Hay Shire Council

Hay Water Supply System Water Quality and Telemetry Strategy Report

APRIL 2021

ABN 16 602 201 552

Report Details

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Document History and Status

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A	Draft	Michael Carter David Longmuir	Evan Jack	Michael Carter	26/03/2021
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Executive Summary

Hay Shire Council (HSC) are investigating the opportunity to implement new online water quality monitoring at Hay WTP to improve process control and monitoring and, in doing so, water safety. HSC have also taken a holistic view to the upgrades for the Hay WTP and also investigated the shire wide telemetry system to best inform any required upgrade strategy.

These projects are driven by a desire to improve operability and reduce the likelihood of a water quality incident occurring at the Hay WTP. The WTP being largely manually operated with little automation, monitoring, alarming, interlocks or control of the existing plant and hence reliant on individuals and documentation. 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.

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.

HSC has therefore embarked on this journey by sourcing Safe and Secure Water Program (SSWP) funding through DPIE for the initial scoping study - Hay WTP Automation and Process Instrumentation Audit. Funding was sought based on work undertaken through collaboration with NSW Health when updating Councils Drinking Water Management System and the risk of CCP compliance was raised and the recommendation for online water quality monitoring and a new laboratory was made. Funding for this project was supported by the SSWP technical review panel.

HSC have since commissioned three investigation reports focused on the Hay WTP and the shire wide telemetry system:

- Hay WTP Automation and Process Instrumentation Audit
- Hay WTP Capacity and Capability Assessment
- Hay Shire Telemetry Audit.

The identified recommended upgrade scope of works for the WTP and shire wide telemetry systems have been separated into two separate packages of work:

- Package 1 - Upgrades to Hay WTP
- Package 2 - Upgrades to the Hay water and wastewater telemetry network.

Cost estimates for the two packages were:

- Package 1 - Upgrades to Hay WTP - $2.62M
- Package 2 - Upgrades to the Hay water and wastewater telemetry network - $0.7M.

The overall combined estimated cost is therefore ~**$3.3M.**

Council wishes to seek funding to support these identified upgrades to improve water safety, water security, the resilience of the water treatment process and sanitation within the Hay community through robust and reliable infrastructure that is monitored and controlled effectively.

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1 Introduction

1.1 General

The Hay Shire is in lower central NSW, and HSC primarily operates from its' offices in Hay. The Shire is positioned on the Stuart Highway, mid-way between Mildura and Wagga Wagga. The location of the shire is shown in Figure 1-1 below.

Figure 1-1: Location of Hay Shire

The shire covers an area of approximately 11,320 km^2 and has a population of approximately 2,979 people. The Shire includes the towns of Booligal, Maude and One Tree, however reticulated drinking water supply is only provided to the town of Hay.

1.2 Project background

HSC are investigating the opportunity to implement new online water quality monitoring at Hay WTP to provide the ability to monitor, alarm and shutdown the WTP control systems in the event of water quality exceedances, ultimately to improve water safety and the reliability of a safe supply. HSC have also taken a holistic view to the upgrades for the Hay WTP and also investigated the shire wide telemetry system to best inform any required upgrade strategy.

HSC has embarked on this journey by sourcing SSWP funding through DPIE for the initial scoping study - Hay WTP Automation and Process Instrumentation Audit. Funding was sought based on work undertaken through collaboration with NSW Health when updating Councils Drinking Water Management System and the risk of CCP compliance was raised and the recommendation for online water quality monitoring and a new laboratory was made. Funding for this project was supported by the SSWP technical review panel.

Following the site visit undertaken by Hunter H2O during the SSWP funded scoping study (Hay WTP Automation and Process Instrumentation Audit), a number of potential process issues were raised along with concerns related to the main switchboard location and age and lack of control functionality at the WTP presenting both WHS risks and the inability to shutdown the WTP in a timely fashion when a CCP exceedance occurs due to lack of online water quality monitoring and controls.

Process related issues were investigated further through the Hay WTP Capacity and Capability Assessment.

In addition, a council wide telemetry audit was undertaken for both water and wastewater assets to determine the need for any upgrade to work holistically with the planned updates at the WTP in terms of automation, control and SCADA systems.

1.3 Report Purpose

The purpose of this overarching report is to consolidate the key findings, from the three recent investigations that have been undertaken, into a consolidated strategy or pathway forward for Council to embark on. Council also wish to seek funding to support these identified upgrades and therefore this report has been structured in a way to assist with beginning to seek funding by consolidating findings into a concise overarching report.

2 Summary of Reports

HSC have commissioned three investigation reports focused on the Hay WTP and the shire wide telemetry system. The following three reports are summarised in the following sections:

- Hay WTP Automation and Process Instrumentation Audit
- Hay WTP Capacity and Capability Assessment.
- Hay Shire Telemetry Audit.

A copy of each report can be found in the appendices.

2.1 Hay WTP Automation and Process Instrumentation Audit

The *Hay WTP Automation and Process Instrumentation Audit* report can be found in Appendix A.

2.1.1 Key project objectives and drivers

The key project objective is to ensure a reliable and safe water supply for the residents of Hay.

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

The project is driven by a desire to improve operability and reduce the likelihood of a water quality incident occurring at the Hay WTP. The WTP being largely manually operated with little automation, monitoring, alarming, interlocks or control of the existing plant and hence reliant on individuals and documentation. 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.

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.

2.1.2 Summary

Hunter H2O visited the Hay WTP on the 16-17th June 2020 with Councils operations staff, reviewing the WTP automation, telemetry, monitoring and instrumentation at the site. Comparing the existing instrumentation with HSC’s Drinking Water Management System (DWMS), Hunter H2O determined the instrumentation and automation recommended to monitor and control the plant, in order to ensure effective operation and prevent poor quality water from entering the distribution network.

The investigation was driven by a desire to improve operability and reduce the likelihood of a water quality incident occurring at the Hay WTP. The WTP being largely manually operated with little automation, monitoring, alarming, interlocks or control of the existing plant and hence reliant on individuals and documentation.

The recommended control and automation outlined in this report 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 plant and reduce the strain on operational staff.

The recommended process and instrumentation upgrades for Hay WTP 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 within the report for the plant would be in addition to a total control system design 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 the plant. Options for the upgrade of the plant MCC were also considered alongside the simultaneous upgrade of the laboratory room at the WTP.

With respect to the electrical and control system it was recommended that the MCC, PLC and RTU are all upgraded. The key justification being; the age of the equipment, non-compliance with Australian Standards and the associated safety risks, and lack of space to expand as the current MCC and control equipment does not have sufficient space for the proposed upgrades.

The condition of the existing MCC is poor with several issues within the PLC panel, which means the panels no longer comply with current Australian Standards (AS3000). As a result, the MCC needs to be replaced, including the existing PLC and installation of a new dedicated SCADA system for the plant. This will allow lead into the plant RTU at a later stage.

The design of a new MCC panel will be larger than the current panel as it will be Form 3 to be compliant with the current Australian Standards. The location of the new MCC panel and the length of the existing cables will also need to be considered, along with the access high of the room to install and remove equipment. Various options were therefore considered along side the need for a new laboratory/testing room.

System Upgrade options

Four possible options for the plant laboratory room and MCC upgrade were considered:

1. Do nothing
2. Move the laboratory into a new location and replace the existing MCC within the existing control room
3. Move the existing MCC into a new location and rebuild a new lab room in the existing location
4. Remove both the Laboratory and MCC rooms into separate locations.

Option 1 – Do nothing

If option 1 is taken this would effectively stop any opportunity to improve or expand the current WTP control system as there is currently no spare I/O or space within the PLC, RTUs or Panels.

Option 2 – Lab in new room

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.

Within this option the laboratory would be moved to a new building. It is recommended that this location is on the traffic island located opposite the plant, at the front of the site. The existing lab room would be gutted to allow for the new MCC to be installed and wet instruments moved to the lab room.

Option 3 – MCC in new room

The location for a new MCC switch room will depend on factors such as underground services, cable lengths and site access. As part of this option it is assumed that the MCC is placed in the current location of the Alum tank for this option.

Within this option the laboratory would stay in its current location. With the old MCC removed, the Lab room could be expanded and remodelled to allow more space.

Option 4 – MCC and lab in new rooms

This option would be a combination of both options 2 and 3. The MCC would be in the existing Alum tank position and a new Lab room would be established in front of the plant.

Summary of costs

A summary of the costs presented within the *Hay WTP Automation and Process Instrumentation Audit* report are tabulated in Table 2-1.

Table 2-1: Estimated cost of overall plant upgrades for each identified option

Item	Option 1 Cost	Option 2 Cost	Option 3 Cost	Option 4 Cost
Process Instrumentation (Incl. Indirect Costs)	$0	$617,500	$617,500	$617,500
MCC and Laboratory Option Costs	$0	$650,000	$800,000	$900,000
Project Management	$0	$108,500	$123,500	$133,500
Total Cost Estimate (-50% to +50%)	**$0**	**$1,376,000**	**$1,541,000**	**$1,651,000**
Contingency (30% of Total Project Cost)	$0	$412,800	$462,300	$495,300
Total Cost Estimate + Contingency (±50%)	**$0**	**$1,788,800**	**$2,003,300**	**$2,146,300**

2.1.3 Key outcomes

Following a workshop with HSC on the 7th January 2021, it was determined that the preferred option was Option 4.

2.2 Hay WTP Capacity and Capability Assessment

The *Hay WTP Capacity and Capability Assessment* report can be found in Appendix B.

2.2.1 Key project objectives and drivers

The key project objective was to take a holistic approach and undertake a full WTP assessment of each process unit and its ability to achieve the desired treated water targets.

The project is driven by a desire to ensure a robust and reliable multi barrier approach to water treatment is achieved and maintained to reduce the likelihood of a water quality incident occurring at the Hay WTP

2.2.2 Summary

A site visit to Hay Water Treatment Plant (WTP) was undertaken by Hunter H2O in June 2020 as part of the Automation and Process Instrumentation Audit. During this site visit, several potential key process issues were identified:

- negligible PAC contact time
- insufficient mixing for coagulation and flocculation
- uneven sludge blanket distribution and sludge boil-up in the clarifier
- manual backwashing of filters with no filter outlet turbidity monitoring
- potential short circuiting in the unbaffled clear water tank (CWT)
- lack of flow measurement specific to post chemical dosing, leading to an overdosing risk
- lack of safety features on alum and soda ash dosing pumps, and no bunding on the aging alum storage tank.

As a result of these process observations, Hunter H2O was commissioned by HSC to conduct a capacity assessment of Hay WTP. This would provide further information on the scope of any upgrades required at Hay WTP, and thus compliment the findings of the previous *Hay WTP Automation and Process Instrumentation Audit Report (2020)*.

Hay WTP was designed with a capacity of 2.1 ML/d, which corresponds to a treated flow production of 27 L/s over 22 hours. Assuming a 90% plant efficiency, the raw water design flowrate would be approximately 30 L/s.

A brief summary of the process unit capacity findings is presented in Figure 2-1. Given that the plant was originally constructed in 1988 when treated water quality targets were less stringent, it is understandable that some original process units may not be capable of achieving the original capacity requirements when assessed against current industry best practice and the most recent water quality guidelines.

The assessment was undertaken by rating the capacity of the process units against a series of typical industry design criteria. These criteria include loading rates, detention times, and capacity to meet maximum dose rates. These have been referred to as Industry Standard Design Values (ISDV) in this report. The actual values for these criteria may change slightly between water authorities, regulators and designers around the world. The ISDV used in the assessment of Hay WTP are values Hunter H2O considers typical in the industry in Australia and are a useful guide in considering the capacity of a process in lieu of an additional performance assessment. The ISDVs provide a reasonable estimate on the ability of the plant to achieve modern water quality performance targets, although further investigation quantifying actual performance is recommended for areas where an issue is identified.

This Capacity Assessment report is focused on production/capacity only. Factors such as process performance, which can be an important factor in the suitability of a system, should also be considered in planning for the future of the WTP.

The process units that do not meet the ISDV and are considered capacity limiting are:

- PAC contact time
- coagulation mixing energy (weir overflow)
- backwash air scour and water wash rates
- treated water storage time.

Since the average capacity is slightly less than 1 ML/d at Hay WTP, the lagoons should be sufficiently large, even during wet periods, until average demand increases beyond ~1.4 ML/d.

The chlorine gas dosing capacity for disinfection does not appear to meet the ISDV. However, the standby chlorinator (which was previously used for pre-chlorination) has a capacity of 1 kg/h compared to the 200 g/h capacity of the duty chlorinator. Hence, if high chlorine doses were required, the standby chlorinator could be used.

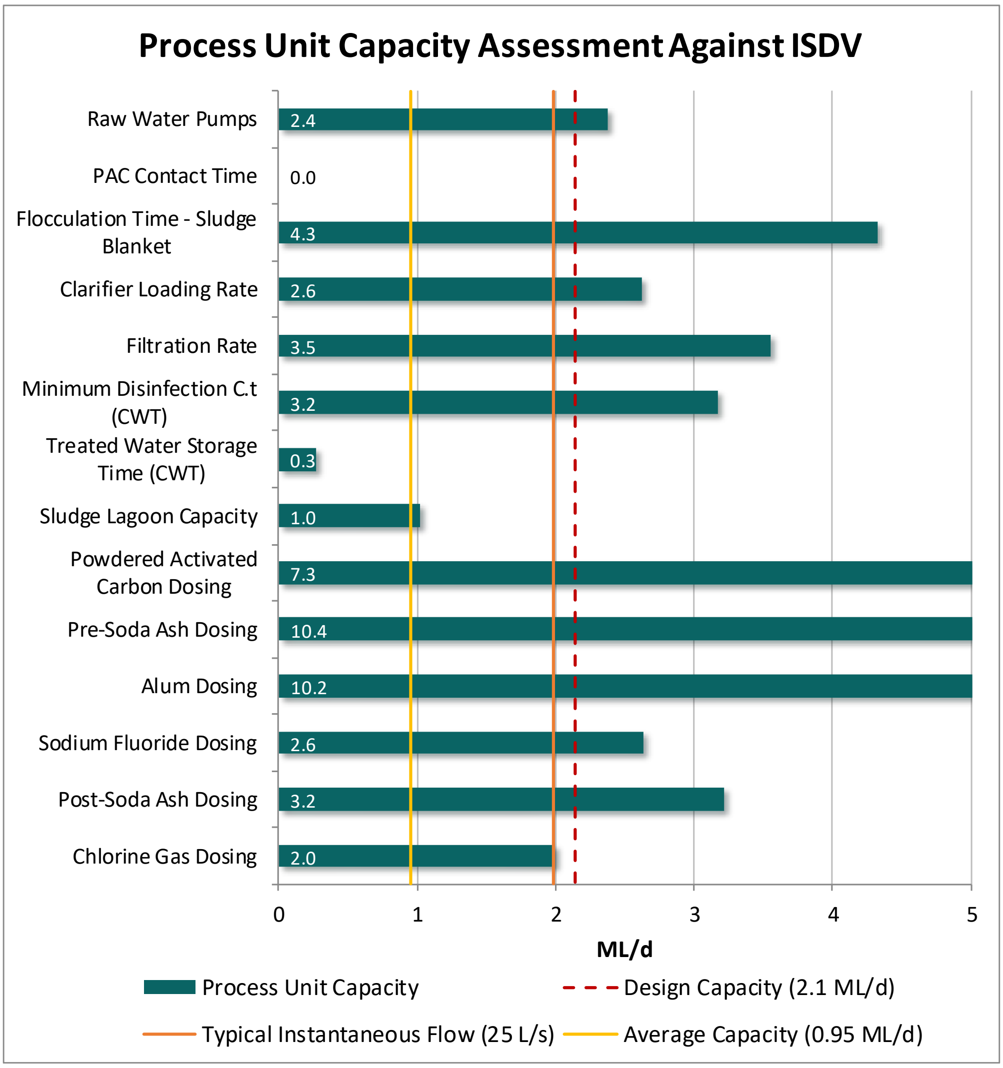

Figure 2-1: Process Capacity Assessment Summary

Some of the original plant components exceed acceptable rates at the original design raw water capacity, estimated to be 30 L/s. The maximum historical instantaneous daily flow recorded since 2012 was 28 L/s while the maximum instantaneous flow calculated based on the daily extraction data equates to 29 L/s over a 22-hour period. Typically, however, the flowrate is set to 25 L/s, with flows greater than this being uncommon. At this flowrate most process unit loading rates and sizing is considered ok with the exception of the PAC contact time, CWT storage time and sludge lagoon capacity.

A number of recommendations are made which have been listed based on their priority. These are provided in Table 2-2.

Table 2-2: Summary of Recommendations

Priority	Recommendation
Short Term (High Priority)	▪ Implement the recommended control system upgrades and process instrumentation installation (as per the *Hay WTP Automation and Process Instrumentation Audit* report) to improve automation and safe operation of the processes at Hay WTP. ▪ Fix or replace the non-functional vacuum pump to improve flocculation and reduce issues such as uneven sludge blanket distributions and sludge build-up at the inlet manifold. ▪ Consider redundancy requirements for the critical PAC feeding and dosing system components due to their critical nature and the lack of standby equipment at the WTP. ▪ Perform an audit of the fluoride dosing system to determine compliance with the Code of Practice and WHS requirements.
Medium Term (Moderate Priority)	▪ Investigate alternative PAC contacting options (such as dosing at or near the Murray Street Pumping Station) to ensure that the WTP has an effective barrier against algal toxins and taste and odour compounds. ▪ Closely review the performance of coagulation, flocculation and clarification, particularly since coagulation rapid mixing energy is low. This will allow for an assessment of the opportunity to improve the clarifier supernatant, improve filter run times and reduce the risk of filter breakthrough. If coagulation issues become apparent, the addition of a static mixer just after alum dosing could be considered. ▪ Undertake a filter inspection to determine the effectiveness of the current backwashing process and to ensure that the low air scour and wash rates are not resulting in sludge build up. Sludge volume indexing and backwash turbidity profiling can be used to determine the existing effectiveness of the backwashing process to clean the filter media. Changes to the backwashing process may be required if the current process is not effective. ▪ Include monitoring of filter run time and UFRV as a measure, along with settled supernatant turbidity, of the performance of the upstream coagulation, flocculation and clarification process. ▪ Set up a system (spreadsheet or other) to perform monthly (at a minimum) settled supernatant turbidity percentile analysis to monitor clarifier performance. ▪ Set up a system (spreadsheet or other) to perform monthly (at a minimum) individual filtered water turbidity percentile analysis to monitor the performance of each filter. This will allow for validation of the performance of each filter against standards set in the WSAA guidelines and HBT guidance material for when HBT are incorporated into the ADWG. ▪ Refurbish or replace the existing alum storage tank, including the construction of a bund for spill containment.
Long Term (Low Priority)	▪ If instantaneous flowrates were to be increased to meet increases in demand were to be increased, investigate the need for polymer dosing or installation of inclined plates/ tubes to improve clarifier performance at increased loading rates. ▪ Undertake a microbial health-based target assessment in line with the Water Services Association of Australia (WSAA) guidelines and HBT guidance material to ensure WTP compliance for when HBT are included in the ADWG.

Priority	Recommendation
	▪ Implement an automated control system with maximum dose rate exceedance interlocks to minimise the risk of overdosing. Consider downsizing of the pre-soda ash and alum dosing pump to minimise overdosing risks.

Cost estimates were initially not developed during this investigation for each recommended upgrade item as the upgrade items were not identified until the assessment was completed, however cost estimates have subsequently been developed and are included within Section 2.2.3 of this report.

2.2.3 Additional cost estimation

A number of items were not costed during the *Hay WTP Capacity and Capability Assessment* which have been estimated in Table 2-3. Additional costing detail can be found in Appendix D.

Options that were considered for the PAC dosing system to increase the contact time were:

1. Addition of a dedicated PAC contact tank
2. Relocation of PAC dosing system to the Raw Water Pumping Station
3. Extension of the PAC dosing line.

The first two options were discarded due to the significantly higher cost of a dedicated PAC contact tank with limited space on site and the fact that the RWPS site is inundated during floods. Hence Option 3 was adopted and costed as seen in Table 2-3.

Table 2-3: Estimated cost for capacity and capability report recommendations

Item	Cost Estimate	Comments
Alum Dosing System and delivery bund	$169k	New Alum storage in bund and dosing system, including new static mixer. Includes chemical delivery bund.
PAC Dosing system	$109k	Included 1.7km dosing line extension and dosing pumps.
Indirect Costs	$73k	Design, project management, commissioning and contractor profit/overhead/risk.
Overall Project Cost Estimate (including contingencies)	**$456k**	Assumes 30% contingency

2.3 Hay Water and Wastewater Telemetry Audit

The *Hay Water and Wastewater Telemetry Audit* report can be found in Appendix C.

2.3.1 Key project objectives and drivers

The project objective was to review and assess the need to upgrade or replace the shire wide telemetry network.

The key project driver is to improve water safety, water security and sanitation within the Hay community through robust and reliable infrastructure that is controlled effectively. Some upgrade drivers include:

- Improved operator accessibility
- Secure operation of the system
- Improved data collection, analysis, reporting and archiving
- Improved redundancy of telemetry and SCADA systems
- Integration of SCADA with water and wastewater hydraulic models
- Improved safety by compliance with latest Australian Standards and Regulations

- Standardisation of design
- Improved reliability of the communications network
- Improved alarm monitoring and control through SCADA
- Improved power monitoring
- Industry standards and best practice
- Operational cost and maintenance cost reduction
- Intelligent device and instrumentation data available to SCADA

Essentially Radtel parts, components and servicing are no longer available and therefore a major shire-wide upgrade is becoming essential.

2.3.2 Summary

Hunter H2O completed an on-site condition assessment of water and wastewater telemetry assets throughout the Hay shire. This report outlines the preferred upgrade path for telemetry equipment with the aim of providing a solution that is reliable, secure and cost-effective.

In order to have a reliable and secure SCADA and telemetry network that meets current water and wastewater control and monitoring system industry standards, Council needs to remove the existing redundant Radtel system and install a modern DNP3 based SCADA and telemetry system. HSC currently has the DNP3 GeoSCADA installed at both the WTP and the WWTP, this will reduce the cost of the upgrade.

The Hay repeater base needs coverage to reach all outstations in the shire, the existing repeater location at Pine St reservoir is the perfect location, using a single digital radio product across the entire radio network.

The use of the local 4G network to compliment the radio network is also recommended. Being used as a backup or redundant communications link for critical sites if needed, or for alternate low I/O count sites such as flow meters, PRVs, chlorine analysers, rain gauges, non-critical Reservoirs and Sewage pump station.

A summary of the costs presented within the *Hay Water and Wastewater Telemetry Audit* report are tabulated in Table 2-4.

Table 2-4: Estimated cost of overall plant upgrades for each identified option

Item	Cost Estimate	Comments
Radio Network Cost Estimate (includes 30% contingency)	$31k	Pine St Repeater including include single base radios, duplexer, antenna and cables, UPS, radio and SCADA development, FAT and site commissioning
SCADA & Outstation Direct Costs	$360k	Includes new control panels, RTU, radio, antenna and cables, SCADA servers, SCADA licencing, SCADA development, RTU development, FAT, installation and site commissioning for 16 sites around the shire.
SCADA & Outstation Indirect Costs	$80k	Includes PM, project development, electrical drawings, drafting, FDS, training and manuals for the shire wide project
SCADA & Outstation Contingency	$89k	Includes 20% contingency
Overall Project Cost Estimate (including contingencies)	**$560k**	

3 Holistic Upgrade Strategy

HSC intends to seek funding to support the identified upgrades based on the findings from the three investigation reports. A proposed holistic upgrade strategy, scope of works and cost estimates were developed based on the findings of the three investigations undertaken.

3.1 Scope of works

The upgrade scope of works for the WTP and shire wide telemetry systems have been separated into two separate packages of work.

Package 1 - Upgrades to Hay WTP include:

- Process instrumentation:
  - online monitoring to facilitate effective implementation of CCPs
  - process instrumentation to support improved process control
  - process instrumentation to improve process control
  - filter backwash and flow paced dosing upgrades.
- MCC and Laboratory:
  - new MCC switchroom
  - new laboratory.
- Hay WTP process improvements and capacity/capability upgrades:
  - Alum dosing system upgrades
    - new Alum dosing system within bund and a drive on delivery bund
    - relocation of the coagulant dosing point and static mixer.
  - PAC dosing system upgrades
    - relocation and extension of the dosing point to 1.7 km upstream of the coagulant dose point to increase PAC contact time
    - dosing pump upgrades to enable delivery through the extended dosing line.

Package 2 - Upgrades to the Hay water and wastewater telemetry network include:

- Radio Network – Pine Street Repeater.
- SCADA & Outstations - 16 SCADA and outstation sites.

3.2 Site layouts

Indicative site layouts for the upgrade works were developed and are shown in Figure 3-1 and Figure 3-2.

Figure 3-1: Hay WTP relocated PAC dosing point

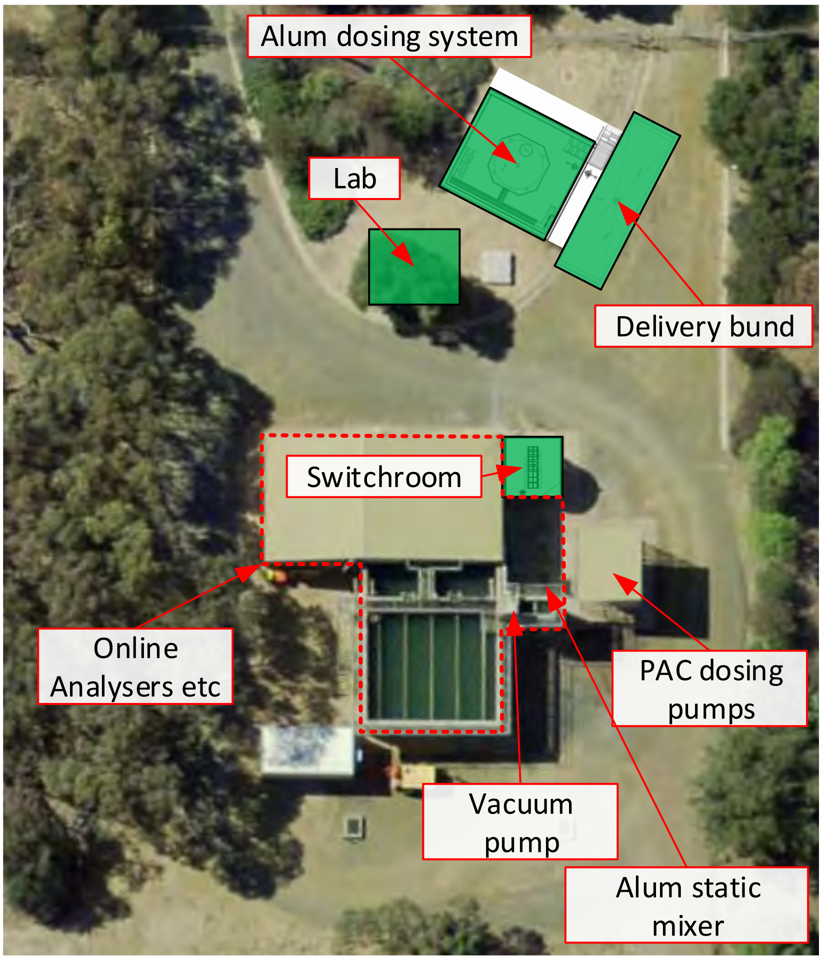

Figure 3-2: Hay WTP Upgrade Scope Items

3.3 Proposed Delivery Strategy and Pathway Forward

The proposed delivery strategy for work Packages 1 & 2 would be a design and construct approach with technical support (external consultant) during critical phases for each package of the work.

The upgrades associated within the WTP boundary are proposed to be undertaken as Package 1 of the works while the shire wide water and wastewater telemetry upgrades project (Package 2) could be undertaken as a separate D&C project once further development has occurred.

The delivery stages for Package 1 and Package 2 works are described below, however either Package could be undertaken first as each is a separable project even though they must be integrated once completed.

Package 1: Hay WTP Upgrades:

1. Concept Design -
   i. Process design with the ultimate confirmation on equipment selection, including:
      a. Alum and PAC dosing system design
      b. P&ID development
      c. Equipment List
      d. Functional Design Specification/Control Philosophy
      e. Safety in Design (HAZOP and CHAZOP etc).
   ii. Civil and mechanical design and drawings with:
      a. site general arrangement showing locations of equipment with sample point tie ins
      b. alum dosing system
   iii. Electrical design
   iv. Cost estimate
2. Scope of works document and technical specifications.
3. Tendering

4. External Technical Support and Project Delivery
    i. Technical support during tendering and project delivery
    ii. Assessment of tenders and recommendation of preferred tenderer
    iii. Review technical documents and drawings
    iv. Attendance for site testing (SAT) and factory acceptance testing (FAT)
5. Design, construction and commissioning
6. Update of Drinking Water Management System
7. Internal Council tasks (and related costs):
    i. Project coordination including workshop and meeting attendance
    ii. General project management and general day to day operations etc.

Package 2: Hay Telemetry Upgrades:

1. Develop a Detailed Electrical Standard
    i. This could be considered in a broader sense and created in conjunction with other RAMJO councils to create a common Detailed Electrical Standard that could be adopted and used across multiple councils.
2. Develop a SCADA Contract and Technical Specifications
3. Tendering
4. External Technical Support and Project Delivery
    i. Technical support during tendering and project delivery
    ii. Assessment of tenders and recommendation of preferred tenderer
    iii. Review technical documents and drawings
    iv. Attendance for site testing (SAT) and factory acceptance testing (FAT)
5. Design, construction and commissioning
6. Internal Council tasks (and related costs):
    i. Project coordination including workshop and meeting attendance
    ii. General project management and general day to day operations etc.

3.4 Overall Cost Estimate

The cost estimates have been developed to include direct and indirect costs along with project delivery costs through external consultants or contractors. Internal Council costs have not been included however the input from Council required is mentioned in the delivery strategy task summary in Section 3.3.

The overall cost estimation for the WTP and shire wide telemetry upgrades (Work Packages 1 & 2) have been collated in Table 3-1.

Table 3-1: Overall Hay WTP and Shire Telemetry Upgrade Cost Estimate

Item	Cost	Comments
Package 1: Hay WTP Upgrades		
Automation and Process Instrumentation Upgrades	$2,146k	Includes the process instrumentation costs, MCC and laboratory costs, PM and 30% contingency)
Hay WTP process improvements and capacity/capability upgrades	$456k	Includes the costed items developed in Section 2.2.3
Package 2: Hay Telemetry Upgrades:		
SCADA and telemetry upgrade cost	$560k	Construction cost only
Project Development	$140k	Additional costs required to get project to construction stage, including: ▪ Detailed Electrical Standard - $30k ▪ Develop a SCADA Contract and Technical Specifications - $30k ▪ External Technical Support and Project Delivery - $80k
Grand Total (Ex GST)	**~$3.3M**	Combined Package 1 and 2 cost

Appendix A Hay WTP Automation and Process Instrumentation Audit

hunterh2O

Hay Shire Council

Hay WTP Automation and Process Instrumentation Audit

APRIL 2021

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Report Details

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1 Introduction

1.1 General

The Hay Shire is in lower central NSW, and primarily operates from its' offices in Hay. The Shire is positioned on the Stuart Highway, mid-way between Mildura and Wagga Wagga, which also services Adelaide. The location of the shire can be seen in Figure 1-1 below.

Figure 1-1: Location of Hay Shire

The shire covers an area of approximately 11,320 km^2 and has a population of approximately 2,979 people. The Shire also includes the towns of Booligal, Maude and One Tree, however reticulated drinking water supply is only provided to the town of Hay.

In line with the Australian Drinking Water Guidelines, to improve water safety Hay Shire Council (HSC) are investigating the opportunity to implement online water quality monitoring at Hay WTP. 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…"

1.2 Audit

Hunter H2O visited the Hay WTP on the 16-17th June 2020 with operations staff, reviewing the WTP automation, telemetry, monitoring and instrumentation at the site. Comparing the existing instrumentation with HSC's Drinking Water Management System (DWMS), Hunter H2O determined the instrumentation and automation recommended to monitor and control the 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 plant and reduce the strain on operational staff.

1.2.1 Hay WTP Automation and Telemetry Overview

Originally the plant was controlled via a Hitachi PLC. This was changed out to be an Omron PLC by the department of public works. This PLC was then replaced with another Omron PLC due to a failure of the PLC. There is no HMI screen/terminal at the WTP for Operator interaction.

The Hay WTP PLC controls the basic function of the plant, monitoring and controlling digital I/O allowing for start and stop of the drives within the plant.

The plant PLC is connected to the plant RTU via hard wiring. The RTU monitors the site's analogue signals. The outputs from the RTU are for the clearwater pumps, indicating that the control system does not shut the plant down on exceedance of the existing CCPs (but can stop the clearwater pumps).

Council's telemetry was originally an Elpro system, however this was replaced with a RADTEL system in approximately 2004. The RADTEL RTU was declared obsolete in 2008 and as such replacement parts and expertise in the product is limited. Council have taken steps to move away from the RADTEL system with the installation of a pair of ClearSCADA servers, one at the WTP and the other at the STP. These servers act as a pair of duty / standby servers for the network that both talk to the local repeater. These servers still use the RADTEL driver to communicate, with all of the system logic held on the duty SCADA server.

Some of the RADTEL RTUs have been changed out to be Brodersen RTUs, however it is not clear how many sites have been changed out.

1.2.2 Site locations and hardware

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

Table 1-1: Site Locations and Hardware

Site	Hardware	Coordinates
Hay WTP	Radtel 5000	34°30'19.8"S 144°51'08.6"E

1.3 Project objectives

The overarching project objective is to ensure a reliable and safe water supply for the residents of Hay.

The objective of the *Hay 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.

The target outcomes of the project are:

- Address deficiencies in automation and monitoring to enable the water supply system to align with the requirements of the Australian Drinking Water Guidelines (ADWG) through the implementation of real time response at critical control points.
- Upgrade the monitoring and control system to enable the WTP 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 WTP as required
    - improved plant flow control to allow longer plant runtimes for improved water quality
    - remote alarming notification to operators to reduce downtime
    - providing WTP shutdown capability in the event of CCP exceedances.

In addition to these project objectives Council requested Hunter H2O to take a holistic approach to identifying opportunities for improvement at the WTP. As such observations were made during the site visit regarding the suitability and performance of the entire treatment process. The notes made from these observations are outlined in Section 2 of this report.

1.4 Project drivers

The project is driven by a desire to improve operability and reduce the likelihood of a water quality incident occurring at the Hay WTP. The WTP being largely manually operated with little automation, monitoring, alarming, interlocks or control of the existing plant and hence reliant on individuals and documentation. 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 1-2: Hierarchy of Controls[1]

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.

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

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

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 far west NSW, with getting, and keeping, trained operators. 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 Hay 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.

1.5 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 Hay 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 the plant requiring a new PLC, there may be some minor additions to the required scope of works.

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

- Continuous online water quality monitoring
- Flow control
- Automation of filter backwashing and clarifier scours
- Recommissioning of the existing vacuum flocculator
- 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 Process Site Inspection Notes

During the site visit Hunter H2O took note of potential process issues by taking a holistic view of the treatment plant and making observations regarding the overall water treatment process performance. This was undertaken to ensure that this project addresses key issues at the WTP as no previous holistic investigation has occurred to date. It is also important to note that overarching issues with plant performance may also lead to the requirement for upgrades that could change the monitoring and instrumentation required at the plant.

Several potential key process issues with the current treatment plant were identified during the site visit. The following potential issues have not been investigated in detail however were identified through discussions with operations staff, observations during the site visit, a brief review of onsite information and drawings and drawing from Hunter H2Os operational and technical experience.

The key issues identified are as follows:

- **PAC contact time:**
  - Powdered activated carbon (PAC) dosing currently occurs directly after coagulant dosing on the raw water inlet to the plant. The ability of PAC to remove organic material, including, algal metabolites (toxins and taste and odour compounds), is improved as the contact time increases. For algae toxins and taste and odour compounds, in particular, a long contact time in the order of >15 minutes is recommended to maximise removal efficiency and reduce PAC dose rates. The current PAC dosing point is located following coagulant dosing and therefore would be bound within the flocc formation shortly after dosing. This can significantly reduce the effectiveness of the PAC. Typically, PAC is dosed at a location which enables contact times of at least 15 minutes to be achieved at maximum plant flow. This can sometimes be achieved through a raw water rising main if long enough, however most often is achieved through a dedicated PAC contact tank with mixers to ensure PAC remains in suspension.
- **Coagulation and flocculation:**
  - Currently there is no rapid mixing process at the point of coagulant dosing to rapidly disperse the coagulant throughout the water body. Rapid mixing vastly improves the effectiveness of coagulant as the coagulation reaction occurs rapidly in a fraction of a second. Therefore, rapid mixing is typically provided immediately following the dose point. The current mixing provided by the hydraulic jump over the inlet box weir is located too far away from the dosing point to ensure optimum coagulation occurs, and is not expected to provide sufficient mixing energy where required. Ineffective coagulation is usually overcome by overdosing coagulant. Typically, when using hydraulic mixing, as the rapid mixing step, the coagulant is dosed immediately prior to the crest of the weir through a dosing manifold to disperse the coagulant across the length of the weir.
  - The current flocculation process has not been in operation for some years. The flocculation process adopted at Hay WTP includes a pulse flocculator column in combination with a vacuum pump (currently out of service) to draw the air from the chamber. This results in raising the water level, which is then suddenly lowered driving the flocculated water across the base of the clarification unit, through the distribution manifold and up into the sludge blanket, once an actuated valve opens to allow air to re-enter the chamber. As this process is not in operation, there is currently no dedicated flocculation mixing process provided.
- **Clarification:**
  - The existing clarifier was designed with a single sludge overflow outlet trough on the northern clarifier wall which removes sludge through two adjacent scour points on the western end of the tank. Therefore, it was observed during the site visit that, the clarifier sludge blanket builds up much higher on the south side of the clarifier. This uneven sludge blanket distribution has reportedly resulted in increased 'boil-ups' on one side, and a difference in performance across the clarifier.
  - Some sections of the clarifier inlet distribution manifolds appear to be blocked, therefore preventing even distribution of flocculated water, evidenced by the mounts of sludge forming in some sections of the clarifier and not in others. Operations staff had ensured the sludge was not cleaned out prior to our visit and thus was higher than usual. The clarifier is cleaned out 2 to 3 times a year. However the uneven sludge distribution across the clarifier, with increased sludge accumulation in certain 'hotspots' indicated some orifices may be blocked. This results in the water penetrating through the sludge blanket in several 'hotspots', observed during the site visit, which would be resulting in localised high surface loading rates

as the full clarification area is not being utilised. It was also noted that clarifier 'boil-ups' can occur at temperatures less than 10°C related to temperature inversion. Boil-ups are when flocc from the sludge blanket or the sludge blanket itself are raised to a level at which sludge overflows into the settled water launders. Increased solids in the settled water can reduce filter runtimes and lead to increased risks of turbidity breakthrough in the filters. This may reflect an issue with the frequency of clarifier sludge scours.

  - Operations staff have reported that the additional solids created during algae blooms causes the clarifier sludge to 'boil up' over the launders, resulting in the filters becoming blocked. Algae has a tendency to float however this could also reflect ineffectiveness in the existing coagulation and flocculation practices at the WTP which are making it increasingly more difficult to capture algae cells.

- **Filtration:**
  - The filters are currently backwashed twice per week, unless the operators notice through daily grab samples an increase in treated water turbidity or headloss (visual based on the outlet valve opening position). Online turbidity monitoring is undertaken after the clear water tank (CWT) which is a delay of at least 0.5 – 2 hours, and so there is a risk that the tank could be contaminated with unsafe water following turbidity breakthrough.
- **Disinfection:**
  - The current underground CWT tank has no baffling, and the location of the inlet and outlet create a direct path diagonally across the rectangular tank, over which a significant amount of short-circuiting would be expected. As the treated water feeds into the reticulation network before storage in the reservoir, the CWT tank is the only storage that can be used to provide chlorination contact time (C.t) for disinfection. It is expected that the current storage with the potential for short circuiting would not provide sufficient C.t for effective disinfection. Based on Hunter H2Os experience through recent tracer testing investigations, we believe that the previous C.t calculation did not fully factor in the extent of potential short circuiting that could occur in the CWT tank, and thus this should be re-evaluated. Furthermore, the short storage time, and potential for short circuiting, has led to chlorine-related taste and odour complaints from customers nearest to the WTP in the reticulation network when free chlorine residuals are high, thereby limiting the ability to simply increase chlorine residuals to increase C.t.
  - Hunter H2O recommends that a C.t target of 30 mg.min/L should be adopted if there is a risk of algae toxins in the raw water. This is to ensure there is a multi-barrier approach in place due to the difficulty of targeting correct PAC dose rates for algae toxins removal and the inability to validate the removal in real time. The current C.t was calculated to be 15 mg.min/L (equal to the NSW Health, WHO and ADWG recommendations), which we believe may be an overestimate as stated above, hence achieving a higher Ct using the existing system is considered unlikely without undertaking upgrades to the CWT including baffling.
  - To confirm the baffle factor fluoride tracer testing is recommended to be undertaken which would then inform any baffle upgrade options that could be considered.
- **Post chemical dosing:**
  - Currently fluoride, chlorine and post soda ash are dosed into the CWT inlet. However, there is no flow monitoring at this point. The only flow monitoring undertaken prior to these dose points is on the raw water main prior to coagulant dosing. Therefore, if post chemical dose rates are adjusted based on the plant raw water flow, then there is a risk of overdosing when the clarifier sludge is scoured if the WTP remains online. As the instantaneous flowrate of the WTP is quite low (typically ~25 L/s) the proportion of the sludge scour to the raw water flow could be quite substantial, potentially up to 25-50% based on the large diameter of the sludge scour pipes.
- **Chemical dosing systems:**
  - The alum and soda ash dosing pumps are in a location which is unergonomic to access. In addition, there are no flow switches to enable confirmation of dosing. Hence if a coagulant dosing pump failed, with no interlocks and if the site was not attended the first alert of the situation could be the treated water turbidity CCP exceedance via the online analyser.
  - The alum storage tank (~30 yrs old) would be approaching (if not already exceeded) its 25-30 year design life and will require replacement soon. In addition, the storage tank is not bunded. Although aluminium sulphate (alum) is not classified as a Class 8 corrosive according to the Australian Dangerous Goods Code, it is industry best practice to ensure the alum is bunded for safety and environmental reasons. Thus, adherence to *AS3780 - Storage and Handling of Corrosive Substances* is recommended for the design of the tank bunding.

Due to the number and nature of the potential process issues identified as a result of the preliminary observations, Hunter H2O recommends that Council conduct a full process assessment / capacity review of Hay WTP to determine the extent of these process issues, quantify the issues, determine and identify any further issues and confirm the need for any potential WTP upgrades. Combined with the audit of automation and process instrumentation detailed in this report, the process assessment would provide clarity on the overall pathway forward and need for upgrades at Hay WTP to ensure a safe supply of water is delivered to the community through a resilient and robust treatment process.

3 Audit Findings Proposed Works

When assessing the Hay WTP, Hunter H2O have taken into consideration the integration of the new instrumentation into the existing site control system and telemetry. This includes the replacement of the existing plant programable logic controller (PLC), the addition of an independent SCADA system and the upgrade of the existing site telemetry system. Due to the limitation of the plant PLC and RTU.

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.

3.1 Methodology

The recommended process and instrumentation upgrades for Hay WTP 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 the plant would be in addition to a total control system design 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 the plant. Options for the upgrade of the plant MCC were also considered alongside the simultaneous upgrade of the laboratory room at the WTP.

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 the 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.

3.1.1 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 the cost estimate sections. A contingency allowance (30%) was added to the traditional engineering estimates.

Cost estimates were developed for the various options provided in Section 3.3.2 for the control system and laboratory upgrades. The process cost estimate common to all of the MCC/laboratory upgrade options (provided in Section 3.2.3.1) was calculated as a standalone cost that would be common to each option. The options cost estimates were then individually added to the common process cost estimate to give the overall project cost estimation for each option (provided in Section 4).

3.2 Hay WTP

3.2.1 Existing WTP and instrumentation

Hay WTP was built in 1988, and has a design capacity of 2.1 ML/d. Water to the township of Hay is sourced from the Murrumbidgee River, with drinking water to the treatment plant being supplied by the Murray St pump station. Water is also drawn by the Leonard Street pump station for chlorination and distribution as a non-potable water supply, for external domestic use only. Only the potable water system has been considered in this audit, within the bounds of the Hay WTP site.

The current treatment process consists of:

- pre-coagulation pH correction with soda ash,
- coagulation with aluminium sulphate (alum),
- PAC dosing for taste and odour/algal toxin removal (as required),
- vacuum flocculation (not currently working),
- sludge blanket clarification,
- media filtration (via two sand filters),
- disinfection with chlorine gas,
- pH correction with soda ash, and
- fluoridated with sodium fluoride.

Treated water is stored in the onsite underground clear water tank (CWT) before being transferred into the town reticulation network and storage at Pine St reservoir. There is also a pre-coagulation chlorination system present, although it is disconnected and has not been used recently.

Control Philosophy

- A low level in the Pine St reservoir calls the treated water pumps (clear water pumps) to start, following which a low level in the CWT calls the raw water pumping station to start pumping water from the river.
- Once flow is detected by the raw water flowmeter at the WTP all pre-chemical dosing is called to start.
- Post chemical dosing is called to start when the filter outlet level probe detects water going over the filter outlet weir into the CWT.
- A high level in the CWT triggers the raw water pumps to stop, and a high level in the reservoir triggers all pumping to stop. However, the plant is often manually controlled by operators.

Raw and treated water flow meters are available to monitor the flow into and out of the plant, although they appear to be reaching the end of their effective service life.

Water quality analysers provide information visually to operators through the controller screen on the treated water free chlorine, turbidity and pH; the free chlorine is the only online monitoring interlocked and alarmed to CCPs however, and the treated water pH meter is reported to provide false readings unless regularly calibrated. Frequent calibration of the meter is required as part of the daily/weekly routine. Furthermore, there are no other water quality analysers on the raw water or throughout the treatment process.

Therefore, aside from free chlorine monitoring, 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’ to all other water quality parameters when operations staff are not in attendance. In addition, the lack of water quality monitoring throughout the process makes it difficult to control and ensure the effectiveness of treatment processes.

The existing WTP has the following online analysers, summarised in Table 3-1.

Table 3-1: Existing online water quality analysers at Hay WTP

Water Quality Parameter	Monitoring Point
Turbidity	Treated water
Free chlorine	Treated water
pH	Treated water

The existing WTP has the following key main process control functionality, summarised in Table 3-2.

Table 3-2: Existing process control functionality at Hay WTP

Process Parameter	Monitoring Point
Flow monitoring	Raw water (mag flow)
	Raw Water (Murray St)
	Treated water (mag flow)
	Air scour (orifice plate)
	Backwash water (flow totaliser)
Level Monitoring	Clear water tank
	Pine St reservoir
Level switches	CWT high/low levels
	Pine St reservoir high/low levels
	Filtered water weir (used for flow confirmation)
Flow switches	Pine St reservoir clear water – flowmeter pulse

3.2.1.1 Raw water pumping station and control system

Although this study's focus is on the WTP itself and the raw water pump station was not visited, based on the findings of the SCADA system inspection it was determined that the Murray St RWPS has two pumps that feed the WTP as a duty / standby pair. There is a level transmitter that monitors the river level. The system also monitors the operation of the pumps for running and failure, along with the sump and dry well flood levels and the site power status.

3.2.2 CCP summary

The critical control points (CCPs) for the Hay water treatment network are summarised in Table 3-3 (Hay Shire Council , DWMS Implementation Project – Final Report, Bligh Tanner 2019).

Each critical control point has a target, alert level and critical limit. The target levels are where the system should be operating, alert levels 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. The public health unit must be notified of breaches in the critical CCP limits.

Table 3-3: Summary of CCPs for Hay WTP (Hay Shire Council, 2018)

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Level	Critical Limit
1	Filtration	All pathogens	Filtered Water Turbidity	<0.25 NTU	>0.3 NTU	>0.5 NTU
2	Disinfection (gas)	Chlorine sensitive pathogens	Chlorine	1.3 – 1.5 mg/L	<1.3 mg/L, >1.5 mg/L	<1.0 mg/L, >5.0 mg/L
3	Fluoridation	Fluoride	Fluoride	0.95 – 1.1 mg/L	<0.9 mg/L, >1.3 mg/L	>1.5 mg/L
4	Reservoirs	All pathogens and all chemicals	Reservoir Integrity	Secure and vermin proof	Evidence of breaches	Breach not rectified or serious breach

Council also implemented several operational control points (OCPs) in 2018, which are summarised in Table 3-4.

These are designed to ensure effective operation of the WTP and support the implementation of the CCPs through operational controls, but do not trigger a requirement to report to the public health unit if a limit is breached.

Table 3-4: Summary of OCPs for Hay WTP (Hay Shire Council, 2018)

OCP ID	Monitoring Parameter	Target	Adjustment	Alert Level
1	Clarification	Turbidity: <2 NTU pH: 6 - 7 Colour: 2.5 - 5 HU	Turbidity: >2.5 NTU pH: <6, >7 Colour: >10 HU	Turbidity: >5 NTU pH: <5.8 Colour: >15 HU
2	Treated Water	Turbidity: <0.2 NTU pH: 7.6 – 7.8 Colour: 0 HU	Turbidity: >0.3 NTU pH: <7.3, >8.2 Colour: >3 HU	Turbidity: >1 NTU pH: <6.8, >8.5 Colour: >5 HU
3	Reticulated water chlorine	>0.2 mg/L	-	<0.2 mg/L, >1.5 mg/L

3.2.3 Recommended process instrumentation and upgrades

The recommended process instrumentation for Hay WTP is outlined in the following tables:

- Table 3-5 – outlines the online monitoring recommended to facilitate effective implementation of CCP control parameters for the Hay WTP
- Table 3-7 – outlines additional online monitoring recommended to support improved process control, Council's OCPs and assist with the effective operation of the treatment plant
- Table 3-7 – outlines the process instrumentation recommended to support improved process control.

Online turbidity, free chlorine and fluoride water quality monitoring should be provided to ensure safe drinking water and ensure that only water that is compliant with CCPs is sent to the community. Several online pH monitoring points should also be provided to assist with effective operation of the overall plant and individual processes.

The existing raw and treated water magflow flowmeters appear to be the original meters installed with the plant, and hence will be approaching or will have already exceeded their recommended service life. These should be replaced to ensure effective control of the plant and improve dosing accuracy once flow paced dosing is implemented. 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.

New filtered water magflow meters are also required on the filter outlets to monitor filtered water flow. This will enable flow-paced chemical dosing based on the actual filtered water flow rather than the raw water flow. Currently filtered water chemical dosing (post chemical dosing) is flow-paced on the raw water flow, however during clarifier scours the filtered water flow could potentially drop to half of the raw water flow, meaning that chemical dose rates are effectively doubled for this period. Providing flow monitoring for the filtered water will eliminate this issue and risk.

The existing chlorine gas dosing system should be linked to online setpoints for the treated water free chlorine 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). This will improve reliability of chlorine dosing and ensure CCPs for disinfection are met.

New dosing flow switches on chemical dosing lines are required for the PAC, alum and soda ash dosing systems to enable flow confirmation and provide alarming for flow errors. Level indicating transmitters should also be installed on the alum storage tank and soda ash mixing tanks to ensure chemical levels are correctly maintained and provide alarming at reorder levels. This will ensure reliability 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.

Addition of a pre-filter chlorine dosing system is recommended to provide treatment for iron and manganese issues that have been recorded at the plant. Chlorine acts as an oxidant by increasing the oxidation-reduction potential (ORP) of the water, which promotes the formation of a manganese oxide coating on the sand filter media. Operation of this oxide-coated media process in turn promotes the further removal of soluble iron and manganese through a catalytic adsorption then oxidation process. As there is already an existing pre-chlorine dosing system that isn’t used, pre-filter chlorine dosing could be implemented by simply moving the dosing point from the raw water inlet to the filter inlet pipes (using a splitter). An additional free chlorine analyser would be installed to measure filtered water free chlorine, which would enable automated chlorine dosing with feedback trim control functionality. The oxidation process is less effective at a lower pH, and therefore a settled water pH meter would also be installed to monitor the pH of the water entering the oxide-coated media filters to ensure the pH remains above 6.2.

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).

Clarifier sludge scours should generally occur multiple times per day for effective clarifier operation. This process can also be automated to improve reliability and reduce the operational time required for manual sludge scours.

The vacuum flocculator should also be recommissioned. This utilises a vacuum pump to draw water up a column and release it to the clarifier to create turbulence and mixing. This mixing process is essential for effective flocculation to occur, which directly effects the solids removed by the clarifier. The current vacuum pump is not working, and will need to be replaced.

Table 3-5: Recommended online monitoring to facilitate effective implementation of CCPs

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Turbidity	Filtered Water Turbidity Filter 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.
	Filtered Water Turbidity Filter 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.
Chlorine	Treated Water Free Chlorine (existing)	Online free chlorine analyser (existing) (1AI + DI)	Provide monitoring, alarming and interlocks on free chlorine concentrations in the treated water to ensure chlorine dosing does not trigger CCP limits. Link the existing analyser to setpoints to provide trim dosing control for the automated chlorine gas dosing system. Ensure the free chlorine required for disinfection is sufficient for the treated water. If baffling was installed in the CWT, a free chlorine analyser could be installed in the middle of the tank to improve the accuracy of this feedback trim dosing control system.
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. Although online fluoride monitoring is not required to meet the NSW code of practice, it is considered best practice based and is in line with Victoria and Queensland. Online fluoride analysers are a mitigation measure to improve water safety and this is deemed appropriate given there is a high consequence if overdosing occurs and this mitigation measure is a reasonable cost.

Table 3-6: Recommended online monitoring to support improved process control

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
Turbidity	Raw Water Turbidity (to be located at RWPS)	Online turbidity analyser (1AI + DI)	Located at the raw water pumping station to provide an early warning system of high turbidity before it enters the WTP, and can be used to pro-actively alarm and shutdown the WTP when high turbidity is triggered and operator attention is required. Reduces the likelihood of the filters being over-whelmed by changing raw water quality. Allows for 'business hours' response to the issue.
	Settled Water Turbidity	Online turbidity analyser	Provide alarming for high turbidity water leaving the clarifier before it reaches the filters as an

CCP Control Parameter	Parameter	Recommended Instrumentation and I/O	Justification
		(1AI + DI)	early warning of loss of coagulation and flocculation control before impacting the Filter CCP. Used to identify when control of coagulation and flocculation is lost so that action can be taken before the filtration critical control point is breached.
	Treated Water Turbidity (existing)	Online turbidity analyser (1AI + DI)	Provide connection to SCADA, as well as alarming and interlocks. This is the final check that the water is compliant.
Chlorine	Filtered Water Free Chlorine	Online free chlorine analyser (1AI + DI)	Provide monitoring of free chlorine in the filtered water tile chamber to enable control of the automated pre-filter chlorine dosing system. See the details above for the addition of an oxide coated media process.
pH	Raw water pH & Temperature (located at RWPS)	Online pH & temperature analyser (2AI + DI)	Provide monitoring (and alarms) for variations in raw water pH, and assist in the control of 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-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 pH & Temperature	Online pH & temperature analyser (2AI + DI)	The pH of settled water is an important parameter for oxide-coated media filtration processes to remove iron and manganese. Oxidation of iron and manganese is favoured at higher pH. If the pH of water entering the filters is too low, the oxide coating on the filter media could be solubilised and stripped, thus rendering the removal process ineffective. See the details above for the addition of an oxide coated media process.
	Treated Water pH & Temperature	Online pH & temperature analyser (2AI + DI)	Replace the existing treated water pH and temperature meter that is currently providing incorrect readings. This ensures accurate monitoring (and alarms) for treated water pH and temperature, before it is sent to the community.

