure is on lot DP756849. Access is off West of Miller Street by an easement on an informal gravel road. In considering the DP756849 lot, there is a large open area which can be sufficient for the WTP infrastructure (Figure 6-11), which is required to be purchased. The Maclaughlin River water and Bore water would be mixed in a balance tank before treatment. The treated water then is pumped to the reservoir. In addition, the land nearby appears to be suitable for irrigation which can be considered as one of the options for managing liquid residuals (filter backwash water).

The land available at Nimmitabel STP is located on lot DP623283, as shown in Figure 6-12. Although there is enough space to construct the Nimmitabel WTP on this land, with relocation of sludge drying, the land is not ideal, in addition to the requirement for new pipeline from the raw water sources and to the reservoir which would add cost.

Figure 6-10: Lake Wallace, Maclaughlin River, Bores, Reservoir and STP Location.

Figure 6-11: Proposed Nimmitabel WTP Location Near the Lucan Bore and Reservoir.

Figure 6-12: Nimmitabel STP Lot Location.

6.7 Shortlisted Options

Following a consideration of barriers available to manage the identified raw water hazards for Nimmitabel, the following three treatment trains were shortlisted for further assessment and comparison.

- Option 1 – Direct Membrane Filtration (MF or UF)
- Option 2 – Dissolved Air Flotation and Filtration (DAF/F)
- Option 3 – Inclined Plate Settler/ Media Filtration

6.7.1 Comparison of Options Against Health Based Targets

Table 6-4 presents the LRV removal expectation for the shortlisted options. The pathogen removal credits are taken from the WSAA guideline (WSAA 2015) and for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

Noting that the assessment of a Category 4 raw water was conservative and based on a desktop assessment.

Based on industry best practice UV disinfection is recommended for all options to provide a multi barrier approach.

Table 6-4: LRV Expectation for the Shortlisted Options.

	Log Reduction Values			
	Bacteria	**Virus**	***Cryptosporidium***	**Process Critical Limits**
Required Treatment (Category 4 Source)	**6.0**	**6.0**	**5.5**	
Option 1				
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***6.0***	***4.0***	
Shortfall or Excess Log Removal	***2.0***	***0***	***1.5***	Shortfall can be addressed by UV
Option 2				
DAFF	2.0	2.0	3.0 – 4.0	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***6.0***	***6.0***	***3.0 – 4.0***	
Shortfall or Excess Log Removal	***0***	***0***	***1.5 to 2.5***	Shortfall can be addressed by UV
Option 3				
Coagulation/Flocculation/Sedimentation/Media Filtration	2.0	2.0	3.0-4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***6.0***	***6.0***	***3.0-4.0***	
Shortfall or Excess Log Removal	***0***	***0***	***1.5 to 2.5***	Shortfall can be addressed by UV

6.7.2 Common Elements

6.7.2.1 Blending

The intent for all options is to continue blending bore water and River water. This is based on an assumption that whilst there is a license to supply up to ~186kL/day from the River every day of the year, there is a benefit in reducing extraction of surface water through supplementing with ground water. This operating scenario means that there is a smaller change in hardness and alkalinity when transferring to bore only supply during emergency scenarios.

With a bore water flow of 2.5 L/sec the current 'base' blend for instantaneous flow is for ~20% bore water and 80% River Water (2.5 L/sec and 11 L/sec). The intent would be to investigate the installation of variable speed drives on the raw water pumps to provide a ratio of up to 50:50 by slowing down the River Water supply to ~ 2.5 L/sec.

6.7.2.2 Residuals Handling

The preferred option for residuals handling is to utilise two sludge lagoons for balancing instantaneous flows and capturing, and ultimately drying, solids. Supernatant will then be returned to the WTP.

The lagoon design should consider that the supernatant return flow should be less than 10% as an instantaneous flow and during winter only in the order of 7 kL/day can be returned through the WTP due to the daily demand. Hence an ability to irrigate would be advantageous.

6.7.2.3 UV Treatment Barrier

Based on the assessment of the source as being a Category 4, UV is recommended to ensure a multi barrier approach to chlorine resistant protozoa. Hence regardless of the process train a UV system is recommended.

6.7.2.4 Chlorine Disinfection

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided with any new treatment infrastructure.

6.7.2.5 Fire Risk

The site is close to town and surrounded by open grassland, hence the fire attack level is expected to be low.

Recommend a fire attack study be completed to inform the materials and construction methods for the WTP.

6.7.2.6 Power Availability

Site power is delivered via overhead lines and available capacity will need to be confirmed during the next phase.

6.7.3 Option 1 – Membrane Filtration

Raw water would be pumped to the WTP from the McLaughlin River and bores at an Operator controlled blend ratio being dosed with coagulant prior to entering a coagulation/flocculation and balance tank.

The coagulated and flocculated water will then be pumped through a strainer, a membrane, a UV unit and be dosed with chlorine prior to a treated water storage tank.

Membrane fouling through solids accumulation and adsorption of dissolved contaminants will occur. Regular backwashing, every 30 to 60 minutes, is required to remove accumulated particles, with chemical cleaning undertaken monthly.

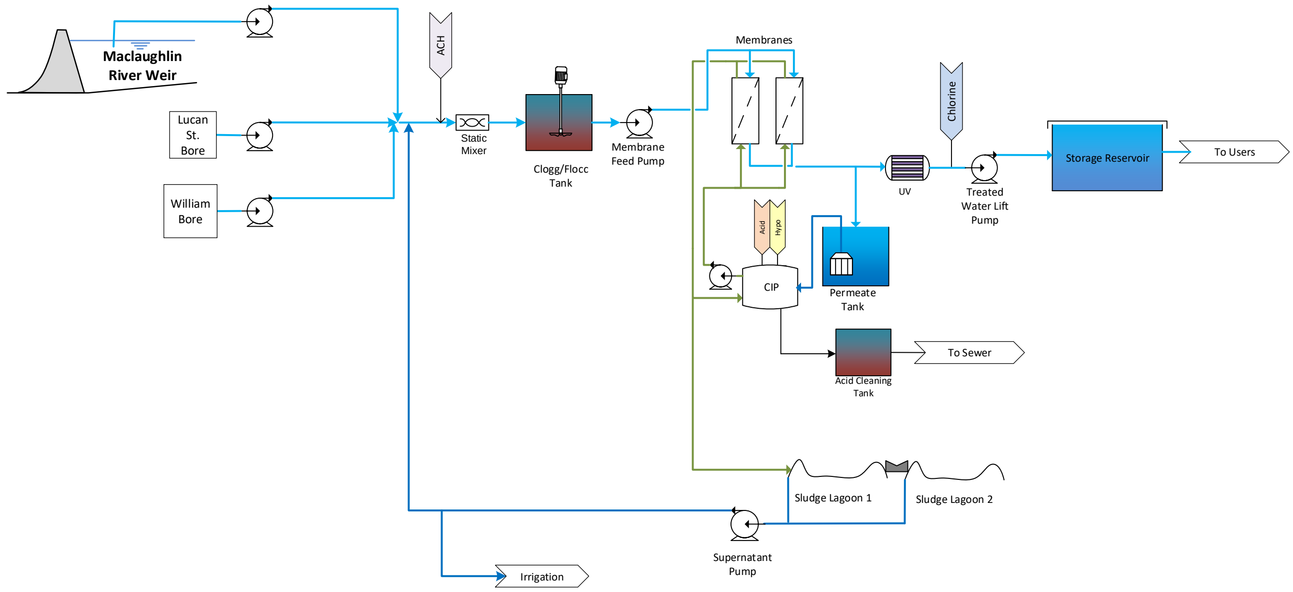


Figure 6-13: Schematic of the Nimmitabel Membrane Filtration WTP.

The key elements of Option 1 are:

1. Variable Speed transfer of River Water to blend with bore water from 10% to 50%
2. Raw Water Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   iii. High level estimate for coagulant usage is less than 530 L/annum allowing for delivery of 15 L packages with small pumped transfer into a 100L to 200 L tank.
3. Membrane filtration]
   i. Membrane feed pumps take water from the coagulation/flocculation tank and push it through strainers and the membrane all the way to the treated water storage reservoir (or local treated water tank before pumping to the reservoir)
   ii. Due to the low temperature and to minimise chemical cleaning the flux would be limited to a value of < 35 l/m^2/hour
   iii. In the order of 550 m^2 of filtration surface area provided by 10 to 15 membrane filtration modules.
   iv. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500 mg/L to manage organic and biological fouling.
4. Sludge lagoons
   i. At a yearly production of 38 ML (104 kL/day)
   ii. An estimated TSS of 20 mg/L (conservative)
   iii. There is a production of 25.3 m^3 of 3% TSS sludge
   iv. Provide 2 lagoons, each approximately 50m^2 base area
   v. Supernatant pump station to return supernatant to the raw water storage tank
5. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
6. Chlorine disinfection

6.7.3.1 Membrane Chemical Cleaning

Strategies for managing chemical cleaning for small membrane WTP's include.

