Warrumbungle Shire Council

WTP Automation and Process Instrumentation Audit

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1 Introduction

1.1 General

The Warrumbungle Shire is located in central NSW, and primarily operates from its' two offices; one in Coonabarabran and one in Coolah. The Shire is strategically positioned on the Newell Highway, mid-way between Brisbane and Melbourne. Several highways and main roads traverse the shire providing links with surrounding regional centres. The location of the shire can be seen in Figure 1-1 below.

Figure 1-1 Location of Warrumbungle Shire

The shire covers an area of approximately 12,380 km^2 and has a population of approximately 9,500 people. The Shire includes the towns of Baradine, Binnaway, Coolah, Coonabarabran, Dunedoo and Mendooran as well as the villages of Bugaldie, Cobbora, Kenebri, Leadville, Merrygoen, Neilrex, Purlewaugh, Uarbry, Ulamambri, Weetaliba and Yearinan.

These locations are spread around the main township of Coonabarabran, with large geographical distances providing one of the main challenges to the Council in their operation and monitoring of the water treatment plants (WTPs). In line with the Australian Drinking Water Guidelines, and due to several water quality near misses and boil water alerts, to improve water safety Warrumbungle Shire Council (WSC) are investigating the opportunity to implement online water quality monitoring at the WTPs. Online monitoring of operational and critical control points will provide timely feedback on WTP performance so that action can be taken to keep the process under control. Further, and as a worst case, online monitoring and associated automation can be utilised to alarm and shutdown the WTP to prevent unsafe water from being supplied into the network.

Chapter 3, ADWG Version 3.5, page 38 states:

"Operational parameters should be monitored with sufficient frequency to reveal any failures in good time. Online and continuous monitoring should be used wherever possible, particularly at critical control points…"

Warrumbungle Shire Council operates and maintains numerous water treatment plant assets. These assets are configured in two main styles of plants, conventional WTP (complex); with multiple process units, chemical dosing and monitoring systems, or bore plants (simple); with chlorine dosing and a minimum level of monitoring. The style of each system is presented in Table 1-1.

Table 1-1 WSC Water Treatment System Styles

Conventional WTPs	Bore WTPs
Baradine, Binnaway, Coonabarabran and Mendooran.	Bugaldie, Coolah, Dunedoo and Kenebri.

1.2 Audit

Hunter H2O visited all the above sites between 17-19th December 2019 with Council operations staff, reviewing automation, monitoring and instrumentation at each WTP. Comparing the existing instrumentation with WSC's Drinking Water Management System (DWMS), Hunter H2O determined the instrumentation and automation recommended to monitor and control each plant, in order to ensure effective operation and prevent poor quality water from entering the distribution network.

The recommended control and automation outlined in this document will provide adherence with Council's critical control points (CCPs), as well as automation interlocks from water quality exceedances within the plant control systems. Hunter H2O also reviewed the potential to automate key plant operations to ensure effective operation of the plants and reduce the strain on operational staff.

1.2.1 Automation and Telemetry Overview

Council's automation and telemetry system varies in manufacturer, age and technology. WSC was formed from the merger of the Coonabarabran and Coolah Shires. These shires originally operated independently sourced SCADA and radio networks to manage their respective water networks.

Coonabarabran operated a RAD-TEL SCADA system with a telemetry network based on RAD-TEL RTUs and an analogue radio network.

Coolah Shire operated a REDLION SCADA HMI system with a telemetry network based on ELPRO RTUs and their fully integrated radios.

WSC propose to fully replace the two separate SCADA systems and telemetry networks, and establish a full integrated SCADA and telemetry network to be utilised in the monitoring and control of Council's water networks.

1.3 Site Locations and Hardware

The coordinates for each site and the telemetry hardware currently in use are displayed in Table 1-2.

Table 1-2 Site Locations and Hardware

Site	Hardware	Coordinates
Baradine WTP	Radtel 5000	30°57'11.94"S 149° 4'5.04"E
Binnaway Raw Water Pumping Station	Radtel 5000	31°33'0.00"S 149°22'0.00"E
Binnaway WTP & Reservoir	Radtel 5000	31°33'2.46"S 149°23'27.90"E
Bugaldie WTP and Reservoir	Radtel 3000	31° 7'23.91"S 149° 6'37.93"E
Coolah WTP	ELPRO 105U-1	31°48'41.88"S 149°44'34.56"E
Coonabarabran WTP	Radtel 5000	31°16'25.98"S 149°15'43.02"E
Dunedoo WTP	ELPRO 105U-1 ELPRO 115S-12	32° 0'42.84"S 149°23'17.40"E
Kenebri WTP & Reservoir	Radtel 3000	30°46'50.82"S 149° 1'23.88"E
Mendooran WTP	ELPRO 105U-G-MD1	31°49'14.94"S 149° 7'46.74"E

1.4 Project objectives

The overarching project objective is to ensure a reliable and safe water supply for the residents of Baradine, Binnaway, Bugaldie, Coolah, Coonabarabran, Dunedoo, Kenebri and Mendooran.

The objective of the *Warrumbungle Shire Council WTP Automation and Process Instrumentation Audit scoping study* was to identify options to improve process control and, in doing so, water safety.

The key output of the scoping study/audit is the selection and documentation of the preferred option/s and a high-level preliminary cost estimate for each site.

The target outcomes of the project are:

- Address deficiencies in automation and monitoring to enable each water supply system to align wit the requirements of the Australian Drinking Water Guidelines (ADWG)
- Upgrade the monitoring and control systems to enable the WTPs to operate automatically, in an efficient, safe and robust manner with reduced manual intervention, to improve water safety and reduce reliance on Operator attendance. This includes:
    - The capability to remotely operate and shutdown the WTPs as required
    - Improved plant flow control to allow longer plant runtimes for improved water quality
    - Remote alarming notification to operators to reduce downtime
    - Provide WTP shutdown capability in the event of CCP exceedances.

1.5 Project drivers

The project is driven by a desire to improve operability and reduce the likelihood of a water quality incident occurring at the Baradine, Binnaway, Coonabarabran, Mendooran, Coolah, Dunedoo, Bugaldie and Kenebri WTPs. The WTPs being largely manually operated with little to no automation, monitoring, alarming, interlocks or control of the existing plants and hence reliant on individuals and documentation (with the exception of Mendooran which is the most complex of the WTPs). This being akin to “Administrative Controls” in the hierarchy of hazard control, which is less effective than “Engineering” due to the opportunity for human error.

Figure 2. Hierarchy of Controls[1]

[1] https://tapintosafety.com.au/workplace-hazards-and-the-hierarchy-of-controls/

Manual operation of a WTP, with no online monitoring, relies on a reactive approach to maintain water safety. Under a reactive model the water utility must wait for complaints, or infrequent verification testing results, to indicate a problem has occurred before it can be addressed. This is not in line with the preventative philosophy of the framework for managing drinking water safety of the ADWG, in place since 2004.

Under a reactive model consumers can be exposed to water that is unsafe for a period of hours to days, under a preventive model, utilising continuous online monitoring of critical control points, the water utility can be confident that water reaching the customers tap is safe. The need for a preventative model is more apparent in the Warrumbungle context due to the number of water supply systems spread over a large geographical area being operated by a limited number of operations staff.

A secondary driver is to reduce time taken to perform manual tasks through improved plant monitoring and automation. Monitoring, to alert the Operator when the process begins to get out of control, so that it takes less time to rectify the issue. Automation to complete tasks in the same manner, regardless of the Operator and also to stop the process before unsafe water enters the network and takes longer to manage.

Currently manual operation of a WTP with no online water quality monitoring results in many risks related to water quality, operation and performance of the WTP being managed by an Operator. Operational procedures are an administrative control and located at the bottom of the hierarchy of control pyramid. In addition, there are many instances documented where human error due to various circumstances has resulted in water borne disease outbreaks.

Council see value in moving away from having a heavy reliance on individuals to reduce the likelihood, and hence risk, of supplying unsafe water. In particular, Council recognise the risk faced, in western NSW, with getting, and keeping, trained operators. Council has struggles in recent years to secure resources to fill a number of vacancies. Whilst an experienced and well trained operator is an asset and can effectively pre-empt issues and manage multiple risks, there is a real and foreseeable risk in any of the water supply systems in the Warrumbungle shire of needing to operate through a period of time from days to months, with untrained, or new staff. This is just one unique challenge faced by many local water utilities with small teams in remote locations and adds weight to the case to improve automation and monitoring in regional locations.

1.6 Project limitations

The high-level nature of this scoping study/audit means that a detailed analysis of the cost and benefit of all the possible instrumentation and control has not been undertaken. However, the findings of this study are sufficient to identify the key issues, need for change and the expected cost (including contingency for additional items) for the key components to vastly improve the automation, control, instrumentation and monitoring at each WTP.

The review has focused on opportunities to improve the potable water safety and reliability of quality and supply through improved CCP monitoring and compliance (which has been addressed in this report). However, it is noted that following a detailed Hazard and Operability Analysis (HAZOP) study of each plant requiring a new PLC, there may be some minor additions to the recommended scope of works.

Another key limitation of this scoping study/audit is that the assessment was focussed on automation of the existing plant and therefore major process unit upgrades were not considered. However, it is noted that the current practices used for the sedimentation lagoons (which are inherent in the original design) present a high risk of contamination at Coonabarabran, Binnaway and Mendooran WTPs. There are numerous identified issues associated with the sedimentation lagoons which have been defined in previous reports, however the focus of this study is automation and control. Therefore, the key issues identified in this regard are:

1. Stop/start operation of the settled water pumping station which impacts on filtration rates (discussed further in Section 2.1.1)
2. Filter washwater return at high rate to the sedimentation lagoon inlets (down stream of the coagulant dose point):
    i. High rate return streams for short durations result in difficulty controlling flow paced dosing systems and increase the risk that under or overdosing may occur. Return streams should be flow balanced and returned at no greater than 10% of the raw water flowrate and returned at less than ~10 NTU.
    ii. It is noted that the washwater is returned after the coagulant dosing point. This presents a high risk to water safety and is non-compliant with best practice. Any return water should be

returned before the point of coagulation and control enabling the coagulant dose to be adjusted to account with this additional load/flow.

iii. The high rate of return flow currently disturbs the settled sludge within the sedimentation lagoons which should be avoided.

If and when the sedimentation lagoons are replaced at each of these plants, the upgraded control system will need to ensure there is sufficient space for input/output (I/O) required for any new clarification process installed.

The key areas of focus for the scoping study/audit were:

- Continuous online water quality monitoring
- Flow control
- Automation of filter backwashing
- Automation of clarifier scours (Baradine only)
- Flow paced chemical dosing (dosing pumps and chlorinators)
- Feedback trim control chemical dosing (dosing pumps and chlorinators)
- Dosing system flow switches to improve reliability
- Storage level monitoring.

2 Audit Findings Proposed Works

When assessing the current treatment plants, Hunter H2O have taken into consideration the integration of the new instrumentation into the existing site control system and telemetry. This includes the installation or replacement of the existing plant programable logic controller (PLC), SCADA and telemetry systems if required.

Depending on the available I/O at the time of the audit, the new instrumentation may be wired into the existing control system or implemented into a proposed future control system upgrade.

2.1 Methodology

For each WTP the recommended process and instrumentation upgrades were separated into CCP online monitoring (instrumentation recommended to provide timely information on the effectiveness of a CCP to indicate the process is going out of control and that the process has failed) and process instrumentation recommended to improve operation of the treatment plant, improving efficiency and reliability.

The recommended key instrumentation and I/O listed in the tables for each plant would be in addition to a total control system design, if required, to control and monitor the WTP. The recommendations were not developed through undertaking a complete detailed MCC upgrade, but rather highlighting the key elements and likely upgrade scope and costs for each plant.

Operational control points, or inter-process water quality monitoring, allows for an operator to be alerted to a possible issue and undertake rectification works before the process gets out of control and impacts upon a CCP. This reduces operator effort through early action and reduces the overall risk of the process getting out of control and as such improves the plants ability to maintain compliance with CCPs.

Taking one step further, the monitoring and control of equipment is a valuable tool to improve reliability of water treatment processes. An example would be confirmation of the addition of coagulant into the process. If the SCADA/PLC has called the coagulant dosing pump to start and confirms the pump is running but a hand valve is closed preventing coagulant flow to the dose point, then coagulation is impaired. This may be picked up by clarified water turbidity or pH prior to filtration, and would be identified through individual filter turbidity monitoring after some time, at which point the clarifier and filters are full of water that must be disposed of. However, the addition of a coagulant flow switch could be used to confirm coagulant flow and mitigate the risk of filling up the WTP with uncoagulated water that must be scoured away, taking time and resulting in an environmental discharge.

This is one example of using a proactive approach to risk mitigation rather than a reactive approach (i.e. wait till the water quality is compromised before rectifying), of many small instrumentation additions that should be considered at a WTP to ensure efficient operation and provide suitable reliability and robustness that the WTP can deliver safe drinking water when called to.

The level or degree of automation recommended at each WTP was determined first with a view of achieving best practice levels of control and automation and second, applying a lens of value for money and appropriateness in a regional context, whilst ensuring water safety is not compromised.

Upgrade scope items were developed and are specific to each WTP however there was also some commonality applied across sites especially for the conventional WTPs which all required a new PLC (with the exception of Mendooran WTP) while all the bore WTPs could be serviced by RTUs.

2.1.1 Value for money vs best practice

The level or degree of automation recommended at each WTP was determined with a view of achieving best practice levels of control and automation however also applying a lens of value for money and appropriateness in a regional context. An example of this was not implementing control features like raw water flow control at sites where the cost benefit ratio would be low (e.g. Binnaway) or that the current fixed speed flow is considered appropriate (e.g. Baradine and the other bore plants).

Flow balancing and filtration rate control

In the case of the conventional WTPs with sedimentation lagoons however, settled water pumping flow control was considered a ‘must have’, as the current arrangement and design does not promote good filtration practices. It was found that all of the sedimentation lagoon plants (Coonabarabran, Binnaway and Mendooran) used stop/start control of the settled water pumps based on either fixed level switches or a level setpoint from a level indicating transmitter. This stop/start control will affect filter flow control functionality and ultimately result in changes in filtration rates.

Changes in filtration rates should be avoided, minimised and/or undertaken gradually when they have to occur as particle shedding is a risk. Particle shedding occurs when sudden flow changes occur across the filter bed. This is not always detected through online turbidity monitoring however can be using online particle counters and therefore controls should be in place to ensure the risk is minimised regardless of whether online monitoring exists or not. This is especially important for surface water plants with a higher risk catchment, in terms of Cryptosporidium, such as Coonabarabran, Binnaway and Mendooran.

Flow paced dosing

Flow pacing of chemicals is a low cost solution to mitigate any potential flow changes caused by changes in river level or incorrect operation of a valve. Without flowpaced chemical dosing a sudden flow change would not be detected and could cause the plant to shutdown due to production of unsafe water (loss of effective coagulation and flocculation). The existing chemical dosing pumps already have the functionality to enable flow paced dosing when linked to the flowmeters, therefore the additional cost for this mitigation measure is low.

Filter backwash automation

Currently a filter backwash requires the operator to manually initiate, manually open and close valves and walk up and down the walkways and stairs. In addition, the manual operation of the air scour release valve required the use of PPE to protect the operators hearing. Typically, manually operated WTPs would have a filter control panel where all of these steps can be performed from the one position of safety while observing a backwash. However, Hay WTP does not have a filter control panel and thus the current practices present many WHS risks which are deemed unacceptable today. To reduce the risk of something going wrong or to prevent operator injury automation of the backwash sequence is recommended.

Automation of filter backwash sequences should also be provided to ensure filters are backwashed at the correct time and in the correct way, to improve backwash efficiency, thus conserving treated water used for the backwash, and decreasing the volume of washwater that needs to be handled in the sludge lagoons. With Hay WTP's reliance on a surface water from an unprotected catchment, filtration is the primary and most critical barrier to particles, including pathogens, that if not removed would result in poor disinfection, dirty water complaints and an increased disease burden on the community. Backwashing a filter incorrectly can easily disrupt the filter media layers or result in failure of the underdrain system (high consequence). Backwash sequences would be automatically triggered by setpoints for either filter headloss or filtered water turbidity, and would not require manual control from the operator. This would also reduce the operational time currently occupied by carrying out manual filter backwash tasks. Additionally, actuation of valves would allow the filters to be backwashed individually, meaning the plant could continue producing treated water through a single filter whilst the other filter is backwashed (assuming there is adequate raw water flow control and turndown available).

2.1.2 Cost estimation

Preliminary capital cost estimates for the proposed upgrades have been developed using a combination of the following:

- Market pricing (@ current exchange rate for overseas equipment)
- Benchmarking and scaling of recent projects and tender prices
- First principals estimating where no previous project data existed
- Preliminary scope of works.

Information from the following sources was also used to derive the cost estimates:

- Rawlinsons (2020)
- Budget estimates from suppliers.

The remaining items of works that have not been directly priced from the market have been estimated from a mix of first principles or using benchmarking and rates observed by Hunter H2O in other similar projects. The preliminary capital cost estimates are estimated to an accuracy of -50% to +50%. The engineering cost estimate consists of the direct and indirect costs, as detailed in each cost estimate section for each WTP. A contingency allowance (30%) was then added to the traditional engineering estimate.

2.2 Baradine WTP

2.2.1 Existing WTP and instrumentation

Baradine WTP upgraded in 2001, sources water from two artesian bores. The main bore in use is located within the site boundary of the WTP, at the corner of Walker and Narren Streets. A second bore is located adjacent to the park at Wellington Street and is used primarily to irrigate the sports field but is also used as a backup for town water supply.

The treatment process consists of aeration and pH correction using soda ash, followed by coagulation using aluminium chlorohydrate (ACH) then clarification and dual media filtration (coal/sand filter). The filtered water is then disinfected using chlorine gas, prior to storage in the underground CWT. The plant also has a fluoride dosing system that is not currently in use (planned for replacement). The treated water is then pumped to a concrete storage reservoir (1.1 ML) prior to being released to the main Baradine community, however there are several direct connections to the treated water line between the CWT and the storage reservoir.

Low level in the reservoir triggers initiation of the primary bore pump, rapid mixer, aerator blower and the chemical dosing systems (soda ash, ACH and polymer). Chlorine dosing is called by the filtered water flow switch. High level in the CWT calls the treated water pumps to start pumping water to the reservoir and reticulation system. A high level in the reservoir then triggers a shutdown of the entire process (bore and treated water pumps and dosing etc). However, if the bore pump stops or fails, there are no interlocks with the rest of the plant, and dosing would continue, resulting in potential overdosing. In addition, if the coagulant or pH correction dosing pumps failed (or were turned off) there are no interlocks with the rest of the plant and thus water quality would be compromised without any alarms being raised.

A raw water flow meter, filtered water flow switch, treated water flowmeter, treated water flow switch, and storage level switches make up the only current instrumentation available at Baradine WTP. Currently there are no online water quality analysers available to confirm compliance against CCPs. Therefore, it is impossible to monitor or verify the quality of treated water, or to shut down the treatment process if quality exceedances are detected when the WTP is not attended. The WTP is essentially running ‘blind’ when operations staff are not in attendance.

The existing WTP has the following process control functionality, summarised in Table 2-1.