Table 3-7: Recommended process instrumentation to improve process control

Parameter	Recommended Instrumentation and I/O	Justification
Vacuum Flocculator – Vacuum Pump	Vacuum pump and acoustic cover (4DI / 2DO)	Replace the broken vacuum pump to enable recommissioning of the vacuum flocculator for effective flocculation and solids removal in the clarifier.
Vacuum Flocculator – Air Inlet	Air inlet valve and actuator (2DI / 2DO)	Replace the air inlet valve and provide actuation to allow automatic operation of the vacuum flocculator. This valve allows air to flow back into the column in order to drop the raised column of water.
Clarifier Scour Automation – Sludge Scour Outlet (x2) (existing)	Clarified sludge control valve and actuator (existing) (x2) (4DI / 4DO)	Provide control for the existing electric actuators on the two clarified sludge scour outlet control valves. See above regarding clarifier scour automation using a turbidity based sludge scour (TBSS) technique.
Filter Backwash Automation – Filter Inlet (x2)	Inlet control valve (existing) and actuator (x2) (4DI / 4DO)	Provide automation of filter backwash sequences to ensure filters are backwashed at the correct time, and to improve backwash efficiency, this conserving treated water sued for backwash and decreasing the volume of washwater that needs to be handled.
Filter Backwash Automation – Filter Outlet Flow Control (x2)	Modulating filter flow control valve (existing) and actuation (x2) (2AI / 2AO)	Provide modulating flow control for the existing individual filter outlet valves using level indication of each filter. This allows the filters to operate effectively at a constant level, and can be used for draining and filling during backwash sequences. See above regarding filter backwash automation.
Filter Backwash Automation – VSD Control on Backwash Pump	Backwash pump VSD (2DI / 2DO / 2AI / 1AO)	Installation of a variable speed drive (VSD) on the existing backwash pump for backwash flow control. This provides the ability to control backwash flow using a new backwash magflow meter. See above regarding filter backwash automation.
Filter Backwash Automation – Backwash Inlet (x2)	Inlet control valve (existing) and actuator (x2) (4DI / 4DO)	Provide automatic open/close control for isolation of the individual filter backwash inlets using the existing backwash inlet valves. See above regarding filter backwash automation.
Filter Backwash Automation – Washwater Outlet (x2)	Washwater outlet control valve and actuator (x2) (4DI / 4DO)	Provide automatic open/close control for isolation of the washwater outlet valves. See above regarding filter backwash automation.
Filter Backwash Automation – Air Scour Inlet (x2)	Inlet control valve (existing) and actuator (x2) (4DI / 4DO)	Provide automatic open/close control for the individual filter air scour inlets using the existing air scour inlet valves. See above regarding filter backwash automation.
Filter Backwash Automation – Air Scour Soft Start	Soft start control valve (existing) and actuator (x2) (2DI / 2DO)	Provide automatic open/close control for the common air scour soft start valve. See above regarding filter backwash automation.

Parameter	Recommended Instrumentation and I/O	Justification
Filter Backwash Automation – Filter Level (x2)	Level indicating transmitter (x2) (2AI)	Provide monitoring of level in each filter for control of the individual filter outlet modulating valves. See above regarding filter backwash automation.
Filter Backwash Automation – Backwash Flow	Magnetic flowmeter (1AI + 2DI)	Provide monitoring of backwash flow and allow for backwash flow control using the new VSD on the backwash pump (above). Provides more accurate flow monitoring and greater control for backwash automation compared to the existing pilot tube flowmeter. See above regarding filter backwash automation.
Raw Water Flow Control	Raw water pumps VSDs (existing x2) (4DI / 4DO / 4AI / 2AO)	Connect the existing variable speed drives (VSDs) on the raw water pumps to the plant PLC and SCADA to allow for remote plant flow control.
Treated Water Flow Control	Clear water pumps VSDs (existing x2) (4DI / 4DO / 4AI / 2AO)	Connect the existing variable speed drives (VSDs) on the clear water pumps to the plant PLC and SCADA to allow for remote plant flow control.
Raw Water Flow	Magnetic flowmeter (1AI + 2DI)	Replacement of the existing raw water flowmeter, which is near the end of its service life. This ensure reliable online monitoring of flow into the plant.
Filtered Water Flow (x2)	Magnetic flowmeter (x2) (2AI + 4DI)	Filtered water flow measurement is required to provide accurate flow pacing for dosing of chemicals into the treated water. Flow pacing from the raw water flow is not suitable as it will give increased chemical doses during clarifier scours and filter backwash. Specialty magflow meters that don't require straight pipe lengths upstream and downstream would be installed on each filter outlet pipe to provide total filtered water flow monitoring.
Treated Water Flow	Magnetic flowmeter (1AI + 2DI)	Replacement of the existing treated water flowmeter, which is suspected to be near the end of its service life. This ensures reliable online monitoring of flow out of the plant.
PAC Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the PAC is being dosed.
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.
Alum Dosing Flow	Flow switch (1DI)	Provide alarming and confirmation that the coagulant is being dosed.
Soda Ash Tank Level (x2)	Level indicating transmitter (x2) (2AI)	Provide monitoring and alarming for level in the two soda ash mixing tanks. Ensure soda ash level is correctly maintained. Enable alarming when tanks need to be refilled/batched.

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 Batching	Vacuum Bag Unloader	Provide a vacuum bag unloader increase the operational safety of batching soda ash into mixing tanks by reducing the dust produced and reducing manually handling risks.
Pre-Filter Automated Chlorine Dosing (using existing chlorinator)	Automatic chlorinator (existing) (1AI + DI)	Configure the existing standby chlorinator to dose chlorine gas before the filters to improve reliability of chlorine dosing and maintaining a constant free chlorine residual to enable manganese removal across the filter. See the details above for the addition of an oxide coated media process.
Treated Water Automated Chlorine Dosing (existing)	Automatic chlorinator (existing) (1AI + DI)	Improve reliability of chlorine dosing by linking the existing treated water duty chlorinator to set points for treated water chlorine residual. Configuration of the two existing chlorinators should allow either duty/duty operation for pre-filter and treated water dosing, or duty/standby for treated water dosing. This means disinfection can be maintained if one of the chlorinators fails (improved process robustness).
Chlorine Gas Flow (x2)	Gas flow switch (2DI)	Install gas flow switches on each of the chlorine gas dosing lines to provide alarming and confirmation that the chlorine gas is flowing when gas dosing occurs.
Chlorine Dosing Carrier Water Flow (x2)	Flow switch (2DI)	Install a flow switch on the common chlorine carrier water line to provide alarming and confirmation that the carrier water is flowing when gas dosing occurs.

3.2.3.1 Potential for additional bore water source

Council has indicated that there is interest in a potential future backup bore water supply that would feed the WTP during dirty water events or extended drought conditions. All ground waters are different however some typically have water quality risks such as iron, manganese and carbon dioxide. A dedicated aeration process could be used in the future to remove carbon dioxide and iron, while the manganese (and iron) would be removed via the oxide coated media filters once up and running. If salinity is an issue with increase concentrations of TDS and sodium, then more complex and expensive process options may be required. Blending can also be considered with the river water if bromide concentrations are not high enough to cause concerns with brominated THM formation.

A detailed water quality monitoring program would be required on any new future bore water source to determine the water quality parameters of concern and then compare the existing process and any shortfalls in the process train required to mitigate the newly identified bore water risks.

3.2.4 Process cost estimation

The estimated cost of the required process instrumentation can be seen in Table 3-8. The table shows the total cost for the process instrumentation and installation, 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. This estimate does not include the cost of control equipment and laboratory upgrade options which will need to be added to the costs below. The cost estimates for each individual option are outlined in Section 3.3.2, whilst an overall project cost estimate for each option is provided in Section 4.

The indirect costs provided are considered to be common to all options considered for the control equipment and laboratory room, and therefore they have been presented in this section.

It should also be noted that the estimate for the recommissioning of the vacuum flocculator is only considered to be preliminary, as more information regarding the design of the column would be required to provide a detailed cost estimate of it's recommissioning.

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

Table 3-8: Estimated cost of recommended process instrumentation and installation

Item	Cost (excl. GST)
Direct Costs	
Water Quality Analysers	$96,100
Flow Meters	$31,900
Instruments	$2,400
Dosing Automation	$16,300
Backwash Automation	$57,800
Recommissioning vacuum flocculator	$62,000
Instrumentation installation	$18,500
Electrical installation	$150,000
Indirect Costs	
Engineering Design	$122,500
Engineering Support	$30,000
Commissioning and Training	$30,000
Project Management	$43,500
Total Process Cost Estimate (-50% to +50%)	**$661,000**
Contingency (30% of Total Project Cost)	$198,300
Process Cost Estimate + Contingency (±50%)	**$859,300**

3.2.5 Existing plant and RTU controls

The plant is controlled via a simple Omron CJ2M Programable Logic Controller (PLC) that is housed in a Motor Control Centre (MCC), in the site's laboratory room. Although the PLC is a current model that is supported and manufactured, it will not be suitable for the proposed process upgrades. This is due to the lack of space on the PLC's I/O and the MCC gear plate.

The same is true for the Remote Telemetry Unit (RTU), it is an obsolete RADTEL Series 5000 RTU. It is currently the main source of information onto the telemetry ClearSCADA system, however, it has no room for expansion.

The existing RADTEL RTU has:

- 3 Digital input cards (16 points) with 2 spare inputs
- 1 Digital output card (8 points) with 5 spare outputs
- 1 Analogue input card (8 Points) with 1 spare input

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.

The existing RTU currently monitors the following I/O:

RTU digital inputs

- Clearwater pump 1 running
- Clearwater pump 1 fault

- Clearwater pump 2 running
- Clearwater pump 2 fault
- Duty pump
- Telemetry battery low
- Murray street flow meter pulse
- Telemetry mains failure
- Alum pump 1 running
- Alum pump 1 fault
- Alum pump 2 running
- Alum pump 2 fault
- Chlorine pump 1 running
- Chlorine pump 2 running
- Soda ash pump 1 running
- Soda ash pump 1 fault
- Soda ash pump 2 running
- Soda ash pump 2 fault
- Soda ash pump 3 running
- Soda ash pump 3 fault
- PAC pump running
- PAC pump fault
- Vacuum pump running
- Vacuum pump fault
- Raw water request
- Clear water well low alarm
- Intrusion alarm
- Mains failure

RTU Analogue inputs

- Clearwater well level
- Murray Street flow rate
- Outlet Flow rate
- Chlorine analyser
- Chlorine cylinder 1 weight
- Chlorine cylinder 2 weight

The site electrical drawings were in the council's filing system. It appears that a high majority of the drawings are present, however they are clearly outdated. It is recommended that prior to any updates the site is audited to confirm the drawings.

As described below the condition of the existing MCC is poor and needs to be replaced. Council should take this opportunity to replace the existing PLC and install a dedicated SCADA system for the plant. This will allow Council to upgrade the plant RTU at a later stage, but for now the existing PLC I/O could be left wired to the RADTEL RTU for remote indication and alarming.

The MCC was built in 1988, 32 years ago and as such it has reached the end of its serviceable life. The condition of the MCC is average with several issues within the PLC panel, which means the panels no longer comply with current Australian Standards (AS3000). These issues include:

- Outdated drawings
- IP2X touch potential
- The room not conforming to standards with respect to open door space, points of exit and personal working in an electrical control room
- Obsolete equipment
- Doors not being locked to stop unqualified personal entering the MCC
- Open gland plates allowing pest access
- Possible unprotected power points on standard circuit breakers, no earth leakage protection
- Missing duct covers, therefore unsupported cables
- The use of PB connector instead of terminals
- Lack of cable protection on door hinge points
- Spare wires left unterminated
- Devices and wires not identified
- The use of substandard cable (i.e. twin flat building wire)
- No protection of cables for sharp edges
- No room for expansion on the MCC space, the PLC I/O or the RTU controls.

Council are currently looking at the option of installing a new generator connection point at the WTP. This should be used as an opportunity for council to install a new Main Switch Breaker (MSB) panel that will feed the existing panel and the future MCC panel. This will allow for both panels to be energised during the cutover, giving more time and flexibility to move the electrical devices from one panel to the other.

The design of a new MCC panel will be larger than the current panel as it will be a Form 3 format in order to be compliant with the current Australian Standards. This will need to be considered during the cutover. The design will need to consider the location of the new MCC panel and the length of the existing cables. A new Junction box may be required to extend the cable lengths if the new MCC panel is not placed in the existing position within the laboratory room.

The existing panel is 2300mm high, however, the door height for the room is 2000mm, making the extraction of the old panel difficult. It is suggested that the wall on the end of the lab room is removed to allow for the new panel to be installed and the old panel to be removed. This would also help with two-way access to the MCC room if a new room is not considered. To remove this wall the existing electrical meter panel and earth point will need to be relocated.

3.2.6 Recommended control system upgrades

With respect to the electrical and control system it is recommended that the MCC, PLC and RTU are all upgraded. The key justification being; the age of the equipment, non-compliance with Australian Standards and the associated safety risks, and lack of space to expand as the current MCC and control equipment does not have sufficient space for the proposed upgrades.

Several options have been identified in Section 3.3.1 that also consider the options for the upgrade of Council's laboratory room.

The plant control would be achieved by a new PLC that would be installed in the new MCC, with the long-term goal to connect the PLC via a new plant RTU and radio. 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.

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

- 96 digital input points
- 48 digital output points
- 40 analogue input points
- 4 analogue outputs.

However, the above would need to be confirmed and refined during the concept design.

3.3 Control System and Laboratory Options

The following sections outline the available options for the simultaneous upgrade of the plant control system (MCC) and the laboratory room. Section 3.3.1 provides an overview of the advantages and disadvantages, whilst Section 3.3.2 provides cost estimates for each option.

3.3.1 Options available

Four possible options for the plant laboratory room and MCC upgrade were considered:

1. Do nothing
2. Move the laboratory into a new location and replace the existing MCC within the existing control room
3. Move the existing MCC into a new location and rebuild a new lab room in the existing location
4. Remove both the Laboratory and MCC rooms into separate locations.

3.3.1.1 Option 1 – Do nothing

If option 1 is taken this would effectively stop any opportunity to improve or expand the current WTP control system as there is currently no spare I/O or space within the PLC, RTUs or Panels. It will also mean the current safety and operational risk will remain. This option is therefore not considered acceptable.

3.3.1.2 Option 2 – Lab in new room

In this option 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. A detailed cut over plan would need to be developed to ensure minimal down time. This may include generator operation, a termination box to be installed where the current panel is located or a total panel replacement of the panel in the current location.

Within this option the laboratory would be moved to a new building. It is recommended that this location is on the traffic island located opposite the plant, at the front of the site. This will give the operators clear vison of who is coming into the plant and to be able to monitor the plant deliveries. The existing lab room would be gutted to allow for the new MCC to be installed and wet instruments moved to the lab room.

3.3.1.3 Option 3 – MCC in new room

The location for a new MCC switch room will depend on factors such as underground services, cable lengths and site access. However, in this high level study, it is assumed that the MCC is placed in the current location of the Alum tank for this option.

This would require the implementation of a junction box in either the existing MCC location or on the opposite side of the wall of the MCC, next to the plant power distribution panel. New cables would then need to be run from this junction box to the new MCC.

The current Alum storage area location may allow the redirection of the existing cables from the old MCC to the new MCC, as most of the drives are placed on that side of the plant. Cable runs for the new devices will be direct to the new MCC. As the MCC is only 160 amps it could be placed into a simple insulated garage on the wall of the plant room. It will also allow the old Alum tank to be replaced with a new tank in a different location, fitted within a bunded area compliant with AS3780 (Storage and Handling of Corrosive Substances).

Within this option the laboratory would stay in its current location. With the old MCC removed, the Lab room could be expanded and remodelled to allow more space.

3.3.1.4 Option 4 – MCC and lab in new rooms

This option would be a combination of the both options 2 and 3. The MCC would be located in the existing Alum tank position and a new Lab room would be established in front of the plant.

Each of the four options advantages and disadvantages have been compared in Table 3-9.

Table 3-9: Comparison of options

Item	Option 1 – Do nothing	Option 2 – Lab in new room	Option 3 – MCC in new room	Option 4 – MCC & lab in new rooms
Description	Do nothing	Move the laboratory into a new location and replace the existing MCC within the existing control room.	Move the existing MCC into a new location and rebuild a new lab room in the existing location.	Remove both the Laboratory and MCC rooms into separate locations.
Key advantages	▪ no cost	▪ replacement of end of life equipment ▪ reduction in safety risk ▪ reduction in operational risk ▪ reduction in water quality risk ▪ increased lab space. ▪ lowest cost to implement	▪ Replacement of end of life equipment ▪ reduction in safety risk ▪ reduction in operational risk ▪ reduction in water quality risk ▪ increased lab space ▪ simpler cutover plan for the old MCC ▪ no modification to the existing lab room wall	▪ Replacement of end of life equipment ▪ reduction in safety risk ▪ reduction in operational risk ▪ reduction in water quality risk ▪ increased lab space ▪ simpler cutover plan for the old MCC ▪ no modification to the existing lab room wall
Key disadvantages	▪ end of life equipment still in service ▪ safety risk ▪ operational risk ▪ water quality risk ▪ limited lab space.	▪ difficult cutover of the new MCC ▪ modifications to the existing lab room wall.	▪ medium cost to implement ▪ possible small junction box to remain in the lab room.	▪ possible small junction box to remain in the lab room. ▪ highest cost to implement

Figure 3-1: MCC and Lab room

Figure 3-2: Plant PLC

Figure 3-3: Option 2, proposed doorway location

Figure 3-4: Option 3 & 4 proposed MCC location

3.3.2 Cost estimation for each option

The estimated cost of each option described in Section 3.3.1 can be seen in Table 3-10. The estimates provided are based on previous project experience for a turnkey solution including design, programming, materials, installation and commissioning. A contingency of 30% has been provided on top of the total cost estimates. These estimate does not include the cost of the process instrumentation required for the upgrade, which will need to be added to the costs below. The process cost estimate is outlined in Section 3.2.3.1, whilst an overall project cost estimate for each option is provided in Section 4.

It should be noted that the costs of Option 1 are provided as zero, as this is the “do nothing” approach. Section 3.3.1 above outlines the operational and safety risks associated with this option.

A detailed breakdown of the control system and laboratory options cost estimation is provided in Appendix A.

Table 3-10: Estimated cost of recommended control system and laboratory options

Item	Option 1 Cost (excl. GST)	Option 2 Cost (excl. GST)	Option 3 Cost (excl. GST)*	Option 4 Cost (excl. GST)*
MCC Option	$0	$500,000	$750,000	$750,000
Laboratory Option	$0	$150,000	$50,000	$150,000
Project Management	$0	$65,000	$80,000	$90,000
Total Process Cost Estimate (-50% to +50%)	**$0**	**$715,000**	**$880,000**	**$990,000**
Contingency (30% of Total Project Cost)	$0	$214,500	$264,000	$297,000
Process Cost Estimate + Contingency (±50%)	**$0**	**$929,500**	**$1,144,000**	**$1,287,000**

* Note that these costs do not include a new bunded Alum storage area as this is recommended and would be common to all options. However, Options 3 & 4 mean that the replacement of the bunded Alum storage area would need to occur prior to the works being undertaken.

4 Overall Project Cost Estimation

The cost estimation for the required process instrumentation is provided in Section 3.2.3.1, which includes process instrumentation, installation and indirect costs associated with the upgrades. In addition, the cost estimation for each option provided for the MCC upgrade and upgrade of the existing plant laboratory room is provided in Section 3.3.2. This section serves to combine the two individual cost estimates to provide an overall project cost estimate for each option.

It should be noted that the costs of Option 1 are provided as zero, as this is the “do nothing” approach. If this approach was taken for the MCC, it would not allow the installation of any additional process instrumentation for the plant, and therefore it also represents a “do nothing” approach for the process upgrades as well as the control and laboratory system. Section 3.3.1 above outlines the operational and safety risks associated with this option and as such this option is considered unacceptable.

The overall project cost estimates can be seen in Table 4-1 below. The costs for each section are provided before the addition of project management and a 30% contingency, in order to provide an overview of the overall project management costs and project contingency addition for each option.

Table 4-1: Estimated cost of overall plant upgrades for each identified option

Item	Option 1 Cost (excl. GST)	Option 2 Cost (excl. GST)	Option 3 Cost (excl. GST)	Option 4 Cost (excl. GST)
Process Instrumentation (Incl. Indirect Costs)	$0	$617,500	$617,500	$617,500
MCC and Laboratory Option Costs	$0	$650,000	$800,000	$900,000
Project Management	$0	$108,500	$123,500	$133,500
Total Cost Estimate (-50% to +50%)	**$0**	**$1,376,000**	**$1,541,000**	**$1,651,000**
Contingency (30% of Total Project Cost)	$0	$412,800	$462,300	$495,300
Grand Total Cost Estimate + Contingency (±50%)	**$0**	**$1,788,800**	**$2,003,300**	**$2,146,300**

5 Proposed Delivery Strategy

The proposed delivery strategy for the implementation of the recommended upgrades from this audit 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. To address the process issues identified in Section 2, it is recommended that a full process assessment / capacity/capability review is undertaken for the treatment plant. This will provide further details of the preliminary issues identified with the plant treatment process, and will clarify the scope of upgrades required for the overall plant.

This scoping study and audit has identified the existing levels of monitoring, control and automation for Hay WTP, then identified the key upgrade components required and estimated a cost for each upgrade option.

Therefore, the next stage in this project (automation and process instrumentation audit) 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 (HAZOP & CHAZOP etc)
    iii. Site general arrangement drawing 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 identified in this report and to refine the details for the site. A HAZOP and CHAZOP is also required to ensure that the recoding of the WTP control addresses risks and identifies other process and operability improvements that may be realised with 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. Followed correctly, it prevents many of the issues often experienced in WTPs that are only partially commissioned.

5.1 Pathway forward

The above approach however may be modified pending the outcomes of a detailed process assessment. A process assessment of the plant will provide further information on the scope of any plant upgrades required. In addition, Council have indicated that an audit of the council wide telemetry system is required.

Therefore, Hunter H2O recommend undertaking the process assessment and council wide telemetry system audit before progressing this project further. As part of the process assessment Hunter H2O strongly recommend undertaking fluoride tracer testing of the CWT to confirm the baffle factor and validate the C.t calculation. The actual detention time in a CWT can be determined through tracer testing. In a WTP this is most easily done by stopping and starting fluoride dosing. The test is best undertaken at different flows and storage levels, to determine the various detention times at various operating levels. These additional investigations may identify a larger upgrade requirement and thus can be used to define the scope of works when considering holistic approached to the upgrades at Hay WTP.

2021 Update: *Council engaged Hunter H2O to undertake the follow investigations noted above and the results are presented in the other appendices. A strategic report has been prepared to serve as an overarching report summarising all three investigations undertaken. This report was reviewed by DPIE and comments received for Council to address, which have been considered by Council and Hunter H2O. Additional commentary has been provided to consider areas of risk. Based on the risk of unknowingly providing unsafe water to the community and the WHS risks associated with manual operation of filter backwashing we consider the recommendations in this report as being the best pathway forward to mitigate the identified risks that have been considered.*

Appendix A Cost Estimation Spreadsheets

5814 WTP Automation and Process Instrumentation Audit

Automation Cost Estimate

Date of Estimate: Mar-21

Site: Hay WTP

hunterh2o

Process Costs

Direct Costs	Process Costs
1. Water Quality Analysers	$96,100
2. Flow Meters	$31,900
3. Instruments	$2,400
4. Dosing Automation	$16,300
5. Backwash Automation	$57,800
6. Recommissioning Vacuum Flocculator	$62,000
7. Intrumentation Installation	$18,500
8. Electrical Installation	$150,000
Indirect Costs	
9. Engineering Design	$122,500
10. Engineering Support	$30,000
11. Comissioning and Training	$30,000
Total (excluding control equipment)	$617,500
12. Project Management	$43,500
Grand Total (excluding contingency)	$661,000
Contingency (30%)	$198,300
Total (Inlcuding Contingency)	$859,300

Control and Laboratory Option Costs

	Option 2	Option 3	Option 4
1. MCC and Control Equipment Option	$500,000	$750,000	$750,000
2. Laboratory Room Option	$150,000	$50,000	$150,000
Total (excluding process costs)	$650,000	$800,000	$900,000
Project Management	$65,000	$80,000	$90,000
Total (excluding contingency)	$715,000	$880,000	$990,000
Contingency (30%)	$214,500	$264,000	$297,000
Total (Inlcuding Contingency)	$929,500	$1,144,000	$1,287,000

Overall Costs

	Option 1 - Do Nothing	Option 2	Option 3	Option 4
Process and Indirect Costs	$0	$617,500	$617,500	$617,500
Option Costs	$0	$650,000	$800,000	$900,000
Total (Excluding PM and Contingencies)	$0	$1,267,500	$1,417,500	$1,517,500
Project Management	$0	$108,500	$123,500	$133,500
Grand Total (excluding contingency)	$0	$1,376,000	$1,541,000	$1,651,000
Contingency (30%)	$0	$412,800	$462,300	$495,300
Grand Total (Inlcuding Contingency)	$0	$1,788,800	$2,003,300	$2,146,300

<u>5814 WTP Automation and Process Instrumentation Audit</u>

Process and Instumentation Costing

Date of Estimate: Mar-21

Site: Hay WTP

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
CHANGE IN CPI					
2015 - 2020				1.0830	
2018 - 2020				1.0290	
Direct Costs					
1. Water Quality Analysers					
Raw Water Contactless Turbidity Analyser & Controller	1	Item	$12,500	$12,500	
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	4	Item	$2,000	$8,000	
pH and Temperture Controller	4	Item	$2,300	$9,200	
					$96,100
2. Flow Meters					
New Raw Water Magflow Meter	1	Item	$4,300	$4,425	
Filtered Water Magflow Meters	2	Item	$6,500	$13,000	
Filtered Water Flowmeters Installation	2	Item	$5,000	$10,000	
New Treated Water Magflow Meter	1	Item	$4,300	$4,425	
					$31,900
3. Instruments					
Level Indicating Transmitter	3	Item	$800	$2,400	
					$2,400
4. Dosing Automation					
Pre-filter Chlorine Dosing Line and Flow Splitting	1	Lump Sum	$4,500	$4,500	
Chlorine Gas Flow Switch	2	Item	$1,100	$2,200	
Dosing System Flow Switches	5	Item	$500	$2,500	
Soda Ash Vacuum Bag Unloader	1	Item	$6,500	$7,040	
					$16,300
5. Backwash Automation					
Filter Inltet Valves Actuation	2	Item	$3,000	$6,000	
Backwash Water Inlet Valves Actuation	2	Item	$3,000	$6,000	
VSD Control on Backwash Pump	1	Item	$20,000	$20,000	
Air Scour Inlet Vavles Actuation	2	Item	$1,500	$3,000	
Air Scour Soft Start Valve Actuation	1	Item	$1,500	$1,500	
Filter Outlet Valves Modulating Flow Control	2	Item	$4,000	$8,000	
Washwater Outlet Valves Actuation	2	Item	$3,000	$6,000	
Backwash Magflow Meter	1	Item	$5,500	$5,660	
Filter Level Transmitters	2	Item	$800	$1,600	
					$57,800
6. Recommissioning Vacuum Flocculator					
New air valve	1	Lump Sum	$500	$500	
Air valve actuation	1	Item	$1,500	$1,500	

<u>5814 WTP Automation and Process Instrumentation Audit</u>

Process and Instumentation Costing

Date of Estimate: Mar-21

Site: Hay WTP

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
New Vacuum Pump & Acoustic Cover	1	Item	$60,000	$60,000	
					$62,000
7. Instrumentation Installation					
Plumbing and Piping for Analysers	10	Item	$500	$5,000	
Labour Hours	168	Hours	$80	$13,440	
					$18,500
8. Electrical Installation					
Electrical Installation Equipment (e.g. Cabling)	1	Lump Sum	$60,000	$60,000	
Labour Hours	1	Lump Sum	$90,000	$90,000	
					$150,000
<u>Indirect Costs</u>					
9. Engineering Design					
Process Design	80	Hours	$250	$20,000	
P&ID Preparation	50	Hours	$250	$12,500	
Site GAs (Instrument Locations)	20	Hours	$250	$5,000	
HAZOP and CHAZOP	40	Hours	$250	$10,000	
Functional Design Specification (FDS)	100	Hours	$250	$25,000	
Electrical Preliminary Design	40	Hours	$250	$10,000	
Scope of Works Document	40	Hours	$250	$10,000	
Technical Specification for D&C	120	Hours	$250	$30,000	
					$122,500
10. Engineering Support					
Tender Review	40	Hours	$250	$10,000	
Technical Support (Owners Engineer/Representative)	80	Hours	$250	$20,000	
					$30,000
11. Commisioning and Training					
Commissiong and Training Time	120	Hours	$250	$30,000	
					$30,000
<u>Total, PM and Contingency</u>					
Total					
Total Cost (Excluding PM and Contingency)					$617,500
Project Management					
Project Management Costs					$43,500
Grand Total					
Grand Total (excluding contingency)					$661,000
Contingency					$198,300
Grand Total excluding control equipment					$859,300

5674 WTP Automation and Process Instrumentation Audit

Control Costing

Date of Estimate: Mar-21

Site: Hay WTP - Control Option 2

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
Direct Costs					
1. MCC and Control Equipment Option					
New MCC in Existing Location	1	Lump Sum	$500,000	$500,000	
					$500,000
2. Laboratory Room Option					
New Laboratory Room & Control Room, New Location	1	Lump Sum	$150,000	$150,000	
					$150,000
Total, PM and Contingency					
Option 2 Total Direct Cost					
Total Cost (Excluding PM and Contingency)					$650,000
Option 2 Project Management					
Project Management Costs					$65,000
Option 2 Total (excluding process costs)					
Total (excluding contingency)					$715,000
Contingency					$214,500
Total (inlcuding contingency)					$929,500
Grand Total (including process costs)					
Total Process Cost (including contingency)					$859,300
Total Control Option 2 Cost (including contingency)					$929,500
Option 2 Grand Total					$1,788,800

5674 WTP Automation and Process Instrumentation Audit

Control Costing

Date of Estimate: Mar-21

Site: Hay WTP - Control Option 3

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
Direct Costs					
1. MCC and Control Equipment Option					
New MCC in New Switchroom + Control Room	1	Lump Sum	$750,000	$750,000	
					$750,000
2. Laboratory Room Option					
Lab Room in Exisitng Location	1	Lump Sum	$50,000	$50,000	
					$50,000
Total, PM and Contingency					
Option 3 Total Direct Cost					
Total Cost (Excluding PM and Contingency)					$800,000
Option 3 Project Management					
Project Management Costs					$80,000
Option 3 Total (excluding process costs)					
Total (excluding contingency)					$880,000
Contingency					$264,000
Total (inlcuding contingency)					$1,144,000
Grand Total (including process costs)					
Total Process Cost (including contingency)					$859,300
Total Control Option 3 Cost (including contingency)					$1,144,000
Option 3 Grand Total					$2,003,300

5674 WTP Automation and Process Instrumentation Audit

Control Costing

Date of Estimate: Mar-21

Site: Hay WTP - Control Option 4

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
Direct Costs					
1. MCC and Control Equipment Option					
New MCC in New Switchroom + Control Room	1	Lump Sum	$750,000	$750,000	
					$750,000
2. Laboratory Room Option					
New Laboratory Room & Control Room, New Location	1	Lump Sum	$150,000	$150,000	
					$150,000
Total, PM and Contingency					
Option 4 Total Direct Cost					
Total Cost (Excluding PM and Contingency)					$900,000
Option 4 Project Management					
Project Management Costs					$90,000
Option 4 Total (excluding process costs)					
Total (excluding contingency)					$990,000
Contingency					$297,000
Total (inlcuding contingency)					$1,287,000
Grand Total (including process costs)					
Total Process Cost (including contingency)					$859,300
Total Control Option 4 Cost (including contingency)					$1,287,000
Option 4 Grand Total					$2,146,300

Appendix B Hay WTP Capacity and Capability Assessment

hunterh2o

Hay Shire Council

Hay WTP Capacity Assessment

APRIL 2021

ABN 16 602 201 552

Report Details

Report Title	**Hay Shire** Council: **Hay WTP** Capacity Assessment
Project No.	5814
Status	Final
File Location	P:\Hay Shire Council\5814 WTP Automation & Process Instrumentation Audit\2. Tasks\Var A - Cap Assessment\Report\Final\5814 Var A - Hay WTP Capacity Assessment_Final_Issued.docx
Enquiries	Michael Carter P: (02) 4941 4957 E: Michael.Carter@hunterh2o.com.au

Document History and Status

Revision	Report Status	Prepared by	Reviewed by	Approved by	Issue Date
A	Draft	Mitchell Cole	Michael Carter	Michael Carter	23/11/2020
B	Final (revised based on DPIE comments)	Michael Carter	Michael Carter	Michael Carter	13/04/2021

Executive Summary

A site visit to Hay Water Treatment Plant (WTP) was undertaken by Hunter H2O in June 2020 as part of the Automation and Process Instrumentation Audit. During this site visit, several potential key process issues were identified. These potential issues included:

- Negligible PAC contact time
- Insufficient mixing for coagulation and flocculation
- Uneven sludge blanket distribution and sludge boil-up in the clarifier
- Manual backwashing of filters with no filter outlet turbidity monitoring
- Potential short circuiting in the unbaffled clear water tank (CWT)
- Lack of flow measurement specific to post chemical dosing, leading to an overdosing risk
- Lack of safety features on alum and soda ash dosing pumps, and no bunding on the aging alum storage tank.

As a result of these process observations, Hunter H2O was commissioned by Hay Shire Council (HSC) to conduct a capacity assessment of Hay WTP. This would provide further information on the scope of any upgrades required at Hay WTP, and thus compliment the findings of the previous *Hay WTP Automation and Process Instrumentation Audit Report (2020)*.

Hay WTP was designed with a capacity of 2.1 ML/d, which corresponds to a treated flow production of 27 L/s over 22 hours. Assuming a 90% plant efficiency, the raw water design flowrate would be approximately 30 L/s.

A brief summary of the process unit capacity findings is presented in Figure ES-1. Given that the plant was originally constructed in 1988 when treated water quality targets were less stringent, it is understandable that some original process units may not be capable of achieving the original capacity requirements when assessed against current industry best practice and the most recent water quality guidelines.

The assessment was undertaken by rating the capacity of the process units against a series of typical industry design criteria. These criteria include loading rates, detention times, and capacity to meet maximum dose rates. These have been referred to as Industry Standard Design Values (ISDV) in this report. The actual values for these criteria may change slightly between water authorities, regulators and designers around the world. The ISDV used in the assessment of Hay WTP are values Hunter H2O considers typical in the industry in Australia and are a useful guide in considering the capacity of a process in lieu of an additional performance assessment. The ISDVs provide a reasonable estimate on the ability of the plant to achieve modern water quality performance targets, although further investigation quantifying actual performance is recommended for areas where an issue is identified.

This Capacity Assessment report is focused on production/capacity only. Factors such as process performance, which can be an important factor in the suitability of a system, should also be considered in planning for the future of the WTP.

The process units that do not meet the ISDV and are considered capacity limiting are:

- PAC contact time
- Coagulation mixing energy (weir overflow)
- Backwash air scour and water wash rates
- Treated water storage time.

Since the average capacity is slightly less than 1 ML/d at Hay WTP, the lagoons should be sufficiently large, even during wet periods, until average demand increases beyond ~1.4 ML/d.

The chlorine gas dosing capacity for disinfection does not appear to meet the ISDV. However, the standby chlorinator (which was previously used for pre-chlorination) has a capacity of 1 kg/h compared to the 200 g/h capacity of the duty chlorinator. Hence, if high chlorine doses were required, the standby chlorinator could be used.

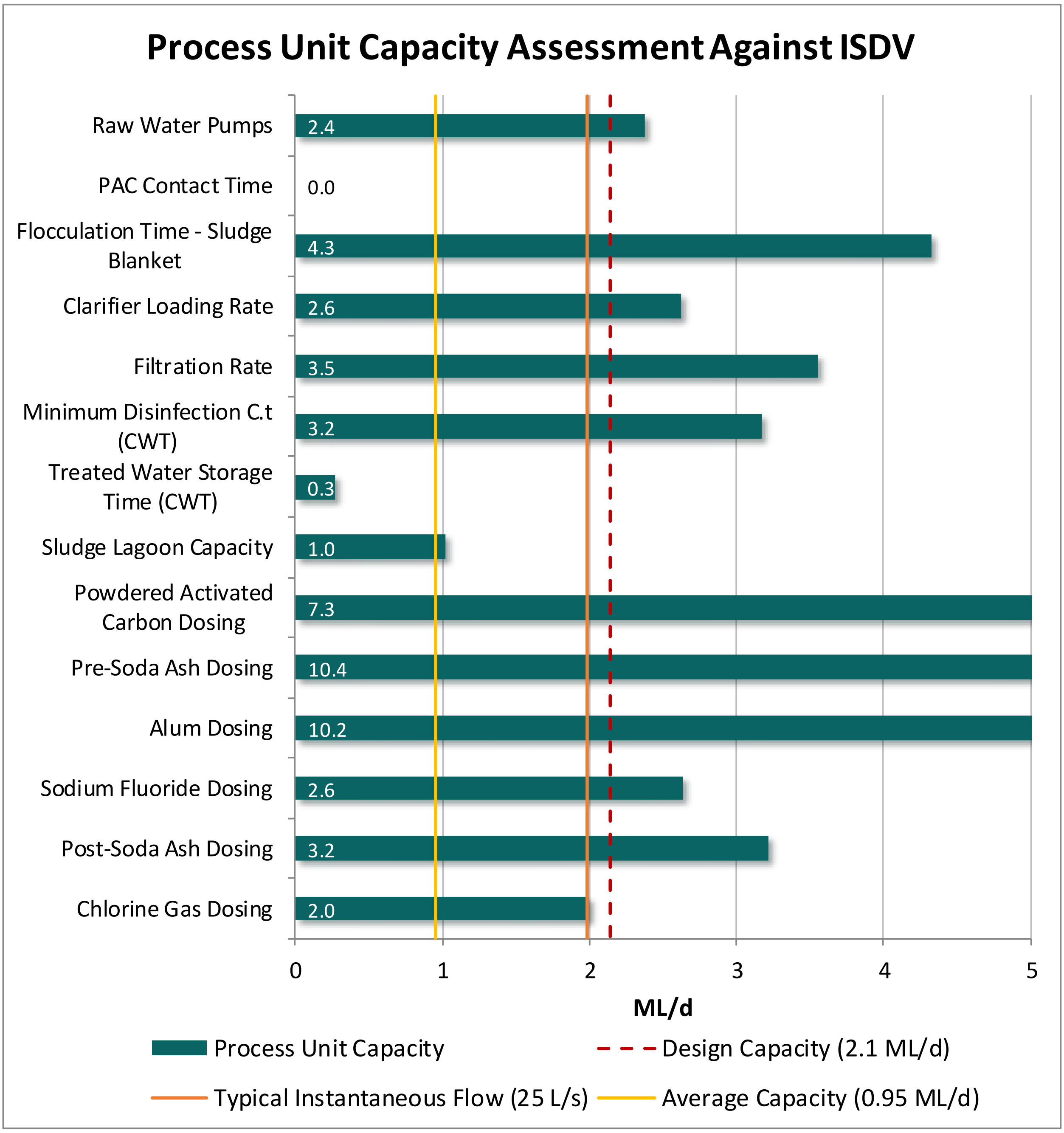

Figure ES-1: Process Capacity Assessment Summary

According to modern industry standards, which formed the basis for this capacity assessment, some of the original plant components would exceed acceptable rates at the original design raw water capacity, estimated to be 30 L/s. The maximum historical instantaneous daily flow recorded since 2012 was 28 L/s while the maximum instantaneous flow calculated based on the daily extraction data equates to 29 L/s over a 22-hour period. Typically, however, the flowrate is set to 25 L/s, with flows greater than this being uncommon.

A number of recommendations are made which have been listed based on their priority. These are provided in Table ES-1.

Table ES-1: Summary of Recommendations

Priority	Recommendation
Short Term (High Priority)	▪ Implement the recommended control system upgrades and process instrumentation installation (as per the *Hay WTP Automation and Process Instrumentation Audit* report) to improve automation and safe operation of the processes at Hay WTP. ▪ Fix or replace the non-functional vacuum pump to improve flocculation and reduce issues such as uneven sludge blanket distributions and sludge build-up at the inlet manifold. ▪ Consider redundancy requirements for the critical PAC feeding and dosing system components due to their critical nature and the lack of standby equipment at the WTP. ▪ Perform an audit of the fluoride dosing system to determine compliance with the Code of Practice and WHS requirements.
Medium Term (Moderate Priority)	▪ Investigate alternative PAC contacting options (such as dosing at or near the Murray Street Pumping Station) to ensure that the WTP has an effective barrier against algal toxins and taste and odour compounds. ▪ Closely review the performance of coagulation, flocculation and clarification, particularly since coagulation rapid mixing energy is low. This will allow for an assessment of the opportunity to improve the clarifier supernatant, improve filter run times and reduce the risk of filter breakthrough. If coagulation issues become apparent, the addition of a static mixer just after alum dosing could be considered. ▪ Undertake a filter inspection to determine the effectiveness of the current backwashing process and to ensure that the low air scour and wash rates are not resulting in sludge build up. Sludge volume indexing and backwash turbidity profiling can be used to determine the existing effectiveness of the backwashing process to clean the filter media. Changes to the backwashing process may be required if the current process is not effective. ▪ Include monitoring of filter run time and UFRV as a measure, along with settled supernatant turbidity, of the performance of the upstream coagulation, flocculation and clarification process. ▪ Set up a system (spreadsheet or other) to perform monthly (at a minimum) settled supernatant turbidity percentile analysis to monitor clarifier performance. ▪ Set up a system (spreadsheet or other) to perform monthly (at a minimum) individual filtered water turbidity percentile analysis to monitor the performance of each filter. This will allow for validation of the performance of each filter against standards set in the WSAA guidelines and HBT guidance material for when HBT are incorporated into the ADWG. ▪ Refurbish or replace the existing alum storage tank, including the construction of a bund for spill containment.
Long Term (Low Priority)	▪ If instantaneous flowrates were to be increased to meet increases in demand were to be increased, investigate the need for polymer dosing or installation of inclined plates/ tubes to improve clarifier performance at increased loading rates. ▪ Undertake a microbial health-based target assessment in line with the Water Services Association of Australia (WSAA) guidelines and HBT guidance material to ensure WTP compliance for when HBT are included in the ADWG. ▪ Implement an automated control system with maximum dose rate exceedance interlocks to minimise the risk of overdosing. Consider downsizing of the pre-soda ash and alum dosing pump to minimise overdosing risks.

Contents

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Appendices

1 Introduction

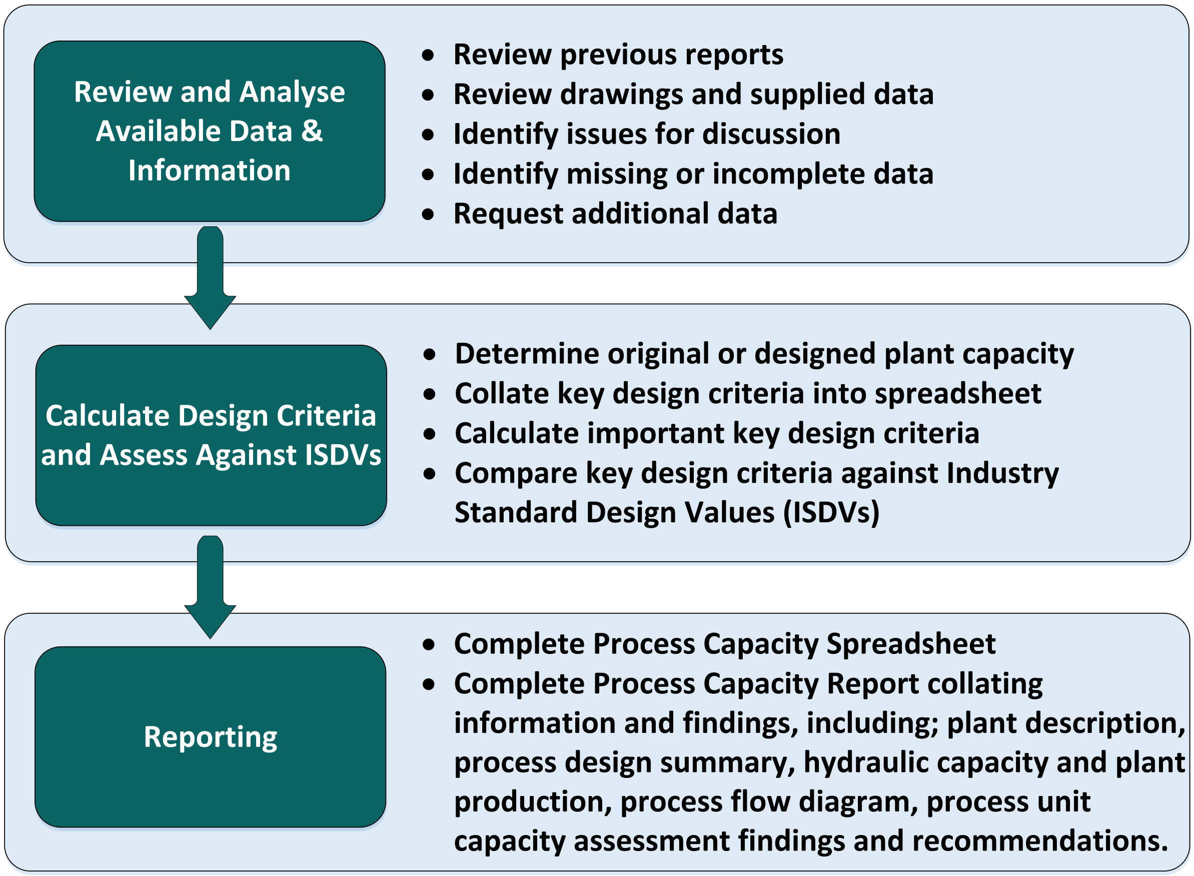
Hunter H2O was engaged by Hay Shire Council (HSC) to undertake a capacity assessment for the Hay Water Treatment Plant (WTP) due to the potential process issues identified during a site visit undertaken for the Automation and Process Instrumentation Audit. Hay WTP has a design capacity of 2.1 ML/d, which was assumed to refer to the treated production capacity.

This Capacity Assessment Report for Hay WTP captures the methodology used to undertake the process review, along with the assessment outcomes, including design criteria for each process unit, assessment of each process against Industry Standard Design Values (ISDV), and an estimate of the actual plant operating capacity.

This Capacity Assessment Report is focused on production/capacity only. Factors such as process performance, which can be an important factor in the suitability of a system, should also be considered in planning for the future of the WTP.

1.1 Capacity Assessment Methodology

The capacity assessment is primarily based around the application of Industry Standard Design Values, and hence may not correlate directly to capacity constraints or bottlenecks experienced by operations in the past. Hence, the results from this assessment should be complimented with an assessment of the historical plant performance to deliver the design water quality and quantity.



The capacity assessment was undertaken by rating the capacity of the process units against a series of typical industry design criteria, including loading rates, detention times, and capacity to meet maximum dose rates. These have been referred to as ISDV in this report. The actual values for these criteria may change slightly between water authorities, regulators and designers around the world. The ISDV used in the assessment of Hay WTP are values Hunter H2O considers typical in the industry in Australia and are a useful guide in considering the capacity of a process in lieu of an additional performance assessment. The ISDV provide a reasonable estimate on the ability of the plant to achieve modern water quality performance targets, although further investigation quantifying actual performance is recommended.

1.2 Data Collection

A site inspection of the Hay WTP was undertaken by Thomas Davies and David Longmuir on the 16th and 17th of June 2020 to collect information and complete onsite measurements which were used to perform this assessment, to complement the reports and documentation provided by HSC. Michael Carter assisted virtually during the site visit through a virtual headset.

Note: during the inspection, the clarifier was not emptied, preventing visual inspection of its internal condition.

2 Plant Description

2.1 WTP Overview

Hay WTP is located on the corner of Cadell Street and Coke Street in Hay, NSW. The WTP sources raw water from the Murrumbidgee River, supplied via the Murray Street Pump Station. Water is also drawn by the Leonard Street pump station for chlorination and distribution as a non-potable water supply, for external domestic use only. Only the potable water system, within the bounds of the Hay WTP site, has been considered in this assessment.

Hay WTP was constructed in 1988 with a capacity of 2.1 ML/d. It was assumed that the quoted capacity referred to the treated production, and that the plant efficiency was 90% efficiency, which corresponds to an estimated raw water design flowrate of 30 L/s over 22 hours.

Hay WTP is a conventional treatment process consisting of pre-coagulation pH correction with soda ash, coagulation with aluminium sulphate (alum), powdered active carbon (PAC) dosing for taste and odour/algal toxin removal (as required), sludge blanket flocculation through vacuum pulsation (vacuum system not currently working), sludge blanket clarification and media filtration (via two sand filters). The filtered water is then disinfected with chlorine gas, pH corrected with soda ash, and fluoridated with sodium fluoride before being stored in the onsite underground clear water tank (CWT). It is then transferred into the town reticulation network and the Pine Street Reservoir town storage.

Hay WTP operates in an cascade mode of production, with a low level in the Pine Street Reservoir calling the treated water pumps to start. A low level in the CWT then calls the raw water pumping station to transfer water from the river to the WTP. The average daily plant runtime between November 2014 and July 2020 was calculated as 10.7 hours, with longer operational hours being more common during the warmer summer months, on rare occasions exceeding 22 hours.

An aerial photo of Hay WTP is presented in Figure 2-1.

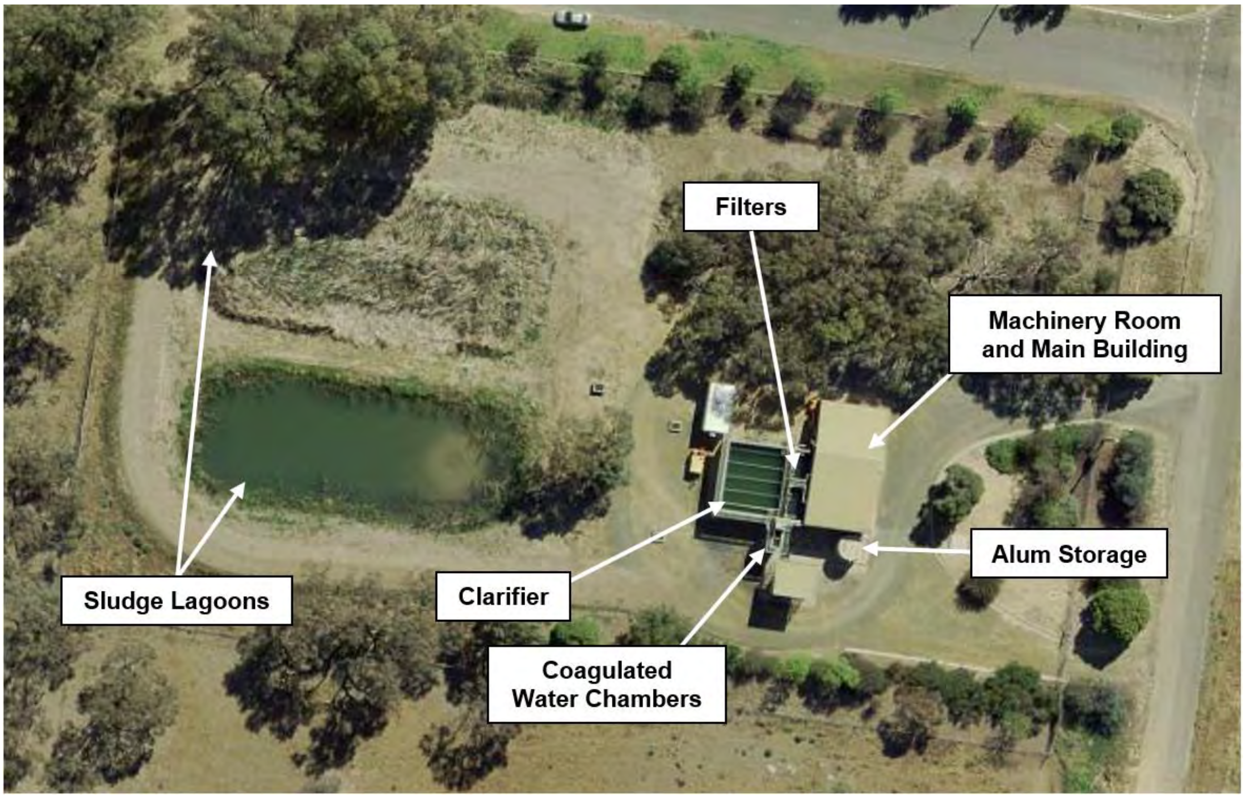


Figure 2-1: Hay WTP Aerial View (SIX Maps, 2020)

2.2 Process Design Summary

A summary of the process design criteria for Hay WTP is presented in Table 2-1. The treated design capacity of 2.1 ML/d is used, with the instantaneous raw water design flowrate estimated as 30 L/s using an assumed plant efficiency of 90%. Further analysis is provided in the individual process unit capacity assessment sections for different flowrates.

Data used for the calculated values below was sourced from the provided drawings, reports, daily Operational Data Log Sheets and onsite measurements, complemented by onsite data collection for specific equipment. Operations and Maintenance Manuals (O&MM) were not available for this assessment.