- Specification of minimum use of chemicals, for example chemical cleaning interval of at least 6 weeks with no intermittent "maintenance" or "enhanced" chemical cleaning.
- Collection of cleaning waste in a dedicated lagoon and allowing for evaporation

- Collection and neutralisation of sodium hypochlorite cleaning waste and recycle through the sludge lagoons back to the plant feed at a low rate
    - Not suitable for citric acid or phosphorous based cleaners.

6.7.4 Option 2 – DAFF or DAF followed by Filtration

The key advantage of DAF/F is to ensure that a conventional filtration plant can operate effectively, safely and efficiently through dirty water events which are relatively common, if not particularly bad, on the Maclaughlin River which will challenge a direct media filter process.

Raw water would be pumped to the WTP from the McLaughlin River and bores at an Operator controlled blend ratio being dosed with coagulant prior to entering the flocculation zone of the DAF/F.

The coagulated and flocculated water then enters the DAFF cell and is contacted with small microbubbles, released from solution, following the introduction of an air saturated water stream, which attach to flocs as they rise to the surface. The clarified water is either removed from underneath the DAF (in the case of a straight DAF process) or passes directly onto the filter under the DAF (in the case of an in-filter DAF or DAF on filter process – commonly referred to as a DAFF process). The float is removed periodically using a mechanical scraping mechanism or a temporary flooding process and is assisted via water sprays to separate the float from the walls. The saturated air stream is prepared by pumping clarifier or filtered water into a high pressure saturator where air is introduced. Under these high pressure conditions, the water becomes saturated with air. The air saturated water is then returned to the DAF injection system and bubbles are released via a pressure drop provided from a dispersion valve. This pressure drop releases the micro bubbles from the water and allows them to contact with the flocs and a float is formed.

Depending on the raw water pH and the selected coagulant, pH correction (through acid or alkali dosing) may be required prior to coagulant dosing to achieve the optimal coagulation pH range.

Filtered water would then pass through a UV unit prior to chlorination and entry into a local treated water storage tank which would act as a buffer to allow the transfer pumps to operate effectively to transfer water to the reservoir.

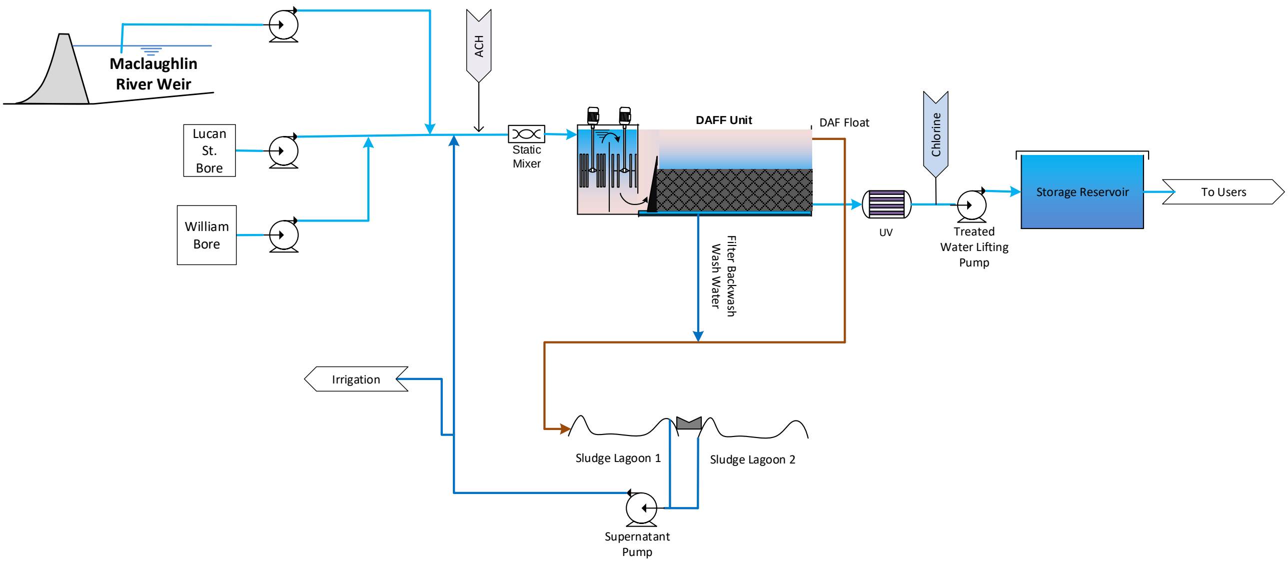


Figure 6-14: Schematic of the Nimmitabel DAFF WTP.

The key elements of Option 2 are:

1. Variable Speed transfer of River Water to blend with bore water from 10 to 50%
2. Coagulation and flocculation
    i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
    ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.

iii. High level estimate for coagulant usage is less than 530L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.

3. Floatation and filtration
   i. Floatation of the flocculated water through contacting with microbubbles with the maximum recycle rate of 15% and loading rate of <10 m/h.
   ii. In the order of 2.2 m^2 of DAF surface area in a single DAFF.
4. Sludge lagoons – As per option 1
5. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
6. Chlorine disinfection

6.7.5 Option 3 – Inclined Plate Settler Clarification/Media Filtration

Raw water would be pumped to the WTP from the McLaughlin River or the bores at a constant rate to a raw water storage tank, before being dosed with a coagulant, and transferring to a Inclined Plate Settler (IPS) tank at a constant rate. After settlement of the flocculated solids in IPS, the water will be passed through the media filters.

Depending on the raw water pH and the selected coagulant, pH correction (through acid or alkali dosing) may be required prior to coagulant dosing to achieve the optimal coagulation pH range.

Filtered water would then pass through a UV unit prior to chlorination and entry into the treated water storage reservoir.

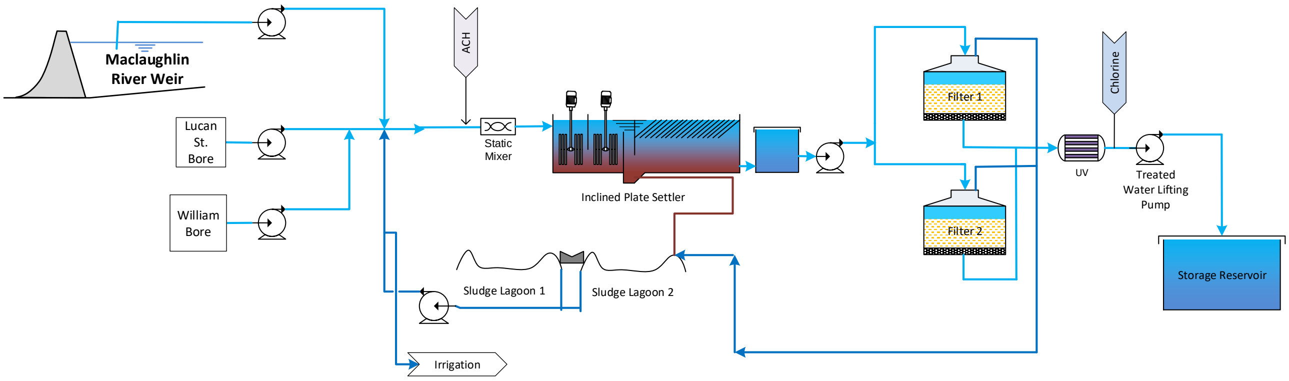


Figure 6-15: Schematic of the Bredbo Membrane Filtration WTP.