Table 2-1 Existing process control functionality at Baradine WTP

Process Parameter	Monitoring Point
Flow monitoring	Raw water (orifice plate)
	Treated water – pre CWT (mag flow)
	Treated water – post CWT (orifice plate)
	Air scour (orifice plate)
	Backwash water (orifice plate)
Level switches	Clear water tank high/low level
	Reservoir high/low level
Flow switches	Filtered water
	Treated water

2.2.2 CCP summary

The critical control points (CCPs) for the Baradine water treatment network are summarised in Table 2-2 (Warrumbungle DWMS Annual Report Aug-18 to Jul-19).

Each critical control point has a target level, alert limit and critical limit. The target levels are where the system should be operating, alert limits are the first indication that the system may have a problem to allow corrective action to be taken, while critical limits represent a loss of control of the system, and thus require a shutdown.

Table 2-2 Summary of CCPs for Baradine WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
BDN1	Filtration	All pathogens	Turbidity	<0.2 NTU	>0.4 NTU	>0.8 NTU
BDN2	Disinfection (gas)	Chlorine sensitive pathogens	Chlorine	1.4 – 1.9 mg/L	<1.2 mg/L, >2.5 mg/L	<1.0 mg/L, >4.0 mg/L
BDN3	Fluoridation	Fluoride	Fluoride	1 mg/L (leaving WTP, leaving reservoir and throughout distribution system)	<0.9 mg/L for >24 hrs, >1.1 mg/L	>1.5 mg/L, <0.9 mg/L for >72 hrs, 0.0 mg/L for >24 hrs
BDN4	Reservoirs	All pathogens and all chemicals	Reservoir integrity	No breach of integrity (hatches locked, no holes in meshing)	-	Breach of integrity identified
BDN5	Distribution	Chlorine sensitive pathogens and all chemicals	Chlorine	>0.8 mg/L, <2.0 mg/L	< 0.5 mg/L, >2.5 mg/L	< 0.2 mg/L, >4.0 mg/L
BDN6	Distribution (OCP)	All Pathogens	Turbidity	<1.0 NTU	>1.0 NTU	>4.0 NTU

2.2.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Baradine WTP is outlined in the following tables. Table 2-3 outlines the process instrumentation recommended to address the CCP control parameters for the Baradine WTP, whilst Table 2-4 outlines additional instrumentation recommended to assist with the effective operation of the treatment plant.

New chlorine gas dosing equipment is recommended for the implementation of automated chlorine dosing for pre-filter chlorine dosing, to improve manganese removal, and for the main disinfection dosing point to enable feedback trim control functionality (automatically adjusting chlorine dose based on the free chlorine residual remaining which ensures target free chlorine residuals are more easily achieved). These additions shall improve manganese removal and disinfection reliability whilst also provide redundancy to improve reliability of chlorine dosing and ensure CCPs for disinfection are met. This would significantly improve the existing manual chlorine dosing equipment at Baradine WTP, and would be installed within the existing chlorine dosing room.

New magflow meters are recommended to replace existing orifice plate flow meters (currently unreliable), which will enable effective control of the plant and enable flow paced dosing to occur. New dosing pumps, dosing flow switches and level indicating transmitters on chemical storage tanks are recommended for both the ACH and soda ash dosing systems to enable more accurate flow pacing and pH trim control dosing functionality. This will enable effective automation and control of coagulant dosing and pH correction at the plant which are essential for effective coagulation and flocculation to occur, which is in turn essential for effective downstream clarification and filtration processes. This will also enable implementation of critical plant interlocks to improve water safety and plant reliability.

With the addition of a new plant PLC, control can be implemented with various interlocks and/or alarming to ensure the process is operating effectively. For example the aeration process can be monitored via a run status and alarm on the aerator fan drive while online pH analysers can be used on the raw and aerated water to confirm the removal of CO_2 and other dissolved sulphides therefore confirm the effectiveness of the aeration. If lower performance is detected, then this may be a result of a fan drive failure or blockage of the sprays which can then be identified and rectified early.

No allowance for raw water flow control was made as the plant flowrate does not change often currently and the bore is located onsite which makes flow changes quick and easy to implement. Inclusion of the raw water flow meters will further improve the ability to change the flows at the plant manually and achieve the desired flowrates.

Table 2-3 Process instrumentation to facilitate effective implementation of CCPs for Baradine WTP

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Turbidity	Raw Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks for high turbidity water entering the WTP or rapid changes in raw water turbidity indicating potential surface water ingress into the bore head (surface water ingress was identified as a risk in the 2014 DWMS water quality risk assessment).
	Settled Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming for high turbidity leaving the clarifier before it reaches the filters. This helps to lengthen filter runtimes and reduce potential filter breakthrough. It will also help to identify when coagulation and flocculation fails, which impacts clarifier performance.
	Filtered Water Turbidity	Online turbidity analyser (1AI + DI)	Ensure that the filtered water is within CCP turbidity limits. This ensures the CWT is not filled with water exceeding the CCP turbidity limits. Provide control functionality to initiate a filter backwash on detection of high filtered water turbidity.
	Treated Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks to ensure water exceeding CCP limits is not sent to the community. This is the final check that the water is compliant.
Chlorine	Filtered Water Free Chlorine	Online free chlorine analyser (1AI + DI)	Monitoring free chlorine from pre-filter chlorine dosing system to ensure free chlorine residual is sufficient for the oxide coated media process (manganese removal). Provide control functionality to enable free chlorine trim control dosing for pre-filter dosing.
	Treated Water Free Chlorine Pre-CWT	Online free chlorine analyser (1AI + DI)	Ensure the free chlorine required for disinfection is sufficient for water going into the CWT. This ensures the CWT is not filled with water that does not have sufficient chlorine residual and also confirms that chorine dosing is occurring. Provide control functionality to enable free chlorine trim control dosing. As the plant treats bore water the chlorine demand is expected to be low and thus no Post-CWT analyser is required.
	Pre-filter Automated Chlorine Dosing	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by providing a new automated chlorinator and linking to set points for filtered water chlorine residual to maintain a constant free chlorine residual and improve manganese removal.
	Treated Water Automated Chlorine Dosing	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by providing a new automated chlorinator and linking to set points for treated water chlorine residual. Additional automation features (e.g. auto shutoff chlorine valves etc) will also ensure the required safety standards are met for the handling of chlorine gas.

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Fluoride	Treated Water Fluoride	Online fluoride analyser (1AI + DI)	Provide monitoring, alarming and interlocks on fluoride concentrations in the treated water to ensure fluoride dosing does not exceed CCP limits.

Table 2-4 Process instrumentation to support improved process control at Baradine WTP

Parameter	Recommended Instrumentation and I/O	Justification
Raw Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Providing monitoring (and alarms) for pH comparison between raw and aerated water to confirm aeration performance and operation.
Aerated Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Providing monitoring (and alarms) for pH comparison between raw and aerated water to confirm aeration performance and operation. In addition, provide monitoring (and alarms) for pH correction systems. Enable plant shutdown if outside limits to allow time for jar tests and changes to chemical doses to maintain effective coagulation and flocculation.
Coagulation pH & Temperature Meter	Online pH & temperature analyser (2AI + DI)	Ensure optimum conditions for coagulation can be maintained to improve solids and manganese removal (high pH coagulation). Provide control functionality to enable pH trim control dosing for pre-soda ash dosing. Enable plant shutdown if outside limits to allow time for jar tests and changes to chemical doses to maintain optimum pH for effective coagulation and flocculation.
Treated Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Provide monitoring (and alarms) for treated water pH and temperature, before it is sent to the community.
Clarified Sludge Control	Desludge control valve and actuator (2DI + 2DO)	Provide ability to enable automatic desludge sequences to ensure the sludge blanket level is maintained and to prevent blanket boil-up which currently affects settled water quality.
Filter Backwash Automation – Replacement of existing filter head loss differential pressure transmitter (DPT)	Online differential pressure unit (1AI)	Provide automation of filter backwash sequences and backwash initiation triggers (differential pressure) to ensure filters are backwashed at the correct time, and to improve backwash efficiency.
Filter Backwash Flow	Magnetic flowmeter (1AI + 2DI)	See above regarding filter backwash automation information. Provides more accurate flow monitoring and greater control for backwash automation compared to existing orifice plate flowmeter.
Filter Air Scour Flow	Online differential pressure unit (1AI)	Replacement of existing differential pressure transmitter for air scour orifice plate. The orifice plate itself should be in good condition.
Raw Water Flow	Magnetic flowmeter (1AI + 2DI)	Provide more accurate flow monitoring and enable flow paced dosing.

Parameter	Recommended Instrumentation and I/O	Justification
Treated Water Flow – Post CWT	Magnetic flowmeter (1AI + 2DI)	Provide more accurate flow monitoring and improve demand management.
ACH Tank Level	Level indicating transmitter (1AI)	Provide monitoring and alarming for level in the coagulant storage tank. Ensure coagulant level is correctly maintained. Enable alarming at reorder levels etc.
ACH Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the coagulant is being dosed.
ACH Dosing	2 x Digital dosing pumps (D/S) (2AI/O+2DI)	Improve reliability of coagulant dosing by improving turndown capability and enabling more accurate flow paced dosing.
Soda Ash Tank Level	Level indicating transmitter (1AI)	Provide monitoring and alarming for level in the soda ash mixing tank. Ensure soda ash level is correctly maintained.
Soda Ash Dosing Flow (x2)	2 x Flow switches (2DI)	Provide alarming and confirmation that soda ash is being dosed to aerated water and/or treated water.
Soda Ash Dosing	2 x Digital dosing pumps (D/D) (2AI/O+2DI)	Improve reliability of soda ash dosing by improving turndown capability and enabling automated dosing control through feedback trim control to target set points for pH.

2.2.4 Existing plant and RTU controls

There is currently no PLC control system for this plant. The operation of the drives and devices are controlled via hardwired timers and relays. There is one main MCC control panel that is in the main treatment room. The serviceable life of most electrical equipment is 25-30 years, with the age of the MCC being well in excess of 30 years old (originally built in 1962 and thus 23 years past usual service design life), poor condition and not complying with the current AS3000 wiring rule, it should be replaced immediately. The Plant RTU is mounted on the back of the MCC panel and houses the RADTEL RTU unit. This unit is no longer manufactured or supported and as part of the future telemetry SCADA project, it will be replaced. The existing RTU currently monitors the following I/O:

- Bore 1 running
- Bore pump 1 failed
- Stop / Start Plant
- Telemetry power failure
- FM9 Raw water flow
- R15 Bore Level
- FM 10 Clear Water Flow
- FM 12 Backwash Flow

The existing RADTEL RTU has:

- 2 Digital input cards (32 points) with 28 spare inputs
- 1 Digital output card (8 points) with 7 Spare outputs
- 1 Analogue input card (8 Points) with 4 spare inputs

Due to the lack of RTU inputs available and no plant PLC, there is no way that the existing equipment can bring back the required inputs or control the plant to shut down on poor water quality. Therefore, a total control system upgrade is recommended.

There are limited electrical drawings on site, with the only drawings located being for the backwash panel and the polymer dosing system. No main plant electrical drawings were located. It is recommended that the MCC is audited and the main drive and instrument wiring information is recorded. This will allow for the implementation of new cable and wire numbers into a newly designed MCC panel.

2.2.5 Recommended control system upgrades

It is recommended that the MCC is totally replaced and a new plant PLC is installed as part of the upgrade. There is an area that is located on the northern end of the plant where the soda ash dosing system is currently mounted that would be the ideal location for a new MCC and RTU panel, once the existing dosing tank is relocated / removed. The existing site mains power runs past this location and could easily be rerouted to the new panel. The old MCC panel could be fed off the new panel temporarily during the cut over, reducing the down time of the plant.

The plant control would be achieved by a new PLC that will be installed in the MCC. With the remote connection via a new plant RTU and radio located in the PLC section of the MCC. The RTU would be connected to the PLC via a Modbus connection to extract a subset of data for the plant, including the new instrumentation.

To cover the existing plant controls the new PLC should need to contain approximately:

- 64 digital input points
- 32 digital output points
- 8 analogue input points

However, this installation would also need to cover the additional 31 analogue and 30 digital points required for the new instrumentation listed in Table 2-3 and Table 2-4. This would be confirmed and refined during the concept design.

Figure 2-1 Baradine MCC

Figure 2-2 Baradine RTU location

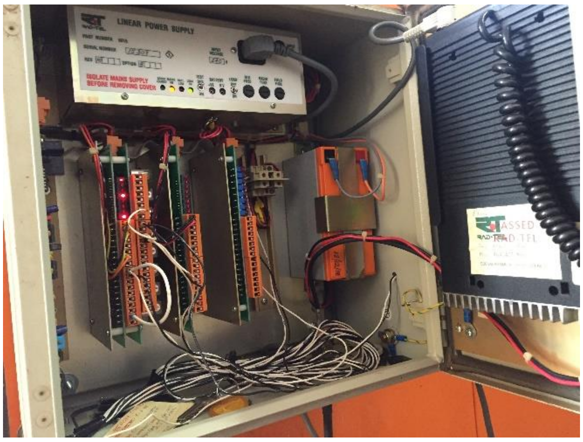

Figure 2-3 Baradine RTU Internal layout

Figure 2-4 Baradine proposed new MCC location

2.2.6 Cost estimation

The estimated cost of the recommended upgrades for Baradine WTP can be seen in Table 2-5. The table shows the total cost for Baradine WTP, as well as the breakdown of costs in various upgrade areas. A contingency of 30% has been provided on top of the total cost estimate.

It should be noted that the cost estimate for control equipment is based on previous project experience for the installation of a new MCC and PLC in a new plant switch room. The estimate provided is for a turnkey solution including electrical design, programming, materials, installation and commissioning. It is also noted that Council are currently considering replacing the control equipment at a number of their sites, however these estimates assume that this work has not been completed.

A detailed breakdown of the cost estimation is provided in Appendix A.

Table 2-5 Estimated cost of recommended upgrades for Baradine WTP

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$85,400
Flow Meters	$16,000
Instruments	$3,100
Pumps, Valves and Actuators	$2,000
Dosing Automation (includes dosing skids and pumps)	$96,000
Backwash Automation	$5,000
Control Equipment	$1,000,000
Instrumentation installation	$15,900
Electrical installation	$20,000
Indirect Costs	
Engineering Design	$79,000
Engineering Support	$22,500
Commissioning and Training	$10,000
Project Management	$124,400
Total Project Cost Estimate (-50% to +50%)	**$1,479,300**
Contingency (30% of Total Project Cost)	$443,800
Project Cost Estimate + Contingency (±50%)	**$1,923,100**

2.3 Binnaway WTP

2.3.1 Existing WTP and instrumentation

Water to the township of Binnaway is sourced from the Castlereagh River. Raw water is pumped through a 200mm diameter rising main, via a pump station next to the river, to the Binnaway WTP. The raw water pumps are submersible and located in an in river wet well which becomes inundated under high river levels (even when not in flood).

The treatment process includes coagulation using aluminium sulphate, sedimentation in two sedimentation lagoons and media filtration through two mono media filters (sand only) which are currently operating in an oxide coated media mode where chlorine (temporary sodium hypochlorite (hypo) dosing system) is dosed to the filter feed to establish and maintain a manganese oxide coating on the filter media to enhance manganese removal. Filtered water then undergoes pH correction using soda ash dosing, followed by disinfection using chlorine gas, and fluoridation. The treated water is then pumped to the town reservoir for storage prior to release to the community.

Low level in the reservoir calls the treated water pumps to start, following which a low level in the CWT calls the settled water pumps to start, and a low level at the settled water pumping station triggers the raw water pumping station to start pumping water from the river. A high level in the reservoir triggers all pumping to stop.

Raw and treated water flow meters are available to monitor the flow into and out of the plant, and level switches are used in the storages to operate the plant, however there are currently no water quality analysers available to confirm compliance against CCPs. Therefore, it is impossible to monitor or verify the quality of treated water, or to shut down the treatment process if quality exceedances are detected when the WTP is not attended. The WTP is essentially running 'blind' when operations staff are not in attendance.

The existing WTP has the following process control functionality, summarised in Table 2-6.

Table 2-6 Existing process control functionality at Binnaway WTP

Process Parameter	Monitoring Point
Flow monitoring	Raw water (orifice plate)
	Bore water (mag flow)
	Treated water (mag flow)
	Backwash water (orifice plate - not working)
Level switches	Sedimentation lagoon 1 high/low level
	Sedimentation lagoon 2 high/low level
	Filter levels
	CWT high/low levels
	Reservoir high/low level
	Alum storage tank high level
Flow switches	Settled water pump 1
	Settled water pump 2
	Treated water pump 1
	Treated water pump 2
	Reservoir inlet

2.3.1.1 Raw water pumping station and control system

Although this studies focus is on the WTP itself and raw water pump stations were not visited. The RWPS for Binnaway was quickly inspected on the way to the new bore as time permitted. It was found that the RWPS MCC was well past its design life and no longer complies with current safety regulations and construction standards. Materials used are likely to contain asbestos. There is also currently a risk of electric shock to operators and contractors who may be working in the area. Therefore, Hunter H2O recommend that options are investigated to replace the current system. This could include alternate locations or incoming mains power supplies etc. A condition assessment of the control building, MCC, raw water pumps and intake structure should however be undertaken to inform the development of options and determine the extent of the recommended upgrades. Due to the many unknowns around the replacement and relocation of this site, no allowance was made within the identified scope of works during this project and no costs were allocated. For Binnaway WTP, due to the extensive costs associated with the RWPS site it would be much more cost effective to enable raw water flow control via a flow control valve.

2.3.2 CCP summary

The critical control points (CCPs) for the Binnaway water treatment network are summarised in Table 2-7 (Warrumbungle DWMS Annual Report Aug-18 to Jul-19).

Table 2-7 Summary of CCPs for Binnaway WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
BWY1	Filtration	All pathogens	Turbidity	<0.2 NTU	>0.3 NTU	>0.5 NTU
BWY2	Disinfection (gas)	Chlorine sensitive pathogens	Chlorine	2.0 – 3.2 mg/L	<1.5 mg/L, >3.6 mg/L	<1.0 mg/L, >4.0 mg/L
BWY3	Fluoridation	Fluoride	Fluoride	1 mg/L (leaving WTP, leaving reservoir and throughout distribution system)	<0.9 mg/L for >24 hrs, >1.1 mg/L	0.9mg/L for >72 hrs, >1.5 mg/L, 0.0 mg/L for >24 hrs
BWY4	Reservoirs	All pathogens and all chemicals	Reservoir integrity	No breach of integrity (hatches locked, no holes in meshing)	-	Breach of integrity identified
BWY5	Distribution	Chlorine sensitive pathogens and all chemicals	Chlorine	0.8 – 2.0 mg/L	< 0.5 mg/L, >2.5 mg/L	< 0.2 mg/L, >4.0 mg/L
BWY6	Distribution (OCP)	All pathogens	Turbidity	<1.0 NTU	>1.0 NTU	>4.0 NTU

2.3.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Binnaway WTP is outlined in the following tables. Table 2-8 outlines the process instrumentation recommended to address the CCP control parameters for the Binnaway WTP, whilst Table 2-9 outlines additional instrumentation recommended to assist with the effective operation of the treatment plant.

New chlorine gas dosing equipment is recommended for the implementation of automated chlorine dosing for pre-filter chlorine dosing (replacing the temporary hypo dosing system), to improve manganese removal, and for the main disinfection dosing point to enable feedback trim control functionality (automatically adjusting chlorine dose based on the free chlorine residual remaining which ensures target free chlorine residuals are more easily achieved). These additions shall improve manganese removal and disinfection reliability whilst also provide redundancy to improve reliability of chlorine dosing and ensure CCPs for disinfection are met. This would significantly improve the existing manual chlorine dosing equipment at Binnaway WTP, and would be installed within the existing chlorine dosing room.