Table 2-1: Hay WTP Design Criteria Summary

Process Parameter	Value or Description	Units
WTP Design Capacity		
Maximum Daily Plant Production (based on 22 hours of operation and 90% efficiency)	2.1	ML/d
Maximum WTP Treated Water Flow Rate	27	L/s
WTP Process Units Design Summary		
Pre-Dosing		
Chemical Type 1	Soda Ash	-
Typical Dose	0.0	mg/L
Minimum Dose	0.0	mg/L
Maximum Dose	14.6	mg/L
Chemical Type 2	Powdered Activated Carbon (PAC)	-
Typical Dose (median, when dosed)	5.0	mg/L
Minimum Dose (when dosed)	5.0	mg/L
Maximum Historical Dose	20.0	mg/L
PAC Contacting		
Contact Time (current operation)	0.0	min
Contact Time (if dosed at Murray St RWPS)	43.6	min
Coagulation and Rapid Mixing		
Coagulant Type	Aluminium Sulphate (Alum)	-
Typical Dose (median)	42.0	mg/L
Minimum Dose	18.0	mg/L
Maximum Dose	90.4	mg/L
Rapid Mixing Type	Hydraulic (Flow Over Weir)	-
Mixing Velocity Gradient, *G*	187	s^{-1}
Rapid Mixing Time	1	s
Detention Time (inlet chamber)	2.5	min
Flocculation		
Type	Sludge Blanket/ Fluidised Bed	-
Detention Time (2nd chamber)	2.2	min
Detention Time (vacuum chamber)	2.2	min
Time to Fill (vacuum chamber)	*N/A (no vacuum)*	s

Process Parameter	Value or Description	Units
Time to Discharge (vacuum chamber)	*N/A (no vacuum)*	s
Flocculation Time (sludge blanket)	36.4	min
Flocculation Energy, *G*	3.3	s^{-1}
Clarification		
Type	Sludge Blanket Clarifier - Pulsator	-
Number of Clarifiers	1	no.
Rising Velocity	1.8	m/h
Detention Time	2.1	hours
Desludge Type	Gravity	-
Filtration		
Type	Mono-Media Gravity Filters	-
No. of Filters	2	no.
Filtration Rate	5.4	m/h
Filtration Area (per filter)	10.1	m^2
Filtration Area (total)	20.2	m^2
Filter Media Type	Sand	-
Filter Media Effective Size (d10) - Sand Layer 1	0.65	mm
Filter Media Effective Size (d10) - Sand Layer 2	1.3	mm
Filter Media Depth - Sand Layer 1	600	mm
Filter Media Depth - Sand Layer 2	150	mm
L/d Ratio - Combined	1038	-
Filter Backwashing		
Air Scour Duration	10	mins
Air Scour Flow Rate	59.5	m/h
Water Wash Duration	10	mins
Water Wash Flow Rate	29.3	m/h
Bed Expansion	Not Measured	-
Wash Water Volume (single filter)	6.5	Bed volumes
Backwash Supply Tank Capacity	19.8	Bed volumes
Backwash Supply Tank Capacity	3.0	No. of backwashes
Post-Dosing		
Chemical	Soda Ash	-
Typical Dose (median)	23.5	mg/L
Minimum Dose	13.0	mg/L
Maximum Dose	47.0	mg/L
Disinfection		
Chemical Type	Chlorine Gas	-
Typical Dose (median)	1.54	mg/L
Minimum Dose	1.09	mg/L
Maximum Dose	2.00	mg/L
Chlorine Contact Time (C·t) - Minimum (CWT)	20.0	mg·min/L

Process Parameter	Value or Description	Units
Chlorine Contact Time (C·t) - Typical (CWT)	28.2	mg·min/L
Chlorine Contact Time (C·t) - Maximum (CWT)	50.0	mg·min/L
Fluoridation		
Chemical Type	Sodium Fluoride	-
Typical Dose (median)	1.07	mg/L as F^-
Minimum Dose	0.90	mg/L as F^-
Maximum Dose (ideal)	1.00	mg/L as F^-
Treated Water Storage		
No. of Treated Water Storages	1	-
Total Capacity	150	m^3
Detention Time	1.4	hours
Sludge Dewatering		
Type	Sludge Lagoons	-
No. of Lagoons	2	no.
Sludge Lagoon Floor Area (each, 28 m x 7 m)	196	m^2
Lagoon Height at Top Water Level (TWL)	1.3	m
Sludge Lagoon Capacity (each, at TWL)	509	m^3
Maximum Lagoon Capacity (each, before overflow)	2342	m^3
Typical Dosed Water Sludge Generation	42	mg/L
Time to Fill at 0.95 ML/d Production Rate	352	days
Dry Solids Loading Rate – Average (no PAC)	37	kg DS/m^2
Dry Solids Loading Rate – Average (includes 5 mg/L PAC)	42	kg DS/m^2
Wet Sludge Filling Period - Continuous	12	months
Drying Period Per Cycle	12	months

2.3 Hydraulic Capacity and Plant Production

The maximum hydraulic capacity of Hay WTP was not documented in the available reports or Work as Executed (WAE) drawings. Anecdotally, however, the plant can operate at 30 L/s with sufficient level in the river and available freeboard without overflowing plant structures, and thus the design production capacity is not suspected to be inhibited by the hydraulic design and arrangement of the WTP.

The recorded instantaneous flowrates and raw water usage are provided in the following figures.

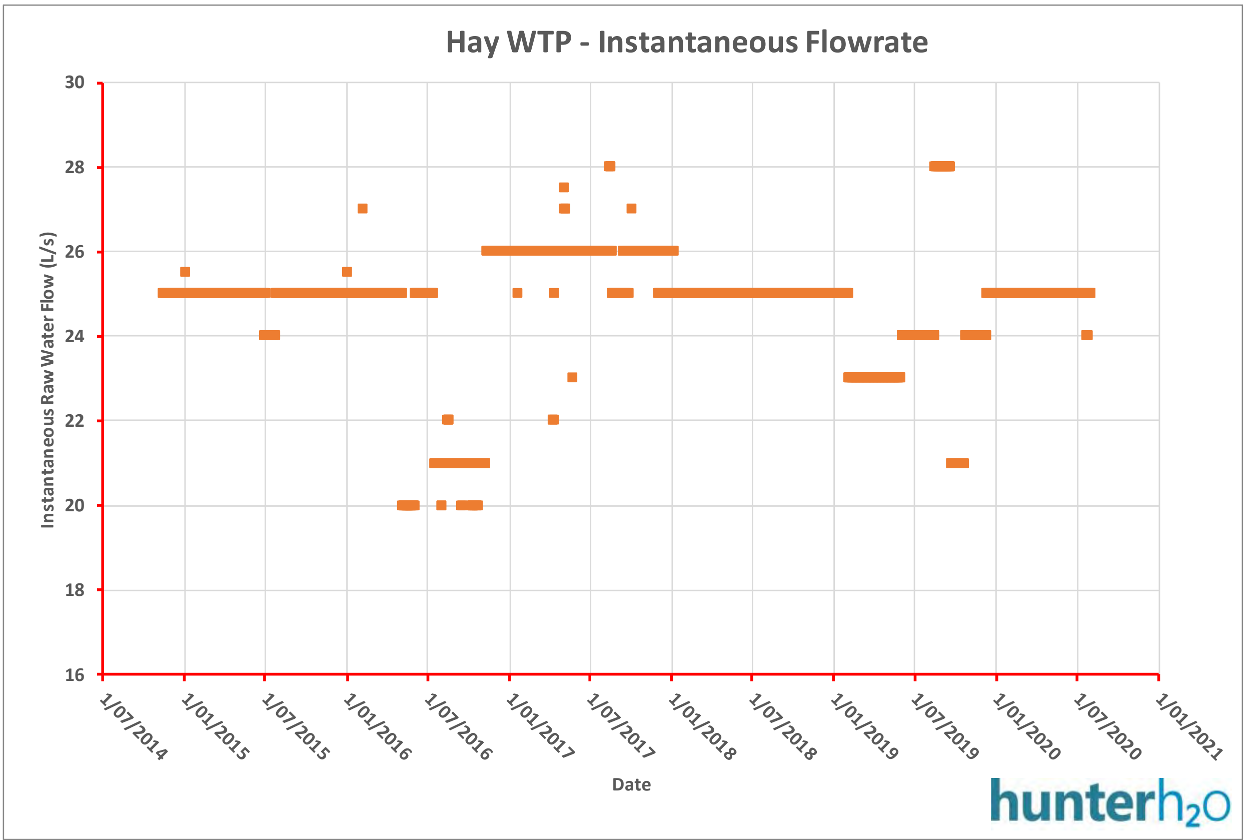


Figure 2-2: Hay WTP Recorded Instantaneous Flowrate (November 2014 – July 2020)

It can be seen from Figure 2-2 that the historical maximum flowrate during the period examined was 28 L/s, the minimum flow setting was 20 L/s, and that the typical setting appears to be 25 L/s.

Figure 2-3 presents the historical raw water extraction rate, with a maximum of 2,297 kL/d recorded. This was equivalent to an instantaneous flowrate of 29 L/s over an assumed 22-hour period (or 26.6 L/s over a 24-hour period) which roughly aligned with the maximum historical plant flow setting of 28 L/s. There appeared to be a slight increase in demand over the examined period. Additionally, there appeared to be a slightly higher demand during the warmer summer months although there was significant variability all year round. It was noted, however, that changes in demand tended to be addressed via a change in plant runtime, while the plant flowrate mostly remained fixed for longer periods of time.

Figure 2-4 demonstrates the historical production demand trends through averaging. The blue curve represents the yearly (365-day) cumulative raw water consumption in ML, and the orange curve represents the average daily raw water flow required to achieve this cumulative yearly consumption in kL. Based on these yearly consumption averages, there was a gradual increase in demand up until 2019, after which the demand has gradually decreased. This may be due to the severe drought conditions that were present during 2019-2020.

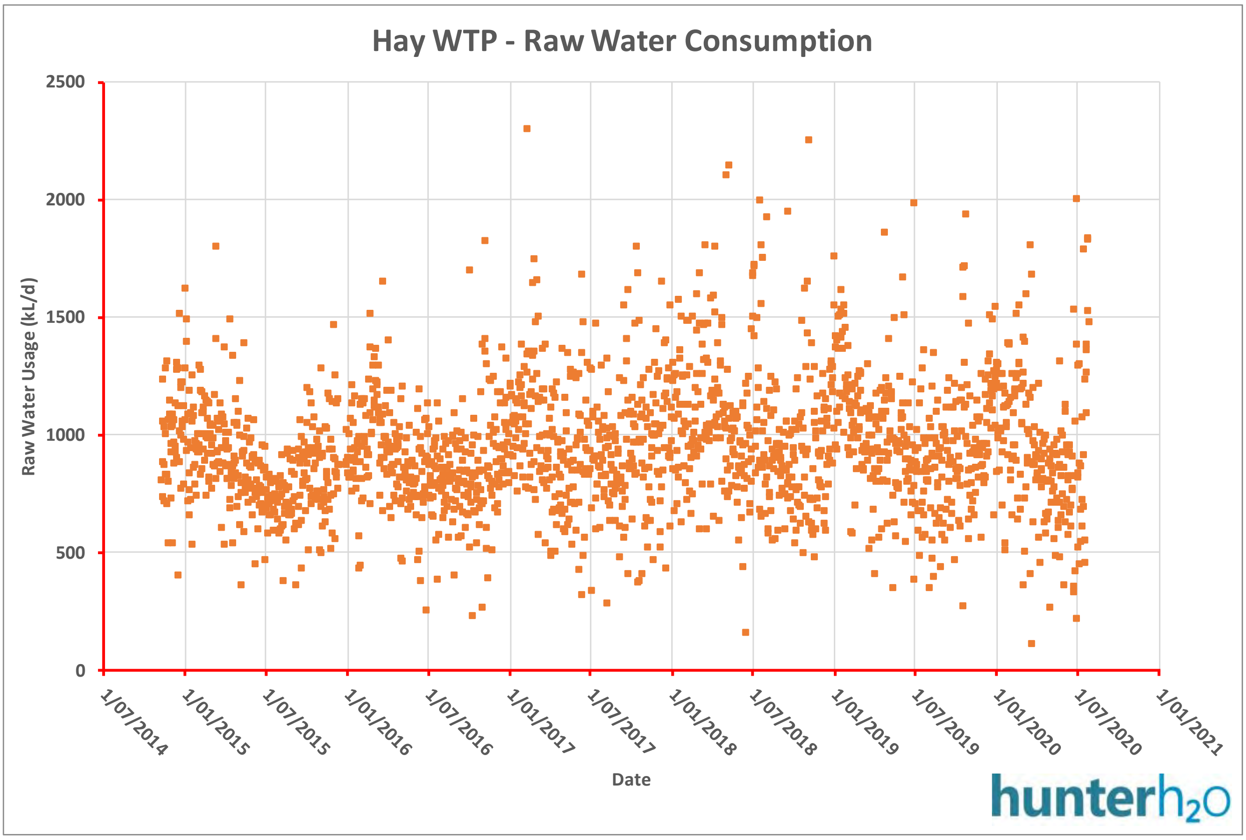


Figure 2-3: Hay WTP Actual Raw Water Usage (November 2014 – July 2020)

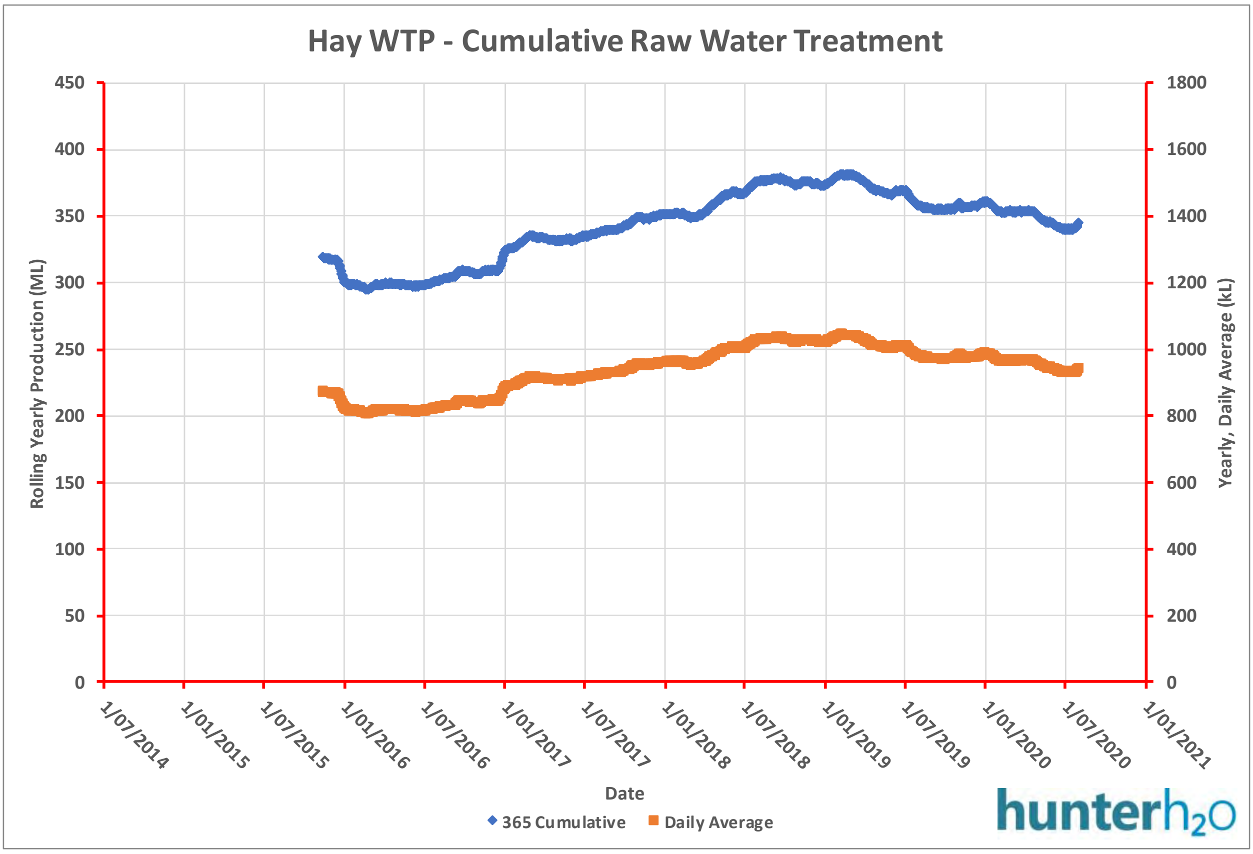


Figure 2-4: Rolling 365-Day Yearly Production and Daily Average Raw Water Flow

The current IWCM (October 2017) estimated that the current peak day demand was 2.4 ML/d, which exceeds the designed production capacity (2.1 ML/d) of the WTP. Hence, the 2.3 ML Pine Street Reservoir storage would be required to meet the peak demand. The reservoir level would not decrease significantly to meet this demand (assuming the reservoir level was initially at 90%, it would reduce to 77%).

While demand was previously thought to remain relatively stable, it is now understood that demand could increase upward of 50%, resulting in a potential peak day demand of 3.6 ML/d. At this demand, the Pine Street Reservoir level would significantly reduce, although would not be expected to empty during the day (for example assuming the reservoir level was initially at 90%, it would reduce to 25%). Extended periods of operation at this flow would present an issue, however. These scenarios also assume that Hay WTP can supply the designed 2.1 ML/d each day and that forward planning is used to ensure storages are full before peak days are experienced.

2.4 Process Flow Diagram

A process flow diagram (PFD) for the Hay WTP as it currently operates is provided in Figure 2-5. The vacuum system that provides intermittent discharge of coagulated water into the sludge blanket clarifier is not currently operational.

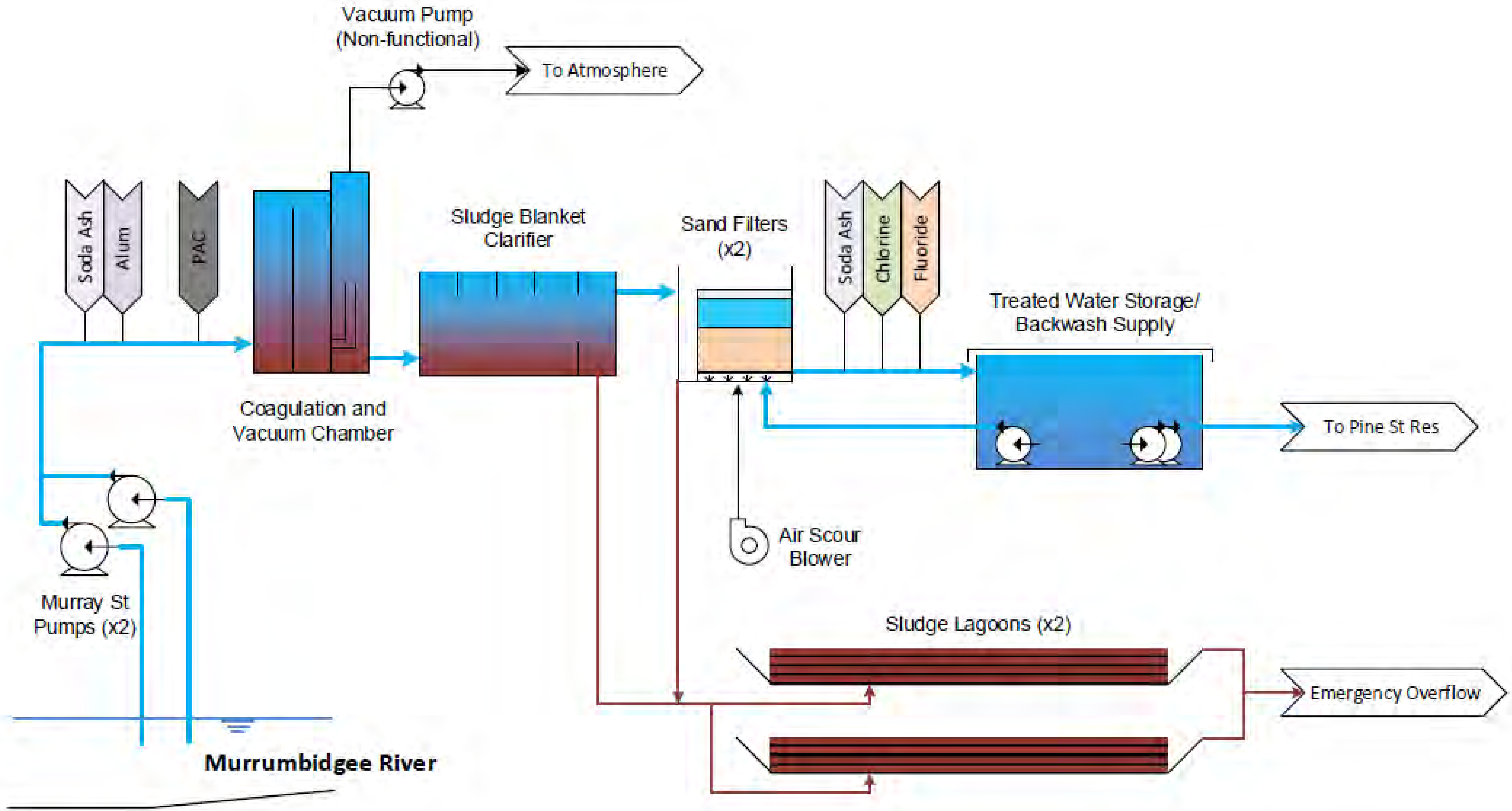


Figure 2-5: Hay WTP Process Flow Diagram

2.5 Plant Automation and Control

The existing plant automation was considered in the previous *Hay WTP Automation and Process Instrumentation Audit* Report. The recommended control system upgrades and instrumentation additions listed in that report remain unchanged and have not been reproduced in full below.

The main distribution system is controlled via a PLC, and for the WTP consists of the following:

- A low level signal in the Pine Street Reservoir calls the clear water pumps to start
- A low level signal in the CWT calls the raw water pumps (Murray Street Pumping Station) to start
- A high level in the CWT triggers the raw water pumps to stop transferring from the river
- A high level in the Pine Street Reservoir triggers all pumping to stop.

Within Hay WTP, chemical pre-dosing is initiated by a flow signal in the raw water flowmeter, while post-dosing is initiated by detection of flow into the clear well. Chemical dosing is not flow paced, however, so dose rates must be manually adjusted when the plant flowrate is changed. Filter backwashing must also be performed manually, rather than being automatically initiated by filter headloss or high filter outlet turbidity.

Most water quality parameters at Hay WTP are monitored through bench testing by operational staff. Online water quality monitoring is only available for the following:

- Treated water turbidity
- Treated water free chlorine
- Treated water pH.

Three critical control points (CCP) are in place at the WTP, and one exists for the distribution system. The CCP and their values are provided in Table 2-2.

Table 2-2: Summary of CCP at Hay WTP

CCP ID	Control Point	Hazard	Control Parameter	Target	Alert Level	Critical Limit
1	Filtration	All pathogens	Filtered Water Turbidity	<0.25 NTU	>0.3 NTU	>0.5 NTU
2	Disinfection (gas)	Chlorine sensitive pathogens	Chlorine	1.3 – 1.5 mg/L	<1.3 mg/L, >1.5 mg/L	<1.0 mg/L, >5.0 mg/L
3	Fluoridation	Fluoride	Fluoride	0.95 – 1.1 mg/L	<0.9 mg/L, >1.3 mg/L	>1.5 mg/L
4	Reservoirs	All pathogens and all chemicals	Reservoir Integrity	Secure and vermin proof	Evidence of breaches	Breach not rectified or serious breach

As only the free chlorine is currently monitored online, any breach of the CCP for filtration or fluoridation would not be immediately detected. Hence, the plant could continue operating above the critical limits for these parameters for extended periods, until issues become apparent to operational staff.

Several operational control points (OCP) are also in place at the WTP, and an additional OCP for the distribution network. These are provided in Table 2-3.

Table 2-3: Summary of OCP at Hay WTP

OCP ID	Monitoring Parameter	Target	Adjustment	Alert Level
1	Clarification	Turbidity: <2 NTU pH: 6 - 7 Colour: 2.5 - 5 HU	Turbidity: >2.5 NTU pH: <6, >7 Colour: >10 HU	Turbidity: >5 NTU pH: <5.8 Colour: >15 HU
2	Treated Water	Turbidity: <0.2 NTU pH: 7.6 – 7.8	Turbidity: >0.3 NTU pH: <7.3, >8.2	Turbidity: >1 NTU pH: <6.8, >8.5

OCP ID	Monitoring Parameter	Target	Adjustment	Alert Level
		Colour: 0 HU	Colour: >3 HU	Colour: >5 HU
3	Reticulated water chlorine	>0.2 mg/L	-	<0.2 mg/L, >1.5 mg/L

Hay Shire Council is currently in the process of performing a full WTP monitoring, instrumentation and control upgrade investigation to advance the implementation of automated control systems at Hay WTP. A list of the required instrumentation is available in the *Hay WTP Automation and Process Instrumentation Audit* Report.

3 Process Unit Capacity Assessment

The key water treatment plant process unit capacity and design criteria have been assessed against ISDVs and are presented in the following sections for each process unit. Data was sourced from information provided (including Work as Executed drawings and 2014 – 2020 Operational Data Log Sheets) and onsite data collection for specific equipment. An Operations and Maintenance Manual (O&MM) was not available for review.

In each of the tables, the design criteria are presented for the following plant flowrates shown in Table 3-1. Whilst the WTP duty and actual production varies, for a majority of items the ISDV considers the operation of the plant for a full 22 hours at the maximum design flow (30 L/s), typical flow (25 L/s) and at low flow (21 L/s).

For some elements, including sludge handling, a more appropriate approach is taken for the specific process unit that considers yearly production figures as daily instantaneous values may not be the key constraint for systems with large buffer capacity, like sludge lagoons.

Table 3-1: Process Unit Capacity Flowrates

Parameter	Units	Design Flow	Typical Flow	Low Flow	Comments
Raw Water Flow	ML/d	2.4	2.0	1.7	Raw water design capacity based on 30 L/s and 22 h/d plant operation. Typical and low raw water flow conditions based on 2014 – 2020 operational instantaneous flow data and 22 h/d plant operation. Treated water flow assumed based on raw water flow and 90% overall plant efficiency.
Treated Water Flow	ML/d	2.1	1.8	1.5	

Commentary is provided for any important key design criteria parameters that do not meet or exceed the ISDV (where appropriate) in each process unit section.

The completed capacity assessment spreadsheet can be found in Appendix A, completed with all assumptions made and sources used during the assessment. Instantaneous flowrates provided in the heading row of each table are specific to the process it relates to (i.e. is the raw water flow for some processes and the filtered water flow for others).

3.1 Inlet Works

There was limited information provided regarding the Murray Street Raw Water Pumping Station (RWPS), and the site was not visited during the site inspection. Based on the SCADA system inspection, it was determined that the RWPS consists of two raw water pumps in duty / standby configuration. The capacity of each pump was not available, although operational staff indicated that there was no capacity issue with the raw water pumps.

Upon entering the plant, raw water is dosed with alum (and soda ash as required) in the inlet dosing pit, as shown in Figure 3-1.

Figure 3-1: Raw Water Inlet and Pre-dosing

3.2 PAC Contacting

Powdered activated carbon (PAC) is dosed as required into the coagulated water at Hay WTP during algae events and to mitigate taste and odour issues. Currently, PAC is dosed after alum, which will reduce adsorption efficiency and increase the dose rate required to achieve an equivalent outcome. Typically, it is recommended that PAC is dosed into the raw water combined with a long contact time to promote and enhance adsorption of algal metabolites. The location of the current dose point is shown in Figure 3-2.

Figure 3-2: PAC Dose Point

The process unit capacity assessment summary for PAC contacting against the ISDV is presented in Table 3-2. The PAC contact time has been calculated based on the difference in time between the PAC and alum dose points at the stated flowrates; as alum is currently dosed before PAC, this technically results in a contact time of 0 seconds.

Due to the negligible contact time achieved with the current operating practices, other various scenarios were considered as the PAC will still work to some extent however not be as effective as when dosed into the raw water. These included:

- The intended contact time that would be achieved if the original process and instrumentation diagram (P&ID) was followed. In this scenario, PAC would be dosed approximately 15 cm prior to alum in the 150 NB DICL pipe (per the as-built chemical dosing point drawing).
- The contact time achieved between the current PAC dosing point and the start of flocculation (assumed to be the clarifier inlet). This contact volume includes approximately 1 m of 150 NB DICL pipe and the three chambers before the clarifier. Due to probable short circuiting in these three chambers, the calculated contact time is likely an overestimate in this scenario.

- The contact time that would be achieved if the PAC dosing point were moved to the Murray Street Pumping Station. This contact volume includes approximately 2.5 km of 200 NB UPVC pipe (per the works as executed ‘rising main from intake works to treatment plant’ drawings).

All dimensions used to calculate the contact volumes were stated in or estimated from the provided WAE drawings, with all dimensions available in Appendix A.

Table 3-2: Process Unit Capacity Assessment – PAC Contacting

Parameter	Units	Design Flow (30 L/s)	Typical Flow (25 L/s)	Low Flow (21 L/s)	ISDV
PAC Contact Time (Current)	min	0.0	0.0	0.0	>15
PAC Contact Time (P&ID)	min	0.0	0.0	0.0	>15
PAC Contact Time (Before Clarifier)	min	6.9	8.3	9.9	>15
PAC Contact Time (RWPS)	min	43.6	52.4	62.3	>15

The ISDV for PAC contacting is not achieved for any of the examined flows when PAC is dosed within the WTP site boundary. When PAC is dosed after the coagulant, by definition, no PAC contact time is achieved with the raw water where it is most effective. If dosing were adjusted to align with the P&ID, approximately 0.1 seconds would be achieved which is inadequate.

Additional PAC contacting still does occur in the clarifier due to the high sludge concentration and solids contacting within the sludge blanket (Degremont Suez, 2007). However, this has not be considered in this analysis as it is best practice to ensure that all PAC contacts with the raw water to enhance removal. Alternatively, if the contact time was extended to incorporate the residence time before the clarifier sludge blanket (i.e. the total contact time between PAC dosing and the clarifier inlet), an ~8-minute contact time could be achieved at typical flow conditions.

As the PAC contact time is insufficient it is recommended to increase the PAC contact time. Therefore if the PAC dose point was moved to the Murray Street Pump Station, a contact time greater than 40 minutes would be achievable prior to coagulant addition. Although the ISDV is set at 15 minutes based on industry standards, some literature does recommend contacts times in order of 30-60 minutes to maximum removal for some algae toxins. This option would therefore provide a much more effective barrier against algal metabolites, with extended PAC contact times being particularly critical for algae toxin removal. If the contact time within the raw water rising main from the RWPS to the WTP was insufficient a dedicated PAC contact tank would have been required. However, there is adequate contact time available within the raw water rising main and thus negates the capital expenditure associated with the construction and installation of a dedicated PAC contact tank.

Hence, it is recommended to investigate moving the PAC dosing point to the Murray Street Pumping Station to increase the achievable PAC contact time. This may either involve construction of a ~2.5km dosing line from the existing dosing system to the dose point and replacement of the PAC dosing pump or relocation of the PAC dosing system to the RWPS site. However it is noted there are can be flooding issues at the RWPS site.

3.3 Coagulation and Flocculation

Prior to PAC dosing, soda ash and alum are dosed into the raw water via the inlet dosing area. No immediate coagulant mixing is provided other than pipe mixing effects at the dose point and downstream hydraulic mixing provided by the weir overflow from the inlet chamber to the second chamber.

In functional Pulsator Sludge Blanket Clarifiers, the flocculation energy is provided by the intermittent discharge to the clarifier, which requires an operational vacuum pump, and the turbulence created. A slight vacuum is applied in the vacuum chamber, drawing coagulated water upwards. Once the level in the chamber reaches a pre-set height, a valve opens to equalise the pressure, resulting in a downward surge that is directed into the clarifier. This intermittent discharge into the clarifier produces a ‘surge’ that fluidises and expands the sludge blanket, which then contracts between each pulse. These expansion and contraction cycles in the fluidised sludge blanket provide the gentle mixing to promote floc formation and growth. Partially flocculated water then flows through the sludge blanket where flocculation is completed and the particles are retained within the fluidised sludge blanket through the mechanisms of adsorption and filtration.

As the vacuum pump is not currently functional at Hay WTP, however, the flocculation achieved throughout the sludge blanket would not be optimal. Fortunately, if the sludge blanket remains suspended by the influent flow, some flocculation will still be provided by localised fluidisation.

The inlet chambers and the weir used for coagulation are shown in Figure 3-3. The small enclosure situated above the vacuum chamber houses the vacuum pump and ancillary equipment.

Figure 3-3: Inlet and Vacuum Chambers (left), Inlet Weir (right)

The process unit capacity assessment summary for coagulation and flocculation against the ISDVs are presented in Table 3-3. For flocculation calculations, the sludge blanket was assumed to be fluidised, and the velocity gradient was calculated by equating the drag and weight forces to estimate the power dissipation. Sludge density and volumetric concentration within the sludge blanket were assumed. All ISDV are specific to hydraulic or sludge blanket/ fluidised bed flocculation.

Table 3-3: Process Unit Capacity Assessment – Coagulation and Flocculation

Parameter	Units	Design Flow (30 L/s)	Typical Flow (25 L/s)	Low Flow (21 L/s)	ISDV
Rapid Mixing Energy (Weir Overflow)	s^{-1}	186.5	170.3	156.1	>600
Total Rapid Mixing, *Gt* (Assumes 1 s of Rapid Mix)	-	186.5	170.3	156.1	300 – 1500
Detention Time (Inlet Chamber)	min	2.5	3.0	3.6	-
Detention Time (Middle Chamber)	min	2.2	2.6	3.1	-
Detention Time (Vacuum Chamber, Average)	min	2.2	2.6	3.1	-
Flocculation Mixing Energy (Fluidised Sludge Blanket)	s^{-1}	2.4	2.2	2.0	2 - 5

Parameter	Units	Design Flow (30 L/s)	Typical Flow (25 L/s)	Low Flow (21 L/s)	ISDV
Flocculation Time	min	36.4	43.7	52.0	>20
Total Flocculation, *Gt*	-	5244	5744	6268	2500 - 20,000

The coagulation mixing targets are not achieved for any of the examined flows, although the proprietary nature of the combined flocculation-clarification process increases the uncertainty of the target ISDV in this case. Although the flocculation system is not operational, each of the sludge blanket flocculation ISDVs are achieved.

Typically, rapid mixing is provided immediately after the coagulant dose to rapidly disperse the coagulant throughout the entire water body. This is important as the coagulation reaction occurs over a fraction of a second and this its effectiveness is greatly impacted by mixing energy. At Hay WTP the coagulant mixing is not optimised, with the weir overflow (mixing) occurring approximately three minutes after alum dosing into the pipe where no dedicated mixing occurs. It is suspected that the reductions in efficiency of the coagulation process is being masked by the sludge blanket which works to improve coagulation/flocculation performance. It is suspected that a dedicated coagulant mixing system could result in reduced coagulant demand, improved settled water turbidity and organics removal.

Given that the coagulation parameters are below the ISDV and the vacuum pump is not operational, potential improvements in this process should be investigated. It is recommended to reinstate the vacuum pump functionality and closely monitor the performance of coagulation, flocculation and clarification both before and after to detect any improvements. By monitoring the reinstatement of the vacuum pump and pulsation flocculation system, we can then assess the magnitude of any improvements and thus determine if there is a need to provide a static mixer for the alum dose point in order to improve efficiency and potentially reduce coagulant dose rates whilst realising improvements to clarification performance and solids capture (thereby addressing the ISDV shortfalls for rapid mixing).

3.4 Sludge Blanket Clarification

Coagulated water is delivered to the Pulsator Sludge Blanket Clarifier (PSBC) by an inlet manifold consisting of a series of perforated pipes, which discharge towards the floor of the clarifier. The influent water is evenly distributed throughout the clarifier via the inlet lateral manifold and stilling baffles, then rises upwards through the sludge blanket. The sludge blanket should be fully fluidised through the effects of the Pulsation, however, as this is not working, it is expected that the sludge blanket would not be fully fluidised to the extent that or as evenly as the design intended. The clarified water is collected at the top of the PSBC through submerged collection launders and directed to the filter inlet channel and filters. Excess sludge is collected by overflowing into the sludge concentrator side weir and periodically discharged to the sludge lagoons to maintain a constant sludge blanket level.

The PSBC is shown in Figure 3-4 while the observed sludge blanket mounds (discussed below) are shown in Figure 3-5.

Figure 3-4: Sludge Blanket Clarifier (Pulsator) and Waste Outlet Lines

Figure 3-5: Uneven Sludge Blanket with Mounds Visible.

The process unit capacity assessment summary for clarification against the ISDV is presented in Table 3-4. Italicised values are relevant to a functional, pulsating clarifier with an operating vacuum system and intermittent filling and discharge of the vacuum chamber only. The loading rate per pulse was estimated based on an assumed vacuum chamber filled height and pulse duration.

Table 3-4: Process Unit Capacity Assessment – Sludge Blanket Clarification

Parameter	Units	Design Flow (30 L/s)	Typical Flow (25 L/s)	Low Flow (21 L/s)	ISDV
Rising / Loading Rate (Average)	m/h	1.8	1.5	1.3	2 (no polymer) 5 (with polymer)
Detention Time	h	2.1	2.5	3.0	1 - 2
Vacuum Chamber Height Above Clarifier TWL (*Pulsating*)	m	*0.8*	-	-	0.6 - 1.0
Pulsation Frequency (*Pulsating*)	s	*26.7*	*32.0*	*38.1*	30 - 50
Pulse Duration (*Pulsating*)	s	*10*	-	-	7 - 15

Parameter	Units	Design Flow (30 L/s)	Typical Flow (25 L/s)	Low Flow (21 L/s)	ISDV
Rising / Loading Rate per Pulse (*Pulsating*)	m/h	*4.8*	-	-	7 - 8 (low settleable solids) 10 - 12 (high settleable solids)

The ISDV targets are achieved for all parameters at each of the examined flows. Notably, however, the vacuum pump is not operational, and so the clarifier does not operate with the intermittent 'pulses' of flow that are required in the Pulsator design. As well as providing mixing for flocculation, this pulsing operation acts to evenly distribute the flocculated water through the inlet manifold and fluidise the sludge blanket. If water is instead injected continuously at a low flowrate, full blanket fluidisation may not occur and sludge is likely to gradually accumulate in certain areas within the blanket. Over time this can result in compacted masses of sludge forming, resulting in preferential pathways for incoming flocculated water. The PSBC efficiency and performance is reduced if this occurs as the particle capture efficiency diminishes.

The effects of this uneven sludge blanket distribution may also be causing the inlet manifold lateral orifices to block. Uneven sludge distribution was observed during the site visit to Hay WTP where the sludge blanket was not evenly distributed and large mounds of sludge were identified in some locations throughout the clarifier. Although it is understood that cleaning was delayed so that Hunter H2O staff could observe the clarifier at its worst condition (highest sludge blanket level), the uneven nature suggests an underlying issue.

Sludge blanket clarifiers can be prone to floc 'boil-ups' caused by the formation of density gradients throughout the clarifier. Typically, this results from temperature inversion, which can be caused by preferential heating of clarifier walls, or a temperature difference between the influent water and the water already residing within the clarifier. Boil-ups can cause floc to carry over to the filters, with the increased solids concentration in the settled supernatant reducing filter runtimes increasing the risk of turbidity breakthrough.

It should also be noted that Pulsator clarifiers are not typically suited to stop/start operation. Anecdotally, poor clarifier performance is observed at Hay WTP, with settled water turbidity taking some time to reduce and stabilise after the plant is turned on. Stoppages of 3 – 6 hours can usually be accommodated by sludge blanket clarifiers (Brandt et al., 2017), although re-fluidisation of the sludge blanket would likely be required. Extended shutdowns where the sludge blanket is lost should be avoided where possible, as re-establishing the sludge and re-forming the blanket can be operationally intensive and in some circumstances can take longer than 24 hours (Brandt et al., 2017).

To maintain the proper functionality of the clarifier as it was designed, it is recommended to fix or replace the vacuum system and re-establish the intermittent pulsing clarifier operation. If demand were to be increased, the existing clarifier setup should remain feasible, although the addition of polymer dosing, or inclined tubes/ plates may become necessary to produce a high quality settled water. This is not recommended at this stage however could be investigated if plant capacity increases are required in the future.

Given a concern over the delayed time between coagulant addition and rapid mixing and the lack of pulsation to promote additional flocculation, the clarifier supernatant turbidity was investigated by calculating yearly percentiles for 2014 through 2020. These percentile trends are provided in Figure 3-6. Percentiles are based on daily supernatant grab samples arranged in order of turbidity. A common target for clarification performance is to consistently achieve a supernatant turbidity of less than 1 NTU and to have a 95th percentile of less than 2 NTU.

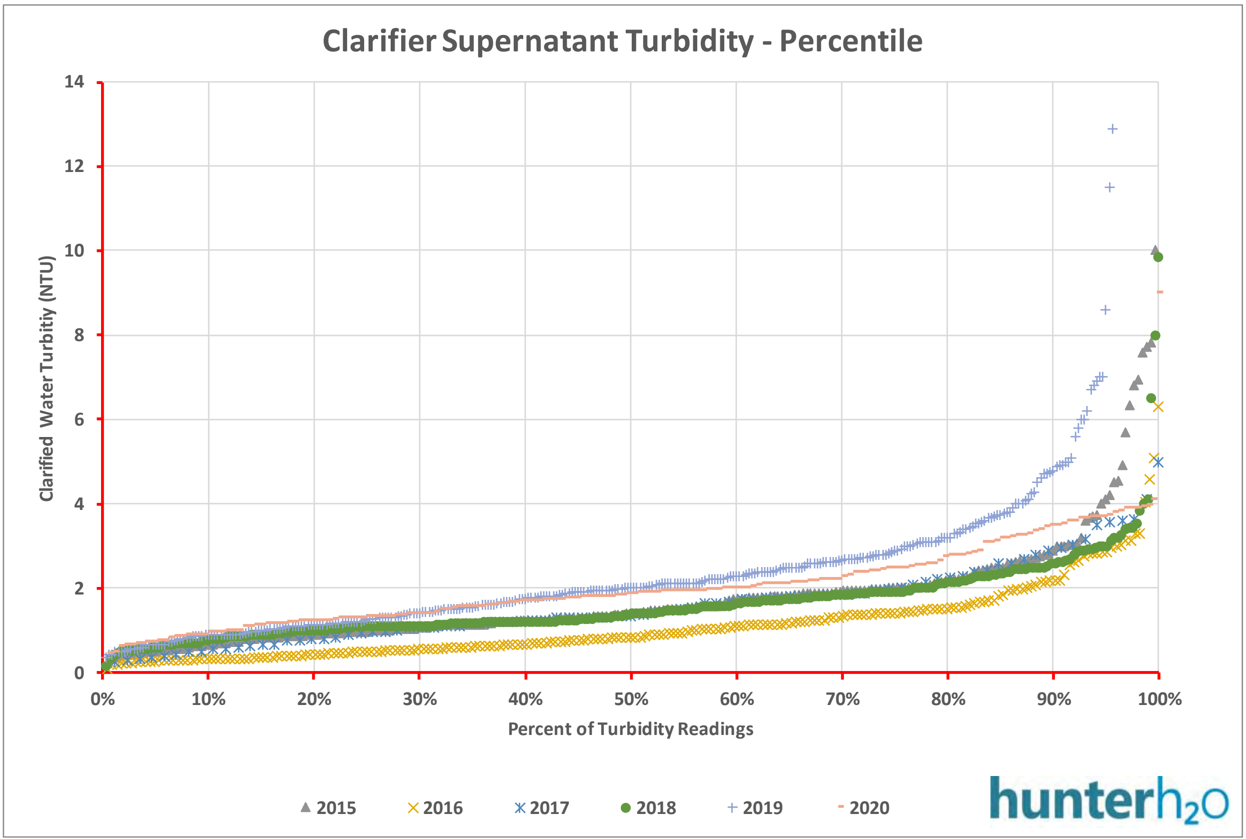


Figure 3-6: Clarifier Supernatant Turbidity Percentiles

It can be seen from Figure 3-6 that the best 'years' performance was 2016, where the supernatant turbidity was less than 1 NTU approximately 50% of days and had a 90th percentile of approximately 2 NTU. The data indicates that performance has worsened since 2016, with both 2019 and 2020 (to July) having a 50th percentile of 2 NTU.

Several instances of poor clarifier performance (settled water turbidity >5 NTU) can be seen in all years of the data, however the circumstances that led to the poor performance or any corrective actions taken are unknown.

Clarifier settled water turbidity is a valuable parameter to monitor the typical clarification performance and should be analysed daily, or preferably continuously via online turbidity analysers with automatic summary reporting on a SCADA system.

3.5 Filtration

The filtration process consists of two mono-media (sand) gravity filters, which are shown in Figure 3-7. Each filter has approximately 0.75 m of sand located above 0.54 m of support gravel. Two layers of sand are used, with the upper layer consisting of 0.60 m of 0.6 – 0.7 mm effective size (ES) filter sand, and the lower layer consisting of 0.15 m of 1.2 – 1.4 mm ES filter sand. The average ES of each layer was used to calculate the combined L/d ratio.

Figure 3-7: Gravity Sand Filters (left), Filter Inlet Pipe (middle) and Backwash Discharge Line (right)

The process unit capacity assessment summary for filtration against the ISDVs are presented in Table 3-5. The ISDVs are specific to a mono-media sand configuration. It is understood that the filters are backwashed one after the other, and that the plant is shut down to accommodate this. Hence, the filtration rate during backwash would only apply if plant automation was adopted which enabled the plant to run during a single filter backwash.

Table 3-5: Process Unit Capacity Assessment – Filtration

Parameter	Units	Design Flow (30 L/s)	Typical Flow (25 L/s)	Low Flow (21 L/s)	ISDV
No. of Filters	no.	2	-	-	>3
Filtration Rate (All Filters)	m/h	5.4	4.5	3.8	≤8
Filtration Rate (1 Filter Backwashing)	m/h	*10.7*	*8.9*	*7.5*	≤8
Elapsed Operational Time Between Backwashes[1]	h	84	-	-	>24
Unit Filter Run Volume	m^3/m^2	At 1 ML/d and b/w every 3rd day – 149 At 1 ML/d and b/w every 4th day – 198			>192 (24 hours at 8 m/h)
L/d Ratio - Sand	-	1038	-	-	>1250

The plant was originally designed with two filters. While three (or more) are typically preferred from a redundancy perspective (and to minimise flow disturbances if the plant continues to run while a filter backwashes) adding additional filters would be cost-prohibitive for a small plant like Hay WTP.

The *L/d* ratio for the sand media is slightly below the ISDV. Although this is not ideal, seeking to improve the *L/d* ratio would only be justified if achieving filtered water turbidity targets becomes difficult through other operational changes (coagulation and flocculation optimisation). If achieving filtered water turbidity targets continued to be an issue, then a detailed filter inspection is recommended. Improvement opportunities would include increasing the *L/d* ratio which may involve increasing the bed depth or potentially different filter media configurations.

[1] It is understood that filters are typically backwashed every Monday and Friday unless headloss is high or water quality is poor.

The filtration rate is well below the ISDV when both filters are operating. While the plant does not currently operate while either filter is backwashing, if automation upgrades enabled this in the future, the filtration rate during a backwash cycle would exceed the recommended 8 m/h for a mono-media sand filter. To achieve this ISDV, the total instantaneous flow to a single filter would need to be reduced to 22.4 L/s while a filter is backwashing otherwise the flow increase to the operational filter would be 100%. It is important to minimise disturbances to the filter bed by reducing sudden flow changes, thus the flow to the online filter would need to be gradually increased, requiring throttling of the influent flow.

The unit filter run volume (UFRV) calculation requires plant flow, duty, backwash interval and the reason for backwashing. During this investigation not all information was available, and assumptions have been made to consider a ‘typical’ UFRV. In this case from discussions with operational staff, it is understood that during normal operation each filter is manually backwashed every Monday and Friday. The UFRV was then calculated assuming that the filter reached terminal headloss prior to backwashing, every third or fourth day, each filter having filtered (for a plant production of 1 ML/d):

- 1.5 ML every three days
- 2.0 ML every four days.

Under these scenarios, the filters achieve the target 24 hour run time but the UFRV is less than the ISDV of 192 m^3/m^2. This is mainly due to the low filtration rate the filters operate at, whereas the more standard filtration rate of 8 m/h would improve the UFRV. This means the filters have spare capacity and thus could process more water if required. The UFRV could also be increased if the filter runtimes were longer (based on backwashing on headloss rather than manually), however current runtimes are considered acceptable and seeking even longer runtimes may result in biological growth issues.

A preliminary investigation was completed into the performance of the filters as measured by the combined filtered water turbidity. Daily turbidity results were ordered and plotted for each year to display a turbidity percentile, as shown in Figure 3-8.

It is recommended to set up a system, automatic or manual, to complete such an analysis monthly, on the individual filtered water turbidity. This allows for validation of the performance of each filter against standards set in the Water Services Association of Australia (WSAA) guidelines (WSAA, 2015) and health-based target (HBT) guidance material. These are not regulated in NSW as yet but are widely accepted as best practice and are expected to be incorporated, in some form, into the Australian Drinking Water Guidelines (ADWG) in the future. As such this type of analysis is becoming increasingly important to validate filtration performance as a barrier to pathogens. Additionally, this analysis allows for the early identification of issues within a filter, or with all filters and hence with upstream processes.

A draft discussion paper for inclusion of HBT into the ADWG (NHMRC, 2011) was released in November 2016 for comment. Hence it is recommended that HSC, if not already completed, undertake a microbial health-based target assessment in line with the Water Services Association of Australia (WSAA) guidelines (WSAA, 2015) and HBT guidance material.

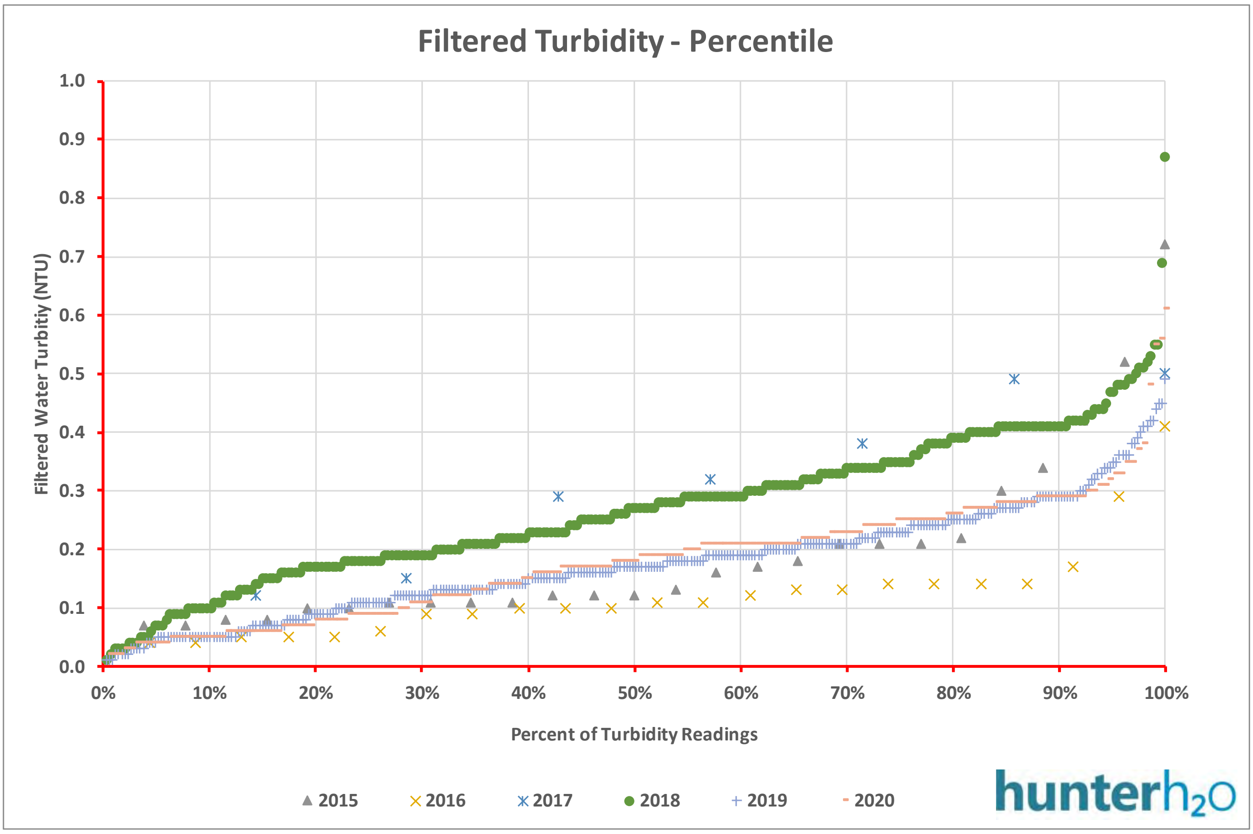


Figure 3-8: Combined Filtered Water Turbidity Percentiles

It can be seen from Figure 3-8 that at a high level the filters, whilst operating at rates below the ISDV, have only maintained a filtered turbidity less than 0.2 NTU for 70% of samples in the last two years. Improvements should therefore be investigated.

Whilst filtered water turbidity results are typically within the critical control point (shut down) upper limit of 0.5 NTU, filter outlet turbidity should ideally be below 0.2 NTU to minimise pathogenic risks to consumers in line with the recommendations from the ADWG. The current target CCP of <0.25 NTU should be reduced to align with the ADWG and NSW Health recommendations which state *"The target for individual filter turbidity is <0.2 NTU, measured at each filter outlet. Continuous on-line monitoring of individual filters is recommended."*. Therefore, based on the filters current performance, there is justification to seek improvements to reduce filtered water turbidities.

3.5.1 Filter Backwashing

The mono-media sand filters are backwashed manually with each backwash cycle including an initial air scour followed by a water only wash. Typically, both filters are backwashed one after the other each Monday and Friday. More frequent backwashing has occurred when headloss has increased or water quality reduced. Anecdotally, daily backwashing has been required during algae blooms. The filter wash water is discharged to the online sludge lagoon. The chlorinated backwash water supply is sourced from the clear water storage tank. The backwash launder, backwash pump and air scour blower are shown in Figure 3-9.

Figure 3-9: Backwash Launder (left), Pump (middle) and Air Scour Blower (right)

The process unit capacity assessment summary for filter backwashing against the ISDVs are presented in Table 3-6. Minimal information regarding the backwashing process was available, so sequence durations were based on discussions with operational staff. Air scour and water wash throughputs were calculated based on maximum respective flowrates of 600 m^3/h air and 82 L/s water, which were retrieved from the air flow gauge and pump nameplate, respectively. Bed volumes include both layers of sand, but not the support gravel.

Table 3-6: Process Unit Capacity Assessment – Filter Backwashing

Parameter	Units	Value	ISDV
Air Scour Duration	min	10	≥3
Air Scour Flowrate	m/h	59.5	≥60
Water Wash Duration	min	10	>5
Water Wash Flowrate	m/h	29.3	≥45
Bed Expansion	%	Not recorded but unlikely achieved given the low wash rate	≥20
Wash Water Volume (Single Filter)	bed volumes	9.6	≥3.5
Backwash Supply Tank Capacity (Clear Water Storage)	bed volumes	19.8	≥7.7
Backwash Supply Tank Capacity (Clear Water Storage)	no. of backwashes	3.0	≥2

Most of the ISDV are achieved by the current backwashing operation, and the air scour rate is only slightly below the ISDV. However, the water wash flowrate used during a single backwash is well below the ISDV target, although this cannot be easily increased due to the backwash pump operating at a fixed speed. It should be reiterated that minimal backwashing data was available for this analysis and as backwashing is undertaken manually, actual values may be different and vary over time.

In Section 3.5 it was identified that the improvements to filtered water turbidity are required based on historical performance to date. Even with the extended air scour, the low wash water rate may be resulting in sludge build-up in the filters and impacts to filtered water turbidity. It is recommended that a filter inspection be undertaken to determine the current effectiveness of the filter backwashing process and other opportunities to reduce filtered water turbidity. Sludge volume indexing and backwash turbidity profiling can be used to determine the existing effectiveness of the backwashing process to clean the filter media. This may result in changes to the current backwashing process.

It should be noted that the backwash storage supply was calculated assuming that the clear water storage tank was full; in practice, the storage capacity will be less than this value.

3.6 Disinfection and Treated Water Storage

The clear water tank (CWT) is located under the machinery room and has an approximate capacity of 150 kL. Soda ash (for pH correction), fluoride and chlorine are dosed into CWT inlet. The treated water free chlorine residual is monitored online at the outlet of the CWT. The filtered water tile chamber, CWT entryway and treated water pumps are shown in Figure 3-10.