The Key elements of Option 3 are:

1. Coagulation, flocculation and sedimentation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered. High level estimate for coagulant usage is less than 530 L/annum allowing for delivery of 15 L packages with small pumped transfer into a 100L to 200L tank.
   ii. Flocculation time of 10 to 15 minutes in flocculation zone of the IPS to assist the growth of coagulated particles to enhance their sedimentation in the sedimentation zone of the IPS.
   iii. Sedimentation of the flocculated solids in sedimentation zone of IPS with the loading rate of about 7 m/h and in the order of 2.7 m^2 surface area.
2. Pressure media filtration
   i. Filtration rate of less than 10 m^3/hr per m^2 of surface area (m/hr)
   ii. In the order of 2.4 m^2 of filtration surface area provided in 2 to 5 individual pressure media filters.
3. Sludge lagoons – As per option 1
4. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
5. Chlorine disinfection

6.7.6 Hardness Reduction

At the workshop (13/10/20) a minute was made to incorporate a discussion of hardness removal in the WSSS and to engage with the community around this option. In particular, considering a willingness to pay by the community for hardness reduction when the bores were used as the sole supply. The following is a summary of the option for hardness reduction. For community engagement a detailed yield study is required to nominate the likely frequency of 100% bore use and the likely duration of these events.

6.7.6.1 Frequency and Duration of 100% Bore use and softening

Softening is not being pursued under a typical operating scenario when blending of the River and bore water is able to achieve a total hardness in the range of 100 to 140mg/L as $CaCO_3$. This is achieved through utilising the historical blend ratio of ~60% River and 40% bore water and likely a blend of up to 70% River and 30% bore water once controls are in place through a new WTP.

To consider the frequency and duration of operation with 100% bore water, the scenarios that would result in this outcome have been summarised as

- A pipe break between the River pumping station and the new WTP
  - Likelihood - possible but a low likelihood
  - Duration – Unlikely to stop supply for more than 1 week
- A major failure of the Maclaughlin River pumping station
  - Likelihood - possible but unlikely with appropriate preventative maintenance
  - Duration - weeks up to a couple of months to get a temporary solution in place
- Planned maintenance of the pipeline/pumping station
  - Can be undertaken in winter with low demand and existing storage provides 4 – 5 days before bore water would need to be used as 100%
- During extended drought
  - likelihood – will happen, with a drought needing to be more severe than the drought leading into the start of 2020
  - duration – anywhere from days to months, unable to predict.

For the above scenarios the only one that would require softening for more than a couple of weeks would be the extended drought scenario. The likelihood of the frequency and duration of such events requires a detailed yield analysis to be undertaken. However, ultimately droughts are unpredictable.

6.7.6.2 Softening Process and Target

During the Workshop it was recommended that the use of nano filtration (NF) or reverse osmosis (RO) would be the most appropriate for softening of the bore water for a small and relatively clean supply with a yield in the order of 200 kL/day. The target hardness was suggested as 100 mg/L as $CaCO_3$ to match the hardness of the water that would be supplied under a typical blend scenario of River and Bore water.

Both NF and RO require very low suspended solids and so the upstream treatment would remain essentially the same up to the inlet to the Treated water balance tank (TWBT), where a portion of the feed would be diverted to the RO Feed tank with the remainder, around 40kL/day, travelling to the TWBT without being softened.

The chlorination point, typically on the inlet to the TWBT, would be relocated to the outlet of the tank as RO membranes are not tolerant of chlorine.

From the RO Feed tank a package NF/RO plant would take the 160kL/day and return ~130kL/day to the TWBT where the blend would be transferred with the existing transfer pump to the Storage reservoir, receiving chlorination on the way.

The NF/RO would have in the order of 80% recovery with 30 kL/day of concentrate being directed to evaporation lagoons built next to the WTP. These lagoons would be lined to prevent contamination of local groundwater and be sized based on the yield study and an estimate of the maximum duration of 100% bore water supply and the demand over this period.

As a high level example, to cover 3 months of NF/RO operation to produce 15ML of potable water, in a low evaporation period an area of around 2000m^2 would be required with a storage of ~2.5ML. This in theory would dry in 6 – 12 months with the typical pan evaporation of 1200mm/annum. Noting that it is very hard to guarantee as evaporation rates decrease as TDS increases (Figure 6-17).