New magflow meters are recommended to replace existing orifice plate flow meters as some of these are failing. This will enable effective control of the plant and enable flow paced dosing to occur. New dosing pumps, dosing flow switches and level indicating transmitters on chemical storage tanks are recommended for both the alum and soda ash dosing systems to enable more accurate flow pacing and pH trim control dosing functionality. This will enable effective automation and control of coagulant dosing and pH correction at the plant which are essential for effective coagulation and flocculation to occur, which is in turn essential for effective downstream clarification and filtration processes. This will also enable implementation of critical plant interlocks to improve water safety and plant reliability.

A new raw water flow control valve is recommended to enable automatic plant flowrate adjustments. A flow control valve is recommended for Binnaway as the cost of adding VSD's to the raw water pumping station in its current condition would be very costly. The raw water flow control valve would be located at the inlet to the WTP to enable flow control from both river and bore water sources.

Settled water pump VSDs are recommended to ensure the WTP can maintain a constant flowrate, rather than the current operation whereby the settled water pumps stop and start based on lagoon level which creates issues with trying to achieve a stable flow through the filters.

Similar to Baradine WTP, with the addition of a new plant PLC, control can be implemented with various interlocks and/or alarming to ensure the process is operating effectively.

Table 2-8 Process instrumentation to facilitate effective implementation of CCPs for Binnaway WTP

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Turbidity	Raw Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks for high turbidity water entering the WTP or rapid changes in raw water turbidity. Rapid changes in turbidity require coagulant dose rate changes and thus should alert the operator or be used in lookup tables to automatically adjust coagulant dose once a sufficient correlation is established.
	Settled Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming for high turbidity water leaving the sedimentation lagoons before it reaches the filters. This helps to lengthen filter runtimes and reduce potential filter breakthrough. It will also help to identify when coagulation and flocculation fails, which impacts sedimentation performance.
	Filtered Water Turbidity Cell 1	Online turbidity analyser (1AI + DI)	CCP turbidity limits for filtration should be applied to filtered water from each individual filter or filter cell. This is to ensure sufficient protection from protozoa in treated water and compliance with CCPs. Provide control functionality to initiate a filter backwash on detection of high filtered water turbidity.
	Filtered Water Turbidity Cell 2	Online turbidity analyser (1AI + DI)	CCP turbidity limits for filtration should be applied to filtered water from each individual filter or filter cell. This is to ensure sufficient protection from protozoa in treated water and compliance with CCPs. Provide control functionality to initiate a filter backwash on detection of high filtered water turbidity.
	Combined Filtered Water Turbidity	Online turbidity analyser (1AI + DI)	Confirmation that the combined filtered water is within CCP turbidity limits. This ensures the CWT is not filled with water exceeding the CCP turbidity limits.
	Treated Water Turbidity	Online turbidity analyser	Provide alarming and interlocks to ensure water exceeding the CCP turbidity limits is not sent to the

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
		(1AI + DI)	community. This is the final check that the water is compliant.
Chlorine	Combined Filtered Water Free Chlorine	Online free chlorine analyser (1AI + DI)	Monitor free chlorine from pre-filter chlorine dosing system to ensure chlorine dosing free chlorine residual is sufficient for the oxide coated media process (manganese removal). Provide control functionality to enable free chlorine trim control dosing for pre-filter dosing.
	Treated Water Free Chlorine	Online free chlorine analyser (1AI + DI)	Ensure the free chlorine required for disinfection is sufficient for the treated water and provide trim dosing control for the automated chlorine gas dosing system.
	Pre-filter Automated Chlorine Dosing	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by providing a new automated chlorinator and linking to set points for filtered water chlorine residual to maintain a constant free chlorine residual and improve manganese removal.
	Treated Water Automated Chlorine Dosing	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by providing a new automated chlorinator and linking to set points for treated water chlorine residual. Additional automation features will also ensure the required safety standards are met for the handling of chlorine gas.
Fluoride	Treated Water Fluoride	Online fluoride analyser (1AI + DI)	Provide monitoring, alarming and interlocks on fluoride concentrations in the treated water to ensure fluoride dosing does not exceed CCP limits.

Table 2-9 Process instrumentation to support improved process control at Binnaway WTP

Parameter	Recommended Instrumentation and I/O	Justification
Coagulation pH & Temperature	Online pH & temperature analyser (2AI + DI)	Ensure optimum conditions for coagulation can be maintained to improve solids and organics (colour) removal. Provide control functionality to enable pH trim control dosing for pre-soda ash dosing. Enable plant shutdown if outside limits to allow time for jar tests and changes to chemical doses to maintain optimum pH for effective coagulation and flocculation.
Treated Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Provide monitoring (and alarms) for treated water pH and temperature, before it is sent to the community.
Raw Water Flow Control	Modulating raw water flow control valve and actuation (1AI / 1AO)	Provide the ability to automatically change the raw water flowrate into the WTP from either source (river or bore). Provide flow control for the combined raw water inlet valve using the raw water magflow meter.
Filter Backwash Automation – Inlet	Inlet control valve and actuator (2DI / 2DO)	Provide automation of filter backwash sequences to ensure filters are backwashed at the correct time, and to improve backwash efficiency, thus

Parameter	Recommended Instrumentation and I/O	Justification
		conserving treated water used for the backwash, and decreasing the volume of washwater that needs to be handled. Provides control for isolation of the filter inlet line.
Filter Backwash Automation – Filter Outlets (x2)	2 x outlet control valves and actuators (4DI / 4DO)	See above regarding filter backwash automation. Provides control for isolation of the individual filter outlets so that one filter cell can be backwashed at a time.
Filter Backwash Automation – Filter Outlet Flow Control	Modulating filter flow control valve and actuation (1AI / 1AO)	See above regarding filter backwash automation. Provide flow control for the combined filter outlet valve using level indication in the filter.
Filter Backwash Automation –Modulation Backwash Inlet Flow Control Valve	Modulating filter backwash flow control valve and actuation (1AI / 1AO)	See above regarding filter backwash automation. Provide flow control for the backwash inlet valve using the backwash magflow meter.
Filter Backwash Automation – Washwater Outlet	Washwater outlet control valve and actuator (2DI / 2DO)	See above regarding filter backwash automation. Provide control for isolation of the backwash water outlet valve.
Filter Backwash Automation – Filter Level	Level indicating transmitter (1AI)	See above regarding filter backwash automation. Provide monitoring of filter level for control of the combined filter outlet valve.
Filter Backwash Automation – Backwash Flow	Magnetic flowmeter (1AI + 2DI)	See above regarding filter backwash automation. Provide reliable monitoring of backwash flow to allow for backwash flow control.
Settled Water Pumps (Existing) flow control	2 x Settled water pump VSDs (2AI / 2AO / 4DI)	Provide capability to enable flow pacing to ensure settled water flowrate is matched to raw water flows and thus reduce current start/stop operation based on levels.
Settled Water Pumping Station Level	Level indicating transmitter (1AI)	See above regarding flow pacing and balancing.
Raw Water Flow	Magnetic flowmeter (1AI + 2DI)	Provide more accurate flow monitoring and enable flow paced dosing.
Alum Tank Level	Level indicating transmitter (1AI)	Provide monitoring and alarming for level in the coagulant storage tank. Ensure coagulant level is correctly maintained. Enable alarming at reorder levels etc.
Alum Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the coagulant is being dosed.
Alum Dosing	2 x Digital dosing pumps (D/S) (2AI/O+2DI)	Improve reliability of coagulant dosing by improving turndown capability and enabling more accurate flow paced dosing.
Soda Ash Tank Level	Level indicating transmitter (1AI)	Provide monitoring and alarming for level in the soda ash mixing tank. Ensure soda ash level is correctly maintained.

Parameter	Recommended Instrumentation and I/O	Justification
Soda Ash Dosing Flow (x2)	2 x Flow switches (2DI)	Provide alarming and confirmation that soda ash is being dosed to raw water and/or treated water.
Soda Ash Dosing	2 x Digital dosing pumps (D/D) (2AI/O+2DI)	Improve reliability of soda ash dosing by improving turndown capability and enabling automated dosing control through feedback trim control to target set points for pH.

2.3.4 Existing plant and RTU controls

The plant is controlled via a simple Omron C60H PLC that is housed in an MCC, in the site's laboratory room. The serviceable life of most electrical equipment is 25-30 years, and the PLC and MCC were manufactured in 1995. The PLC is no longer supported or available. The condition of the MCC is average and there are several issues within the PLC panel, which means the panels no longer comply with current Australian Standards (AS3000), with the MCC being at the point of being replaced due to age and the average condition of the installation. Planning to replace the MCC and PLC should start immediately.

If the MCC was to be updated it would be recommended that the room is converted to a dedicated MCC control room, with no lab equipment within the room as this would be the most cost effective way to upgrade the MCC.

The Plant RTU is not located in the MCC, it is mounted on top of the site reservoir and is connected to the PLC panel via a hardwired multicore cable. The RTU is a RADTEL unit and is no longer manufactured or supported. As part of the telemetry SCADA planning, it will be replaced with a modern DNP3 system. The existing RTU currently monitors the following I/O:

- Call for water
- Plant general alarm
- Plant shutdown alarm
- Reservoir overflow alarm
- Telemetry mains failure
- Reservoir level
- FM5 Raw water flow
- FM6 Reservoir outlet flow (future)

The site electrical drawings were located on site and at the Coonabarabran filing system. There were several copies of the drawings found and hand mark-ups were done across the multiple sets. It would be recommended that the mark-ups are audited with the site drawings to confirm the status of the wiring on site.

The existing RADTEL RTU has:

- 1 Digital input card (16 points) with 11 spare inputs
- 1 Digital output card (8 points) with 5 Spare outputs
- 1 Analogue input card (8 Points) with 7 spare inputs

Due to the lack of RTU inputs available, however, and the outdated plant PLC, there is no way that the existing equipment can support/bring back the required inputs or control the plant to shut down on poor water quality. Therefore, a total control system upgrade is recommended.

2.3.5 Recommended control system upgrades

As a minimum it is recommended that the PLC panel is replaced, however with the age of the equipment being 25 years old the MCC is at or nearing the end of its service life (25-30 years) and should also be replaced. As the existing cabling enters the MCC via the top and the bottom of the panel it will be difficult to mount the new MCC anywhere else beyond the current location without a significant upgrade requiring rewiring of the whole plant. However, the room dimensions will need to be confirmed to ensure the existing room complies with Australian Standards with respect to motor control switchrooms. If the room dimensions are compliant, the existing cables could however be extended, with all cables entering the new MCC via the bottom of the panel. If the existing lab bench was removed, then there may be an opportunity to mount the new panel on the right of the existing MCC. A new laboratory room would however need to be constructed to replace the existing laboratory room to allow this conversion to occur. The current laboratory location and proximity to electrical switchgear is of concern, while the space available for operators to perform routine grab sample testing is very limited. Hence a new laboratory room with control room would rectify these issues and also allow space for the new MCC and PLC.

The plant control would be achieved by a new PLC that would be installed in the MCC, with the remote connection via a new plant RTU and radio. The new RTU may be mounted in the new PLC section of the MCC if the site radio can achieve a good signal strength to the repeater via a new antenna that would be mounted on top of the building. The final height of the antenna would need to be approximately 8 meters from ground level. The RTU would be connected to the PLC via a Modbus connection to extract a subset of data for the plant operation and monitoring, including the new instrumentation. If the signal strength of the radio is not acceptable from the building, then it will have to be mounted at the top of the reservoir and connected to the PLC via fibre to avoid lightning damage.

To cover the existing plant controls the new PLC should need to contain approximately:

- 64 digital input points
- 32 digital output points
- 8 analogue input points

However, this installation would also need to cover the additional 34 analogue and 45 digital points required for the new instrumentation listed in Table 2-8 and Table 2-9. This would be confirmed and refined during the concept design.

Figure 2-5 Binaway exisitng MCC

Figure 2-6 Binaway RTU location

Figure 2-7 Binaway RTU internal layout

Figure 2-8 Binaway proposed new MCC location

2.3.6 Cost estimation

The estimated cost of the recommended upgrades for Binnaway WTP can be seen in Table 2-10. The table shows the total cost for Binnaway WTP, as well as the breakdown of costs in various upgrade areas. A contingency of 30% has been provided on top of the total cost estimate.

It should be noted that the cost estimate for control equipment is based on the installation of a new MCC and PLC in the existing laboratory room, and the package construction of a new laboratory and control room to replace the existing laboratory area. The estimate provided is based on previous project experience for a turnkey solution including design, programming, materials, installation and commissioning. It is also noted that Council are currently considering replacing the control equipment at a number of their sites, however these estimates assume that this work has not been completed.

A detailed breakdown of the cost estimation is provided in Appendix A.

Table 2-10 Estimated cost of recommended upgrades for Binnaway WTP

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$97,600
Flow Meters	$32,900
Instruments	$4,400
Pumps, Valves and Actuators	$55,000
Dosing Automation (includes dosing skids and pumps)	$96,000
Backwash Automation	$21,300
Control Equipment (includes portable laboratory/control room)	$1,050,000
Instrumentation installation	$16,600
Electrical installation	$20,000
Indirect Costs	
Engineering Design	$79,000
Engineering Support	$22,500
Commissioning and Training	$10,000
Project Management	$139,400
Total Project Cost Estimate (-50% to +50%)	**$1,644,700**
Contingency (30% of Total Project Cost)	$493,500
Project Cost Estimate + Contingency (±50%)	**$2,138,200**

2.4 Bugaldie WTP

2.4.1 Existing WTP and instrumentation

WSC has 14 registered connections to their Bugaldie potable water network, with many properties on private bore water and/or rainwater systems. Water supplying the network is drawn from a sub-artesian bore which is approximately 100 m deep. Cattle and manure were observed to be within ~20m from the bore head (along the boundary fence), hence bore head integrity should be monitored to ensure contamination does not occur due to surface water ingress.

The Bugaldie system utilises sodium hypochlorite dosing for disinfection. No further treatment is provided. Treated water is stored in an 8.5 kL surface storage tank before being pumped to an 8.5 kL Elevated Polytank. Water is distributed to the township via pressure pump with pressure switch through a single 75 mm AC main.

Low level in the elevated reservoir calls the transfer pump to start pumping water from the surface storage tank, whilst a low level in the surface storage tank calls the bore to start pumping. Similarly, a high level in the elevated reservoir triggers the transfer pump to stop, and a high level in the surface storage tank triggers the bore to stop pumping. Flow from the bore calls the sodium hypochlorite dosing pump to start.

The only instrumentation currently at the plant is a pressure switch (linked to the pressure pump) and an offline treated water free chlorine analyser (not yet connected), with no interlocks to plant controls. No other online water quality instrumentation or analysers currently exist on site to confirm compliance against CCP/OCPs (turbidity). Therefore, it is impossible to monitor or verify the quality of treated water, or to shut down the treatment process if quality exceedances are detected when the WTP is not attended. The WTP is essentially running 'blind' when operations staff are not in attendance.

The existing WTP has the following online analysers, summarised in Table 2-11.

Table 2-11 Existing online water quality analysers at Bugaldie WTP

Water Quality Parameter	Monitoring Point
Free chlorine (currently not online or connected)	Treated water

The existing WTP has the following process control functionality, summarised in Table 2-12.

Table 2-12 Existing process control functionality at Bugaldie WTP

Process Parameter	Monitoring Point
Level switches	Surface storage tank high/low level
	Elevated reservoir high/low level
Pressure switches	High pressure reticulation pump

2.4.2 CCP summary

The critical control points (CCPs) for the Bugaldie water treatment network are summarised in Table 2-13 (Warrumbungle DWMS Annual Report Aug-18 to Jul-19).

Table 2-13 Summary of CCPs for Bugaldie WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
BUG1	Disinfection (hypo)	Chlorine sensitive pathogens	Chlorine	1.5 – 2.3 mg/L	<1.2 mg/L, >2.8 mg/L	<1.0 mg/L, >4.0 mg/L
BUG2	Reservoirs	All pathogens and all chemicals	Reservoir integrity	No breach of integrity (hatches locked, no holes in meshing)	-	Breach of integrity identified

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
BUG3	Distribution	Chlorine sensitive pathogens and all chemicals	Chlorine	-	<0.4 mg/L, >2.5 mg/L	<0.2 mg/L, >4.0 mg/L
BUG4	Distribution (OCP)	All pathogens	Turbidity	<1.0 NTU	>1.0 NTU	>4.0 NTU

2.4.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Bugaldie WTP is outlined in the following tables. Table 2-14 outlines the process instrumentation recommended to address the CCP control parameters for the Bugaldie WTP, whilst Table 2-15 outlines additional instrumentation recommended to assist with the effective operation of the treatment plant.

A new magflow meter is recommended to monitor flows and demand remotely and enable flowpaced dosing. Raw water flow control for this plant was not deemed necessary.

Table 2-14 Process instrumentation to facilitate effective implementation of CCPs for Bugaldie WTP

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Chlorine	Treated Water Free Chlorine & pH (Existing)	Combined free chlorine and pH analyser (2AI + DI)	Provide control functionality using the existing analyser to enable automated hypo dosing and ensure the free chlorine residual is sufficient for treated water CCP. This can be achieved through the existing Wallace and Tiernan control unit. It is noted that Council is currently in the process of installing a new free chlorine analyser for this site.
	Treated Water Automated Chlorine Dosing	Digital dosing pump (1AI/O+1DI)	Digital dosing pump to replace existing hypo dosing pump to enable automated hypo dosing and provide the ability to adjust hypo dosing remotely.
Turbidity (OCP)	Treated Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks for high turbidity water entering the WTP or rapid changes in raw water turbidity indicating potential surface water ingress into the bore head. Ensure compliance with OCP.

Table 2-15 Process instrumentation to support improved process control at Bugaldie WTP

Parameter	Recommended Instrumentation and I/O	Justification
Treated Water Pressure	Pressure indicating transmitter (1AI)	Monitoring of treated water pump/reticulation pressure.
Bore Level	Level indicating transmitter (1AI)	Provide bore water level monitoring to improve water security by enabling better control and implementation of water restriction triggers. Also enable data collection for improved long-term yield modelling. Could also be used

Parameter	Recommended Instrumentation and I/O	Justification
		to detect sudden level increases caused by surface water intrusion.
Treated Water Flow	Magnetic flowmeter (1AI + 2DI)	Provide more accurate flow monitoring and improve demand management.
Hypo Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the hypo is being dosed.

2.4.4 Existing plant and RTU controls

The site consists of a bore pump that feeds into a concrete tank at ground level. The water is then pumped up to a plastic tank on a stand to provide head pressure. The water from the above ground tank is then fed into a pressure boosting pump that pressurises the distribution network for the township. This system is controlled via simple hardwiring level switches. The control system is mounted in a basic external meter panel and appears to be in reasonable condition, however the controls for the site should be mounted in a purpose-built panel that conforms to AS3000. There is no presence of a voltage transformer in the panel which indicates that the control system is based on 240VAC. This may present a safety risk to the maintenance and operational staff as the level floats will be powered via 240VAC. It would be advisable to mount the equipment in a more weatherproof arrangement with a low voltage supply to external devices. The sodium hypochlorite dosing system is a basic configuration that is a drum that holds the sodium hypochlorite liquid, which is pumped into the water when the bore pump is running via a variable speed dosing pump that has been fixed to a single speed and is powered when the bore runs.