Figure 3-10: Clearwater Inspection Sump (left), CWT entry access point (middle) and Treated Water Pumps (right)

The process unit capacity assessment summary for disinfection and treated water storage against the ISDVs are presented in Table 3-7. The discharge flow of the treated water is reportedly matched to the influent raw water flowrate, and so the same flow rates have been examined for the CWT analysis. The baffling factor was an approximate average determined through several fluoride tracer tests performed onsite at Hay WTP. Further discussion of this fluoride testing is provided in the Section 3.6.1.

It should be noted that the following assessment only considers the CWT at Hay WTP. Additional contact time in the reticulation network and the Pine Street Reservoir will increase the total chlorine contact time prior to distribution to downstream customers. However, it is understood that customer connections exist on the treated water main prior to the Pine Street Reservoir, so this additional contact time will not apply as the disinfection contact time requirement must be achieved prior to the first customer.

Table 3-7: Process Unit Capacity Assessment – Disinfection and Treated Water Storage

Parameter	Units	Design Flow (30 L/s)	Typical Flow (25 L/s)	Low Flow (21 L/s)	ISDV
Storage Time (Max)	hours	1.4	1.7	2.0	>12
CWT Baffling Factor (T_{10}/T)[2]	-	0.4	-	-	>0.1
Chlorine C·t (Typical)	mg·min/L	28.2	33.8	40.2	>15
Chlorine C·t (Min)	mg·min/L	20.0	24.0	28.6	>15

Most ISDV targets are achieved by the current clear water disinfection and storage system, except for the onsite storage time. However, customers connected to the Pine Street Reservoir achieve a minimum additional 15 hours of storage time, so the short storage time achieved within the WTP site boundary is not considered critical.

The ability of the clear water storage to achieve the required chlorine C·t will be slightly diminished during backwashing, as the backwash water is supplied from this tank. However, it is thought that the CWT will not pump out until the tank again fills to level between the operating setpoints. It is best practice to

[2] Approximate average from fluoride tracer testing performed onsite for the Hay WTP CWT.

achieve the target disinfection C·t before the water exits the WTP site, as this is where the disinfection process can be controlled most effectively. Furthermore, it is essential to provide safe potable water to customers to all customers and this the nearest customer is the where the target must be achieved.

The minimum (worst case) disinfection C·t was calculated based on the following assumptions:

- Worst-case chlorine residual = 1.0 mg/L (based on the CCP limit)
- Baffle factor = 0.4 (from fluoride tracer testing)
- Minimum treated water storage level = 60% (clear water transfer pumps stop)
- Minimum treated water storage volume = 90 kL.

The typical disinfection C·t was calculated based on the following assumptions:

- Typical chlorine residual = 1.3 mg/L (lower limit of CCP target range)
- Baffle factor = 0.4 (from fluoride tracer testing)
- Typical treated water storage level = 65% (average of the 60% low and 70% high level alarms)
- Maximum treated water storage volume = 97.5 kL.

The disinfection C·t ISDV of 15 mg·min/L is achieved at each of the examined conditions for all flows. A C·t of 15 mg·min/L is recommended by the World Health Organisation (WHO), the ADWG and NSW Health for mitigating pathogen risks, and so should be achieved even under the worst-case operating conditions. Based on the tracer testing performed, it is not necessary to install an array of baffles within the CWT to achieve the required disinfection C·t of 15 mg·min/L.

Hunter H2O's experience recommends adopting a higher C·t of 30 mg·min/L when algal toxins are of concern, however. This is not achieved for any flow at the minimum C·t conditions or the maximum design flow at the typical C·t conditions. Where the raw water is suspected of containing algal toxins, it is recommended to reduce flow (which is typical at Hay WTP during algae blooms), increase the CWT operating level or slightly increase the chlorine residual to maintain a C·t of at least 30 mg·min/L.

It is understood that HSC intend to increase their water supply network, which may increase the flows at Hay WTP and potentially require more frequent operation at a reduced CWT level. C·t values achieved at various flow and CWT level conditions are provided in Table 3-8. All C.t calculations assume that the free chlorine residual is maintained at 1 mg/L and the baffling factor remains at 0.4. At such low CWT levels, the baffling factor may decrease below 0.4. Any selected baffling factor can be examined at the provided conditions by multiplying the value in the table by *X*/0.4, where *X* is the new baffling factor of interest. Similarly, different chlorine residuals (*Y*) can be examined by multiplying the value in the table by *Y*/1.

Table 3-8: C·t (in mg·min/L) at Various Flow and Level Conditions in the Hay WTP CWT

Flowrate (L/s)	Clear Water Tank Level (%)			
	30	40	50	60
27	11.1	14.8	18.5	22.2
28	10.7	14.3	17.9	21.4
29	10.3	13.8	17.2	20.7
30	10.0	13.3	16.7	20.0

Clearly, at increased flowrates, the CWT level should still be maintained above 50% to achieve the typical C·t target of 15 mg·min/L. Even though it is understood that the operating level in the CWT has not dropped below 60% to date and increasing the plant runtime rather than the instantaneous flow would is usually practiced to meet any increased demand, baffles would be required within the CWT to enable a C·t greater than 30 mg·min/L to be achieved during algal events if high flowrates are required. The Pine Street Reservoir level would drop considerably at peak demands if typical or low flowrates (25 L/s or 21 L/s were adopted, however, and so would need to be filled to near capacity in preparation of any peak flows during summer. Therefore, demand side requirements may result in the need to add baffles to the CWT if a C·t greater than 30 mg·min/L cannot be reliably achieved.

3.6.1 Fluoride Tracer Testing

Fluoride tracer tests were performed onsite at Hay WTP to determine the actual detention time in the CWT, and thus determine its baffling factor for flows of 20 L/s (minimum) and 25 L/s (typical maximum) at CWT levels of 60% (minimum) and 70% (maximum). The results are summarised in Table 3-9.

Table 3-9: Fluoride Tracer Testing Results

Test Number	Flowrate (L/s)	CWT Level (%)	T10	Baffling Factor	C.t (1 mg/L at Outlet)
1A	25	60	26	0.43	26
1B	25	60	21	0.35	21
2A[3]	25	70	35	0.49	35
2B[4]	25	70	30	0.43	30
3A	20	60	37	0.49	37
3B	20	60	30	0.40	30
4A	20	70	33	0.39	33
4B	20	70	37	0.44	36.5

It can be seen from Table 3-9 that the calculated baffling factor ranged from 0.35 to 0.49 across the various scenarios examined. The baffling factor did not appear to be strongly affected by the CWT level or discharge flow over the examined range, however the range investigated was not highly variable as it reflects the existing bounds of the plants operation to date (most typically). If the minimum free chlorine residual is maintained at or above 1 mg/L, the C·t would remain above 15 mg·min/L for all expected flow and level conditions, and so would provide an effective disinfection treatment barrier within the WTP site boundary with regards to pathogens.

During blue-green algae blooms or other periods where algal toxins are of concern, the recommended minimum of 30 mg·min/L is achieved for all but the high flow (25 L/s) and low level (60%) condition. During such periods, it is recommended to increase the CWT level (during high flow periods) or slightly increase the chlorine dose to increase the free chlorine residual in order to achieve the greater than 30 mg·min/L target. At this stage under the conditions tested baffling would not be required if Council can continue operating according to the conditions tested above and adopting lower flowrates and higher tank levels during algae blooms. If demand increases however this may trigger the need to operate the plant under high flow conditions during summer when algal toxins are more of a risk, and hence this may trigger the justification to add baffles to the CWT.

3.7 Wash Water and Sludge Handling

Hay WTP has two sludge lagoons, shown in Figure 3-11 which operate in duty/standby mode which allows one to dry while the other is filled. The clarifier sludge scours and filter backwash water are discharged to the online sludge lagoon. Sludge lagoon supernatant is not recovered or returned to the head of the plant for retreatment, and there does not appear to be an underdrain system to aid in sludge dewatering. If the lagoons are overfilled (e.g. during extended wet periods), Hay WTP is licensed to discharge up to 20 ML to the surrounding waters.

[3] Results may have been impacted by the delay caused by transfer from the sample point to the lab.

Figure 3-11: Sludge Lagoons

The process unit capacity assessment summary for sludge handling via lagoons against the ISDVs are presented in Table 3-10.

Table 3-10: Process Unit Capacity Assessment – Sludge Lagoons

Parameter	Units	Average Flow (0.95 ML/d)	Maximum Design Flow (2.4 ML/d)	ISDV
No. of Lagoons	no.	2	2	≥3
Dry Solids Loading Rate - Typical	kg DS/m^2	37	93	<40 (wet areas) <80 (dry areas)
Dry Solids Loading Rate - 5 mg/L PAC	kg DS/m^2	41	104	<40 (wet areas) <80 (dry areas)
Wet Sludge Filling Period	months	12	12	≥3
Drying Period per Cycle	months	12	12	≥9

While three lagoons are typically preferred to increase redundancy and allow for reduced filling and increased drying times, most small WTPs have just two lagoons and still operate effectively.

As sludge lagoons are large storages that are filled over extended periods of time, they are usually designed using the expected average flow and water quality conditions of the plant rather than the maximum flow. At Hay WTP, where the average capacity is approximately 1 ML/d, the lagoons appear adequately sized.

However, if the average capacity were to increase, the existing lagoons may become unsuitable. A sensitivity analysis was performed, with Figure 3-12 and Figure 3-13 providing an estimation of the filling time, and as there are two lagoons, the drying time available when all solids are discharged to the online lagoon, for both when there is no PAC dosing and when there is PAC dosing. The case when no PAC dosing occurs is applicable for most of the year. It should be noted that the following charts are based on the available volume of the lagoons rather than a dry solids loading rate ISDV.

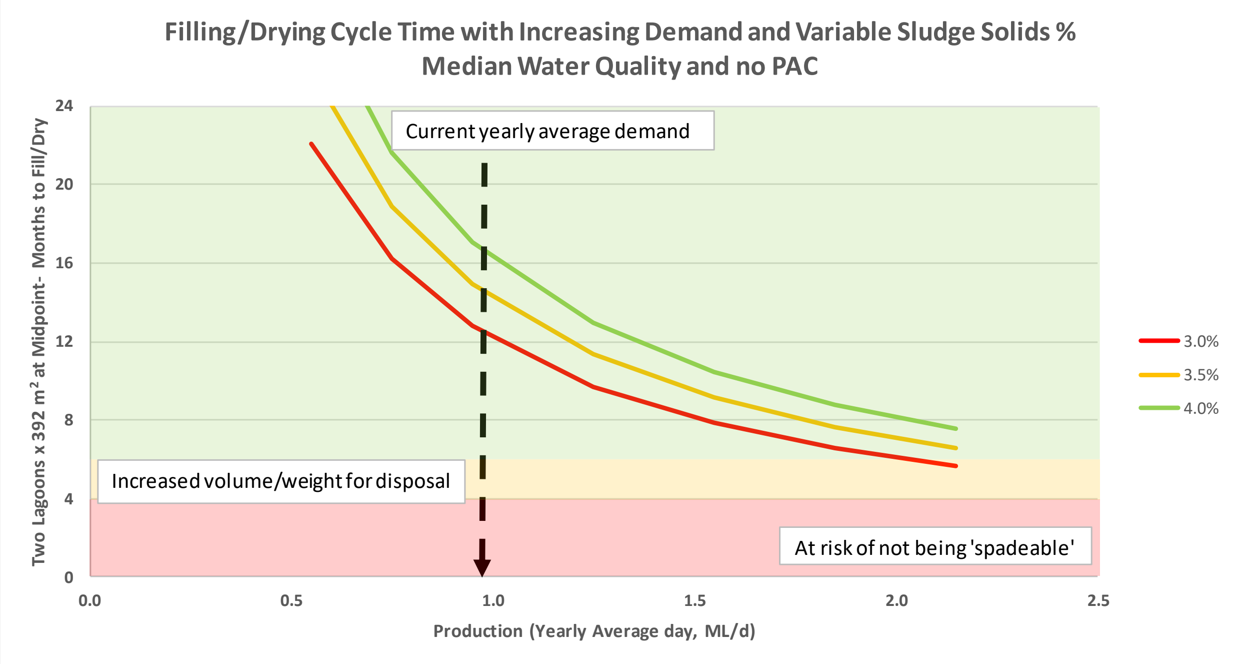


Figure 3-12: Sludge Lagoon Filling Time

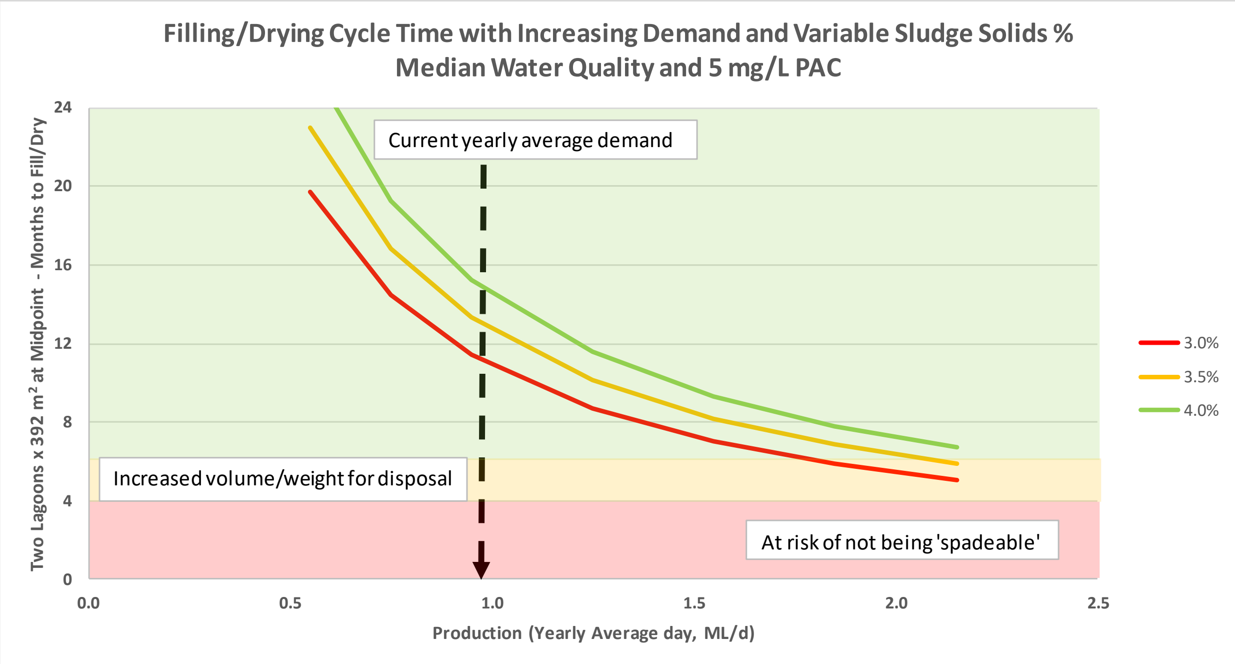


Figure 3-13: Sludge Lagoon Filling Time with 5 mg/L PAC

It can be seen from Figure 3-12 and Figure 3-13 that the lagoons, with good climatic conditions, should be suitable for all expected flows at Hay WTP (up to an average raw flow of 2.0 ML/d). With an additional 5 mg/L of PAC, which is typical during summer, the capacity drops slightly to 1.8 ML/d, which is still much greater than the current average plant flowrate. This correlates well with discussions with operational staff, who indicated that there were no sludge handling issues and that lagoon overflows are rare. If operating at these higher capacities, however, the lagoon filling and drying cycle times would likely need to be reduced to accommodate the additional sludge. For a 4% dry sludge at the end of the filling period, a 12-month filling and drying cycle should remain feasible up to ~1.3 – 1.4 ML/d average plant flow.

3.8 Chemical Dosing Systems

The chemical dose rates and storage quantities have been based on the onsite data collection for specific equipment and the daily Operational Data Log Sheets (for maximum, median, and minimum dose rates). Bulk chemical storage is based on the plant duty at each instantaneous flowrate, with the typical flow based on the plant duty in summer (anecdotally 14 h/d) and the low flow based on the plant duty during winter (anecdotally 8 h/d).

The reviews of the chemical dosing systems have been based purely on the information available to assess their capacity and redundancy for key equipment. The critical nature of chemical dosing systems means that their safety of operation, operability, reliability, performance capability and condition require investigation to determine suitability and upgrade requirements.

3.8.1 Soda Ash Dosing

Soda ash is dosed at Hay WTP as both a pre-dose (into the raw water) and post-dose (into the filtered water) for alkalinity adjustment and pH correction. Typically, the raw water pH and alkalinity is sufficiently high, and pre-dosing is not required to achieve the desired coagulation pH. Hence, only the post-dose is regularly monitored in the daily Operational Data Log Sheets, thus most of this assessment is specific to the post-dosing system.

Soda ash is supplied in 25 kg bags and batched in two mixing tanks, shown in Figure 3-14. Dedicated pumps are used for pre- and post-dosing, although it appears that the valve setup would allow any pump to transfer flow to either dosing location if required.

Figure 3-14: Soda Ash Supply and Batching System

The chemical dosing system capacity assessment summary for soda ash dosing against the ISDVs are presented in Table 3-11.

Table 3-11: Process Unit Capacity Assessment – Soda Ash Dosing

Parameter	Units	Design Flow (30 L/s, 22 h/d)	Typical Flow (25 L/s, 14 h/d)	Low Flow (21 L/s, 8 h/d)	ISDV
Bulk Chemical Storage (Typ. Post-dose only)	weeks	2.6	4.8	10.1	>4
Bulk Chemical Storage (Typ. Pre- and Post-dose)	weeks	1.6	3.0	6.2	>4
Dosing Standby Capacity (Pre- and Post-dose)	%	50	-	-	100
Maximum Dosing Capacity (Pre-dose)	%	479	575	685	>110
Maximum Dosing Capacity (Post-dose)	%	149	179	213	>110

**Note that the bulk chemical storage is calculated based upon the respective flow relative to the median historical dose. The maximum dosing capacity is calculated based upon the respective flow relative to the maximum pump dose.*

It can be seen from Table 3-11 that the existing soda ash dosing system does not achieve the bulk storage capacity ISDV for the design flow, or the typical flow when pre-dosing is also required. However, this is not considered a major concern, as the flows are typically well below the design value (as the plant rarely operates for 22 hours per day or at 30 L/s), and pre-dosing is rare. Anecdotally, approximately 200 kg of soda ash is consumed per week, which would result in a 5-week bulk storage period if 1 tonne deliveries are typical. The dosing capacity is adequate for both the pre- and post-soda ash systems, although the pre-dosing pumps have excess capacity. If the pre-dose pump malfunctioned, a large quantity of soda ash could be dosed to the raw water, resulting in high coagulation and treated water pH, as well as poor coagulation performance. In addition, a recent cyber-attack in the US resulted in a pH dosing system overdosing, hence limiting the ability of a system to overdose is prudent. It is therefore recommended to implement an automated control system with maximum dose rate exceedance interlocks to minimise the risk of overdosing. Downsizing of the dosing pumps could also be considered when the pumps next required replacement.

There is currently only one standby pump shared by both the pre-soda ash and post-soda ash dosing systems. A single standby pump should be sufficient for this system, however, due to the reliability of the dosing pumps and the small size of the WTP.

3.8.2 Alum Dosing

Liquid aluminium sulphate (alum) is used as the coagulant at Hay WTP. Daily drop tests are performed to determine the alum pump dose. The dosing pumps and storage tank are shown in Figure 3-15.

Figure 3-15: Alum (and Soda Ash) Dosing Pumps (left) and Alum Storage Tank (right)

The alum storage tank would have recently exceeded its 25 – 30-year design life and will require replacement soon. In addition, the alum (and soda ash) dosing pumps are in a location that is unergonomic to access, and the alum storage tank is not bunded. Although aluminium sulphate (alum) is not classified as a Class 8 corrosive according to the Australian Dangerous Goods Code, it is industry best practice to ensure the alum storage tank is bunded for safety and environmental reasons. Thus, adherence to *AS3780 – Storage and Handling of Corrosive Substances* is recommended for the design of a new storage tank bund which should be constructed when the alum storage tank is replaced.

The chemical dosing system capacity assessment summary for alum dosing against the ISDVs are presented in Table 3-12.

Table 3-12: Process Unit Capacity Assessment – Alum Dosing

Parameter	Units	Design Flow (30 L/s, 22 h/d)	Typical Flow (35 L/s, 14 h/d)	Low Flow (21 L/s, 8 h/d)	ISDV
Bulk Chemical Storage (@ 42.0 mg/L)	weeks	22.1	41.6	86.8	>4

Parameter	Units	Design Flow (30 L/s, 22 h/d)	Typical Flow (35 L/s, 14 h/d)	Low Flow (21 L/s, 8 h/d)	ISDV
Dosing Standby Capacity	%	100	-	-	100
Maximum Dosing Capacity (@ 90.4 mg/L)	%	474	569	677	>110

**Note that the bulk chemical storage is calculated based upon the respective flow relative to the median historical dose. The maximum dosing capacity is calculated based upon the respective flow relative to the designed maximum dose. Alum doses are provided as the effective (i.e. "active ingredient") dose rather than the as-supplied ("actual") dose.*

It can be seen from Table 3-12 that the existing alum dosing system meets or exceeds the ISDV for bulk storage capacity, dosing redundancy and dosing capacity for all flow conditions. The dosing pumps appear oversized, however, and could present an overdosing risk if a malfunction that increased the dose rate to the maximum capacity of the operating dosing pump occurred. It is recommended to implement an automated control system with maximum dose rate exceedance interlocks to minimise the risk of overdosing. Downsizing of the alum dosing pumps could also be considered when the pumps next required replacement.

3.8.3 Powdered Activated Carbon Dosing

The PAC dosing system is not continuously used and is only operated during summer, or when algal events or taste and odour issues in the raw water are detected. Anecdotally, the base PAC dose during summer is 5 mg/L, which is increased to 10 mg/L or 20 mg/L during algal blooms, depending on the severity.

PAC is supplied in 500 kg bags and dosed via the wetting system shown in Figure 3-16.

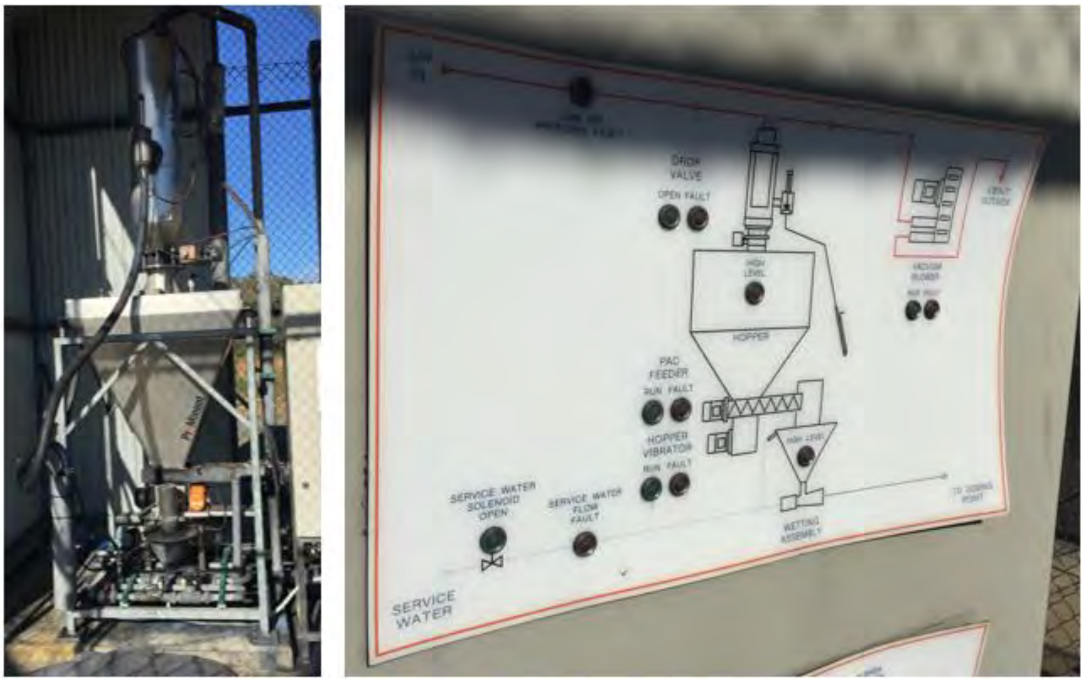


Figure 3-16: PAC Batching and Dosing System

The chemical dosing system capacity assessment summary for powdered activated carbon (PAC) dosing against the ISDVs are presented in Table 3-13.

Table 3-13: Process Unit Capacity Assessment – Powdered Activated Carbon Dosing

Parameter	Units	Design Flow (30 L/s, 22 h/d)	Typical Flow (25 L/s, 14 h/d)	Low Flow (21 L/s, 8 h/d)	ISDV
Bulk Chemical Storage (@ 5 mg/L)	weeks	18.0	34.0	70.9	>4
Dosing Standby Capacity	%	0	-	-	100
Maximum Dosing Capacity (@ 20 mg/L)	%	337	404	481	>110
Maximum Possible Dose	mg/L	67.3	80.8	96.2	≥30 (toxins) 5 - 20 (T&O)

*Note that the bulk chemical storage is calculated based upon the respective flow relative to the median historical dose. The maximum dosing capacity is calculated based upon the respective flow relative to the designed maximum dose.

It can be seen from Table 3-13 that the existing PAC dosing system has sufficient bulk chemical storage and dosing capacity available under all flow conditions. Similarly, the screw feeder capacity would enable a PAC dose rate greater than 67 mg/L to be achieved, even at the maximum plant flow. A dose rate of this magnitude should be sufficient to combat most algae toxins and would be greater than the dose required to address typical taste and odour issues.

There is currently no PAC standby screw feeder or transfer pump and as such these components are critical and their maintenance should be closely considered. This is of particular importance if algal toxins are detected, as these are a health concern as opposed to taste and odour compounds which are an aesthetic issue. It is understood that the mixer has also previously failed, requiring PAC to be dosed directly into the clarifier for a period.

3.8.4 Fluoride Dosing

Sodium fluoride is used to fluoridate the water at Hay WTP and is dosed via a typical downflow fluoride saturator system, shown in Figure 3-17. In the batching process, solid sodium fluoride, supplied in 5 kg bottles, is added to the 250 L batching tank to form a 4% saturated solution.

Figure 3-17: ProMinent FluorSat 5-250 and Sodium Fluoride Supply

The chemical dosing system capacity assessment summary for fluoride dosing against the ISDVs are presented in Table 3-14.

Table 3-14: Process Unit Capacity Assessment – Fluoride Dosing

Parameter	Units	Design Flow (30 L/s, 22 h/d)	Typical Flow (35 L/s, 14 h/d)	Low Flow (21 L/s, 8 h/d)	ISDV
Bulk Chemical Storage (@ 1.07 mg/L as Fl^-)	weeks	29.0	54.7	113.9	>4
Dosing Standby Capacity	%	0	-	-	100
Maximum Dosing Capacity (@ 1.00 mg/L as Fl^-)	%	119	143	170	>110

**Note that the bulk chemical storage is calculated based upon the respective flow relative to the median historical dose. The maximum dosing capacity is calculated based upon the respective flow relative to the ideal maximum dose.*

It can be seen from Table 3-14 that the existing fluoride dosing system has an adequate bulk chemical storage and maximum dosing capacity available under all flow conditions. To maximise health benefits, the treated water exiting the plant should contain a fluoride concentration of 0.95 – 1.05 mg/L as Fl^-. Hence, a 1.0 mg/L as Fl^- maximum dose has been considered rather than the historical maximum fluoride dose from the Operational Data Log Sheets.

There is currently no standby fluoride dosing pump available. Consideration could be given to purchasing a cold standby pump as fluoride is not a ‘critical’ dosing system with respect to the production of safe potable water. Hence, small durations of downtime to change out pumps if required are not considered to be a major concern.

It should be noted that the 90th percentile fluoride dose in the Operational Data Log Sheets exceeds 1.25 mg/L as Fl^-. Raw water fluoride concentrations and fluoride dosing should be carefully monitored to ensure that the risk of overdosing is minimised, and that the finished water fluoride concentration is always approximately 1.00 mg/L.

Council should consider conducting an audit of the fluoride dosing system to determine compliance with the latest NSW Code Of Practice for fluoridation systems and start planning for any upgrades required.

3.8.5 Chlorine Gas Dosing

The chlorine gas dosing system consists of six 70 kg cylinders. Two of these cylinders are connected to a dedicated chlorinator. The original design intention was for one chlorinator to supply pre-dosing chlorine to the raw water, and the second to supply chlorine for treated water disinfection. This system has been rearranged so that the pre-dosing system is now used as a standby for the disinfection system. The duty chlorinator used for disinfection has a capacity of 200 g/h, while the standby chlorinator has a capacity of 1 kg/h. The chlorine dosing system is shown in Figure 3-18.

Figure 3-18: Chlorine Gas Dosing System

The chemical dosing system capacity assessment summary for chlorine gas dosing against the ISDVs are presented in Table 3-15.

Table 3-15: Process Unit Capacity Assessment – Chlorine Gas Dosing

Parameter	Units	Design Flow (30 L/s, 22 h/d)	Typical Flow (35 L/s, 14 h/d)	Low Flow (21 L/s, 8 h/d)	ISDV
Bulk Chemical Storage (@ 1.54 mg/L)	weeks	18.2	34.4	71.6	>4
Dosing Standby Capacity	%	500	-	-	100
Maximum Dosing Capacity (@ 2.00 mg/L)	%	103	123	147	>110

**Note that the bulk chemical storage is calculated based upon the respective flow relative to the median historical dose. The maximum dosing capacity is calculated based upon the respective flow relative to the maximum historical dose.*

It can be seen from Table 3-15 that the existing chlorine dosing system meets or exceeds each of the ISDVs for each flow condition, apart from the maximum dosing capacity at the design flow. However, this is not considered critical, as the plant does not operate at the design flow rate. Additionally, if increased chlorine doses were required, the standby chlorinator (with five times the capacity of the duty chlorinator) could be used for disinfection.

3.9 Unit Process Capacity Summary

A process capacity assessment of the key process units and design criteria against ISDV targets was completed and is presented in Figure 3-19. It should be noted that these are based against the ISDVs and do not necessarily relate to a bottleneck based on actual plant performance. Conversely, process performance may identify a bottleneck or capacity issue while the process may be compliant with the ISDV.

The capacity assessment of the key process units identified a lack of redundancy with some systems, and that the ISDV, when operating at the design treated capacity of 2.1 ML/d, cannot be achieved for the following process units:

- PAC contact time
- Coagulation mixing energy (weir overflow)
- Backwash air scour and water wash rates
- Treated water storage time.

As sludge lagoons are filled and dried over extended periods of time, they were compared to the average capacity (approximately 1 ML/d) rather than the maximum design capacity. The sludge lagoons were found to be adequately sized, for both wet and dry periods, at the current average flow.

The maximum chlorine dosing capacity appears to be slightly lower than the design capacity. This is true when using the duty chlorinator (200 g/h), although if the plant were to operate at the design flow, the standby chlorinator (1 kg/h) could be used to meet the chlorination requirements.

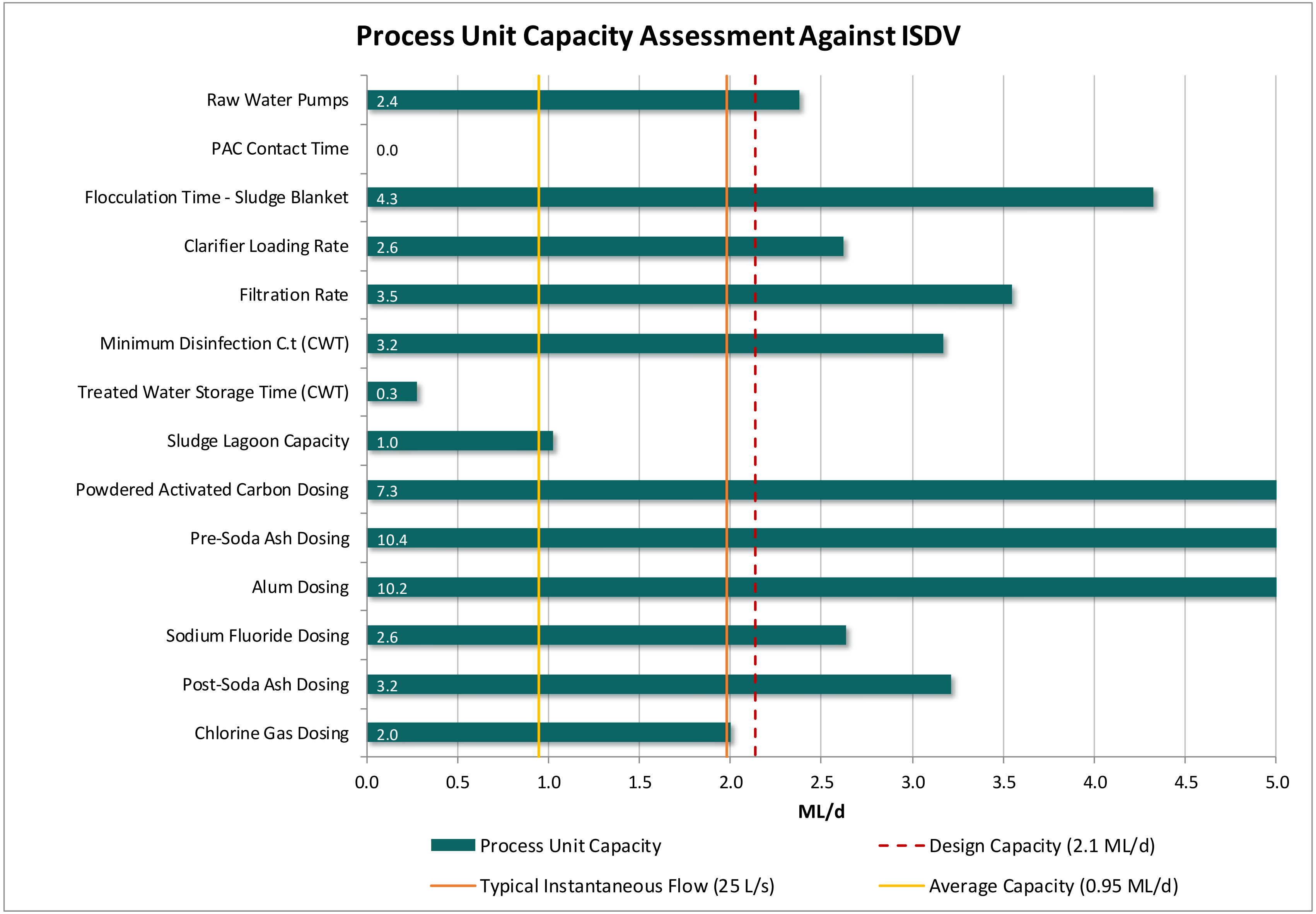


Figure 3-19: Hay WTP Process Unit Capacity Assessment Summary

4 Recommendations

Recommendations from the Process Unit Capacity assessment have been summarised and grouped into low, medium and high priority in Table 4-1 below.

Table 4-1: Summary of Recommendations

Priority	Recommendation
Short Term (High Priority)	▪ Implement the recommended control system upgrades and process instrumentation installation (as per the *Hay WTP Automation and Process Instrumentation Audit* report) to improve automation and safe operation of the processes at Hay WTP. ▪ Fix or replace the non-functional vacuum pump to improve flocculation and reduce issues such as uneven sludge blanket distributions and sludge build-up at the inlet manifold. ▪ Consider redundancy requirements for the critical PAC feeding and dosing system components due to their critical nature and the lack of standby equipment at the WTP. ▪ Perform an audit of the fluoride dosing system to determine compliance with the Code of Practice and WHS requirements.
Medium Term (Moderate Priority)	▪ Investigate alternative PAC contacting options (such as dosing at or near the Murray Street Pumping Station) to ensure that the WTP has an effective barrier against algal toxins and taste and odour compounds. ▪ Closely review the performance of coagulation, flocculation and clarification, particularly since coagulation rapid mixing energy is low. This will allow for an assessment of the opportunity to improve the clarifier supernatant, improve filter run times and reduce the risk of filter breakthrough. If coagulation issues become apparent, the addition of a static mixer just after alum dosing could be considered. ▪ Undertake a filter inspection to determine the effectiveness of the current backwashing process and to ensure that the low air scour and wash rates are not resulting in sludge build up. Sludge volume indexing and backwash turbidity profiling can be used to determine the existing effectiveness of the backwashing process to clean the filter media. Changes to the backwashing process may be required if the current process is not effective. ▪ Include monitoring of filter run time and UFRV as a measure, along with settled supernatant turbidity, of the performance of the upstream coagulation, flocculation and clarification process. ▪ Set up a system (spreadsheet or other) to perform monthly (at a minimum) settled supernatant turbidity percentile analysis to monitor clarifier performance. ▪ Set up a system (spreadsheet or other) to perform monthly (at a minimum) individual filtered water turbidity percentile analysis to monitor the performance of each filter. This will allow for validation of the performance of each filter against standards set in the WSAA guidelines and HBT guidance material for when HBT are incorporated into the ADWG. ▪ Refurbish or replace the existing alum storage tank, including the construction of a bund for spill containment.
Long Term (Low Priority)	▪ If instantaneous flowrates were to be increased to meet increases in demand were to be increased, investigate the need for polymer dosing or installation of inclined plates/ tubes to improve clarifier performance at increased loading rates. ▪ Undertake a microbial health-based target assessment in line with the Water Services Association of Australia (WSAA) guidelines and HBT guidance material to ensure WTP compliance for when HBT are included in the ADWG. ▪ Implement an automated control system with maximum dose rate exceedance interlocks to minimise the risk of overdosing. Consider downsizing of the pre-soda ash and alum dosing pump to minimise overdosing risks.

5 References

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Appendix A Capacity Assessment Spreadsheet

Hay WTP

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
Plant Flows							
Raw water flowrate	ML/d	2.4	1.3	0.6		Plant can do 30 L/s with head, historical maximum in provided ops logs is 28 L/s. Typically 25 L/s, minimum of 20 L/s (used 5%ile = 21 L/s as low flow). Note that plant flow is typically still 25 L/s during winter, while flow is reduced during algae blooms (summer)	
Instantaneous raw water flow	L/s	30.0	25.0	21.0			Site Visit (notes), Operational Log Sheets
Instantaneous raw water flow	m3/h	108.0	90.0	75.6			
Supernatant flowrate	ML/d	0.00	0.00	0.00			
Instantaneous supernatant flow	L/s	0.0	0.0	0.0		No supernatant return from lagoons	
Instantaneous supernatant flow	m3/h	0.0	0.0	0.0			
Total influent water flowrate	ML/d	2.4	1.3	0.6			
Total instantaneous influent flow	L/s	30.0	25.0	21.0			
Total instantaneous influent flow	m3/h	108.0	90.0	75.6			
Plant operation	h/d	22	14	8		Operator statements from site notes, confirmed by calcs from ops logs	Site Visit (notes), Operational Log Sheets (HH2O calculation)
Plant efficiency	%	90	90	90		Assumed - no treated flow data available to calculate from, no supernatant return etc.	
Plant production flowrate	ML/d	2.1	1.1	0.5			
Instantaneous treated water flow	L/s	27.0	22.5	18.9		Assuming that the 2.1 ML/d design is in reference to the treated flow, not the raw flow	
Instantaneous treated water flow	m3/h	97.2	81.0	68.0			
PAC Contacting							
Raw Water Main - Design Intention and Current Practice							
Number of raw water mains	no.	1					WAE DWG 86240-008
Raw water main internal diameter	mm	150				150 NB DICL pipeline - Design intention, PAC no longer dosed before alum	WAE DWG 86240-008
Internal surface area	m2	0.02					
Raw water main length	m	0.15				Using the drawings, where PAC is dosed 150mm upstream of alum	WAE DWG 86240-008
Line water velocity	m/s	1.70	1.41	1.19			
Contact time	min	0.001	0.002	0.002		0.11 seconds - in reality the drawings are not followed, and PAC is dosed after alum (0 s contact time)	
Prior to Flocculation / Clarification							
Pipe length after PAC dose	m	1.0				Estimate based on site visit photos (PAC dosed just before the first water column)	Site Visit
Pipe internal diameter	m	150.0				150 NB DICL pipeline	WAE DWG 86240-001, -008
Internal surface area	m2	0.02					
Line water velocity	m/s	1.70	1.41	1.19			
Contact time	min	0.01	0.01	0.01		0.71 seconds - negligible	
Inlet chamber 1 - width	m	1.000				Section C-C of DWG	WAE DWG 86240-003
Inlet chamber 1 - length	m	1.000				Section B-B of DWG	WAE DWG 86240-003
Inlet chamber 1 - height	m	4.57				TWL (95.670) and RL at floor (91.105) - note: TOC = 95.905, Top of weir = 95.600	WAE DWG 86240-007
Inlet chamber 1 - volume	m3	4.6					
Inlet chamber 1 - contact (residence) time	min	2.54	3.04	3.62		Less when applying a baffle factor to convert from residence time to contact time	
Pre-floc chamber 2 - width	m	1.000				Section C-C of DWG	WAE DWG 86240-003
Pre-floc chamber 2 - length	m	1.000				Section B-B of DWG	WAE DWG 86240-003
Pre-floc chamber 2 - height	m	3.95				TWL (base of weir) appears to be at approximately 95.055, and RL at floor (91.105) - note: TOC = 95.905, Top of weir = 95.600	WAE DWG 86240-007
Pre-floc chamber 2 - volume	m3	4.0					
Pre-floc chamber 2 - contact time	min	2.19	2.63	3.13			
Vacuum chamber 3 - width	m	1.000					
Vacuum chamber 3 - length	m	1.000					
Vacuum chamber 3 - height (continuous operation)	m	3.90					
Vacuum chamber 3 - volume	m3	3.9					
Vacuum chamber 3 - contact (residence) time	min	2.16	2.60	3.09			
Total contact (residence) time	min	6.90	8.29	9.86			
Total contact time assuming 0.3 baffle factor in concrete chambers	min	2.08	2.49	2.97		0.3 baffle factor is still unlikely - 0.1 probably more accurate (no obvious baffles etc.)	
Moving PAC Dose to RWPS							
Number of rising mains	no.	1					WAE DWG 86466-2, -3, -4
RIsing main internal diameter	mm	200				Rising main stated to be 200 NS UPVC Class 9	WAE DWG 86466-2, -3, -4
Internal surface area	m2	0.03					
Rising water main length	m	2500				Rising main chainage = 2500 m (intake pump station to WTP site) - straight line (from Google Earth) is ~1970 m	WAE DWG 86466-2, -3, -4
Line water velocity	m/s	0.95	0.80	0.67			
Contact time	min	43.6	52.4	62.3		Does not include plant inlet works piping before alum dosing (provides extra contact time)	

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV
PAC Contact Time - Current	min	0	0	0	>15
PAC Contact Time - P&ID	min	0.001	0.002	0.002	>15
PAC Contact Time - Dosing at RWPS	min	43.6	52.4	62.3	>15

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
Coagulation, Mixing and Flocculation						Alum dosed into pipe (no static mixer inserts etc.) in the inlet dosing pit. No real bends etc to promote coagulation before the first water chamber. Does not appear to be any other flow obstructions to promote coagulation in the pipe (or jet mixing etc.)	
Tank Design		Flow over weir (coag); pulsed/fluidised sludge blanket (flocc, pulsing not operational)					
No. of trains	no.	1					
No. of compartments (before clarifier)	no.	3				2 chambers and the vacuum chamber (which feeds the clarifier)	
Total Volume	m3	12.4					
Total Detention Time	s	413.7	496.4	591.0			
Flow Over Weir - Compartment 1							
Depth	m	4.57				TWL (95.670) and RL at floor (91.105) - note: TOC = 95.905, Top of weir = 95.600	WAE DWG 86240-007
Length	m	1.000				Section B-B of DWG	WAE DWG 86240-003
Width	m	1.000				Section C-C of DWG	WAE DWG 86240-003
Volume	m3	4.6					
Detention time	s	152.2	182.6	217.4		Rapid hydraulic mixing will only occur over a short period (1 second assumed)	
Flow to Vacuum Chamber - Compartment 2							
Depth	m	3.95				TWL (base of weir) appears to be at approximately 95.055, and RL at floor (91.105) - note: TOC = 95.905, Top of weir = 95.600	WAE DWG 86240-007
Length	m	1.000				Section B-B of DWG	WAE DWG 86240-003
Width	m	1.000				Section C-C of DWG	WAE DWG 86240-003
Volume	m3	4.0					
Detention time	s	131.7	158.0	188.1			
Vacuum Chamber - Compartment 3							
Depth (assumed - continuous operation)	m	3.90				No indication of filling level before intermittent discharge on hydraulic profile. RL at top is 96.205, at base is 91.105 - should be 0.6 - 1m above clarifier water level	
Length	m	1.000				Section C-C of DWG	WAE DWG 86240-003
Width	m	1.000				Section B-B of DWG	WAE DWG 86240-003
Volume (continuous operation)	m3	3.9					
Detention time (continuous operation)	s	129.83	155.80	185.48		Could add time to fill (after discharge to clarifier) - ideally 20 - 40 seconds (Degremont)	
Filled water level height (pulsating operation)	m	4.70				Assuming that the vacuum chamber releases when 0.8 m above clarifier TWL	
Volume transferred per pulse (pulsating operation)	m3	0.80					
Filling time/ time between pulses (pulsing operation)	s	26.67	32.00	38.10			
Sludge Blanket - Continuous (Vacuum System Non-functional)							

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Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
Volumetric sludge concentration	v/v	0.225				Typically 20 - 25%	Tworts Water Supply
Floc density	kg/m3	1005				Assumed (Svarovsky)	Solid-Liquid Separation (Svarovsky)
Sludge blanket height	m	1.1				From stilling baffles to sludge collection hopper 'weir' (where sludge fill oveflow and fill)	WAE DWG 86240-003
Power dissipated	W	0.43	0.36	0.30			
Velocity gradient, *G*	s-1	2.40	2.19	2.01			
Flocculation time (in blanket)	min	36.42	43.70	52.03			
Camp number, *Gt*	-	5243.85	5744.35	6267.60			

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments
Rapid Mixing Energy (compartment 1)	s^{-1}	186.5	170.3	156.1	>600	
Rapid Mixing Detention Time (compartment 1)	min	2.54	3.04	3.62	<1	
Total Rapid Mixing, *Gt* (1 s of rapid mix)	-	187	170	156	300 - 1500	Hydraulic
Flocculation Mixing Energy (in Blanket)	s^{-1}	2.4	2.2	2.0	2-5	Solid-Liquid Separation - Svarovsky (4th Ed. 2000) - pg 157
Flocculation Time (in Blanket)	min	36.4	43.7	52.0	>20-30	Fluidised bed flocculation (as above)
Total Flocculation, *Gt*	-	5244	5744	6268	2500 - 20000	Combination of Svarovsky (low) and Water Quality & Treatment handbook (high)

Clarification - Solids Contact (Sludge Blanket)

Pulsator clarifier - coagulated water is supplied INTERMITTENTLY (when vaccum system working) to maintain a uniform sludge blanket. Does not appear to be any lamella plates etc. — Source: Degremont Water Treatment Handbook (7th ed.)