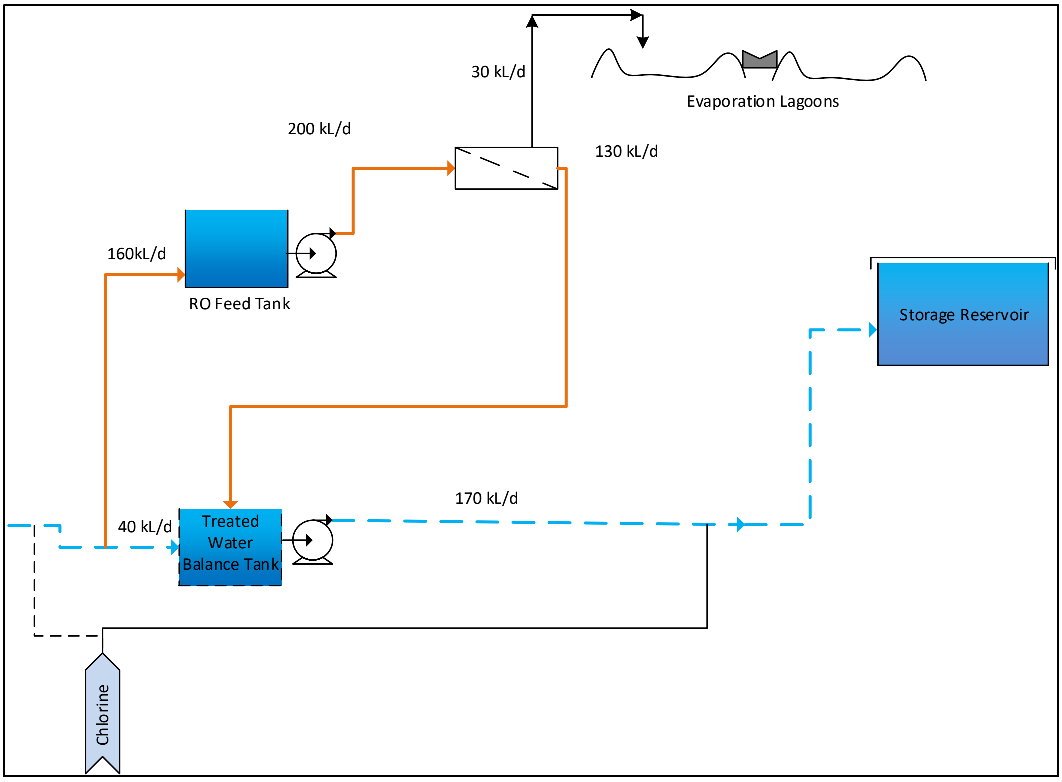


Figure 6-16 Preliminary NF/RO concept

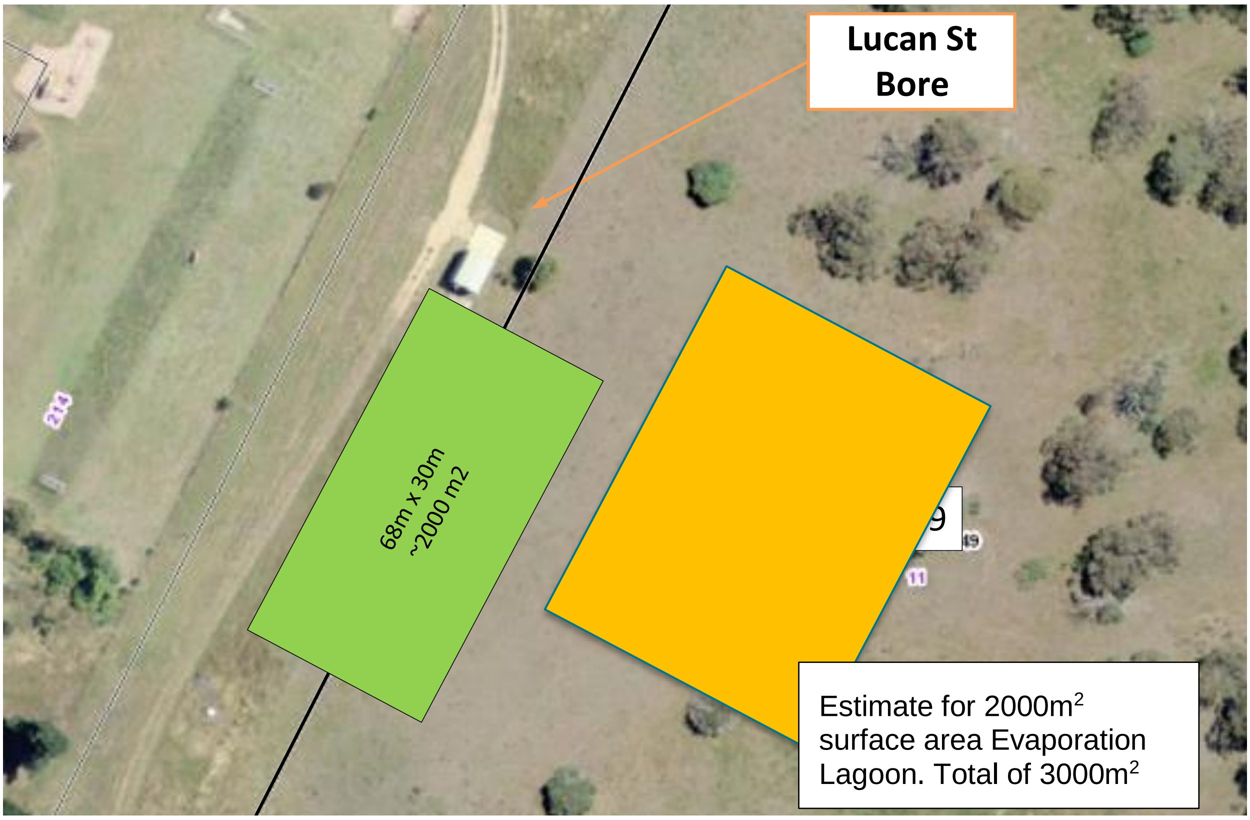


Figure 6-17 High level estimate of a "3 month" evaporation Lagoon

6.7.6.3 Order of Magnitude Costing

At a high level, a 200 kL/day RO unit in a shipping container with essentially standalone control is $300k (supplier budget quote). To this based cost it is reasonable to add $50k for integration into an existing WTP giving a total cost of $350k. This is a basic package plant cost so there is no choice of components, materials, valves, pumps, PLC etc..

An estimate for a very simple HDPE lined lagoon with a surface area of 2000m^2 would be $150k, assuming reasonably flat and suitable ground and suitable geotech.

So in total an order of magnitude estimate, without management, additional studies (eg a review of environmental factors), contingency etc, would be $500k when constructed in addition to a complete WTP.

6.8 Preferred Option

The strengths and weaknesses of the shortlisted options have been compared and scored in Table 6-5;

- 1 is given for an option that has the most weaknesses
- 2 is given for an option that has both strengths and weaknesses
- 3 is given for an option that demonstrates strengths that align with the requirements of the location.

The simplified scoring suggests that Option 1, direct membrane filtration and Option 2, DAF/F are comparable solutions across the criteria selected with a score of 15.

However, in considering the treatment trains preferred for other Village locations and to provide a single preferred option, given the historical 95th turbidity percentile of less than 15 NTU, with rapid increase and decrease that may be difficult for a clarification process to manage, Option 1 – Membrane Filtration is preferred for Nimmitabel.

Table 6-5: Nimmitabel Comparison of Key Strengths and Weaknesses.

	Option 1 Direct Membrane Filtration	Option 2 DAF/F	Option 3 Inclined Plate Settler Clarification/Media Filtration
Total Score	**15**	**15**	**14**
Footprint	Filtration unit is the smallest of the options but there are requirements for additional tankage and strainers which evens out the footprint.	Relatively small and compact.	Narrow. Filtration: Compact with skid mounted pressure media filters.
	2	**2**	**2**
Water Quality/Quantity Typical	Easily able to manage the typical water quality. Automatic test to demonstrate integrity of membrane. No issue with multiple start/stop operation.	Be easily able to comply with the ADWG, both in the quality of water produced and in the validation of the treatment process to achieve the required log removal of pathogens. Typically start easily and so can be used start/stop.	Easily able to manage the typical water quality. Some Australian installations have treated water in excess of 3,000 NTU water with IPS.
	Coagulant utilised to remove organics. If no coagulant is used then backwash water not able to be returned, would need to be irrigated. Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks.	Most efficient when operated at their design flow for shorter periods as opposed to running at lower flows for longer periods. With a good 'float' start and stop of the process is not a concern however the stability of the float cannot be guaranteed with the testing undertaken to date.	
	3	**3**	**3**
Water Quality/Quantity during "Events" (For Nimmitabel this is a rapid increase in turbidity from ~4 NTU to above 30 NTU)	Membranes are a barrier and quality (pathogens and TSS) will not be affected by raw water quality change. Can't get 'breakthrough' of turbidity.	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. Consistent filter run time without early breakthrough given upfront clarification. Low risk of over loading the filter and filter breakthrough if pre-treatment is optimised during an event with turbidity up to 100 NTU.	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. Consistent filter run time without early breakthrough given upfront clarification. Low risk of over loading the filter and filter breakthrough if pre-treatment is optimised during an event with turbidity up to and above 100 NTU.
	Some extra backwashing required with increasing turbidity and a reduction in throughput. If close to needing a chemical clean, increased solids can trigger a CIP and halt production. Will not treat soluble metals. Will not treat taste and odour. Can have colour breakthrough if there is 'true colour'.	Large water quality changes require the operator to optimise the pre-treatment coagulant dose to achieve low subnatant turbidity. Not suitable for turbidity over 100 NTU for long periods (days).	Large water quality changes require the operator to optimise the pre-treatment coagulant dose to achieve low supernatant turbidity. As quality improves pre-treatment must be managed to limit overdosing of coagulant that may reduce filter run times. Site visit and a level of attendance will be required during the event and as the quality improves. Some algae is difficult to settle.
	2	**2**	**1**

	Option 1 Direct Membrane Filtration	Option 2 DAF/F	Option 3 Inclined Plate Settler Clarification/Media Filtration
Total Score	**15**	**15**	**14**
Control and Monitoring	Basis of control and monitoring as per conventional filtration. Can stop and start numerous times and not impact the quality.	During periods of stable raw water quality with a proper design (online monitoring) daily attendance is not required.	IPS: Simple process to control, few variables other than chemical dosing. Very little operator intervention required. Filtration: Simple to understand and monitor headloss and filtered water turbidity. During periods of stable raw water quality with a proper design (online monitoring) daily attendance is not required.
	Lots of different sequences to understand when troubleshooting. “Black box” control and monitoring of a proprietary system. Need to monitor over the long term to pick up slow building problems that can fall over the cliff. Post dosing is stop start every 30 – 45 minutes when there is a backwash, and this can complicate monitoring of post treatment.	DAFF requires careful operation of the DAF and regular optimisation of the coagulation chemistry, particularly during raw water turbidity and colour events. Changing raw water quality will require close remote monitoring and likely daily attendance to allow for optimising the process.	Chemical dose rates and wasting require modification to adapt to changing conditions.
	2	**2**	**2**
Ease of Maintenance	Ancillary equipment is standard and can be maintained in house.	Fairly standard mechanical kit and can be maintained in house. A typical media filter will only require media replacement every 10 – 20 years.	IPS: Low - Flocculation mixers only Filters: Can incorporate multiple filters to improve redundancy. Commonly available components can be maintained in house.
	Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks. Valves are often at awkward heights and locations due to the systems being proprietary. Typically have a third party engagement to manage membranes which has a cost. Typically involve some proprietary kit needing external assistance (e.g. membrane repair).	Likely to only have a single DAF and Filter making maintenance on some components difficult.	Need access with a crane to pull out mixers. Need to ensure that access is provided around the filter and to the top of the filter for media removal and replacement. Sludge can build up in the sludge hopper.
	2	**2**	**1**

	Option 1 Direct Membrane Filtration	Option 2 DAF/F	Option 3 Inclined Plate Settler Clarification/Media Filtration
Total Score	**15**	**15**	**14**
Residuals Handling	Small volume every 30 – 45 minutes.	High recovery due to clarification extending filter run times. DAF float generally breaks up when travelling to the next process and settles well.	Sludge scour and filter backwash, typically around 5% of flow.
	Typically, slightly lower first pass recovery than conventional at ~ 95%. Need to manage cleaning chemical residuals.	The instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant. DAF float is not always easily settled however typically with some mixing when the float is removed on its way to a sludge lagoon the float settles well.	For one or two filters the instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant.
	2	**2**	**2**
Environmental Impact Physical Visual Noise Energy	Slightly less coagulant than a conventional plant.	Would be housed indoor.	Quiet operation, backwashing can be scheduled for 'business' hours as typically once a day. Low energy and chemical use.
	Has to backwash every 30 - 45 minutes which makes more noise at night (supplier dependent). Membranes have a 7 – 10 year life and will end up in landfill. Uses more chemicals with hypo and citric acid required for chemical cleaning. However, practically small volumes.	Tall building required. Coagulant is required introducing aluminium to the backwash water and limiting reuse potential. Continuous operation of the recycle pumps and compressor make this the highest base load noise option. Slightly higher power consumption in the order of 0.15kWhr/kL. Recycle of 15% of the water at 600kPa principal energy demand along with compressed air.	Coagulant is required introducing aluminium to the backwash water and limiting reuse potential.
	2	**2**	**3**

7 Eucumbene Cove

Table 7-1: Eucumbene Cove Summary.