The RTU is in a meter panel within the pump shed and monitors the operation of the bore pump and the lift pump, as well as the tower reservoir level. The RTU is a RADTEL unit and is no longer manufactured or supported and as part of the telemetry SCADA planning, it will be replaced. The existing RTU currently monitors the following I/O:

- Bore pump running
- Bore pump Fault
- Lift pump running
- Lift pump Fault
- High tank low level
- Low tank low level
- Low tank overflow level
- Power failure

The existing RADTEL RTU has:

- 8 digital input points with 0 spare inputs
- 8 digital output points with 8 Spare outputs
- 2 analogue input points with 2 spare inputs

Due to the lack of RTU inputs available there is no way that the existing equipment can bring back the required inputs or control the plant to shut down on poor water quality. Therefore, a total control system upgrade is recommended.

There is a new free chlorine residual analyser fitted to the site however it is not wired to the RTU.

There were no electrical drawings present on site.

2.4.5 Recommended control system upgrades

To help improve the operation and safety of the site it is recommended that the current wiring system is replaced, and the panel upgraded to a new IP weather rated panel. With Council's RTU and telemetry system being preplaced it would be logical to replace the hardwired control with an RTU based control system. The RTU could then monitor and control the site.

The new site electrical panel would be a simple form 1 constructed panel that has 2 sections, a 415V section and a telemetry RTU section. The panel would be mounted adjacent to the existing meter panel with all the existing devices rewired to the panel. As part of the upgrade the new instruments could be wired to the new RTU panel.

To cover the existing plant controls the new RTU should need to contain approximately:

- 16 digital input points
- 8 digital output points
- 4 analogue input points

However, this installation would also need to cover the additional 4 analogue and 4 digital points required for the new instrumentation listed in Table 2-14 and Table 2-15. This would be confirmed and refined during the concept design.

Figure 2-9 Bugaldie site layout

Figure 2-10 Bugaldie pump house

Figure 2-11 Bugaldie RTU internal layout

Figure 2-12 Bugaldie control panel

2.4.6 Cost estimation

The estimated cost of the recommended upgrades for Bugaldie WTP can be seen in Table 2-16. The table shows the total cost for Bugaldie WTP, as well as the breakdown of costs in various upgrade areas. A contingency of 30% has been provided on top of the total cost estimate.

It is noted that Council are currently considering replacing the control equipment at a number of their sites, however these estimates assume that this work has not been completed.

A detailed breakdown of the cost estimation is provided in Appendix A.

Table 2-16 Estimated cost of recommended upgrades for Bugaldie WTP

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$10,400
Flow Meters	$3,100
Instruments	$3,600
Dosing Automation	$4,000
Control Equipment	$20,000
Instrumentation installation	$1,600
Electrical Installation	$15,000
Indirect Costs	
Engineering Design	$39,000
Engineering Support	$10,000
Commissioning and Training	$10,000
Project Management	$5,800
Total Project Cost Estimate (-50% to +50%)	**$122,500**
Contingency (30% of Total Project Cost)	$36,800
Project Cost Estimate + Contingency (±50%)	**$159,300**

2.5 Coolah WTP

2.5.1 Existing WTP and instrumentation

WSC has 440 registered connections to their Coolah potable water network. Water for the network is pumped to the township from one of two bores located outside the town, next to the Coolaburragundy River. A backup bore has been installed at Neilrex Rd, but is currently not commissioned.

Chlorine gas dosing is utilised for disinfection. No further treatment is provided. Treated water is stored in a reservoir located on Martin St (1.08 ML) and/or in two reservoirs on Wentworth Avenue (2 x 0.09 ML). Water then gravitates via reticulation mains into the township. The plant also has a fluoride dosing system that is not currently in use. Currently the fluoride doing point is located on the Bore 2 discharge main, while chlorine carrier water is drawn immediately after Bore 1 and the chlorine dosing point is located on the common rising main after Bore 2. This means that fluoride dosing can only be applied to Bore 2 and chlorine dosing is only called to start when Bore 2 is operating as there is no flowmeter on Bore 1.

Low level in the Martin St reservoir calls the primary bore (Bore 2) to start pumping, whilst a high level in the reservoir triggers the bore to stop pumping.

A flow meter and level instrument are present on the primary bore (Bore 2). As the bores are only 20m apart the bore levels would be expected to be similar (assuming the bore depths are similar), however when Bore 1 is used there is no flow monitoring or potential to dose fluoride. No water quality instrumentation or analysers currently exist on site to monitor and confirm compliance against CCPs. Therefore, it is impossible to monitor or verify the quality of treated water, or to shut down the treatment process if quality exceedances are detected when the WTP is not attended. The WTP is essentially running 'blind' when operations staff are not in attendance.

The existing WTP has the following process control functionality, summarised in Table 2-17.

Table 2-17 Existing process control functionality at Coolah WTP

Process Parameter	Monitoring Point
Flow monitoring	Bore 2 (mag flow)
Level monitoring	Bore 2 level
Level switches	Reservoir high/low level
Flow switches	Fluoride dosing (not used)

2.5.2 CCP summary

The critical control points (CCPs) for the Coolah water treatment network are summarised in Table 2-18 (Warrumbungle DWMS Annual Report Aug-18 to Jul-19).

Table 2-18 Summary of CCPs for Coolah WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
CLH1	Disinfection (gas)	Chlorine sensitive pathogens	Chlorine	1.0 – 2.2 mg/L	<0.7 mg/L, >3.0 mg/L	<0.4 mg/L, >4.0 mg/L
CLH2	Reservoirs	All pathogens and all chemicals	Reservoir integrity	No breach of integrity (hatches locked, no holes in meshing)	-	Breach of integrity identified
CLH3	Fluoridation	Fluoride	Fluoride	1 mg/L (leaving WTP, leaving reservoir and throughout distribution system)	0.9 mg/L for >24 hrs, 1.1 mg/L	<0.9 mg/L for >72 hrs, >1.5 mg/L, 0.0 mg/L for >24 hrs

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
CLH4	Distribution	Chlorine sensitive pathogens and all chemicals	Chlorine	1.0 – 2.0 mg/L	<0.7 mg/L, >3.0 mg/L	<0.2 mg/L, >4.0 mg/L
CLH5	Distribution (OCP)	All pathogens	Turbidity	<1.0 NTU	>1.0 NTU	>4.0 NTU

2.5.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Coolah WTP is outlined in the following tables. Table 2-19 outlines the process instrumentation recommended to address the CCP control parameters for the Coolah WTP, whilst Table 2-20 outlines additional instrumentation recommended to assist with the effective operation of the treatment plant.

A new chlorine gas dosing facility is being considered to rectify the structural issues with the existing dosing room (located in the flood plain) and the WHS issues. The current chlorine dosing room has compliance issues and WHS issues associated with access etc, and as such would need a detailed audit to identify any potential upgrades and improvements recommended. The construction of a new chlorine dosing room would remove these issues.

A new portable chlorine gas dosing facility would be built to enable future relocation when/if a future filtration plant is built at the reservoir site (to be confirmed). The new chlorine dosing room would house new automated chlorine gas dosing equipment which is recommended for the implementation of automated chlorine dosing, to improve reliability of chlorine dosing and ensure CCPs for disinfection are met. This would supplement some of the existing chlorine dosing equipment at Coolah WTP. The new equipment could either be installed in the existing chlorine dosing room, or in a new dosing room.

A new magflow meter is recommended to be located on the common main leaving the site. Transfer of the existing fluoride dosing flow switch to the chlorine dosing pit will enable effective control of the fluoridation dosing system and ensure compliance with the Code of Practice.

Raw water flow control for this plant was not deemed necessary.

Table 2-19 Process instrumentation to facilitate effective implementation of CCPs for Coolah WTP

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Chlorine	Treated Water Free Chlorine	Online free chlorine analyser (1AI + DI)	Ensure the free chlorine residual required for disinfection is sufficient for the treated water and provide trim dosing control for the automated chlorine gas system.
	Automated Chlorine Dosing	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by linking an automated dosing system to set points for treated water chlorine residual. Additional automation features will also ensure the required safety standards are met for the handling of chlorine gas.
Fluoride	Treated Water Fluoride	Online fluoride analyser (1AI + DI)	Supporting the commissioning of the fluoride dosing system. Provide monitoring, alarming and interlocks on fluoride concentrations in the treated water to ensure fluoride dosing does not exceed CCP limits.
Turbidity (OCP)	Treated Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks for high turbidity water entering the WTP or rapid changes in raw water turbidity indicating potential surface water ingress into the bore head (as the bores are located within a flood plain).

Table 2-20 Process instrumentation to support improved process control at Coolah WTP

Parameter	Recommended Instrumentation and I/O	Justification
Treated Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Provide monitoring (and alarms) for treated water pH and temperature, before it is sent to the community.
Treated Water Flow	Magnetic flowmeter (1AI + 2DI)	Provide more accurate flow monitoring and improve demand management. Enable flow paced dosing.
Fluoride Flow (existing)	Existing flow switch (1AI)	Move existing fluoride dosing flow switch to the chlorine dosing pit for effective operation.

2.5.4 Existing plant and RTU controls

The site is made up of several separate systems that are scattered over the site, but these systems are not all monitored or controlled by one central system. There is a chlorine dosing room that has a typical manual gas injector and two gas bottle weight cells. This is mounted in a building that is elevated off the ground about ~1.7m. The site electrical feed comes from a transformer that is pole mounted within the compound. The transformer feeds a small distribution board that is mounted in a meter box on the chlorine building.

Nearby is bore pump 1 which has its own control panel and pit. This control panel also controls the starting and stopping of the chlorine pump. It is also assumed that the second bore pump starts the chlorine system via hardwiring as well.

The second bore pump is mounted away from bore pump 1 and has its own independent flow meter pit that monitors the water flow via a flow meter and flow switch, both of which are used to control the site fluoride dosing system.

The site also houses a fluoride dosing system. The system appears to only be controlled when bore 2 is running as there is no flow monitoring mounted in the Bore 1 pit. Although there is power to the fluoride control system it is not currently in use, however Council are keen for the system to reinstated or replaced.

There is an Elpro RTU mounted adjacent to bore pump 2 that monitors some points on the site and controls the starting and stopping of the two bores.

The RTU unit is still manufactured and supported however it is a low-level unit with no local logic control functions available. The existing RTU currently monitors and controls the following I/O:

- Bore pump 1 running
- Bore pump 1 fault
- Bore pump 2 running
- Bore pump 2 fault
- Bore pump 1 override (output)
- Bore pump 1 inhibit (output)
- Bore pump 2 override (output)
- Bore pump 2 inhibit (output)
- Call for water (output)
- Bore 1 Water Level
- Bore 2 water Level (future)

The existing Elpro RTU has:

- 16 digital input / output points with 5 spare input / outputs
- 11 analogue input points with 9 spare inputs

Although the RTU has enough analogue inputs available it is short on the digital inputs. There is not enough room within the existing panel, therefore a new panel will have to be manufactured. The Elpro

RTUs are not intelligent and therefore any logic to shut the bore pumps down would have to be done via hardwiring.

As a short-term solution Council could install an independent DNP3 based RTU that can communicate via Modbus to the Elpro unit. This will allow the RTU to monitor and control the site, while at the same time communicating key information to the Elpro system. Once the telemetry system has been upgraded, the Elpro can be removed and redirect the site communicate directly to the SCADA via DNP3.

There are some electrical drawings for sections of the site equipment, but there is no overarching set that show the interconnection of the assets. There are drawings for Bore 1, Bore 2, the RTU panel and the Fluoride panel. There is also some hand marked up sketches that were also found on site. It was noted that the site may be affected by flood levels, however both Bore 1 and the fluoride system are located at ground level, where Bore 2 and the chlorine controls are elevated.

2.5.5 Recommended control system upgrades

As the site has been pieced together over time there is no consistency to how things are controlled or monitored. Ideally there would be a site RTU that would control the duty pumping of the two bore pumps. The site fluoride system also needs to be corrected to allow dosing on the common rising main leave the site so as to enable dosing when either bore pump 1 or bore pump 2 is in operation. The fluoride system currently has no monitoring back to the RTU which needs to be corrected.

It has been recommended that the chlorine system is upgraded to have an automatic dosing system that monitors the chlorine residual and corrects the dosing rate accordingly. This should be monitored via the RTU system.

Depending on the result of a flood review (currently being undertaken), the location of a new RTU panel should be adjacent to Bore 2 or in its current location at Bore 1.

To cover the existing plant controls the new RTU should need to contain approximately:

- 32 digital input points
- 16 digital output points
- 8 analogue input points

However, this installation would also need to cover the additional 7 analogue and 7 digital points required for the new instrumentation listed in Table 2-19 and Table 2-20. This would be confirmed and refined during the concept design.

Figure 2-13 Coolah Chlorine dosing room

Figure 2-14 Coolah Chlorine bottles and weight cells

Figure 2-15 Coolah bore pump 2

Figure 2-16 Coolah bore pump 2 contorl panel

Figure 2-17 Coolah bore pump 1 control panel

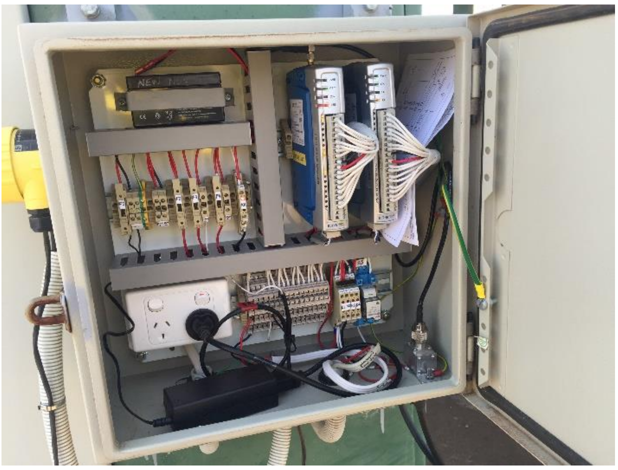

Figure 2-18 Coolah RTU panel

Figure 2-19 Coolah Fluoride dosing room

2.5.6 Cost estimation

The estimated cost of the recommended upgrades for Coolah WTP can be seen in Table 2-21. The table shows the total cost for Coolah WTP, as well as the breakdown of costs in various upgrade areas. A contingency of 30% has been provided on top of the total cost estimate.

It should be noted that the cost estimate for dosing automation is based on previous project experience for the installation of a new chlorine gas dosing system in a new dosing room. As stated previously, due to the condition of the existing chlorine dosing room, the existing room may need to either undergo refurbishment and upgrading, or be replaced with a new dosing room. The estimate provided is for a turnkey solution including design, materials, installation and commissioning of a new portable shed-type dosing room, and has factored in some of the continued use of existing automatic chlorine dosing equipment (such as weight scales etc) in the new room to reduce cost. The estimate also includes and allowance for earthworks and construction of retaining walls to raise the level of the new dosing room out of the flood zone.

It is also noted that Council are currently considering replacing the control equipment at a number of their sites, however these estimates assume that this work has not been completed.

A detailed breakdown of the cost estimation is provided in Appendix A.

Table 2-21 Estimated cost of recommended upgrades for Coolah WTP

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$35,500
Flow Meters	$5,200
Instruments	$5,000
Dosing Automation (includes new chlorine gas dosing room)	$232,000
Control Equipment	$25,000
Instrumentation installation	$2,800
Electrical Installation	$20,000
Indirect Costs	
Engineering Design	$49,000
Engineering Support	$10,000
Commissioning and Training	$12,500
Project Management	$32,600
Total Project Cost Estimate (-50% to +50%)	**$429,600**
Contingency (30% of Total Project Cost)	$128,900
Project Cost Estimate + Contingency (±50%)	**$558,500**

2.6 Coonabarabran WTP

2.6.1 Existing WTP and instrumentation

Water supplying Coonabarabran WTP is sourced from Timor Dam, located 12 km west of Coonabarabran on the Castlereagh River (off Timor Rd). Five emergency backup bores are also used to top up the storage volume in the dam when drought periods lead to lowering of the dam level. In addition, a further 6 emergency bores have recently been constructed to supply the WTP directly during drought conditions, which have been in use during the current drought.

The treatment process consists of coagulation with aluminium sulphate, hydraulic flocculation, lagoon sedimentation and filtration (via sand filters). The filtered water is then pH corrected with hydrated lime, disinfected with chlorine gas and fluoridated before being pumped to one of three reservoirs located around town.

Low level in the Oxley Highway Reservoir (2.2 ML) calls water to pump from Rifle Range Reservoir 1 (1.1 ML). Low level in either Rifle Range Reservoir 1 or Rifle Range Reservoir 2 (4.5 ML) calls the treated water pumps to start pumping. Consequently, a low level in the CWT calls the settled water pumps to start, and a low level at the settled water pumping station calls to start flow of raw water. The WTP is also often manually started in the morning to ensure the WTP is running while operations staff are in attendance. A high level in Rifle Range Reservoir 2 triggers the WTP to stop. Coagulant dosing is started by the raw water flow meter, and has no flow pacing control.

The 1992 Public Works O&M Manual for Coonabarabran WTP states that the pre-chemical dosing (alum, lime and polymer) will not be called to commence dosing until the raw water flow has achieved 20% of the design plant flowrate (95 L/s). If still current, this flow confirmation trigger is much too high and potentially higher than some of the new bore pump capacities, resulting in some raw water potentially entering the lagoons uncoagulated for a period of time. This and other unusual and outdated control features and triggers present a current risk to water safety, and hence must be rectified.

Instrumentation currently available at the plant consists of various flowmeters (refer Table 2-23), switches and a filtered water turbidity analyser on Filter 1. Council is currently installing two new individual filtered water turbidity analysers and then will use the existing analyser for combined filtered water analysis. Council has also recently installed a new treated water free chlorine analyser. However, none of these have the ability to initiate a plant shutdown on water quality exceedance yet or raise water quality exceedance alarms. Therefore, it is currently not possible to verify the quality of treated water, or to shut down the treatment process if quality exceedances are detected when the WTP is not attended.

The existing WTP has the following online analysers, summarised in Table 2-22.

Table 2-22 Existing online water quality analysers at Coonabarabran WTP

Water Quality Parameter	Monitoring Point
Turbidity	Filter 1 filtered water (new)
	Filter 2 filtered water (new)
	Combined filtered water (currently on Filter 1)
Free chlorine	Treated water (new)

The existing WTP has the following key main process control functionality, summarised in Table 2-23.

Table 2-23 Existing key main process control functionality at Coonabarabran WTP

Process Parameter	Monitoring Point
Flow monitoring	Timor Dam raw water (orifice plate)
	Some individual bores*
	Combined raw water at WTP inlet (orifice plate)
	Treated water (pre CWT) (orifice plate)
	Backwash water (orifice plate)
	Air scour (orifice plate)
Level monitoring	Filter level

Process Parameter	Monitoring Point
	CWT level
	Oxley Highway reservoir
Pressure monitoring	Filter differential pressure (x2)
Level switches	Sedimentation lagoon 1 high/low level
	Sedimentation lagoon 2 high/low level
	Settled water pump station high/low level
	2 x Filter levels
	CWT high/low levels
	3 x Reservoir high/low levels
Flow switches	Settled water pump 1
	Settled water pump 2
	Settled water pump 3
	Treated water (pre CWT)
	Treated water pump 1
	Treated water pump 2
	Treated water pump 3
	Backwash water pump

* Individual bores were not visited, however the flowmeters at these bores are expected to be magflow.