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
Tank Design		Sludge blanket clarifier - Pulsator				8700 L x 6850 W (note: additional sludge extraction area pushed it to 8000 W)	
No. of trains	no.	1					
Depth	m	3.82				Approximate - TWL at start is 94.955, drops to 94.890 part-way along. RL at base = 91.105	WAE DWG 86240-007
Width	m	6.850				Many different widths used in drawings (difficult to tell where concrete etc. begins). 6.850 (Section J-J) appears to be correct for the clarifier itself (does not include the sludge extraction chamber under the walkway/between the clarifier and filters)	WAE DWG 86240-004 (8.000 total with sludge extraction chamber & some concrete in -003; 7.325 on 99073/14)
Length	m	8.700					WAE DWG 86240-003, -004
Sludge extraction chamber width	m	1				Not stated on drawings - somewhat less than 1m	
Volume (per train)	m3	228					
Settling surface area (per train)	m2	59.6					
Detention time	h	2.1	2.5	3.0			
Rising rate/ loading rate (average)	m/h	1.8	1.5	1.3			
Rising rate/ loading rate (pulsating operation)	m/h	4.8				Assuming 10 s discharge and 0.8 m level above clarifier	

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments
Rising/ Loading Rate (average)	m/h	1.8	1.5	1.3	2 (no polymer) 5 (with polymer)	ISDV from Degremont + Tworts
Vacuum Chamber Height Above Clarifier TWL	m	*0.8*	-	-	0.6 - 1.0	ISDV from Degremont. 0.8 assumed for calcs
Pulsation Frequency (*pulsating operation*)	s	*26.7*	*32.0*	*38.1*	30 - 50	ISDV from Degremont
Pulse Duration (*pulsating operation*)	s	*10*	-	-	7 - 15	ISDV from Degremont. 10 assumed for calcs
Rising/ Loading Rate (*pulsating operation*)	m/h	*4.8*	-	-	7 - 8 (low settleable solids) 10 - 12 (high settleable solids)	ISDV from Tworts
Detention Time	h	2.1	2.5	3.0	1 - 2	ISDV from Suez industrial handbook (online) - for upflow clarifiers

Gravity Filtration - Monomedia Sand

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
Filter Design							
No. of filters	no.	2					
Total sand media bed depth	m	0.750	0.75			Also from DWG 86240-007: T.O Sand RL = 92.395, T.O Gravel RL = 91.645	
Total gravel depth	m	0.540	0.54			Also from DWG 86240-007: T.O Gravel RL = 91.645, Base RL = 91.105	
Total media depth	m	1.290	1.29				
Filter length	m	2.4				Approximated from Section B-B	WAE DWG 86240-005
Filter width	m	4.2				Same total inner width as clarifier (8700 mm), 300mm concrete separating 2x filters	WAE DWG 86240-004, -005
Area per filter	m2	10.1					
Total filtration area	m2	20.2					
Filtration rate	m/h	5.4	4.5	3.8			
Filtration rate (1 filter backwashing)	m/h	10.7	8.9	7.5			
Elapsed time between backwashes	h	84				Backwashes typically occur Monday & Friday (both filters) unless triggered (manually, not automatic) by high filtered turbidity (CCP - 0.5 NTU) or headloss (1.5 m). During poor water quality events (e.g. algae blooms) backwashes occur daily.	Site Visit (notes)
Unit filter run volume (typical backwash routine)	m3/m2	412.5	218.8	105.0			
Unit filter run volume (poor water - daily backwashing)	m3/m2	117.9	62.5	30.0			
Filter Media							
Effective size (ES) - sand layer 1	mm	0.65				0.6 - 0.7 (average)	WAE DWG 86240-005
Bed depth - sand layer 1	m	0.6				Detail 'D' of DWG - assumes same media as original, no replacement/change	WAE DWG 86240-005
L/d ratio - sand layer 1	-	923.1					
Effective size (ES) - sand layer 2	mm	1.30				1.2 - 1.4 (average)	WAE DWG 86240-005
Bed depth - sand layer 2	m	0.15				Detail 'D' of DWG - assumes same media as original, no replacement/change	WAE DWG 86240-005
L/d ratio - sand layer 2	-	115.4					
L/d ratio - sand combined	-	1038.5				*This is the important value - gravel assumed to only be for support, not additional filtration*	
Effective size (ES) - gravel layer 1	mm	2.5				2 - 3 (average)	WAE DWG 86240-005
Bed depth - gravel layer 1	m	0.08				Detail 'D' of DWG - assumes same media as original, no replacement/change	WAE DWG 86240-005
L/d ratio - gravel layer 1	-	32.0					
Effective size (ES) - gravel layer 2	mm	4.5				3 - 6 (average)	WAE DWG 86240-005
Bed depth - gravel layer 2	m	0.08				Detail 'D' of DWG - assumes same media as original, no replacement/change	WAE DWG 86240-005
L/d ratio - gravel layer 2	-	17.8					
Effective size (ES) - gravel layer 3	mm	9.5				6 - 13 (average)	WAE DWG 86240-005
Bed depth - gravel layer 3	m	0.08				Detail 'D' of DWG - assumes same media as original, no replacement/change	WAE DWG 86240-005
L/d ratio - gravel layer 3	-	8.4					
Effective size (ES) - gravel layer 4	mm	16				13 - 19 (average)	WAE DWG 86240-005
Bed depth - gravel layer 4	m	0.3				Detail 'D' of DWG - assumes same media as original, no replacement/change	WAE DWG 86240-005
L/d ratio - gravel layer 4	-	18.8					
L/d ratio - gravel combined		76.9					
L/d ratio - total (sand + gravel)	-	1115.4					

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments
Number of Filters	no.	2			>3 (filters)	
Filtration Rate	m/h	5.4	4.5	3.8	≤8	
Filtration Rate (1 filter backwashing)	m/h	10.7	8.9	7.5	≤8	
Elapsed Time Between Backwashes	h	84			>24	
Unit Filter Run Volume (1 ML/d, backwashed every 3 days)	m^3/m^2	149			>192 (24 hours at 8 m/h)	As these are manually performed and not initiated by headloss under normal circumstances, this is not a reflection of the 'true' UFRV that could be achieved in the filters
L/d Ratio - Sand	-	1038			>1250	

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Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
Backwash						Filters are backwashed one after the other, and are manually initiated and controlled (by turb >0.5 NTU, headloss >1.5m, or runtime (Mondays and Fridays). Backwash water is chlorinated (sourced from CWT).	
Air scour duration	mins	10				No definitive info available - approximate (from operator)	Site Visit (notes)
Air scour flow rate	m/h	59.5				No info from photos - there is a m3/hr gauge that operators can look at for the typical value	Site Visit (blower maximum)
Combined air and water wash duration	mins	0				There is no combined air/water wash stage	
Water wash duration	mins	10				No definitive info available - approximate (from operator)	Site Visit (notes)
Water wash flow rate	m/h	29.3				Note - backwash pump is single-speed (not VSD controlled)	Site Visit (notes)
Bed expansion		Not Measured					
Wash water volume (single filter)	m3	49.2				Everflow 250FHH pump - does 82 L/s (fixed speed as per site notes)	Site Visit (photos, notes)
Filter refill volume (single filter)	m3	0.0				Filters are refilled using settled water rather than backwash water	Site Visit
Total water required per backwash (single filter)	m3	49.2					
Wash water volume (single filter)	Bed volumes	6.5					
Backwash supply tank capacity	m3	150				Backwash water supplied from the clearwater storage tank	WAE DWG 86240-006
Backwash supply tank capacity	Bed volumes	19.8					
Backwash supply tank capacity	No. of backwashes	3.05					

Report Tables

Parameter	Units	Maximum Design Flow	ISDV
Air Scour Duration	mins	10	≥3
Air Scour Flow Rate	m/h	59.5	≥60
Water Wash Duration	mins	10	>5
Water Wash Flow Rate	m/h	29.3	≥45
Wash Water Volume (single filter)	Bed volumes	6.5	≥3.5
Backwash Supply Tank Capacity	Bed volumes	19.8	≥7.7
Backwash Supply Tank Capacity	No. of backwashes	3.0	≥2

Disinfection and Treated Water Storage

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
Tank Design		Clearwater sump/well located underneath the machinery room					
No. of storages (onsite CWT)	no.	1					
Depth - Zone 1	m	1.805					WAE DWG 86240-006, -007
Depth - Zone 2	m	2.25	27				WAE DWG 86240-006, -007
Depth - Zone 3	m	2.85	28				WAE DWG 86240-006, -007
Width - Zone 1	m	1.45	29			Shallowest zone, dimensions from DWG give (1300 + 150) ('indent' from machinery room)	WAE DWG 86240-006
Width - Zone 2	m	2.93	30			Calculated from other dimensions, and DWG states sump is 7530 wide (bottom of Section B-B)	
Width - Zone 3	m	3.15				Deepest zone (with pumps) stated to be 3150 wide (inner) in Section B-B of DWG	WAE DWG 86240-006
Length	m	8.7				Dimensions given in Section A-A of DWG	WAE DWG 86240-006
Volume (max)	m3	158.23				Does not account for pump suction lines, supports in CWT etc.	
Volume (approximate max)	m3	150				Approximate (rounded down) from max calculation - also operator states volume is ~150 kL, stated in DWMS as maximum	Site Visit (Tom's notes - operator); rounded down calculation from WAE DWG 86240-006, -007; 2018 DWMS pg 47
Volume (typical)	m3	97.5				High alarm at 70%, low alarm at 60% - assumed 65% is typical	SCADA
Minimum reservoir storage level	%	60%				Control system calls for RWPS to turn on once CWT is at 60% level, could drop lower with lag time (also used in DWMS)	Site Visit (Tom's notes - operator for 60%); 2018 DWMS pg 47
Minimum reservoir volume	m3	90					
Baffling factor (T10/T)	-	0.4				Approximate average value obtained via fluoride tracer testing	
Free Cl2 residual (min)	mg/L	1.0				Critical control point (CCP) #2 (disinfection) - critical free chlorine low limit	2018 DWMS pg 34
Free Cl2 residual (typical - lower limit)	mg/L	1.3				CCP2 - target dose is between 1.3 - 1.5 mg/L as free chlorine	2018 DWMS pg 34
Free Cl2 residual (typical - upper limit)	mg/L	1.5					
Storage time (max - CWT)	hours	1.4	1.7	2.0		All based on the raw water flow of 25 L/s (TWPS matches the RWPS)	Site Visit (notes)
Chlorine C.t (max - CWT)	mg.min/L	50.0	60.0	71.4			
Storage time (typical - CWT)	hours	0.9	1.1	1.3			
Chlorine C.t (typical - CWT)	mg.min/L	28.2	33.8	40.2			
Storage time (min - CWT)	hours	0.8	1.0	1.2			
Chlorine C.t (min - CWT)	mg.min/L	20.0	24.0	28.6			
Including Pine St Potable Reservoir						Note - there ARE connections before the town reservoir (where is the first?), so the additional time does not apply to all residents	
Straight-line distance from CWT to potable reservoir	m	1425				Straight line distance from the WTP (above CWT) to Pine St potable reservoir	Google Earth
Conservative pipe length estimate	m	1500				Likely longer in reality - short length taken to not overestimate C.t	
Treated water pipe diameter	mm	150				Small section of 150 ND DICL, followed by 150 NB PVC - may expand to larger DN downstream of WTP	WAE DWG 86240-001
Internal surface area	m2	0.02					
Line water velocity	m/s	1.70	1.41	1.19		Note - assumes 25 L/s treated flow through the entire pipe. SCADA showed only 7.0 L/s into the reservoir (due to connections? Less flow = longer contact time)	
Contact time	min	14.73	17.67	21.04		Pipe (plug flow) baffle factor is 1	
Average free Cl2 residual through pipe (assumed)	mg/L	0.8				Assumed - would start at ~1.0 - 1.5 (depending on value in CWT) and decay with time	
Chlorine C.t (treated water pipe main)	mg.min/L	11.78	14.14	16.83			
Maximum Pine St reservoir volume	m3	2300				2.3 ML	2018 DWMS pg 18
Typical Pine St reservoir volume	m3	2162.0				High level alarm 97%, low level alarm 90%, low low alarm at 70%	SCADA
Minimum Pine St reservoir volume	m3	1610.0				Low low level alarm at 70%	SCADA
Baffling factor (T10/T)	-	0.1				Assumed - unbaffled	
Average free Cl2 residual in reservoir (assumed)	mg/L	0.4				Assumed - further decay	
Storage time (max - Pine St reservoir)	hours	21.3	25.6	30.4			
Chlorine C.t (max - Pine St reservoir)	mg.min/L	51.1	61.3	73.0			
Storage time (typical - Pine St reservoir)	hours	20.0	24.0	28.6			
Chlorine C.t (typical - Pine St reservoir)	mg.min/L	48.0	57.7	68.6			
Storage time (min - Pine St reservoir)	hours	14.9	17.9	21.3			
Chlorine C.t (min - Pine St reservoir)	mg.min/L	35.8	42.9	51.1			
Total C.t (max)	mg.min/L	112.9	135.5	161.3			
Total C.t (typical)	mg.min/L	88.0	105.6	125.7			
Total C.t (min)	mg.min/L	67.6	81.1	96.5			

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV
Storage Time (max)	hours	1.4	1.7	2.0	>12
Baffling Factor (T10/T)	-	0.4			>0.1
Chlorine C.t (CWT - max)	mg.min/L	50.0	60.0	71.4	>15
Chlorine C.t (CWT - typical)	mg.min/L	28.2	33.8	40.2	>15
Chlorine C.t (CWT - min)	mg.min/L	20.0	24.0	28.6	>15

Sludge Lagoons (note: 'average' refers to the average surface area between the lagoon floor and TWL)

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
					AVERAGE FLOW	Regardless of values here, operator states no issues. Have an EPA overflow license (0-20 ML), but lagoons usually don't overflow. Calculations are based on an average dry solids loading rate (or required net bed area)	Site Visit (notes, photos)
Design		Earthen-walled basins		Average Flow (ML/d) =	0.95	Assumed. Note that lagoon wall slope is 1:3 for 3 sides (N, E, W), and 1:6 on 1 side (S)	
No. of lagoons	-	2					
Lagoon base - length	m	28					WAE DWG 86277-2
Lagoon base - width	m	7					WAE DWG 86277-2
Top of lagoon - length	m	46.9					WAE DWG 86277-2

Hay WTP

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
Top of lagoon - width	m	19.6					WAE DWG 86277-2
Lagoon height - total	m	2.1	2.1	2.1		Based on sloping wall ratio (1:3, 1.6) and length (6300, 12600) [also RL at top = 90.60]	WAE DWG 86277-2
Lagoon depth - water/sludge	m	1.3				RL at base = 88.50, TWL = 89.80	WAE DWG 86277-2
Lagoon depth - sludge (assumed)	m	1				Assumed	
Volume (max) - lagoon 1 and 2 (at TWL)	m3	509.3				TWL refers to the volume held in the lagoons from the base to the TWL, including slopes	
Volume (max) - lagoon 1 and 2 (actual, before overflow)	m3	1171.0				This refers to the volume held to the top of the berm, including slopes	
Total lagoon/bed volume (at TWL)	m3	1018.6				TWL refers to the volume held in the lagoons from the base to the TWL, including slopes	
Total lagoon/bed volume (actual, before overflow)	m3	2342.0				This refers to the volume held to the top of the berm, including slopes	
Area of single lagoon (floor)	m2	196.0				Floor area only - does not account for additional area as the filled height increases up the slope	
Area of single lagoon (average)	m2	391.8				Average of the area at the lagoon base and TWL (not the top of berm)	
Sludge solids percent	%	4				Assumed	
Dry solids capacity per lagoon (average)	tonne	15.7				More realistic as it is based on the aveage area	
Time to fill lagoon (floor - typical sludge generation)	days	70.3	132.7	276.4	175.9	Underestimation as this is based on the floor area	
Time to fill lagoon (average - typical sludge generation)	days	140.6	265.2	552.4	351.7	More realistic as it is based on the aveage area	
Flow to achieve 180-day lagoon capacity (average, typical raw water quality)	ML/d	1.9			334.1	ML total over 180 days	
Time to fill lagoon (maximum sludge generation, average)	days	50.8	95.7	199.4	127.0		
Dry solids loading rate (lagoon, no PAC) - typical (average)	kg DS/m2	92.6	49.1	23.6	37.0		
Dry solids loading rate (lagoon, no PAC) - max (average)	kg DS/m2	242.9	128.8	61.8	97.1		
Dry solids loading rate (lagoon, PAC) - typical (average)	kg DS/m2	103.6	54.9	26.4	41.4		
Dry solids loading rate (lagoon, PAC) - max (average)	kg DS/m2	287.0	152.2	73.1	114.8		
Wet sludge filling period - continuous	months	12				Assumed - 2 lagoons	
Drying period per cycle	months	12				Assumed - 2 lagoons	

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Average Flow (0.95 ML/d)
Number of Lagoons	-	2	2	2	≥3	
Dry Solids Loading Rate - Typical	kg DS/m^2	92.6	49.1	23.6	<40	37.0
Wet Sludge Flling Period - Continuous	months	12	12	12	3	12
Drying Period per Cycle	months	12	12	12	9	12
Time to Fill One Lagoon (at typical 47 mg/L sludge generation)	days	141	265	552	≥180	352
Time to Fill One Lagoon (at maximum 130 mg/L sludge generation)	days	51	96	199	≥180	127
Flowrate to Achieve 180-day Capacity at Typical Raw Water Quality	ML/d	1.9			1.8 (75% of design)	

Chemical Dosing Systems

Algae Metabolites Removal - Powdered Activated Carbon

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	Comments	Source
					Note - currently dosed after soda ash & alum, just before 'flocculation'. Supplied by Redox	Supply - DWMS 2018 pg 42
Bulk storage capacity	kg	1500			Looks to be 3 pallets, each with 1 bag (assumed 500 kg)	Site Visit
Typical dose (median)	mg/L	5.00			5 mg/L base dose during summer. 10 - 20 mg/L during algae blooms	Site Visit (operator)
Typical consumption	kg/d	11.9	6.3	3.0		
Typical consumption	kg/h	0.5	0.5	0.4		
Maximum dose	mg/L	20.0			20 mg/L upper dose range during algae blooms. Was dosed higher during a short period in 2019 when mixer broke (PAC dosed directly into clarifier)	Site Visit (operator)
Maximum consumption	kg/d	47.5	25.2	12.1		
Maximum consumption	kg/h	2.2	1.8	1.5		
Bulk chemical storage @ typical dose	weeks	18.0	34.0	70.9		
No. of duty screw feeders	no.	1			1 duty pump, no standby - also appears to be only a duty screw feeder	Site Visit (photos)
No. of standby screw feeders	no.	0			1 duty pump, no standby - also appears to be only a duty screw feeder	Site Visit (notes)
Dosing standby capacity	%	0%				
Maximum duty capacity (feeder)	kg/h	7.27			Dry feeder rate is controlled by a variable speed motor, maximum feed rate is 7.27 kg/h	ProMinent O&MM pg 10, 17
Maximum dosing capacity (feeder)	%	337%	404%	481%		
Maximum possible dose	mg/L	67.3	80.8	96.2	Instantaneous flows, screw feeder dosing 7.27 kg/h	

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV
Bulk Chemical Storage at Median Dose	weeks	18.0	34.0	70.9	>4
Dosing Standby Capacity	%	0%			100%
Maximum Dosing Capacity	%	337%	404%	481%	>100%

pH Correction - Soda Ash (Pre and Post)

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	Comments	Source
					Supplied by Redox in 25 kg bags (12 in photo, assumed delivery on 1 t pallets)	DWMS 2018 pg 42, Site Visit (photos)
Bulk storage capacity	kg	1000			Assumed - 12 x 25 kg bags (300 kg) visible in site photo	Site Visit (photo + assumption)
Soda ash product purity	%	100%			>= 99.5%	Redox SDS - Soda Ash, Dense
Number of batching tanks	no.	2				WAE DWG 86240-016, Site Visit
Mixing tank effective volume	L	7000			2 x 3500 L soda ash solution tanks	WAE DWG 86240-016
Batch strength	g/L	50.4			Calculated - average solution strength ~50 g/L (ranging from 41 g/L to 62 g/L, recently ~54 g/L)	Operational Log Sheets (HH2O calculated)
Pre-soda Dosing					From P&ID - setup has 3 pumps, valves opened to transfer to pre- or post- dose as required. Appears that the middle pump is a standby, the other 2 pumps are intended to be used as pre- and post. Only the post-soda dose is recorded daily in the operational logs - 1 pre-dose value provided.	
Typical dose (median) - only dose provided	mg/L	0.0			Appears to be off typically	Operational Log Sheets
Typical consumption	kg/h	0.0	0.0	0.0		
Typical slurry flowrate	L/h	0.0	0.0	0.0	Was not running on day of site visit. Not usually in use.	
Maximum dose - only dose provided	mg/L	14.6			Maintenance/comments section of operational logs - only 1 value provided	Operational Log Sheets
Maximum consumption	kg/d	34.7	18.4	8.8	~200 kg per week (total) typical. 2 batches per week.	
Maximum consumption	kg/h	1.6	1.3	1.1		
Maximum slurry flowrate	L/h	31.3	26.1	21.9		
Bulk chemical storage @ typical dose	weeks	#DIV/0!	#DIV/0!	#DIV/0!		
No. of duty transfer pumps / ejectors	no.	1			Three pumps total - 1 currently operating as of site visit - assumed post (note: valve also open on a 2nd, but display not on) - pre, post, standby assumed	
No. of standby transfer pumps / ejectors	no.	1			Three pumps total - 1 currently operating as of site visit - assumed post (note: valve also open on a 2nd, but display not on) - pre, post, standby assumed	
Dosing standby capacity	%	100%				
Maximum duty pump capacity	L/h	150			Grundfos DDI 150-4 - each does 150 L/h, 3x pumps total	
Maximum dosing capacity	%	479%	575%	685%		
Post-soda Dosing					From P&ID - setup has 3 pumps, valves open to transfer to pre- or post- dose accordingly as required. Appears that the middle pump is a standby, the other 2 pumps are intended to be used as pre- and post. Only the post-soda dose is recorded daily in the operational logs.	
Typical dose (median)	mg/L	23.5			Median from operational logs (ranges from 13 to 47 mg/L), most recently 23.5 mg/L also. Set manually on pump.	Operational Log Sheets
Typical consumption	kg/h	2.5	2.1	1.8		
Typical slurry flowrate	L/h	50.4	42.0	35.3	Was 35 L/h on day of site visit	
Maximum dose	mg/L	47.0			Maximum from operational logs	Operational Log Sheets
Maximum consumption	kg/d	111.7	59.2	28.4	~200 kg per week (total) typical. 2 batches per week.	
Maximum consumption	kg/h	5.1	4.2	3.6		
Maximum slurry flowrate	L/h	100.8	84.0	70.5		
Bulk chemical storage @ typical dose	weeks	2.6	4.8	10.1		

Hay WTP

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
No. of duty transfer pumps / ejectors	no.	1				Three pumps total - 1 currently operating as of site visit - assumed post (note: valve also open on a 2nd, but display not on) - pre, post, standby assumed	Site Visit (photos), WAE DWG 86240-001
No. of standby transfer pumps / ejectors	no.	1				Three pumps total - 1 currently operating as of site visit - assumed post (note: valve also open on a 2nd, but display not on) - pre, post, standby assumed	Site Visit (photos), WAE DWG 86240-001
Dosing standby capacity	%	100%					
Maximum duty pump capacity	L/h	150				Grundfos DDI 150-4 - each does 150 L/h, 3x pumps total	Site Visit (photo)
Maximum dosing capacity	%	149%	179%	213%			
Combined							
Bulk chemical storage @ typical post-dose and operating pre-dose	weeks	1.6	3.0	6.2			
No. of duty transfer pumps / ejectors	no.	2					
No. of standby transfer pumps / ejectors	no.	1					
Dosing standby capacity	%	50%					

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV
Bulk Chemical Storage at Median Dose - Post-Dose	weeks	2.6	4.8	10.1	>4
Bulk Chemical Storage at Median Dose - With Pre-Dosing	weeks	1.6	3.0	6.2	>4
Dosing Standby Capacity - Post-Dose	%	100%			100%
Dosing Standby Capacity - Combined	%	50%			100%
Maximum Dosing Capacity - Post-Dose	%	149%	179%	213%	

Coagulant - Alum

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
						Supplied by Omega Chemicals	DWMS 2018 pg 42
Bulk storage capacity	L	20000				2 given values (12m3 on P&ID, 25m3 on alum tank GA, <23.5m3 calculated from dimensions) - used 20 kL as a substitute (less than calculated due to non-cylindrical shape)	WAE DWG 86240-018 (dimensions)
Batch strength/supplied strength	% w/w	58%				Median from operational logs (ranges from 50 to 64%)	Operational Log Sheets
Supplied SG		1.33				Assumed	
Typical dose (median) - EFFECTIVE DOSE	mg/L (as alum)	42.0				Median from operational logs (ranges from 18 to 90.4 mg/L) - 20 to 100 mg/L from site visit notes, and typically 30 - 40 mg/L (most recently 46 mg/L). Set manually on pump.	Operational Log Sheets
Typical consumption	L/h	5.9	4.9	4.1		Set at 4.6 L/h on day of site visit	
Typical consumption	L/d	129.4	68.6	32.9		Typical consumption appears to be ~38 kg/day as alum (ops log sheets)	
Maximum dose	mg/L (as alum)	90.4				Maximum from operational logs	Operational Log Sheets
Maximum consumption - EFFECTIVE DOSE	L/h	12.7	10.5	8.9			
Maximum consumption	L/d	278.4	147.7	70.9			
Bulk chemical storage @ typical dose	weeks	22.1	41.6	86.8			
No. of duty transfer pumps	no.	1				Two pumps total - duty/standby	Site Visit (photos), WAE DWG 86240-001
No. of standby transfer pumps	no.	1				Two pumps total - duty/standby	Site Visit (photos), WAE DWG 86240-001
Dosing pump standby capacity	%	100%					
Maximum duty pump capacity	L/h	60				Grundfos DDI 60-10 - each does 60 L/h	Site Visit (photo)
Maximum dosing capacity	%	474%	569%	677%			

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV
Bulk Chemical Storage at Median Dose	weeks	22.1	41.6	86.8	>4
Dosing Pump Standby Capacity	%	100%			100%
Maximum Dosing Capacity	%	474%	569%	677%	>110%

Disinfection - Chlorine Gas

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
						Supplied by Orica (site visit - Ixom cylinders)	DWMS 2018 pg 42
Bulk storage capacity	kg	420				6x70kg canisters - 2 mounted and connected, 2 nearby, 2 in corner (storage)	WAE DWG 86240-001, Site Visit (photos)
Typical dose (median)	mg/L	1.54				Median from operational logs (ranges from 1.09 to 2.0 mg/L) - current dose ~1.77 mg/L. Set manually.	Operational Log Sheets
Typical consumption	kg/h	0.15	0.12	0.10			
Maximum dose	mg/L	2.00				Maximum from operational logs	Operational Log Sheets
Maximum consumption	kg/h	0.19	0.16	0.14		180 g/hr maximum from operational logs	
Bulk chemical storage @ typical dose	weeks	18.2	34.4	71.6			
No. of duty chlorinators	no.	1				2 chlorinators, duty/standby - duty does 200 g/hr max, standby (assumed this was the pre-chlorine previously) does 1000 g/hr max	Site Visit (photos, notes)
No. of standby chlorinators	no.	1				2 chlorinators, duty/standby - duty does 200 g/hr max, standby (assumed this was the pre-chlorine previously) does 1000 g/hr max	Site Visit (photos, notes)
Chlorinator standby capacity	%	500%				Standby chlorinator max is 1000 g/hr, duty chlorinator max is 200 g/hr	
Maximum duty chlorinator capacity	kg/h	0.2	1				
Maximum dosing capacity (duty chlorinator)	%	103%	123%	147%			
Maximum dosing capacity (standby chlorinator)	%	514%	617%	735%			

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV
Bulk Chemical Storage at Median Dose	weeks	18.2	34.4	71.6	>4
Chlorinator Standby Capacity	%	500%			100%
Maximum Dosing Capacity	%	103%	123%	147%	>110%

Fluoride - Sodium Fluoride

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV	Comments	Source
						NaF supplied by ProMinent Fluid Controls (site photos - 20 kg boxes of Klorman Watertech NaF, assumed to be supplied as 4x5kg bottles of solid)	DWMS 2018 pg 42
Bulk storage capacity	kg	1200				Assumed - currently >1000 kg in storage in 20kg boxes	Site Visit (photos)
Batch strength/supplied strength	g/L as NaF	40				NaF solubility is ~4% (i.e. 40 g/L)	https://www.prominentfluid.com.au/fluoride-saturator
Batch strength/supplied strength	g/L as Fl- ion	18.1				Fluoride content of soluble NaF (based on molecular composition)	
Fluoride content (purity)	%	43.0%				% fluoride of 95% NaF	https://klorman-industries.com/water-treatment/product/klorman-watertech-sodium-fluoride-naf/
Typical dose (median)	mg/L as NaF	2.49					
Typical dose (median)	mg/L as Fl- ion	1.07				Median from operational logs (ranges from 0 to 1.88 mg/L as Fl-). CCP target is 0.95 - 1.1	Operational Log Sheets
Typical consumption	kg/h as NaF	0.27	0.22	0.19			
Typical consumption	L/h	6.4	5.3	4.5			
Maximum dose (1 mg/L target)	mg/L as Fl- ion	1.00				Target dose - dose rate should not be greater than this	DWMS 2018 pg 35
Maximum consumption	kg/h as NaF	0.25	0.21	0.18			
Maximum consumption	L/h	6.0	5.0	4.2			
Bulk chemical storage @ typical dose	weeks	29.0	54.7	113.9			
No. of duty transfer pumps/feeders	no.	1				1 duty pump, no standby. Manually fed solids as required (5 kg bottles)	Site Visit (notes)
No. of duty transfer pumps/feeders	no.	0				1 duty pump, no standby. Manually fed solids as required (5 kg bottles)	Site Visit (notes)
Dosing pump/feeder standby capacity	%	0%					
Maximum duty pump capacity	L/h	7.8				Delta solenoid metering pump - 1608	Site Visit (photos)
Maximum dosing capacity	%	131%	157%	187%			

Report Tables

Parameter	Units	Maximum Design Flow	Typical Flow	Low Flow	ISDV
Bulk Chemical Storage at Average Dose	weeks	29.0	54.7	113.9	>4
Dosing Pump Standby Capacity	%	0%			100%
Maximum Dosing Capacity	%	131%	157%	187%	>110%

Appendix B Tracer Testing Methodology

1 Introduction

This procedure has been developed to assist Hay Shire Council in determining the actual detention time in the Hay WTP clear water tank and thus determine the baffle factor. This information will be used to inform a decision on the benefits of installing baffles within the tank to improve the chlorine contact time, improve water safety and support future funding initiatives.

This memo outlines a standard method for determining contact time by manipulating the fluoride dose rate. It is recommended that the method be reviewed by Councils operational staff to consider any site specific operational risks before proceeding. (i.e. to ensure fluoride overdosing does not occur and ensure effective disinfection is maintained).

The actual detention time in a clear water tank (CWT) can be determined through tracer testing. In a water treatment plant (WTP) this is most easily done by stopping and starting fluoride dosing. The test is best undertaken at different flowrates and storage levels, to determine the various detention times at various operating levels.

2 Tracer Testing Methodology *(undertaken by Council)*

The below tracer methodology is to be undertaken by Hay WTP operations staff:

1. Bring the WTP online and ensure fluoride dosing is operational and set to the correct dose rate based on the plant flowrate
2. Establish a stable plant flowrate and clear water tank level
   i. The raw water flowrate and treated water flowrate will therefore have to be the same to ensure the CWT level remains constant during the whole trial run
3. Commence monitoring of the fluoride concentration in the water leaving the CWT at regular intervals to ensure steady state conditions establish (i.e. constant fluoride concentration).
   i. Using the “Fluoride Tracer Testing Run Sheet” provided in the below sections.

Note: For a successful test, the fluoride dose rate as well as the plant flow rate must be constant for the duration of the test. It is also important for the CWT level to be relatively constant as this has a direct influence on the baffle factor calculation.

4. Once steady state conditions are achieved and allowed to run for some time, stop fluoride dosing (concentration decreasing profile).
5. Continue to collect and test CWT outlet samples for fluoride concentration at regular intervals:
   i. Ensure fluoride concentration is regularly recorded to measure residual as a function of time since dosing was stopped, until the concentration is seen to reach a steady state condition at the naturally low raw water concentration.
   ii. As there is no online fluoride instrument, manual sample collection will be required at regular intervals during the trial. Collection of samples at 5 minute intervals during the start (initial ~60 mins) and end of the test is recommended (refer to Figure 4-1 example).
   iii. Record the flowrate through the CWT and CWT level at each time interval.

The data can then be used to identify the time taken for certain percentages of the fluoride applied to pass through the tank. This enables the “t_{10}” to be determined, which is the time taken for 10% of the inflow of water to pass through the tank. The t_{10} (minutes) is used in conjunction with the outlet concentration C (mg/L) to calculate Ct_{10} (mg.min/L). Hunter H2O shall undertake this work following receipt of the data collected by Council.

6. Repeat the test in reverse (concentration increasing profile). That is, from a stable low natural fluoride concentration in water passing through the CWT, restart fluoride dosing and monitor (via grab samples) until the residual reaches a stable dosed level again.
   i. By using this method of using two tests by stopping then starting the fluoride dosing, results from the first test (concentration decreasing profile) can then be used to confirm the second reverse test (concentration increasing profile), thereby improve the confidence of the data set.
   ii. The USEPA LT1ESWTR Disinfection Profiling and Benchmarking -Technical Guidance Manual (USEPA, 2003) recommends that the baffle factor is determined by the ‘concentration increasing profile’ method and hence more focus should be made on the

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test where fluoride dosing is re-started. However, collection of both trends will improve the reliability of the data

Note: It is important for the system to reach steady state at both the beginning and end of the trial. This would mean that there is a steady concentration of background fluoride monitored for a period of time before restarting fluoride dosing, and similarly the final fluoride concentration should reach steady state at a concentration of the background level combined with the fluoride dose rate applied (i.e. the target fluoride concentration in the treated water).

3 Calculation of the Baffle Factor *(undertaken by Hunter H2O)*

Once Council has collected the above data and sent to Hunter H2O, Hunter H2O shall then follow the below steps in order to process the data and calculate the baffle factor:

- Enter the raw data (time and fluoride residual) into Microsoft Excel for graphical calculation of the t_{10} and resultant baffling factor. The t_{10} is the time to recover 10 % of the tracer which is equivalent of the time taken for 10% of the inflow to the tank to exit. The t_{10} is used to calculate the Ct_{10} for disinfection purposes.
- The concentration data is entered alongside the time data responding to when each measurement occurred.
- The concentration data is then corrected by subtracting the background fluoride concentration. This will result in another column of data for the 'dimensionless concentration'.
- The dimensionless concentration (C/C_0) is then determine by dividing the concentration, C (mg/L) at each time interval by the dosed concentration, C_0 (mg/L).
- C/C_0 is then plotted against time (minutes).
- t_{10} can then be directly read from C/C_0 versus time chart. t_{10} corresponds to the point on the curve where C/C_0 is equal to 10%.

Note: In the case where the trial was performed with decreasing fluoride concentration then the reverse would occur where T_{10} would be determined by directly reading from the graph where C/C_0 is equal to 90%.

- t_{10} can then be used to determine the baffle factor.
- This is performed by calculating the theoretical residence time, t (minutes) of the clear water reservoir at the assumed operating level and trial flowrate, where t is simply equal to the volume of the tank (m_3) divided by the flowrate (m_3/min).
- The baffle factor is then determined by dividing t_{10} by the t.
- The baffle factor should be between 0.1 and 0.6, with higher values for well baffled contact tanks.

4 Testing Conditions *(performed by Council)*

The USEPA LT1ESWTR Disinfection Profiling and Benchmarking -Technical Guidance Manual (USEPA, 2003) states:

"Ideally, tracer tests should be performed for at least four flow rates that span the entire range of flow for the segment being tested. The flow rates should be separated by approximately equal intervals to span the range of operation, with one near average flow, two greater than average, and one less than average flow. The flows should also be selected so that the highest test flow rate is at least 91 percent of the highest flow rate expected to ever occur in that segment. Four data points should assure a good definition of the segment's hydraulic profile."

It is recommended that for each test below that a concentration increase profile, and decrease profile is recorded which will provide further confidence in the results and calculation of the baffle factor.

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For Hay WTP we are trying to assess the need for baffling in the clear water tank and therefore only need to test certain conditions (lower storage levels and a range of flowrates).

Table 1: Hay WTP Fluoride Tracer Testing Runs

Test Run Number	Plant Flowrate (L/s)	Clear Water Tank Level (%)
1	Maximum plant flow ~ 25	Minimum – 60
2	Maximum plant flow ~ 25	Typical – 70
3	Minimum plant flow ~ 20	Minimum – 60
4	Minimum plant flow ~ 20	Typical – 70

Note: the maximum, typical and minimum plant flowrates are to be confirmed by Council. The IWCM states 26 L/s as the capacity of the raw water pumps at Murray St pump station, while the DWMS adopts 25 L/s in the Ct calculations, while the operational data indicates the WTP has operated at 28 L/s in the past. In addition, agreement on the minimum and typical CWT levels needs to be confirmed.

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Example tracer testing results presented graphically

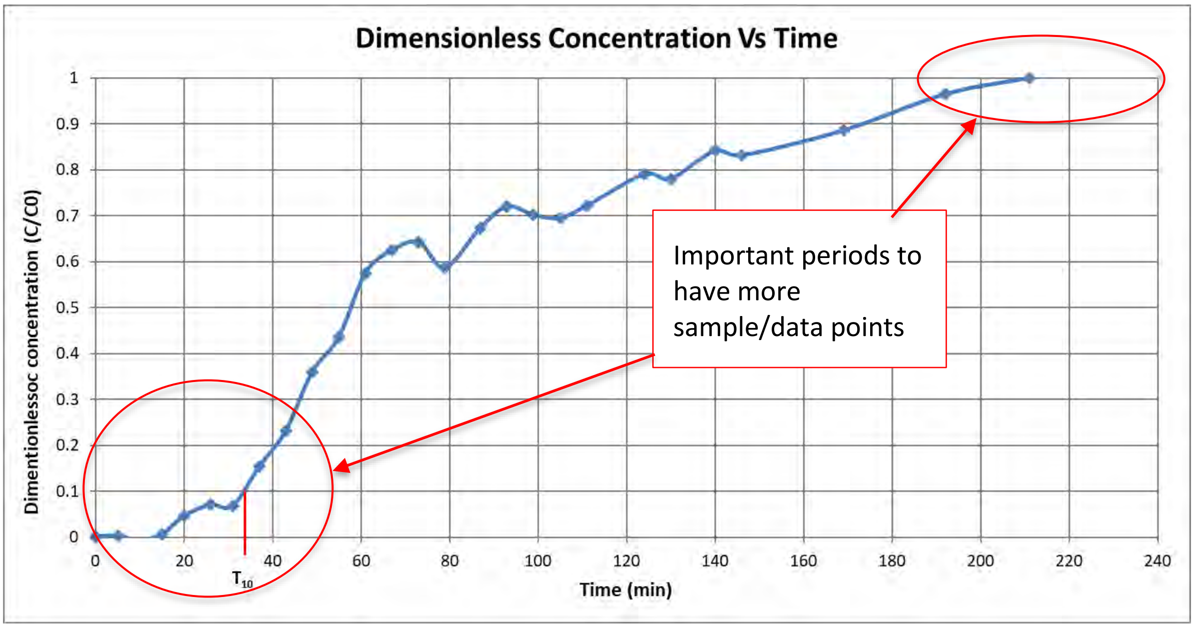

Figure 4-1: Example of fluoride concentration (concentration increasing profile) as a function of time (5 minute manual grab samples).

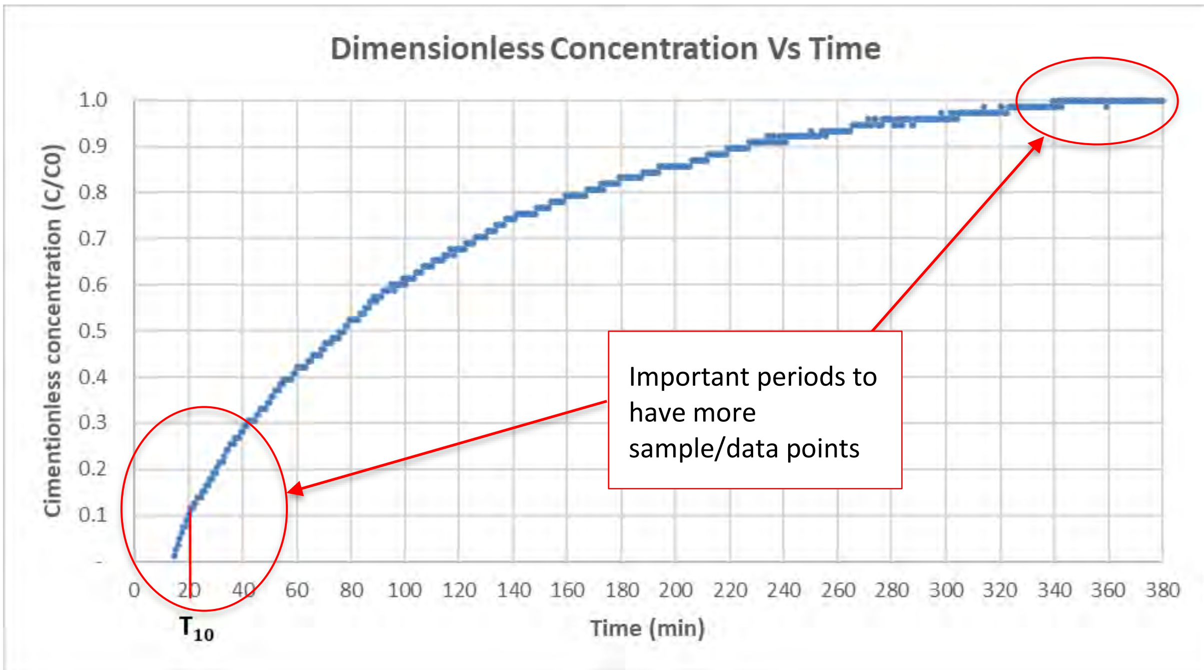

Figure 4-2: Example of fluoride concentration (concentration increasing profile) as a function of time (1 minute SCADA data).

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Hunter H2O Holdings Pty Ltd
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Fluoride Tracer Testing Run Sheet

Date: __________________	**Plant start time:** ____________________
Test Run Number: __________________	**Fluoride dosing stop/start time:** ____________
Target Plant Flowrate: __________________	**Plant stop time:** ____________________
Target CWT level: __________________	

Time (24 hr)	CWT level (%)	Plant Flowrate through CWT (L/s)	CWT outlet fluoride concentration (mg/L)

Time (24 hr)	CWT level (%)	Plant Flowrate through CWT (L/s)	CWT outlet fluoride concentration (mg/L)

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Appendix C Hay Water and Wastewater Telemetry Audit

hunterh2O

Hay Water and Wastewater

Telemetry Audit

Hay Shire Council

APRIL 2021

ABN 16 602 201 552

Report Details

Report Title	Hay Water and Wastewater: Telemetry Audit
Project No.	5939
Status	Final
File Location	P:\Hay Shire Council\5939 Hay Telemetry Audit\2. Tasks\2 Design\Report\5939-RPT-EL-001 Hay Telemetry Audit_RevC.docx
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Document History and Status

Revision	Report Status	Prepared by	Reviewed by	Approved by	Issue Date
A	Draft	D. Milajew	D. Longmuir	S. Ambrose	20/11/2020
B	Issue for Client review	D. Milajew	D. Longmuir	S. Ambrose	08/12/2020
C	Final revision	D. Longmuir	D. Longmuir	D.Webb	13/04/2021

Executive Summary

Hunter H2O was engaged by Hay Shire Council (HSC) to conduct site audits and condition assessment of the existing telemetry system. Based on an informal site workshop and the information collected, this report presents the recommendations and upgrade strategies for Hay SCADA and telemetry upgrades.

A strategic driver for HSC is to operate a reliable and secure SCADA and telemetry network that meets current water and wastewater control and monitoring system industry standards. A long-term solution relies on choosing proven technology and appropriate equipment that can be supported by both internal staff and local contractors.

The repeater radio network forms the basis of any SCADA and telemetry network. For Hay the repeater base needs coverage to reach all outstations in the shire, the existing repeater location at Pine St reservoir remains a suitable location to provide the required radio network coverage.

It is recommended to employ a single digital radio product across the entire radio network. The current market leaders in this area are the 4RF Aprisa radios and the Schneider QR series radios. The 4RF radio system can be licenced to be 50kHz which will allow great bandwidth (i.e. more Data / faster communications), however this bandwidth will have to be approved by the ACMA on the application of the new repeater frequencies. As the system is only small, a 50kHz bandwidth may be in excess of Councils requirements, unless Council wish to have the functionality of remote online fault finding of the RTUs. Considering the small number of sites and the close proximity of the sites to the repeater, an unlicensed radio network may also be considered.

Incorporating the mobile 4G network is also recommended. When combined with radio communication it provides broader coverage in the district and can also provide a backup or redundant communications link for critical sites if needed. In specific cases such as reservoirs and SPS, using the 4G network can potentially offer lower cost reporting solutions. It also offers the Council newer technology such as battery powered RTUs that can be used to monitor low I/O count sites such as flow meters, chlorine analysers, rain gauges, etc.

HSC requires a SCADA platform that uses the DNP3 protocol, one that is reliable, enduring, is an industry standard system, and is expandable. GeoSCADA (previously ClearSCADA) is the industry standard for DNP3 based SCADA communications. It is a proven and familiar product to integrators in the water industry. GeoSCADA is recommended because it has a robust DNP3 driver, is telemetry focused, modern, and SCADA client connections can be deployed through HSC's existing corporate network to allow the monitoring of the system. HSC currently has GeoSCADA installed at both the WTP and the WWTP, this will reduce the cost of the upgrade.

It is recommended that HSC choose modern RTUs that are DNP3 capable, programmable, reliable and well supported by local Australian organisations. The recommended programmable RTUs include the Schneider SCADAPack, Brodersen RTU32M and Siemens S7-1200.

A telemetry system upgrade strategy is outlined in this report. This includes the architecture design, specifications, and installations requirements.

Cost budgets have been included and are based on Schneider SCADAPack RTUs with separate Aprisa SR+ radios. The budget also includes upgrades for the repeater network.

Abbreviation	Description
ACMA	Australian Communications and Media Authority
AHF	Active Harmonic Filter
APN	Access Point Name
AS	Australian Standard
CCP	Critical Control Point
DNP	Distributed network Protocol
DOL	Direct On Line
EIRP	Effective, or Equivalent, Isotropically Radiated Power
HSC	Hay Shire Council (local government authority acronym)
HH2O	Hunter H2O
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
LAN	Local Area Network
LCS	Local Control Station
NZS	New Zealand Standard
PAC	Powder Activated Carbon
PF	Power Factor
PLC	Programmable Logic Controller
PTP	Point to Point
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SPS	Sewerage Pump Station
VPN	Virtual Private Network
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive
WAN	Wide Area Network
WHS	Work Health and Safety
WPS	Water Pump Station
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

Contents

Figures

Tables

1 Introduction

1.1 Background

Hunter H2O (HH2O) has undertaken an on-site condition assessment of water and wastewater telemetry assets throughout the Hay region. This report outlines the preferred upgrade path for telemetry equipment with the aim of providing a solution that is reliable, secure and cost-effective.

The report considers the following factors:

- the physical condition and capability of the existing equipment
- technology advances since the original system was installed
- operational and maintenance cost minimisation
- network optimisation
- operational control
- disaster recovery and cyber security
- repeater UPS power
- SCADA reporting
- SCADA/telemetry disaster recovery

The report also contains a concept design for the Hay system, highlighting:

- an upgrade philosophy and methodology
- detailed cost estimates and a staged plan

1.2 Assumptions

This Telemetry Upgrade Strategy report makes the following assumptions:

- Some of the condition assessment items represent a Work Health and Safety risk and must be actioned immediately irrespective of the recommendations within this report.
- This report documents the upgrade strategy for the Telemetry system only. This is limited to the radio and communications network for the RTU and SCADA system, RTUs, SCADA servers and SCADA software.

2 Telemetry Assets

2.1 Site List

The table below lists all the Hay Council sites considered by this report and provides information about the current installation at each site.

Facility	Site Type	System	RTU Type
1 Stephen St SPS	Sewer Pump Station	Sewage	Radtel 3001
2 East Hay SPS	Sewer Pump Station	Sewage	Radtel 5000
3 Murray St RWPS	Raw Water Pump Station	Water	Radtel 3001
4 Hospital Well SPS	Sewer Pump Station	Sewage	Radtel 5000
5 Leonard St Reservoir	Raw Water Reservoir	Water	Radtel 5000
6 Leonard St RWPS	RW PS with Water Treatment	Water	Radtel 5000
7 Queen St SPS	Sewer Pump Station	Sewage	Radtel 5000
8 Pal Richards Park SPS	Sewer Pump Station	Sewage	Radtel 3001
9 Depot SPS	Sewer Pump Station	Sewage	Radtel 5000
10 Hay WWTP	WWTP	Sewage	Broderson RTU32S
11 Sandy Point SPS	Sewer Pump Station	Sewage	Radtel 3001
12a Pine St Reservoir	Raw Water Reservoir	Water	None
12b Pine St Repeater	Radio Repeater	Repeater	None
12c Pine St Reservoir	Clear Water Reservoir	Water	Miri AD2006
12d Pine St RWPS	Raw Water Pump Station	Water	Broderson RTU32S
13 Lang St Reservoir	Raw Water Reservoir	Water	Radtel 3001
14 Russell St SPS	Sewer Pump Station	Sewage	Radtel 3001
15 Palmer St SPS	Sewer Pump Station	Sewage	Radtel 3001
16 WTP	Radtel 5000	Water	Radtel 5000

Table 2-1: Hay Council Water and Waste Water Asset Site List

2.2 Data Sources

Where available, HH2O has drawn from the following sources to collect information for this project:

- Electrical wiring diagrams (typical only)
- Discussions with the operators and contractors on site during the audit
- Australian Communications and Media Authority (ACMA) licencing

2.3 Assumptions

Where details had not been provided or were unavailable during the site audit, it has been assumed:

- That the equipment has been in operation since the associated civil structure was commissioned
- Regular maintenance is being performed
- Where equipment details such as manufacturer and product numbers have not been provided, generic generally accepted expected lifetime and time between services for the item has been applied or estimated. Some manufacturers may recommend less or more than has been assumed for this assessment.

3 Current condition assessment

3.1 Existing RTU and SCADA system

A Schneider ClearSCADA SCADA system is installed at the Hay WWTP and WTP, acting as a duty standby pair for the network. The sites are linked via the Council's corporate network. This allows the control and monitoring of the Hay sewage and water assets with RTUs installed.

For a list of SCADA screen shots please refer to "Appendix C: SCADA "

Site Name	RTU
1 Stephen St SPS	Radtel 3001
2 East Hay SPS	Radtel 5000
3 Murray St RWPS	Radtel 3001
4 Hospital Well SPS	Radtel 5000
5 Leonard St Reservoir	Radtel 5000
6 Leonard St RWPS	Radtel 5000
7 Queen St SPS	Radtel 5000
8 Pal Richards Park SPS	Radtel 3001
9 Depot SPS	Radtel 5000
10 WWTP	Broderson RTU32S
11 Sandy Point SPS	Radtel 3001
12a Pine St Reservoir	None
12b Pine St Repeater	None
12c Pine St Reservoir	Miri AD2006
12d Pine St RWPS	Broderson RTU32S
13 Lang St Reservoir	Radtel 3001
14 Russell St SPS	Radtel 3001
15 Palmer St SPS	Radtel 3001
16 WTP	Radtel 5000

Table 3-1: Sites that have an existing RTU, antenna and radio installed

3.2 Existing Communications Network

3.2.1 Main Repeater Network

The telemetry network utilises licenced 450Mhz analogue radios and Radtel / Brodersen RTU's.

The main radio repeater is located at the Pine St Reservoir site. The radio repeater cabinet is mounted at ground level at the base of the Clear Water reservoir, with the collinear antenna mounted on top of the reservoir.

The sewage and water asset RTU's communicate through this repeater back to the redundant SCADA system located at the Hay WWTP and the WTP.

The ACMA licence for this repeater site is 1229677/1.

The area of Hay is flat with little to no obstructions from the sites to the repeater. The overview of the repeater and elevations and geographic locations are shown in the following figures.

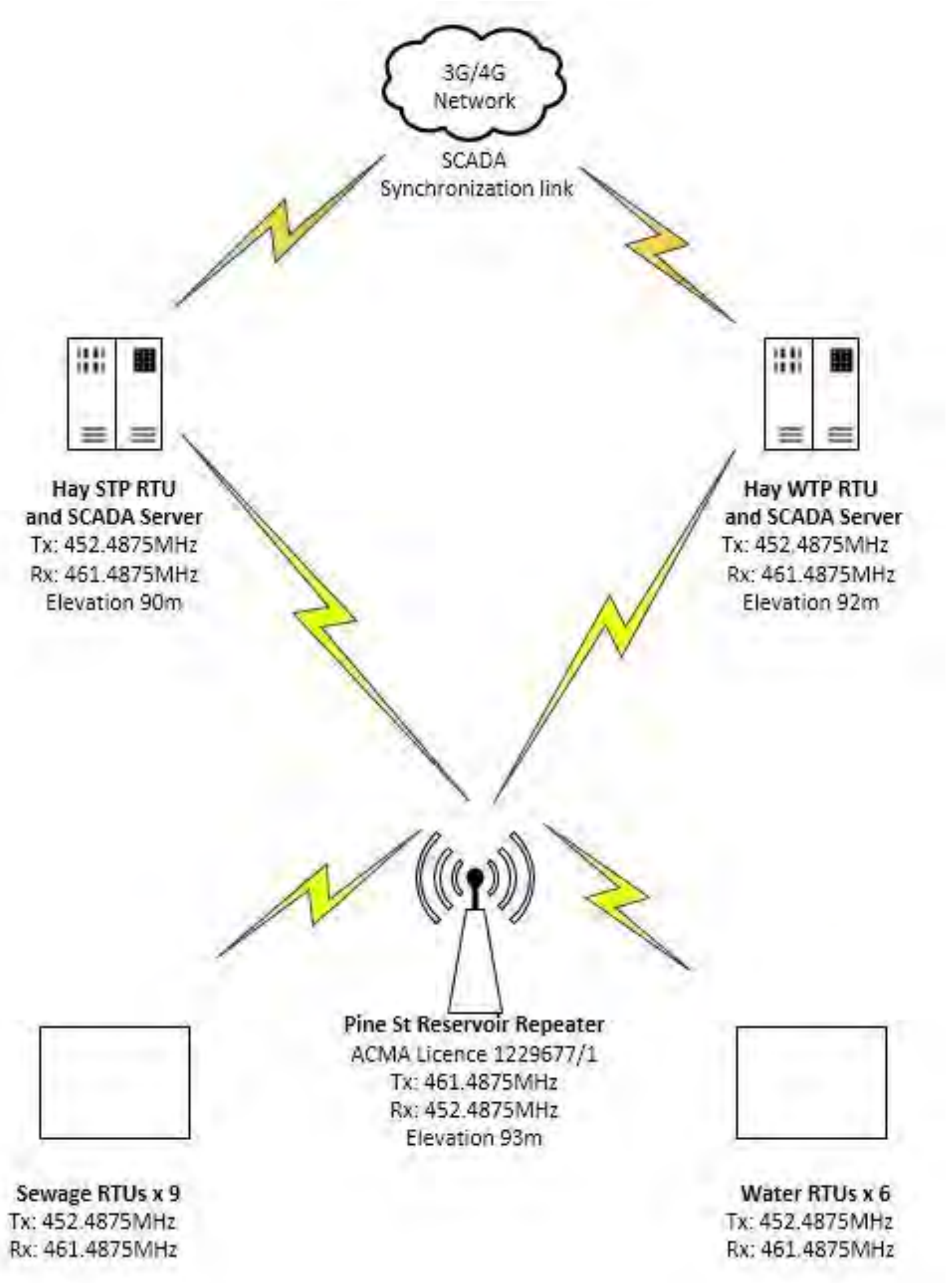


Figure 3-1: Overview of the Hay Radio Network as configured with transmit and receive frequencies and site elevations.

Figure 3-2: Overview of the Hay Repeater Network. The red line showing the longest radio paths of 2.7 and 3.2 km.

3.2.1.1 ACMA Licence 1229677/1 – Pine St Point to Multipoint

Licensee details	
Customer ID	1370225
Licensee	Hay Shire Council
Licensee address	PO Box 141, HAY, NSW 2711
Licence details	
Licence service	Fixed
Licence subservice	Point to Multipoint
Licence number	1229677/1
Date of issue	11/09/2020
Date of effect	11/09/2020
Date of expiry	17/08/2021

Site details		
Site ID	205367	
Site address	Pine Street Reservoir, HAY NSW 2711	
Co-ordinates (GDA94)	Latitude: -34.512973	Longitude: 144.839507

Transmitter details	
Assigned frequency	461.487500 MHz
Bandwidth	25.0000 kHz
Freq. assign. ID	0000637026
Transmitter power	5.00 W
EIRP	17.00 W
Emission designator	16K0F2D
Antenna details	
Antenna ID	70193
Antenna polarisation	V - Vertical linear
Antenna azimuth	
Antenna height (m)	10
Antenna type	Colinear Vertical-U
Receiver details	
Assigned frequency	452.487500 MHz
Bandwidth	25.0000 kHz
Freq. assign. ID	0000637029
Transmitter power	N/A
EIRP	N/A
Emission designator	16K0F2D
Antenna details	
Antenna ID	70193
Antenna polarisation	V - Vertical linear
Antenna azimuth	
Antenna height (m)	10
Antenna type	Colinear Vertical-U

3.2.2 Existing Backup Power

Most sites are fitted with backup batteries to keep the RTU and instruments powered during a power outage. This battery will not allow the control of the site equipment, only the monitoring of the site. No calculations on the battery size have been done, however it is recommended that this is completed to determine the up time of the system based on each sites power consumption. It is also recommended that all RTU sites are fitted with backup batteries and that the batteries are replaced every 2 years as a minimum.

3.2.3 Mobile 3G/4G Network Coverage

Currently the 3G/4G network is not used to bring back data from the RTU network. All sites will have adequate coverage to allow for a mobile data connection to the site.

3G/4G modems are on option instead of the radio links that can be used at:

- Flow meters
- Reservoirs
- Possible SPS if there are low risk

The sites that have low I/O counts and would suit the implementation of a simple, low cost battery powered RTUs, as long as peer communications to the site is not needed. These RTUs will typically reduce engineering, manufacturing and installation costs. A limitation is these RTUs have only digital and analogue inputs making them suitable for monitoring applications only. The RTU can also be programmed to take measurements and return data at pre-set times, or when signals change state or reach a predefined level or deviation. If the Council requires the data to come back regularly, then an external power source to the RTU will need to be considered.

A basic mobile 3G/4G network coverage survey was recorded at every location to assess the 3G/4G signal strength for communications suitability. There was a minimum of 2 bars of 3G/4G at every site; to see full details please refer to Section 13 *Appendix A: Full Site List.*

3.3 Existing Electrical Panels

3.3.1 Electrical Panels in good condition

The following electrical panels and motor control centres are in good condition and do not require replacing or modifications.

Site Name	Motor Control Unit
3 Murray St SPS	WEG CFW701
6 Leonard St RWPS	Auto Transformer
8 Pal Richards Park	DOL
10 WWTP	Various

Table 3-2: Hay Council Sewage and Water Assets - Electrical Panels and Motor Control Centres that do not need to be replaced

3.3.2 Electrical Panels that require replacing

The following motor control centres should be replaced because they are in poor condition that may impact on the performance and reliability of the site, but more importantly safety. Details of these panels are shown in the following sections.

Site Name	Motor Control Unit
1 Stephen St	DOL
2 East Hay	DOL
4 Hospital Well	DOL
7 Queen St	DOL
9 Depot	Star/Delta
11 Sandy Point	DOL
14 Russell St	Star/Delta
15 Palmer St	Star/Delta
16 WTP	DOL Star/Delta
Lang St RW Reservoir	N/A
Leonard St RW Reservoir	N/A
Pine St Reservoirs & Repeater	N/A

Table 3-3: Hay Council Sewage and Water Assets - Motor Control Centres that need to be replaced

A specific breakdown of the issues that were found on site can be found in Appendix D

4 Site Types

The following site types will govern the templates created for the RTU logic and SCADA. At present it appears that templates can be made for the following sites:

- Water Pump Station
- Sewerage Pump Station
- Reservoir (both Clear Water (CW) and Raw Water (RW))
- Reservoir with Water Pump
- Repeater

The plant SCADA controls and displays will need to be developed on an individual basis as they are unique from the other templated sites:

- Water Treatment Plant
- Waste Water Treatment Plant

4.1 Reservoir Sites

The Hay water network has three RW reservoirs and one CW reservoir. The RW reservoir at Pine St also has a booster pump used to fill Lang St reservoir at South Hay.

Site Name	Existing RTU in separate enclosure
5 Leonard St RW Reservoir	Radtel 5000
12a Pine St RW Reservoir	None
12c Pine St CW Reservoir	Miri AD2006
13 Lang St RW Reservoir	Radtel 3001

Table 4-1: Reservoirs for Hay Shire Council water assets.

- Leonard St Raw Water Reservoir, a new RTU and panel is required. This site also has a flowmeter and an inlet valve controlled by the RTU.
- Pine St RW Reservoir does not have an RTU. It has an instrument panel located at ground level containing: a level transmitter and 2 level switches. This instrument panel will remain. The level instrument and switches are currently connected to the Pine St CW Reservoir RTU and will be re-connected to the new CW Res RTU. These input signals are currently cabled to the radio repeater panel than into the CW Res RTU. Pine St RW Reservoir also has a booster pump with its own RTU which is detailed in the RW Pump section 4.2.
- Pine St CW Reservoir has the following four panels located at ground level:
  1. RTU panel - a new RTU and panel is required, the new RTU can be utilised to connect digital and analog inputs from the following assets:
     a. RW Reservoir
     b. CW Reservoir
     c. RW Pump Station
  2. Flowmeter panel – containing two flowmeters (CW and RW) and coax filter panel – this panel will remain
  3. Repeater panel – containing radio repeater and terminals – this panel can remain and be utilised as a junction box for the RW reservoir signals that are then connect into the CW reservoir RTU. The Radio Repeater will be replaced and require a new panel.

4. Instrument panel – containing a level transmitter and two pressure switches – this panel will remain.

- Lang St RW Reservoir, a new RTU and panel is required. The current RTU panel is located at the top of the reservoir, for safe personnel access to maintain the RTU, it is recommended that the new panel be located at ground level.

The table below shows the existing I/O sent from the Reservoir RTUs to the current SCADA system and the I/O that is recommended for the upgraded RTU's.