Component	Eucumbene Cove – 60 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	No Data	No Data	58.2
Reservoir Capacity	400kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 24 days 2020 PDD ~ 4 day		
Key Water Quality Challenges	Raw water hazards ▪ Turbidity / suspended solids ▪ Pathogens (Category 3 source water) ▪ Bore Water Hardness ▪ Algae		
Raw Water Quality Uncertainties	▪ Presence or absence of soluble iron		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 5% in the reservoir		
Raw Water Pumping	The existing pump has sufficient capacity at 1.2 L/sec,150% higher than the required flow at 0.8 L/s.		
Site location			
Land Acquisition Required?	No		
Shortlisted Options Considered	The only feasible option for Eucumbene Cove is direct membrane filtration (MF or UF).		
Preferred Option	direct membrane filtration (MF or UF)		
Residuals Management	The backwash water can be stored in a small tank and directly used for local irrigation. The membrane cleaning solution can be collected by operations in a 'back of the truck' container to be emptied at a STP.		
UV Disinfection	Not recommended due to the preliminary catchment categorisation of 3. "Poorly Protected Catchment"		

Recommendations	In addition to the recommendations of previous reports ▪ Approach Snowy Hydro to confirm the design of the outlet and related risk of soluble metals ▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Chlorine decay testing and impact on the pH from continual top up.

7.1 Overview

Eucumbene Cove is located approximately 60km by road from Cooma. Eucumbene Cove draws water from Lake Eucumbene. Eucumbene cove accesses raw water from the Eucumbene Dam wall outlet (controlled by Snowy Hydro).

The town is essentially a holiday destination with few permanent residents with 41 supply connections (SMRC).

	
Gravel access road to reservoir location	Storage Reservoir and the old storage tank

Figure 7-1: Overview of Eucumbene Cove Infrastructure.

7.2 Service Area

GIS data from SMRC was used to provide an indicative service area for each Village and is presented below in Figure 7-2.

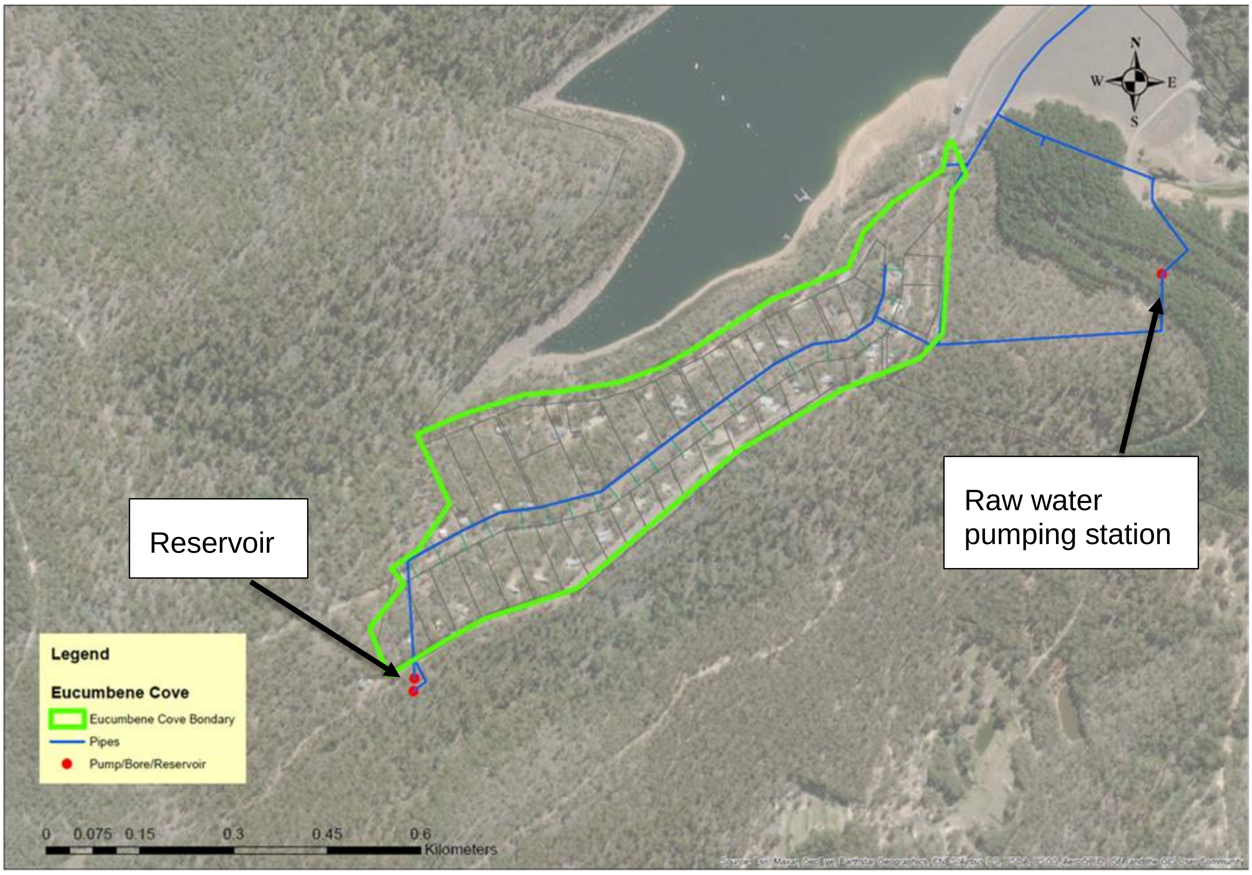


Figure 7-2: Eucumbene Cove Service Area.

7.3 Historical and Forecast Demand

Table 5-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

Table 7-2: Eucumbene Cove Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Eucumbene Cove	Lake Eucumbene (Dam Wall)	104	No data	No data	58.2	60

Note 1. 1% annual population growth was adopted for the 2050 projections.

7.4 Source Water Assessment

The Eucumbene Cove raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

7.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water

Assessment (Hunter H2O, 2020). The assessment determined that the Eucumbene Cove source was conservatively a Category 3 source (Hunter H2O, 2020).

As a Category 3 source to achieve a target of an additional health burden, from potable water, of less 1×10^{-6} DALY's (Disability Adjusted Life Years) the following log reductions are recommended by the guidance manual and will require a multi barrier approach.

- **5.0 log_{10} reduction in Bacteria**
- **4.0 log_{10} reduction in Viruses and**
- **3.5 log_{10} reduction in Protozoa**

7.4.2 Chemical/Physical

From a review of the available raw water data the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Eucumbene Cove.

Turbidity / Suspended Solids

- The raw water turbidity is routinely low but still above the target for disinfection of less than 1NTU.

Colour

- The true colour from the reticulation is typically low with a maximum of 7 HU.
    - This is above the best practice target of 5 HU.

Organics

- There is no data available for any organic material level for Eucumbene Cove.

pH and Alkalinity

- The water has a very low alkalinity
- Data available suggests that the pH is typically 7 to 8.5.

Hardness

- The raw water total hardness results from the reticulation of Eucumbene cove were in the range of 6.9 to 11.8 mg/L as $CaCO_3$.

Algae (To Be Confirmed)

- Not raised as a risk
- Recommend contacting Snowy Hydro and asking them to share water quality monitoring results which may include algae.