2.6.2 CCP summary

The critical control points (CCPs) for the Coonabarabran water treatment network are summarised in Table 2-24 (Warrumbungle DWMS Annual Report Aug-18 to Jul-19).

Table 2-24 Summary of CCPs for Coonabarabran WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
CBN1	Filtration	All pathogens	Turbidity	<0.3 NTU	>0.5 NTU	>0.7 NTU
CBN2	Disinfection (gas)	Chlorine sensitive pathogens	Chlorine	2.0 – 3.5 mg/L	<1.8 mg/L, >3.5 mg/L	<1.5 mg/L, >4.0 mg/L
CBN3	Fluoridation	Fluoride	Fluoride	1 mg/L (leaving WTP, leaving reservoir and throughout distribution system)	<0.9 mg/L for >72 hrs, >1.1 mg/L	<0.9 mg/L for >72 hrs, >1.5 mg/L, 0.0 mg/L for >24 hrs
CBN4	Reservoirs	All pathogens and all chemicals	Reservoir integrity	No breach of integrity (hatches locked, no holes in meshing)	-	Breach of integrity identified
CBN5	Distribution	Chlorine sensitive pathogens and all chemicals	Chlorine	0.6 – 3.0 mg/L	< 0.4 mg/L, >3.5 mg/L	< 0.2 mg/L, >4.0 mg/L

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
CBN6	Distribution (OCP)	All pathogens	Turbidity	<1.0 NTU	>1.0 NTU	>4.0 NTU

2.6.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Coonabarabran WTP is outlined in the following tables. Table 2-25 outlines the process instrumentation recommended to address the CCP control parameters for the Coonabarabran WTP, whilst Table 2-26 outlines additional instrumentation recommended to assist with the effective operation of the treatment plant.

New magflow meters are recommended to replace existing orifice plate flow meters and enable effective control of the plant as the existing orifice plate flowmeters are reported to have issues and are unreliable. Provision of level indication in chemical dosing tanks, as well as addition of liquid chemical dosing flow switches, will enable effective control of chemical dosing systems.

New chlorine gas dosing equipment is recommended for the implementation of automated chlorine dosing for pre-filter chlorine dosing, to improve manganese removal, and control for the new main disinfection dosing point to enable feedback trim control functionality. These additions shall improve manganese removal and disinfection reliability whilst also provide redundancy to improve reliability of chlorine dosing and ensure CCPs for disinfection are met. This would significantly improve the existing chlorine dosing equipment at Coonabarabran WTP, and would be installed within the existing chlorine dosing room.

New magflow meters are recommended to replace existing orifice plate flow meters and enable effective control of the plant as the existing orifice plate flowmeters are reported to have issues and are unreliable. This will enable effective control of the plant and enable flow paced dosing to occur. New dosing pumps, dosing flow switches and level indicating transmitters on chemical storage tanks are recommended for both the alum and lime dosing systems to enable more accurate flow pacing and pH trim control dosing functionality. This will enable effective automation and control of coagulant dosing and pH correction at the plant which are essential for effective coagulation and flocculation to occur, which is in turn essential for effective downstream clarification and filtration processes. This will also enable implementation of critical plant interlocks to improve water safety and plant reliability.

Automatic raw water flow control is already achieved at the WTP through the inlet flow control valve (primarily used to control flow from Timor Dam). VSD's however have been added to some raw water pumps and bores to enable greater flexibility in raw water source selection and blending.

Settled water pump VSDs are recommended to ensure the WTP can maintain a constant flowrate, rather than the current operation whereby the settled water pumps stop and start based on lagoon level which creates issues with trying to achieve a stable flow through the filters.

Similar to Baradine and Binnaway WTPs, with the addition of a new plant PLC, control can be implemented with various interlocks or alarming to ensure the process is operating effectively.

Table 2-25 Process instrumentation to facilitate effective implementation of CCPs for Coonabarabran WTP

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Turbidity	Raw Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks for high turbidity water entering the WTP or rapid changes in raw water turbidity. Rapid changes in turbidity require coagulant dose rate changes and thus should alert the operator or be used in lookup tables to automatically adjust coagulant dose once a sufficient correlation is established.
	Settled Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming for high turbidity water leaving the sedimentation lagoons before it reaches the filters. This helps to lengthen filter runtimes and reduce potential filter breakthrough. It will also

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
			help to identify when coagulation and flocculation fails, which impacts sedimentation performance.
	Filtered Water Turbidity Unit 1 (new existing)	Online turbidity analyser (1AI + DI)	CCP turbidity limits for filtration should be applied to filtered water from each individual filter. This is to ensure sufficient protection from protozoa in treated water and compliance with CCPs. Provide control functionality to initiate a filter backwash on detection of high filtered water turbidity.
	Filtered Water Turbidity Unit 2 (new existing)	Online turbidity analyser (1AI + DI)	CCP turbidity limits for filtration should be applied to filtered water from each individual filter. This is to ensure sufficient protection from protozoa in treated water and compliance with CCPs. Provide control functionality to initiate a filter backwash on detection of high filtered water turbidity.
	Combined Filtered Water Turbidity (existing to be relocated)	Online turbidity analyser (1AI + DI)	Confirmation that the combined filtered water is within CCP turbidity limits. This ensures the CWT is not filled with water exceeding the CCP turbidity limits.
	Treated Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks to ensure water exceeding the CCP turbidity limits is not sent to the community. This is the final check that the water is compliant.
Chlorine	Combined Filtered Water Free Chlorine	Online free chlorine analyser (1AI + DI)	Monitor free chlorine from pre-filter dosing system to ensure chlorine dosing free chlorine residual is sufficient for the oxide coated media process (manganese removal). Provide control functionality to enable free chlorine trim control dosing for pre-filter dosing.
	Treated Water Free Chlorine (existing)	Online free chlorine analyser (1AI + DI)	Ensure the free chlorine required for disinfection is sufficient for the treated water and provide trim dosing control for the automated chlorine gas system.
	Pre-filter Automated Chlorine Dosing	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by providing a new automated chlorinator and linking to set points for filtered water chlorine residual to maintain a constant free chlorine residual and improve manganese removal.
	Treated Water Automated Chlorine Dosing (existing)	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by linking to the existing automated dosing system to set points for treated water chlorine residual. Additional automation features will also ensure the required safety standards are met for the handling of chlorine gas.
Fluoride	Treated Water Fluoride	Online fluoride analyser (1AI + DI)	Provide monitoring, alarming and interlocks on fluoride concentrations in the treated water to ensure fluoride dosing does not exceed CCP limits.

Table 2-26 Process instrumentation to support improved process control at Coonabarabran WTP

Parameter	Recommended Instrumentation and I/O	Justification
Raw Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Provide monitoring (and alarms) for pH correction systems. Enable plant shutdown if outside limits to allow time for jar tests and changes to chemical doses to maintain effective coagulation and flocculation.
Coagulation pH & Temperature	Online pH & temperature analyser (2AI + DI)	Ensure optimum conditions for coagulation can be maintained to improve solids and organics (colour) removal. Provide control functionality to enable pH trim control dosing for pre-lime dosing. Enable plant shutdown if outside limits to allow time for jar tests and changes to chemical doses to maintain optimum pH for effective coagulation and flocculation.
Treated Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Provide monitoring (and alarms) for treated water pH and temperature, before it is sent to the community.
Settled Water Pumps (Existing) flow control	3 x Pump VSDs (3AI / 3AO / 3DI)	Provide capability to enable flow pacing to ensure settled water flowrate is matched to raw water flows and thus reduce current start/stop operation based on levels.
Settled Water Pump Station Level	Level indicating transmitter (1AI)	See above regarding flow pacing and balancing.
Little Pound Yard VSD Control	Pump VSD (1AI / 1AO / 1DI)	Provide capability to implement automatic flow control for Little Pound Yard pumping rates. This will enable operations staff to target a set range of plant flowrates based on selection of multiple bores from the borefield and also using VSD to top the flow to a desired flow setting.
Homeleigh Drive Bore 10 VSD Control	Pump VSD (1AI / 1AO / 1DI)	Provide capability to implement automation and control for Homeleigh Drive Bore 10 pumping rates (as per the above).
Raw Water Flow	Magnetic flowmeter (1AI + 2DI)	Provide more accurate flow monitoring and enable flow paced dosing. Replaces the current unreliable orifice plate flowmeter.
Filter Backwash Automation – Backwash Flow	Magnetic flowmeter (1AI + 2DI)	Provide monitoring of backwash flow to allow for backwash flow rate control using the existing backwash flow control valve and flowmeter. Replaces the current unreliable orifice plate flowmeter.
Alum Tank Level	Level indicating transmitter (1AI)	Provide monitoring and alarming for level in the coagulant storage tank. Ensure coagulant level is correctly maintained. Enable alarming at reorder levels etc.
Alum Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the coagulant is being dosed.
Alum Dosing	2 x Digital dosing pumps (D/S) (2AI/O+2DI)	Improve reliability of coagulant dosing by improving turndown capability and enabling more accurate flow paced dosing.
Lime Dosing Flow (x2)	2 x Flow switches (2DI)	Provide alarming and confirmation that Lime is being dosed to raw water and/or treated water.

Parameter	Recommended Instrumentation and I/O	Justification
Polymer Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the polymer is being dosed.

2.6.4 Existing plant and RTU controls

The plant is a basic conventional plant with chemical dosing systems implemented. Located at ground level below the control room is the plants main MCC. Based on the drawing set the plant was built in 1992, making the asset 28 years old. The main building also contains the chlorine dosing room, air compressor room, chemical dosing room (Polymer and Lime), Control and lab room. The site electrical feed comes from a transformer that connects to this building where the meter panel is located. There is also a Fluoride plant located just outside of the main building.

The plant is controlled via an Omron C200H PLC that is obsolete and needs to be upgraded. The PLC is mounted in a Control / Mimic panel in the control room upstairs. There is no SCADA system for the treatment plant, but the PLC is hardwired to a local RADTEL PLC that is mounted adjacent to the PLC control panel. A subset of data from the plant is then presented onto the RADTEL telemetry system.

The treatment plant houses the Council's RADTEL telemetry and SCADA system for the Northern area. The SCADA server is housed upstairs in the control room. The RADTEL unit is no longer manufactured or supported and as part of the telemetry SCADA planning, it will be replaced. The existing RTU currently monitors the following I/O:

- Stop (RR3 Level) Start
- Stop (RR1 Level) Start
- Plant Shutdown alarm
- LCU (Ctrl Mode CMF Alarm
- Telemetry mains failure
- CW Pump 1 running
- CW Pump 1 Healthy
- CW Pump 2 running
- CW Pump 2 Healthy
- CW Pump 3 running
- CW Pump 3 Healthy
- CW Tank Overflow
- CW Tank Low
- Turbidity Extra High
- Turbidity Extra High
- Chlorine Extra High
- Chlorine High
- R1 Clear Water Tank Level
- Chlorine Level
- Turbidity Level

The existing RADTEL RTU has:

- 5 Digital input cards (72 points) with 55 spare inputs
- 4 Digital output cards (32 points) with 19 spare outputs
- 1 Analogue input card (8 Points) with 5 spare inputs

Due to the lack of RTU inputs available and the outdated plant PLC, there is no way that the existing equipment can bring back the required inputs or control the plant to shut down the system on poor water quality. Therefore, a total control system upgrade is recommended.

The electrical drawings for the site were located, however the accuracy of the drawings is unknown.

2.6.5 Recommended control system upgrades

With the site PLC being obsolete and the status of the code unknown it is recommended that the PLC control panel is totally updated with a new panel that will allow for the new water quality instrumentation and future spares. The old panel and hardwired mimic panel should be totally decommissioned with all of the existing site I/O to be wired into the new panel. There may be an opportunity to mount the panel on the left-hand side of the existing PLC/Mimic panel, but this would mean the relocation of the site office and RADTEL panel. The detail of this and the cutover plan would have to be designed at the time of the upgrade.

The new PLC would be configured to communicate to the new Telemetry RTU via Modbus protocol, once the RADTEL is removed.

To cover the existing plant controls the new PLC should need to contain approximately:

- 96 digital input points
- 32 digital output points
- 8 analogue input points

However, this installation would also need to cover the additional 33 analogue and 27 digital points required for the new instrumentation listed in Table 2-25 and Table 2-26. This would be confirmed and refined during the concept design.

 *Figure 2-20 Coonabarabran and mimic control panel*	 *Figure 2-21 Coonabarabran plant MCC (picture 1)*
 *Figure 2-22 Coonabarabran plant MCC (picture 2)*	 *Figure 2-23 Coonabarabran plant MCC (picture 3)*

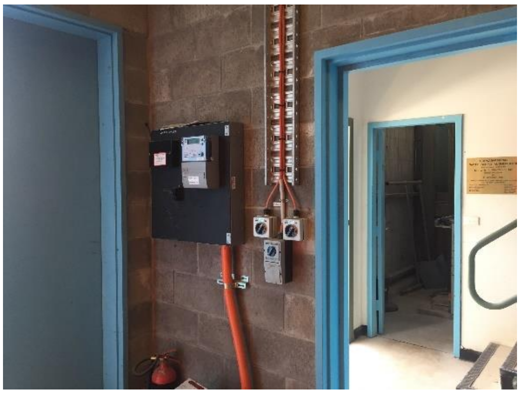

Figure 2-24 Coonabarabran mains power supply to MCC

Figure 2-25 Coonabarabran gallery cable tray near filters (picture 1)

Figure 2-26 Coonabarabran gallery cable tray near filters (picture 2)

Figure 2-27 Coonabarabran gallery cable tray near filters (picture 3)

2.6.6 Cost estimation

The estimated cost of the recommended upgrades for Coonabarabran WTP can be seen in Table 2-27. The table shows the total cost for Coonabarabran WTP, as well as the breakdown of costs in various upgrade areas. A contingency of 30% has been provided on top of the total cost estimate.

It should be noted that the cost estimate for control equipment is based on previous project experience for the installation of a new PLC and panel in the upstairs area. The estimate provided includes the recommended control equipment, panel materials and all installation costs. It is noted that Council are currently considering replacing the control equipment at a number of their sites, however these estimates assume that this work has not been completed.

A detailed breakdown of the cost estimation is provided in Appendix A.

Table 2-27 Estimated cost of recommended upgrades for Coonabarabran WTP

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$68,900
Flow Meters	$27,300
Instruments	$4,100
Pumps, Valves and Actuators	$115,000
Dosing Automation (includes dosing skid and pumps)	$58,100

Item	Cost (excl. GST)
Control Equipment	$650,000
Instrumentation installation	$11,700
Electrical Installation	$75,000
Indirect Costs	
Engineering Design	$179,000
Engineering Support	$22,500
Commissioning and Training	$50,000
Project Management	$101,100
Total Project Cost Estimate (-50% to +50%)	**$1,362,700**
Contingency (30% of Total Project Cost)	$408,900
Project Cost Estimate + Contingency (±50%)	**$1,771,600**

2.7 Dunedoo WTP

2.7.1 Existing WTP and instrumentation

WSC has 450 registered connections to their potable water network in the township of Dunedoo. The main bore (No.1), located on the Talbragar River, was replaced in 1984 and a second bore (No. 2) was installed, which now extracts ground water and delivers to the town.

Water is treated using liquid sodium hypochlorite dosing for disinfection. No further treatment is provided. Water is pumped from the bores to one of two reservoir sites in Dunedoo. The first reservoir is located on Bullinda Street (0.85 ML), whilst two reservoirs are located on Rhodes Street (2 x 0.24 ML), at a higher elevation.

A Telstra telemetry line links the reservoir in Bullinda Street to the bore pump. Low levels in Bullinda St Reservoir or the Rhodes St Reservoirs will call the bore to start pumping. Bullinda St Reservoir is always filled first via an altitude valve to prevent overflowing. Once the altitude valve closes the Rhodes St Reservoirs continue to fill due to their difference in elevation. High level in the Rhodes St Reservoirs calls the bore to stop pumping. Flow through the flow meter enables power for the chlorine dosing pump.

Currently the only instrumentation in the system is a treated water flow meter and bore level analyser. No water quality instrumentation or analysers currently exist on site to monitor and confirm compliance against CCPs. Therefore, it is impossible to monitor or verify the quality of treated water, or to shut down the treatment process if quality exceedances are detected when the WTP is not attended. The WTP is essentially running 'blind' when operations staff are not in attendance.

The existing WTP has the following process control functionality, summarised in Table 2-28.

Table 2-28 Existing process control functionality at Dunedoo WTP

Process Parameter	Monitoring Point
Flow monitoring	Treated water (magflow)
Level monitoring	Bore 2 level
	Bullinda St reservoir high/low level
	Rhodes St reservoir high/low level

2.7.2 CCP summary

The critical control points (CCPs) for the Dunedoo water treatment network are summarised in Table 2-29 (Warrumbungle DWMS Annual Report Aug-18 to Jul-19).

Table 2-29 Summary of CCPs for Dunedoo WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
DDO1	Disinfection (hypo)	Chlorine sensitive pathogens	Chlorine	1.1 – 2.2 mg/L	<0.9 mg/L, >3.0 mg/L	<0.7 mg/L, >4.0 mg/L
DDO2	Reservoirs	All pathogens and all chemicals	Reservoir integrity	No breach of integrity (hatches locked, no holes in meshing)	-	Breach of integrity identified
DDO3	Distribution	Chlorine sensitive pathogens and all chemicals	Chlorine	1.0 – 2.0 mg/L	< 0.5 mg/L, >3.0 mg/L	< 0.2 mg/L, >4.0 mg/L
DDO4	Distribution (OCP)	All pathogens	Turbidity	<1.0 NTU	>1.0 NTU	>4.0 NTU

2.7.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Dunedoo WTP is outlined in the following tables. Table 2-30 outlines the process instrumentation recommended to address the CCP control parameters for the Dunedoo WTP, whilst Table 2-31 outlines additional instrumentation recommended to assist with the effective operation of the treatment plant.

The existing sodium hypochlorite dosing system has many WHS issues and does not comply with AS3780 (*Storage and Handling of Corrosive Substances*). The dosing system does not have a bund and is located very tightly within a small shed attached to the main control building. Inadequate ventilation is also allowing corrosion to occur on the metal access doors and roof. The small dosing shed can also be very hot in summer which will result in increased hypochlorite degradation and by-product formation. For these reasons and others Council are considering building a new Chlorine Gas dosing system within a new building. A new chlorine gas dosing equipment will enable implementation of automated chlorine dosing. The new system will facilitate a switch from disinfection with sodium hypochlorite to the use of chlorine gas, in order to improve the reliability of chlorine dosing and ensure CCPs for disinfection are met. A new chlorine gas dosing room would also be recommended to house the automated chlorine dosing system.

Raw water flow control for this plant was not deemed necessary.