IO Type	Existing IO	Upgraded RTU IO
Digital In	Motorised Valve Open	Motorised Valve Open
	Motorised Valve Close	Motorised Valve Close
	Mains Fail Alarm	Mains Fail Alarm
	Intrusion Alarm	Intrusion Alarm
	Low Battery Alarm	Low Battery Alarm
	Flow Pulse TBC	Flow Pulse TBC
	Telemetry Mains Fail Alarm	Telemetry Mains Fail Alarm
	Motorised Valve Auto Alarm	Motorised Valve Auto Alarm
	Reservoir Overflow Alarm	Reservoir Overflow Alarm
	Reservoir Low Alarm	Reservoir Low Alarm
		Motorised Valve Travel Alarm
		UPS Mode Alarm
		UPS Battery Alarm
Digital Out	Valve Open	Valve Open
	Valve Close	Valve Close
	Valve Auto Control	Valve Auto Control
Analog In	Reservoir Level	Reservoir Level
	Reservoir Level Flow rate	Reservoir Level Flow rate
Analog Out	None	None

Table 4-2:Leonard St Reservoir existing and upgraded IO list.

IO Type	Existing IO	Upgraded RTU IO
Digital In	Clear Water Required	Clear Water Required
	CW Res Overflow Alarm	CW Res Overflow Alarm
	Raw Water Required	Raw Water Required
	CW Res Low Alarm	CW Res Low Alarm
	Intrusion Alarm	Intrusion Alarm
	RW Res Overflow Alarm	RW Res Overflow Alarm
	RW Res Low Alarm	RW Res Low Alarm
	Mains Fail Alarm	Mains Fail Alarm
	CW Flow Pulse TBC	CW Flow Pulse TBC
	RW Flow Pulse TBC	RW Flow Pulse TBC
		UPS Mode Alarm
		UPS Battery Alarm

Digital Out	None	None
Analog In	Clear Water Res Level	Clear Water Res Level
	Raw Water Res Level	Raw Water Res Level
	Battery Voltage	Battery Voltage
	Clear Water Flow rate	Clear Water Flow rate
	Raw Water Flow rate	Raw Water Flow rate
Analog Out	None	None

Table 4-3:Pine St Reservoirs existing and upgraded IO list.

IO Type	Existing IO	Upgraded RTU IO
Digital In	Reservoir Overflow Alarm	Clear Water Required
	Intrusion Alarm	CW Res Overflow Alarm
	Reservoir Low Alarm	Raw Water Required
		UPS Mode Alarm
		UPS Battery Alarm
Digital Out	None	None
Analog In	Reservoir Level	Reservoir Level
	Battery Voltage	Battery Voltage
Analog Out	None	None

Table 4-4:Lang St Reservoir existing and upgraded IO list.

4.2 Raw Water Pump

Within the Hay network there are two raw water pump sites that pump water from the Murrumbidgee River and one raw water booster pump.

Site Name	Existing RTU in separate enclosure
3 Murray St	Combined
6 Leonard St	Separate
12d Pine St	Separate

Table 4-5: Raw Water Pump Stations for Hay Shire Council water assets.

The following is a general description of the water distribution network:

1. Murray St RWPS pumps water to the Hay WTP for treatment
2. Leonard St RWPS the raw water is disinfected with chlorine gas and pumped to the Leonard and Pine St reservoirs for distribution.

3. Pine St RWPS booster (located adjacent to Pine St reservoirs) pumps to the Lang St reservoir and distribution network.

The recommended electrical works include:

- Murray St RWPS: a new RTU and panel is required, the existing RTU is located within the MCC which is in good condition and doesn't require replacement. A new RTU can be retrofitted within the existing panel
- Leonard St RWPS: a new RTU and panel is required. This site also has a flowmeter connected to the RTU.
- Pine St RWPS booster: this RTU panel contains a Broderson RTU and is in good condition. There are two options for this RTU site:
  a. Leave the site RTU it as is
  b. Remove this RTU panel to another indoor site for reuse. Terminate the existing pump I/O cables in a junction box then trench the cabling to connect to the new CW reservoir RTU.

The table below shows the existing I/O sent from the Raw Water Pump RTUs to the current SCADA system and the I/O that is recommended for the upgraded RTU's.

IO Type	Existing IO	Upgraded RTU IO
Digital In	Pump 1 Running	Pump 1 Running
	Pump 1 Fault	Pump 1 Fault
	Pump 2 Running	Pump 2 Running
	Pump 2 Fault	Pump 2 Fault
	Well High Level	Well High Level
	Battery Low Alarm	Battery Low Alarm
	Telemetry Mains Fail Alarm	Telemetry Mains Fail Alarm
	Chlorinator Pump Running	Chlorinator Pump Running
	Chlorinator Pump Fault	Chlorinator Pump Fault
	Raw Water Flow Pulse	Raw Water Flow Pulse
	Dry Well Flooded Alarm	Dry Well Flooded Alarm
	Intruder	Intruder
	Mains Fail	Mains Fail
	Intruder	Intruder
	Station Inhibited	Station Inhibited
		UPS Mode Alarm
		UPS Battery Alarm
Digital Out	Pump 1 Start	Inhibit Station
	Pump 2 Start	Start Station
		Inhibit Pump 1
		Inhibit Pump 2
Analog In	Raw Water Flow Rate	Raw Water Flow Rate
	River Level TBC	River Level TBC
Analog Out		

Table 4-6: Leonard St Raw Water pump existing and upgraded IO list.

IO Type	Existing IO	Upgraded RTU IO
Digital In	Pump 1 Running	Pump 1 Running
	Pump 1 Fault	Pump 1 Fault
	Pump 2 Running	Pump 2 Running
	Pump 2 Fault	Pump 2 Fault
	Intruder	Intruder
	Battery Low Alarm	Battery Low Alarm
	Dry Well Flood Alarm	Dry Well Flood Alarm
	Sump Level High Alarm	Sump Level High Alarm
	Mains Fail Alarm	Mains Fail Alarm
		UPS Mode Alarm
		UPS Battery Alarm
Digital Out	Water Call	Water Call
Analog In	Battery Voltage	
Analog Out		

Table 4-7: Murray St Raw Water pump existing and upgraded IO list.

4.3 Water Treatment Plant

The RTU and automation and process upgrade requirements for the WTP site are discussed in the Hunter H2O draft report

5814-Hay WTP Automation and Process Instrumentation Audit_Draft_Issued

There is currently a Radtel 5000 RTU and Omron Sysmac CJ2M_CPU12 PLC currently installed at Hay WTP.

The Radtel RTU monitors the plant I/O, this information is transferred to SCADA via the radio network.

The WTP uses the Omron PLC to control the plant. The PLC is not currently connected to the SCADA system.

It is proposed that the RTU, PLC and plant switchboard are upgraded as per the **5814-Hay WTP Automation and Process Instrumentation Audit_Draft_Issued**

The new RTU would connect to the new PLC via a Modbus connection to extract a subset of data to allow for the plant operation and monitoring from SCADA.

The current PLC has the following approximate number of hardwired I/O

- 48 Digital inputs
- 16 Digital outputs
- 16 Analog inputs

- 8 Analog outputs

The current RTU has the following inputs connected

IO Type	Existing IO	Existing IO
Digital In	Clearwater pump 1 running	Soda ash pump 1 running
	Clearwater pump 1 fault	Soda ash pump 1 fault
	Clearwater pump 2 running	Soda ash pump 2 running
	Clearwater pump 2 fault	Soda ash pump 2 fault
	Duty pump	Soda ash pump 3 running
	Telemetry battery low	Soda ash pump 3 fault
	Murray street flow meter pulse	PAC pump running
	Telemetry mains failure	PAC pump fault
	Alum pump 1 running	Vacuum pump running
	Alum pump 1 fault	Vacuum pump fault
	Alum pump 2 running	Raw water request
	Alum pump 2 fault	Clear water well low alarm
	Chlorine pump 1 running	Intrusion alarm
	Chlorine pump 2 running	Mains failure
Analog In	Clearwater well level	
	Murray Street flow rate	
	Outlet Flow rate	
	Chlorine analyser	
	Chlorine cylinder 1 weight	
	Chlorine cylinder 2 weight	

Table 4-8: WTP RTU existing IO list.

4.4 Sewage Pump Station

There are 9 Sewerage Pump Station (SPS) assets within the Hay area. All these sites are monitored by Radtel RTUs and communicate to the SCADA system.

Site Name	Replace RTU	Replace MCC	Existing RTU in separate enclosure to MCC	New RTU in separate enclosure to MCC
1 Stephen St	Yes	Yes	Separate	Combined or Separate
2 East Hay	Yes	Yes - could retrofit into existing	Combined	Combined
4 Hospital Well	Yes	Yes	Separate	Combined or Separate
7 Queen St	Yes	Yes	Separate	Combined or Separate
8 Pal Richards Park	Yes	No	Separate	Separate
9 Depot	Yes	Yes	Separate	Combined or Separate
11 Sandy Point	Yes	Yes	Separate	Combined or Separate
14 Russell St	Yes	Yes	Combined	Combined or Separate
15 Palmer St	Yes	Yes	Combined	Combined or Separate

Table 4-9: Sewerage pump site locations for Hay Shire Council sewage assets.

There are 8 sites with substandard MCC panels. It is recommended that these panels are replaced, however this is outside of the scope of this report, with further design to be undertaken as a separate project.

It is recommended that new RTU panels are installed at all 9 SPS sites. The RTU can be installed in a dedicated RTU panel or in a separate compartment within the new MCC.

If the RTUs are to be installed in the MCC sufficient space is required for RTU, radio, an independent power supply, UPS, backup battery, protection devices and terminals.

At present, the SCADA system only monitors the pump stations and allows for inhibiting of the pump station without being able to directly control pumps. Any upgrade should consider the integration of the RTUs into the existing pump station controls for automatic operation via the RTU.

The table below shows the existing I/O sent from the SPS RTUs to the current SCADA system and the I/O that is recommended for the upgraded RTU's.

IO Type	Existing IO	Upgraded RTU IO
Digital In	Pump 1 Running	Pump 1 Running
	Pump 1 Fault	Pump 1 Fault
	Pump 2 Running	Pump 2 Running
	Pump 2 Fault	Pump 2 Fault
	Well High Level	Well High Level
	Mains Fail	Mains Fail
	Intruder	Intruder
	Station Inhibited	Station Inhibited
		UPS Mode Alarm
		UPS Battery Alarm
Digital Out	Inhibit Station	Inhibit Station
		Start Station
		Inhibit Pump 1
		Inhibit Pump 2

Analog In	Battery Volt	Well Level*
Analog Out		

Table 4-10: Sewerage pump station existing and upgraded IO list.

*Note: well level would require the installation of a hydrostatic level instrument into the well.

4.5 Sewerage Treatment Plant

There is a Broderson RTU32S RTU and an Omron SYSMAC CJ2M CPU33 PLC currently installed at Hay STP.

The RTU, PLC and MCC are all in good condition and do not require replacement.

The Broderson RTU is available to connect to plant I/O via a Modbus interface, this information could then be transferred to SCADA via the radio network. Currently there are only hardwired 2 digital inputs connected to this RTU currently.

The STP uses the Omron PLC to control the plant. The PLC is may be connected to the RTU via Modbus. This connection would allow for the plant operation and monitoring from SCADA system. It is noted that currently the SCADA system does not include the WWTP data point configurations or displays. To allow the plant to be controlled and operated from SCADA then configuration of the PLC, RTU and SCADA will be required.

The current PLC has the following I/O

- 176 Digital inputs
- 16 Digital outputs
- 24 Analog inputs
- 4 Analog outputs

4.6 Repeater

The Hay telemetry network has one radio repeater located at Pine St reservoir.

The radio equipment panel is located at the base of the clear water reservoir and the antenna is mounted on top of the reservoir.

The radio equipment is required to be replaced with a modern digital radio to accommodate the telemetry network upgrade. To ensure network reliability upgrading the repeater radio should include a new panel containing the radio equipment, 24VDC power supply, UPS and backup battery system.

5 Communications Network

5.1 Radio path review

As part of the scope, a radio path desktop review was performed using Google Earth. The review inputs included the collected telemetry site location data, existing radio license information, and radio information.

With consideration of site locations, site topography and communications paths, it was determined that maintaining the repeater antenna on the top of Pine St Reservoir offers a suitable radio path to all existing telemetry monitored assets.

5.2 Duty Standby Repeaters

Repeater redundancy will contribute to SCADA network reliability. A duty-standby arrangement of two radio repeater bases can be installed at the Pine St Point to Multipoint location. This redundancy allows all the outstations that are communicating to this location to continue to be monitored in the event of a single repeater base failure.

As the existing repeater control panel size and space is limited it is recommended to implement a new panel at Pine St repeater site.

If upgraded, the hardware at the repeater sites can be configured in a Duty / Standby arrangement, with a hot swappable function that would provide uninterrupted operation of the repeater in the event of hardware failure. However, in achieving this, the cost of the radio equipment is doubled. There is a risk that if the tower receives a direct lightning strike or if there is a fire in the communications panel, then both the duty and standby repeaters will be lost. If the repeaters are configured to have no redundancy, then the only down time is the time it takes for Council to attend site and replace the radio with a cold standby.

Council will need to compare the advantages and disadvantages of implementing redundant repeaters, with respect to cost and risk.

With the failure of power supplies being the most common point of failure, the repeater base sites should also employ redundant DC power supplies. With the availability of a generator connection to the panel.

5.3 Repeater Additional 3G/4G Mobile Links

If the communications link between the repeaters or the SCADA server connection to the Pine St repeater fails, it is possible to add a 3G/4G mobile redundant pathway between the SCADA servers and repeater. This requires routing to be added to the radios and modems, along with communications testing of the links to detect the failure.

5.4 Peer Data Communications

The current radio telemetry network utilises peer communications. Peer communications is data from an outstation RTU transmitted to another outstation RTU through the repeater radio, typically used to send a control parameter or control signal to another location for the purpose of control. These peer communication links will need to be maintained in the upgraded telemetry system.

The sites identified as utilising peer communications are:

Site A	Site B
Murray St RWPS	WTP
Leonard St RWPS	Leonard St RW Reservoir
Leonard St RWPS	Pine St RW Reservoir
Pine St RW Booster	Lang St Reservoir

5.5 Radio Hardware

It is recommended to employ a single radio product across the entire radio network. 4RF Aprisa radios can be implemented in a 50 kHz network if the site is in a low population density and the licencing is approved by ACMA, however at the time of this report the Aprisa radios are more expensive than the Schneider based QR450 radios. The QR450 radios have the same functionality as the 4RF radios, but can only be configured to 25 kHz, this means a smaller bandwidth and therefore slower communications speeds. But on a small network such as Hay this will not be critical.

5.6 Radio Diagnostics

To provide indication of the performance of the radio and communications network diagnostic information is available from the radios and should be regularly reported to SCADA. This data can be collected through built in diagnostics or SNMP, dependant on the brand and type of radio being deployed, with the information to be recorded and displayed on the SCADA system.

Typical data recorded may include:

- Received Signal Strength Indication (RSSI)
- Radio supply voltage and temperature
- Packet/transmission statistics.

5.7 Backup Power

The radio repeater will require battery backup or UPS power. The repeaters are important and form part of the network backbone. While the electrical loads will be different to regular outstations, Hay should choose a roughly equivalent autonomy time.

Backup power is detailed further in the Disaster Recovery section of this report.

5.8 Cyber Security

With network connectivity being a core aspect of modern Telemetry and SCADA systems, cyber security must be carefully considered in ensuring the risk of cyber and malicious attacks is sufficiently reduced.

Best practise for SCADA and Telemetry systems is for the network to be totally segregated from Council's corporate networks with secure access points for remote connections.

The purpose of the following design is to limit any control system access, to within the telemetry and SCADA network. It provides total separation from the corporate network therefore reducing the potential for external cyber-attacks on the system.

Access between networks is achieved via secure APN (Access Point Name) or VPN (Virtual Private Network) connections and firewall protection. A typical medium scale system will rely on 2 servers in two separate locations and Client / tablet access to the main servers.

With respect to client access, security will be set up in the SCADA server to only allow users with sufficient access to perform control actions, configuration etc. The Server must also have up to date Windows updates, and antivirus and antimalware definitions. If the SCADA is capable it should use Active Directories to centrally manage IT access and security.

If the network that the SCADA server is located on has access to the internet, then this access needs to be restricted. Any remote access to the server should be restricted to particular machines.

The diagram below is an indicative diagram for the SCADA and telemetry network configuration. It is to be used as a guide to assist in building a secure and stable network for the Telemetry system.

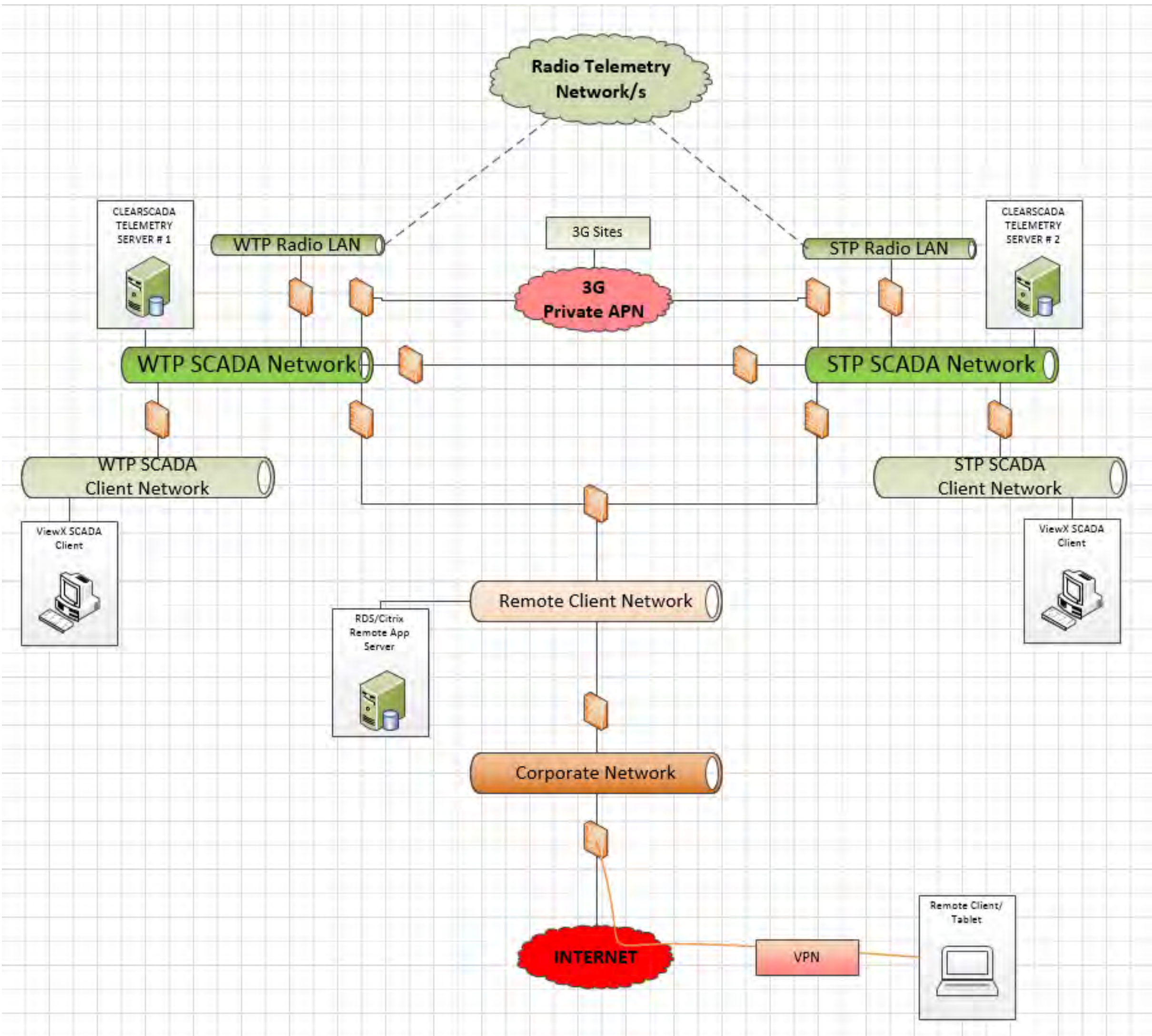


Figure 5-1: Proposed SCADA Network showing

NB: The many locations of logical firewalls at different network zones are indicated, however there may only need to be a single physical firewall.

Any access to the SCADA servers i.e. for a client, should be through a secure connection. If the client is on the corporate network, then there should be restrictions in place to ensure that only certain client machines are allowed where possible. These client machines are to have up to date Windows updates, antivirus and antimalware definitions. These clients will be positioned behind a firewall before access to the internet. Working with Council IT adequate firewall rules and IP addressing will be implemented by the Councils IT department.

For the clients that are outside of the corporate network and connection is through a VPN connection, then these computers will be installed with Windows updates, antivirus/antimalware definitions. The firewall rules need to be implemented such that they can only access the servers on particular ports i.e. the ClearSCADA ViewX/Server connection ports.

“NATing” (Network Address Translation) is to be disabled as the ClearSCADA server responds to a client connection with a separate connection back to the client.

There will always be a firewall protecting the servers from external access. If there is an internet connection, then access to the server will be restricted by a firewall at that point. Firewall will also be installed to restrict traffic into the Control network.

6 SCADA

6.1 Recommended SCADA System

It is recommended that a single SCADA platform be used to supervise the Hay telemetry system.

Schneider-Electric's GeoSCADA (was ClearSCADA) system is recommended as an appropriate choice, which is already installed at the WTP and the WWTP locations.

Some of the advantages of GeoSCADA are as follows:

- commonly used in the water industry, especially for telemetry
- has an excellent DNP3 driver and interfaces well with any modern RTU (particularly well with Schneider-Electric SCADAPack RTUs)
- ability to make online changes
- has a built in Historian
- software is well supported by most telemetry engineering groups, both locally and around Australia

It is capable of being integrated into many third-party historians, maintenance and operational software

Its distributed architecture, online configuration features, and remote client options lend itself well to be efficiently expanded to cover all the Hay Shire Council assets and operation centres.

A typical SCADA system will have two servers in a Duty-Standby type arrangement. These are often be geographically separated to allow for local system failures (for example a local power outage). In the event of losing one SCADA server, the other can take control and keep the network operational.

Depending on the configuration of the new RTUs and the amount of information that is polled the current SCADA Licence point count may need to be upgraded.

It is recommended to utilise the existing SCADA servers at the following locations:

- Hay WTP (Duty)
- Hay STP (Standby)

It is recommended at the time of the project installation that the existing SCADA software is upgraded to the latest version of the software and that the latest windows updates are implemented.

Where possible the server should be mounted with existing IT equipment so that it can benefit from any existing UPS systems, corporate WAN on fibre, mobile 3G connection, air-conditioning and firewall.

The SCADA servers will require a solid network link such as the existing ICT WAN connection between both SCADA servers. Sometimes other corporate services and traffic may be shared on this link, so it is important to dedicate sufficient bandwidth for this operational link.

A link of 2 Mbps with 50ms latency is the minimum recommended by Schneider-Electric (full recommendation of 100Mbps, 1ms latency). Ideally a second link should be created specifically for the SCADA network to ensure a reliable connection. The Hay WTP and WWTP currently has a connection to the NBN to synchronise the servers.

Each server will have to be connected to the radio network and will each require a radio and antenna or 3G modem to be installed.

SCADA screens should be developed to effectively manage the water and wastewater control and monitoring systems. Site names should be unique and contain postal addresses or directions.

6.2 VM Configurations

SCADA servers are commonly installed in virtual environments with the help of IT departments.

The main advantage of this installation method is not necessarily to efficiently manage IT resources, but specifically for rapid disaster recovery situations, like restoring a server machine from a backup.

6.3 Clients and Locations

Client terminals should be located at the workstations of operators who are responsible for controlling setpoints, responding to the alarms, or optimising components from all or part of that SCADA system.

It is recommended that the SCADA servers and clients are kept separate from the Council's IT network, as the Council's IT network will connect to the internet and so poses a security risk to SCADA system. To access the SCADA servers or clients from corporate PCs or from remote devices (devices outside of the SCADA network), it is recommended to install a firewall, Citrix or equivalent remote access software.

Access from remote devices is becoming common for operators, particularly for operators that are required to travel between sites. Operators use tablets, phones, iPads etc that have an internet connection that connect to the SCADA network through a firewall and Citrix. This means the operators can access the SCADA network from locations other than the main terminals even though the SCADA network is 'isolated' from the internet.

By designing the SCADA graphics to be zoom-able with large icons and menu structures the SCADA can be deployed to mobile devices without additional mimic engineering. It is recommended that the standard screens are implemented and that "Fat finger friendly" icons are implemented.

6.4 SCADA Reporting

6.4.1 Alarms & SMS Messaging

Alarm phrases need to be clear and unambiguous. This allows for prompt, accurate and safe operator responses. Alarms in SCADA should be related to the location and the process of the equipment that is in fault or warning. If the SCADA is designed wisely the alarm phrase will match the SCADA database structure. It should also include asset numbering or P&ID labels and an accurate description of its state.

To provide user friendly management of alarm banners and lists, alarms in SCADA are to be categorised. Any number of alarm priorities can be defined. However, the following set alarm priority groups are commonly used:

- Critical
- High
- Medium
- Low

Critical priority is given to alarms that require immediate attention and are always sorted to the top of alarm lists. Council operations staff will be aware of the kind of failures and warnings that require this kind of response. Examples include pumping station failures, overflows, Critical Control Point (CCP) warnings, water quality instruments, security events, critical communications failures, etc.

This alarm class is mostly used to categorise "callout" alarms. SMS alarming is common way to notice remote or after-hours staff. When a "Critical" alarm is not acknowledged by an operator after a given delay it will be "dialled-out" to a secondary contact number or number. The SCADA system can be the manager of phone numbers, SMS messaging, and rosters.

The remaining alarm priorities High, Medium, and Low are used to group alarms in order of criticality. The priority groups should match way that operations prioritise their responses to alarms and breakdowns.

6.4.2 SCADA Generated Reports

SCADA generated reports are created to run automatically and are customisable to the requirements of the specific user. Reports generated by SCADA can be an invaluable resource that can provide specific and/or holistic analysis of the telemetry system. Reports give accurate and swift feedback for pro-active activities like maintenance.

Example SCADA report types can include:

- Pump Starts Summary
- Runtime Hours Summary
- High-priority (callout) alarm list
- Energy usage
- Flow Totals
- Average Reservoir Levels
- Radio network diagnostics
- Maintenance scheduling

Reports would be automatically generated weekly, monthly, annually, but also allow for a custom time period. The reports would be automatically emailed by the SCADA system to appropriate personnel. Formats of reports should be chosen based on their application (PDF, TEXT or EXCEL).

If there are specific reporting requirements (e.g. Spreadsheets that are sent to other authorities), design a report to that exact format, generate and email it when it is required to be lodged (e.g. monthly: 1 Jun to 31 Jun, etc.).

6.5 DNP3 Communications

As a water and wastewater industry standard, DNP3 communications is an open protocol that is designed for distributed communications networks. This is due to its low overhead structure that is ideal for lower speed networks such as radio and 3G, when compared to Ethernet. The key aspects of DNP3 are:

- Time stamped data
- Buffered event data
- Solicited and unsolicited data reporting
- Efficient DNP3 protocol
- Encrypted protocol
- Open protocol supported by numerous vendors
- Seamless integrate into ClearSCADA
- SCADAPack and Brodersen remote configuration and downloads

7 Remote Telemetry Units

7.1 RTU Upgrade Options

It is recommended to replace the Radtel RTU equipment with programmable DNP3 capable RTUs with an associated external radio and integrate the upgraded sites into the current ClearSCADA system. No additional sites were identified as requiring telemetry to be installed.

This system provides the control options and features associated with modern SCADA system. It can support any DNP3 capable RTU and radio outstation.

The outstation will be controlled by the local RTU and have the capability to act independently of the central SCADA system.

Site specific and complex control is available and offers IEC 61131-3 programming languages.

This is recommended for Hay to provide the area a scalable, future proof, reliable and secure SCADA telemetry system. Using DNP3 will reduce the risk of losing data as all the outstations will be capable of buffering DNP3 time stamped data. The network traffic of the RTUs will also be greatly reduced due to the structure of the DNP3 driver.

7.2 RTU Products

The following lists a selection of modern DNP3 capable RTUs used within the water industry that would suit HSC's requirements:

1. Schneider-Electric SCADAPack x70
2. Brodersen RTU32M
3. Siemens S7-1200

For each RTU, the specific number of digital and analogue inputs and outputs varies, where this can be either built-in to the RTU or via expansion or modular options.

The following features are considered necessary for an RTU:

- DNP3
- I/O capabilities
- Expandable I/O
- Ethernet ports
- DNP3 Master function
- Programmable
- Software & languages with IEC 61131-3 programming
- Separate radio
- Warranty
- Low power
- Buffering of events during communication failures.

SCADAPacks, Brodersen RTU32M and Siemens S7-1200 offer all these features.

The following features are only supported by the SCADAPack 570 and Brodersen RTU32M:

- IP Routing
- Remote SCADA downloads

- Multiple CPU cores to run independent programs on the same RTU

In addition:

- The Schneider SCADAPack allows IP routing by easily configuring tables in the RTU configuration (an external program must be run on the Brodersen RTU). The SCADAPack x70 RTU configuration is easily modified through Excel sheets, allows quick and maintainable configurations for the RTUs. It also uses a development environment which allows almost all changes to be done online, allowing easy maintenance and avoiding downtime of equipment.
- The Brodersen RTU32M offers the best I/O flexibility, with I/O cards that can be added as required. It supports setup of VPNs to the RTUs for extra security. It also supports up to 4 independent programs running simultaneously on one CPU.

  For communication with the Bingara WTP and Northern Star WTP, this RTU has native support for the Ethernet/IP driver.
- The Siemens S7-1200 only buffers 125 events during a communication failure, while the others have event buffers of 2500+.

7.3 Comparison of DNP3 RTUs

Below is a table that compares different DNP3 RTUs on the market.

RTU Feature	SCADAPack 575	Brodersen RTU32M	Siemens S7-1200
DNP3	✓	✓	✓
I/O Capabilities	18DI, 8 relay outputs, 6 AI, 2 AO	20DI, 8 relay out, 8 AI, 2 AO	14 DI, 10 DO, 6 AI, 2 AO
Expandable I/O	✓	✓	✓
Ethernet Ports	✓	✓	✓
DNP3 Master Function	✓	✓	✓
Programmable	✓	✓	✓
Software Language with IEC 61131-3	Remote Connect	WorkSuite	TIA Portal
Separate Radio	✓	✓	✓
Price	$6700*	$4800 (including I/O modules equivalent to SCADAPack 575)	$2500 (including I/O modules equivalent to SCADAPack 575)
Other Protocols	Modbus, DF1	Modbus, Profinet, Profibus, DF1, Ethernet/IP	Profinet, Profibus, Modbus
Serial Ports	✓	✗	✓
Remote SCADA configured downloads	✓	✓	✗

Table 7-1: Comparison of DNP3 RTUs

*Schneider now have a new SCADAPack 400 series RTU that is a cheaper option to the 500 series RTU.

SCADAPack, Brodersen and Siemens RTUs fulfil Hay Shire Council requirements of DNP3 capable, programmable and can function as a DNP3 Master.

SCADAPack, and Brodersen RTUs are commonly used by nearby utilities, and are well supported by most integrators.

SCADAPack and Brodersen RTUs pair well with ClearSCADA and can be configured remotely from the SCADA, and the site program can be downloaded from SCADA.

For a small-scale installation such as Hay the Siemens RTU will be more than adequate.

7.4 Logic in RTUs

In the event of a communications network or SCADA failure, it becomes important that the RTU can independently control a site. An RTU that has internal control logic loaded can continue to operate the site during a communications or SCADA failure.

The ability for an RTU to be programmable provides the Council with many opportunities to create site specific control that can meet process, mechanical or electrical requirements.

For example, specific logic in RTUs can allow the local control of:

- Tariff control of the pump station
- Peer communications to the corresponding reservoir
- Local pressure control
- Duty / standby control of the pumps
- Pump protection (Current, flow)
- Totalised data recording of flow meters
- Recording of “pump run hours” and “number of starts”
- Communications to devices via Modbus (i.e. Power meters, flowmeters, analytical instruments)
- Intelligent selection of redundant instruments (i.e. level sensors)
- No reliance on the SCADA to operate

7.5 Development of Standard Code

Standard code should be developed to ensure identical assets have the same controls, interfaces, communications, SCADA screens and alarms. This make the system easier to understand and repair for operators and maintenance crew and also allows external contractors to expand the system in a consistent way. These leads to a higher quality yet lower cost overall system.

The following standard code and configurations would be typical for the Hay Council water asset sites:

- Flowmeter
- Sewerage Pump Station (SPS)
- Water Pump Station (WPS)
- Reservoir

The standard software would generally be developed to allow the various options to be combined as required with little engineering effort. For example, a site may contain a water pump station as well as a flow meter and reservoir – this site can use the standard code and configurations for the individual water pump station, reservoir and flowmeter templates.

8 Disaster Recovery

8.1 Documentation and Drawings

For future documentation, consistent naming of assets and equipment will aid with asset identification and naming, database records, accuracy in billing, reliable and safe emergency responses, etc.

8.2 Spares

Spare equipment including RTU, radio, antenna, fuses, electrical components, batteries, should be stored and readily available at depot or maintenance locations. For smart devices these can be pre-programmed or configured.

Quick and ready access to critical spares is important to provide a high level of availability to the system in the event of disaster or equipment failure.

8.3 Software Backups

In a disaster recovery or equipment failure scenario the specific software program or configuration will be required. It is recommended to maintain up to date copies of all device software and configurations. This includes:

- SCADA configurations & backups
- Radio configurations
- PLC code
- VSD configurations
- RTU programs & configurations

Note that an advantage of combining the SCADAPack and Brodersen RTUs with ClearSCADA is that a site RTU program & configuration is backed up within the SCADA database. This allows for it to be downloaded across the radio network from the SCADA to a new RTU unit.

8.4 Server Configuration

SCADA servers are commonly installed in virtual environments, to allow efficient management of IT resources however, another benefit is realised during disaster recovery situations, such as server hardware failure. This is because virtual machines can be restored far more quickly from server backups than reinstalling complete operating systems and associated software packages, etc.

All ClearSCADA configurations and changes can be conducted from the same client terminals that operators use to monitor setpoints and alarms. It is also useful to also allow remote access to SCADA clients from external users such as your preferred Telemetry Engineering Support companies. Since it is remote access, the preferred company could be either local or national.

8.5 Training & External Support

To provide familiarity on the features, controls and operation of the software and systems being installed or deployed it is important that a component of staff training be included in telemetry upgrades. This will ensure that staff will have the ability to recover from disaster situations, or at least be aware of what needs to be done in these events.

Telemetry support contracts are commonplace and can be drawn upon when additional technical help is needed.

8.6 Backup Power

Consideration of different autonomy times can occur at typical sites such as those that would require generators and their associated peer messaging site, solar sites (see below) and sites that have unusual response times (difficult to access sites or remote sites with large travel times), critical sites with river/dam levels, licence points or Critical Control Points (CCPs).

Depending on the chosen physical location, it may be a dedicated UPS unit or additional capacity added to the load of a larger existing IT infrastructure UPS, for example in an IT server room. In either case the UPS should be rack or floor mounted with an option for battery capacity expansion. Note that this may require an amount of panel RU space.

The UPS backup or autonomy time should be chosen based on the desired network visibility during a power outage in the server's district (e.g. Council chambers). A backup time of 4 hours is typical of most server racks however this can be reliant on the quality of the regions power supply infrastructure.

Also, the SCADA client machines will require a UPS which is typically considered when specifying the computer hardware. The same autonomy time used for servers should be used for critical control clients, except that clients are not usually located in server rooms, but at operator desks or treatment plants, with monitors, on separate UPS systems.

8.6.1 Repeaters Backup Power

For each of the radio base repeaters backup power will need to be operational for up to an equivalent amount of time, typically up to 4-6 hours. This amount of time allows peer messaging between outstations to continue and general network monitoring during partial geographic power outages. Backup power can again be achieved with sealed lead-acid batteries. The electrical loads will be largely dependent upon the rate of radio transmits; therefore a busy network will use more energy. When site power is lost, the batteries allow the repeater station to operate autonomously by providing ample energy to supply the base radio/s, link radio & RTU (if used), and its instrumentation.

8.6.2 Outstations Backup Power

Each outstation will require battery backup. Hay should choose an autonomy time at least longer than a regular power outage. The battery will allow the site to continue to monitor instrumentation such as levels, overflows, water quality meters, flow meters and communications status including the sending of peer messaging (for pumping).

Where sites are more critical than others and need to operate for longer, a consistent battery setup should be employed. Choose a common and locally available battery type, so that batteries can be replaced easily and promptly by any technician. Only the number of batteries will change from site to site. Particular consideration would be given to sites with unusual response times and sites with critical monitoring points.

The system will typically consist of one or more small-sized (7.6-14Ah) sealed lead-acid (SLA) batteries that are capable of operating the site for a period of at least 4 hours. Note that when RTUs that are capable of buffering data are used, the network will benefit from this feature, as when the network power is restored it will recover all data collected and stored at the outstations. When site power is lost, the batteries allow the outstation to operate autonomously by providing power to supply the RTU, radio (or modem), and its instrumentation.

8.6.3 SCADA Servers and Clients

SCADA servers also require secondary power. Uninterruptable Power Supplies (UPS) are most appropriate for this task. A UPS will need to be included in the hardware requirements for a SCADA server, and meet roughly the same autonomous time as the rest of the network, typically up to 4 hours. SCADA server autonomy is the time of network visibility from the beginning of a power outage.

SCADA servers are often installed in server rooms or server racks alongside active IT infrastructure, so frequently an existing server room UPS will cover these requirements but will require an assessment and potential increase of battery capacity. When primary power is lost, the UPS allows the SCADA server to operate autonomously by providing ample energy to supply the server machine (sometime in a virtual environment), IT switches, RTU, radio, modems and VPN connections.

SCADA client machines, usually desktop PCs will also require UPSs. These machines could be supplied by an existing IT UPS if it is available, however are usually supplied by smaller sized stand-alone UPS units. They are needed for network visibility and should match the SCADA server autonomy time. When power is lost, the UPS allows the SCADA client to operate autonomously by providing ample energy to supply the PC (includes monitor), IT switches and modems.

This is to be considered when specifying the new server hardware.

8.6.4 Solar Powered Sites

Batteries are also used at solar powered sites, which are installed using an inverter system operating in parallel with the PV cells. This system combined with the mains power forms the primary source of power.

The battery selection and autonomy time considerations are different for solar sites where battery types are often chosen under different specifications as the charging cycles are more regular and they form part of the primary power onsite.

Best practice is to develop and deploy a standard solar sizing formula for Council technicians and contractors.

9 Other Opportunities

9.1 Battery Powered 3G RTUs

Some remote assets could be considered as basic and present an opportunity to use a smaller specialised type of RTU. Sites where this could apply typically do not require control and may not require the full functionally of an RTU. They may also have a small number of I/O to monitor (e.g. rain gauge, weather station, single level, chlorine, or flow) and may not have site power available or warrant a normal telemetry enclosure.

Battery powered RTUs that use DNP3 protocol over 3G communications can be a viable solution in these cases. These do not require the same amount of electrical equipment and installation, are less expensive to install when compared to a typical RTU panel and can be used outside of the radio network coverage.

While there are several low-powered 3G RTUs available on the market with DNP3 capability, proven examples include:

Halytech MicroSpider 2

Metasphere Point Orange

37 South Site Sentinel

These devices briefly “wake-up” at set intervals and are DNP3 capable, battery powered, and use mobile 3G networks would be fit for purpose for most monitoring only sites. The units have high ingress protection (IP) ratings and expected battery life of up to 5+ years. They can potentially be installed without a panel in remote locations that do not have available power. The units often have serial MODBUS interface to allow connection to equipment with communications capability.

The limitations of these less powerful RTUs are:

No site control (monitoring only)

Low I/O capacity (Typically only 1 analogue input, up to 4 digital inputs, MODBUS port)

Wakes up to transmit (i.e. not continuously online)

Knowing these advantages and limitations, Council can assess where these types of devices will add value. They are ideal for many situations, with examples including flow meters and pressure monitoring on pipelines, river/dam levels, standalone reservoir levels, rain gauges or weather stations, monitoring basic SPSs, and Automatic Meter Reading (AMR).

Figure 9-1: 3G RTU Examples: MicroSpider 2, Point Orange, and Site Sentinel

ClearSCADA has drivers which allow communication with these devices via a Council APN, as with any other RTU, creating a hybrid network of radio and mobile data communications.

Using this type of RTU enables SCADA monitoring of simple sites without the high upfront installation and infrastructure costs.

9.2 Business Interface

At the corporate level, ClearSCADA can integrate with Business Intelligence systems using open industry standard interfaces such as OPC, ODBC, .NET.

Critical infrastructure systems including GIS and ERP, can share data with ClearSCADA using open SQL, ODBC, OLE-DB, and OPC standards.

ClearSCADA can be combined with water modelling software such as AQUIS for hydraulic modelling, flow and pressure simulations, leak detection, scenarios and planning, and process optimisations.

9.3 Internet of Things

The Internet of Things (IOT) is a concept where small and relatively low-price network capable devices are installed throughout a distributed network. This technology is becoming more prevalent for applications such as flow and pressure monitoring, and revenue metering. Examples of these systems are the Taggle and Sigfox systems.

Systems such as that these are typically cloud based and provide data to the user at pre-defined intervals. A modern SCADA system such as ClearSCADA can use and incorporate data from these systems for use by operations and other users of the SCADA and Telemetry system. Based on HSC’s current assets the use of IOT devices would not be economical for Council.

10 Upgrade Methodology

10.1 Upgrade Drivers

There are several upgrade drivers that are applicable to all HSC assets. These include:

- Improved operator accessibility
- Secure operation of the system
- Improved data collection, analysis, reporting and archiving
- Improved redundancy of telemetry and SCADA systems
- Integration of SCADA with water and wastewater hydraulic models
- Improved safety by compliance with latest Australian Standards and Regulations
- Standardisation of design
- Improved reliability of the communications network
- Improved alarm monitoring and control through SCADA
- Improved power monitoring
- Industry standards and best practice
- Operational cost and maintenance cost reduction
- Intelligent device and instrumentation data available to SCADA

10.2 Specifications and Systems

Prior to the design of the system the development of standard specifications should be a priority. Standardisation provides a consistent design across the region. This ensures technology compatibility, increased operator awareness and safety, consistent troubleshooting approach, and increased availability of spares while reducing the number of spare components in storage.

Standard specifications will also assist in the rollout, upgrade and maintenance of the sites so that they are completed consistently whilst providing a common platform for future modifications to the system.

In addition, the standard specifications for installation of electrical systems and a preferred equipment list, includes the following Telemetry, and SCADA standard specifications which are typical of a system of this size and capacity.

SCADA Programming and architecture

- details the SCADA system architecture
- server and client configuration and database structure
- navigation
- graphics
- alarming
- reporting
- trending and history
- system interfaces
- templates
- outstations

- security

PLC programming

- details the minimum PLC programming requirements
- PLC languages
- communications configuration
- tag and variable naming
- code structure
- function blocks

RTU programming and configuration

- details the minimum RTU configuration
- logic configuration
- communications interfaces and configuration
- tag and variable naming
- code structure
- DNP settings

Radio and networking

- Radio configuration
- Ethernet device configuration

10.3 Standard Designs

The remote monitoring RTU sites, telemetry design and software design within the HSC area will be upgraded to a uniform standard, according to a common design. While each site is unique and has its own specific requirements, the components can be standardised. Each site can then be designed by compiling the required components from the standard design set.

The information collected from each site, and the system standards are used to create standard designs for the remote telemetry site types.

Typical standard designs would be:

- WPS
- SPS
- Reservoir

Each standard design would generally include electrical design, telemetry and RTU design, SCADA template and RTU or PLC logic function blocks and logic.

The design of the standard components and software can be developed as they are required by the upgrade timing for the assets. It is not necessary to complete the design for a component until it is required by the upgrade program. As each electrical component is designed, it can be rolled out for future use, thus saving engineering time and cost.

10.4 SCADA

The SCADA server architecture will be upgraded to provide redundancy with servers being located in separate locations. This requires some coordination with ICT services to provide the corporate network connection between the sites, however this can be done with firewalls at each site.

10.5 Software Library Development

Additional engineering cost savings can be made by implementing PLC, RTU and SCADA software programming standards across all HSC assets. Each site can use the common library of software components and logic blocks.

A library of PLC, SCADA, radio and other configuration files can be used for future works and as reference for the modifications.

10.6 Radio Network

To achieve the higher availability radio network, the new radio sites and modification to the existing radio sites (where required) can be undertaken. This can be performed as a separate project independent to the outstation upgrades.

10.7 Upgrading Similar Assets or Areas

By upgrading similar sites at the same time, further savings may be recognised. Multiple sites of similar design may be constructed simultaneously by the same manufacturer. Savings may be made through consolidation of construction contracts to the same manufacturers. Boards can be factory tested and site commissioned at similar times, thus reducing mobilisation costs and time frames.

10.8 Utilisation of Existing Assets

A large portion of cost savings in the upgrade process can come from utilising existing materials and the selection of the correct materials. For these two points the upgrade should look at using mild steel panels at sites that are inside a building structure and are not exposed to external weather conditions. It is recommended that the panels are no smaller than 600x600 and are in good condition.

10.9 Field Works

As electrical switchboards and telemetry equipment is upgraded, consideration should be given to the renewal of the field installation at the same time. During the audit, some sites were found to have deficiencies in the field installation, such as perishing cables, exposed electrical connections, inadequate cable supports and protection, old instrumentation and field devices. This report does not detail the extent of these issues, however if required this detail auditing could be undertaken from the photo information recorded within this audit.

10.10Disaster Recovery

While sites are undergoing upgrade or modifications the backup power or redundancy features can be installed.

For example:

- hot standby radio hardware at designated repeaters in conjunction with adding UPS
- generator connections for critical site

11 Upgrade Strategy

Based on the results of the site audit and system requirements and recommendations described in the previous sections, a Telemetry system upgrade strategy has been developed.

11.1 Upgrade Strategy

As part of the upgrade process the following activities are required.

- Finalise the network architecture design
- Develop system requirements and standard specifications
- Server and network modifications
- Site specific design
- Site installation and commissioning

In performing the above tasks an assessment should be conducted with HSC to identify critical sites that may require priority, I/O requirements for sites, peer to peer links and new telemetry or monitoring sites.

The following tables list the upgrade phases and tasks, in the recommended upgrade order.

Upgrade Strategy	Specific Upgrade Drivers	Design Components
▪ Finalise system network architecture ▪ Design radio and communications networks	▪ Provide a high availability radio network ▪ Provide redundancy and disaster recovery for SCADA and network equipment	▪ Application of new repeater site ▪ Field radio survey of proposed sites (if required) ▪ Confirm location of radio repeaters ▪ Confirm server and client locations and access ▪ Corporate ICT interface and inputs ▪ Rollout methodology (i.e. in parallel with existing)

Table 11-1: Upgrade Strategy – Finalise Network architecture Design

Upgrade Strategy	Specific Upgrade Drivers	Design Components
▪ Develop standard specifications	▪ Provide standard system and design for basis of upgraded system	▪ Review site audit findings ▪ Selection of preferred hardware ▪ Confirm minimum requirement for network, SCADA, RTU, DNP3, performance, operation ▪ Implementation of monitoring only sites, battery sites, peer to peer sites ▪ Develop standard documents

Table 11-2: Upgrade Strategy – Standard Specifications

Upgrade Strategy	Specific Upgrade Drivers	Design Components
▪ Server and Radio Network Rollout	▪ Provide a high availability radio network ▪ Provide redundancy and disaster recovery for SCADA and network equipment	▪ Upgrade the existing SCADA servers ▪ Configure and commission Corporate connection between servers ▪ Install and commission upgraded radio network

Table 11-3: Upgrade Strategy – Server and Radio Network Rollout

Upgrade Strategy	Specific Upgrade Drivers	Design Components
▪ Site Design	▪ Upgrade sites to new telemetry system	▪ Site detailed electrical and panel designs ▪ Develop site specific functional documents

Table 11-4: Upgrade Strategy – Site Specific Design

Upgrade Strategy	Specific Upgrade Drivers	Design Components
▪ Site Installation and Commissioning	▪ Upgrade sites to new telemetry system	▪ Development of standard SCADA, PLC and RTU templates and function blocks ▪ Software development for each site ▪ Factory Acceptance Testing of software and hardware ▪ Site installation of new telemetry equipment ▪ Site Commissioning ▪ Finalise as built documentation and conduct user training

Table 11-5: Upgrade Strategy – Site Installation and Commissioning

11.2 Timing Strategy

The site design can be developed in stages, according to the types of sites required at each stage. However, most of the design work will be required up front, with some variations developed later in the upgrade schedule, building upon the original design.

12 Cost Budget Estimate

By standardising common components of the telemetry design, the engineering cost of the upgrade can be reduced, while ensuring all sites software and hardware are implemented with the same high level of quality.

12.1 Radio Repeater Network

Network Topology Upgrade Option 1: No Repeater redundancy

Utilising the existing Hay Council repeater site location with no redundant communication hardware. If the repeater radio fails, the network fails all remote RTU data to SCADA and peer communications fails. A cold standby repeater could be added to the Council spares to improve availability of the system.

Costs include single base radios, duplexer, antenna and cables, UPS, radio and SCADA development, FAT and site commissioning.

Facility	Cost Estimate
Pine St Repeater	$25,800
Contingency (30% of Total Project Cost)	$5,200
Project Cost Estimate + Contingency (+30%)	**$31,000**

Table 12-1: Radio Network Cost Estimate

12.2 SCADA & Outstations

At all outstations, replace Radtel RTU equipment with programmable DNP3 capable RTUs, digital radio, and new GeoSCADA template screens. This system provides the control options and features associated with a modern SCADA system. This system can support any DNP3 capable RTU and radio outstation. A key feature is that outstation automation will be controlled at the outstation RTU and will act independently from the central SCADA. The RTU will offer site specific and complex control and offers standard IEC 61131-3 programming languages.

Costs include a new control panel, RTU, radio, antenna and cables, SCADA servers, SCADA licencing, SCADA development, RTU development, FAT, installation and site commissioning.

Cost savings can be made by using Siemens S7-1200 PLC with DNP3 card at the outstation sites.

The below pricing has been estimated using list pricing from the suppliers. At the time of tendering these prices will be reduced based on the level of discount offered by the suppliers.

It has been assumed that the existing SCADA system may require a licence point count upgrade as part of the project.

The pricing does not include a new panel at the following locations as it is already using modern DNP3 RTUs. For these locations, the price is only to integrate into GeoSCADA:

- Pine St booster pump

Pricing is for stainless steel panels that are suitable for outdoor and indoor installation. Cost savings could be made by using marine grade aluminium panels and mild steel for indoor installations.

Facility	Cost Estimate
1 Stephen St	$18,979
2 East Hay	$20,459
3 Murray St	$20,459
4 Hospital Well	$20,459
5 Leonard St	$20,459
6 Leonard St	$20,459
7 Queen St	$20,459
8 Pal Richards Park	$20,459
9 Depot	$20,459
10 WWTP	$20,159
11 Sandy Point	$20,459
12a Pine St RW Res	$14,309
12b Pine St Repeater	$25,800
12c Pine St CW Res	$7,600
12d Pine St RWPS	$7,600
13 Lang St	$20,459

14 Russell St	$20,459
15 Palmer St	$20,459
16 WTP	$20,159
PANEL SUB TOTALS	**$360,115**
Project management	$15,000
Project development	$20,000
Electrical drawings	$15,000
Drafting	$15,000
FDS	$5,000
Training	$5,000
Manuals	$5,000
Total Project Cost Estimate	**$440,115**
Contingency (20% of Total Project Cost)	$88,685
Project Cost Estimate + Contingency (+20%)	**$528,800**

Table 12-2: SCADA & Outstation Cost Estimate

Note: these estimates are only for the cost to upgrade the telemetry system and not to replace or rectify the existing MCC panels. The WTP MCC upgrade is also excluded from this pricing.