7.4.3 Raw Water Quality Design Envelope

Table 7-3 outlines the preliminary raw water design envelope for the Eucumbene Cove WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Eucumbene Cove that are recommended to be filled being;

- The presence or absence of soluble iron

Table 7-3 Preliminary Raw Water Envelope

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	5
pH		6.5	6.9	7.7	8.0[1.]

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
TDS	mg/L	12	17.5	32	32
Alkalinity	mg/L as $CaCO_3$	15[1.]	20[1.]	30[1.]	70[1.]
Turbidity	NTU	0.9	3[1.]	10[1.]	15[1.]
True Colour	Hazen	0.5	2	15[1.]	30[1.]
Calcium	mg/L (Ca)	2.2	2.6	3.5	3.5
Magnesium	mg/L (Mg)	0.67	0.76	0.95	0.95
Total Hardness	mg/L $CaCO_3$	9.1	9.7	11.7	11.7
Total Iron	mg/L	0.04	0.2[1.]	0.3[1.]	0.5[1.]
Soluble Iron	mg/L		0.15[1.]	0.2[1.]	0.3[1.]
Total Mn	mg/L	0.0025	0.005	0.011	0.011
Soluble Mn	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.9	1.0	1.0	1.1

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

7.5 Existing Instructure

The following information is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

7.5.1 Raw Water Pumping

Raw water is sourced from a take-off point inside the Eucumbene Dam outlet tunnel (Snowy Mountains Hydro-Electric Authority, 1997). The water from Lake Eucumbene to the reservoir is transferred via a pump with capacity of 1.2 L/s.

It is recommended that the operation of the outlet tunnel, in particular the level (below the surface/above the base of the dam wall) which water is drawn from, is confirmed.

In comparing the raw water flow requirements of the proposed WTP, the existing pump has sufficient capacity at 1.2 L/sec,150% higher than the required flow at 0.8 L/s.

7.5.2 Reservoir

Key capacity information on the Eucumbene Cove Reservoir from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 15% of the reservoir capacity of 400kL.
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD 20%.
- 60% of the reservoir provides 24 days to repair an issue for the average day demand.
- 60% of the reservoir provides 4 day to repair an issue for the PDD.

Based on the available information capacity upgrades are not recommended for the Eucumbene Cove Reservoir.

Figure 7-3: Eucumbene Cove Reservoir (Left).

7.5.3 Disinfection

A disinfection dosing and monitoring system was installed but has been abandoned.

7.6 Proposed Site Location

Figure 7-4 shows the location of the storage reservoir and also the old storage tank with the only location identified to locate new infrastructure being to remove the old storage tank.

There is no available land area for sludge lagoons, and mechanical dewatering is not practical for such a small plant with low TSS.

Following the high-level consideration of barriers available to manage the identified raw water hazards for Eucumbene Cove, a small containerised direct membrane filtration plant without coagulation would be suitable to meet the water quality targets. This allows the backwash water to be used for local irrigation without any treatment or settlement and prevents the construction of the high foot-print sludge lagoons. Due to the small volume of cleaning chemicals they would be collected and removed by operations in a 'back of the truck' /trailer container to be emptied at a STP.

The membrane shipping container can be installed in place of the old storage tank, as is shown in Figure 7-4.

Figure 7-4: Eucumbene Cove Reservoir and Old Storage Tank.

7.6.1 Health Based Targets

Table 7-4 presents the LRV removal expectation for the direct membrane filtration. The pathogen removal for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

Table 7-4: LRV Expectation for the Direct Membrane Filtration.

	Log Reduction Values			
	Bacteria	Virus	*Cryptosporidium*	Process Critical Limits
Required Treatment (Category 3 Source)	**5.0**	**4.0**	**3.5**	
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***6.0***	***4.0***	
Shortfall or Excess Log Removal	***3.0***	***2.0***	***0.5***	

7.7 Preferred Option - Membrane Filtration

Raw water would be pumped to the WTP from Lake Eucumbene at a constant rate to a balance tank external to the package plant. The water will then be pumped through a strainer, a membrane filter and be dosed with chlorine prior to entering the clear water tank.

Membrane fouling through solids accumulation and adsorption of dissolved contaminants will occur. Regular backwashing, every 30 to 60 minutes, is required to remove accumulated particles, with chemical cleaning undertaken monthly.

A key element for Eucumbene cove is to have mixing in the treated water tank, chlorine monitoring on the outlet of the Treated water tank and a small recycle loop sufficient to allow for a top up dose of chlorine to be added to maintain the minimum free chlorine level in the reservoir.

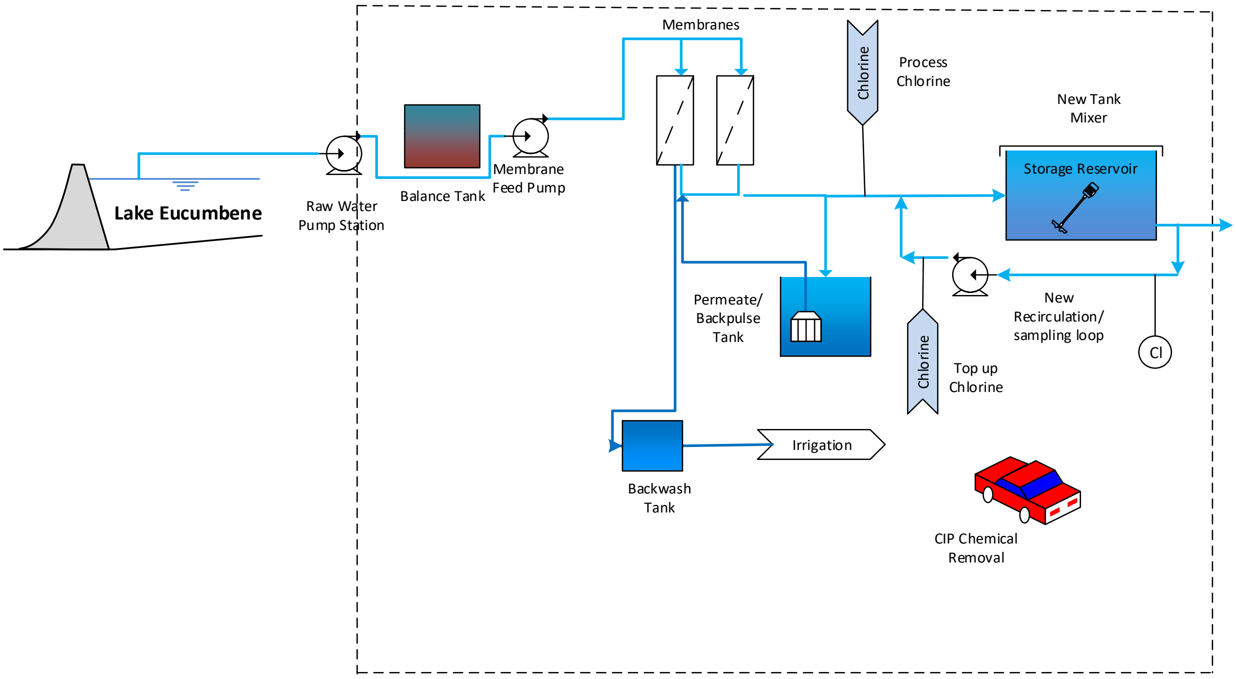


Figure 7-5: Schematic of the Eucumbene Cove Membrane Filtration WTP.

The key elements of the Eucumbene option are:

1. Raw water balance tank
2. Membrane filtration
    i. Membrane feed pumps take the raw water and push it through strainers and the membrane all the way to the treated water storage reservoir.
    ii. In the order of 40 m^2 of filtration surface area provided by about 2 - 4 membrane filtration modules.
    iii. Tankage required for the collection and storage of cleaning solution for transport to a regional WWTW.
    iv. Backwash water is collected in a tank (~1 kL) and used for local irrigation.
3. Chlorine disinfection
4. Reservoir mixing (PAX mixer or similar)
5. Treated water chlorine monitoring and the ability to top up when the WTP is not producing water.

7.7.1 Residuals Handling

The backwash water can be stored in a small tank and directly used for local irrigation.

The membrane cleaning solution can be collected by operations in a ‘back of the truck’ container to be emptied at a STP.

7.7.2 Chlorine Disinfection

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided.

7.7.3 Fire Risk

The site is a high fire risk and protections will need to be considered in the next phase. Recommend a fire attack study be completed to inform the materials and construction methods for the WTP.

7.7.4 Power Availability

Available capacity is to be confirmed during the next phase.