Table 2-30 Process instrumentation to facilitate effective implementation of CCPs for Dunedoo WTP

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Chlorine	Treated Water Free Chlorine	Online free chlorine analyser (1AI + DI)	Ensure the free chlorine residual required for disinfection is sufficient for the treated water and provide trim dosing control for the automated chlorine gas system.
	Automated Chlorine Dosing	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by linking an automated dosing system to set points for treated water chlorine residual. Additional automation features will also ensure the required safety standards are met for the handling of chlorine gas. (Included as part of a new Chlorine Gas dosing system)

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Turbidity OCP	Treated Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks for high turbidity water entering the WTP or rapid changes in raw water turbidity indicating potential surface water ingress into the bore head. This will ensure water exceeding the CCP turbidity limits is not sent to the community. This is the final check that the water is compliant.

Table 2-31 Process instrumentation to support improved process control at Dunedoo WTP

Parameter	Recommended Instrumentation and I/O	Justification
Treated Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Provide monitoring (and alarms) for treated water pH and temperature, before it is sent to the community.
Bore Level	Level indicating transmitter (1AI)	Provide bore water level monitoring to improve water security by enabling better control and implementation of water restriction triggers. Also enable data collection for improved long-term yield modelling.
Bore Pressure	Pressure indicating transmitter (1AI)	Monitoring and control of bore pump pressure.

2.7.4 Existing plant and RTU controls

The site is made up of 2 bore pumps and a sodium hypochlorite chemical dosing system. The sodium hypochlorite is dosed via a variable speed pump that has been set to a fixed speed with no feedback to the telemetry system. The sodium hypochlorite system is housed in a basic room on the eastern side of the main building.

Bore pump 1 is located approximately 30m from Bore pump 2, with the Control room situated between the two Bore Pumps. There is a pit located just outside of the control room that acts as the chlorine dosing point. Just outside of the fence line is another pit that houses the sites treated water flow meter.

There is an Elpro RTU mounted adjacent to bore pump number two that monitors some points on the site and controls the starting and stopping of the two bores.

The RTU unit is still manufactured and supported, however it is a low-level unit with no locate logic control functions available. The existing RTU currently monitors and controls the following I/O:

- Flow pulse signal
- Bore pump 1 running
- Bore pump 1 fault
- Bore pump 2 running
- Bore pump 2 fault
- Bore pump 3 running
- Bore pump 3 fault
- Phase failure relay
- No Flow alarm
- Switchboard surge protection
- Output 1 (Not labelled)
- Output 2 (Not labelled)
- Output 3 (Not labelled)
- Bore 1 Water Level
- Bore flow Rate

The existing Elpro RTU has:

- 12 digital input points with 1 spare input / outputs
- 6 analogue input points with 4 spare inputs

The RTU does not have enough digital or analogue inputs available for the proposed new instruments. There is also not enough room within the existing panel to expand the RTU I/O, therefore a new panel will have to be manufactured. The Elpro RTUs are not intelligent and therefore any logic to shut the bore pumps down would have to be done via hardwiring.

As a short-term solution Council could install an independent DNP3 based RTU that can communicate via Modbus to the Elpro unit. This will allow the RTU to monitor and control the site, while at the same time communicating key information to the Elpro system. Once the telemetry system has been upgraded the Elpro can be removed and redirect the site communicate directly to the SCADA via DNP3.

There are some electrical drawings for the main MCC and the RTU panel which appear to be current, however the RTU drawings have been marked up.

2.7.5 Recommended control system upgrades.

A new RTU and panel is recommended.

It is also recommended that the Chlorine system is upgraded to have an automatic dosing system that monitors the Chlorine residual and corrects the dosing output accordingly. This should be monitored via the RTU system.

To cover the existing plant controls the new RTU should need to contain approximately:

- 32 digital input points
- 16 digital output points
- 4 analogue input points

However, this installation would also need to cover the additional 8 analogue and 5 digital points required for the new instrumentation listed in Table 2-30 and Table 2-31. This would be confirmed and refined during the concept design.

Figure 2-28 Dunedoo control room

Figure 2-29 Dunedoo bore pump 1

Figure 2-30 Dunedoo bore pump 2

Figure 2-31 Dunedoo MCC

Figure 2-32 Dunedoo RTU panel

Figure 2-33 Dunedoo Chlorine dosing point

Figure 2-34 Dunedoo Chlorine dosing room

Figure 2-35 Dunedoo Chlorine dosing pump

2.7.6 Cost estimation

The estimated cost of the recommended upgrades for Dunedoo WTP can be seen in Table 2-32. The table shows the total cost for Dunedoo WTP, as well as the breakdown of costs in various upgrade areas. A contingency of 30% has been provided on top of the total cost estimate.

It should be noted that the cost estimate for dosing automation is based on previous project experience for the installation of a new chlorine gas dosing system in a new portable shed-type dosing room.

It is also noted that Council are currently considering replacing the control equipment at a number of their sites, however these estimates assume that this work has not been completed.

A detailed breakdown of the cost estimation is provided in Appendix A.

Table 2-32 Estimated cost of recommended upgrades for Dunedoo WTP

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$16,500
Flow Meters	$5,200
Instruments	$3,100
Dosing Automation (includes new chlorine gas dosing room)	$215,000
Control Equipment	$25,000
Instrumentation installation	$2,600
Electrical Installation	$20,000
Indirect Costs	
Engineering Design	$49,000
Engineering Support	$10,000
Commissioning and Training	$12,500
Project Management	$28,800
Total Project Cost Estimate (-50% to +50%)	**$387,700**
Contingency (30% of Total Project Cost)	$116,400
Project Cost Estimate + Contingency (±50%)	**$504,100**

2.8 Kenebri WTP

2.8.1 Existing WTP and instrumentation

WSC has 13 registered connections to their Kenebri potable water network, with many properties on private bore water and/or rainwater systems. The water supply system draws water from a single artesian bore.

The Kenebri system utilises sodium hypochlorite dosing for disinfection. No further treatment is provided. Water is pumped from the bore site to two ground level poly storage tanks arranged in series. Water is then pumped and pressured by a dedicated pressure pump, with integral pressure switch, through a 75 mm AC distribution main into the township.

Low level in the storage tanks calls the bore to start pumping. Water in the reticulation system is controlled under pressure by the pump and pressure switch control. A high level in the storage tanks triggers the bore to stop pumping.

The only instrumentation currently at the plant is an offline treated water free chlorine analyser (not yet connected), with no interlocks to plant controls. No other online water quality instrumentation or analysers currently exist on site to confirm compliance against CCP/OCPs (turbidity). Therefore, it is impossible to monitor or verify the quality of treated water, or to shut down the treatment process if quality exceedances are detected when the WTP is not attended. The WTP is essentially running 'blind' when operations staff are not in attendance.

The existing WTP has the following online analysers, summarised in Table 2-33.

Table 2-33 Existing online water quality analysers at Kenebri WTP

Water Quality Parameter	Monitoring Point
Free chlorine (currently not online or connected)	Treated water

The existing WTP has the following process control functionality, summarised in Table 2-34.

Table 2-34 Existing process control functionality at Kenebri WTP

Process Parameter	Monitoring Point
Level switches	Ground level storage tank high/low level
Pressure switches	High pressure reticulation pump

2.8.2 CCP summary

The critical control points (CCPs) for the Kenebri water treatment network are summarised in Table 2-35 (Warrumbungle DWMS Annual Report Aug-18 to Jul-19).

Table 2-35 Summary of CCPs for Kenebri WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
KBI1	Disinfection (hypo)	Chlorine sensitive pathogens	Chlorine	1.5 – 2.3 mg/L	<1.2 mg/L, >2.8 mg/L	<1.0 mg/L, >4.0 mg/L
KBI2	Reservoirs	All pathogens and all chemicals	Reservoir integrity	No breach of integrity (hatches locked, no holes in meshing)	-	Breach of integrity identified
KBI3	Distribution	Chlorine sensitive pathogens and all chemicals	Chlorine	1.0 – 2.0 mg/L	< 0.4 mg/L, >2.5 mg/L	< 0.2 mg/L, >4.0 mg/L

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
KBI4	Distribution (OCP)	All pathogens	Turbidity	<1.0 NTU	>1.0 NTU	>4.0 NTU

2.8.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Kenebri WTP is outlined in the following tables. Table 2-36 outlines the process instrumentation recommended to address the CCP control parameters for the Kenebri WTP, whilst Table 2-37 outlines additional instrumentation recommended to assist with the effective operation of the treatment plant.

A new magflow meter is recommended to monitor flows and demand remotely and enable flowpaced dosing. Raw water flow control for this plant was not deemed necessary.

Table 2-36 Process instrumentation to facilitate effective implementation of CCPs for Kenebri WTP

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Chlorine	Treated Water Free Chlorine & pH (Existing)	Combined free chlorine and pH analyser (2AI + DI)	Provide control functionality using the existing analyser to enable automated hypo dosing and ensure the free chlorine residual is sufficient for treated water CCP. This can be achieved through the existing Wallace and Tiernan control unit. It is noted that Council is currently in the process of installing a new free chlorine analyser for this site.
	Treated Water Automated Chlorine Dosing	Digital dosing pump (1AI/O+1DI)	Digital dosing pump to replace existing hypo dosing pump to enable automated hypo dosing and provide the ability to adjust hypo dosing remotely.
Turbidity (OCP)	Treated Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks for high turbidity water entering the WTP or rapid changes in raw water turbidity indicating potential surface water ingress into the bore head. Ensure compliance with OCP.

Table 2-37 Process instrumentation to support improved process control at Kenebri WTP

Parameter	Recommended Instrumentation and I/O	Justification
Treated Water Pressure	Pressure indicating transmitter (1AI)	Monitoring of treated water pump/reticulation pressure.
Bore Level	Level indicating transmitter (1AI)	Provide bore water level monitoring to improve water security by enabling better control and implementation of water restriction triggers. Also enable data collection for improved long-term yield modelling. Could also be used to detect sudden level increases caused by surface water intrusion.
Treated Water Flow	Magnetic flowmeter (1AI + 2DI)	Provide more accurate flow monitoring and improve demand management.

Parameter	Recommended Instrumentation and I/O	Justification
Hypo Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the hypo is being dosed.

2.8.4 Existing plant and RTU controls

The site consists of a bore pump that feeds into a two poly tanks at ground level. The water is then pumped directly into the distribution network via a pressure pump system. This system is control via simple hardwiring and level switches. The control system in mounted in a basic meter panel within the pump room and appears to be in poor condition and may be made of asbestos. There is no voltage transformer in the panel which indicates that the control system is based on 240VAC. This may present a safety risk to the maintenance and operational staff as the level floats will have 240VAC on devices such as the level switches. It would be advisable to mount the equipment in a more weatherproof arrangement with a low voltage supply to external devices. The sodium hypochlorite dosing system is a basic configuration that is simply a drum that holds the liquid, which is pumped into the water when the bore pump is running via a variable speed dosing pump that has been fixed to a single speed.

The RTU is in a meter panel within the pump shed and monitors the operation of the bore pump and the pressure pump, as well as the reservoir level. The RTU is a RADTEL unit and is no longer manufactured or supported and as part of the telemetry SCADA planning, it will be replaced. The existing RTU currently monitors the following I/O:

- Bore pump running
- Bore pump Fault
- High tank low level
- Low tank low level
- Power failure
- Reservoir level (0-100%)

The existing RADTEL RTU has:

- 8 digital input points with 3 spare inputs
- 8 digital output points with 8 spare outputs
- 2 analogue input points with 2 spare inputs

Due to the lack of RTU inputs available there is no way that the existing equipment can bring back the required inputs or control the plant to shut down on poor water quality. Therefore, a total control system upgrade is recommended.

There is a new Chlorine residual unit fitted to the site however it is not wired to the RTU.

There were no electrical drawings present on site.

2.8.5 Recommended control system upgrades.

To help improve the operation and safety of the site it is recommended that the current wiring system is replaced, and the panel upgraded to a new IP weather rated panel. With the councils RTU and telemetry system being preplaced it would be logical to replace the hardwired control with an RTU based control system. The RTU could then monitor and control the site. It is recommended that a new DNP3 RTU is placed onto the site to monitor and control the assets.

The new site electrical panel would be a simple form 1 constructed panel that has 2 sections, a 415V section and a telemetry RTU section. The panel would be mounted adjacent to the existing meter panel with all the existing devices rewired to the panel. As part of the upgrade the new instruments could be wired to the new RTU panel.

To cover the existing plant controls the new RTU should need to contain approximately:

- 16 digital input points
- 8 digital output points
- 4 analogue input points

However, this installation would also need to cover the additional 4 analogue and 4 digital points required for the new instrumentation listed in Table 2-36 and Table 2-37. This would be confirmed and refined during the concept design.

Figure 2-36 Kenebri site layout

Figure 2-37 Kenebri Chlorine analyser

Figure 2-38 Kenebri Chlorine dosing pump

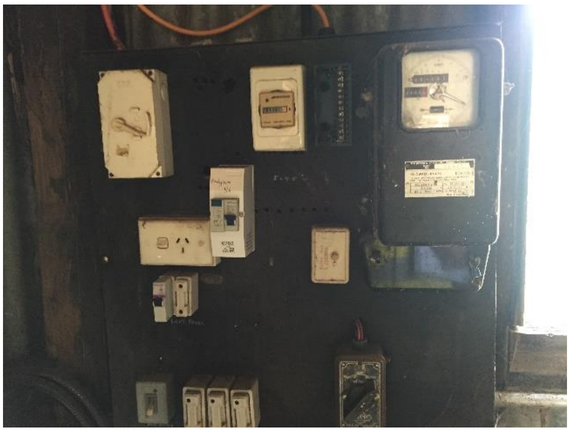

Figure 2-39 Kenebri power distribution and control

2.8.6 Cost estimation

The estimated cost of the recommended upgrades for Kenebri WTP can be seen in Table 2-38. The table shows the total cost for Kenebri WTP, as well as the breakdown of costs in various upgrade areas. A contingency of 30% has been provided on top of the total cost estimate.

It is noted that Council are currently considering replacing the control equipment at a number of their sites, however these estimates assume that this work has not been completed.

A detailed breakdown of the cost estimation is provided in Appendix A.

Table 2-38 Estimated cost of recommended upgrades for Kenebri WTP

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$10,400
Flow Meters	$3,100
Instruments	$3,600
Dosing Automation	$4,000

Item	Cost (excl. GST)
Control Equipment	$20,000
Instrumentation Installation	$1,600
Electrical Installation	$15,000
Indirect Costs	
Engineering Design	$39,000
Engineering Support	$10,000
Commissioning and Training	$10,000
Project Management	$4,800
Total Project Cost Estimate (-50% to +50%)	**$121,500**
Contingency (30% of Total Project Cost)	$36,500
Project Cost Estimate + Contingency (±50%)	**$158,000**

2.9 Mendooran WTP

2.9.1 Existing WTP and instrumentation

The Mendooran WTP was constructed adjacent to the Council Depot, on the corner of Dalglish and Benewa Streets, and operates at a capacity of 1.0 ML/day. Water is sourced from a well (Well 1) in the Castlereagh River, near River and Dalglish Streets. During drought, Well 1 can experience low levels of water which has been experienced in recent years, in which case the system can utilise water drawn from a bore located downstream of the well on Castlereagh River. A new emergency bore has also been constructed onsite (however has potentially contributed to algae issues in the sedimentation lagoons due to high phosphorus concentrations).

The treatment process consists of potassium permanganate dosing and aeration, followed by coagulation using poly-aluminium chloride, hydraulic flocculation, lagoon sedimentation and dual media filtration (coal/sand). Filtered water is collected in a filtered water tank prior to being pH corrected, when required, using soda ash and dosed with sodium hypochlorite for disinfection prior to storage. Treated water from the clear water tank is pumped to the reticulation system and stored in one of four reservoirs that have a combined capacity of 1.4 ML. There is also a fluoride dosing system on site that is currently not operational.

A low level setpoint in any of the reservoirs calls the treated water pumps to start. Following this, a low level in the CWT calls the settled lagoon pumps to start, whilst a low level in the settled water pumping station calls the raw water pumps to start pumping. Raw water pumps will start and stop based on t the 'start' and 'stop' level setpoints in the settled water pumping station. Similarly, the settled water pumps will start and stop based on the 'start' and 'stop' level setpoints in the CWT. The raw water pumps and settled water pumps are however both fixed speed and this flow balancing is problematic, and the plant operates in a batch type operation unless flowrates are aligned via the use of manual valve adjustments. Plant raw water flowrate and settled water flowrate (filtered water flowrate) is set via manual valves. Treated water is delivered to the Standpipe reservoir and Coolabah reservoirs (x3). The Standpipe reservoir is filled preferentially until the high level setpoint is reached, upon which a control valve closes and thus directs treated water to the Coolabah reservoirs. A high level in the Coolabah reservoirs triggers the treated water pumps to stop. The WTP then stops in a cascade manner.

Mendooran WTP is one of the more sophisticated plants in the shire in terms of existing levels of automation and control. The WTP has various flowmeters, level instruments, water quality analysers and switches (refer to Table 2-39 and Table 2-40) along with various control sequences. This includes automatic filter backwashing, flow paced chemical dosing and pump start/stop sequences. Although a detailed review of the control philosophy of the WTPs was not part of the scope of this project, it appears that the WTP was never fully commissioned properly and that certain aspects of the design were not actually included as suggested in the operational manual. This has been confirmed through discussion with operations staff, previous projects (Filter Inspection) and through a quick review of the operational manual. In addition, the design of certain systems such as the chemical dosing pipework configuration suggests that certain safety in design elements were never adhered to. For example, some of the non-return valves on the service water supply to chemical dosing lines are incorrectly placed meaning chemicals could be pumped back through the service water system. This was reported to have occurred on the coagulant dosing system when sludge build-up in the clear water tank was observed and traced back to coagulant dosing bypassing straight into the clear water tank through the service water system. Therefore, a thorough review and reverse engineer of the code is recommended prior to re-commissioning the WTP to ensure that the appropriate controls and interlocks exist and are working effectively. In conjunction with this a HAZOP should be undertaken to ensure the design is inherently safe enough to reduce risk to operations staff and ensure water safety is not compromised when plant items fail.

Instrumentation currently available at the plant consists of multiple water quality analysers and various magflow meters and process control instrumentation. However, it appears that not all the current water quality analysers are correctly interlocked to confirm compliance against CCPs. In addition, there are not enough water quality analysers throughout the process to provide a multiple barrier approach to monitoring and ensure compliance with CCP/OCPs and improve operability. Therefore, further improvements are recommended to verify the quality of treated water, or to shut down the treatment process if quality exceedances are detected when the WTP is not attended.

The existing WTP has the following online analysers, summarised in Table 2-39.

Table 2-39 Existing online water quality analysers at Mendooran WTP

Water Quality Parameter	Monitoring Point
Turbidity	Raw water
	Combined filtered water
Free chlorine	Combined filtered water
	Treated water (post CWT)
pH	Raw water
	Treated water

The existing WTP has the following key process control functionality, summarised in Table 2-40.

Table 2-40 Existing key process control functionality at Mendooran WTP

Process Parameter	Monitoring Point
Flow monitoring	Bore 1 (magflow)
	Bore 2 (magflow)
	Raw water pumping station (magflow)
	Settled water pumping station (magflow)
	Filtered water (magflow)
	Backwash flow (magflow)
	Treated water (magflow)
Level monitoring	Bore 1
	Bore 2
	Raw water pumping station
	Filter level (x2)
	Sedimentation lagoons
	Settled water pumping station
	Filtered water tank
	Clear water tank
	All reservoirs (x4)
	Various chemical storage tanks
Level switches	Filter levels
	Filtered water tank low/high
Flow switches	Raw water pump 1
	Raw water pump 2
	Settled water pump 1
	Settled water pump 2
	Various chemical dosing and service water switches

2.9.2 CCP summary

The critical control points (CCPs) for the Mendooran water treatment network are summarised in Table 2-41 (Warrumbungle DWMS Annual Report Aug-18 to Jul-19).