13 Appendix A: Full Site List – Site Audit Observations October 2020

Site Name	Type	Asset	GPS Latt	GPS Long	Comms Link	TX Freq	RX Freq	Antenna	Antenna Bearing (degrees)	4G (bars)	Pumps	Level TX	Flow TX	PLC	Radio	RTU	Battery	VSD / Control Unit	RTU in separate panel to MCC	Existing MCC Condition	Panel Year of Manufacture or Age (Yrs)	Replace MCC / Electrical Panel?	Needs new RTU cabinet?	Notes
1 Stephen St	SPS	Sewage	34°30'17.25"S	144°51'15.83"E	Pine St Res Repeater	452.4875	461.4875	whip	234	3_4	2				inbuilt to RTU	Radtel 3001	N/A	DOL	Separate	MCC Panel rusted on top and positioned too high to reach	30+	Yes	Yes	
2 East Hay	SPS	Sewage	34°30'20.19"S	144°51'22.18"E	Pine St Res Repeater	452.4875	461.4875	whip	220	3_4	2				GME TX3600	Radtel 5000	N/A	DOL	Combined	Poor internal wiring, 240VAC on door, some 415VAC terminals behind escutcheon not IP2X, External switchboard shell condition is okay	20+	Yes - could retrofit into existing	retrofit gear plate	new RTU gear plate wiring poor not supported in duct
3 Murray St	RWPS	Water	34°30'19.03"S	144°52'25.89"E	Pine St Res Repeater	452.4875	461.4875	YB6	112	2_3	2				inbuilt to RTU	Radtel 3001	12V 7Ah	WEG CFW701	Combined	Form 1 good condition	1987	No	retrofit gear plate	new RTU gear plate some comms issues
4 Hospital Well	SPS	Sewage	34°30'1.44"S	144°51'18.46"E	Pine St Res Repeater	452.4875	461.4875	YB6	142	3_4	2				GME TX3600	Radtel 5000	12V 7Ah	DOL	Separate	some 415VAC terminals behind escutcheon and on door not IP2X	30+	No	Yes	requires plastic covers over 415V terminals
5 Leonard St	RW Res	Water	34°30'22.90"S	144°50'54.72"E	Pine St Res Repeater	452.4875	461.4875	whip	210	4	2	1	1		GME TX3600	Radtel 5000	12V 7Ah	N/A	Separate	None	30+	None	Yes	Antenna to be raised need to control actuator, refer notes sketch
6 Leonard St	RWPS	Water	34°30'26.30"S	144°50'53.68"E	Pine St Res Repeater	452.4875	461.4875	YB6	220	3	2		1	Omron CPU12	GME TX3600	Radtel 5000	12V 7Ah	Auto Transformer	Separate	Form 3b, Installed 2004, good condition	2004	No	Yes	Chlorine Dosing at site could add Off-Peak Pumping
7 Queen St	SPS	Sewage	34°30'28.15"S	144°50'32.17"E	Pine St Res Repeater	452.4875	461.4875	YB6	180	4_5	2				GME TX3600	Radtel 5000	12V 7Ah	DOL	Separate	poor condition, exposed 415V terminals behind door not IP2X, wires cut off in panel and not terminated, switchboard used as a junction box to another MCC starter panel	30+	Yes	Yes	
8 Pal Richards Park	SPS	Sewage	34°30'18.57"S	144°49'48.34"E	Pine St Res Repeater	452.4875	461.4875	whip	130	2	N/A				inbuilt to RTU	Radtel 3001	12V 7Ah	DOL	Separate	some 415VAC terminals behind escutcheon not IP2X	10+	No	Yes	
9 Depot	SPS	Sewage	34°29'52.67"S	144°50'3.73"E	Pine St Res Repeater	452.4875	461.4875	YB6	180	3	2				GME TX3600	Radtel 5000	12V 7Ah	Star/Delta	Separate	Poor internal wiring, 240VAC on door, some 415VAC terminals behind escutcheon not IP2X, not a form-built board, panel mounted too high for easy access	20+	Yes	Yes	
10 WWTP	WWTP	Sewage	34°29'31.96"S	144°49'26.85"E	Pine St Res Repeater	452.4875	461.4875	YB6	126	2	N/A			Omron SYSMAC CJ2M CPU33	GME	Broderson RTU32S	12V 7Ah		Separate	Good condition	2019	No	No	
11 Sandy Point	SPS	Sewage	34°30'54.44"S	144°50'6.39"E	Pine St Res Repeater	452.4875	461.4875	omni	340	2	2				inbuilt to RTU	Radtel 3001	none	DOL	Separate	Poor internal wiring, 240VAC on door, some 415VAC terminals not IP2X, capacitors joined with BP connectors and hanging on wiring	10	Yes	Yes	

Site Name	Type	Asset	GPS Latt	GPS Long	Comms Link	TX Freq	RX Freq	Antenna	Antenna Bearing (degrees)	4G (bars)	Pumps	Level TX	Flow TX	PLC	Radio	RTU	Battery	VSD / Control Unit	RTU in separate panel to MCC	Existing MCC Condition	Panel Year of Manufacture or Age (Yrs)	Replace MCC / Electrical Panel?	Needs new RTU cabinet?	Notes
12a Pine St	RW Res	Water	34°30'46.11"S	144°50'23.42"E		N/A	N/A	N/A	N/A	3	N/A	1	1		N/A	None	none	N/A	None	None - Instrument panel only	20+	None	None	Panel located at ground level of RW Res with 2 Pressure Sw and 1 Level Tx, I/O is connected to CW Res Radio cabinet terminal strip then into CW Res RTU Panel
12b Pine St	Repeater on CW Res	Repeater	34°30'46.97"S	144°50'23.12"E	Pine St Res Repeater	461.4875	452.4875	omni	0	3	N/A				GME	None	12V 7Ah	N/A	None	None		None	Yes - new Radio Rptr panel required	Radio panel located at ground level of CW Res to remain as a junction box for RW signals
12c Pine St	CW Res	Water	34°30'46.97"S	144°50'23.12"E	Pine St Res Repeater	452.4875	461.4875	whip	0		N/A	1	1		inbuilt to RTU	Miri AD2006	12V 7Ah	N/A	Separate	No MCC RTU panel has power supply lose in bottom of panel and wiring BP connected together	20+	None	Yes	CW Res has 4 panels located at ground level: 1. RTU 2. 2*Flowmeters and coax filter 3. Radio Repeater and terminals 4. 2*Pressure Switches and Level Tx
12d Pine St	RWPS	Water	34°30'46.79"S	144°50'24.07"E	Pine St Res Repeater	452.4875	461.4875	dummy load	0	3	1				GME	Broderson RTU32S	12V 7Ah	Xylem Hydrovar	Separate	None	5	None	No	RWPS RTU panel located in small shed. remove RWPS RTU - trench and install cabling to CWRes for RWPS IO
13 Lang St	RW Res	Water	34°31'1.72"S	144°50'59.32"E	Pine St Res Repeater	452.4875	461.4875	whip	215	2	N/A				inbuilt to RTU	Radtel 3001		N/A	Separate	Meter Box only	20+	None	Yes	RTU mounted at top of res relocate RTU to ground antenna survey reqd?
14 Russell St	SPS	Sewage	34°31'7.12"S	144°51'12.28"E	Pine St Res Repeater	452.4875	461.4875	whip	286	2	2				inbuilt to RTU	Radtel 3001	none	Star/Delta	Combined	outdated no form type, individual PVC enclosures with incoming mains and individual pump starter modules, pit directly in front of switchboard access causing a trip/fall hazard whilst accessing switchboard	1977	Yes	Yes	heat issues
15 Palmer St	SPS	Sewage	34°31'6.18"S	144°50'28.04"E	Pine St Res Repeater	452.4875	461.4875	YB6	313	2	2				inbuilt to RTU	Radtel 3001	none	Star/Delta	Combined	outdated no form type, individual PVC enclosures with incoming mains and individual pump starter modules concrete foundations failing	1977	Yes	Yes	need to consider heat issues foundation issues raise antenna
16 WTP	WTP	Water	34°30'20.04"S	144°51'8.79"E	Pine St Res Repeater	452.4875	461.4875	YB6							GME TX3600	Radtel 5000	12V 7Ah	DOL Star/Delta	Separate	average condition, Form 2, terminals and equipment not IP2X, obsolete equipment in panel and in doors, wiring messy and hanging not supported within ducts, no room for expansion for	1988	Yes	Yes	

Site Name	Type	Asset	GPS Latt	GPS Long	Comms Link	TX Freq	RX Freq	Antenna	Antenna Bearing (degrees)	4G (bars)	Pumps	Level TX	Flow TX	PLC	Radio	RTU	Battery	VSD / Control Unit	RTU in separate panel to MCC	Existing MCC Condition	Panel Year of Manufacture or Age (Yrs)	Replace MCC / Electrical Panel?	Needs new RTU cabinet?	Notes
																				additional equipment, Switchroom not to standards in respect to open panel door space and points of exit for personal				

14 Appendix B: ACMA references

Point to Multipoint Definition

A point to multipoint station is defined in the Radio communications (Interpretation) Determination 2015 as a station that:

- is operated under a fixed licence; and
- is operated principally for communication with more than 1 other fixed station; and
- is operated on frequencies specified in the transmitter licence that relates to the station.

A fixed licence authorising a point to multipoint station is used to license radio communications systems that:

- transmit from a point to multiple points; or
- transmit from multiple points to a point; or
- comprise a combination of the above.

The point to multipoint licensing option authorises communications between a station located at a known fixed point (the 'base' station) and more than one other station ('remote' stations) within an area specified on the licence.

Point to Multipoint System

A point to multipoint system option provides for multiple point to multipoint stations to operate under one spectrum access. The term 'point to multipoint system' is defined in the Radio communications (Transmitter Licence Tax) Determination 2015 as:

'a fixed licence authorising the licensee to operate an unlimited number of point to multipoint stations located anywhere within the areas specified in the licence; and

Where a spectrum access exists for each authorisation of the operation of a group of point to multipoint stations that involves a unique combination of:

- a particular transmit frequency; and
- a particular bandwidth; and

A particular geographical area (a circle with a radius of a specified number of kilometres from a specified site).'

A spectrum access exists for each authorisation of the operation of a group of point to multipoint stations that involves a unique combination of:

1. a particular transmit frequency; and
2. a particular bandwidth; and
3. a particular geographical area (a circle with a radius of a specified number of kilometres from a specified site).'

A point to multipoint system is a network of point to multipoint stations operating within a specified coverage area. This coverage area is specified as being within a certain distance of a point that is centrally located and is specified on the licence. The point specified on the licence is not necessarily the location of a station, rather it is the nominal centre point of the coverage area and is used to establish the coverage area.

In a point to multipoint system, individual base stations are authorised to communicate with associated remote stations, supplementary base stations and remote-control stations in a manner similar to the fixed point to multipoint licensing option.

All stations operating within a point to multipoint system, in an area specified on the licence, must operate on the same frequency or frequency pairs. Operation under a point to multipoint system is authorised on the basis that harmful interference must not be caused to other radio communications services and on the understanding that interference protection is not afforded.

15 Appendix C: SCADA Displays Water and Sewage

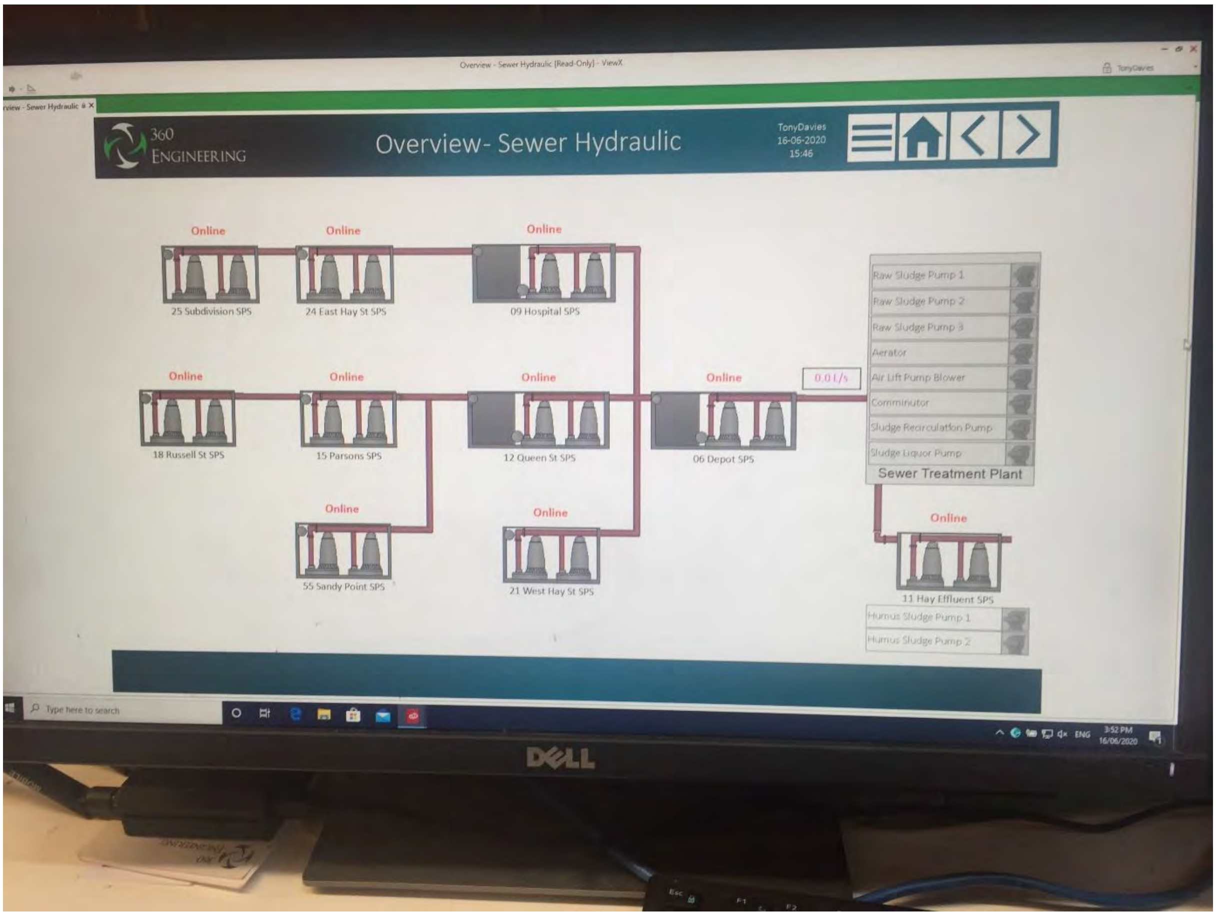
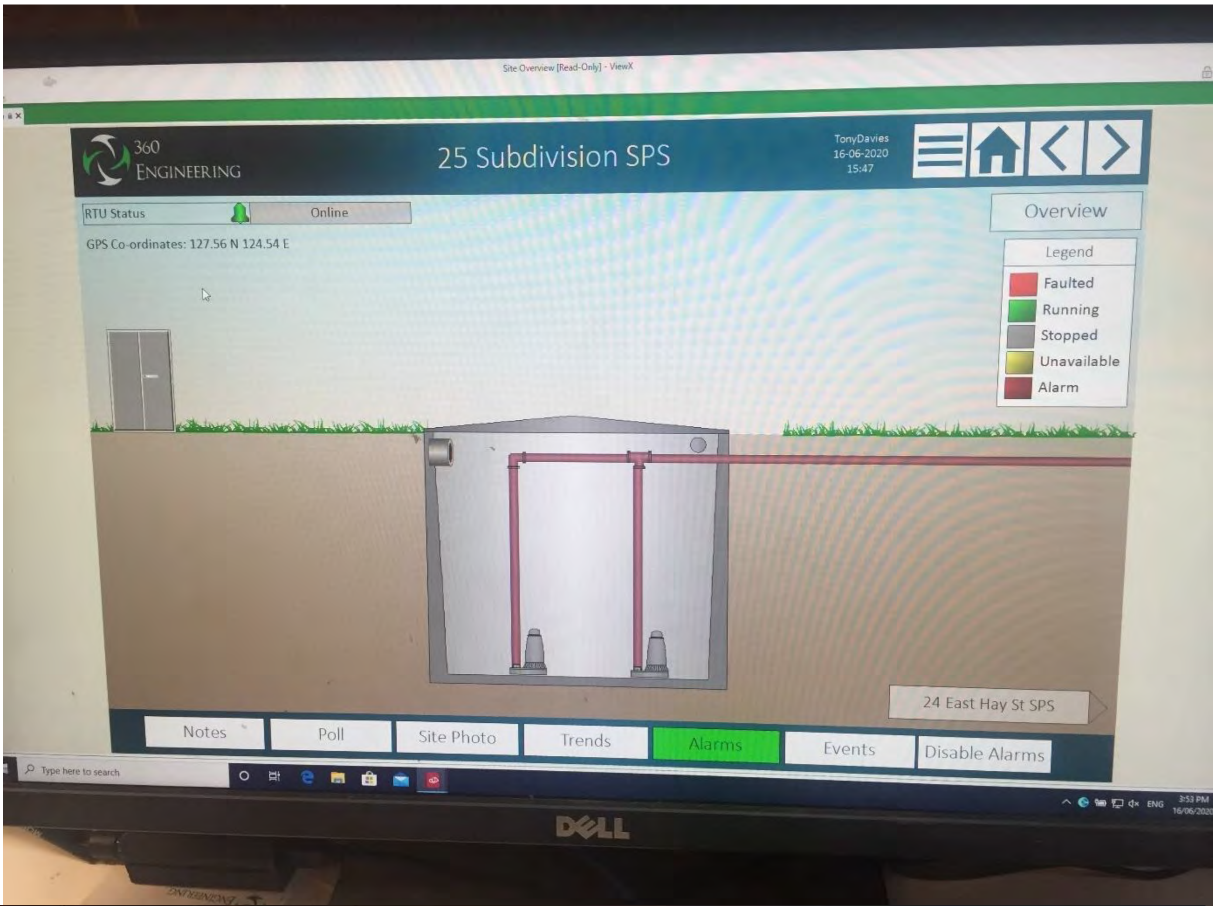
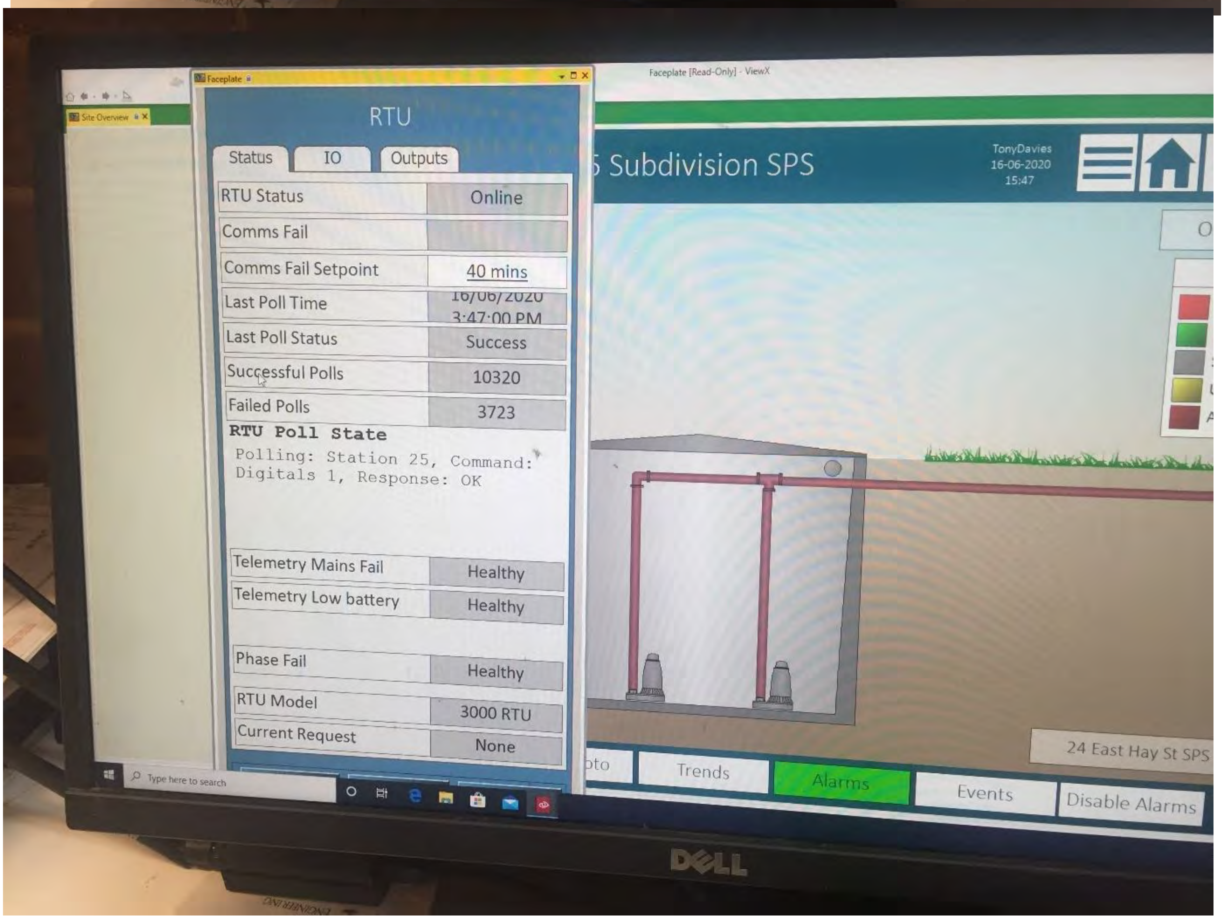


Figure 15-1: SPS Hydraulic Overview


25 Subdivision SPS
360 ENGINEERING
TonyDavies
16-06-2020
15:47
RTU Status
Online
GPS Co-ordinates: 127.56 N 124.54 E
Overview
Legend
Faulted
Running
Stopped
Unavailable
Alarm
24 East Hay St SPS
Notes
Poll
Site Photo
Trends
Alarms
Events
Disable Alarms


RTU
Status
IO
Outputs
RTU Status
Online
Comms Fail
Comms Fail Setpoint
40 mins
Last Poll Time
16/06/2020
3:47:00 PM
Last Poll Status
Success
Successful Polls
10320
Failed Polls
3723
RTU Poll State
Polling: Station 25, Command: Digitals 1, Response: OK
Telemetry Mains Fail
Healthy
Telemetry Low battery
Healthy
Phase Fail
Healthy
RTU Model
3000 RTU
Current Request
None
TonyDavies
16-06-2020
15:47
24 East Hay St SPS
Trends
Alarms
Events
Disable Alarms

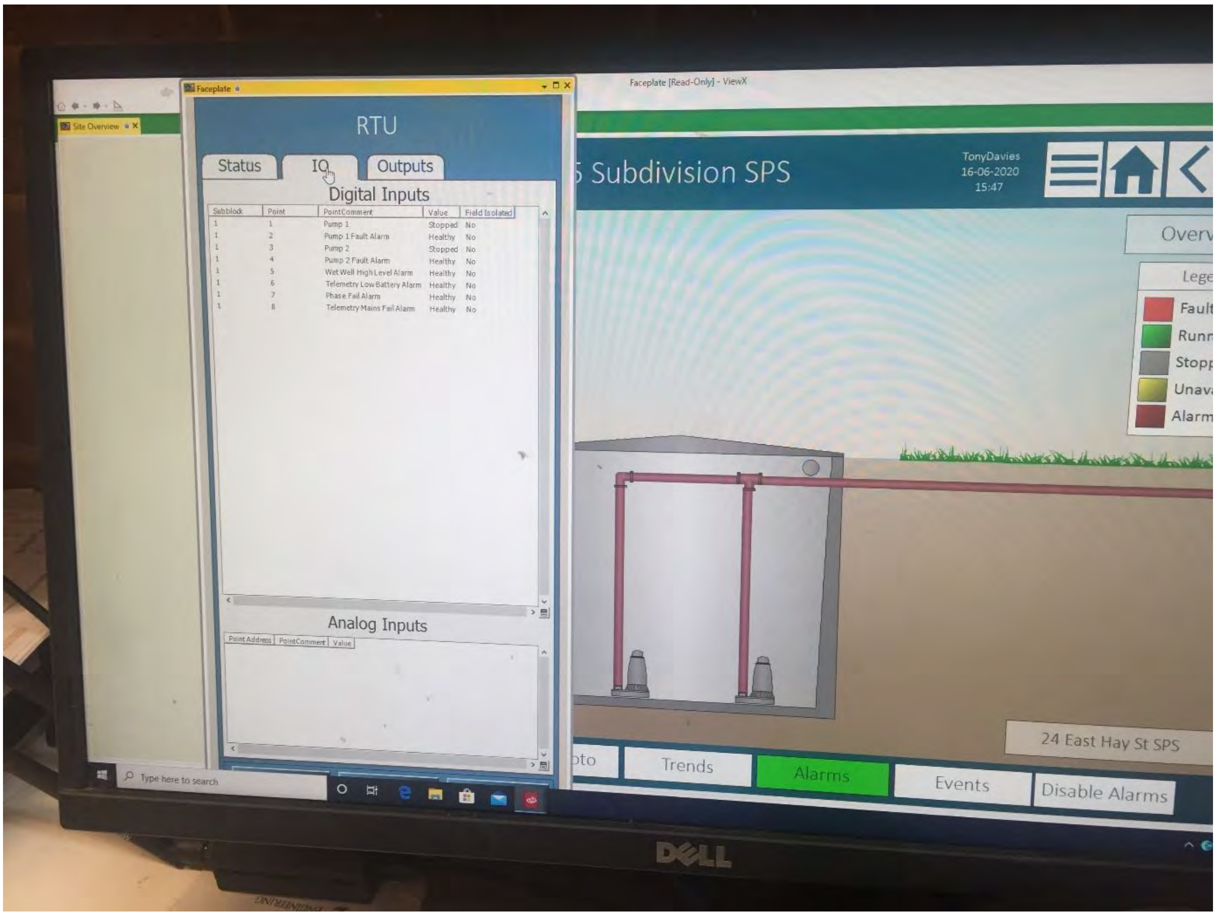
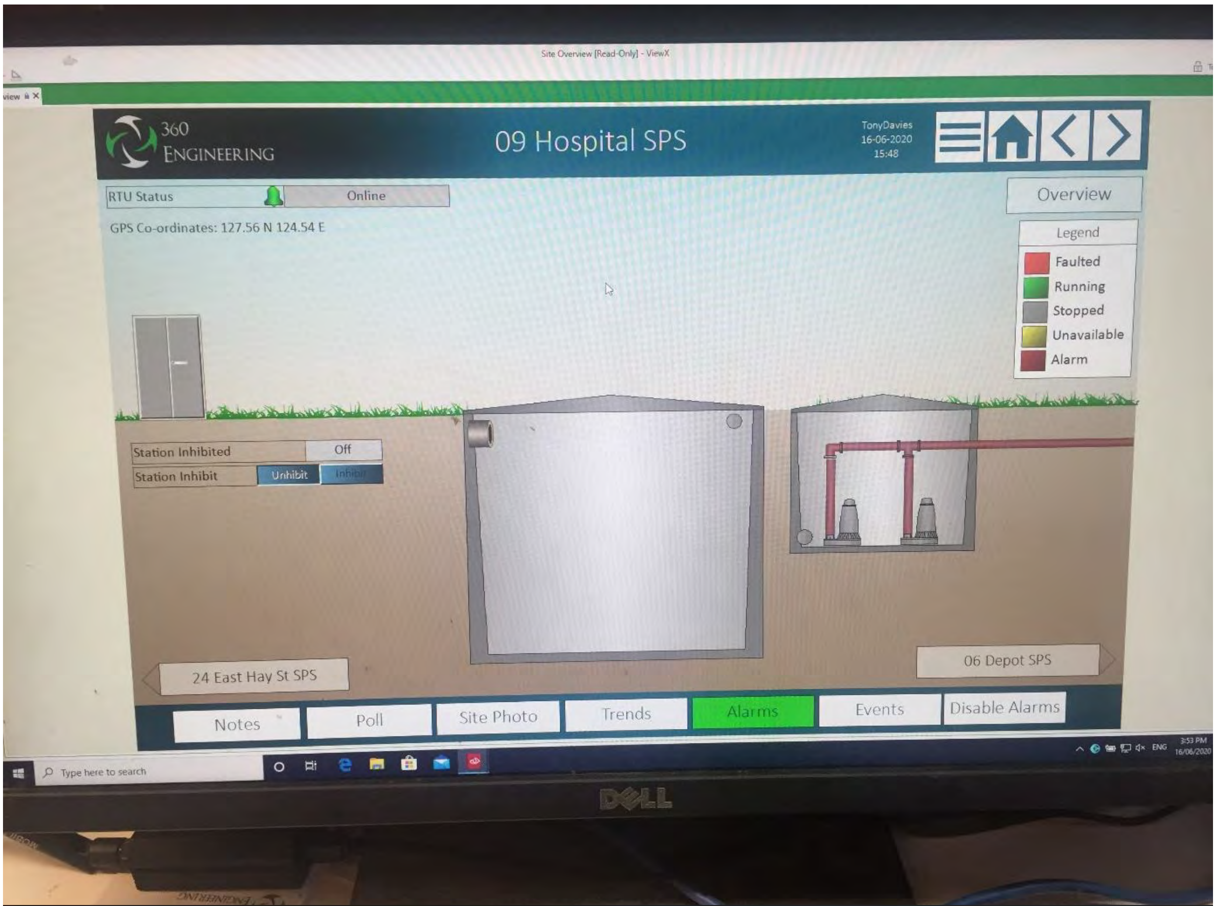
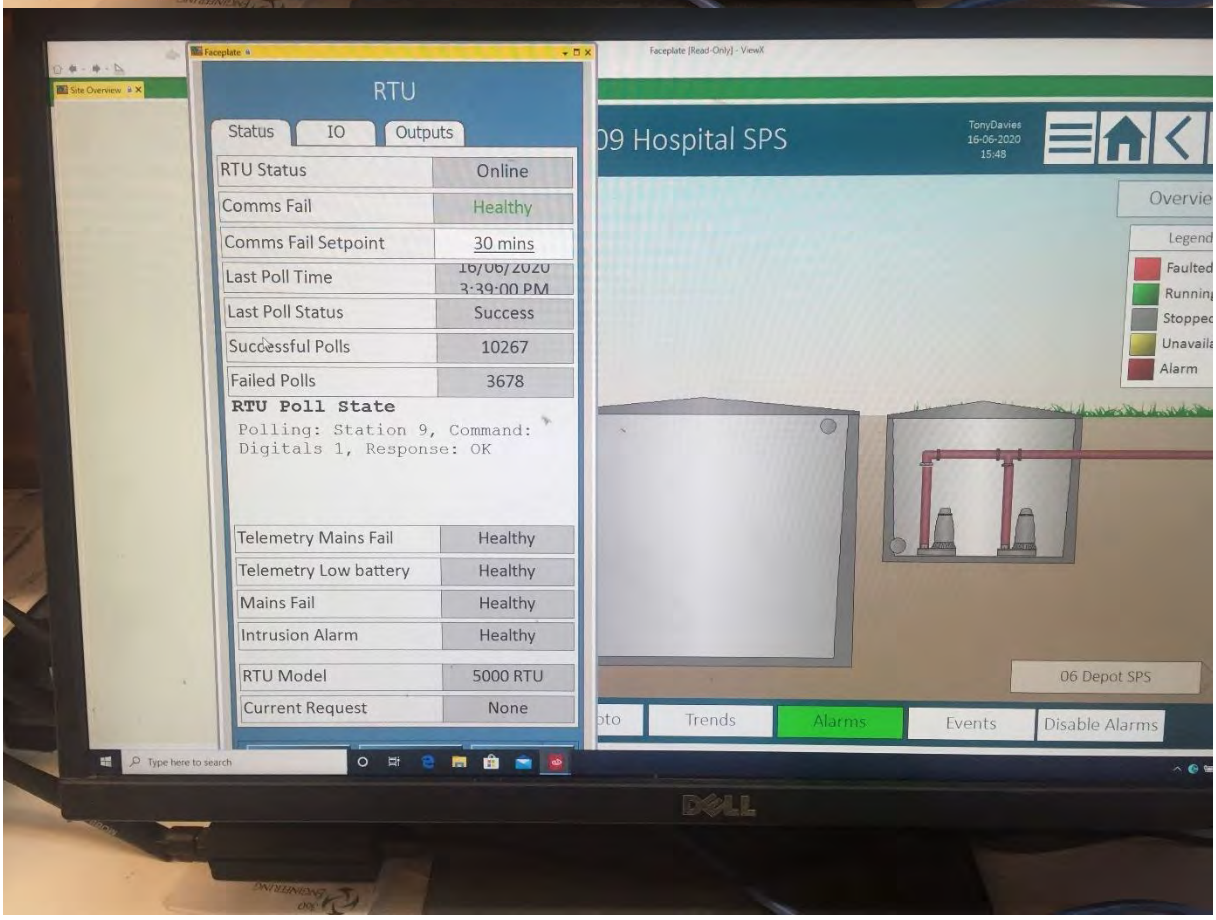


Figure 15-2: SPS – Wet Well


Site Overview [Read-Only] - ViewX
360 ENGINEERING
09 Hospital SPS
TonyDavies
16-06-2020
15:48
RTU Status
Online
GPS Co-ordinates: 127.56 N 124.54 E
Overview
Legend
Faulted
Running
Stopped
Unavailable
Alarm
Station Inhibited
Off
Station Inhibit
Unhibit
24 East Hay St SPS
06 Depot SPS
Notes
Poll
Site Photo
Trends
Alarms
Events
Disable Alarms
Type here to search
DELL


Faceplate [Read-Only] - ViewX
RTU
Status
IO
Outputs
RTU Status
Online
Comms Fail
Healthy
Comms Fail Setpoint
30 mins
Last Poll Time
16/06/2020
3:39:00 PM
Last Poll Status
Success
Successful Polls
10267
Failed Polls
3678
RTU Poll State
Polling: Station 9, Command:
Digitals 1, Response: OK
Telemetry Mains Fail
Healthy
Telemetry Low battery
Healthy
Mains Fail
Healthy
Intrusion Alarm
Healthy
RTU Model
5000 RTU
Current Request
None
09 Hospital SPS
TonyDavies
16-06-2020
15:48
Legend
Faulted
Alarm
06 Depot SPS
Trends
Alarms
Events
Disable Alarms
Type here to search
DELL

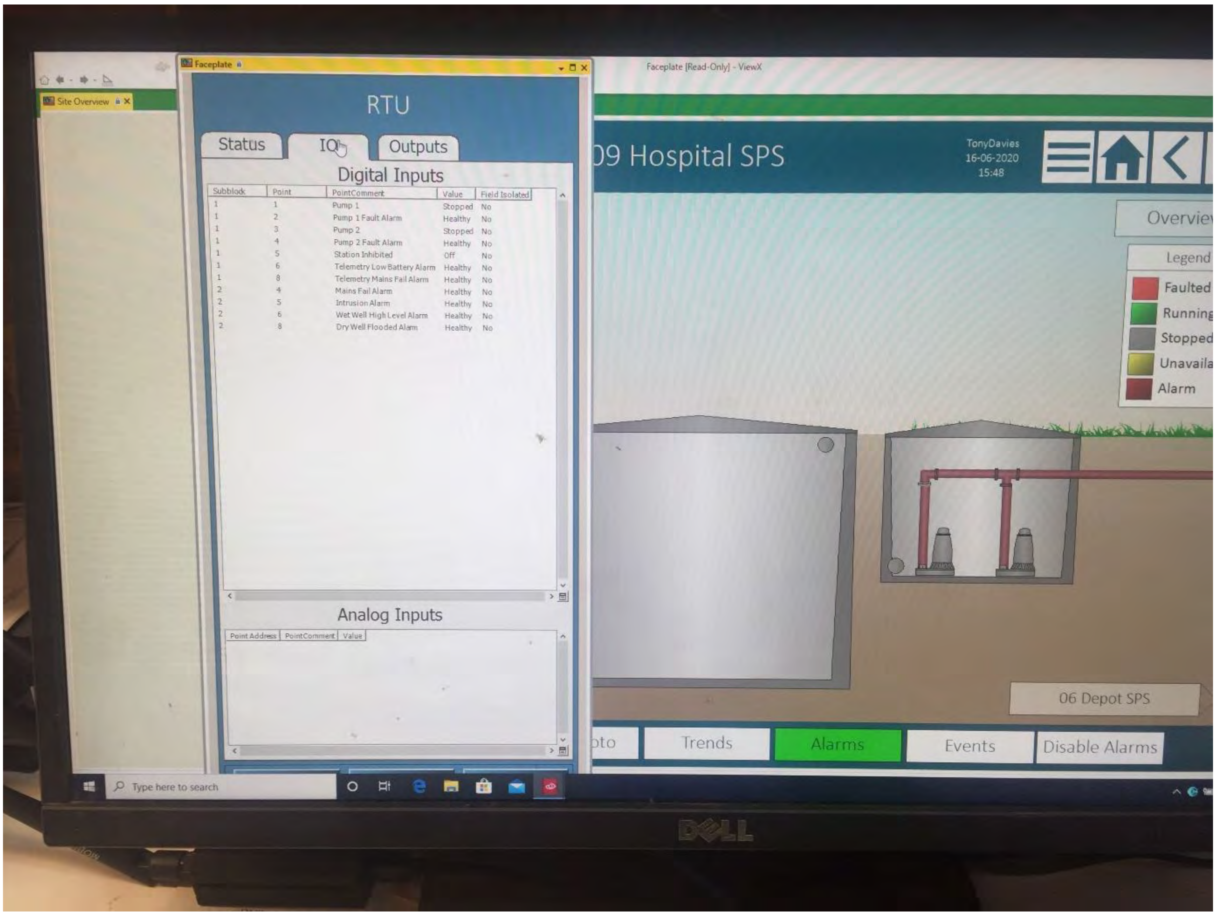


Figure 15-3: SPS – Dry Well

Figure 15-4: STP Overview

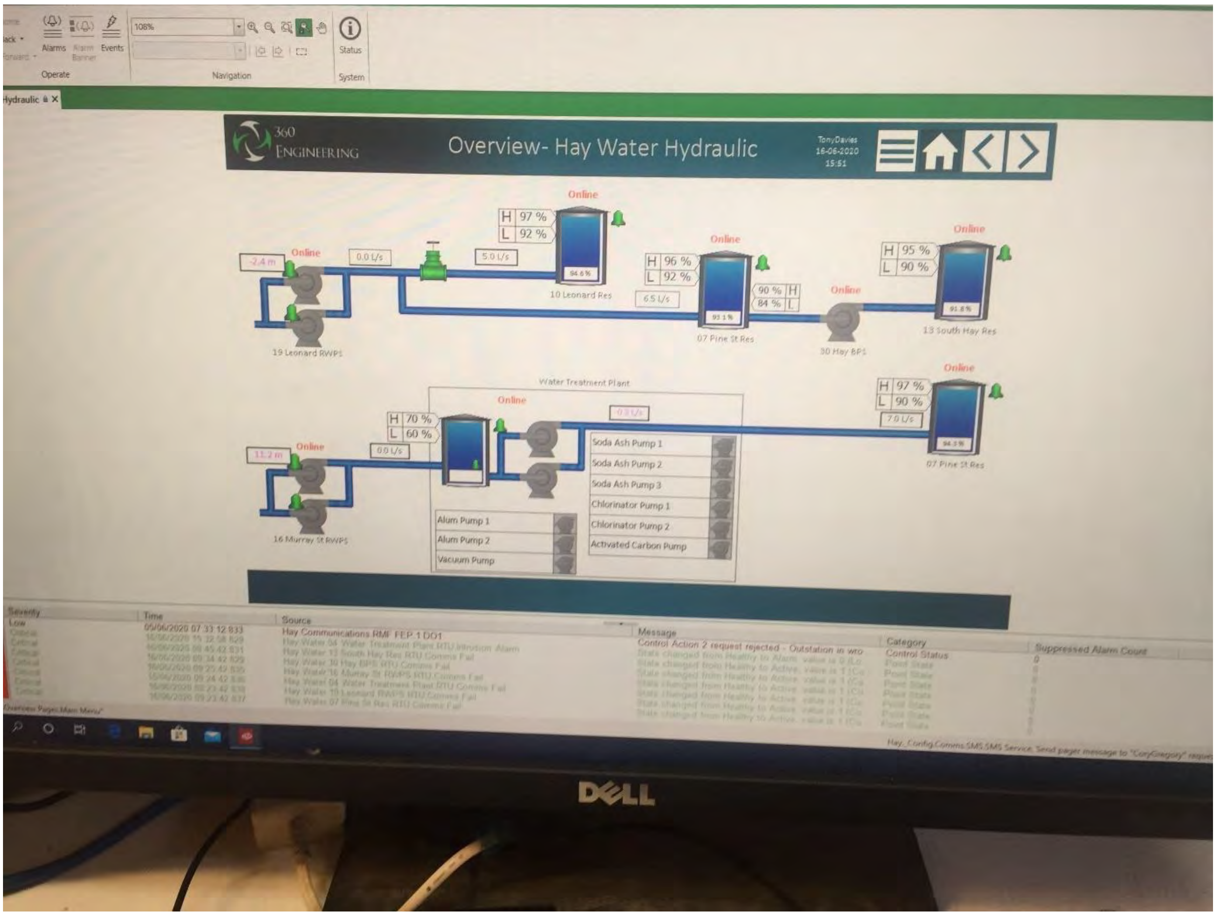
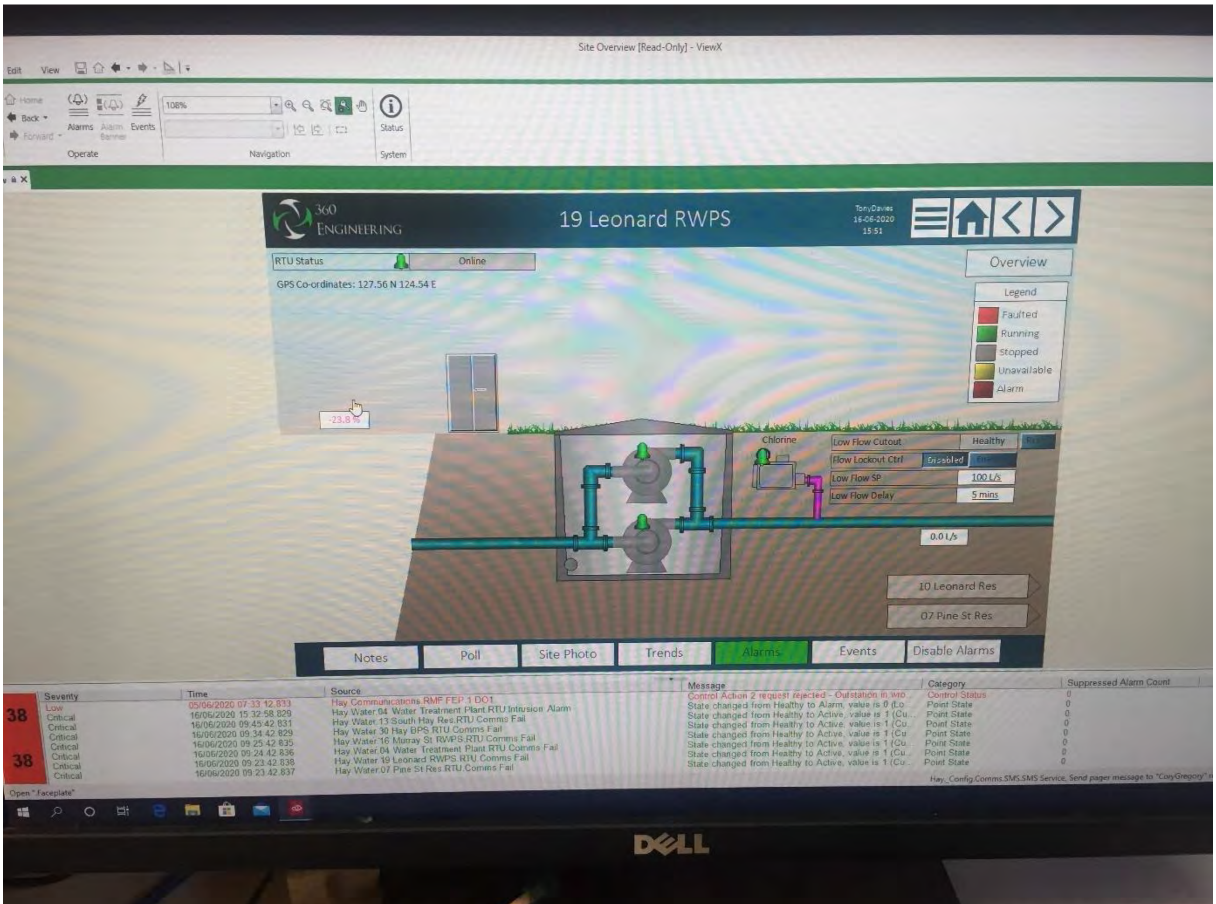
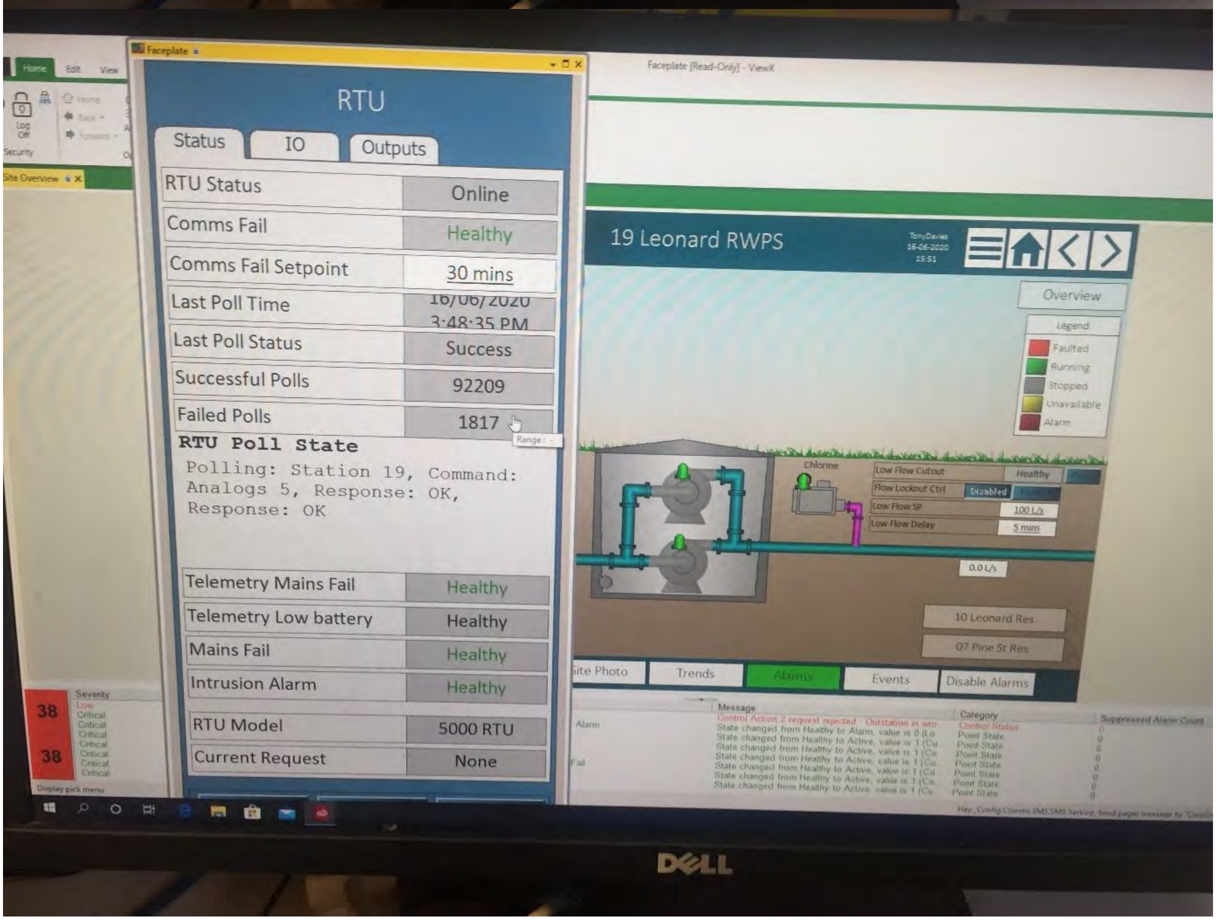
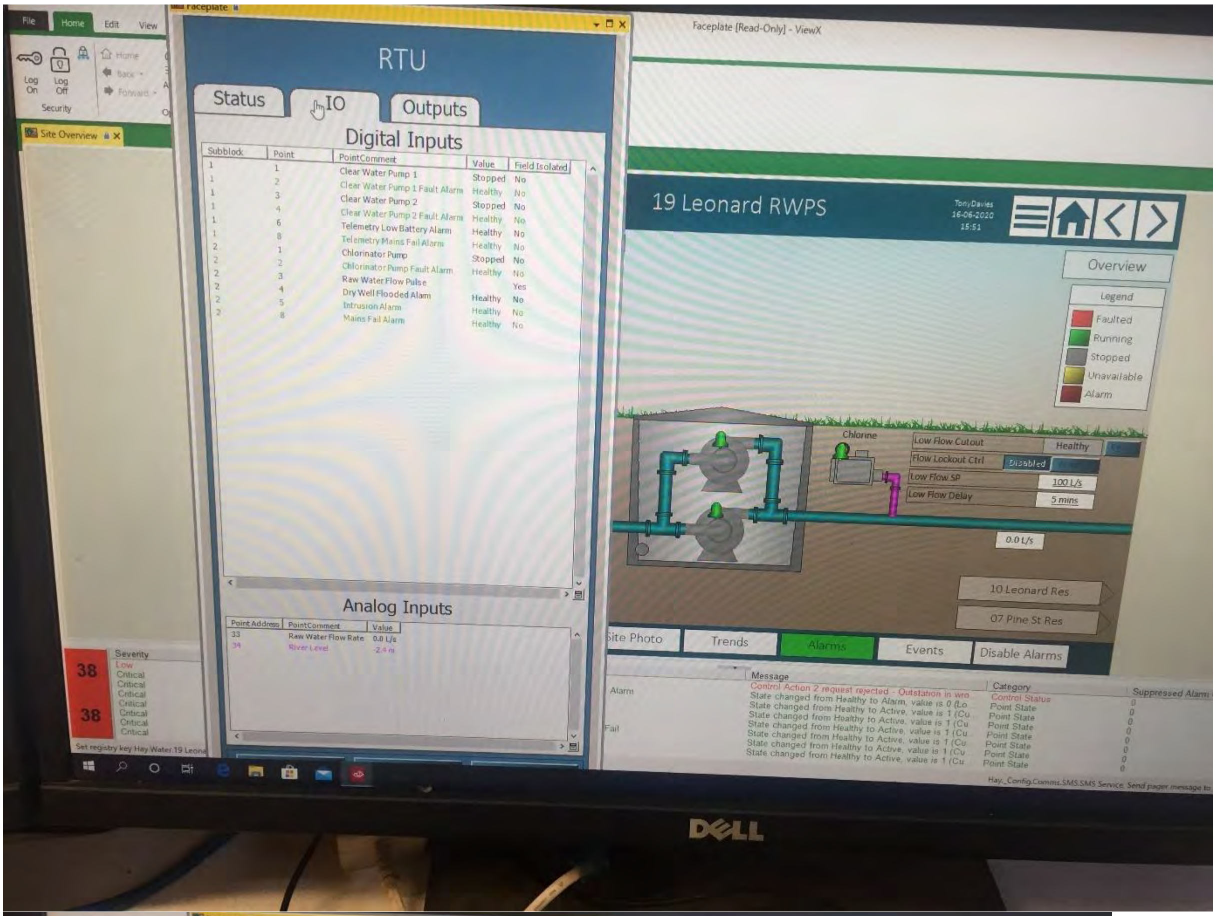


Figure 15-5: Water Hydraulic Overview


Site Overview [Read-Only] - ViewX
19 Leonard RWPS
360 ENGINEERING
RTU Status
Online
GPS Co-ordinates: 127.56 N 124.54 E
Overview
Legend
Faulted
Running
Stopped
Unavailable
Alarm
Chlorine
Low Flow Cutout
Healthy
Flow Lockout Ctrl
Disabled
Low Flow SP
100 L/s
Low Flow Delay
5 mins
0.0 L/s
10 Leonard Res
07 Pine St Res
Notes
Poll
Site Photo
Trends
Alarms
Events
Disable Alarms


RTU
Status
IO
Outputs
RTU Status
Online
Comms Fail
Healthy
Comms Fail Setpoint
30 mins
Last Poll Time
16/06/2020 3:48:35 PM
Last Poll Status
Success
Successful Polls
92209
Failed Polls
1817
RTU Poll State
Polling: Station 19, Command: Analogs 5, Response: OK, Response: OK
Telemetry Mains Fail
Healthy
Telemetry Low battery
Healthy
Mains Fail
Healthy
Intrusion Alarm
Healthy
RTU Model
5000 RTU
Current Request
None
19 Leonard RWPS
Overview
Legend
Faulted
Running
Stopped
Unavailable
Alarm
10 Leonard Res
07 Pine St Res
Trends
Alarms
Events
Disable Alarms



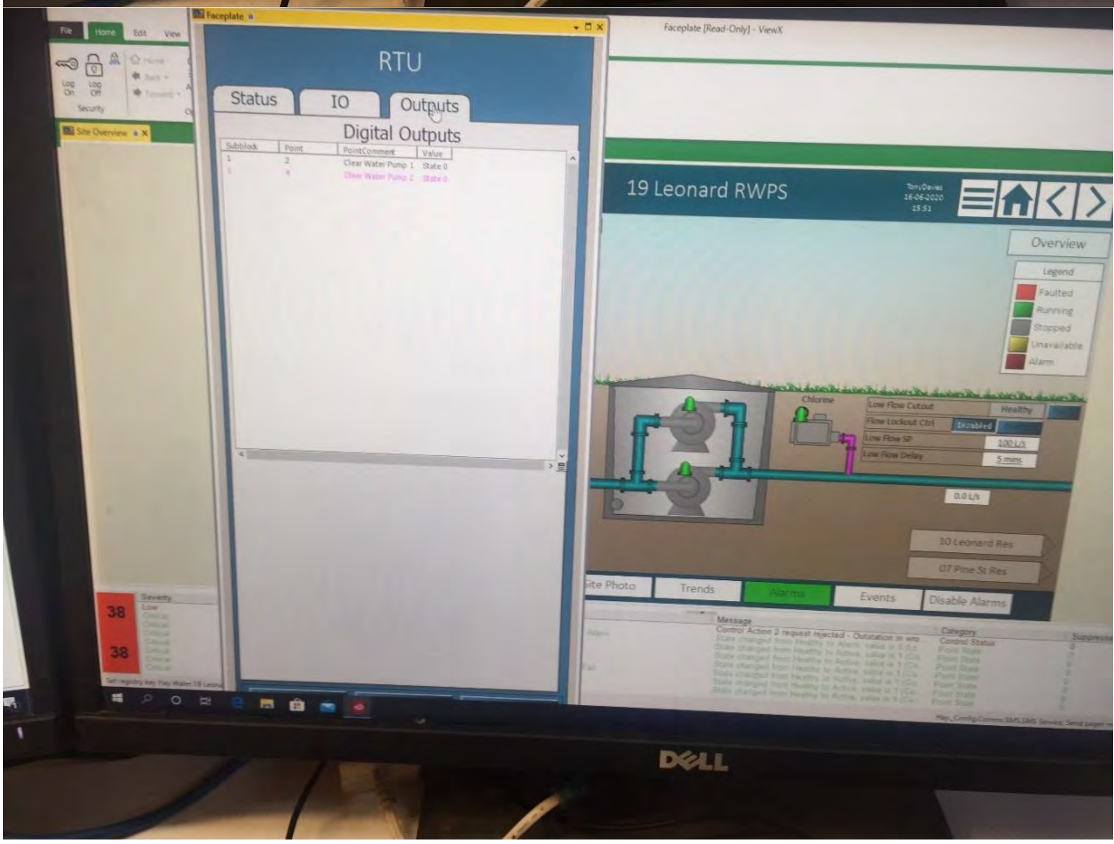
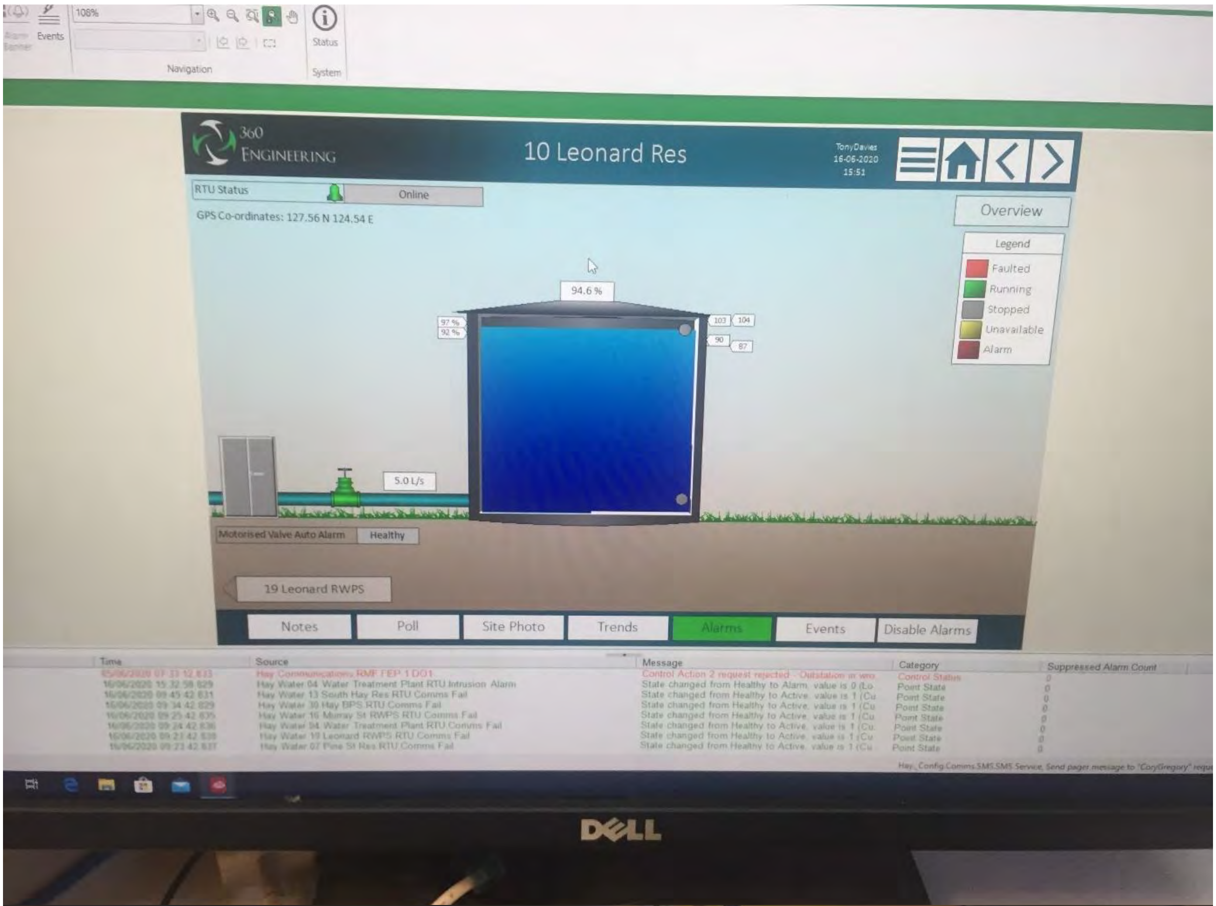
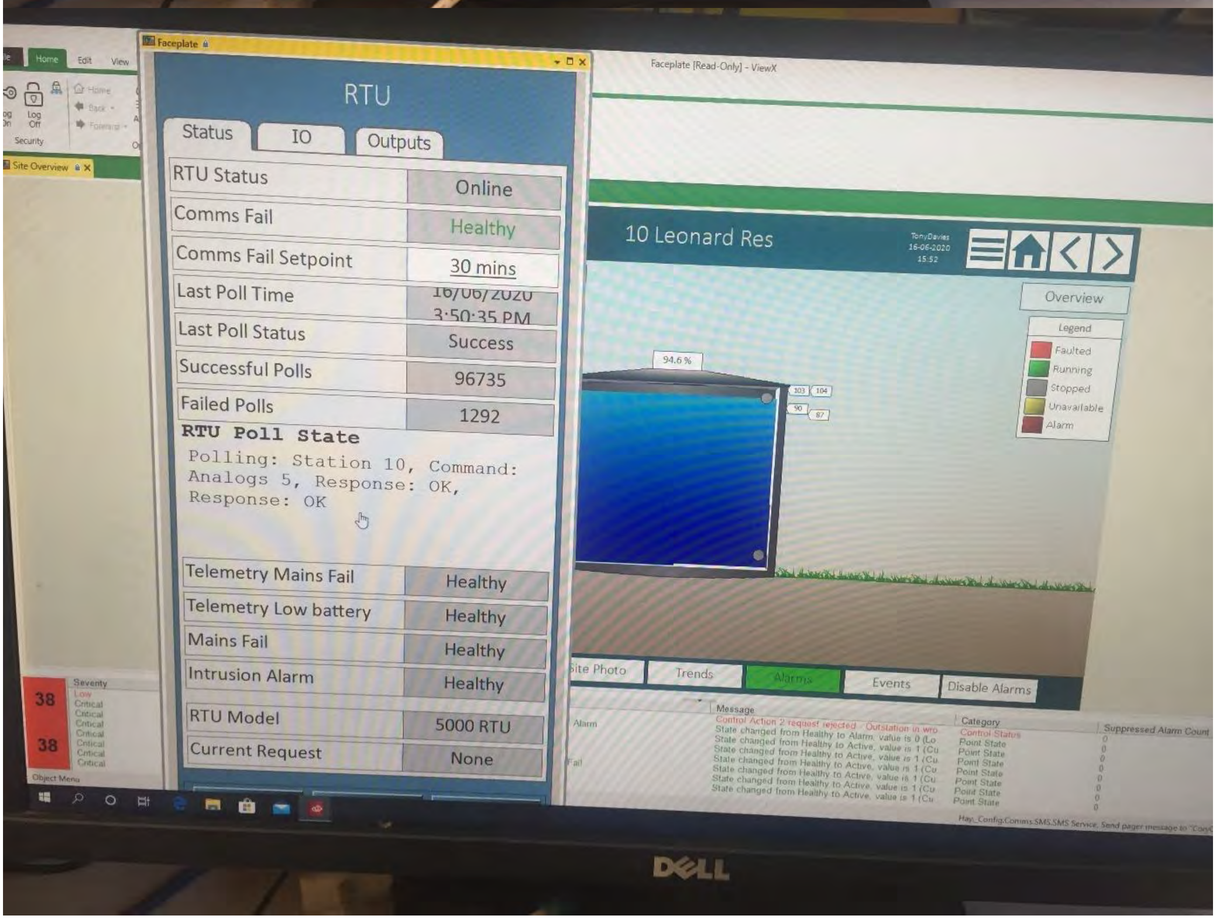