8 Cost Estimates

8.1 Construction Cost Estimates

Two key sources have been utilised to consider the value of works proposed at the Villages. The first is the NSW Reference Rates Manual, the second is the utilisation of tendered rates for specific items and project costs for small water treatment plants with which Hunter H2O has had a role.

A comparison of the estimates is included in Table 8-1 with the Recent project estimates being at least 30% in excess of the NSW reference rates.

It is recommended to move forward with the value of the recent project estimates and revise the estimate during the next phase of the project.

Table 8-1: NSW Reference Rates and Recent Project Cost Estimate Comparison.

	NSW Reference Rate	Recent Projects Estimate	Comment
Adaminaby	$2.93M	$4.09M	Does not include 1000m of new dedicated rising main
Bredbo	$2.45M	$3.68M	Land acquisition required
Nimmitabel	$2.45M	$3.68M	Land acquisition required Does not include 500m of new rising main to the WTP location
Kalkite	$1.98M	$3.27M	Does not include 1000m of new dedicated rising main
Eucumbene Cove	$0.66M	$0.81	Based on 20foot shipping container solution.

8.1.1 NSW Reference Rates

Table 5 of the NSW Reference Rates contains a 2014 value for a 0.3 ML/d and a 0.5 ML/d conventional water treatment plant, which are considered equivalent to the proposals for the Villages.

Key inclusions are;

- Flash mixing, flocculation, sedimentation, filtration and sludge lagoons without supernatant return.

Key exclusions are

- Land acquisition, power supply, data connection, access roads and fencing.

The guidance manual states "for the valuation of future works, a contingency amount should be added to the reference Rates… may also need to be increased to allow for construction difficulty"

Contingencies are required to allow for risk and uncertainty, made up of inherent and contingent risks. Inherent risk is dependent on the type of asset and the stage that the estimate is completed with the value decreasing as the level of design increases. The manual recommends 30% contingency at a feasibility stage and will be applied to the Villages estimate.

Contingent risk are factors that are beyond the control of the designers or constructors and is dependent on each site and prevailing conditions. The manual suggests that the contingent risk should not exceed 20% and given the sites for each site are relatively accessible and flat a contingent risk of 10% is going to be applied to the Villages Estimate.

Using the reference rates (Figure 8-1), including a contingency of 40% (30% Inherent and 10% Contingent) and escalating the values to 2021 gives an estimate for the Villages presented in Table 8-1. The reference rate includes for survey, investigation, design and project management (SID) so this does not have to be added as a separate line item.

Table 5 Water Treatment Works

	Capacity (ML/d)	*Contract Rate ($) 2014*	*Reference Rate ($) 2014*
Conventional Water Treatment	**0.3**	958 000	1 150 000
	0.5	1 420 000	1 700 000
	0.8	1 920 000	2 300 000
	1	2 170 000	2 600 000
	2	3 670 000	4 400 000
	5	7 000 000	8 400 000
	10	11 700 000	14 000 000
	20	19 200 000	23 000 000
	40	30 800 000	37 000 000
	50	35 800 000	43 000 000
	70	46 700 000	56 000 000
	100	59 200 000	71 000 000
Lagoon Sedimentation	**0.8**	1 420 000	1 700 000
	1	1 580 000	1 900 000
	2	2 670 000	3 200 000
	5	4 920 000	5 900 000
	10	8 080 000	9 700 000
	20	13 300 000	16 000 000

NOTES

1. These rates are for June 2014 valuation of the capital cost of existing assets and exclude contingencies and the GST. A suitable percentage for contingencies must be included (section 2.5 on page 8) for valuation of new works. Refer to the box on page 17 for further information on the use of lagoon sedimentation for water treatment.
2. Review of recent contract rates for water treatment works has shown increases of 40% or more above the capital cost inflation rate since 2003.
3. Reference Rate = 1.20 x Contract Rate (ie. Contract Rate plus SID of 20%).
4. The rates include civil, mechanical and electrical costs for both conventional water treatment works and also for lower cost lagoon sedimentation works.
5. For treatment works of ≥ 5 ML/d, the mechanical. electrical and process components of water treatment works are each approximately 13% of the Contract Rate, while the civil component is approximately 60% of the Contract Rate for the water treatment works and includes a clear water tank with 1 hour's storage capacity.
6. Excavation is in OTR.
7. Land acquisition, power supply, data connection, access roads and fencing are not included.
8. Operation and maintenance costs are not included.

Figure 8-1: 2014 Water Treatment Works Reference Rates (Department of Primary Industries, Office of Water, 2014).

8.1.2 Recent Projects / Hunter H2O References

It is the experience of HH2O that the cost estimation of small water treatment plant projects is a difficult exercise, especially at an early stage of development, particularly as there is a general move towards bespoke WTP's for each site. Further, at an early stage it is difficult to apply first principals and assumptions around the acceptability of "package solutions" or moving forward with "council standards", PLC/SCADA and telemetry decisions, and the ‘finish’ of roads and buildings to name a few, can all have a marked impact on the capital cost elevating or decreasing the value substantially.

For example, we have been involved with projects over the last few years where quotes have been received for 0.1 to 0.5 MLD containerised filtration package plants with key elements being;

- Built, tested and commissioned off site,
- limited scope that assumes washwater can be discharged to the environment or sewer
- Site prepared for others for laydown of a container
- No treated water tank and nominated termination points
- acceptance of standard electrical supply (to Australian standards but no separate MCC)
- acceptance of the supplier’s standard mechanical equipment

With a stand-alone Contract price of $0.4M - $1M.

In contrast we have been involved with three recent projects where a 0.3 to 0.7 ML/d WTP that has been tendered. The plants had;

- reference designs developed with the Local Water Utility with operability and longevity in mind,
- went to the market with a detailed specification,
- blockwork plant building,
- sealed roads,
- small concrete reservoir (only one of the three),
- well-constructed lagoons with supernatant return (one of the three),
- council approved PLC/SCADA and

With a Contract value of between $3M and $4M dollars.

The take home is that there is a massive variation in the value of “small WTP’s” that can, on paper, meet the water quality and quantity treatment performance objectives.

Hence at a scoping level, when there remains a reasonable level of uncertainty around the exact nature of the deliverable, the approach is to assume that the plants will be customised, and the estimated value will reflect a focus on best practice, robustness, operability, maintainability and longevity of a council asset that will increase the value.

The Adaminaby estimate is included as an Appendix A, noting key allowances of;

- Construction support – 1% of the Construction base estimate
- Construction management/supervision – 5% of the Construction base estimate
- Contractor Profit – 10% of the Construction base estimate
- PM and Commissioning – 2% of the Construction base estimate
- Contingency - 35% of the Total Base Estimate

9 Conclusions and Recommendations

The objective of the Water Safety Scoping Study was to identify one, or more, preferred options to improve water safety at Adaminaby, Bredbo, Eucumbene Cove, Kalkite and Nimmitabel. A number of reports have been developed as part of the scoping study and provide background detail to support the outcomes of the Scoping Study.

The reports, and a summary of their content, are;

- *Service Area and Demand for Villages Scoping Study Memo, Revision A. from Hunter H2O to Jessica Dunstan (SMRC), 07/09/2020*
  - Provides a summary of available production and consumption data for the villages and compares this to guidance from the water Services Association of Australia as a benchmark.
  - Outlines the existing service area of the villages
  - Provides an estimate for the 2050 demand and hence capacity for treatment infrastructure.
- *Snowy Monaro Villages Water Safety Scoping Study, Source Water Assessment, September 2020, Revision B*
  - A desktop, high level assessment of pathogen risk was completed in line with the Water Services Association of Australia guidance manual (Water Services Association of Australia, September 2015) to nominate a microbiological risk for each source.
  - Chemical and physical hazards were assessed through statistics as well as creating and considering time series charts and summarised for each location and each source.
  - Typical water quality as well as key challenges for each source were nominated
  - A sampling program was provided (included in this report as Appendix B) to better inform the raw water design envelope moving forward.
- *Water Treatment Options Overview, Memo, from Hunter H2O to Jessica Dunstan (SMRC), 23/09/2020*
  - Presents a long list of treatment options for the identified raw water hazards and their strengths and weaknesses
- *Snowy Monaro Villages Water Safety Scoping Study, Options Assessment Report, September 2020, Revision B*
  - Used previous outputs to consider two or three options to improve water safety at each of the villages, compared the associated strengths and weaknesses and selected a preferred option
  - Considered existing assets and available land area to determine a preferred location for siting new treatment infrastructure.