Table 2-41 Summary of CCPs for Mendooran WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Limit	Critical Limit
MDN1	Filtration	All pathogens	Turbidity	<0.2 NTU	>0.3 NTU	>0.5 NTU
MDN2	Disinfection (hypo)	Chlorine sensitive pathogens	Chlorine	1.5 – 3.0 mg/L	<1.2 mg/L, >3.5 mg/L	<1.0 mg/L, >4.0 mg/L
MDN3	Reservoirs	All pathogens and all chemicals	Reservoir integrity	No breach of integrity (hatches locked, no holes in meshing)	-	Breach of integrity identified
MDN4	Distribution	Chlorine sensitive pathogens and all chemicals	Chlorine	0.7 – 2.0 mg/L	<0.4 mg/L, >3.0 mg/L	<0.2 mg/L, >4.0 mg/L
MDN5	Final pH (OCP)	High/Low pH	pH	7.5 – 8.3	7.0 – 8.4	6.5 – 8.5
MDN6	Fluoridation	Fluoride	Fluoride	1 mg/L (leaving WTP, leaving reservoir and throughout distribution system)	<0.9 mg/L for >24 hrs, >1.1 mg/L	>1.5 mg/L, <0.9 mg/L for >72 hrs, 0.0 mg/L for >24 hrs
MDN7	Distribution (OCP)	All pathogens	Turbidity	<1.0 NTU	>1.0 NTU	>4.0 NTU

2.9.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Mendooran WTP is outlined in the following tables. Table 2-42 outlines the process instrumentation recommended to address the CCP control parameters for the Mendooran WTP, whilst Table 2-43 outlines additional instrumentation recommended to assist with the effective operation of the treatment plant.

Following the E.Coli incident and general system audit of Mendooran WTP undertaken in response, the decision was made to replace the existing sodium hypochlorite dosing system with a new chlorine gas dosing system. The new chlorine gas dosing equipment is recommended for the implementation of automated chlorine dosing. This will facilitate a switch from disinfection with sodium hypochlorite to the use of chlorine gas, in order to improve the reliability of chlorine dosing and ensure CCPs for disinfection are met. A new chlorine gas dosing room would also be recommended to house the automated chlorine dosing system to enable trim feedback control dosing.

Provision of level indication in chemical dosing tanks, as well as recommissioning of existing liquid chemical dosing flow switches, will enable effective automation of chemical dosing systems.

Raw water and settled water pump VSDs are recommended to ensure the WTP can maintain a constant flowrate, rather than the current operation whereby the raw water and settled water pumps stop and start based on lagoon level which creates issues with trying to achieve a stable flow through the filters and also maintaining consistent coagulation and flocculation. Plant runtimes should be maximised to improve water quality rather than operating with frequent starts and stops.

Table 2-42 Process instrumentation to facilitate effective implementation of CCPs for Mendooran WTP

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Turbidity	Raw Water Turbidity (existing)	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks for high turbidity water entering the WTP or rapid changes in raw water turbidity. Rapid changes in turbidity require coagulant dose rate changes and thus should alert the operator or be used in lookup tables to automatically adjust coagulant dose once a sufficient correlation is established.
	Settled Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming for high turbidity water leaving the sedimentation lagoons before it reaches the filters. This helps to lengthen filter runtimes and reduce potential filter breakthrough. It will also help to identify when coagulation and flocculation fails, which impacts clarifier performance.
	Filtered Water Turbidity Unit 1	Online turbidity analyser (1AI + DI)	CCP turbidity limits for filtration should be applied to filtered water from each individual filter. This is to ensure sufficient protection from protozoa in treated water and compliance with CCPs.
	Filtered Water Turbidity Unit 2	Online turbidity analyser (1AI + DI)	CCP turbidity limits for filtration should be applied to filtered water from each individual filter. This is to ensure sufficient protection from protozoa in treated water and compliance with CCPs.
	Combined Filtered Water Turbidity (existing)	Online turbidity analyser (1AI + DI)	Confirmation that the combined filtered water is within CCP turbidity limits. This ensures the CWT is not filled with water exceeding the CCP turbidity limits.
	Treated Water Turbidity	Online turbidity analyser (1AI + DI)	Provide alarming and interlocks to ensure water exceeding the CCP turbidity limits is not sent to the community. This is the final check that the water is compliant.
Chlorine	Treated Water Free Chlorine Pre-CWT	Online free chlorine analyser (1AI + DI)	Ensure the free chlorine required for disinfection is sufficient for water going into the CWT. This ensures the CWT is not filled with water that does not have sufficient chlorine residual and also confirms that chorine dosing is occurring. Provide trim dosing control for the automated chlorine gas dosing system.
	Treated Water Free Chlorine Post-CWT (existing)	Online free chlorine analyser (1AI + DI)	Provide final confidence that the water entering the reticulation system has appropriate free chlorine residuals.
	Treated Water Automated Chlorine Dosing	Automatic chlorinator (1AI + DI)	Improve reliability of chlorine dosing by providing a new automated chlorinator and linking to set points for treated water chlorine residual. Additional automation features will also ensure the required safety standards are met for the handling of chlorine gas.
Fluoride	Treated Water Fluoride	Online fluoride analyser (1AI + DI)	Provide monitoring, alarming and interlocks on fluoride concentrations in the treated water to ensure fluoride dosing does not exceed CCP limits.

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Final pH	Treated Water pH & Temperature (existing)	Online pH & temperature analyser (2AI + DI)	Provide monitoring (and alarms) for treated water pH and temperature, before it is sent to the community.

Table 2-43 Process instrumentation to support improved process control at Mendooran WTP

Parameter	Recommended Instrumentation and I/O	Justification
Coagulation pH & Temperature	Online pH & temperature analyser (2AI + DI)	Ensure optimum conditions for coagulation can be maintained to improve solids and organics (colour) removal. Provide control functionality to enable pH trim control dosing for pre-soda ash dosing. Enable plant shutdown if outside limits to allow time for jar tests and changes to chemical doses to maintain optimum pH for effective coagulation and flocculation.
Settled Water Pumps (Existing) flow control	2 x Settled water pump VSDs (2AI / 2AO / 4DI)	Provide capability to enable flow pacing to ensure settled water flowrate is matched to raw water flows and thus reduce current start/stop operation based on levels.
Settled Water Pumping Station Level (existing)	Level indicating transmitter (1AI)	See above regarding flow pacing and balancing. Existing analyser however control and programming required.
River Raw Water Site VSD Control	Pump VSDs (2AI / 2AO / 4DI)	Provide capability to implement automation and control for river raw water pumping rates.
Bore VSD Control	Pump VSDs (2AI / 2AO / 4DI)	Provide capability to implement automation and control for bore water pumping rates.
PACL Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the coagulant is being dosed.
Potassium Permanganate Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the potassium permanganate is being dosed.
Soda Ash Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the soda ash is being dosed.

2.9.4 Existing plant and RTU controls

The plant is the most complex and automated site within the Warrumbungle area. Located in a dedicated switchroom is the MMC and PLC control for the plant. Based on the drawing set the plant was built in 2009, make the asset 11 years old. The MCC and PLC section is in good condition and doesn't need replacing. The main building also contains air compressor room, chemical dosing room (Polymer, Soda ash, Chlorine and potassium permanganate). There is a separate lab room adjacent to the switchroom that is well set out and maintained. There is also a separate Fluoride plant located just outside of the main building, however it is not operational.

The plant is controlled via a CompactLogix L32E PLC that is still manufactured and supported by the Alan Bradley. The PLC is mounted in a dedicated Control panel that is attached to the main MCC. There is no PC based SCADA system for the treatment plant, but there are two HMIs that monitor and control the system. One is mounted on the PLC cubicle door and the other is at the top of the filter platform. The

PLC Code is backed up and available so any changes to accommodate for the new instruments would be possible.

There is an Elpro RTU mounted adjacent to PLC that communicates to the local reservoirs for a call for water signal that is passed through to the PLC via a Communications port, likely to be Modbus. The Elpro also communicates to the FLYGT controller that is mounted in the same panel. This FLYGT unit controls the pumping of the river pumps and the bore pump based on the lagoon levels.

As the site Elpro RTU is wired to the FLYGT unit only it is not clear what information is coming back from plant PLC to the Elpro RTU however it is believed to be minimal. A recent project with Council installed a new 3G unit to provide direct SMS alarming from the plant and not the telemetry system. It is envisaged that any new alarms would be pasted through via this link.

The electrical drawings for the site was located, which appear to be current however, the drawing set does contain red pen mark-ups.

2.9.5 Recommended control system upgrades.

According to the electrical drawings on site there are 17 spare analogue inputs available. And there is a full spare Din rail within the panel to mount the new terminals for connection to the new instruments.

Once the telemetry has been changed over the existing PLC could be configured to pass detailed Modbus information on the new RTU.

The existing PLC should have enough space to cover the additional 14 analogue and 15 digital points required for the new instrumentation listed in Table 2-42 and Table 2-43, however an additional card may be required allow for spares. This would be confirmed and refined during the concept design.

Figure 2-40 Mendooran PLC panel

Figure 2-41 Mendooren RTU

Figure 2-42 Mendooran HMI & FLYGT display

Figure 2-43 Mendooran FLYGT controller

Figure 2-44 Allen Bradley HMI

Figure 2-45 FLYGT display

2.9.6 Cost estimation

The estimated cost of the recommended upgrades for Mendooran WTP can be seen in Table 2-44. The table shows the total cost for Mendooran WTP, as well as the breakdown of costs in various upgrade areas. A contingency of 30% has been provided on top of the total cost estimate.

It should be noted that the cost estimate for dosing automation is based on previous project experience for the installation of a new chlorine gas dosing system in a new portable shed-type dosing room.

It is also noted that Council are currently considering replacing the control equipment at a number of their sites, however these estimates assume that this work has not been completed.

A detailed breakdown of the cost estimation is provided in Appendix A.

Table 2-44 Estimated cost of recommended upgrades for Mendooran WTP

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$71,000
Instruments	$2,300
Pumps, Valves and Actuators	$90,000
Dosing Automation (includes new chlorine gas dosing room)	$215,000
Control Equipment	$15,000
Instrumentation installation	$7,100
Electrical Installation	$25,000
Indirect Costs	
Engineering Design	$139,000
Engineering Support	$22,500
Commissioning and Training	$20,000
Project Management	$42,600
Total Project Cost Estimate (-50% to +50%)	**$649,500**
Contingency (30% of Total Project Cost)	$194,900
Project Cost Estimate + Contingency (±50%)	**$844,400**

3 Cost estimation for proposed works

The estimated costs for the work proposed through the findings of this audit are shown in Table 3-1. The table shows the total cost of the recommended upgrades across all of Council's sites, as well as the distribution of costs to each site. A contingency of 30% has been included in the individual cost estimates for each site.

Breakdown into key cost areas can be seen in the individual cost estimate tables for each site, and a detailed breakdown of the cost estimation has been provided in Appendix A.

Table 3-1 Overall cost estimation for the proposed works.

Site	Cost (Excl. GST)
Baradine WTP	$1,923,100
Binnaway WTP	$2,138,200
Bugaldie WTP	$159,300
Coolah WTP	$558,500
Coonabarabran WTP	$1,771,600
Dunedoo WTP	$504,100
Kenebri WTP	$158,000
Mendooran WTP	$844,400
Total (Including Contingency)	**$8,057,200**

4 Proposed delivery strategy

The proposed delivery strategy would be a design and construct contract with technical support during that period. Further investigation and design are required to progress the project to the point where it is ready to go to market, however. This scoping study and audit has identified the existing levels of monitoring, control and automation for each WTP then identified the key upgrade components recommended and estimated a cost for each upgrade. Therefore, the next stage is to prepare the following:

1. Concept Design -
    i. Process design with the ultimate confirmation on equipment selection, including:
        a. P&ID development
        b. Equipment List
        c. Functional Design Specification/Control Philosophy
    ii. Safety in Design:
        a. HAZOP and CHAZOP
    iii. Site general arrangement drawings showing locations of equipment with sample point tie ins
    iv. Electrical design
    v. Cost estimate
2. Scope of works document and technical specifications.

A concept design is required to further develop the preliminary scope of works and refine the details for each site. A HAZOP and CHAZOP is also required for sites with a new PLC to ensure that the recoding of the WTP control addresses risks and identifies other process and operability improvements that may be realised with minor additions to the scope of works. Following completion of the Concept Design, scope of works document and technical specifications, it is envisaged that Council would proceed with a Design and Construct procurement method while engaging the designer in an owners engineer role to provide technical support during delivery to ensure the original intent of the design is maintained through to construction and commissioning. The importance of following the above process cannot be stressed enough. The example of Mendooran WTP is a case where the above would have prevented many of the issues that the WTP currently experiences and has experienced since it was partially commissioned in 2009.

Appendix A Cost Estimation Spreadsheets

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jun-20

Site: All WSC Sites (Total)

Direct Costs	Baradine	Binnaway	Bugaldie	Coolah	Coonabarabran	Dunedoo	Kenibri	Mendooran	Total for Each Category
1. Water Quality Analysers	$85,400	$97,600	$10,400	$35,500	$68,900	$16,500	$10,400	$71,000	**$395,700**
2. Flow Meters	$16,000	$32,900	$3,100	$5,200	$27,300	$5,200	$3,100	-	**$92,800**
3. Instruments	$3,100	$4,400	$3,600	$5,000	$4,100	$3,100	$3,600	$2,300	**$29,200**
4. Pumps, Valves Actuators	$2,000	$55,000	-	-	$115,000	-	-	$90,000	**$262,000**
5. Dosing Automation	$96,000	$96,000	$4,000	$232,000	$58,100	$215,000	$4,000	$215,000	**$920,100**
6. Backwash Automation	$5,000	$21,300	-	-	-	-	-	-	**$26,300**
7. Control Equipment	$1,000,000	$1,050,000	$20,000	$25,000	$650,000	$25,000	$20,000	$15,000	**$2,805,000**
7. Intrumentation Installation	$15,900	$16,600	$1,600	$2,800	$11,700	$2,600	$1,600	$7,100	**$59,900**
8. Electrical Installation	$20,000	$20,000	$15,000	$20,000	$75,000	$20,000	$15,000	$25,000	**$210,000**
Indirect Costs									
9. Engineering Design	$79,000	$79,000	$39,000	$49,000	$179,000	$49,000	$39,000	$139,000	**$652,000**
10. Engineering Support	$22,500	$22,500	$10,000	$10,000	$22,500	$10,000	$10,000	$22,500	**$130,000**
11. Comissioning and Training	$10,000	$10,000	$10,000	$12,500	$50,000	$12,500	$10,000	$20,000	**$135,000**
12. Project Management	$124,400	$139,400	$5,800	$32,600	$101,100	$28,800	$4,800	$42,600	**$479,500**
Grand Total (excluding contingency)	**$1,479,300**	**$1,644,700**	**$122,500**	**$429,600**	**$1,362,700**	**$387,700**	**$121,500**	**$649,500**	**$6,197,500**
Contingency (30%)	$443,800	$493,500	$36,800	$128,900	$408,900	$116,400	$36,500	$194,900	**$1,859,700**
Grand Total (Inlcuding contingency)	**$1,923,100**	**$2,138,200**	**$159,300**	**$558,500**	**$1,771,600**	**$504,100**	**$158,000**	**$844,400**	**$8,057,200**

Grand Total for all WSC Sites (Inlcuding Contingency)	**$8,057,200**

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jan-21

Site: Baradine

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2013 - 2020				1.1270	
2018 - 2020				1.0290	
Direct Costs					
1. Water Quality Analysers					
Turbidity Analyser	4	Item	$6,400	$25,600	
Turbidity Controller	4	Item	$4,000	$16,000	
Free Chlorine Analyser	1	Item	$5,800	$5,800	
Fluroide Analyser	1	Item	$19,000	$19,000	
pH and Temperature Meter	3	Item	$2,000	$6,000	
pH and Temperture Controller	3	Item	$2,300	$6,900	
Combined Free Chlorine, pH and Temperature	1	Item	$6,100	$6,100	
					$85,400
2. Flow Meters					
Raw & Treated Water Magflow Meters	2	Item	$5,000	$10,290	
Backwash Magflow Meter	1	Item	$5,500	$5,660	
					$16,000
3. Instruments					
Level Indicating Transmitter	2	Item	$800	$1,600	
Dosing System Flow Switches	3	Item	$500	$1,500	
					$3,100
4. Pumps, Valves, Actuators					
Clarified Sludge Control Actuator	1	Item	$2,000	$2,000	
					$2,000
5. Dosing Automation					
Chlorine Dosing					
Automatic Chlorinator	2	Item	$4,900	$9,800	
Vacuum Regulators (2x Pair)	1	Item	$3,300	$3,300	
Injector	2	Item	$1,000	$2,000	
Pipework & Board	2	Item	$5,000	$10,000	
Leak Detection	1	Item	$6,000	$6,000	
Automatic Shutoff System	1	Item	$13,100	$13,100	
Gas Flow Switch	2	Item	$1,100	$2,200	
Dual Cylinder Weight Scales	1	Item	$5,700	$5,700	
Carbon Filter Cylinder	1	Item	$900	$900	
New Soda Ash Dosing Pumps (D/D)	2	Item	$9,900	$19,800	
New ACH Dosing Pumps (D/S)	2	Item	$4,000	$8,000	
Skids and Pipework for ACH & Soda Ash Dosing Pumps	2	Item	$6,700	$15,102	
					$96,000
6. Backwash Automation					

Filter Headloss DPT (Replace Existing)	1	Item	$2,500	$2,500	
Air Scour DPT (Replace Existing)	1	Item	$2,500	$2,500	
					$5,000
7. PLC and Control Equipment					
New MCC and PLC fitted to Plant in New Switchroom	1	Lump Sum	$1,000,000	$1,000,000	
					$1,000,000
8. Instrumentation Installation					
Plumbing and Piping for Analysers	10	Item	$500	$5,000	
Labour Hours	136	Hours	$80	$10,880	
					$15,900
9. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$5,000	$5,000	
Labour Hours	1	Lump Sum	$15,000	$15,000	
					$20,000
Indirect Costs					
10. Engineering Design					
Process Design	40	Hours	$250	$10,000	
P&ID Preparation	20	Hours	$250	$5,000	
Site GAs (Instrument Locations)	16	Hours	$250	$4,000	
HAZOP and CHAZOP	40	Hours	$250	$10,000	
Functional Design Specification (FDS)	100	Hours	$250	$25,000	
Electrical Design	-	-	-	-	
Scope of Works Document	20	Hours	$250	$5,000	
Technical Specification for D&C	80	Hours	$250	$20,000	
					$79,000
11. Engineering Support					
Tender Review	40	Hours	$250	$10,000	
Technical Support (Owners Engineer/Representative)	50	Hours	$250	$12,500	
					$22,500
12. Commisioning and Training					
Commissiong and Training Time	40	Hours	$250	$10,000	
					$10,000
Total, PM and Contingency					
Total					
Total Cost (Excluding PM and Contingency)					**$1,354,900**
Project Management					
Project Management Costs					**$124,400**
Grand Total					
Grand Total (excluding contingency)					**$1,479,300**
Contingency					$443,800
Grand Total					**$1,923,100**