Figure 15-6: Raw Water Pump Station


10 Leonard Res
RTU Status
Online
GPS Co-ordinates: 127.56 N 124.54 E
Overview
Legend
Faulted
Running
Stopped
Unavailable
Alarm
94.6 %
5.0 L/s
Motorised Valve Auto Alarm
Healthy
19 Leonard RWPS
Notes
Poll
Site Photo
Trends
Alarms
Events
Disable Alarms


RTU
Status
IO
Outputs
RTU Status
Online
Comms Fail
Healthy
Comms Fail Setpoint
30 mins
Last Poll Time
16/06/2020
3:50:35 PM
Last Poll Status
Success
Successful Polls
96735
Failed Polls
1292
RTU Poll State
Polling: Station 10, Command: Analogs 5, Response: OK, Response: OK
Telemetry Mains Fail
Healthy
Telemetry Low battery
Healthy
Mains Fail
Healthy
Intrusion Alarm
Healthy
RTU Model
5000 RTU
Current Request
None
10 Leonard Res
Overview
Legend
Faulted
Running
Stopped
Unavailable
Alarm
94.6 %

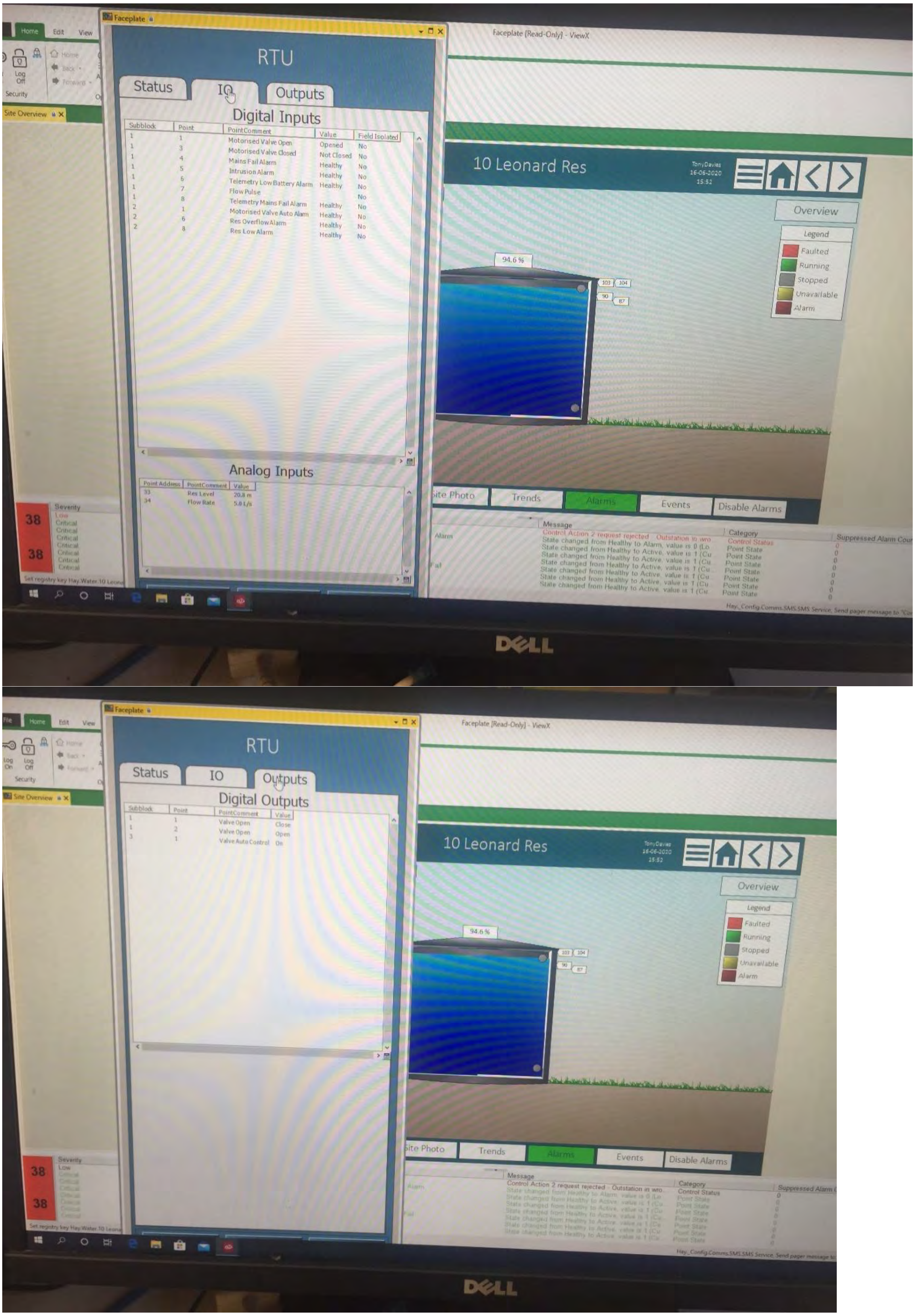


Figure 15-7: Raw Water Reservoir

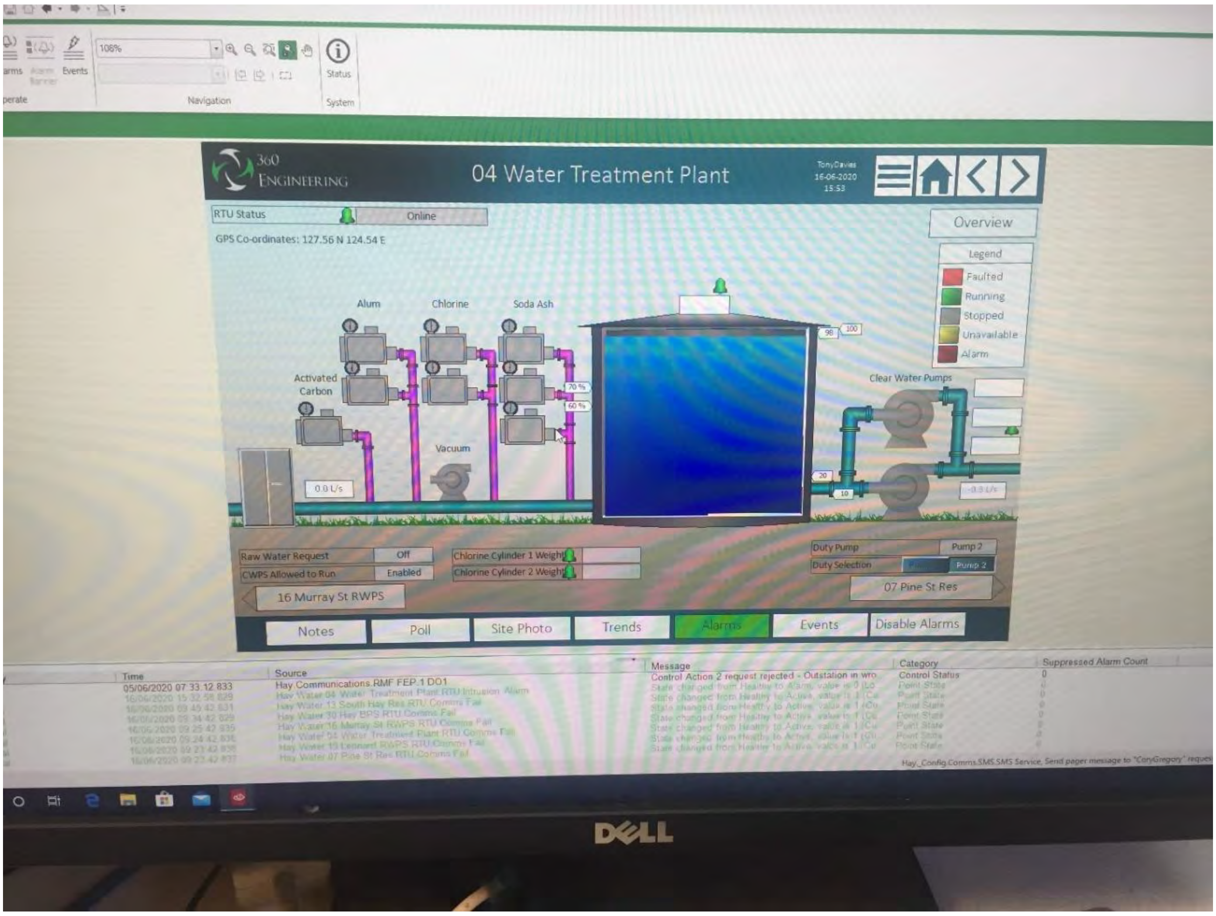
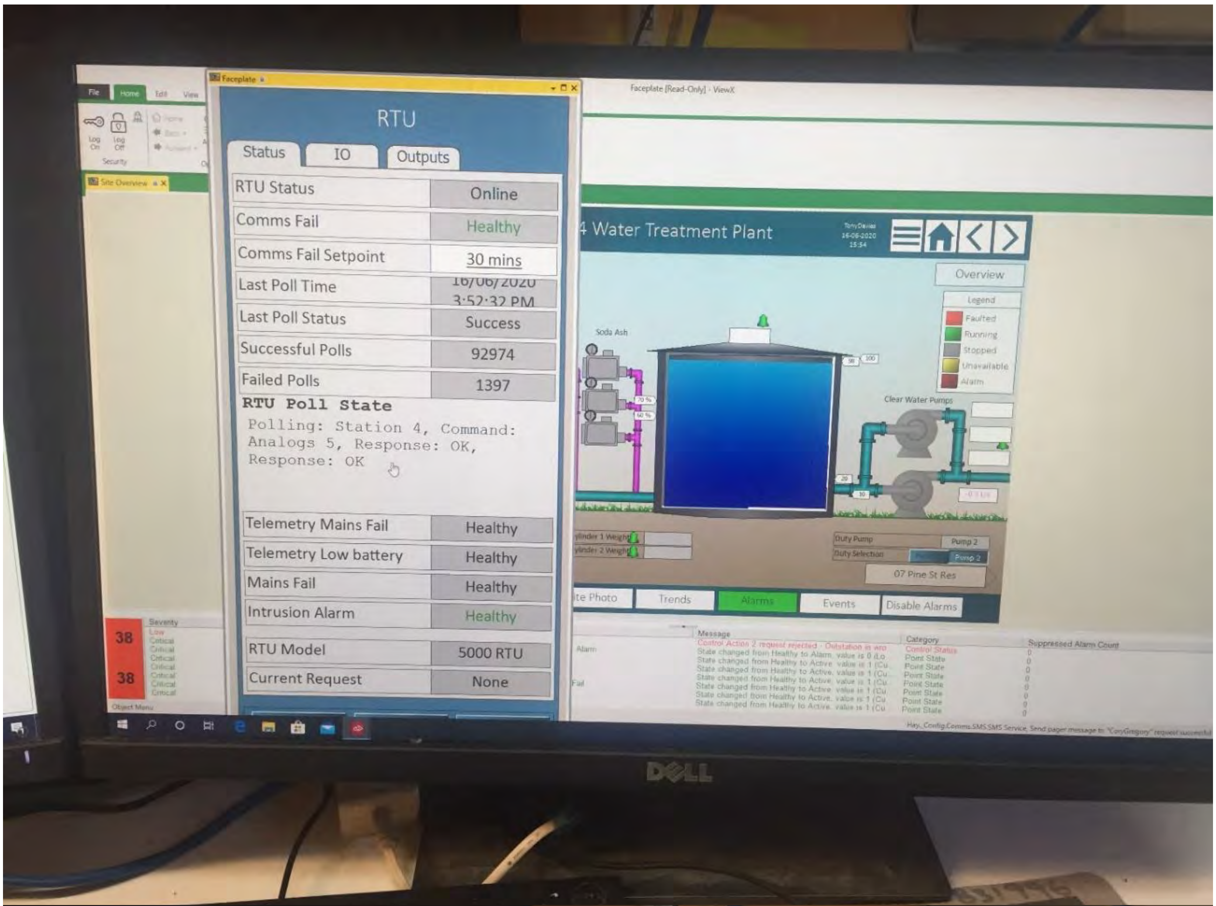
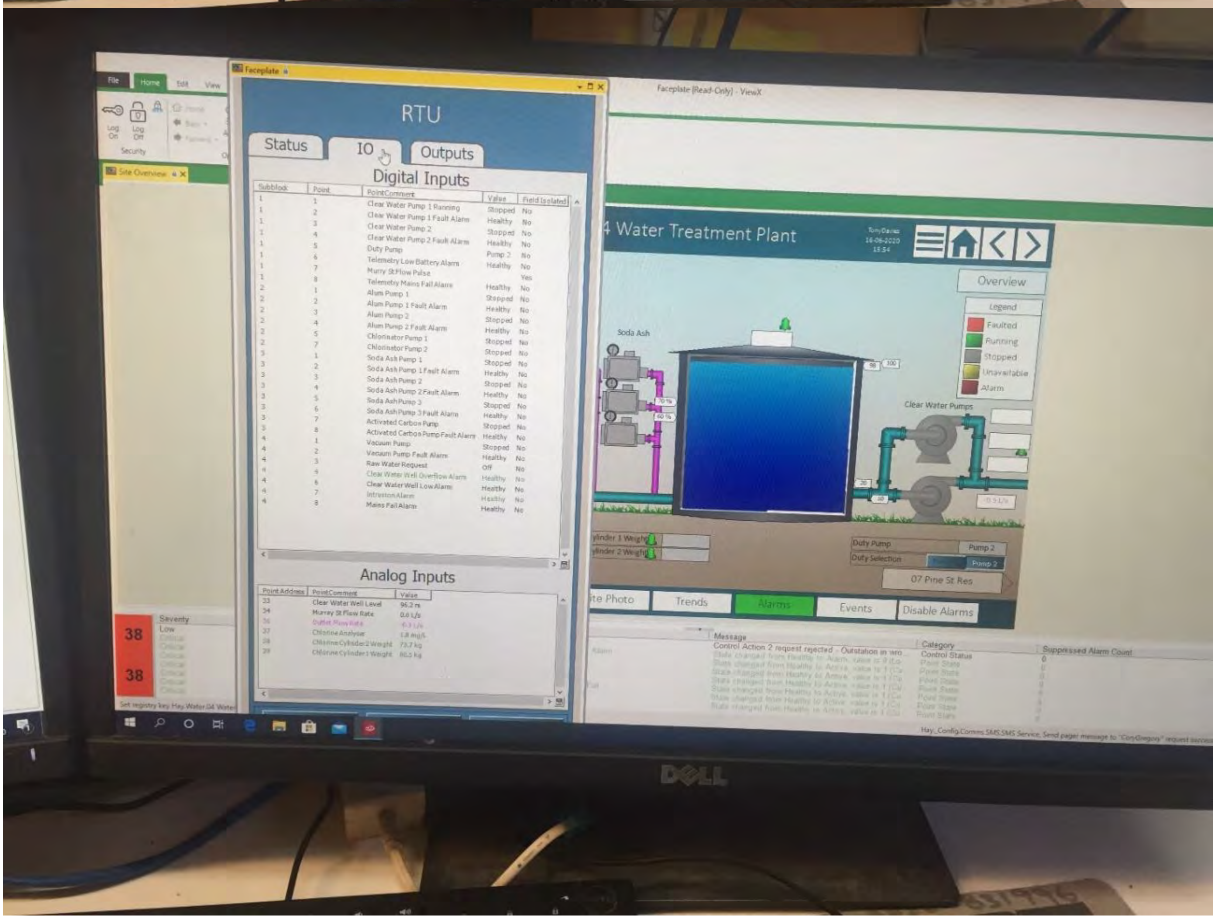
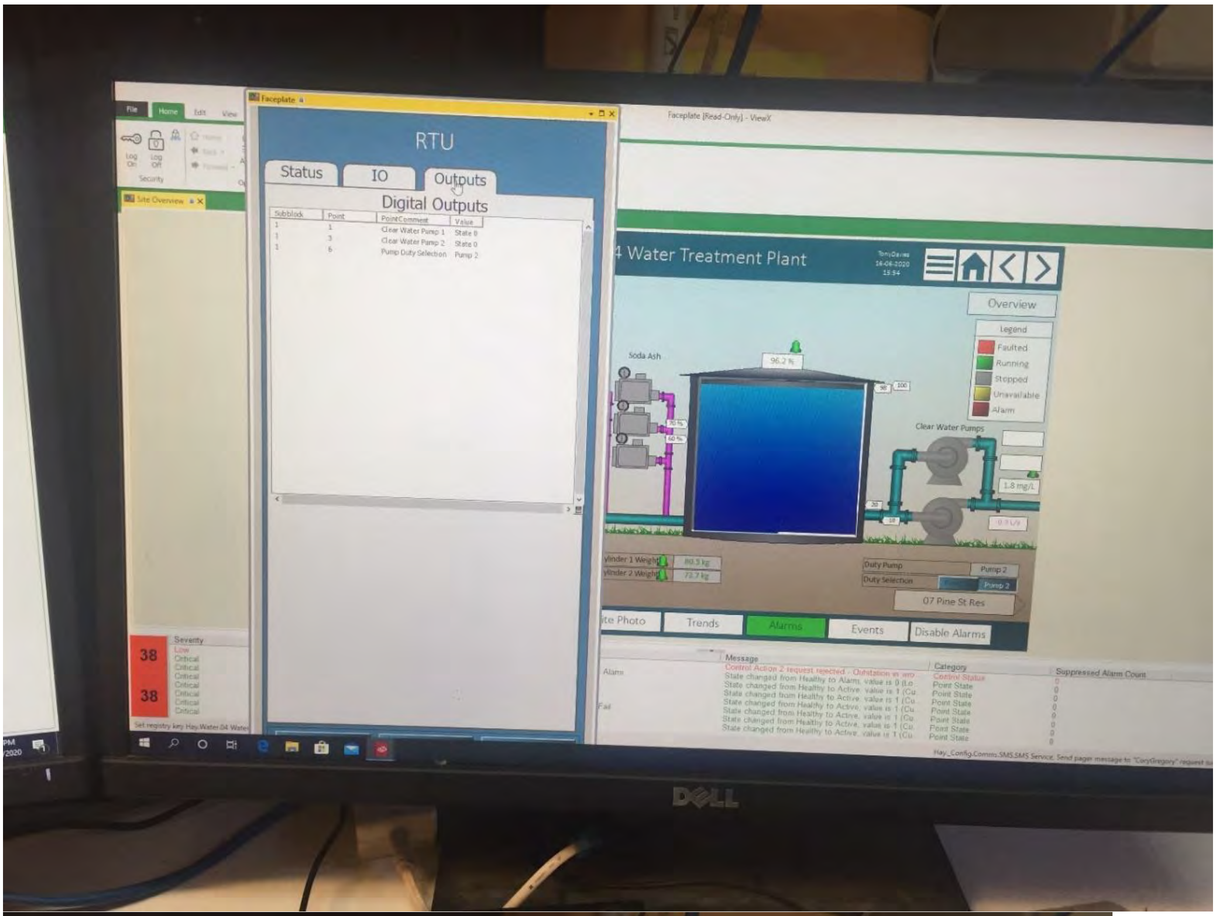


Figure 15-8: WTP Overview


RTU
Status
IO
Outputs
RTU Status
Online
Comms Fail
Healthy
Comms Fail Setpoint
30 mins
Last Poll Time
16/06/2020 3:52:32 PM
Last Poll Status
Success
Successful Polls
92974
Failed Polls
1397
RTU Poll State
Polling: Station 4, Command: Analogs 5, Response: OK, Response: OK
Telemetry Mains Fail
Healthy
Telemetry Low battery
Healthy
Mains Fail
Healthy
Intrusion Alarm
Healthy
RTU Model
5000 RTU
Current Request
None
4 Water Treatment Plant
Overview
Trends
Alarms
Events
Disable Alarms
07 Pine St Res
DELL

RTU
Status
IO
Outputs
Digital Inputs
Analog Inputs
4 Water Treatment Plant
Overview
Trends
Alarms
Events
Disable Alarms
07 Pine St Res
DELL



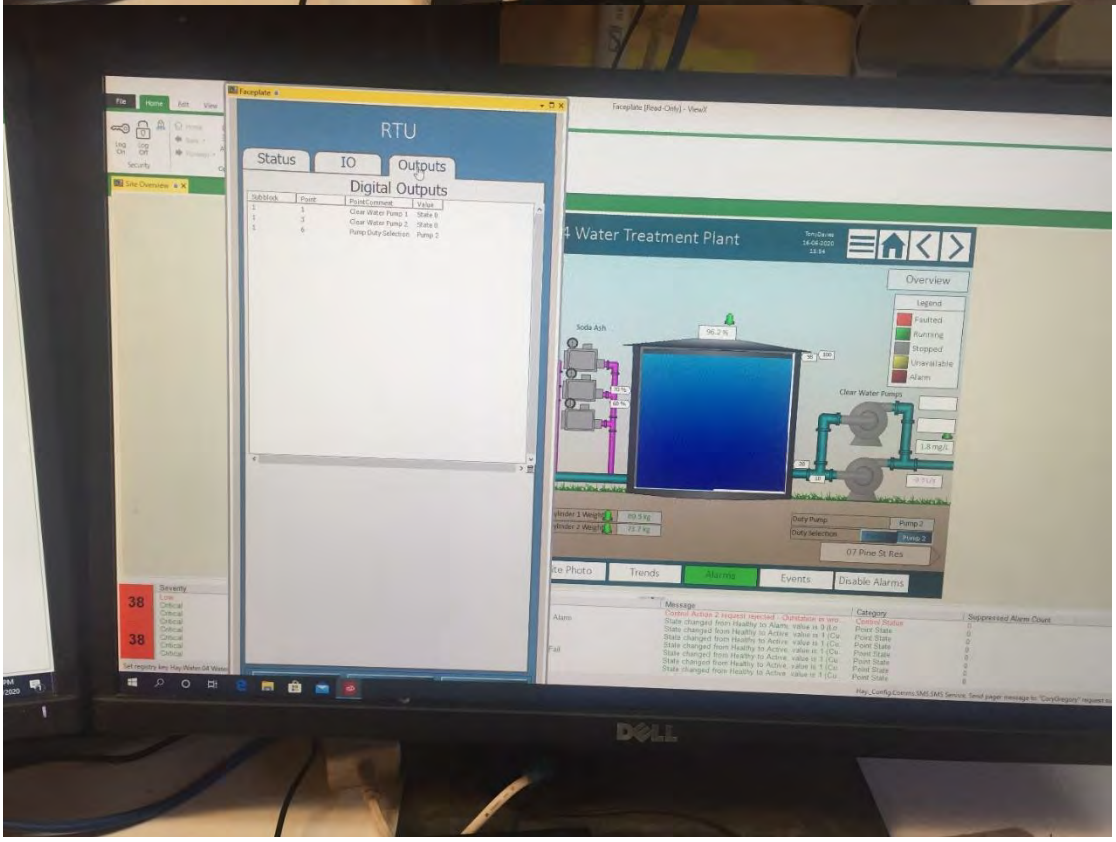


Figure 15-9: WTP IO

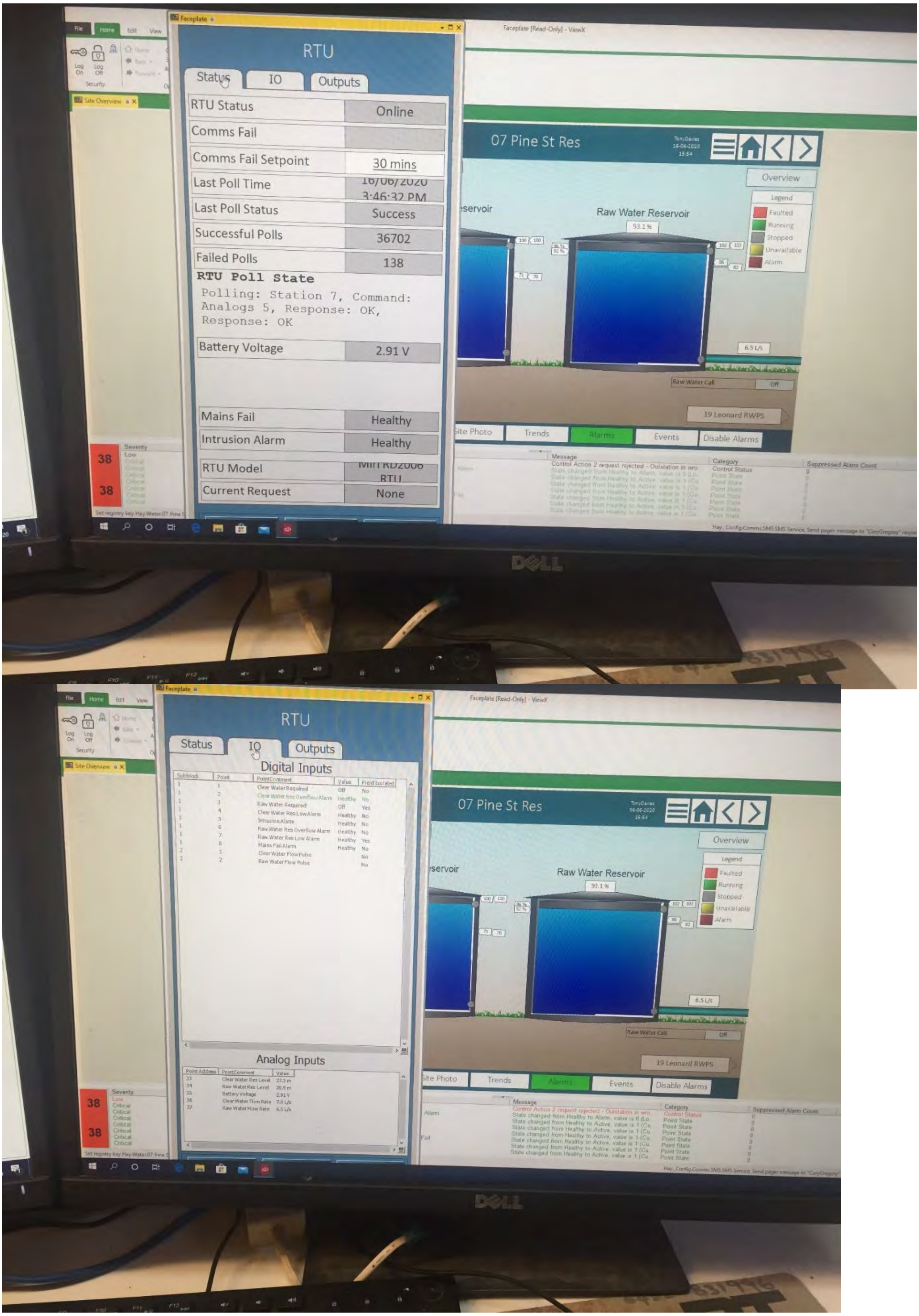


Figure 15-10: Clear and Raw Water Reservoirs

16 Appendix D: Examples of site specific condition assessments

16.1.1.1 Stephen St SPS

When upgrading the RTU at Stephen St SPS the MCC should also be replaced as the existing panel is substandard with:

- Corrosion on panel
- Poor access due to mounting height of panel
- Equipment is past its expected life expectancy
- No wiring schematics
- Panel is small and congested, no separation of the control wiring from the 415V drive wiring. This can lead to a total system failure in the event of a contractor failure / fire.

Figure 16-1: Stephen St SPS MCC panel compound area


Figure 16-2: Stephen St SPS MCC panel – this panel is to be replaced

16.1.1.2 East Hay SPS

When upgrading the RTU at East Hay SPS the internal wiring of the MCC should also be replaced as the existing panel is substandard with:

- wiring not supported in duct
- wiring joined in BP connectors not terminal strips
- Sub-standard control system
- No wiring schematics

Figure 16-3: East Hay SPS MCC panel – internal wiring to be replaced

Figure 16-4: East Hay SPS MCC panel – wiring condition poor

16.1.1.3 Hospital Well SPS

When upgrading the RTU at Hospital Well SPS the MCC should also be replaced as the existing panel is substandard with:

- Panel is be preplaced to allow for the RTU to control the site
- No wiring schematics
- Panel is small and congested, no separation of the control wiring from the 415V drive wiring. This can lead to a total system failure in the event of a contractor failure / fire.

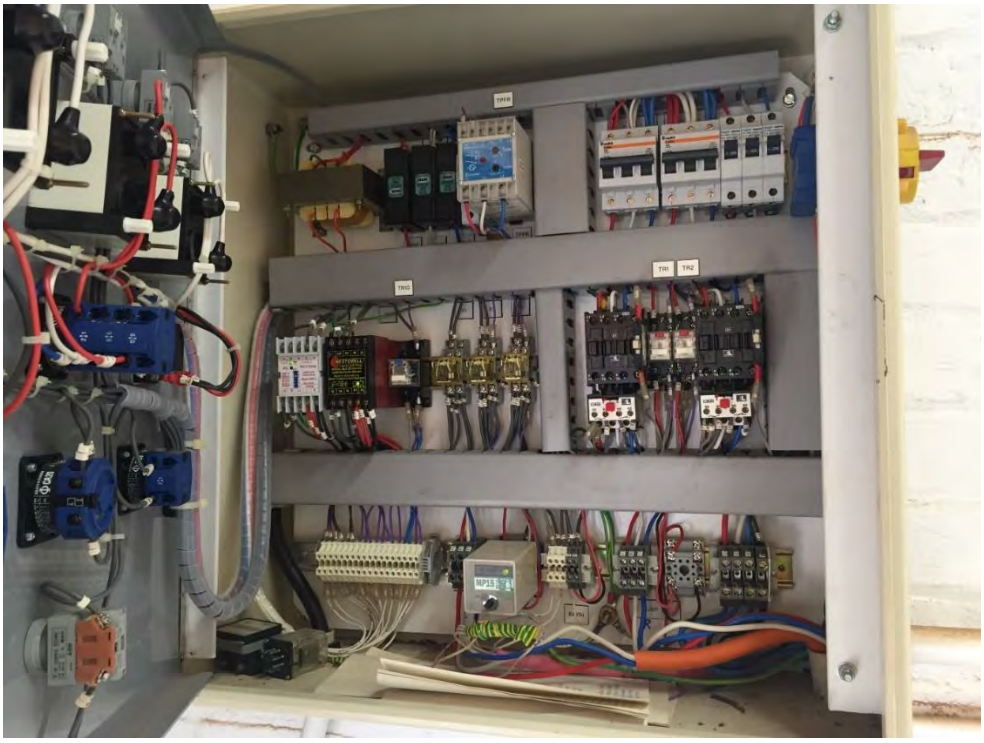


Figure 16-5: Hospital Well SPS MCC panel – this panel is to be replaced

16.1.1.4 Queen St SPS

When upgrading the RTU at Queen St SPS the MCC should also be replaced as the existing panel is substandard with:

- Exposed 415v terminals not IP2X
- Wires cut off in switchboard and not terminated
- Switchboard used as a junction box to the other SPS MCC
- No wiring schematics
- Redundant wiring to be removed
- Panel is small and congested, no separation of the control wiring from the 415V drive wiring. This can lead to a total system failure in the event of a contractor failure / fire.

Figure 16-6: Queen St SPS old power MCC panel

Figure 16-7: Queen St sub-standard pump and power connection

Figure 16-8: Queen St SPS control panel - external

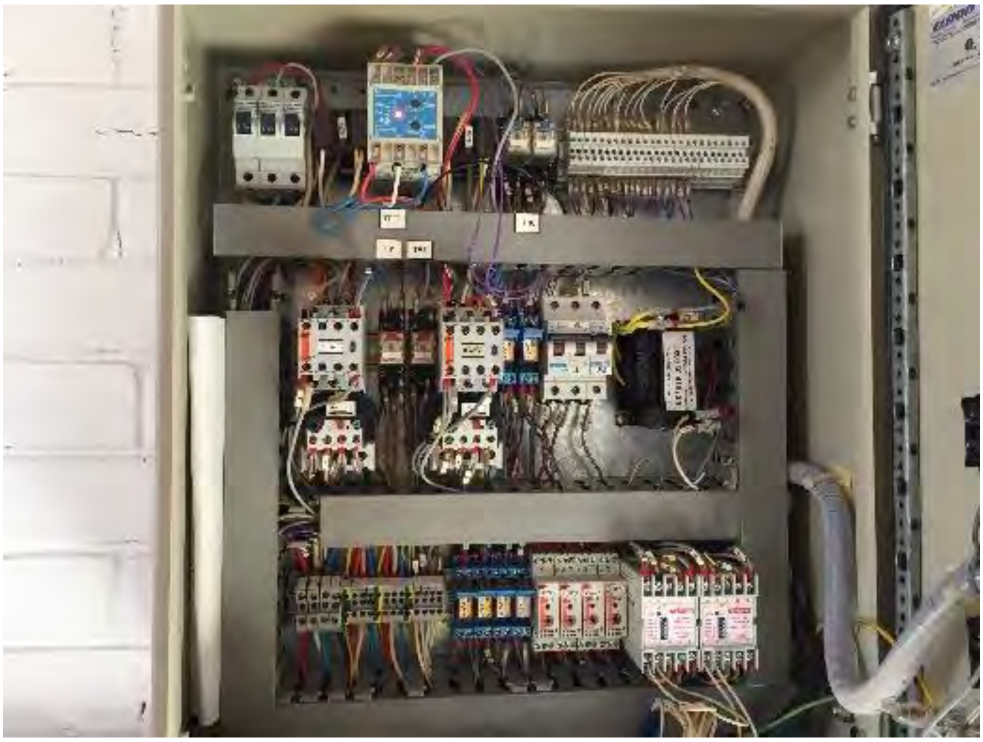


Figure 16-9: Queen St SPS control panel – internal


Figure 16-10: Queen St SPS control panel – door wiring

16.1.1.5 Depot SPS

When upgrading the RTU at Depot SPS the MCC should also be replaced as the existing panel is substandard with:

- Poor internal wiring; wires too short to fit in duct, wiring joined in BP connectors not terminal strips
- not a form built board, 240VAC on door, some 415VAC terminals behind escutcheon not IP2X
- panel mounted too high for easy access
- Exposed 415v terminals not IP2X
- Wires cut off in switchboard and not terminated
- Switchboard used as a junction box to the other SPS MCC
- No wiring schematics
- Redundant wiring to be removed
- Panel is small and congested, no separation of the control wiring from the 415V drive wiring. This can lead to a total system failure in the event of a contractor failure / fire.

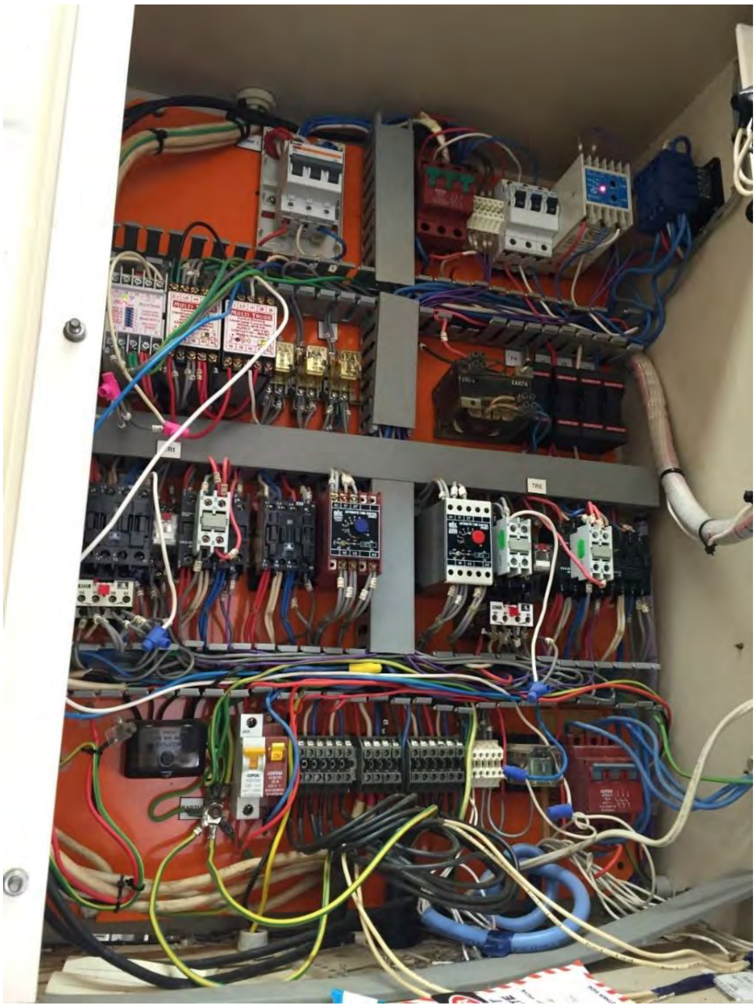


Figure 16-11: Depo control panel wiring

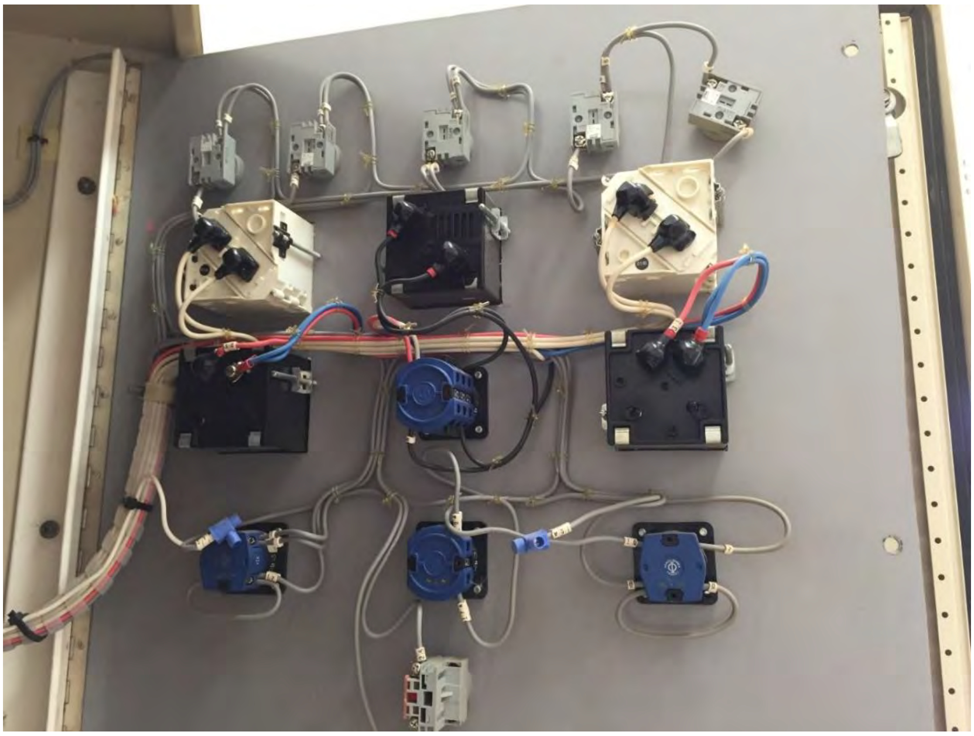


Figure 16-12: Depot SPS MCC internal door wiring

16.1.1.6 Sandy Point SPS

When upgrading the RTU at Sandy Point SPS the MCC should also be replaced as the existing panel is substandard with:

- Poor internal wiring; wires too short to fit in duct, wiring joined in BP connectors not terminal strips
- No wire numbers
- Equipment not identified
- not a form built board, 240VAC on door, some 415VAC terminals behind door not IP2X
- capacitors not supported, hanging from wiring
- No wiring schematics
- Redundant wiring to be removed
- Panel is small and congested, no separation of the control wiring from the 415V drive wiring. This can lead to a total system failure in the event of a contractor failure / fire.

Figure 16-13: Sandy point SPS MCC

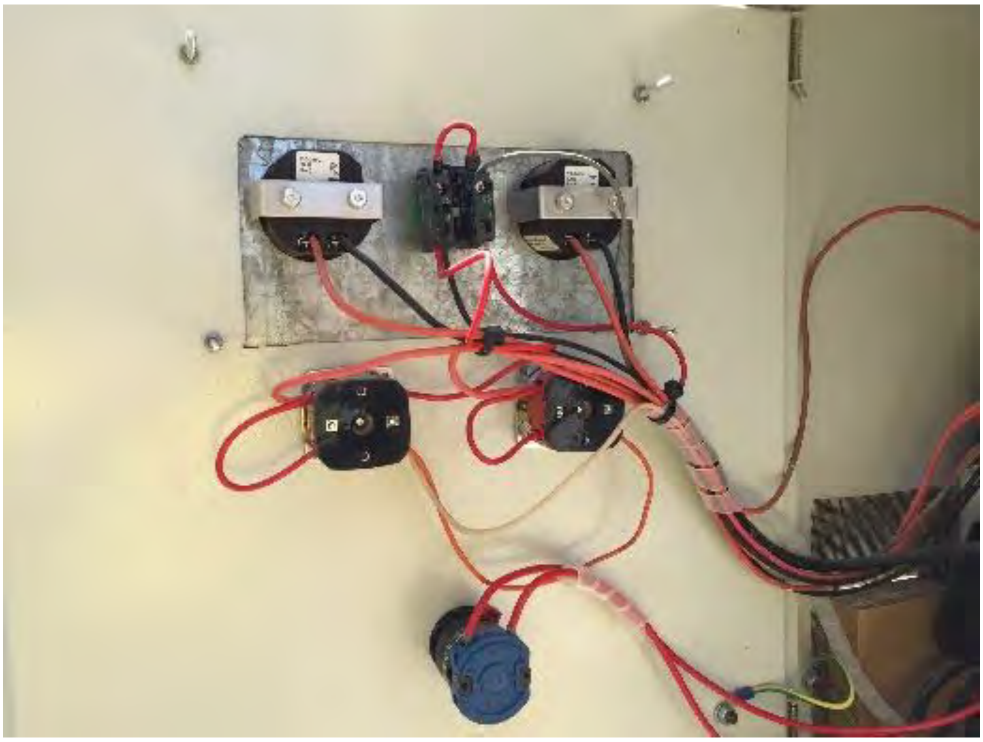


Figure 16-14: Sandy point SPS MCC door wiring

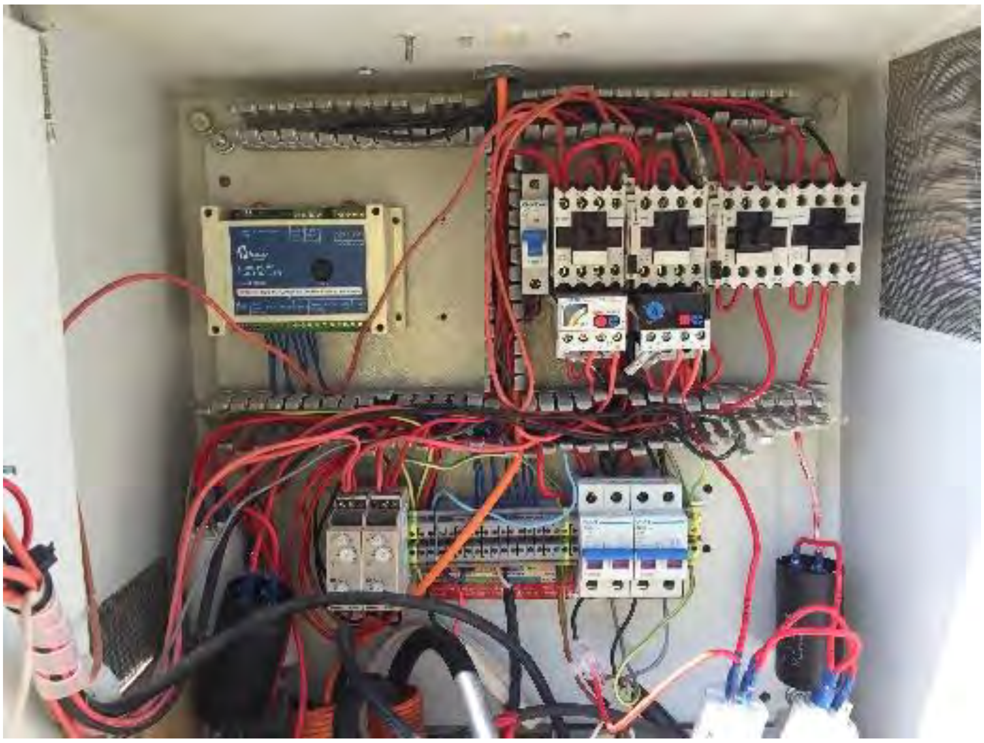


Figure 16-15: Sandy Point SPS MCC panel wiring

16.1.1.7 Russell St SPS

When upgrading the RTU at Russell St SPS the MCC should also be replaced as the existing panel is substandard with:

- Panel manufactured in 1977 and is outdated
- Switchboard consists of individual PVC enclosures within the board for incoming mains and individual pump starter modules, flammable in the incident of a fire
- A pit located directly in front of the switchboard doors poses a trip/fall hazard whilst accessing the switchboard
- No wiring schematics
- Redundant wiring to be removed
- Panel is small and congested, no separation of the control wiring from the 415V drive wiring. This can lead to a total system failure in the event of a contractor failure / fire.

Figure 16-16: Russell St SPS MCC panel wiring layout

Figure 16-17: Russell St SPS MCC starter / control panel internal

16.1.1.8 Palmer St SPS

When upgrading the RTU at Palmer St SPS the MCC should also be replaced as the existing panel is substandard with:

- Panel manufactured in 1977 and is outdated
- Switchboard consists of individual PVC enclosures within the board for incoming mains and individual pump starter modules
- Switchboard concrete base is failing
- Redundant wiring to be removed
- Panel is small and congested, no separation of the control wiring from the 415V drive wiring. This can lead to a total system failure in the event of a contractor failure / fire.
- Concrete plinth is failing putting the panel at risk of falling off.

Figure 16-18: Palmer St SPS MCC panel external

Figure 16-19: Palmer St SPS MCC panel / control panel internal

16.1.1.9 WTP

When upgrading the RTU at WTP the MCC should also be replaced as the existing panel is substandard with:

- Panel is in average condition, Form 2
- terminals and equipment not IP2X
- obsolete equipment in panel and on doors
- wiring is messy and hanging unsupported within ducts
- no room for expansion for additional equipment
- Switchroom not to standards in respect to open panel door space and points of exit for personnel

Figure 16-20: WTP combined MCC and Lab room

Figure 16-21: WTP MCC control door

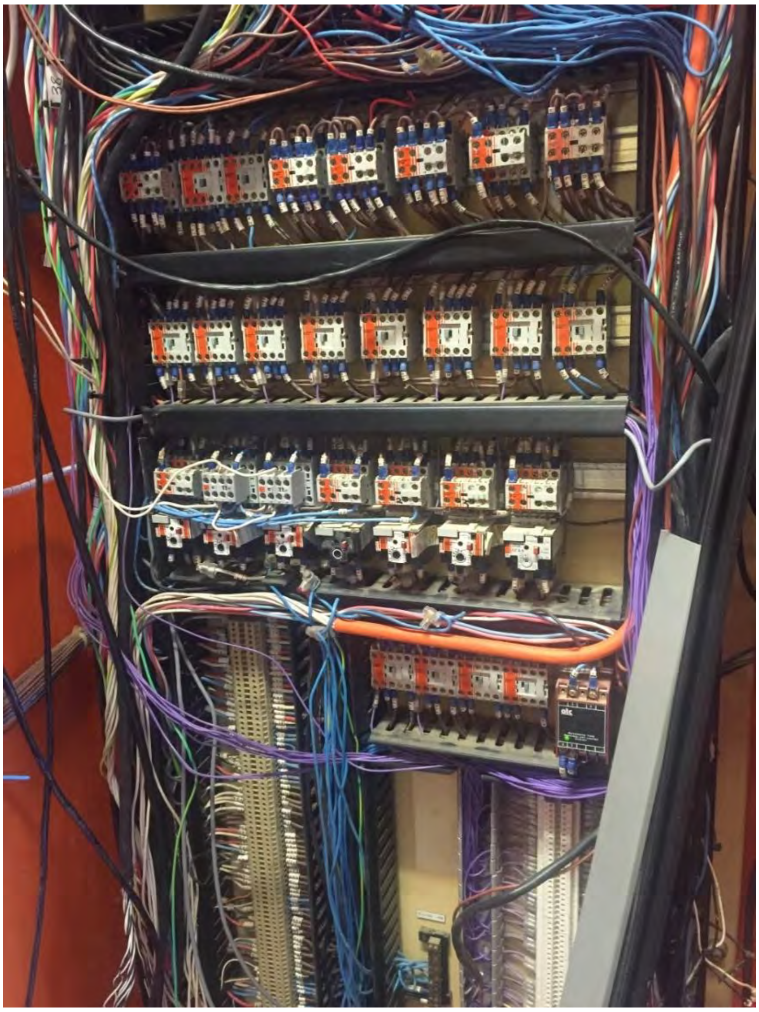


Figure 16-22: WTP motor wiring

Figure 16-23: WTP control wiring

Appendix D Hay WTP Alum and PAC Costs

5814 WTP Automation and Process Instrumentation Audit

Process and Instumentation Costing

Date of Estimate: Mar-21

Site: Hay WTP

hunterh2o

ITEM	QUANTITY	UNIT	RATE	SUB-TOTAL (Inc. change in CPI)	TOTAL
Direct Costs					
1. Alum Dosing System					
Alum Dosing System Bund	13.1	m3	$2,500	$32,750	
Alum Tanks (including delivery)	1	Item	$23,000	$23,000	
Tank level sensors	1	Item	$2,500	$2,500	
Magnetic level indicator	1	Item	$7,800	$7,800	
Flow meters	1	Item	$3,500	$3,500	
Alum dosing skid (including D/S pumps etc)	1	Item	$25,000	$25,000	
Dosing pipework and injection lance	30	m	$100	$3,000	
Process water supply instrumentation & valving	1	item	$4,000	$4,000	
Wash down hose and connections	1	item	$500	$500	
Mechanical Installation	25	hrs	$200	$5,000	
Chemical Unloading Road Bund	30.4	m^3	$1,500	$45,563	
Coagulant Static mixer	1	Item	$16,000	$16,000	
					$168,700
2. PAC Dosing System					
Dosing Line extension	1700	Item	$50	$85,000	
PAC dosing pumps	2	Item	$12,000	$24,000	
					$109,000

Total Direct Costs			$ 277,700	
		say	**$ 278,000**	**A**
Indirect Costs				
Contractor profit /overhead/ risk	10%	$ 27,800		
Project management and commissioning - Contractor	4%	$ 11,120		
Project management – Client	4%	$ 11,120		
Detailed design	8%	$ 22,240		
Sub Total		*$ 72,280*		**B**
Total Indirect Costs			$ 72,280	
		say	**$ 73,000**	**C**
Total Preliminary Project Estimate (excluding contingency)			**$ 351,000**	**D**
Contingency (30%)	30%	$ 105,300		**E**
Total Preliminary Project Estimate (including contingency)			**$ 456,300**	**F**