The Water Safety Scoping has combined key outputs from the previous reports and investigations into a single document that clearly conveys the objectives, design basis and process that was undertaken to determine the preferred options to improve water safety.

Each Village is presented within a dedicated section of the report, in summary;

Bredbo

To address raw water health and aesthetic hazards it is recommended to construct a new 400kL/day direct filtration plant with coagulation, taking water from the existing aeration tower and incorporating UV disinfection as a mutli-barrier approach to chlorine resistant protozoa. The infrastructure would be located on land purchased adjacent to the existing Reservoir site and raw water pumping upgrades will be required.

Kalkite

To address raw water health and aesthetic hazards it is recommended to construct a new 300kL/day membrane filtration plant on land already owned by council between the raw water pumping station and the community. Due to the location and size of the WTP, raw water pumping upgrades will be required. A new dedicated rising main would be constructed to allow for treated water to be sent direct to the existing Reservoirs to improve the consistency of supply to the community and negate the need to construct a dedicated Chlorine contact tank at the new WTP.

Adaminaby

To address raw water health and aesthetic hazards it is recommended to construct a new 500kL/day membrane filtration plant on land already owned by council at the Adaminaby reservoir site. Chlorination and fluoridation equipment at Observation point would be re-located to Adaminaby or abandoned to reduce the requirement to attend the remote pumping station daily. A small number of rural customers would be impacted and receive 'raw water' after the change.

Nimmitabel

To address raw water health and aesthetic hazards it is recommended to construct a new 400kL/day membrane filtration plant on land to be purchased adjacent to the Lucan St Bore. The plant would utilise coagulation to address true colour and organics and treat a blend of River and bore water from 80:20 to 50:50 to take advantage of available groundwater yield. Given the raw water catchment UV disinfectino would be incorporated as a mutli-barrier approach to chlorine resistant protozoa.

The water will maintain a moderate alkalinity and hardness and there remains the ability to run 100% groundwater during emergency scenarios.

Eucumbene Cove

It is recommended that a containerised membrane filtration plant is provided to treat water before it enters the existing reservoir. To address water age and chlorine decay issues, tank mixing is recommended with chlorine monitoring of the bulk tank volume with the ability to dose sodium hypochlorite directly to the tank as a 'top up' dose.

Recommendations that span across all of the Villages are;

- Incorporate the provided sampling program for routine and event monitoring, to better inform the raw water design envelope and reduce risk for SMRC and Contractors.
- Undertake a fire attack study of the proposed sites to inform the construction materials required of the new assets
- Confirm the availability of power at each of the sites to inform the construction of the new assets
- Jar Testing
  - At Bredbo - to determine the effectiveness of coagulation and typical dose rates for conventional filtration
  - At Nimmitabel - to determine the effectiveness of coagulation and typical dose rates for membrane filtration at carious blend ratios
  - At Eucumbene Cove - to assess the impact of maintaining a chlorine residual on the water quality, in particular the pH give the low alkalinity of the water.
  - At Kalkite and Adaminaby jar testing is not essential but could be undertaken to consider the advantage, if any, of coagulation against direct membrane filtration without coagulation. Essentially considering the true colour and chlorine decay of the coagulated and direct filtered water.

Finally an order of cost estimation was undertaken using the NSW reference Rates Manual (Department of Primary Industries, Office of Water, 2014) and a comparison based on recent projects with Hunter H2O visibility. The outputs are provided in the table below with a total project cost for the Villages water safety improvement project being $10.5M (NSW reference rate) to $15.5M.

Table 9-1: NSW Reference rates and Recent Project Cost Estimate Comparison.

	NSW Reference Rate	Recent Projects Estimate	Comment
Adaminaby	$2.93M	$4.09M	Does not include 1000m of new dedicated rising main
Bredbo	$2.45M	$3.68M	Land acquisition required
Nimmitabel	$2.45M	$3.68M	Land acquisition required

			Does not include 500m of new rising main to the WTP location
Kalkite	$1.98M	$3.27M	Does not include 1000m of new dedicated rising main
Eucumbene Cove	$0.66M	$0.81	Based on 20foot shipping container solution.

Appendix A Adaminaby Order of Cost Estimate Summary

Villages WTP Scoping Order of Cost Estimate					
Management Plans					
1	Management Plans		$ 40,000		
Milestone 2 – Design					
2	Design		$ 200,000		
Milestone 3 – Construction					
3	Site Establishment		$ 100,000		
4	Earthworks, Roads, Access and Landscaping		$ 250,000		
5	Raw Water Pumping Station (VSDs)		$ 50,000		
6	Sludge Lagoon Supernatant Pumping Station		$ 75,000		
7	Coagulation and Flocculation Tank		$ 30,000		
8	Coagulant Dosing System		$ 35,000		
9	Hypo Dosing System		$ 35,000		
10	Filtration Process Package		$ 200,000		
11	UV Disinfection		$ 85,000		
12	Sludge Lagoons		$ 200,000		
13	Process Water System		$ 30,000		
14	Instrumentation		$ 120,000		
15	Pipework and Associate equipment		$ 100,000		
16	Process, Control and Amenities Building		$ 300,000		
17	Electrical, PLC and SCADA		$ 500,000		
18	Motor Control Centre (inside building)		$ 100,000		
19	Testing and Commissioning		$ 48,000		
20	O&M Manuals		$ 20,000		
21	Work as Executed Drawings		$ 20,000		
22	Proving Period		$ 24,000		
	TOTAL			**$ 2,562,000**	**A**
	Indirect Costs				
	Construction Management				
	Contruction support including WAE, inspections etc	1% of A	$ 25,620		
	Construction Management/Supervision	5% of A	$ 128,100		
		Sub Total		***$ 153,720***	**B**
	Contractor Profit				
	Contractor Profit	*10% of A*	$ 256,200		
				$ 256,200	**C**
	Project Management & Commissioning				
	Project Management and Commissioning	*2% of A*	$ 51,240		
				$ 51,240	**D**
	Total Indirect Costs (B+C+D)			$ 461,160	
			Rounded up	**$ 470,000**	**E**
	Total Construction Base Estimate (A + E)			**$ 3,032,000**	**F**
	Contingency				
	For a 90% confidence of not being exceeded		35%	$ 1,061,200	**G**
	Total Construction Base Estimate with Contingency (F + G)			**$ 4,093,200**	

Appendix B Proposed Sampling Program

Parameter	Units	Bredbo	Nimmitabel Lucan St Bore	Nimmitabel Lake William Bore	Nimmitabel Maclaughlin River	Kalkite	Adaminaby	Eucumbene Cove	Period
E. coli	MPN/100mL	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	2 years
TDS	mg/L			Weekly					4 weeks
Alkalinity	mg/L as $CaCO_3$			Weekly		Weekly	Weekly	Weekly	12 weeks
True Colour	HU	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	12 weeks
TOC	mg/L	Weekly	*One off Test*	*One off Test*	Weekly	Weekly	Weekly	Weekly	12 weeks
DOC	mg/L	Weekly	*One off Test*	*One off Test*	Weekly	Weekly	Weekly	Weekly	12 weeks
UVT Note 1	%	Weekly	*One off Test*	*One off Test*	Weekly	Weekly	Weekly	Weekly	12 weeks
THMs Note 2	*µg/L*	*Monthly*	*Monthly*			*Monthly*	*Monthly*		*3 months*
Calcium	mg/L (as Ca)			Weekly					4 weeks
Magnesium	mg/L (as Mg)		Weekly	Weekly					4 weeks
Total Iron	mg/L	Weekly	Weekly	Weekly	Weekly				12 weeks
Soluble Iron	mg/L	Weekly	Weekly	Weekly	Weekly				12 weeks
Herbicides and Pesticides	Various	*One off Test*	*One off Test*	*One off Test*	*One off Test*				*Single Sample*
Radiological	Various	*One off Test*	*One off Test*	*One off Test*	*One off Test*	*One off Test*	*One off Test*	*One off Test*	*Single Sample*

Note 1 – Request that this is a filtered sample UVT to estimate the UVT following the installation of filtration.

Note 2 – This is a 'treated water' sample, select a point in the Reticulation where the water is 'old', but is being turned over so has a free chlorine residual. Ie not a dead end.