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jan-21

Site: Binnaway

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2013 - 2020				1.1270	
2017 - 2020				1.0490	
Direct Costs					
1. Water Quality Analysers					
Turbidity Analyser	6	Item	$6,400	$38,400	
Turbidity Controller	6	Item	$4,000	$24,000	
Free Chlorine Analyser	1	Item	$5,800	$5,800	
Fluroide Analyser	1	Item	$19,000	$19,000	
pH and Temperature Meter	1	Item	$2,000	$2,000	
pH and Temperture Controller	1	Item	$2,300	$2,300	
Combined Free Chlorine, pH and Temperature	1	Item	$6,100	$6,100	
					$97,600
2. Flow Meters					
Raw Water Magflow Meter with New Pit	1	Item / Lump Sum	$11,300	$11,854	
Backwash Magflow Meter with New Pit	1	Item / Lump Sum	$20,000	$20,980	
					$32,900
3. Instruments					
Settled Water PS Level Monitoring	1	Item	$1,300	$1,300	
Level Indicating Transmitter	2	Item	$800	$1,600	
Dosing System Flow Switches	3	Item	$500	$1,500	
					$4,400
4. Pumps, Valves, Actuators					
Raw Water Modulating Flow Control Valve	1	Item	$5,000	$5,000	
VSD Control on Settled Water Pumps	2	Item	$25,000	$50,000	
					$55,000
5. Dosing Automation					
Chlorine Dosing					
Automatic Chlorinator	2	Item	$4,900	$9,800	
Vacuum Regulators (2x Pair)	1	Item	$3,300	$3,300	
Injector	2	Item	$1,000	$2,000	
Pipework & Board	2	Item	$5,000	$10,000	
Leak Detection	1	Item	$6,000	$6,000	
Automatic Shutoff System	1	Item	$13,100	$13,100	
Gas Flow Switch	2	Item	$1,100	$2,200	
Dual Cylinder Weight Scales	1	Item	$5,700	$5,700	
Carbon Filter Cylinder	1	Item	$900	$900	
New Soda Ash Dosing Pumps (D/D)	2	Item	$9,900	$19,800	
New Alum Dosing Pumps (D/S)	2	Item	$4,000	$8,000	
Skids and Pipework for Alum & Soda Ash Dosing Pumps	2	Item	$6,700	$15,102	
					$96,000

6. Backwash Automation					
Filter Inltet Valve Actuation	1	Item	$2,000	$2,000	
Filter Outlet Valves Actuation	2	Item	$3,000	$6,000	
Combined Filter Outlet Valve Modulating Flow Control	1	Item	$4,000	$4,000	
Backwash Inlet Valve Modulating Flow Control	1	Item	$5,000	$5,000	
Washwater Outlet Valve Actuation	1	Item	$3,500	$3,500	
Filter Level Transmitter	1	Item	$800	$800	
					$21,300
7. Control Equipment					
New MCC and PLC in Existing Laboratory Room	1	Lump Sum	$900,000	$900,000	
New Laboratory Room	1	Lump Sum	$150,000	$150,000	
					$1,050,000
8. Instrumentation Installation					
Plumbing and Piping for Analysers	10	Item	$500	$5,000	
Labour Hours	144	Hours	$80	$11,520	
					$16,600
9. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$5,000	$5,000	
Labour Hours	1	Lump Sum	$15,000	$15,000	
					$20,000

Indirect Costs

10. Engineering Design					
Process Design	40	Hours	$250	$10,000	
P&ID Preparation	20	Hours	$250	$5,000	
Site GAs (Instrument Locations)	16	Hours	$250	$4,000	
HAZOP and CHAZOP	40	Hours	$250	$10,000	
Functional Design Specification (FDS)	100	Hours	$250	$25,000	
Electrical Design	-	-	-	-	
Scope of Works Document	20	Hours	$250	$5,000	
Technical Specification for D&C	80	Hours	$250	$20,000	
					$79,000
11. Engineering Support					
Tender Review	40	Hours	$250	$10,000	
Technical Support (Owners Engineer/Representative)	50	Hours	$250	$12,500	
					$22,500
12. Commisioning and Training					
Commissiong and Training Time	40	Hours	$250	$10,000	
					$10,000

Total, PM and Contingency

Total	
Total Cost (Excluding PM and Contingency)	**$1,505,300**
Project Management	
Project Management Costs	**$139,400**
Grand Total	
Grand Total (excluding contingency)	**$1,644,700**
Contingency	$493,500
Grand Total	**$2,138,200**

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jan-21

Site: Bugaldie

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2018 - 2020				1.0290	
Direct Costs					
1. Water Quality Analysers					
Turbidity Analyser	1	Item	$6,400	$6,400	
Turbidity Controller	1	Item	$4,000	$4,000	
					$10,400
2. Flow Meters					
Treated Water Mag Flowmeter	1	Item	$3,000	$3,087	
					$3,100
3. Instruments					
Treated Water Pressure	1	Item	$600	$600	
Bore Level	1	Item	$2,500	$2,500	
Dosing System Flow Switch	1	Item	$500	$500	
					$3,600
4. Dosing Automation					
Digital Hypo Dosing Pump	1	Item	$4,000	$4,000	
					$4,000
5. Control Equipment					
New RTU and Panel Manufacture	1	Lump Sum	$20,000	$20,000	
					$20,000
6. Instrumentation Installation					
Labour Hours	20	Hours	$80	$1,600	
					$1,600
7. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$5,000	$5,000	
Labour Hours	1	Lump Sum	$10,000	$10,000	
					$15,000
Indirect Costs					
8. Engineering Design					
Process Design	30	Hours	$250	$7,500	
Site GAs (Instrument Locations)	16	Hours	$250	$4,000	
Electrical Design	80	Hours	$250	$20,000	
Scope of Works Document	10	Hours	$250	$2,500	
Technical Specification for D&C	20	Hours	$250	$5,000	
					$39,000
9. Engineering Support					
Tender Review	20	Hours	$250	$5,000	
Technical Support (Owners Engineer/Representative)	20	Hours	$250	$5,000	
					$10,000
10. Commisioning and Training					
Commissiong and Training Time	40	Hours	$250	$10,000	
					$10,000
Total, PM and Contingency					
Total					
Total Cost (Excluding PM and Contingency)					**$116,700**
Project Management					
Project Management Costs					**$5,800**
Grand Total					
Grand Total (excluding contingency)					**$122,500**
Contingency					$36,800
Grand Total					**$159,300**

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jan-21

Site: Coolah

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2016 - 2020				1.0690	
2018 - 2020				1.0290	
Direct Costs					
1. Water Quality Analysers					
Turbidity Analyser	1	Item	$6,400	$6,400	
Turbidity Controller	1	Item	$4,000	$4,000	
Combined Free Chlorine, pH and Temperature	1	Item	$6,100	$6,100	
Fluoride Analyser	1	Item	$19,000	$19,000	
					$35,500
2. Flow Meters					
Treated Water Magflow Meter	1	Item	$5,000	$5,145	
					$5,200
3. Instruments					
Fluoride FS move to Chlorine Dosing Pit	1	Lump Sum	$5,000	$5,000	
					$5,000
4. Automated Chlorine Dosing					
New Chlorine Dosing Room	1	Item	$188,900	$188,900	
Automatic Chlorinator	1	Item	$4,900	$4,900	
Vacuum Regulators (2x Pair)	1	Item	$3,300	$3,300	
Injector	2	Item	$1,000	$2,000	
Pipework & Board	1	Item	$5,000	$5,000	
Leak Detection	1	Item	$6,000	$6,000	
Automatic Shutoff System	1	Item	$13,100	$13,100	
Gas Flow Switch	2	Item	$1,100	$2,200	
Dual Cylinder Weight Scales	1	Item	$5,700	$5,700	
Carbon Filter Cylinder	1	Item	$900	$900	
					$232,000
5. Control Equipment					
New RTU and Panel Manufacture	1	Lump Sum	$25,000	$25,000	
					$25,000
6. Instrumentation Installation					
Plumbing and Piping for Analysers	3	Item	$500	$1,500	
Labour Hours	16	Hours	$80	$1,280	
					$2,800
7. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$5,000	$5,000	
Labour Hours	1	Lump Sum	$15,000	$15,000	
					$20,000
Indirect Costs					

8. Engineering Design					
Process Design	30	Hours	$250	$7,500	
Site GAs (Instrument Locations)	16	Hours	$250	$4,000	
Electrical Design	120	Hours	$250	$30,000	
Scope of Works Document	10	Hours	$250	$2,500	
Technical Specification for D&C	20	Hours	$250	$5,000	
					$49,000
9. Engineering Support					
Tender Review	20	Hours	$250	$5,000	
Technical Support (Owners Engineer/Representative)	20	Hours	$250	$5,000	
					$10,000
10. Commisioning and Training					
Commissiong and Training Time	50	Hours	$250	$12,500	
					$12,500

Total, PM and Contingency

Total	
Total Cost (Excluding PM and Contingency)	**$397,000**

Project Management	
Project Management Costs	**$32,600**

Grand Total	
Grand Total (excluding contingency)	**$429,600**
Contingency	$128,900
Grand Total	**$558,500**

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jan-21

Site: Coonabarabran

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2013 - 2020				1.1270	
2017 - 2020				1.0490	
2018 - 2020				1.0290	
Direct Costs					
1. Water Quality Analysers					
Turbidity Analyser	3	Item	$6,400	$19,200	
Turbidity Controller	3	Item	$4,000	$12,000	
Free Chlorine Analyser	1	Item	$5,800	$5,800	
Fluroide Analyser	1	Item	$19,000	$19,000	
pH and Temperature Meter	3	Item	$2,000	$6,000	
pH and Temperture Controller	3	Item	$2,300	$6,900	
					$68,900
2. Flow Meters					
Raw Water Magflow Meter with New Pit	1	Item	$20,000	$20,980	
Backwash Magflow Meter	1	Item	$6,100	$6,277	
					$27,300
3. Instruments					
PS Level Monitoring	1	Item	$1,300	$1,300	
Level Indicating Transmitter	1	Item	$800	$800	
Dosing System Flow Switches	4	Item	$500	$2,000	
					$4,100
4. Pumps, Valves, Actuators					
VSD Control on Settled Water Pumps	3	Item	$25,000	$75,000	
VSD Control on Little Pond Yard Bore	1	Item	$20,000	$20,000	
VSD Control on Homeleigh Drive Bore 10	1	Item	$20,000	$20,000	
					$115,000
5. Dosing Automation					
Chlorine Dosing					
Automatic Chlorinator	1	Item	$4,900	$4,900	
Injector	2	Item	$1,000	$2,000	
Pipework and board	1	Item	$5,000	$5,000	
Automatic Shutoff System	1	Item	$13,100	$13,100	
Gas Flow Switch	2	Item	$1,100	$2,200	
Dual Cylinder Weight Scales	1	Item	$5,700	$5,700	
Carbon Filter Cylinder	1	Item	$900	$900	
New Alum Dosing Pumps (D/S)	2	Item	$8,340	$16,680	
Skids and Pipework for Alum Dosing Pumps	1	Item	$6,700	$7,551	
					$58,100
6. Control Equipment					
New PLC and Panel Installed Upstairs	1	Lump Sum	$650,000	$650,000	

					$650,000
7. Instrumentation Installation					
Plumbing and Piping for Analysers	8	Item	$500	$4,000	
Labour Hours	96	Hours	$80	$7,680	
					$11,700
8. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$15,000	$15,000	
Labour Hours	1	Lump Sum	$60,000	$60,000	
					$75,000
Indirect Costs					
9. Engineering Design					
Process Design	40	Hours	$250	$10,000	
P&ID Preparation	20	Hours	$250	$5,000	
Site GAs (Instrument Locations)	16	Hours	$250	$4,000	
HAZOP and CHAZOP	40	Hours	$250	$10,000	
Functional Design Specification (FDS)	100	Hours	$250	$25,000	
Electrical Design	400	Hours	$250	$100,000	
Scope of Works Document	20	Hours	$250	$5,000	
Technical Specification for D&C	80	Hours	$250	$20,000	
					$179,000
10. Engineering Support					
Tender Review	40	Hours	$250	$10,000	
Technical Support (Owners Engineer/Representative)	50	Hours	$250	$12,500	
					$22,500
11. Commisioning and Training					
Commissiong and Training Time	200	Hours	$250	$50,000	
					$50,000
Total, PM and Contingency					
Total					
Total Cost (Excluding PM and Contingency)					**$1,261,600**
Project Management					
Project Management Costs					**$101,100**
Grand Total					
Grand Total (excluding contingency)					**$1,362,700**
Contingency					$408,900
Grand Total					**$1,771,600**

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jan-21

Site: Dunedoo

hunterh2o

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2016 - 2020				1.0690	
2018 - 2020				1.0290	
Direct Costs					
1. Water Quality Analysers					
Turbidity Analyser	1	Item	$6,400	$6,400	
Turbidity Controller	1	Item	$4,000	$4,000	
Combined Free Chlorine, pH and Temperature	1	Item	$6,100	$6,100	
					$16,500
2. Flow Meters					
Treated Water Magflow Meter	1	Item	$5,000	$5,145	
					$5,200
3. Instruments					
Bore Level Monitor	1	Item	$2,500	$2,500	
Pressure Analyser	1	Item	$600	$600	
					$3,100
4. Automated Chlorine Dosing					
New Chlorine Dosing System Including Room	1	Lump Sum	$215,000	$215,000	
					$215,000
5. Control Equipment					
New RTU and Panel Manufacture	1	Lump Sum	$25,000	$25,000	
					$25,000
6. Instrumentation Installation					
Plumbing and Piping for Analysers	2	Item	$500	$1,000	
Labour Hours	20	Hours	$80	$1,600	
					$2,600
7. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$5,000	$5,000	
Labour Hours	1	Lump Sum	$15,000	$15,000	
					$20,000
Indirect Costs					
8. Engineering Design					
Process Design	30	Hours	$250	$7,500	
Site GAs (Instrument Locations)	16	Hours	$250	$4,000	
Electrical Design	120	Hours	$250	$30,000	
Scope of Works Document	10	Hours	$250	$2,500	
Technical Specification for D&C	20	Hours	$250	$5,000	
					$49,000
9. Engineering Support					
Tender Review	20	Hours	$250	$5,000	
Technical Support (Owners Engineer/Representative)	20	Hours	$250	$5,000	
					$10,000
10. Commisioning and Training					
Commissiong and Training Time	50	Hours	$250	$12,500	
					$12,500
Total, PM and Contingency					
Total					
Total Cost (Excluding PM and Contingency)					**$358,900**
Project Management					
Project Management Costs					**$28,800**
Grand Total					
Grand Total (excluding contingency)					**$387,700**
Contingency					$116,400
Grand Total					**$504,100**

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jan-21

Site: Kenebri

hunterh2o

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2018 - 2020				1.0290	
Direct Costs					
1. Water Quality Analysers					
Turbidity Analyser	1	Item	$6,400	$6,400	
Turbidity Controller	1	Item	$4,000	$4,000	
					$10,400
2. Flow Meters					
Treated Water Magflow Meter	1	Item	$3,000	$3,087	
					$3,100
3. Instruments					
Treated Water Pressure	1	Item	$600	$600	
Bore Level	1	Item	$2,500	$2,500	
Dosing System Flow Switch	1	Item	$500	$500	
					$3,600
4. Dosing Automation					
Digital Hypo Dosing Pump	1	Item	$4,000	$4,000	
					$4,000
5. Control Equipment					
New RTU and Panel Manufacture	1	Lump Sum	$20,000	$20,000	
					$20,000
6. Instrumentation Installation					
Labour Hours	20	Hours	$80	$1,600	
					$1,600
7. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$5,000	$5,000	
Labour Hours	1	Lump Sum	$10,000	$10,000	
					$15,000
Indirect Costs					
8. Engineering Design					
Process Design	30	Hours	$250	$7,500	
Site GAs (Instrument Locations)	16	Hours	$250	$4,000	
Electrical Design	80	Hours	$250	$20,000	
Scope of Works Document	10	Hours	$250	$2,500	
Technical Specification for D&C	20	Hours	$250	$5,000	
					$39,000
9. Engineering Support					
Tender Review	20	Hours	$250	$5,000	
Technical Support (Owners Engineer/Representative)	20	Hours	$250	$5,000	
					$10,000
10. Commisioning and Training					
Commissiong and Training Time	40	Hours	$250	$10,000	
					$10,000
Total, PM and Contingency					
Total					
Total Cost (Excluding PM and Contingency)					**$116,700**
Project Management					
Project Management Costs					**$4,800**
Grand Total					
Grand Total (excluding contingency)					**$121,500**
Contingency					$36,500
Grand Total					**$158,000**

5674 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Jan-21

Site: Mendooran

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2016 - 2020				1.0690	
Direct Costs					
1. Water Quality Analysers					
Turbidity Analyser	4	Item	$6,400	$25,600	
Turbidity Controller	4	Item	$4,000	$16,000	
Combined Free Chlorine, pH, temperature (pre-CWT)	1	Item	$6,100	$6,100	
Fluroide Analyser	1	Item	$19,000	$19,000	
pH and Temperature Meter	1	Item	$2,000	$2,000	
pH and Temperture Controller	1	Item	$2,300	$2,300	
					$71,000
2. Instruments					
Level Indicating Transmitter	1	Item	$800	$800	
Dosing System Flow Switches	3	Item	$500	$1,500	
					$2,300
3. Pumps, Valves, Actuators					
VSD Control on Settled Water Pumps	2	Item	$25,000	$50,000	
VSD Control on River Raw Water Site	1	Item	$20,000	$20,000	
VSD Control on Bore	1	Item	$20,000	$20,000	
					$90,000
4. Automated Chlorine Dosing					
New Chlorine Dosing System Including Room	1	Lump Sum	$215,000	$215,000	
					$215,000
5. PLC and Control Equipment					
New PLC Hardware	1	Lump Sum	$15,000	$15,000	
					$15,000
6. Instrumentation Installation					
Plumbing and Piping for Analysers	7	Item	$500	$3,500	
Labour Hours	44	Hours	$80	$3,520	
					$7,100
7. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$10,000	$10,000	
Labour Hours	1	Lump Sum	$15,000	$15,000	
					$25,000
Indirect Costs					
8. Engineering Design					
Process Design	40	Hours	$250	$10,000	
P&ID Preparation	20	Hours	$250	$5,000	
Site GAs (Instrument Locations)	16	Hours	$250	$4,000	
HAZOP and CHAZOP	40	Hours	$250	$10,000	

Functional Design Specification (FDS)	100	Hours	$250	$25,000	
Electrical Design	240	Hours	$250	$60,000	
Scope of Works Document	20	Hours	$250	$5,000	
Technical Specification for D&C	80	Hours	$250	$20,000	
					$139,000
9. Engineering Support					
Tender Review	40	Hours	$250	$10,000	
Technical Support (Owners Engineer/Representative)	50	Hours	$250	$12,500	
					$22,500
10. Commisioning and Training					
Commissiong and Training Time	80	Hours	$250	$20,000	
					$20,000

Total, PM and Contingency

Total	
Total Cost (Excluding PM and Contingency)	**$606,900**

Project Management	
Project Management Costs	**$42,600**

Grand Total	
Grand Total (excluding contingency)	**$649,500**
Contingency	$194,900
Grand Total	**$844,400**